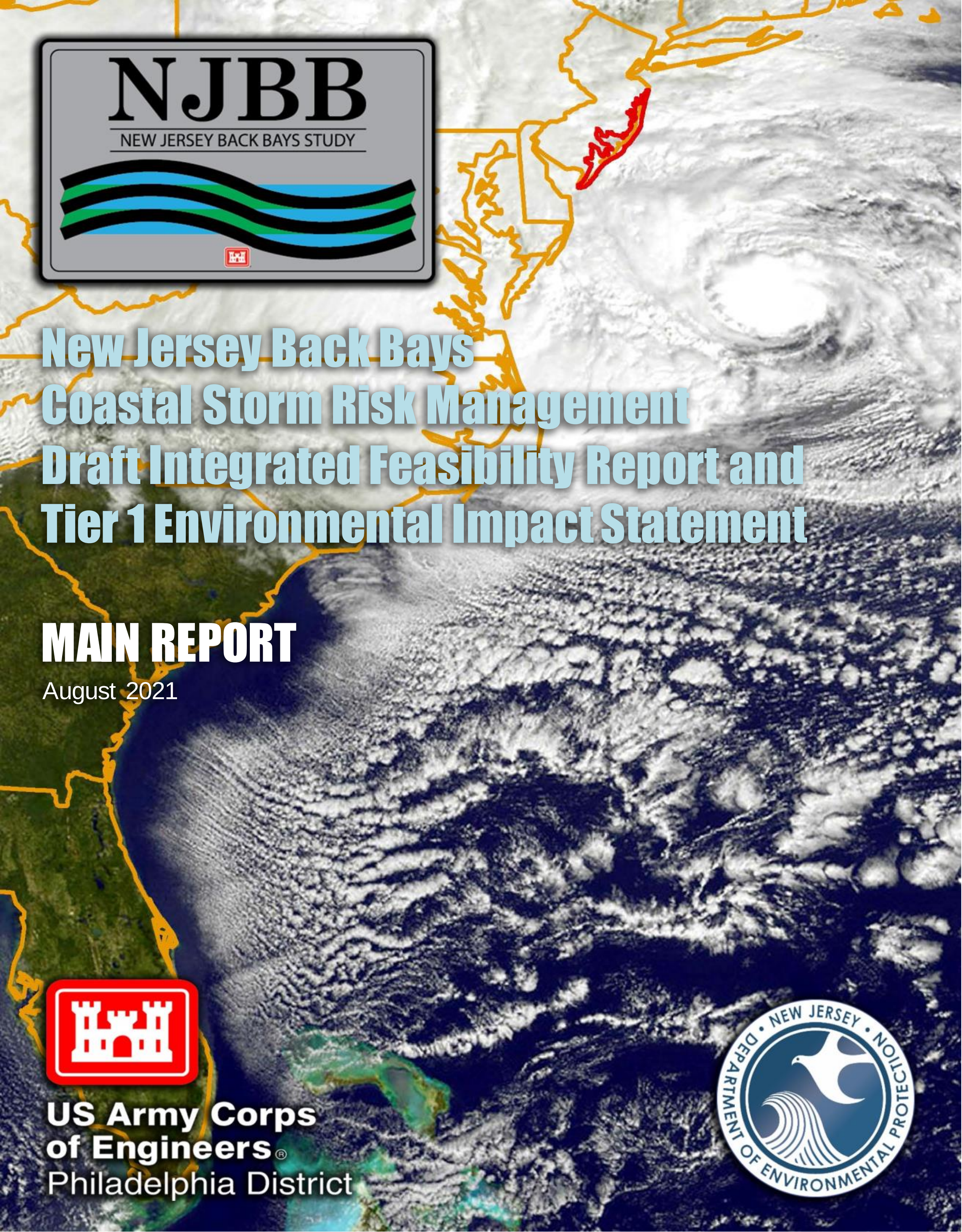

NJBB

NEW JERSEY BACK BAYS STUDY

New Jersey Back Bays Coastal Storm Risk Management Draft Integrated Feasibility Report and Tier 1 Environmental Impact Statement

MAIN REPORT

August 2021

US Army Corps of Engineers®
Philadelphia District

NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION

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New Jersey Back Bays
Coastal Storm Risk Management
Draft Integrated Feasibility Report and
Tier 1 Environmental Impact Statement

LEAD AGENCY:

Department of the Army
U.S. Army Corps of Engineers (USACE), Philadelphia District

COOPERATING AGENCIES:

U.S. Environmental Protection Agency (USEPA), National Oceanic and Atmospheric Administration (NOAA Fisheries), and the U.S. Fish and Wildlife Service (USFWS)

NON-FEDERAL SPONSOR:

New Jersey Department of Environmental Protection (NJDEP)

ABSTRACT:

This Draft Integrated Feasibility Report and Tier 1 Environmental Impact Statement (Draft Integrated Report) presents preliminary findings of a study to identify coastal storm risk management (CSRM) strategies to increase resilience and to reduce risk from future storms and compounding impacts of sea level change (SLC) for the New Jersey Back Bays (NJBB) region. The objective of the NJBB CSRM Study is to investigate CSRM problems and identify solutions to reduce damages from coastal flooding that affect population, critical infrastructure, , property, and ecosystems. This Draft Integrated Report builds upon the analyses and findings presented in the March 2019 NJBB Interim Report. Both reports are available at https://www.nap.usace.army.mil/Missions/Civil-Works/New-Jersey-Back-Bays-Study/.

This Draft Integrated Report has been conducted in accordance with Engineering Regulation (ER) 1105-2-100, Planning Guidance Notebook, and is considered a decision document providing the "consolidated documentation of technical and policy analyses, findings, and conclusions upon which the U.S. Army Corps of Engineers Philadelphia District Commander bases the recommendation to the Major Subordinate Command Commander to approve the recommended project for implementation." This Document describes the engineering, economic, social, and environmental analyses conducted to date towards developing a Final Integrated Feasibility Report and Tier 1 Environmental Impact Statement in 2022.

Per ER 1105-2-100, the feasibility study process to date is aligned with the National Environmental Policy Act of 1969, as amended (NEPA). Specifically, a public notice was issued on October 31, 2016 announcing the initiation of scoping, and to invite the public, resource agencies and stakeholders to participate in the process. An initial scoping/public meeting was held in December 2016. In addition, agency and stakeholder engagement was initiated via scoping letters at that time. A Notice of Intent (NOI) to prepare a Tiered Environmental Impact Statement was published in the Federal Register on December 17, 2019. Since NEPA was initiated prior to the new CEQ rules "Update to the Regulations Implementing the Procedural Provisions of the National Environmental Policy Act" adopted in July 2020, this EIS was developed

in accordance with the applicable regulations, policies, and procedures, including USACE's NEPA regulations in ER 200-2-2 and the previous CEQ NEPA regulations at 40 CFR Part 1500 (NEPA Implementing Regulations).

Because of the large scope, scale, and complexity of the affected environment and alternatives being considered, the EIS will be conducted in tiers. Tiering (defined in 40 CFR 1508.28) is a means of making the environmental review process more efficient by allowing parties to "eliminate repetitive discussions of the same issues and to focus on the actual issues suitable for decision at each level of environmental review". This EIS evaluates potential impacts of the proposed action in accordance with NEPA, and other applicable state and federal laws and USACE policies at a "Tier 1" level. Alternatives such as critical infrastructure, nonstructural measures, structural measures, and natural and nature-based features (NNBFs) were evaluated to determine the potential impacts to the natural and human environment resulting from the proposed action. Potential impacts to land use; tidal processes; water quality; floodplains; vegetation, wetlands, and submerged aquatic vegetation; wildlife and terrestrial habitat; plankton; Essential Fish Habitat and fishery resources; benthic resources; special status species; cultural resources; recreation; aesthetics and visual resources; socioeconomics; hazardous, toxic, and radioactive waste; air quality; and noise are analyzed in the EIS.

Since this Draft Integrated Report is required by NEPA and ER 1105-2-100, USACE is soliciting public comments and questions on this Draft Integrate Report for 45 calendar days in order to promote continued collaboration and transparency. Public scoping meetings were held in December 2016 and September 2018. Public and stakeholder webinars were also held in March 2019 and May 2021 to provide a status of the study and to solicit public comments and questions.

Interested parties can access further information at the USACE's NJBB web Portal which is situated at https://www.nap.usace.army.mil/Missions/Civil-Works/New-Jersey-Back-Bays-Coastal-Storm-Risk-Management/.

Questions and comments regarding the NJBB CSRM Study can be emailed to PDPA-NAP@usace.army.mil (reference "NJBB" in the subject heading of the email).

All comments concerning this Draft Integrated Report are required to be submitted by October 12, 2021.

For further information and to submit comments, please contact the U.S. Army Corps of Engineers, Philadelphia District:

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100 Penn Square East, Wanamaker Building
Philadelphia, Pennsylvania 19107-3390
Attention: Peter R. Blum P.E.
e-mail: PDPA-NAP@usace.army.mil (reference "NJBB" in the subject heading of the email)Phone: 215-656-6515

NOTE TO READER: As discussed further in this Draft Integrated Report, the findings to date have built-in assumptions that will be further evaluated and/or validated as the NJBB CSRM Study progresses. While the critical assumptions were socialized with interested groups and decision makers through public meetings and events and with a risk register, there is inherent risk and potential uncertainty associated with these assumptions that will be continually analyzed and reduced as the NJBB CSRM Study progresses.

Executive Summary

Document Overview

This U.S. Army Corps of Engineers (USACE) New Jersey Back Bays (NJBB) Coastal Storm Risk Management (CSRM) Draft Integrated Feasibility Report and Tier 1 Environmental Impact Statement (EIS)(Draft Integrated Report) presents a preliminary focused array of alternative plans that reduces risk to human life and flooding risk from coastal storms in the NJBB Region. These findings and associated analyses are consistent with study planning objectives in addition to minimizing environmental, social, and economic impacts. The reduction of flood-related damages to residential structures, commercial structures, critical infrastructure, and industries is critical to the national and regional economy.

The long-term strategy for resilience in the NJBB Region is a scalable solution that integrates CSRM efforts included in this Draft Integrated Report as well as CSRM efforts considered by the New Jersey Department of Environmental Protection (NJDEP, the NJBB CSRM Study non-Federal Sponsor), other Federal agencies, NGOs, and municipal entities. The NJBB CSRM Study was developed in association with the New Jersey Draft Climate Change Resilience Strategy (draft April 2021) and the NJ Climate Adaptation Alliance Science and Technical Advisory Panel (STAP) which convened in 2019 and developed sea level change (SLC) projection guidance.

This Draft Integrated Report was prepared in accordance with relevant laws and USACE guidance, was informed by Federal or USACE policy, and is considered a formal decision document, inclusive of a Tiered EIS which is a National Environmental Policy Act of 1970 (NEPA) compliant document.

The USACE will continue to coordinate with the USACE and NJDEP to further study the array of alternatives towards the potential implementation of the recommended project in accordance with current policy.

Study Area & Existing Conditions Overview

The study area (Figure ES-1) has been subdivided into five regions based on problems and opportunities, geomorphology, and hydraulic interconnectedness of water bodies. The NJBB study area is a major populated area that stretches over five New Jersey counties: Cape May, Ocean, Atlantic, Monmouth, and Burlington. The study area encompasses over 674,000 permanent residents (2020), millions of seasonal visitors, and over $40 billion in annual Gross Domestic Product (2019). Furthermore, the asset inventory is valued at over $72 billion (FY2021 Price Level) as evidenced by structure count and value on a County basis (Table ES-1). Additional NED categories, such as transportation delay, non-transferrable income loss, local costs foregone, and emergency costs, further expand the total NED damage pool to over $90 billion total (FY2021 Price Level).

The study area includes the bays and river mouths located landward of the barrier islands and Atlantic Ocean-facing coastal areas in the State of New Jersey. The Atlantic Ocean Coast of New Jersey is fronted by a Federal CSRM program consisting of beach nourishment including dune construction along the oceanfront shoreline. However, the NJBB region currently lacks a comprehensive CSRM program that will protect communities on the bay side of the barrier islands. As a result, the NJBB region experienced major impacts and devastation during Hurricane Sandy and subsequent coastal storm events, including damaged property and the disruption of millions of lives due to the combination of low-lying topography, sea level change, densely populated residential and commercial areas, extensive low-lying infrastructure, and degraded coastal ecosystems.

Further vulnerability to coastal storms and the potential for future, more devastating events due to changing sea level and climate change is significant. Rising sea levels represent an inexorable process causing numerous, significant water resource problems such as increased widespread flooding along the coast; changes in salinity gradients in estuarine areas that impact ecosystems; increased inundation at high tide; decreased capacity for storm water drainage; and declining reliability of critical infrastructure services such as transportation, power, and communications. Addressing these problems requires a paradigm shift in how we work, live, travel, and play in a sustainable manner as a large extent of the area is at a very high risk of coastal storm damage as sea levels continue to rise.

The preliminary focused array of alternative plans is presented by individual region in Chapter 7 of this Main Report. These alternative plans are compared to the No Action/FWOP Condition which includes no additional management measures above the existing condition plus CSRM actions either constructed or currently under construction to manage coastal storm risk. This preliminary focused array of alternative plans and continued study analyses are necessary to determine the plan that reasonably maximizes National Economic Development (NED) benefits while not sacrificing environmental, regional, or social concerns and will ultimately result in the selection of a recommended plan for construction authorization in subsequent phases of the feasibility study. The Tentatively Selected Plan is presented in Chapter 8 of this Main Report.

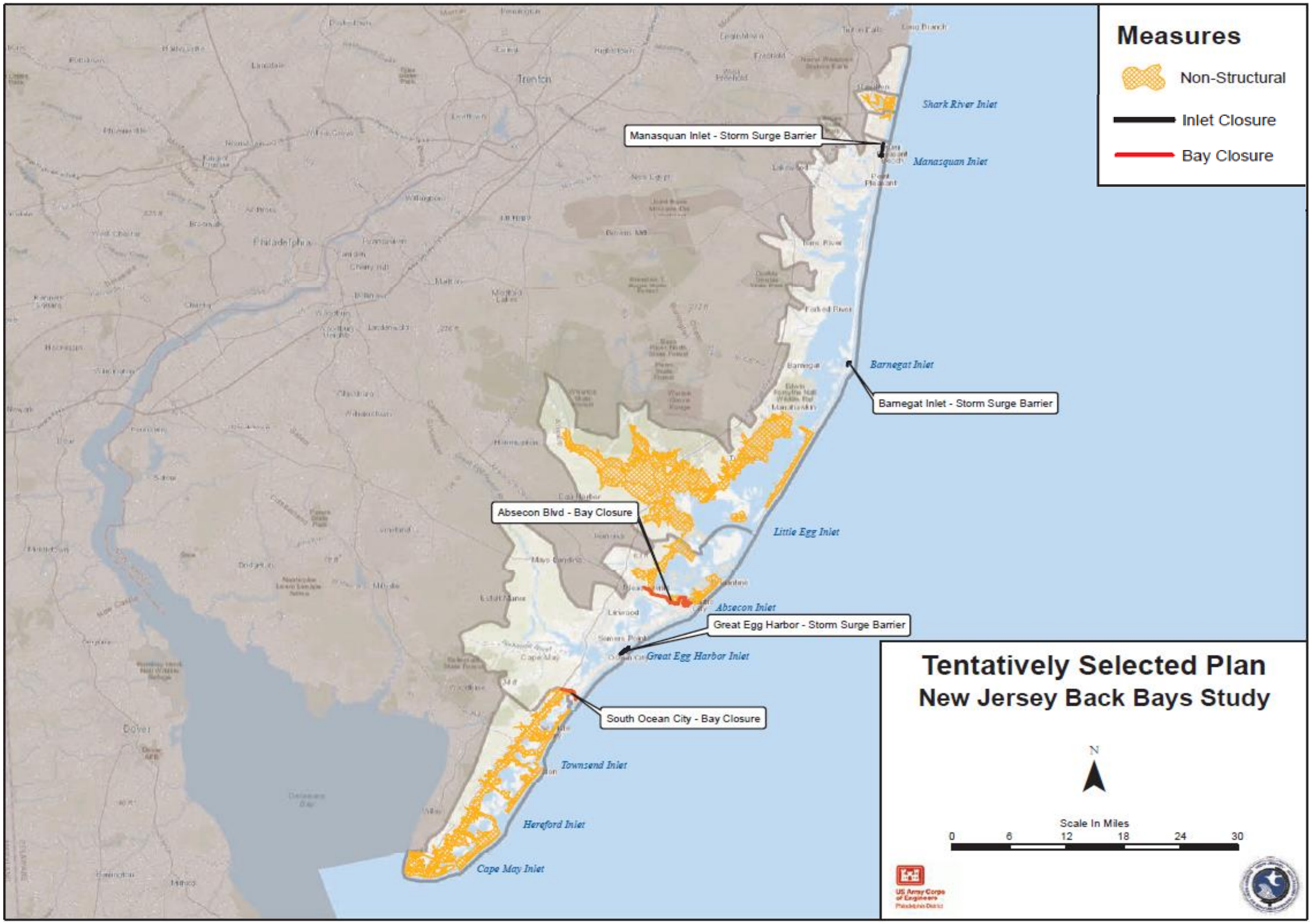


Figure ES-1: The Tentatively Selected Plan

Table ES-1: Structure Inventory Totals and Values within the Project Area

County	Structure Count	Value
Monmouth	10,598	$4,357,499,270
Ocean	81,262	$25,034,178,930
Burlington	322	$99,498,110
Atlantic	32,825	$20,842,857,680
Cape May	57,923	$21,890,206,340
Total	**182,930**	**$72,224,240,330**

Tentatively Selected Plan Overview

The tentatively selected plan (TSP) as identified for the intermediate SLC scenario is presented in Figure ES-1 and is based upon the formulation of management measures into the focused array of alternative plans. The formulation of the focused array follows The USACE six-step planning process as defined in the Planning Guidance Notebook (ER 1105-2-100), and considers several criteria, including:

- Four evaluation accounts identified in the USACE Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (1983) (Principles and Guidelines) which include the National Economic Development, Regional Economic Development, Environmental Quality, and Other Social Effects accounts.
- The four Planning Criteria including effectiveness, efficiency, acceptability, and completeness identified in ER 1105-2-100 were also qualitatively assessed in plan formulation
- A series of additional decision metrics were developed to assist in the formulation of the focused array of alternatives. These additional decision metrics are discussed below and include project performance, sea level change, adaptive capacity and resiliency, reliability and fragility, storm surge barrier (SSB) hydraulic effects, operations and impacts of closures, real estate costs and life safety risk.

The TSP includes:

- Storm surge barriers (SSB) or inlet closures at Manasquan Inlet, Barnegat Inlet, and Great Egg Harbor Inlet;
- Cross-bay barriers (CBB) or interior bay closures at Absecon Boulevard, and southern Ocean City; and
- Elevation and floodproofing of 18,800 structures. These nonstructural solutions are considered for 11% of the study area and are concentrated in the vicinity of the Shark River Inlet and in southern Ocean County, specifically along the mainland shoreline south of Beach Haven West and on Long Beach Island. Nonstructural solutions are also concentrated in northern Atlantic County on the mainland shoreline and on Brigantine, and in large portions of Cape May County.

- Perimeter measures including floodwalls, levees and seawalls which tie SSBs and CBBs into adjacent higher ground.

The TSP is not the plan that maximizing national economic development (NED) benefits. It was selected based on a number of decision criteria including net NED benefits, environmental acceptability, residual risk, life safety risk, long-term performance, and sea level change adaptability.

The total cost of the TSP is $16.07B with annual Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R) of $196M (using the Intermediate SLC curve, FY2021 Price Level). The TSP is expected to provide mean Average Annual Net Benefits (AANB) of $612M with a Benefit-to-Cost ratio (BCR) of 1.8 and 22% in Residual Damages. The TSP is identified to reasonably maximize net NED benefits while accounting for project performance, SLC adaptability, and risk to life safety. A breakdown of the costs both with respect to cost sharing and overall cost summary are provided in Tables ES-2 and ES-3, respectively. Table ES-3 identifies the Total First Cost which does not include Interest During Construction (IDC) and variable nonstructural costs and is therefore less than the Total Initial Construction Cost identified in Table ES-2.

Table ES-2: New Jersey Back Bays cost sharing table for the TSP

Item	Federal Cost (65%)	Non-Federal Cost (35%)	Total Cost
PED	$497,480,199	$267,873,954	$765,354,153
LERRD	$588,672,244	$316,977,363	$905,649,607
Construction	$7,940,303,787	$4,275,548,193	$12,215,851,980
Construction Management	$159,186,555	$85,715,837	$244,902,392
Interest During Construction			$1,935,777,868
Total Project	$10,443,898,400	$5,623,637,600	$16,067,536,000
Note: PED – Preconstruction, engineering, and design; LERRD = Land, Easements, Rights-Of-Way, Relocation, and Disposal Areas.			

Note: FY2021 Price Level

Table ES-3: New Jersey Back Bays Study Overall Cost Summary for the TSP

Construction Item	Cost
Lands & Damages	$905,649,607
Relocations	$5,257,276
Fish & Wildlife Mitigation	$393,189,103
Breakwaters & Seawalls	$5,413,772,034
Levees & Floodwalls	$1,022,257,273
Pumping Plant	$20,828,848
Floodway Control and Division Structures	$252,049,963
Cultural Resources Preservation	$97,662,046
Buildings, Grounds, & Utilities	$5,010,835,348
Preconstruction Engineering & Design (PED)	$765,354,153
Construction Management (E&D, S&A)	$244,902,480
Total First Cost	$14,131,758,131

Note: FY2021 Price Level.

The TSP considers an SSB closure frequency at the 20% annual exceedance probability (AEP) water level. This closure frequency, which remains constant over time, allows the forecasted water level for operation to change over time in response to relative sea level change (RSLC) and the average number of closure operations per year (0.2) to remain fixed. An additional barrier closure is expected to occur on an annual basis for maintenance/training. In subsequent phases on the NJBB CSRM study the cost, benefits, and impacts of closure operations will be evaluated in greater detail to refine the SSB closure criteria, which is likely to evolve during the feasibility study, PED, and even during the life of the SSBs.

Eight of the sixteen lakes in the Coastal Lakes Region were evaluated as part of the TSP. These eight lakes are either: a) ordinary tidewater bodies with direct, open channel tidal connections to the ocean through Manasquan Inlet or upper Barnegat Bay; or b) lakes that do not have direct open channel connections to the ocean but have hydraulic connections to the ocean though topography. These eight lakes include:

- Sylvan Lake (Bradley Beach/Avon-by-the-Sea)
- Silver Lake (Belmar)
- Stockton Lake (Sea Girt/Manasquan)
- Glimmer Glass (Manasquan)
- Lake Louise (Pt Pleasant Beach)
- Little Silver Lake (Pt Pleasant Beach)
- Lake of the Lilies (Pt Pleasant Beach)

- Twilight Lake (Bay Head)

The remaining eight coastal lakes which are not directly connected to tidal inlets and are therefore not subject to coastal flooding and not included in the TSP include:

- Lake Takanassee
- Deal Lake
- Sunset Lake
- Wesley Lake
- Fletcher Lake
- Lake Como
- Spring Lake
- Wreck Pond

A possible alternative study approach for these remaining eight coastal lakes is the USACE Continuing Authorities Program or a General Reevaluation Study for the Sea Bright to Manasquan Inlet CSRM project. Any of these potential future study paths would require approval from USACE higher authority, and endorsement from a non-federal sponsor.

Alternative plans to the TSP are also offered in this Draft Integrated Report based upon USACE's consideration of the assessment of comprehensive benefits across four distinct categories: National Economic Development (NED), Regional Economic Development (RED), Other Social Effects (OSE), and Environmental Quality (EQ)(USACE, 1983; USACE, 2021). A plan that maximizes NED benefits (which differs from the TSP) is offered only in the Central Region of the study area. This difference is highlighted by the inclusion of a combined nonstructural and perimeter measures (including floodwalls, levees, and seawalls) rather than a combined nonstructural and SSB plan (Figure ES-2). A nonstructural only plan is also offered for the entire study area (Figure ES-3). A locally preferred plan is a fourth plan type which can be identified in the future if non-benefit maximizing plan is proposed by a non-Federal entity.

Additional detailed analyses will also be performed prior to final identification of the recommended plan to assess CSRM opportunities offered by natural and nature-based features (NNBFs), critical infrastructure risk management, and separable and complementary management measures. The development of a critical infrastructure plan will offer an alternative, focused assessment of CSRM which potentially could be implemented with a tiered phased, scalable approach. The identification of complementary management measures, or measures that provide risk management in the residual floodplains of structural management measures, will help to address higher frequency flooding events, and provide a uniform level of risk management throughout the region in question. Provision of complementary management measures, typically nonstructural, low elevation floodwalls, or NNBFs, will provide a similar level of risk management when combined with other management measures as offered by the TSP, thus allowing for a more holistic approach to regionwide flood risk management.

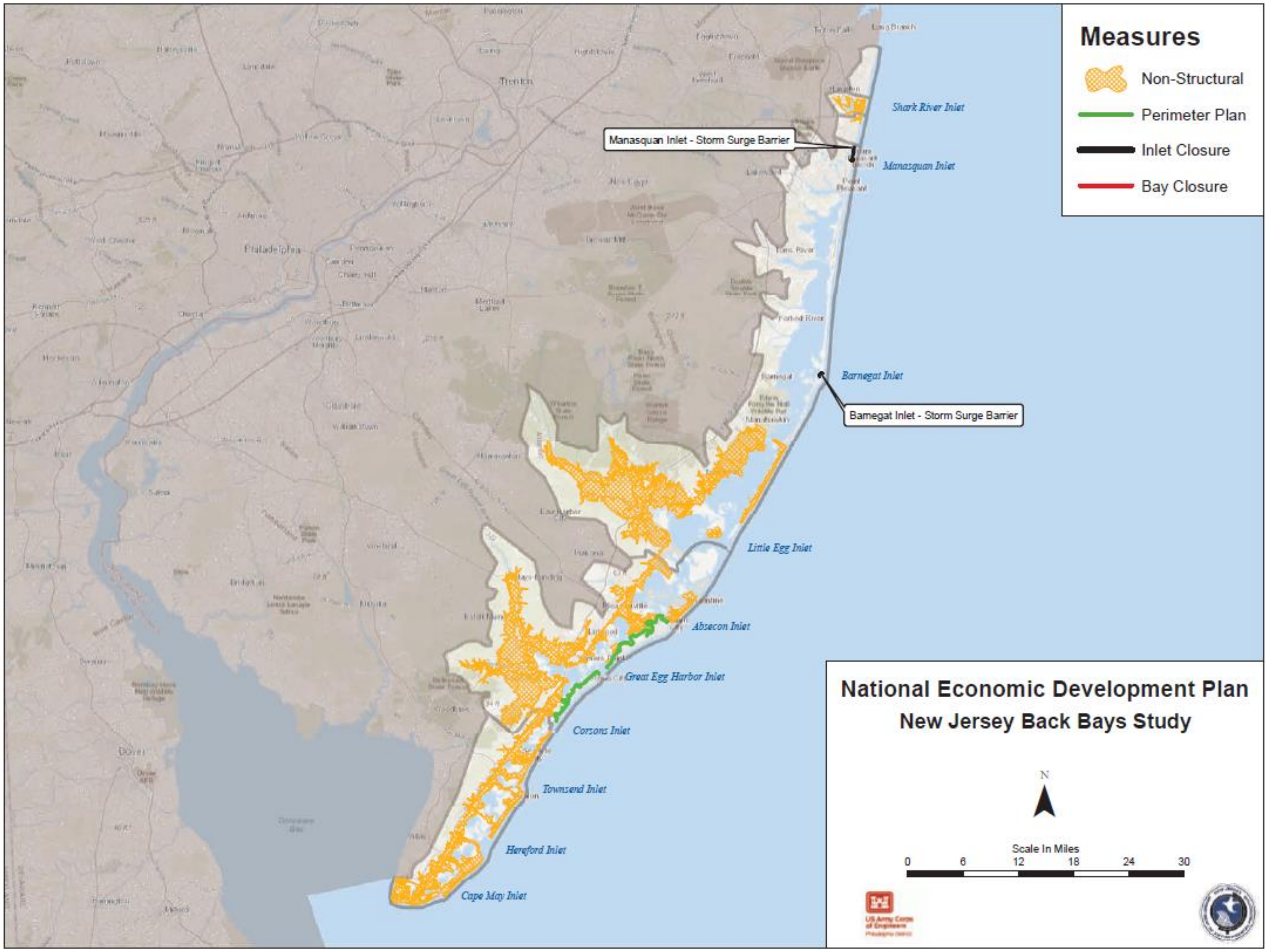


Figure ES-2: National Economic Development Plan for the Study Area

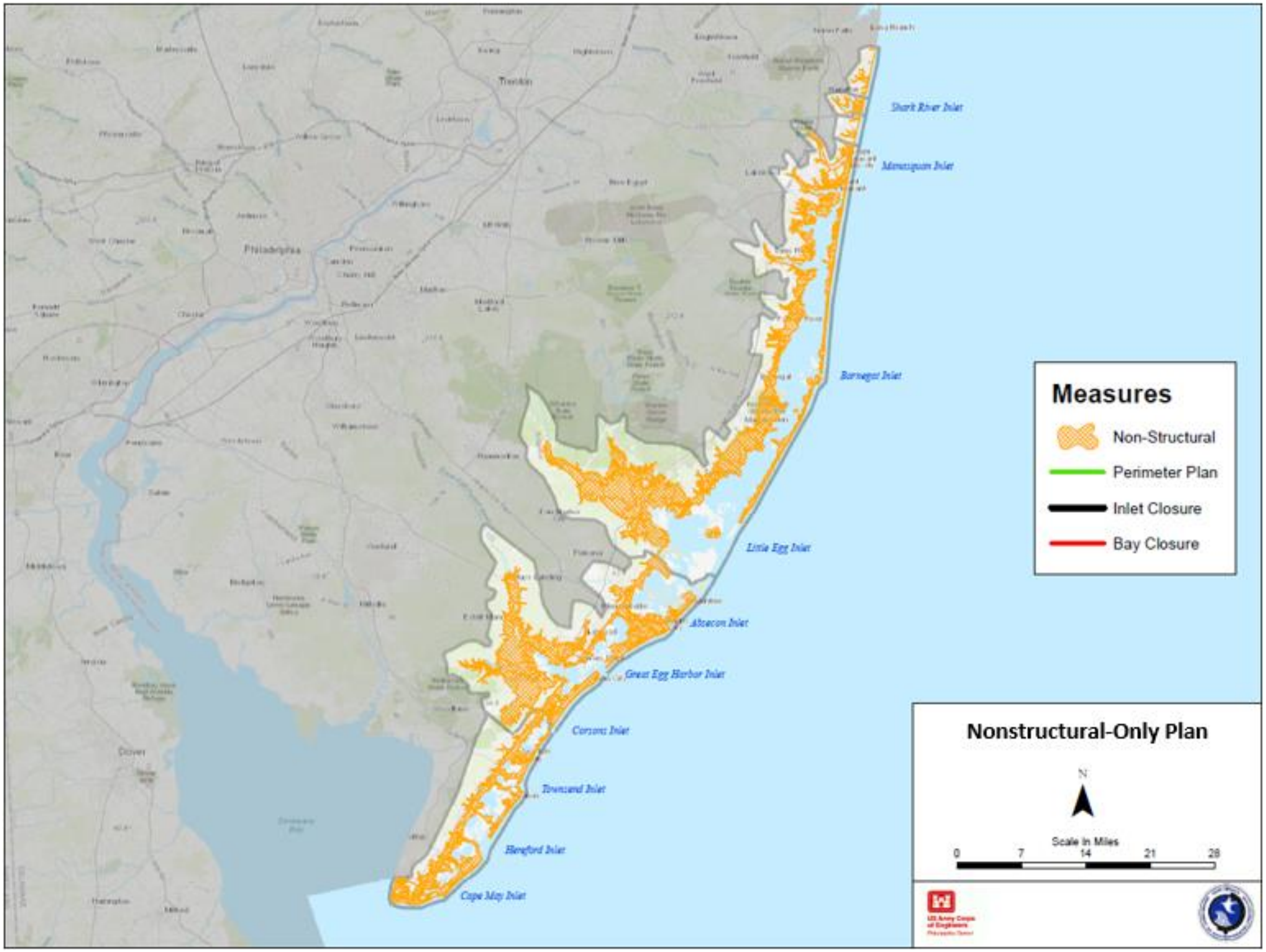


Figure ES-3: Nonstructural-Only Plan for the Study Area

A managed adaptive approach is also considered for the TSP which would enable an incremental implementation schedule over time. This approach identifies eligibility threshold stages over time to accommodate as sea level change causes more structures in the study area to become vulnerable and fall below the eligibility threshold stage. This approach also indexes the SSB closure criteria to certain flood recurrence intervals to identify complementary nonstructural management measures particularly in the Central Region. This managed adaptive approach ensures a constant project performance level with clear closure criteria guidelines and minimizes coastal storm impacts for both high-frequency and low-frequency events.

Natural and nature-based features assist in the incorporation of natural approaches to develop regional climate change and sea level change adaptation planning strategies and solutions in the NJBB region. Both large scale features such as wetland/marsh island creation, storm surge filters and horizontal levees as well as smaller stand-alone management measures including living shorelines, reefs, wetland restoration and submerged aquatic vegetation are being considered. Ongoing analyses are being conducted to determine if NNBFs help to meet the project objectives and provide CSRM attributes in relation to costs along several accounts not limited to economic benefits.

The TSP is based upon detailed analyses but represents a step in the phased, iterative planning process. Additional more detailed analyses will be performed going forward in the NJBB CSRM Study which will likely result in revisions to the TSP, possibly before the Agency Decision Milestone (ADM) Meeting which is currently scheduled for January 2022. At the ADM Meeting, the Project Delivery Team (PDT) presents a clear and logical formulation and evaluation rationale that indicates the PDT is making risk-informed decisions and has a clear direction on next steps to complete the study.

Emphasis is being placed on integrating the findings of the New Jersey Draft Climate Change Resilience Strategy (New Jersey, 2021) and the NJ Climate Adaptation Alliance Science and Technical Advisory Panel (STAP) sea level change projection guidance including comparison to USACE projections. Current analyses indicate that the STAP moderate emissions scenario falls between the USACE intermediate and high scenarios (Refer to Section 6.2.2)**Error! Reference source not found.**. As the TSP was developed using the USACE intermediate scenario curve, all three USACE SLC scenarios and the STAP SLC scenarios will be considered during future NJBB CSRM Study phases. Additional analyses will also consider comparison of differences in the base flood elevation (BFE) height and inundation zone extent and pending revisions to State of New Jersey regulations.

These continued analyses will help to reduce the uncertainty and risk associated with risk management solutions.

Environmental Impacts Overview

In accordance with NEPA, a Tier 1 level Environmental Impact Statement (EIS) was performed to determine the impacts of the selected alternatives and components that comprise the TSP. A Tier 1 EIS involves technical analysis completed on a broad scale and is therefore an effective method for identifying existing and future conditions and understanding the comprehensive effects of the project on the NJBB Region. It provides the groundwork for future project-level environmental and technical studies. This level of environmental evaluation is consistent with the level of engineering and economic analyses performed to formulate the TSP. A number of structural alternatives including SSBs and CBBs were identified as environmental "high risks" for implementation based on the uncertainties of indirect impacts on aquatic ecosystems, high direct impacts, potentially extensive compensatory mitigation, and complex regulatory reviews. TSP components that include nonstructural alternatives are considered low risk for most environmental categories but are potentially high for cultural resources due to the presence of historic structures or historic districts within areas identified for building retrofits or relocations. Except for current structural alignments where direct footprint impacts can be assessed on the various habitats affected, indirect impacts such as on water quality and aquatic life can only be assessed at this level with existing physical modeling. Therefore, only general impacts and/or a range of impacts utilizing existing information have been identified at this stage of the NJBB CSRM feasibility study and associated NEPA analysis, which will continue into a Tier 2 level during the Preconstruction, Engineering and Design (PED) phase. In the Tier 2 EIS, subsequent refinements in structural design features, detailed physical and biological modeling, and the practice of avoiding and minimizing impacts with design refinements and appropriate compensatory mitigation will further inform the environmental risk level with a goal of reducing the environmental risks to a lower level than is currently identified.

Findings to date suggest that structural management measures in the TSP have direct impacts such as loss of wetlands and subtidal aquatic habitats, impacts to historic properties, and aesthetics/views impairment. Based on estimates of preliminary alignments of structural elements, floodwalls and levees are expected to have direct impacts particularly on wetlands and shallow aquatic habitats within the footprint of floodwalls and levees over long linear distances, which would have regional effects. Storm Surge Barriers and CBBs would also have direct impacts on aquatic habitats, but comparatively less than that of floodwalls and levees. A quantification of these direct impacts for SSBs and CBBs is summarized in Table ES-4.

Storm surge barriers and CBBs identified in the TSP could have potential significant indirect impacts on hydrodynamics such as tidal flow and tidal range, water quality, and shifts in flora and fauna abundance, distributions, and migrations. Therefore, preliminary analyses utilizing the Adaptive Hydraulic (AdH) modeling for the open SSB condition was conducted for the TSP and five other alternatives/variations to understand the potential physical impacts of the SSBs as well as the sensitivity of the physical impacts to current design choices. The modeling results demonstrate that the SSBs could cause an increase in velocities in the vicinity of the structures and that the greater the reduction in cross-sectional area, the greater the increase in velocities. The velocity patterns and magnitudes at the proposed structure locations are greatly changed, as expected, but the impact to velocity magnitudes away from the structures is minimal. The changes produced by modifying the flow at the inlets is considered to be fairly localized.

The TSP is estimated to have relatively no impact on the tidal prism at the Manasquan River, and would reduce the mean tidal prism in Barnegat Bay and Great Egg Harbor by 2.5% and 4.8% respectively. The impacts of the TSP extend beyond the immediate bays at which the closures are located, with reductions in tidal prism less than 1.6% elsewhere. The impacts to tidal amplitudes are not evenly distributed throughout the bays with individual reductions in tidal amplitude ranging from 1.3% to 8.3% through Barnegat Bay and 0.1% to 4.5% in Great Egg Harbor for the TSP. Additionally, small changes in tidal amplitudes could have more far-reaching significant cumulative effects along the upper and lower margins of intertidal wetland systems.

Overall, the impact of the SSBs on salinities is small, and the mean salinity is not expected to vary by more than 2 ppt for any given location and alternative. The variation at specific times may be larger but overall, the impact is small. Given the well-mixed nature of the inlets, ocean salinity is pushed into the back-bay areas and moves easily throughout the area.

Hydrodynamic changes caused by SSBs and CBBs may affect residence times within the affected estuaries and indirectly effects water quality and egg and larval transport for fisheries/Essential Fish Habitat. A particle tracking model (PTM) was developed for the NJBB estuaries to compare baseline conditions to with project conditions (including future with sea level change). For the TSP, model results show only small increases in residence time in the South and Central Regions by two to five days and decreases in residence time in the North Region by one to two days. Based on these findings, the PTM suggests minor effects on water quality and fish larval/egg transport.

Although the AdH results suggest minor to moderate effects on overall hydrodynamics of the affected bay systems, these potential effects have a high level of uncertainty due to the unknown frequency of gate closures coupled with changes in tidal flooding events related to sea level change. Further modeling efforts are required to inform the impact assessment associated with these measures. Therefore, additional modeling for the closed SSB condition will be performed prior to the development of the final recommended plan for construction authorization.

There will likely be both temporary and permanent visual adverse effects associated with the construction of structural management measures in the current TSP which may ultimately become the recommended plan for construction authorization. Construction equipment will be visible at locations included in the current TSP and possibly the recommended plan for construction authorization during the construction phase. The SSBs, CBBs, floodwalls, and levees will be permanent and visible both on land and from the water.

Nonstructural structure elevation may have some temporary adverse direct and indirect effects related to earth disturbance. Building acquisition and relocation could provide significant environmental benefits by increasing open space by converting existing privately owned and buildable properties into natural habitat, although there is a potential for significant adverse impacts to cultural resources.

Natural and Nature-Based Features are expected to have temporary and minor impacts on aquatic resources and water quality during their construction, but would have a long-term beneficial effect on aquatic and some terrestrial habitats and the flora and fauna that inhabit these areas.

Cultural resource impacts may include impacts to historic districts and properties that are eligible for listing in the National Register of Historic Properties as well as to sunken historical vessel sites. Further study is needed, and these potential impacts will likely be addressed through a Programmatic Agreement with the New Jersey State Historic Preservation Office.

Because of the direct impacts that TSP structural components will have on aquatic habitats, a compensatory mitigation plan is being developed that will account for the functional losses of ecosystem services that these habitats provide. The TSP components would directly affect over 153 acres of aquatic habitats, which includes about 60 acres of subtidal soft-bottom habitats, about two acres of intertidal mud/sand flats, about nine acres of intertidal sandy beach, and 73 acres of low and high saltmarshes. The remaining 10 acres are adjacent scrub-shrub and other supratidal wetlands. These estimates are preliminary and will undergo subsequent refinement. Preliminary mitigation estimates for losses of saltmarshes were determined by using the New England Marsh Model and the subtidal and intertidal habitat impacts were based on the presence of shellfish bed or SAV mapping. Mitigation estimates for these habitats were based on a replacement of a higher quality habitat such as an SAV bed (subtidal) or a living shoreline (intertidal). The New York Bight Ecological Model (NYBEM) ecosystem model that considers all key aspects of the various marine, estuarine, and freshwater aquatic habitats within the affected area is currently in development and will be applied in subsequent phases to better determine the functional aspects and effects on habitat suitability and new mitigation estimates will be derived.

Table ES-4: Preliminary Estimates of Direct Habitat Impacts and Compensatory Mitigation Estimates of the TSP

		Subtidal		Intertidal		Saltmarsh		Other Supratidal wetlands	
TSP Alt.	Structural Feature	Est. Losses (acres)	Est. Mitigation* (acres)	Est. Losses (acres)	Est. Mitigation (acres)	Est. Losses (acres)	Est. Mitigation (acres)	Est. Losses (acres)	Est. Mitigation (acres)
3E(2)	Manasquan Inlet SSB	2.1	1.7	0	0	0	0	0	0
	Barnegat Inlet SSB	14.8	21.5	0.8	1.1	0	0	0	0
	Total Range (20% diff.):	13.6 to 20.3	18.6 to 27.8	0.6 to 0.9	0.8 to 1.3				
4G(8)	GEHI SSB	20	16	5.6	4.4				
	Absecon Blvd. CBB	21	25.2	6.0	6.4	49.7	83	6.7	9.7
	SOC CBB	1.6	2.1	0	0	23.5	44.4	2.1	3.6
	Total Range (20% diff.):	34.1 to 51.2	34.6 to 52.2	9.3 to 14	8.6 to 12.8	65 to 97	110 to 166	7 to 11	10.6 to 16
TOTAL (20% Range)		**59.5 (48 to 72)**	**66.5 (53 to 80)**	**12.4 (10 to 15)**	**11.9 (10 to 14.1)**	**73.2 (65 to 97)**	**127.4 (110 to 166)**	**8.8 (7 to 11)**	**13.3 (11 to 16)**

Compensatory mitigation estimates for indirect effects have not been fully assessed at this time. It is assumed that there could be significant losses of saltmarsh and intertidal habitats over large areas due to small tidal amplitude changes along, with potential effects on fish larval/egg transport due to increases in velocity in the vicinity of the SSB and CBB gates. Therefore, the cost estimates currently include a 5% contingency (based on first construction costs of the TSP feature) for compensatory mitigation and adaptive management for indirect effects. It is assumed that as modeling is further advanced (AdH -closed gates scenarios and NYBEM), impact estimates will become better quantified and compensatory mitigation can be derived based on applying the available NYBEM ecosystem model. Additionally, subsequent design phases will continually investigate avoidance and minimization measures that would reduce hydrodynamic changes that drive these indirect effects.

The TSP identified in this Draft Integrated Report will undergo a rigorous evaluation of compliance with environmental protection statutes and Executive Orders at subsequent phases of the NJBB CSRM feasibility study and beyond. A detailed examination of impact avoidance and minimization to better quantify both direct and indirect environmental impacts will also be performed in the future.

Environmental concerns will be continually addressed during the NJBB CSRM Study and subsequent phases inclusive of both Tier 1 and Tier 2 assessments. These environmental concerns will also be addressed through coordination and review by the resource agencies, including the U.S. Environmental Protection Agency, the U.S. Fish and Wildlife Service, the U.S. Department of Commerce National Oceanic and Atmospheric Administration Fisheries, New Jersey Department of Environmental Protection, and the New Jersey State Historic Preservation Office, and other agencies.

Next Steps for the NJBB CSRM Study

Following this Draft Integrated Report, the feasibility phase of the NJBB CSRM study will continue with development of a Final Feasibility Report and Tier 1 EIS with a recommended plan for construction authorization in 2023 and a Chief's Report in 2023. This will conclude the feasibility phase. The completion of the Chief's Report is the first step toward implementing the design and construction of the NJBB CSRM Study. The pre-construction engineering and design (PED) phase may begin after the Division Engineer's transmittal of the Final Feasibility Report and Tier I EIS, PED funds have been appropriated by Congress, and a Design Agreement is executed with the non-Federal Sponsor. Funding by the Federal Government to support these activities must meet traditional civil works budgeting criteria. For construction to be initiated, Congress must authorize the project, a Project Partnership Agreements (PPA) must be executed with the non-Federal sponsor, and Congress must appropriate construction funds. PED and construction phases are cost shared 75%/25% and 65%/35% Federal/non-Federal, respectively. . Sequencing of project construction is dependent upon final study findings, congressional project authorization and appropriation of funds. The non-Federal cost share as discussed above would also be necessary to commence project design and construction.

The construction of scaled, incrementally implementable and integrated components of the NJBB recommended plan to manage flooding risk in the region may be massive in scale and will likely cost several billion dollars. A strategy for implementation of the recommended plan for construction authorization would consider a sequenced strategy and would be based on ranking of certain locations or features, level of design detail and uncertainty regarding conditions for CSRM benefits, long term sustainability including low, medium, and high projections for future sea level change, and construction costs. A three-tiered implementation strategy would consider:

- Tier 1 – Critical infrastructure assets risk management;
- Tier 2 – Nonstructural including the elevation of major evacuation routes, elevation of structures or low elevation floodwall in a high-recurrence floodplain (i.e., 5-year); and
- Tier 3 – SSB construction at individual inlets.

Such a strategy will need to be prepared by team partners in order to identify and make available construction funds and to communicate the construction priority to stakeholders. It is anticipated that PPAs could be executed for individual construction components rather than for one large project addressing the entire study area. Project construction would start no earlier than 2030 and is dependent upon Congressional authorization appropriation and funding from the non-Federal sponsor.

This document has considered and incorporated comments from the public, stakeholders, agencies, and NGOs though a series of workshops and meetings since the study commencement in 2016. Throughout the study, coordination was maintained with the State of New Jersey as well as counties and municipalities throughout the study area, academic institutions, environmental/resource agencies, and other key stakeholders. Continued NJBB CSRM Study analyses will incorporate Federal, State, local, NGOs and academic datasets and tools as applicable and will consider ways to coordinate with and leverage other Federal and state coastal resilience projects. The development of relationships with cooperating agencies was and will continue to be critical in conducting future analyses.

NEW JERSEY BACK BAYS
COASTAL STORM RISK MANAGEMENT
DRAFT INTEGRATED FEASIBILITY REPORT AND
TIER 1 ENVIRONMENTAL IMPACT STATEMENT

Table of Contents (* indicates NEPA Requirement)

List of Figures

List of Tables

New Jersey Back Bays
Coastal Storm Risk Management
Draft Integrated Feasibility Report and
Tier 1 Environmental Impact Statement

1 Modifications Included in This Draft Integrated Report from The Interim Report (March 2019)

The following analyses have been performed and included in this Draft Integrated Feasibility Report and Tier 1 Environmental Impact Statement (Draft Integrated Report) since the Interim Feasibility Report and Environmental Scoping Document (March 2019):

- The Tentatively Selected Plan (TSP) including three storm surge barriers (SSB) at Manasquan Inlet, Barnegat Inlet, and Great Egg Harbor Inlet; two cross-bay barriers (CBB) at Absecon Boulevard, and southern Ocean City; and nonstructural solutions including elevation and floodproofing for 18,800 structures comprising 11% of the study area.
- Alternative plans to the TSP qualitative assessment including NED Plan, nonstructural plan and critical infrastructure plan given updated guidance including Comprehensive Documentation of Benefits in Decision Documents Policy Directive (January 2021).
- Separable and complementary management measure qualitative assessment to identify measures to support SSB measures given operational closure frequency,
- Third cycle of iterative plan formulation which considers a higher level of detail including detailed design, costs, and economic benefits analyses for SSB, CBB, and nonstructural components as well as updated planning criteria, systems of accounts analyses including consideration of performance, reliability, life safety and adaptability decision metrics.
- Updated structure inventory identification and type assignment, revised foundation height estimates, revised Depreciated Replacement Value estimates, additional depth-percent damage functions and content-to-structure value ratios, added non-HEC-FDA NED benefit streams, improved accuracy for Average Annual Net Benefits (AANB), Benefit Cost Ratio (BCR), and Residual Risk; provided risk analysis for NED benefits, and qualitatively evaluated study decision criteria such as Reliability, RSLC Adaptability and Life Safety.
- Risk-based perimeter plan design considering multiple floodwall heights, and risk-based SSB and CBB design considering multiple alignments for multiple inlets including SSB gate dimensions and adjusted various SSB design quantities and parameters (barrier alignment, sill elevation, number of gates, and width of navigable gate) to inform hydrodynamic modeling. Modified auxiliary flow gate (vertical lift gate) widths have been designed to promote additional conveyance, and a maritime vessel analysis was completed to provide recommendations for minimum dimensions of navigable SSB gates.
- Hydrodynamic modeling (AdH) of existing conditions and multiple SSB alternatives to assess indirect impacts to tidal range, tidal prism, velocities, salinity, and residence time. Revised storm surge modeling (CSTORM) and stage-frequency curves for baseline and SSB alternatives with updated model bathymetry. Investigated sensitivity of back-bay water levels to dune overwash and breaching with storm surge model (CSTORM).
- Draft nonstructural implementation plan.
- Geotechnical subsurface investigations.
- Preliminary cultural resource analyses for the TSP.
- Natural and Nature-Based Feature (NNBF) analyses and appendix.

•Incorporation of public, stakeholder and environmental resource agency comments on the Interim Report (March 2019) and outreach meetings.

•Continued public, stakeholder and environmental resource agency outreach and meetings.

•Updated Environmental analyses included in this Draft Integrated Report since the Interim Feasibility Report and Environmental Scoping Document (March 2019) include:

-Draft Tier 1 EIS inclusive of broad-in-scope (less detail) risk-informed environmental analyses to assist in alternative evaluation to help identify and evaluate broad impact and mitigation concerns. This draft Tier 1 EIS establishes standards, constraints, and processes to be followed in future phases.

-Performance of an impact assessment informed by available modeling, literature, and proof of concept.

-Environmental Reviews at same level to establish compliance relative to a level of detail available.

-Environmental direct impact assessment for both PP, SSB and NS components

-One Federal Review (EO 13807) incorporation.

-Tier 1 Level Essential Fish Habitat Evaluation to comply with the Magnuson-Stevens Act, Biological Assessments for Endangered Species Act, and a Tier 1 Federal Consistency Review for the Coastal Zone Management Act.

-Environmental modeling process, conceptual models, trajectory of quantitative models, and preliminary quantitative assessments of habitat quantity (not quality).

2 Introduction*

2.1 Study Approach, Purpose* and Scope

The purpose of the U.S. Army Corps of Engineers (USACE) New Jersey Back Bays (NJBB) Coastal Storm Risk Management (CSRM) Draft Integrated Feasibility Study and Tier 1 Environmental Impact Statement (Draft Integrated Report) is to implement comprehensive CSRM strategies to increase resilience and to reduce risk from future storms and compounding impacts of sea level change (SLC). The objective of the NJBB CSRM Study is to investigate CSRM problems and identify solutions to reduce damages from coastal flooding that affects population, critical infrastructure, critical infrastructure, property, and ecosystems.

The Atlantic Coast of New Jersey is fronted by a Federal CSRM program (USACE, 2013). However, the region currently lacks a comprehensive CSRM program that will protect communities on the bay side of the barrier islands. As a result, the NJBB region experienced major impacts and devastation during Hurricane Sandy and subsequent coastal events that damaged property and disrupted millions of lives owing to the low elevation areas and highly developed residential and commercial infrastructure along the back bay coastline.

The NJBB is one of nine focus areas identified in the North Atlantic Coast Comprehensive Study (NACCS), whose goals are to:

a. Provide a risk management framework, consistent with NOAA/USACE Infrastructure Systems Rebuilding Principles; and

b. Support resilient coastal communities and robust, sustainable coastal landscape systems, considering future sea level and climate change scenarios, to reduce risk to vulnerable populations, property, ecosystems, and infrastructure.

While the NACCS provides a regional scale analysis, the NJBB CSRM Study has employed NACCS outcomes and has applied the NACCS CSRM Framework to formulate a more refined and detailed watershed scale analysis for the region. This analysis includes potential municipal or community level implementation of opportunities, strategies, and measures to assist communities in understanding and managing their short-term and long-term coastal risk in a systems context.

2.2 Study Authorization and Policy Guidance

The study authority for the NJBB CSRM Study was the New Jersey Shore Protection Authority (1987). The resolution reads as follows:

> Resolutions adopted by the Committee on Public Works and Transportation of the U.S. House of Representatives and the Committee on Environment and Public Works of the U.S. Senate in December 1987, and by House resolution adopted by the Committee on Public Works and Transportation on December 10, 1987 offers specific authority for the conduct of study along the coast of New Jersey:

"that the Board of Engineers for Rivers and Harbors, created under Section 3 of the Rivers and Harbors Act, approved June 13, 1902, be, and is hereby requested to review existing reports of the Chief of Engineers for the entire coast of New Jersey with a view to study, in cooperation with the State of New Jersey, its political subdivisions and agencies and instrumentalities thereof, the

changing coastal processes along the coast of New Jersey. Included in this study will be the development of a physical, environmental, and engineering database on coastal area changes and processes, including appropriate monitoring, as the basis for actions and programs to prevent the harmful effects of shoreline erosion and storm damage; and, in cooperation with the Environmental Protection Agency and other Federal agencies as appropriate, develop recommendations for actions and solutions needed to preclude further water quality degradation and coastal pollution from existing and anticipated uses of coastal waters affecting the New Jersey Coast. Site specific studies for beach erosion control, hurricane protection, and related purposes should be undertaken in areas identified as having potential for a Federal project, action, or response".

As a result of Hurricane Sandy in October 2012, Congress passed Public Law (P.L.) 113-2, (the Disaster Relief Appropriations Act of 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 actions specific to the USACE, including 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 the U.S. Army Corps of Engineers. The NAACS is the comprehensive study required by P.L. 113-2.

The NACCS identified the NJBB Region as one of nine focus areas in which to comprehensively identify problems, needs and opportunities including the development of CSRM strategies to manage risk associated with coastal flooding and sea level change in areas of need. .

The NJBB CSRM Study aligns with the NACCS goals and purpose to conduct a systems analysis/plan to better understand and manage coastal risk.

2.3 Non-Federal Sponsor and Study Milestones

The non-Federal sponsor for the study is the New Jersey Department of Environmental Protection (NJDEP). The original Feasibility Cost Sharing Agreement (FCSA) was signed in April of 2016 established that this study would cost shared 50/50. The total study costs are currently $18,050,000.

Milestones to completion of the NJBB CSRM Study are provided in Table 1.

Table 1: NJBB CSRM Study Milestones

Milestone	Date
FCSA	11 April 2016
Alternative Milestone Meeting	14 December 2016
Interim Feasibility Report and Environmental Scoping Document	1 March 2019
Tentatively Selected Plan Milestone	*20 January 2020*
Draft Integrated Report Release	August 2021
Agency Decision Milestone	January 2022
Final Feasibility Report	November 2022
State and Agency Review	February 2023
Chief of Engineers Report	April 2023

* Items in italics have occurred.

2.4 Federal Interest

The NJBB region is extremely vulnerable to coastal storm events. Coastal storm risk management is a primary mission area of USACE. This Draft Integrated Report identifies a variety of solutions that have the potential to be economically justified, environmentally acceptable, addressable through engineering solutions, and consistent with USACE principles.

2.5 Stakeholder Coordination

Coordination with stakeholders is a critical component of the NJBB CSRM Study and the development of a regional vision for managing coastal storm risk. Table 2 documents the meetings, workshops, and charrettes that have taken place since the commencement of the study in April of 2016. Stakeholders include but are not limited to citizens, elected municipal officials, federal agencies, state agencies, Non-Governmental Organizations (NGOs), local and regional planning commissions, and commercial and recreational interests.

Table 2: Public and Agency Coordination

Session	Date
Southern Counties Planning Workshop	06/17/2016
Northern Counties Planning Workshop	06/21/2016
Public Meeting	12/01/2016
NEPA Public Scoping	02/01/2017

USACE/NJDEP Partnering Meeting	03/06/2018
USACE & NJDEP Outreach Meeting	05/18/2018
USACE & NJDEP Outreach Meeting	05/24/2018
USACE & NJDEP Outreach Meeting	05/31/2018
Interagency Regulatory Resource Meeting (#1)	06/06/2018
USACE & NJDEP Outreach Meeting	06/19/2018
Southern Counties Public Meeting	09/12/2018
Northern Counties Public Meeting	09/13/2018
USACE Outreach Meeting	11/13/218
Interagency Regulatory Resource Meeting (#2)	11/29/2018
Virtual Public Meeting	3/14/2019
USACE Outreach Meeting	3/20/2019
USACE Cooperating Agency Webinar	4/24/2019
Nonstructural Working Group Meeting	5/17/2019
NNBF Workgroup Teleconference	5/21/2019
Environmental Impact Assessment for USACE CSRM Studies Meeting	6/6/2019
USACE Cooperating Agency Webinar	6/26/2019
Barnegat Bay Partnership Advisory Committee	7/9/2019
USACE Cooperating Agency Webinar	7/31/2019
USACE Cooperating Agency Webinar	8/28/2019
NNBF Workgroup Teleconference	9/9/2019
Brigantine Community Rating System Users Group	9/12/2019
USACE Cooperating Agency Status Meeting	9/25/2019
Ecological Impact Modeling Preliminary Findings Stakeholder Meeting for USACE CSRM Studies Meeting	11/14/2019
Atlantic City Community Rating System Users Group	11/20/2019
USACE Cooperating Agency Webinar	11/27/2019
Coastal Coalition	12/5/2019
Ocean County Community Rating System Users Group	12/19/2019
NJBB OFD Meeting w/ NOAA Fisheries and NAD	12/20/2019
NJBB OFD Meeting w/ USFWS and NAD	12/23/2019

NJBB Strategic Engagement: Interagency Webinar	5/11/2020
NJBB Strategic Engagement: NGO Webinar	5/12/2020
NJBB Strategic Engagement: Elected Official Webinar (North Region)	5/18/2020
NJBB Strategic Engagement: Elected Official Webinar (South Region)	5/19/2020

Detailed discussion of outreach activities of the NJBB CSRM Study can be found in the Correspondence and Communication Appendix.

2.6 Study Area

The geographic limits of the study area include the footprint of the Federal Emergency Management Agency (FEMA) 0.2% annual exceedance probability (AEP) (500-year recurrence interval) flood. This inundation boundary represents the storm surge floodplain associated with the maximum storm tide levels caused by extreme hurricane scenarios across the region, and therefore provides a reasonable approximation of the most extreme flooding extent (Figure 1). Detailed information regarding the with municipalities in the study area can be found in the Plan Formulation Appendix.

The study area includes the bays and river mouths located landward of the barrier islands and Atlantic Ocean-facing coastline in the State of New Jersey. The study area covers more than 950 square miles, and 3,500 linear miles of shoreline from Long Branch at the northern study area boundary to Cape May Point at the southern boundary. It comprises portions of eighty-nine municipalities and five counties including Monmouth, Ocean, Atlantic, Burlington and Cape May Counties. The New York-New Jersey Harbor and Tributaries Study (NYNJHATS) Focus Area addresses coastal risk and vulnerability for coastal areas in the State of New Jersey that lie to the north of the NJBB CSRM Study area.

The NJBB CSRM Study Area was subdivided into five regions based on planning considerations (problems and opportunities), geomorphology and the hydraulic interconnectedness or independence of water bodies. These regions were used to develop and identify potential alternative plans for the study area. The following paragraphs offer a characterization of the current conditions and physical setting of each of the five regions.

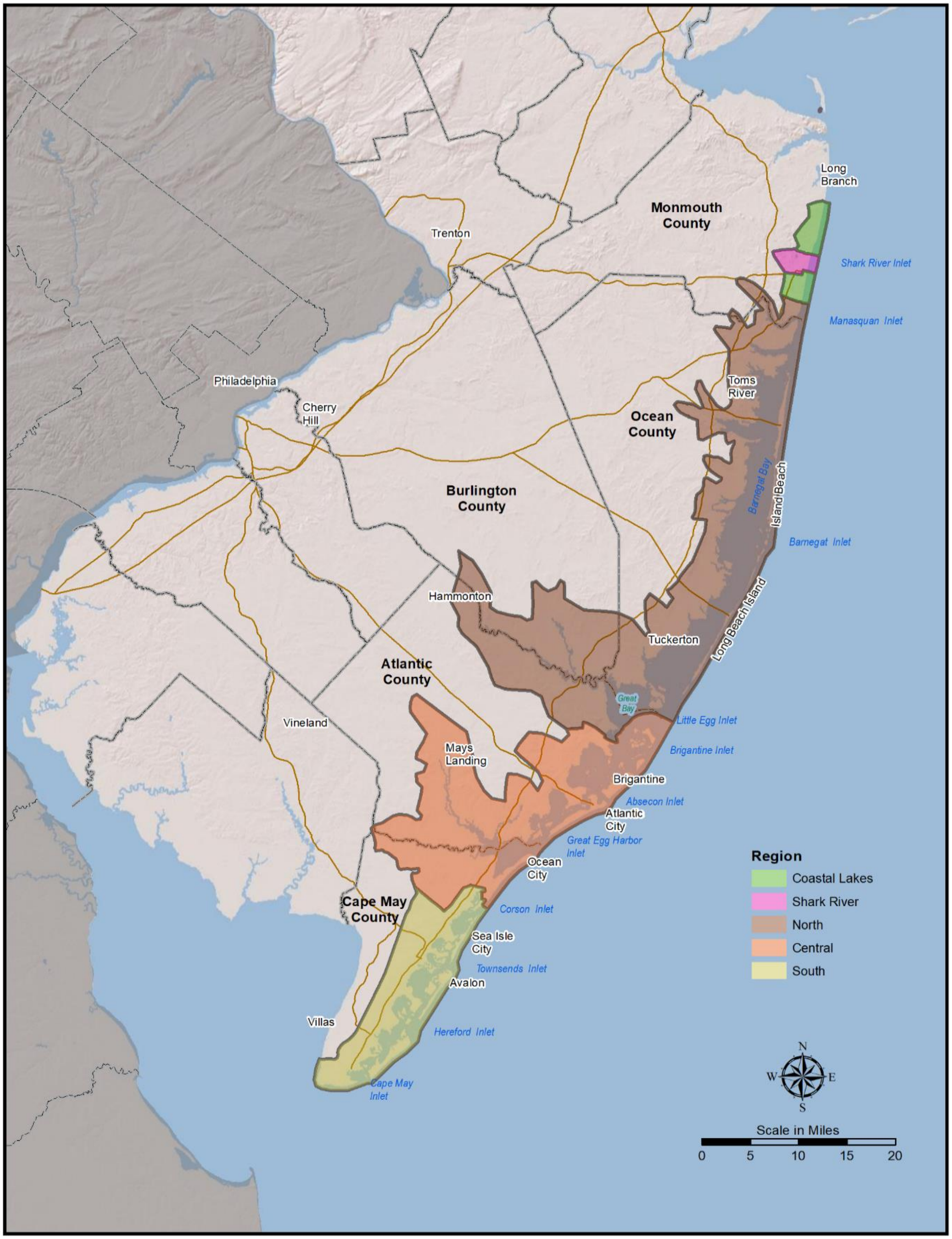


Figure 1: NJBB CSRM Study Area

2.6.1 Shark River And Coastal Lakes Region

This region includes two discontinuous segments separated by the Shark River and Coastal Lakes Region. The Coastal Lakes region is almost entirely urbanized and includes all or portions of fifteen municipalities (Figure 2). In the Coastal Lakes region, there are four coastal lakes in Ocean County and ten coastal lakes in Monmouth County (an additional two coastal lakes in Monmouth County are in the Shark River and Coastal Lakes Region discussed below). None of the lakes is presently connected to the Atlantic Ocean via a tidal inlet. However, 19th Century mapping shows that the lakes at the time were in fact small tidal estuaries, with each inlet subsequently closed by natural or human actions. Most of the lakes have some form of water level management that allows high lake levels to be reduced by discharge to the ocean. For example, Lake Takanassee drains to the Atlantic Ocean under "normal" tidal conditions through a buried culvert that is controlled by a tide gate. Because there are no tidal inlets connected to these lakes, they are subject to a different type of flood risk and will consequently require an alternate method of analysis. Potential flood pathways for these lakes include fluvial (precipitation) flooding, ocean wave and storm surge overtopping of the barrier beach, and ocean storm surge flooding that "backs up" from the ocean into the lake through the underground drainage conduits.

Figure 2: Location Map of the Coastal Lakes Region

The Shark River and Coastal Lakes Region includes the Shark River estuary and all or portions of seven highly urbanized municipalities in Monmouth County (Figure 3). Sylvan and Silver Lakes are coastal lakes that are included in the Shark River and Coastal Lakes Region. This region experienced some of the highest storm surge elevations within the study area during Hurricane Sandy. The storm flooding problem is principally related to the ability of elevated ocean water levels to pass through Shark River Inlet and inundate the adjoining land areas. Under ordinary tidal conditions, this is an isolated hydraulic reach; there is no tidal connection between the Shark River estuary and the Manasquan Inlet estuary to the south.

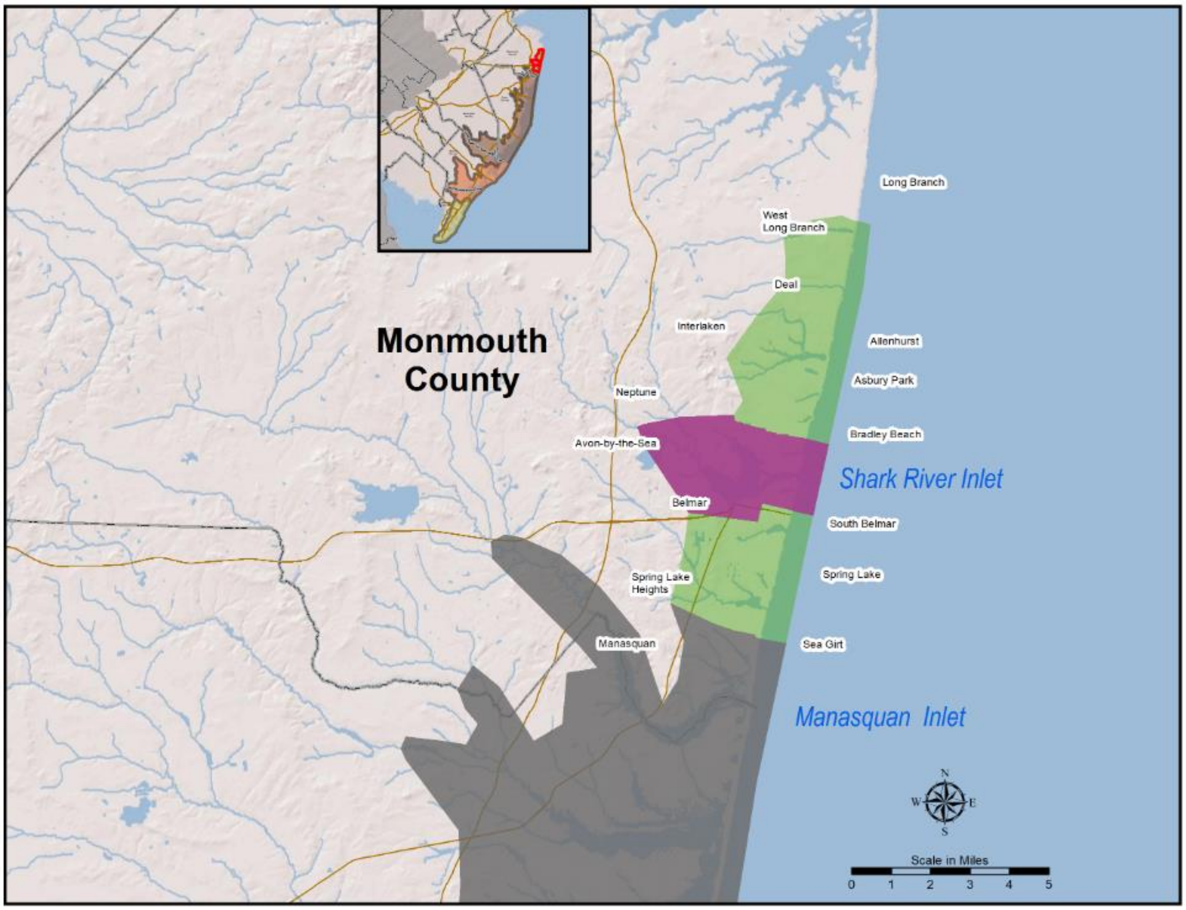


Figure 3: Location Map of the Shark River & Coastal Lakes Region

2.6.2 North Region

The North Region of the Study Area extends from Manasquan Inlet and the Manasquan River Estuary south to Little Egg Harbor Inlet and the Mullica River/Great Bay estuary (Figure 4). This is the largest region established for the NJBB analyses. It covers 536 square miles and includes all or portions of 45 municipalities in Ocean, Burlington, and Atlantic Counties.

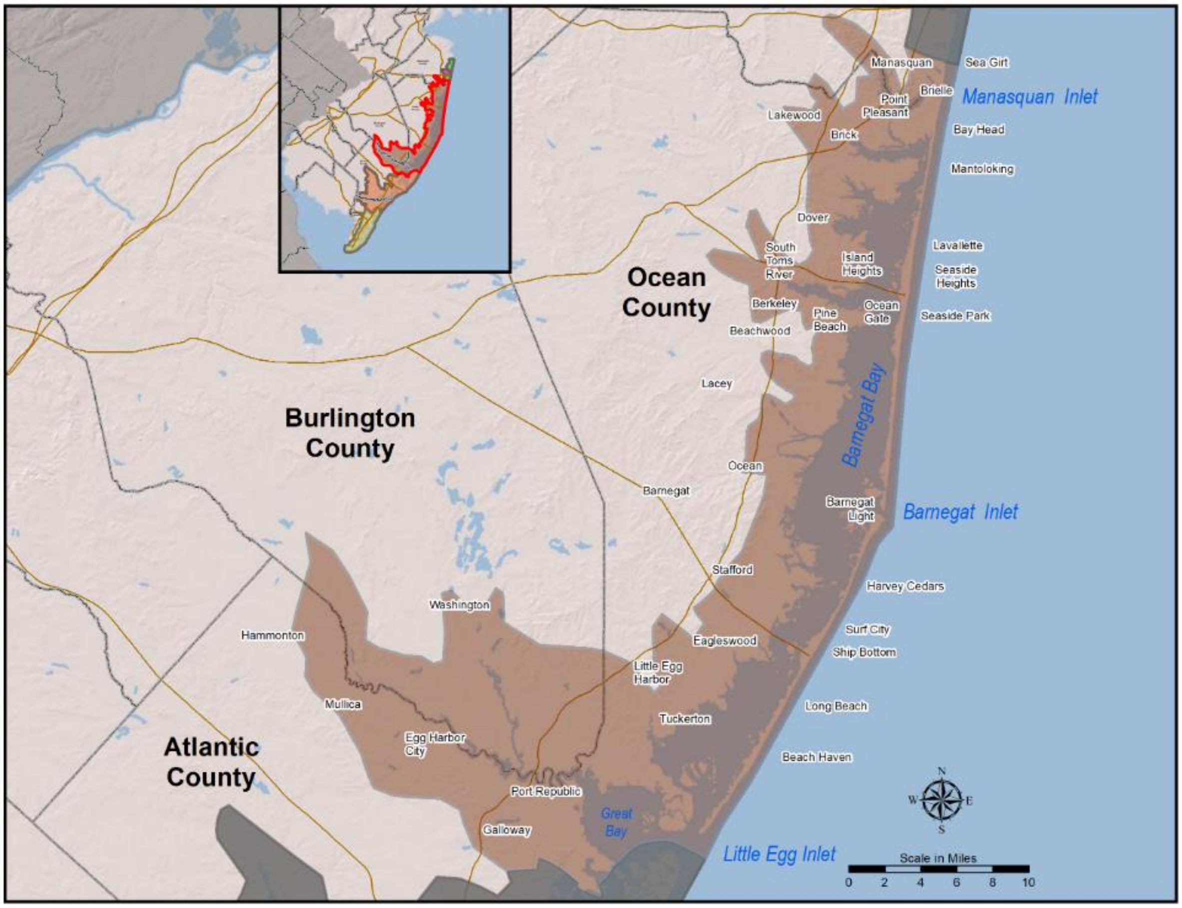


Figure 4: Location Map of the North Region

The North Region is characterized by having three inlets – Manasquan, Barnegat, and Little Egg – along a 45-mile long segment of the NJ coast. These three inlets are the only connections between the Atlantic Ocean and the large shallow back bays that include Barnegat Bay, Manahawkin Bay, Little Egg Harbor, and Great Bay. This contrasts with the much closer average spacing between inlets in the Central and South regions discussed in subsequent paragraphs.

The shorelines on the east side of the back bays, along the barrier spit extending from Manasquan Inlet to Barnegat Inlet and along Long Beach Island, are fully developed. The two exceptions to this generalization include the nine mile-long reach occupied by Island Beach State Park and the three mile-long Holgate Spit at the southwest end of Long Beach Island. Both of these areas are either State or Federal protected land and are unlikely to ever be developed.

In contrast to the eastern shoreline of the back bays, the western shoreline on the mainland of New Jersey is much more heterogeneous. This area is characterized by medium density single family home developments surrounded by back bay wetlands. There are numerous "finger canal" communities, many of which were developed in the period following World War II by bulk heading, dredging, and filling in what were previously tidal wetlands. One example is Beach Haven West in Stafford Township, Ocean County. This community has about 50 miles of bulk-headed residential shoreline and about 5,000 residential structures. In between the finger canal communities are more extensive reaches of back bay shoreline with little or no development. These areas typically consist of intertidal marsh/wetlands

2.6.3 Central Region

The Central Region extends from Little Egg Inlet south to Corson Inlet, with an area of 312 square miles and all or portions of 21 municipalities in Atlantic and Cape May Counties (Figure 5). The ocean shoreline length of this region is about 27 miles and includes five tidal inlets: Little Egg, Brigantine, Absecon, Great Egg, and Corson. The relatively shorter distance between inlets compared to those of the North Region makes the back bays of this reach susceptible to relatively higher 1% AEP storm surge elevations.

As in the North Region, the back bay shorelines of the barrier islands are essentially fully developed with medium density residential and business infrastructure. However, the western (mainland) shorelines of the Central Region are significantly less densely developed than those in the North Region.

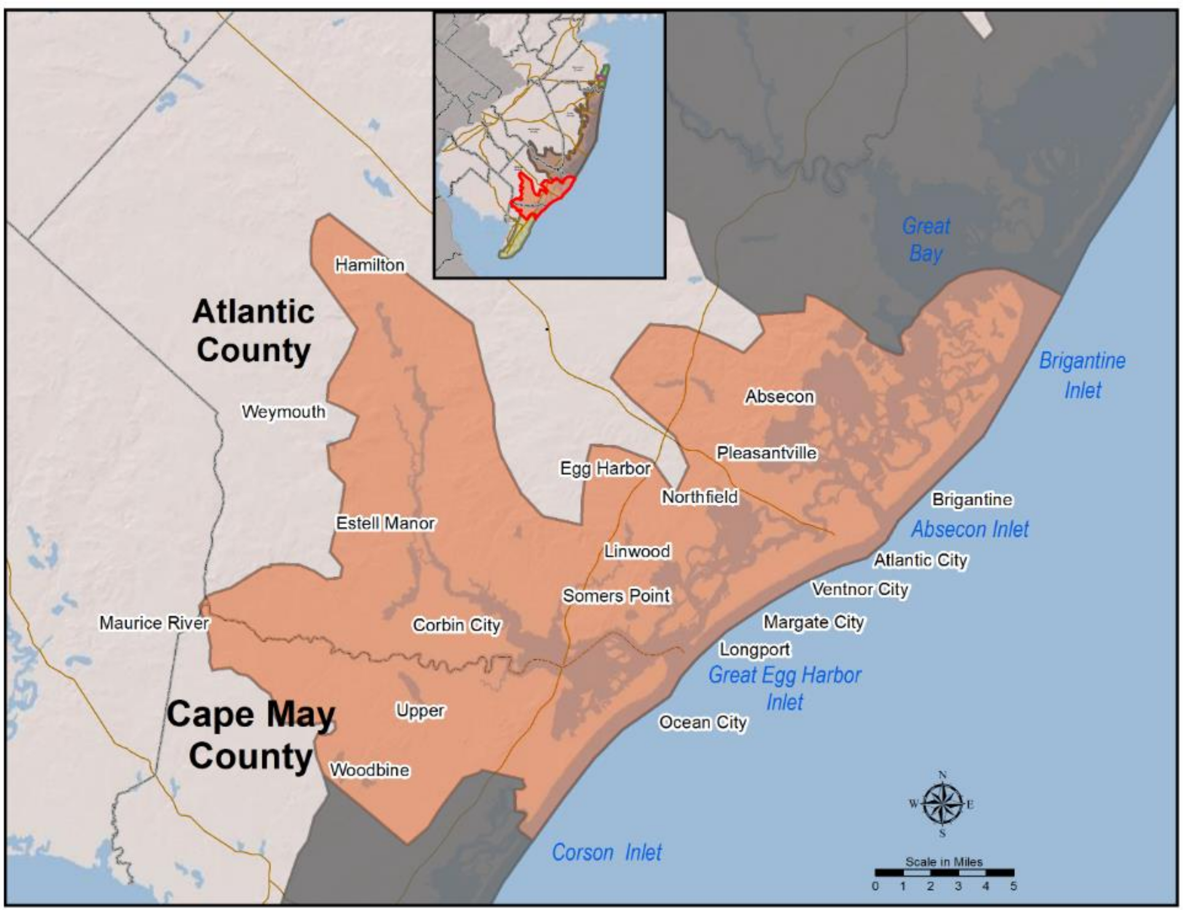


Figure 5: Location Map of the Central Region

2.6.4 South Region

The South Region extends from Corson Inlet south and west around Cape May Point to the west end of the Cape May Canal, with an area of 146 square miles (Figure 6). All or portions of 16 municipalities are included in the region, all of which are part of Cape May County. There are five inlets that connect this region to the Atlantic Ocean and Delaware Bay. They include Corson, Townsends, Hereford, and Cape May Inlets and the western entrance to the Cape May Canal on Delaware Bay. The South Region is similar to the Central region in that the most extensive and dense development is along the west (back bay) side of the barrier islands, with relatively less dense development on the mainland side of the back bays. The 1% AEP storm surge elevations in the South Region are comparable to those in the Central Region, and larger than those in the North Region.

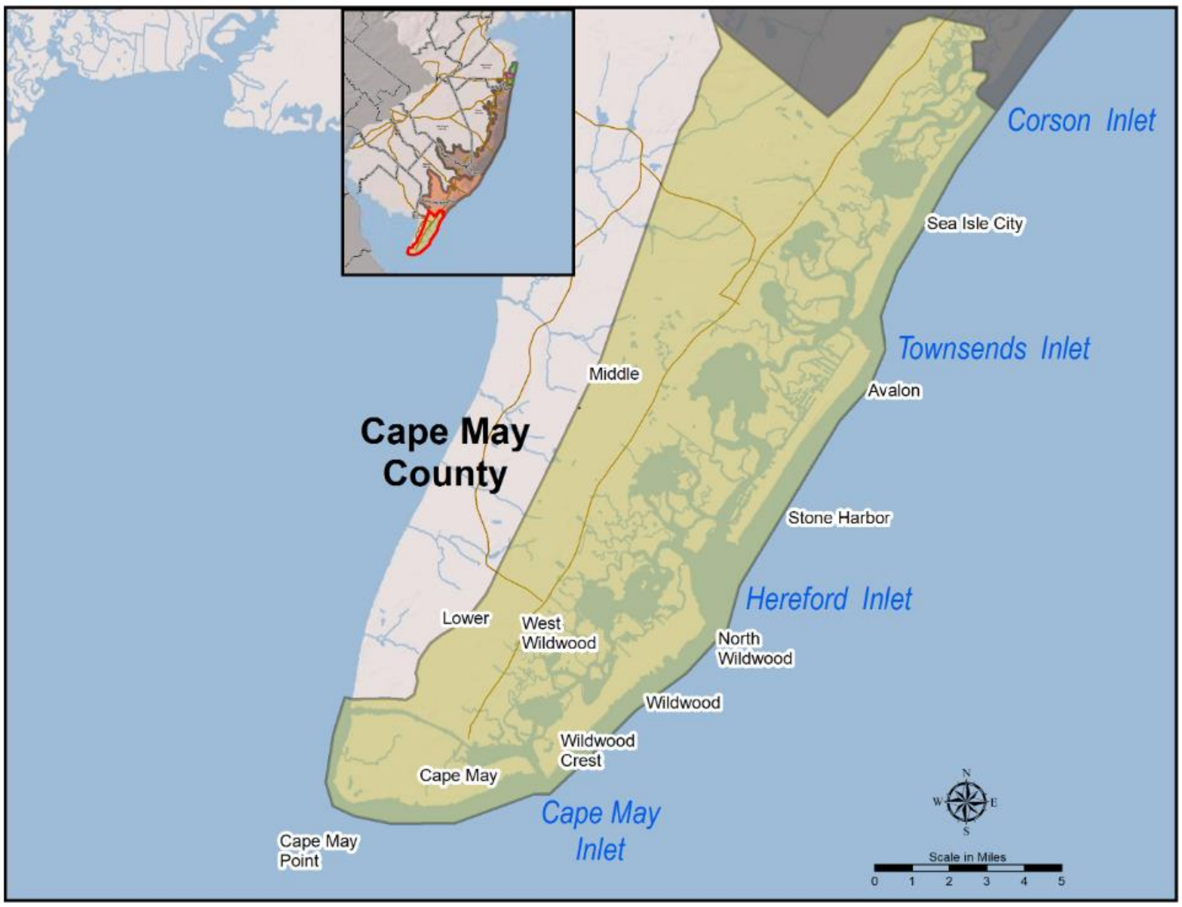


Figure 6: Location Map of the South Region

2.7 National Environmental Protection Act Compliance and Report Structure

A tiered NEPA approach is being applied to the environmental review for this study. The National Environmental Policy Act (NEPA) of 1969 requires federal agencies, including the USACE, to consider the potential environmental impacts of their proposed actions and any reasonable alternatives before undertaking a major federal action, as defined by 40 CFR 1508.18 (Figure 7).

To evaluate potential environmental impacts, USACE has integrated a Draft Environmental Impact Statement (EIS) into the Draft Feasibility Report. An EIS is a detailed written statement required by NEPA to serve as the means of assessing the environmental impact of proposed agency actions. EISs provide full and fair discussion of significant environmental impacts and inform decisionmakers and the public of the reasonable alternatives which would avoid or minimize adverse impacts or enhance the quality of the environment. 40 CFR 1502.1. …. Because of the large scope, scale and complexity of the affected environment and TSP, this EIS will be tiered with a subsequent EIS in accordance with 40 CFR 1502.20. NEPA permits agencies to "tier" their NEPA documents, which is a process by which the agency may incorporate by reference general discussions contained in an earlier document and concentrate solely on the issues specific to the subsequent analysis. Tiering is a means of making the environmental review process more efficient by allowing parties to "eliminate repetitive discussions of the same issues and to focus on the actual issues suitable for decision at each level of environmental review." (40 CFR 1502.20).

Tier 1 of the EIS is a broad-level review, and Tier 2 will consist of subsequent specific detailed reviews. The broad-level review identifies and evaluates the affected environment, no action alternative, and environmental impacts of the array of alternatives that can be fully addressed and resolved, notwithstanding the limited information that exists in this point of the Study. In addition, it establishes the standards, constraints, and processes to be followed in Tier 2. As proposed alternatives are developed and refined, incorporating a greater level of detail, the specific detailed reviews evaluate the remaining issues while incorporating the discussions and findings in Tier 1 of the EIS.

Together, Tier 1 and Tier 2 of the EIS will collectively comprise a complete environmental review as required by NEPA. Tiering the EIS resolves the "big-picture" issues so that subsequent studies can focus on project-specific impacts and issues. Two primary drivers for selecting the tiered NEPA approach is the likelihood that in the time between the end of the feasibility study and the start of the construction, enough time will have passed to justify reassessing the affected environment and second, the likelihood that additional design information will warrant additional assessment, which could include a supplement to the Tiered EIS. The tiered NEPA approach allows the NJBB Project Delivery Team (PDT) and the interagency team to focus on the decisions ready for discussion now, allows for additional public participation once as the design progresses, and allows for the consideration of avoidance, minimization, and mitigation planning using more up to date information.

One of the advantages of tiering a NEPA analysis is that it allows for discussions of issues once they are ready for consideration and to focus on the actual issues ripe for decision at each level of environmental review. The TSP includes several structural measures, nonstructural management measures, and a preliminary NNBF assessment that provide CSRM benefits for the NJBB Region. A broad analysis of the full range of the direct and indirect impacts to the human environment have been identified and described in the Tier 1 EIS using all available information. However, some of the finer scale discussions on avoidance, minimization, and mitigation for these measures will not be possible until the designs for these measures are advanced. For example, preliminary modeling done to predict the changes in tidal velocities that could occur from the SSB gates and the possible impacts on marine organisms resulting from potential change in velocities are discussed in the Tier 1 EIS. These predicted changes in tidal velocities inform the consideration of potential impacts to these species. However, finer scale interactions, like the potential for the structures to create eddies and other turbulences, are dependent on more precise design details that won't be available until additional engineering analysis is performed. Since many of the gate structures are in areas that are important for various life stages of numerous species, small changes in these areas can be impactful to the entire ecosystem. In this example a tiered NEPA strategy would provide opportunity for both the broad level considerations (Tier 1) during the feasibility study phase and for the finer scale analysis (Tier 2) during PED.

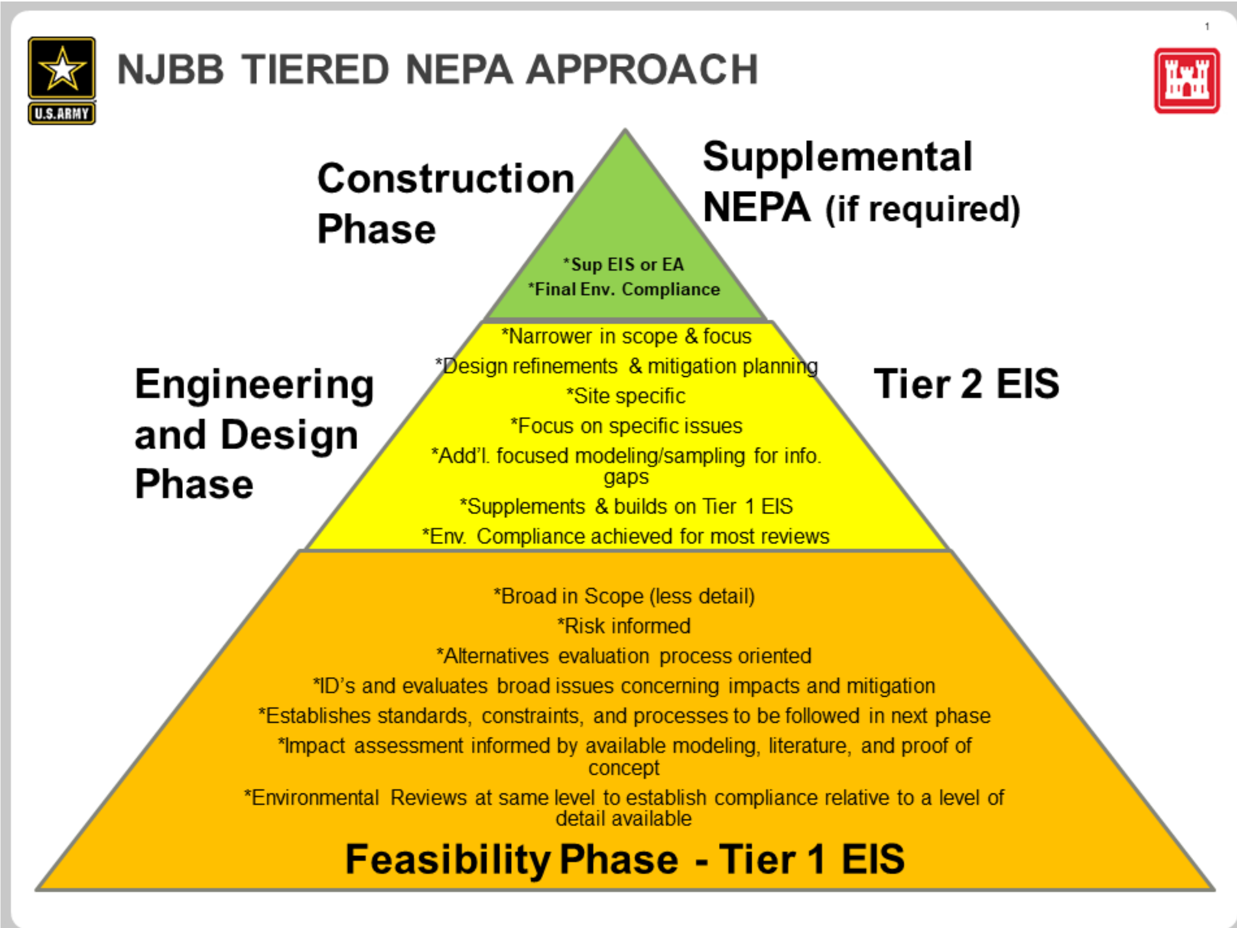


Figure 7: Feasibility Phasing

3 Planning Considerations

3.1 Goals

The primary goal of the NJBB CSRM Feasibility Study is to reduce risk to human life and property through the reduction of storm surge and damage to residential and commercial structures and industries critical to the nation's economy.

3.2 Problems and Opportunities*

3.2.1 Problems

The Atlantic Ocean coast of New Jersey is fronted by a system of Federal CSRM projects that extend from Sea Bright on the north to Cape May Point on the south (USACE, 2013). However, the NJBB CSRM Study area, which encompasses portions of five counties and includes about 950 square miles of land and water, currently lacks a comprehensive CSRM program. As a result, the NJBB region experienced major impacts and devastation during Hurricane Sandy and other coastal storm events, including extensive inundation from storm surge due to the combination of low-lying topography, densely populated residential and commercial areas, extensive low-lying infrastructure, and degraded coastal ecosystems.

The NJBB Region is a dynamic environment that supports densely populated areas with billions of dollars of largely fixed public, private, and commercial investment. Hurricane Sandy emphasized our vulnerability to coastal storms and the potential for future, more devastating events due to rising sea levels and climate change. Rising sea levels represent an inexorable process causing numerous, significant water resource problems such as: increased, widespread flooding along the coast; changes in salinity gradients in estuarine areas that impact ecosystems; increased inundation at high tide; decreased capacity for storm water drainage; and declining reliability of critical infrastructure services such as transportation, power, and communications. Addressing these problems requires a paradigm shift in how we work, live, travel, and play in a sustainable manner as a large extent of the area is at a very high risk of coastal storm damage as we move into the future of changing sea levels.

Individual system-wide problem statements are grouped within three categories to be carried forward to inform the plan formulation process, and include:

Coastal Storm Risk Management:

<u>Inundation</u>: The NJBB CSRM Study area currently lacks a comprehensive CSRM program to protect against inundation (economic disruption to residential and infrastructure & life and safety risks).

<u>SLC/Climate Change</u>: The study area that is currently at risk will likely see an increase in future damages with the potential for sea level change in the FWOP condition.

<u>Erosion</u>: The study area experiences disruption of shoreline from wave attack, wind forces and other elements.

<u>Municipal Jurisdiction Disconnect</u>: The study area lacks a comprehensive, multi-jurisdictional, multi-agency effort that can integrate storm risk management efforts in a way that crosscuts Federal/State/Local business lines, study authorities and agency missions.

Environment:

Degraded Ecosystems: The study area's coastal ecosystems fail to provide their natural ecosystem services (provisioning, regulating, supporting and cultural).

Economy and Infrastructure:

High-Frequency Flooding: The study area experiences high-frequency flooding, also known as nuisance flooding, recurrent flooding, or sunny-day flooding, caused by tides and/or minor storm surge that mostly affects low-lying and exposed assets or infrastructure, such as roads, public storm-, waste- and fresh-water systems and is likely more disruptive (a nuisance) than damaging. However, the cumulative effects of high-frequency flooding may be a serious problem to residents who live and work in these low-lying areas.

Municipal Storm water Infrastructure: The study area experiences flooding from rainfall and inadequate municipal storm water infrastructure that mostly affects low-lying and exposed assets or infrastructure, such as roads, public storm-, wastewater- and fresh-water systems.

Floods have been and continue to be the most frequent, destructive, and costly natural hazard facing the State of New Jersey (New Jersey, 2011). The study area is vulnerable to damage from storm surge, wave attack, erosion, and rainfall-storm water runoff events that cause riverine and/or inland flooding. The State of New Jersey, in the state hazard mitigation plan, has documented the numerous, historic instances of flooding, Presidential disaster declarations, and damage estimates. Historic sea level change has exacerbated the problem over the past century, and the potential for accelerated sea level change in the future will only increase the magnitude and frequency of the problem. These forces constitute a threat to human life and increase the risk of flood damages to public and private property and infrastructure.

The shorelines of most of New Jersey's back bays are characterized by low elevation areas developed with residential and commercial infrastructure and are subject to tidal flooding during storms. Public and private property at risk involves densely populated sections of the barrier island back bay coastline and also mainland portions of the areas bordering the bays and tidal tributaries of the study area. It includes private residences, businesses, schools, infrastructure, roads, and evacuation routes for coastal emergencies. Additionally, the NJBB CSRM Study area includes undeveloped areas that provide ecological, fishery, and recreational benefits. Healthy marshes in the back bay areas have the potential to reduce coastal flooding and storm surge. These areas are subject to erosion, loss, and alteration due to coastal storms. Back bay dune, beach, marsh, and estuarine ecosystems are quite fragile in some locations and are threatened by sea level change. Inundation of sites identified through the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), otherwise referred to as Superfund sites, or other hazardous waste sites may also severely impact water quality.

Based on recorded history, the National Flood Insurance Program (NFIP) records, and analysis of engineering data about flood plains it is clear that New Jersey is one of the more flood-prone States in the nation. The NOAA National Climatic Data Center (NCDC) database reported 1169 flood events just since 1996 (NOAA NCDC, 2011). According to NFIP statistics, flood claims payouts have totaled more than $5.3 billion since the beginning of the NFIP program in 1978 through July 2013. Out of that, nearly $2.9 billion was paid for flood damages to the coastal counties of Monmouth, Ocean, Atlantic and Cape May from Hurricane Sandy damages alone.

New Jersey's low-lying coastline, stretching from Raritan Bay in the north, along the Atlantic Coast to Delaware Bay is highly susceptible to coastal flooding. This region has experienced frequent coastal flooding events over the years, causing extensive beach erosion, marsh loss, damage to dunes and other coastal flood risk management structures. Recent events in the coastal region include floods associated with Tropical Storm Ida in November 2009, a nor'easter in December 2009, a severe storm in April 2010, Hurricane Irene in August 2011 and more recently Hurricane Sandy in October 2012. Since Hurricane Sandy, there have been additional severe coastal storm events, including Hurricane Joaquin in September-October 2015, and extra-tropical cyclone (nor'easter) Jonas in January 2016. Both of these events caused significant oceanfront erosion and back bay flooding.

A more detailed analysis of problems and opportunities for the NJBB CSRM Study area on a regional basis is provided in the Plan Formulation Appendix.

3.2.2 Opportunities

Opportunities associated with the NJBB CSRM Study include the following:

a. Develop a CSRM system that reduces coastal flood inundation damages as well as wave and erosion damages.

b. Develop a CSRM system that mitigates the effects of sea level change.

c. Develop a CSRM system that assists in managing flooding risk from localized tidal flooding.

d. Integrate storm risk management efforts into the NJBB CSRM Agency Coordination and Collaboration Plan to foster partnerships and collaborative goals.

e. Apply adaptive and sustainable solutions through a quantified review of measures and alternatives with partners and stakeholders to promote economic community resilience.

f. Assist and advance local efforts and resources through discussion and qualitative review of measures and alternatives designed to improve forecasting.

g. Identify complementary management measures to address high-frequency flooding and inadequate storm water systems that may be recommended as part of a comprehensive Federal project or recommended for implementation at the local non-federal level

3.3 Objectives

The objective of the New Jersey Back Bay CSRM Feasibility Study is to investigate CSRM problems and develop solutions to reduce damages from coastal flooding affecting population, critical infrastructure, critical infrastructure, property, and ecosystems. The study principles are based upon the authority for the NJBB CSRM Study (Resolutions adopted by U.S. House of Representatives and U.S. Senate Committees in December 1987) which are broad in scope and application, and support NACCS outcomes.

Specific objectives for the Study are to:

a. Reduce economic damages from coastal storm surge and inundation through CSRM risk management within the NJBB CSRM Study area between 2030 and 2080.

b. Reduce risk to human life and life safety from coastal flooding and storms as well as other social effects including community cohesion and prevent post-storm displacement.

c. Reduce the risk of inundation and effects on economic damages and future development owing to SLC through formulation analyses.

d. Support and advocate flood forecasting and evacuation plans and technology.

3.4 Constraints

Coastal communities face tough choices as they adapt local land use patterns while striving to preserve community cohesiveness and economic vitality. In some cases, this may mean that, just as ecosystems migrate and change functions, human systems may have to relocate in a responsible manner to sustain their economic viability and social resilience. Absent improvements to our current planning and development patterns that account for future conditions, the next devastating storm event will result in similar or worse impacts.

Planning constraints associated with the NJBB CSRM Feasibility Study include a) resource; b) universal and c) study-specific constraints.

Two distinctly different categories of planning constraints can be identified. First, there are Resource Constraints in the planning process. These include limits to our knowledge, expertise, experience, ability, data, information, money, and time. These constraints limit the scope of a study in significant ways. A second category of planning constraints can be divided into Universal Constraints and Study-Specific Constraints. Universal Constraints are the legal and policy constraints that need to be included in every planning study. They may vary from study type to study type, but for a given type of study, there are some predictable constraints or considerations. The Corps' guidance, regulations, policies, and authorities define some of these constraints. Others are defined by the laws and regulations of the federal government and the applicable laws and regulations of the State and local governments. Study-Specific Constraints are statements of things unique to a specific planning study that alternative plans should avoid.

a. Resource Constraints:

1. Avoid non-sustainable solutions that cannot be maintained, whether due to expense or complicated technologies, by the non-Federal sponsor.
2. Difficulty in funding long-term operation and maintenance costs.

b. Universal Constraints:

1. Comply with all Federal laws and executive orders, such as the National Environmental Policy Act (NEPA), the Clean Water Act, the Endangered Species Act, and Executive Order 11988.
2. Mutual acceptance must be developed between the Secretary of the Army and the Secretary of the Interior, if the plan lies within jurisdictional boundaries of the National Park Service or U.S. Fish and Wildlife Service.
3. Acquisition of real estate and easements.
4. Avoid additional degradation of water quality, which would put additional stress on aquatic ecosystems.

5. Avoid impacting or exacerbating existing hazardous, toxic, and radioactive wastes (HTRW) that have been identified within the project area.
6. Minimize the impact to authorized navigation projects.
7. Minimize effects on cultural resources and historic structures, sites, and features.

c. Study-Specific Constraints:

1. Consider local land use plans and regulations in developing the Federal plan.
2. Many of the beaches within the study area are recognized as a recreational resource and it is important that this resource be maintained.
3. Some areas within this study area are highly developed, and the density of population may limit the amount of space available for staging and constructing a project.
4. Minimize the impact to other projects and areas where risk has been managed, such as sensitive wetlands, wildlife management areas, etc.

An additional consideration is to avoid increasing the flood risk to surrounding communities and facilities given CSRM management measures development in the study area.

3.5 Period of Analysis

The period of analysis for comparison of the preliminary focused array of alternative plans is the 50-year period from 2030 to 2080. Project implementation in a phased, scalable format is assumed to begin in the year 2030 and continue for five years to 2035. The economic base year is 2030 and is considered the year the alternatives have been implemented and project benefits will commence to accrue sequentially as different parts of the plans achieve implementation. Alternative plan performance has been evaluated as part of the NJBB CSRM Study through the calculation of economic future damages, engineering, and environmental performance for the 2030-2080 fifty-year period according to USACE policy (USACE, 2000). Coastal sustainability associated with sea level change (USACE, 2014; USACE, 2013) will be evaluated for the 100-year period from 2030-2130 for all of the alternative plans in the preliminary focused array.

3.6 Critical Assumptions

The PDT made certain assumptions and generalizations while performing the study and developing this Draft Integrated Report. These decisions affected the decision-making process. As a result, the alternative plans presented in the Draft Integrated Report were formulated with a lower level of detail than will be considered for later in the Study. Critical assumptions from several disciplines were communicated with interested groups and decision makers through the use of a risk register and at a series of stakeholder and public meetings.

Some of these critical assumptions are summarized below:

3.6.1 Economics

The Hydrologic Engineering Center's Flood Damage Reduction Analysis (HEC-FDA) software model was used to perform economic modeling for the study area. While HEC-

FDA is an USACE approved economic model, HEC-FDA is typically applied in riverine flood-prone areas. Also, a reduced sample size is used to inform certain critical variables such as foundation height (for use in First Floor Elevation calculation) and Depreciated Replacement Value adjustment (Marshall & Swift Residential Estimator software) across the entire inventory within the study area.

3.6.2 Engineering

The level of detail on conceptual engineering analyses, calculations, designs, and costs is limited at this point in the study. Thus, parametric estimates for some costs have been used, resulting in high contingency. This lower level of detail is partially a result of the fact that geotechnical and geo-environmental analyses and utility siting/location info are based on existing data in the study area. A preliminary geotechnical subsurface investigation was performed in 2019 but was not incorporated into this Draft Integrated Report. This 2019 subsurface investigation as well as future subsurface investigations will be integrated to the NJBB CSRM Study to develop higher level of design during subsequent study and PED phases of the project.

3.6.3 Environmental

The quantification of some environmental impacts associated with SSBs and associated mitigation has not been performed since not all hydrodynamic environmental circulation and water quality modeling has not been completed at this point in the study. Due to the insufficient detail and preliminary nature of the alternative plans presented in this report, environmental resource agency concurrence and NEPA compliance document development will occur later in the study or during PED. Cultural Resources Section 106 surveys will be conducted later in the study or during PED. Table 3 provides a more comprehensive list of some of the important decisions along with a qualitative assessment of the risks and consequences associated with those decisions.

Table 3: Critical Assumptions

NEW JERSEY BACK BAYS REVISED DRAFT INTERIM REPORT CRITICAL ASSUMPTIONS TABLE			
Risk Register ID Number	**Scoping Choice or Event**	**Risk**	**Consequence**
Geotechnical Engineering	Limited geotechnical subsurface investigation or field data have been collected during the study to support structural features.	Limited site specific data for feasibility level of design and geotechnical engineering analysis of potential TSP features.	1. Conservative assumptions must be used that will drive up cost estimates and associated contingency of potential project features. 2. Existing data may not be sufficient to support an acceptable EIS and proper regulatory compliance. 3. PED schedule could be significantly impacted as final designs can't be completed until data collection and analyses are complete. 4. Even with conservative assumptions, actual construction costs could be significantly higher for some project features due to the varied and complex geologic conditions of the New Jersey coastal environment.
Structural Engineering	Level of detail on conceptual engineering analyses, calculations, and designs. Estimated labor costs may not be comprehensive enough to cover the field of engineering practices for the structural analyses and designs.	Typical structural engineering analyses, calculations, and designs for the project structural features are performed based on assumptions or limited data collection. Typical designs are provided for the different project features. Increasing the level of assumptions increases the risk of unsuitable designs for the different project features, which also increases the risk of redesigning and requiring additional funds. May need more engineers and/or resources to participate in the project.	1. Improper analysis of the proposed project features due to the uncertainty related to a low volume of data and/or assumptions made could result in unrealistic designs, redesigning the structures may be necessary. 2. Estimated labor costs may not be sufficient for analyses and designs of the project features. Designed features may not be practical or could not be constructed as proposed. Potential for inadequate design, factors of safety, and structural stability due to insufficient data. Potential for iterative redesign of elements due to uncertainty of constructability, which could increase in costs as a result. Labor costs can increase, TSP plan may not be practical or could not be constructed as proposed.
Civil Engineering	Civil/Site final feasibility design Level of detail not adequate for environmental resource agencies.	Final design from study is not acceptable to environmental resource agencies due to lack of design detail.	EIS report is deemed inadequate and not acceptable. Study delayed and not enough funds or time to properly attain acceptable design level of detail.
Civil Engineering	Condition and ability of existing CSRM structures to reduce flooding and be incorporated into plan	Existing bulkheads and other existing CSRM structures in poor or failing condition and not able to adequately function or be incorporated into project features. Assumptions made about condition of existing structures is not field verified or analyzed.	Inaccurate project costs due to assumptions about existing CSRM structures being wrong. Possible wrong TSP selected due to inaccurate BCR. Increased P E & D costs and final project construction costs.
Cost Engineering	Design development stage: preliminary	Incomplete technical data.	Higher construction cost due to increased contingencies on the order of 50% or higher. The increased contingencies are the result of lack of adequate/incomplete/conservative technical data and analyses. This will impact cost/benefit calculations and net benefits.
Geo-Environmental Engineering	Defer new geo-environmental exploration/testing and HTRW investigations to PED phase. OR eliminate HTRW investigations entirely from study.	Using existing information for feasibility study could lead to contaminated material being found during PED and incomplete information about subsurface conditions.	Additional construction cost and time. Additional design time. Unknown chemical characteristics of the soil, sediment and groundwater for disposal costs. Conservative volume and cost estimates would be used, resulting in potentially erroneous project estimates.
H&H/Coastal Engineering	H&H Modeling Needs for Impacts from proposed SSBs	Several hydraulic models will be needed to consider significant number of environmental impact risks. These models can be costly and time consuming. With these models, the study cost and time increases.	Because these models are included, the study cost and length is higher. It's possible that even additional time or money could be required if the analysis turns out to take longer than expected.
H&H/Coastal Engineering	Level of effort for the coastal lakes portion of the study area	Except for the coastal lakes that are hydraulically connected to Barnegat Bay or Shark River, the coastal lakes area requires very different analysis such as interior drainage and storm sewer utility evaluation. These analyses will take more extensive time and cost. No extensive analysis will be completed and only recommendations for future work will be addressed for the coastal lakes that are not hydraulically connected to Barnegat Bay or Shark River.	Only recommendations for future work will be addressed in this study. Sponsor and Stakeholders may desired actionable designs/projects as a study outcome.
H&H/Coastal Engineering	Evaluate navigation impacts at inlets where storm surge barriers are proposed using a desktop analysis only.	Per ER 1110-2-1403, hydraulic design studies that affect navigation channels require ERDC's Ship/Tow Simulation Analysis. This detailed analysis requires significant time and cost.	Navigation impacts that affect the design of federal inlets may not properly be identified during feasibility.
Plan Formulation	Full range of flood risk management measures to be considered which include nature based solutions, engineering solutions and non-structural to be aligned with NACCS authority and guidance	Consideration of non-structural, natural and nature based features, and policy/programmatic solutions may not be consistent with VT direction, and may not provide comparable risk management capability of traditional structural solutions and may increase costs without increasing benefits but exclusion may make project inconsistent with NACCS	Inclusion may impact justification, exclusion may make study inconsistent with the goals of NACCS, reduce sponsor interest
Plan Formulation	Plan Formulation - Alternatives Risk	Scope of plan formulation will vary based on the appropriate extent of the alternatives evaluated	Low risk scenarios for planning alternatives will add time and costs to the study by evaluating 8 alternatives, while high risk scenarios will require aggressive screening and only evaluate 4 regional alternatives. Formulation, and removal of alternatives that may be viable options for implementation will present storm damage risks and evaluation of too many alternatives will create additional study and costs risks
Economics	Economics Database	The Economics database will be large and existing databases will need to be supplemented with new surveys/databases	Benefits Calculations
Economics	Use of models for evaluation of benefits	There are 3 models for use in the evaluation of benefits for the study, use of certain models in certain environments is more appropriate than others and limiting the use of models choice could impact benefits	A decision to limit the use of a model to decrease study time and costs would hinder project approval if the model is not approved for that environment type, the model use could have negative impacts on AAD, AAC, BCR, NED
Economics	Sampling % for structure database	There are over 150,000 structures in the NJBB study area, surveying all for first floor elevations would be difficult in the study timeframe regardless of schedule, for this reason sampling will be used for critical economic data	Decreasing the sample size to reduce study costs could result in analytical errors in benefit calculations, larger study samples could improve accuracy of the methods used for first floor elevations, depreciated replacement costs
Data	NFIP elevation certificates have been used to collect data on first floor elevations throughout the study area but may not be of great enough quantity to be the basis for FFE estimation	NFIP elevation certificates are only required on homes that are newly constructed or have significant renovations. Therefore, the data from NFIP elevation certificates may be biased towards structures that are at higher elevations	If the structure inventory is biased towards a higher elevation it could result in the underestimation of damages, which may result in more costly alternatives being inappropriately screened out of consideration.
Environmental	A lower level of design will potentially be used for the Environmental Scoping Document (ESD)/draft Feas. Report that is released for public and agency review.	Inadequate preliminary ESD or having to do a supplemental NEPA document in PED. Not getting resource agency buy in and subsequent approvals due to insufficient detail and information in NEPA document.	Need for supplemental NEPA document. Increase in budget and delay in schedule. Picking the wrong selected plan. Worst case scenarios may preclude selection of a viable plan.

4 Existing Conditions

4.1 Introduction

Existing conditions are characterized and documented in this section and serve as the basis for the problem identification and plan formulation including the development of the FWOP condition. Gathering information about existing conditions across the study area will assist in identifying the vulnerabilities to coastal storm damage. This process helps to identify coastal risk management and resilience opportunities.

The existing conditions are the conditions at the time the study is conducted (Para. 2-3(5)b of the 1105-2-100, USACE Planning Guidance Notebook) and considers the impacts of coastal storms including Hurricane Sandy and include government agency and NGO responses since Hurricane Sandy. This existing condition analysis includes consideration of the general and physical setting including coastal processes, and a characterization of economic, environmental, and cultural resources conditions.

The existing conditions for the State of New Jersey are summarized by the fact that while coastal storm risk is managed along the Atlantic Ocean coast by a number of Federal CSRM projects, the back bay and Delaware Bay coasts are not well protected due to the limited number of CSRM projects.

This Section discusses the existing conditions for the New Jersey Back Bay study area with respect to shoreline types, environmental conditions, economic conditions, and cultural resources.

4.2 General Setting

Barrier islands, barriers spits, and headland beaches make up the eastern side of the study area. These features face the brunt of the ocean forces including waves, currents, swells, winds, tides, and storms and reduce the impacts to the bays and mainland coastlines landward of the islands. The maximum topographic elevations along the ocean coastline vary from approximately +10 to +22 ft. NAVD88 in areas where Federal CSRM projects exist. Only a few areas along the ocean coast are not currently covered by a Federal shore protection project: The Gateway National Recreation Area, the Edwin B. Forsythe National Wildlife Refuge and Island Beach State Park, and Hereford Inlet to Cape May Inlet. While some of the topography in these undeveloped, preserved areas is higher with natural dunes, generally the elevations are lower with no continuous line of higher elevations to limit overtopping and erosion.

The back bays behind the barrier islands collect sediments from rivers and streams that drain from the mainland creating significant areas of shallow tidal marshes. In addition, there are areas of open water that vary in extent. Average depths in the bays behind the barrier islands vary from 3 to 6 ft. with some deeper areas up to 35 ft. near inlets. These depths represent areas outside the New Jersey Intracoastal Waterway (NJIWW), which is dredged for navigation to maintain a depth of 6 ft. in most of the channel, but up to 10 to 12 ft. deep in some locations (USACE, 2016b).

In the northern part of the NJBB CSRM Study area, from the coastal lakes south to Manasquan Inlet, there are no barrier islands; beaches in this segment of shoreline are either headland beaches or barrier spits and are directly impacted by the ocean forces. Maximum topographic elevations along this segment of ocean shoreline range from about +10 to as much as +25 ft.

relative to the North American Vertical Datum of 1988 (NAVD 88). In this area, there are small, non-tidal lakes that drain through outfalls to the ocean. The coastal lakes are shallow, with maximum depths generally not exceeding 10 ft. under normal conditions.

4.3 Existing Studies and Projects

Coastal storm risk is managed along the Atlantic Ocean coast of New Jersey by a number of Federal CSRM projects (Figure 8). However, the NJBB CSRM Study area is presently exposed to significant coastal/tidal flood risk on the bay side, due to the non-comprehensive nature of other CSRM projects, as shown in Figure 9.

The NJBB CSRM Study area includes five authorized Federal navigation projects at inlets, which connect the Atlantic Ocean to the back bays. From north to south the inlets (and their respective entrance channel dimensions (channel width and authorized navigation depth, in ft.) are: Shark River Inlet (100 x 12), Manasquan Inlet (250 x 14), Barnegat Inlet (300 x 10), Absecon Inlet (400 x 20), and Cold Spring (Cape May) Inlet (400 x 25). There is also the NJIWW, which is an authorized Federal navigation project with depths maintained at 6 to 12 ft. depending on location. The northern entrance to the NJIWW is at Manasquan Inlet. The NJIWW transits generally southward through the back bays of the study area until it enters Cape May Harbor, and then westward across the Cape May peninsula through the Cape May Canal. The western terminus of the Cape May Canal on Delaware Bay is also the southwest end of the NJIWW.

A more detailed discussion of existing CSRM Studies, reports, actions, and programs can be found in the Plan Formulation Appendix.

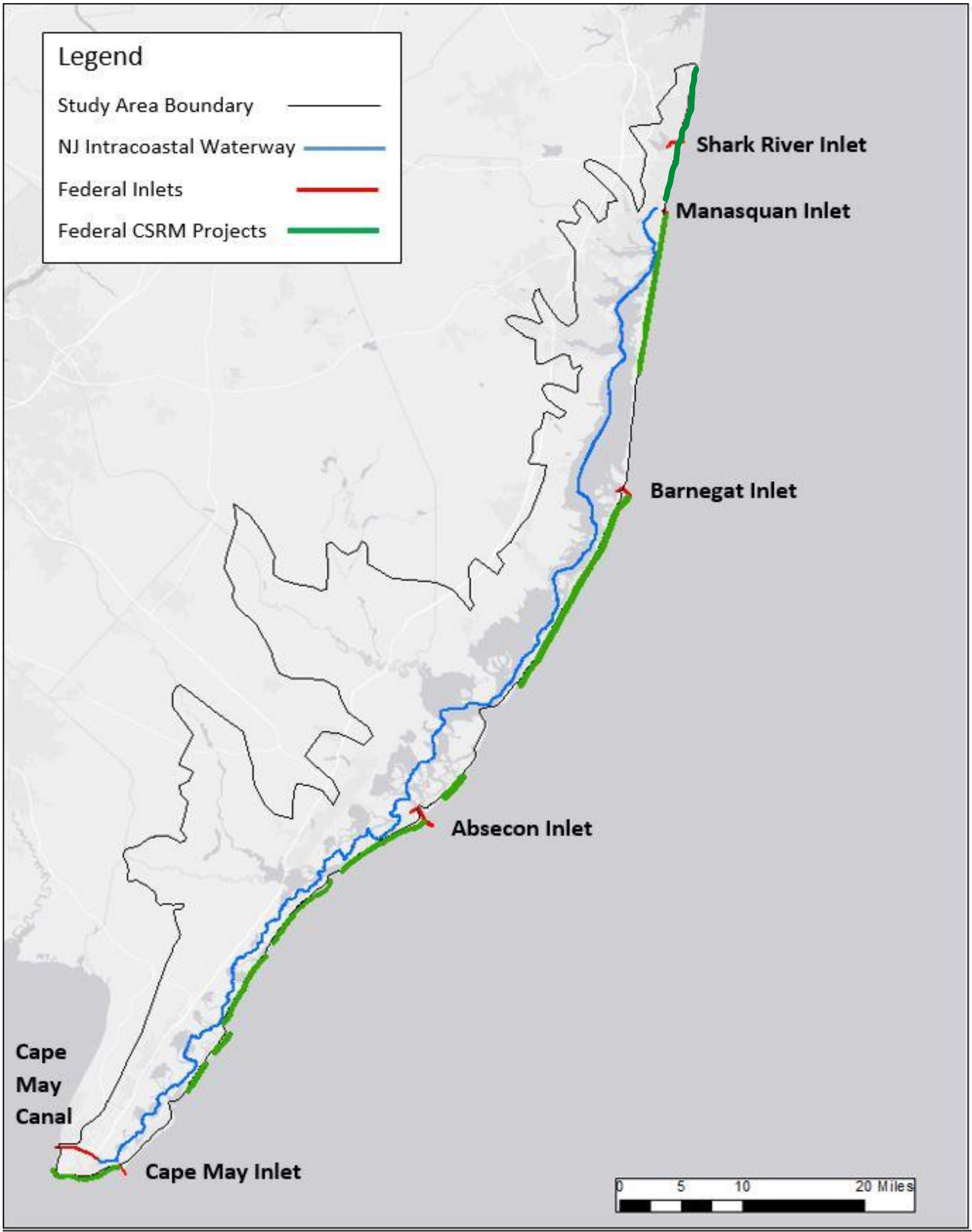


Figure 8: Constructed NJ Intracoastal Waterway, Inlet Navigation and Oceanfront CSRM Projects in the NJBB CSRM Study Area

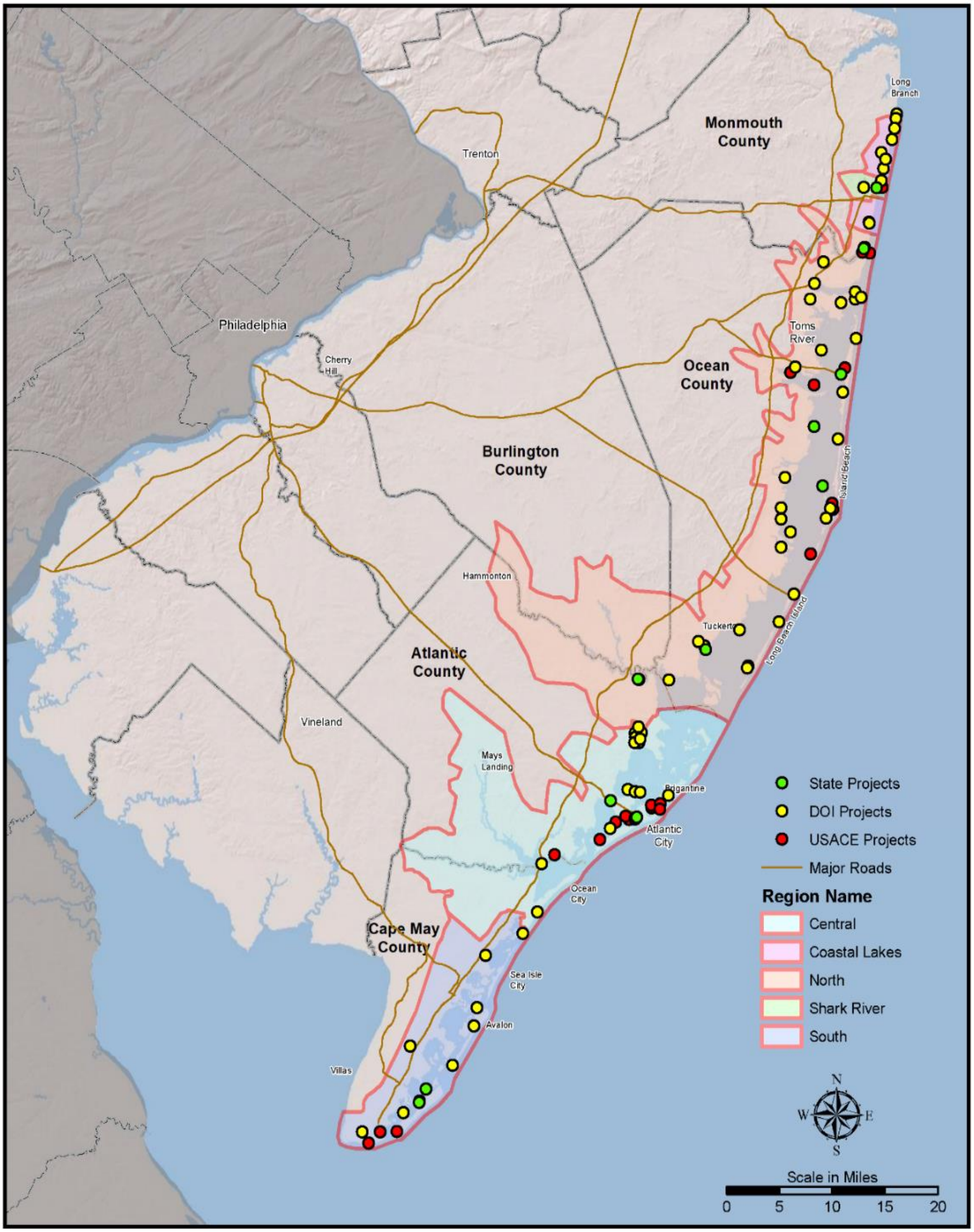


Figure 9: NJBB State, US Department of Interior (DOI), and USACE Projects

4.4 Shoreline Types

Shoreline types within the NJBB CSRM Study area were initially mapped using the NOAA Environmental Sensitivity Index Shoreline Classification (NOAA, undated), which was compiled in the NACCS. This data set includes ten broad shoreline types existing within the entire NACCS study area, from New Hampshire to Virginia. They include rocky shorelines (exposed), rocky shorelines (sheltered), beaches (exposed), manmade structures (exposed), manmade structures (sheltered), scarps (exposed), scarps (sheltered), vegetated high banks (sheltered), vegetated low banks (sheltered), and wetlands/marshes/swamps (sheltered). Each of the shoreline types responds differently to coastal storms, sea level change and adaptive management; therefore, these are important considerations in identifying CSRM management measures.

The most spatially comprehensive and detailed mapping and classification of shoreline types directly applicable to the NJBB CSRM Study area was created by the NJDEP. This data set was subsequently used to map shoreline types in the NJBB CSRM Study Area. The original state-wide dataset was clipped to include only the area within the NJBB CSRM Study area. The total mapped shoreline length within the study area is 3,446 miles and includes 68 classes of shorelines. The 68 classes of shoreline were divided into two broad groups: undeveloped shorelines and developed shorelines, which include 2,729 and 717 miles of shoreline, respectively. The resulting data is summarized in Table 4 and displayed in Figure 10.

Table 4: NJDEP 2012 Shoreline Mapping

Undeveloped Shoreline (UDS)	Miles	% of UDS	% of Total
Saline Marsh	2,521	92	73
Freshwater Wetlands	80	3	2
Forest	32	1	1
Phragmites	80	3	2
Old Field / Agra.	7	<1	<1
Misc.	9	<1	<1
TOTAL UDS	**2,729**	**100**	**79**

Developed Shoreline (DS)	Miles	% of DS	% of Total
Residential	517	72	15
Business/Comm.	34	5	1
Misc. (beach, recreational, lagoon entrances, etc.)	166	23	5
TOTAL DS	**717**	**100**	**21**

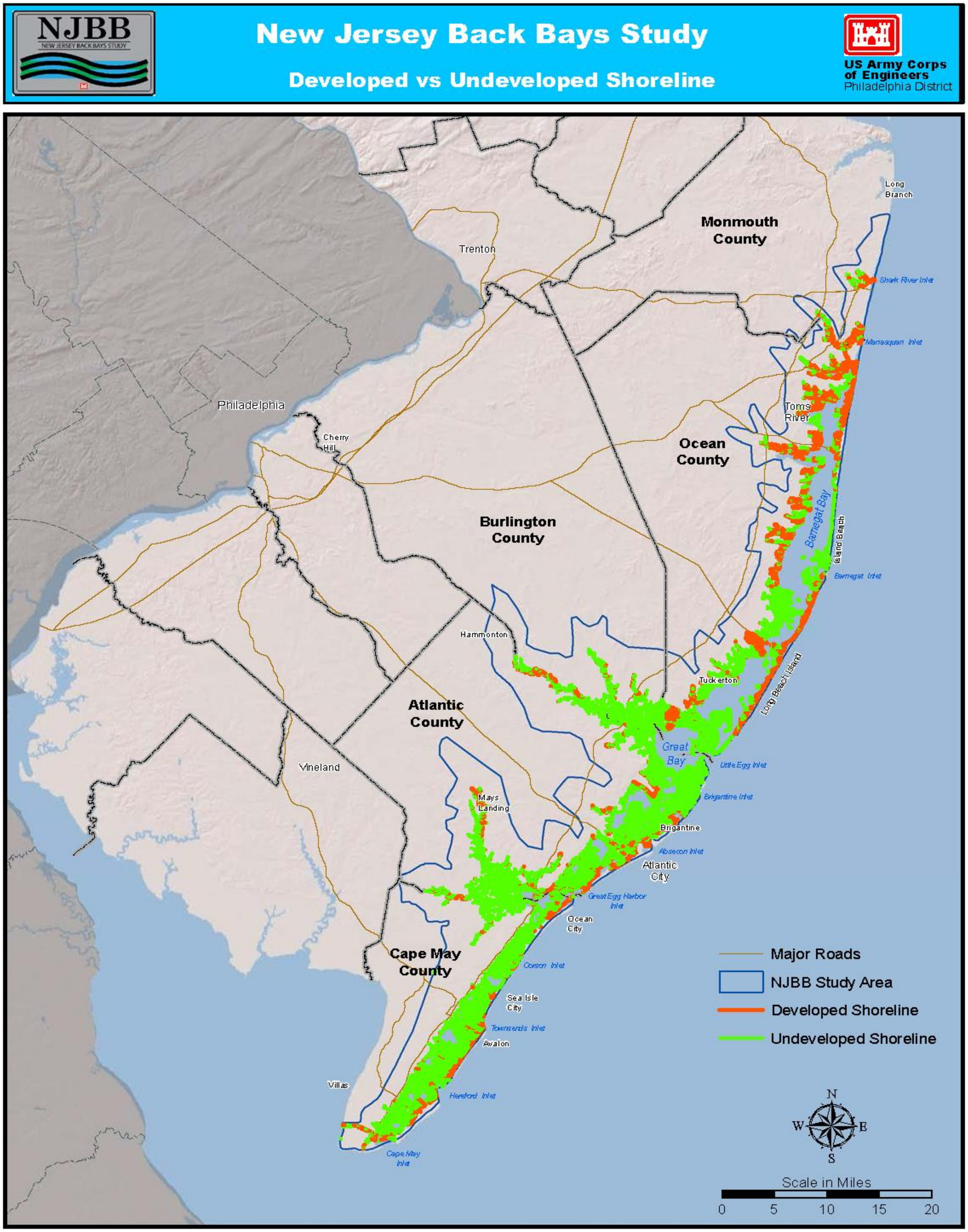


Figure 10: Developed vs. Undeveloped Shoreline

It is important to note that the NJDEP data layer reflects "land use type" only and does not provide additional details such as whether the shoreline in the residential class is bulk headed, for example. It is evident when viewing the data in GIS applications that the majority of the shoreline in the residential class (which includes seven sub-classes) is bulk headed, but there are exceptions to this generalization. Likewise, recreational class (within the Misc. group under, Developed Shoreline), totals 62 miles of NJBB shoreline and is a subjective mix of marinas/docks, open park space, etc.

4.5 Exposure and Impact Analyses

The geographic limits of the NJBB CSRM Study area were established to include the footprint of the FEMA 0.2% Annual Exceedance Probability (AEP) floodplain. In addition, the FEMA 1% AEP floodplain limits were superimposed on the 0.2% AEP floodplain. The FEMA 0.2% and 1% AEP floodplain are regulated by FEMA and the National Flood Insurance Program manages flood insurance using this recurrence probability. Both the 0.2% floodplain (dark blue) and the FEMA 1% AEP floodplain (turquoise) are shown on Figure 11 within the NJBB CSRM Study area.

The NACCS developed a Tier 1 exposure assessment for the entire NAD region to best characterize exposure. Although a many factors or criteria can be used to identify exposure, the NACCS focused on the following categories and criteria:

a. Population Density and Infrastructure: Population density identifies the number of persons per unit area of the study area; infrastructure includes critical infrastructure that supports the population and communities. These factors were combined to reflect overall exposure of the built environment.

b. Social Vulnerability: Social vulnerability includes certain segments of the population that may have more difficulty preparing for and responding to coastal flood events.

c. Environmental and Cultural Resources: The environmental and cultural resources exposure captures important habitat and cultural resources that would be affected by storm surge, winds, and erosion.

Using data developed during the NACCS, a composite exposure index was created that integrates population and infrastructure, social vulnerability, and environmental indices (Figure 12). This index identifies areas of high exposure as indicated by the red colors. In summary, most of the NJBB CSRM Study area is indicated as having high composite exposure. Additional details of the NJBB exposure and vulnerability assessment for additional inundation scenarios to best assess vulnerability to critical infrastructure can be found in the Plan Formulation Appendix.

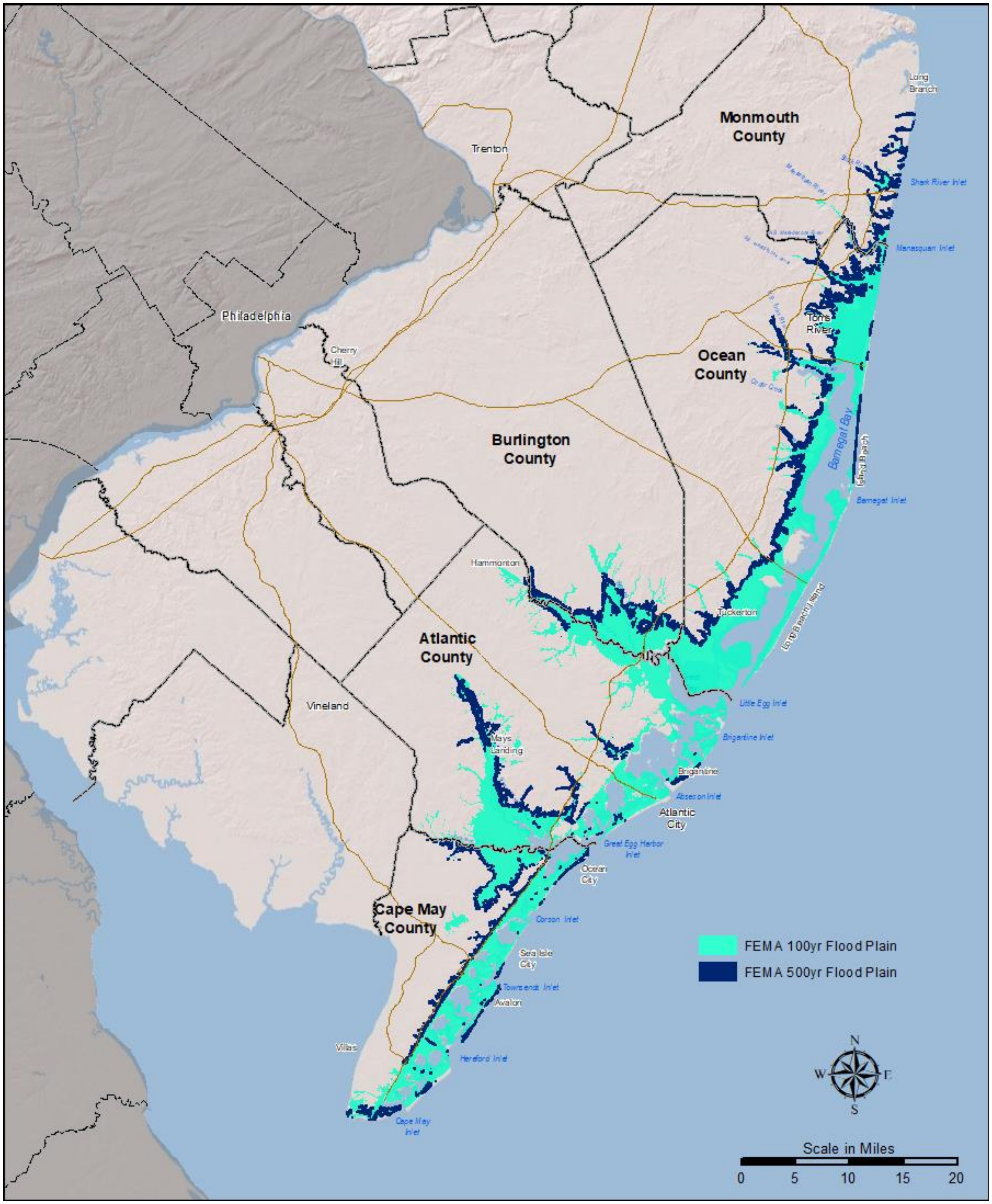


Figure 11: NJBB CSRM Study Area, FEMA 0.2% AEP and 1% AEP Flood Plain

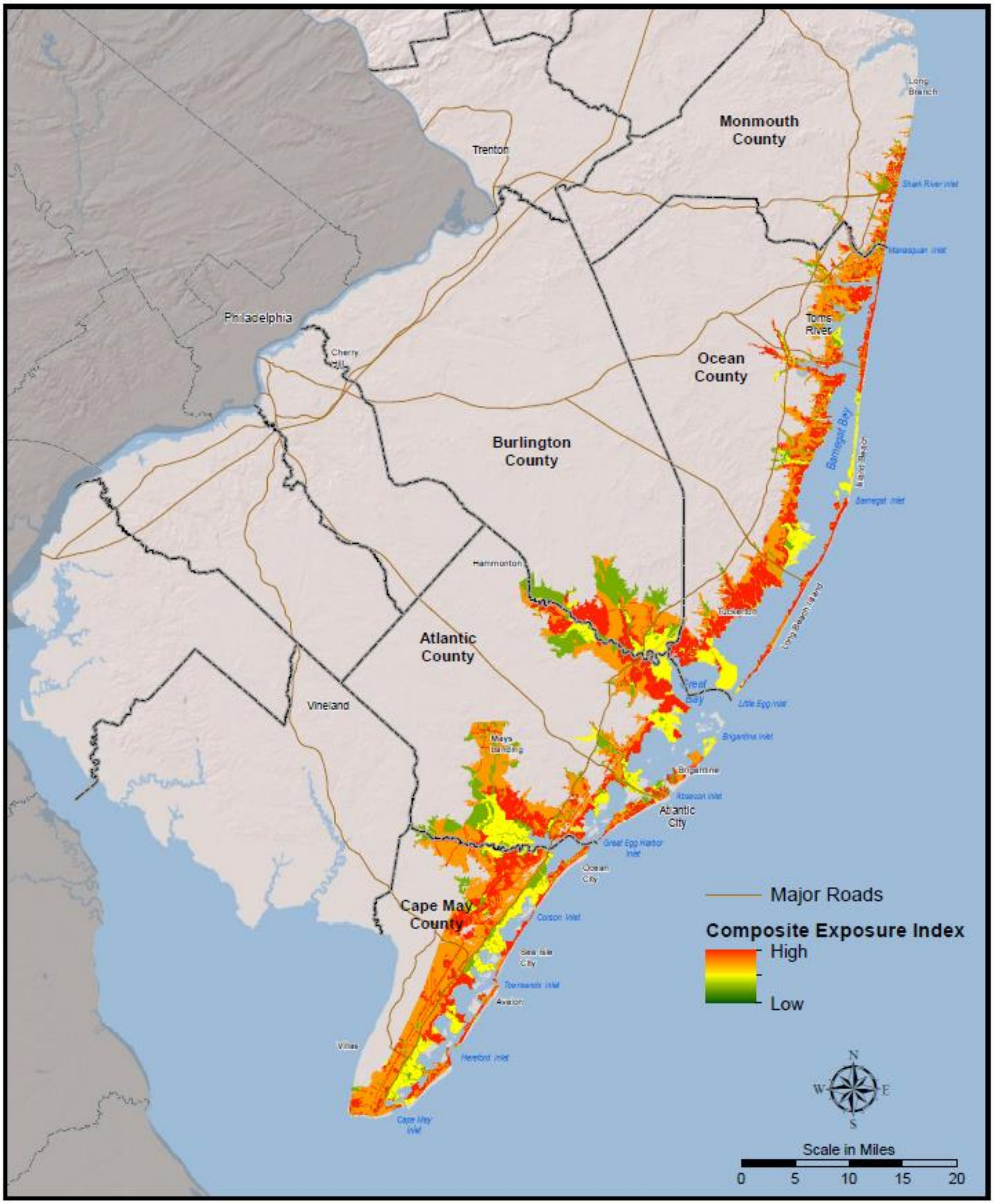


Figure 12: NJBB CSRM Study Area, Composite Exposure Index for the 0.2% AEP Flood Plain

Table 5 presents the top ten municipalities in the NJBB CSRM Study area for several categories of exposure indicators within the footprint of the 0.2% AEP floodplain: population; percentage of municipal population; number of residential structures; and percentage of municipal structures. The light blue highlighting indicates municipalities located within the northern three counties of the NJBB CSRM Study area, and the light orange indicates those municipalities within the southern two counties.

Table 5: Municipalities Affected Within 0.2% AEP Floodplain

Top 10 Municipalities - Ranked by Population Within 500-yr Floodplain	Population Within 500-yr Floodplain	Top 10 Municipalities - Ranked by % of Population Within 500-yr Floodplain
Brick	51,961	Belmar
Dover (Toms River Twp.)	36,116	Point Pleasant Beach
Atlantic City	34,328	Avon-by-the-Sea
Lacey	17,612	West Cape May
Point Pleasant	17,606	Loch Arbour
Little Egg Harbor	17,251	Hammonton
Berkeley	16,566	Bradley Beach
Asbury Park	13,818	Wildwood Crest
Egg Harbor	13,168	Seaside Heights
Middle	13,028	Point Pleasant
Population included in top 10: 231,454 (50% of total)		All 99 to 100 % impacted
Color coding of municipalities		
North = Monmouth, Ocean, & Burlington Counties		
South = Atlantic & Cape May Counties		

Top 10 Municipalities - Ranked by Residential Structures Within 500-yr Floodplain	Residential Structures Within 500-yr Floodplain	Top 10 Municipalities, Ranked by % of Residential Structures Within 500-yr Floodplain
Brick	23,339	Belmar
Dover (Toms River Twp.)	19,084	Point Pleasant Beach
Atlantic City	14,887	Avon-by-the-Sea
Ocean City	13,604	West Cape May
Little Egg Harbor	9,033	Loch Arbour
Berkeley	8,842	Hammonton
Brigantine	8,028	Bradley Beach
Point Pleasant	7,883	Wildwood Crest
Lacey	7,617	Seaside Heights
Asbury Park	7,138	Point Pleasant
Structures included in top 10: 119,455 (42% of total)		All 99 to 100 % impacted

4.6 Economics

The structure inventory indicates that there are approximately 182,930 structures within the NJBB CSRM Study area. The structure inventory was created using a combination of the New Jersey MOD-IV Tax Lists and NJDEP-collected Building Footprint polygons for each of the five counties within the study area. Table 6 outlines the number of structures inventoried by county.

Table 6: Structure Inventory Totals within Project Area

County	Structures
Monmouth County	10,598
Ocean County	81,262
Burlington County	322
Atlantic County	32,825
Cape May County	57,923

Information on the existing economic conditions within the New Jersey Back Bay Study area was collected from the U.S. Census Bureau, FEMA, Bureau of Labor Statistics (BLS), Bureau of Economic Analysis (BEA), New Jersey Department of Labor and Workforce Development, New Jersey MOD-IV Property Tax Records, and County mapping resources.

The structure inventory extent was developed using the NACCS 0.2% AEP Floodplain. Within this study boundary, a detailed structure inventory was developed for all structures residing within the NACCS 0.2% AEP Event Floodplain.

Residential structures comprise the majority of structure type within the study inventory, but non-residential structures (commercial, industrial, public, and academic) have a much higher average value and constitute just under 50% of total structure value.

Table 7 reflects only depreciated replacement structure and content value within the detailed structure inventory and does not account for additional benefit categories such as Infrastructure damages, vehicles damages, emergency costs, or transportation delays.

Table 7: Structure Inventory Summary Information

Structure Count by Type	Value	Percent
Residential	173,845	95.0%
Non-Residential	9,085	5.0%
Total	**182,930**	**100.0%**
Structure Count by County	Value	Percent
Monmouth	10,598	5.8%

Ocean	81,262	44.4%
Burlington	322	0.2%
Atlantic	32,825	17.9%
Cape May	57,923	31.7%
Total	**182,930**	**100.0%**
Structure Value by Type	Value	Percent
Residential	$39,517,404,890	54.7%
Non-Residential	$32,706,835,440	45.3%
Total	**$72,224,240,330**	**100.0%**
Structure Value by County	Value	Percent
Monmouth	$4,357,499,270	6.0%
Ocean	$25,034,178,930	34.7%
Burlington	$99,498,110	0.1%
Atlantic	$20,842,857,680	28.9%
Cape May	$21,890,206,340	30.3%
Total	**$72,224,240,330**	**100.0%**

4.7 Historic Damages

Hurricane Sandy is the largest storm of its kind to strike the East Coast of the United States with $65 billion in damages across 26 states (including 13 states with Major Disaster declarations). Hurricane Sandy also resulted in 159 fatalities, 650,000 homes destroyed or damaged, and years of recovery efforts.

Within the five New Jersey counties included in the New Jersey Back bay Study, 260,958 people and 191,244 structures were exposed to Hurricane Sandy, resulting in 137,309 damaged structures and $4.5 billion in total damages. Table 8 shows the effects of Hurricane Sandy according to the FEMA Modeling Task Force (MOTF) and the NACCS New Jersey State Analysis.

Information on the existing economic conditions and historic damages within the New Jersey Back Bay study area was collected from the U.S. Census Bureau, FEMA, North Atlantic Coast Comprehensive Study (NACCS) and New Jersey MOD-IV Property Tax Records.

Table 8: Historic Damages (Hurricane Sandy) by County

County	Population	Population Exposed	Households Exposed	Structures Damaged	Total Damages ($1000)
Atlantic	274,549	75,537	38,610	21,705	$635,750
Burlington	448,734	11,039	5,898	150	$144,902
Cape May	97,265	34,730	54,516	31,516	$659,828
Monmouth	630,380	45,439	27,538	21,452	$1,137,124
Ocean	576,567	94,213	64,682	62,486	$1,874,934

4.8 Affected Environment and Cultural Resources*

4.8.1 Affected Environment

The Back Bays of New Jersey comprise a vast and rich coastal ecosystem which includes barrier islands; beaches and dunes; salt, brackish, and freshwater marshes; tidal mud flats and maritime forests; rocky shorelines; submerged aquatic vegetation; oyster and rock reefs, shallow bays, and bay islands; terrestrial uplands, flood plains, and riparian zones. These habitats contain a remarkable array of biodiversity and are recognized as an important ecological resource for migratory birds including waterfowl, wading birds, shorebirds, and other species that depend upon these areas during their lifetime. Significant habitats along the coast include coastal wetlands, water bird islands, and Essential Fish Habitat (EFH). The entire study area is part of the Atlantic Flyway which is home to 32 priority bird species.

In general, from an environmental standpoint, habitats will be subject to more stress in the future resulting from human population increases, climate change, sea level change, and other effects.

Additional detail regarding the environment which could be affected by the NJBB CSRM Study can be found in the Environmental and Cultural Resources Appendix (Appendix F).

4.8.2 Land Use

The NJBB CSRM Study area encompasses five coastal counties with a diverse array of land uses that comprises the natural conditions and/or human-modified activities occurring at a particular location. Uses are identified first in general terms such as urban, wetland, agriculture, forest, water, and barren. From there, more specific classifications are derived within each land use category such as residential, commercial, industrial, recreational, forestland, cropland, etc. Further categorization can include density and intensity of land use. Federal and state laws, management plans, and zoning regulations determine the type and extent of land use allowable in specific areas and often intend to protect specially designed or environmentally sensitive areas. Zoning requirements are regulations developed by the local municipality to control potential future development. Comprehensive plans evaluate long-term demographic trends to identify how the region of analysis should be developed. Where zoning focuses on immediate trends in development, comprehensive plans are generally less regulatory in nature and often serve as guidance when current planning department is evaluating applications for development.

With the exception of public lands, the beach communities along the coast including headland and barrier islands contain the most intense development in the upland areas consisting of residential (seasonal) homes, commercial – tourist oriented (amusement areas, marinas, and various smaller attractions and facilities), and some light industrial uses such as fishing related industry. In the coastal barrier complex areas, the mainland areas are generally separated by vast wetlands and open water bays. The mainland communities also include dense residential, commercial development, transportation, utilities services and some sporadic industrial development. Other land uses inland include woodland, farmland, and freshwater and tidal wetlands. Monmouth County is the northernmost county within the study area, which includes the beaches and coastal waters north of Manasquan Inlet, Shark River Inlet, and the Coastal Lakes Region of the study area. The Monmouth County Master Plan (Monmouth County Division of Planning, 2016) tracked land use changes between 1986 and 2012, and determined that the largest land use change was attributed to a growth in residential uses of 6.7% within that time period, which also saw a net decrease of 6.4% in agricultural land uses. Similar trends where urban lands (residential and commercial) saw net increases and agricultural lands saw net decreases were noted in Ocean County, Atlantic County and Cape May County. Ocean County experienced a 7.8% loss of farmland and a 7.7% gain in urban land from 2002 to 2007 (Ocean County Planning Board, 2011), and Atlantic County likewise lost 6.4% of agricultural land and 42.6% of barren land with a net gain of 14% of urban land from 2002 to 2012 (Heyer, Gruel & Associates, 2018). Recognizing the importance of farmlands and open space, all of the county comprehensive plans include goals to preserve farmlands and to acquire more open space for the communities.

New Jersey is a home rule state which means that much of the land use decisions are governed at the local municipal level.

4.8.2.1 Protected Lands

4.8.2.1.1 NJ State Coastal Zone

The entire study area falls within New Jersey's coastal zone, which is defined in N.J.A.C. 7:7-1.2(b) as including the CAFRA area, coastal waters, certain lands outside the CAFRA area, tidal wetlands, and the Hackensack Meadowlands District. These terms are more fully defined at N.J.A.C. 7:7-1.2(b). NJDEP's rules regarding the use and development of coastal resources are set forth in N.J.A.C. 7:7, Coastal Zone Management Rules. Among other things, these rules are also used by NJDEP in the review of water quality certificates subject to Section 401 of the Federal Clean Water Act, 33 U.S.C. § 1341, and Federal consistency determinations under Section 307 of the Federal Coastal Zone Management Act, 16 U.S.C. § 1456 and sets forth rules for the NJDEP regarding the use and development of coastal resources that are reviewed by the Land Use Regulation Program in reviewing permit applications under the Coastal Area Facility Review Act (CAFRA), N.J.S.A. 13:19-1 et seq. (as amended 2016), Wetlands Act of 1970, N.J.S.A. 13:9A-1 et seq., Waterfront Development Law, N.J.S.A. 12:5-3, Water Quality Certification (401 of the Federal Clean Water Act), and Federal Consistency Determinations (307 of the Federal Coastal Zone Management Act).

4.8.2.1.2 Coastal Barrier Resources Act Areas

The Coastal Barrier Resources Act (CBRA) of 1982 is intended to protect fish and wildlife resources and habitat, prevent loss of human life, and restrict the expenditure of Federal funds that may induce development on coastal barrier islands and adjacent nearshore areas. The CBRA established the Coastal Barrier Resources System (CBRS), which consists of mapping of those undeveloped coastal barrier islands and other areas located on the coasts of the U.S. that were made ineligible for most Federal expenditures and financial assistance. Otherwise, protected areas (OPAs) are a separate designation where the only Federal funding prohibition is Federal flood insurance. Other restrictions to Federal funding that apply to CBRS units do not apply to OPA's. Within the NJBB CSRM Study area, there are two existing CBRS units in Barnegat Bay, one CBRS unit located at Hereford Inlet and seven OPAs located throughout the study area (Table 9). Additionally, the US Fish and Wildlife Service prepared "Draft Revised" CBRS maps, which include a number of proposed changes to existing CBRS units and OPAs within the NJBB CSRM Study area; however, these changes require Congressional authorization. Maps of the existing CBRA areas and "Draft Revised" areas are presented in the Environmental and Cultural Resources Appendix F.1.

Table 9: CBRS Units and OPAs in NJBB CSRM Study Area

ID	Location	CBRS Unit	OPA
NJ-04B*	Metedeconk Neck/Barnegat Bay west of Mantoloking	X	
NJ-04BPꜝ	Edwin B. Forsythe NWR on Metedeconk Neck/Barnegat Bay west of Mantoloking		X
NJ-05P*	Island Beach State Park/Barnegat Bay & Inlet		X
NJ-06*	Cedar Bonnet Island west of Ship Bottom/S. of Rt. 72	X	
NJ-06Pꜝ	Cedar Bonnet Island west of Ship Bottom/S. of Rt. 72 and Egg Island		X
NJ-07P*	Edwin B. Forsythe NWR and Little Egg Harbor Inlet		X
NJ-19P**	Great Egg Harbor Inlet		X
NJ-08P*	Corson Inlet/Corson Inlet State Park, Strathmere Natural Area and west.		X
NJ-08**	West of Corson Inlet and Strathmere	X	
NJ-09*	Hereford Inlet/Stone Harbor Point/North Wildwood and west.	X	
NJ-09Pꜝ	West of Hereford Inlet		X
NJ-10P*	Lower Cape May Meadows – Atlantic Coast		X
NJ-11P*	Cape May Canal (Delaware Bay)		X

*Includes changes in boundary designations in "Draft Revised" maps
ꜝ Includes changes in designation from an OPA to a System Unit in "Draft Revised" maps
** Is a new designated CBRS unit or OPA in "Draft Revised" maps

4.8.2.1.3 National Wildlife Refuges

The largest and most significant protected lands in the study area include E.B. Forsythe National Wildlife Refuge and Cape May National Wildlife Refuge. The E.B. Forsythe National Wildlife Refuge, which is divided into the Brigantine Division and the Barnegat Division, encompasses approximately 47,000 acres distributed in a patchwork along more than 50 miles of the coast in Atlantic, Burlington, and Ocean Counties. Approximately 82 percent of the refuge consists of wetlands, of which 78 percent is saltmarsh interspersed with shallow coves and bays. The wetlands include three large impoundments of freshwater and brackish marsh habitat totaling approximately 1,490 acres. The impoundments allow intensive water level management to enhance the habitat value for waterfowl, shorebirds, and wading birds. The remaining 18 percent of the refuge is upland, of which approximately 5,000 acres are forested, and 2,000 acres are a mix of grasslands, beaches, and dunes. The refuge includes two undeveloped barrier island beaches - the Holgate Unit(which consists of the lower 3.5-mile end of Long Beach Island), and Little Beach Island. Little Beach Island is an important nesting area for the federally threatened piping plover with 23 nesting pairs using the area in 2013. Both of these coastal barrier areas, along with a pristine section of saltmarsh on the west side of Great Bay, have been designated a National Wilderness Area.

The Cape May National Wildlife Refuge encompasses approximately 11,800 acres within the Cape May Peninsula. It is divided into three main divisions - the Great Cedar Swamp Division, the Delaware Bay Division, and the Two-Mile Beach Unit. The Great Cedar Swamp Division includes approximately 6,000 acres of primarily moist woodlands and thickets located in the Peninsula's interior. This Division receives limited tidal flow on the north end from Great Egg Harbor and on the south end from Dennis Creek. The Delaware Bay Division includes approximately 5,000 acres of mixed wooded uplands, tidal marsh, and beach habitat that extends for 5 miles along the Delaware Bay shoreline. The Two-Mile Beach Unit consists of approximately 800 acres bordering a 0.7-mile long section of ocean fronting beach just north of the Cape May Inlet.

The Two-Mile Beach Unit is important to shorebirds which stop here in large numbers during their spring and fall migrations. In addition to the abundant shorebirds, the Cape May Peninsula's configuration and strategic location act to concentrate large numbers of songbirds, raptors, and woodcock as these birds funnel down to Cape May Point during the fall migration.

4.8.2.1.4 Parks and Wildlife Management Areas

Other protected areas within the study area include Corson's Inlet State Park, Cape May Point State Park, The Nature Conservancy's South Cape May Meadows Nature Preserve, Island Beach State Park, Barnegat State Park, Great Bay Boulevard State Wildlife Management Area, Manahawkin Wildlife Management Area, and numerous county and municipal parklands.

4.8.2.1.5 State Natural Areas

There are several state natural areas designated under N.J.A.C. 7:5A within the NJBB CSRM Study Area. Natural Areas receive an exceptional degree of protection. Lands in the Natural Areas system may not be sold, leased, or exchanged, or altered in any way without the approval of the NJDEP. When an area becomes part of the Natural Areas System, the NJDEP is required to develop and adopt a comprehensive management plan to ensure the continued protection of the ecosystems and species found within the area. The Natural Areas Council, a seven-member board appointed by the governor, advises the Commissioner on all matters relating to the System. The Natural Areas System Rules at N.J.A.C. 7:5A provide detailed procedures for classification and designation of natural areas, development of management plans, allowable uses and practices, procedures for conducting research and scientific activities, and revising boundaries (https://www.state.nj.us/dep/parksandforests/natural /natareas.html accessed on 1/2/2019). State Natural Areas within the NJBB CSRM Study Area are presented in Table 10.

Table 10: State Natural Areas within NJBB CSRM Study Area

Natural Area	Location	Management	Classification	Agency
Cape May Point Natural Area	Cape May Point State Park, Cape May Point Borough and Lower Township (Cape May County)	Preservation of freshwater marsh behind a coastal dune, habitat diversity for migratory birds, and rare species habitat.	Conservation Preserve	Division of Parks and Forestry – Cape May Point State Park
Cape May Wetlands Natural Area	Avalon Borough, Dennis, and Middle Townships (Cape May County)	Preservation of tidal salt marsh ecosystem and rare species habitat	Ecological Reserve	NJDEP DFW – Cape May Coastal Wetlands Wildlife Management Area
Strathmere Natural Area	Corson's Inlet State Park, Upper Twp. (Cape May County)	Preservation of a dune habitat, plant community associations, and rare species habitat.	Conservation Preserve	Division of Parks and Forestry – Belleplain State Forest
North Brigantine Natural Area	City of Brigantine (Atlantic County)	Preservation of saltmarsh habitat, coastal dune, and rare species habitat.	Conservation Preserve	Division of Parks and Forestry – Bass River State Forest
Great Bay Natural Area	Little Egg Harbor Township (Ocean County)	Preservation of tidal salt marsh ecosystem and rare species habitat	Ecological Reserve	NJDEP DFW – Assunpink Wildlife Management Area
Manahawkin Natural Area	Manahawkin Wildlife Management Area, Stafford Twp. (Ocean County)	Preservation of mature bottomland hardwood forest, and rare species habitat.	Ecological Reserve	NJDEP DFW – Assunpink Wildlife Management Area
Island Beach Northern and Southern Natural Areas	Island Beach State Park (IBSP), Ocean and Berkeley Twp. (Ocean County)	Preservation of barrier island dune system, saltwater marsh, freshwater bogs, and rare species habitat.	Conservation Preserve	Division of Parks and Forestry – IBSP.
Swan Point Natural Area	Brick Twp. (Ocean County)	Preservation of tidal salt marsh ecosystem and Atlantic white cedar swamp.	Ecological Reserve	Division of Parks and Forestry – Island Beach State Park

4.8.2.1.6 National Reserves

New Jersey Pinelands

Portions of the NJBB CSRM Study area fall within the Federal Pinelands National Reserve (PNR), which was created by the National Parks and Recreation Act of 1978. The PNR consists of approximately 1.1 million acres within seven counties in New Jersey, and occupies 22% of New Jersey's total land area. The reserve is a United States Biosphere Reserve and is home to dozens of rare plant and animal species and the Kirkwood-Cohansey aquifer system, which contains an estimated 17 trillion gallons of water. Under this act, the Federal government formed a partnership with the State of New Jersey to form the Pinelands Commission (PC), as an independent agency, whose mission is to "preserve, protect and enhance the natural and cultural resources of the Pinelands National Reserve, and to encourage compatible economic and other human activities consistent with that purpose". The PC implements a Comprehensive Management Plan (CMP) that guides land use, development, and natural resource protection programs in a 938,000-acre "Pinelands Area" of southern New Jersey. This results in two separate, but mostly overlapping boundaries between the Federal PNR and the state "Pinelands Area" (Figure 13). The Federal PNR includes land east of the Garden State Parkway (including portions of the NJBB CSRM Study area) and to the south bordering Delaware Bay, which is omitted from the state Pinelands Area (https://www.nj.gov/pinelands/reserve/; https://www.nps.gov/pine/index.htm; and https://www.nj.gov/pinelands/about/ accessed on 12/31/2018). In Cape May County, the PNR boundary (blue line in Figure 13) is on the western side of the NJBB CSRM Study area along the Garden State Parkway where the boundary turns further west at the Great Egg Harbor Bay along western Somers Point. Large portions of the NJBB CSRM Study area are included within the PNR from north of Absecon Bay and the western side of Brigantine north through Little Egg Harbor Inlet, Little Egg Harbor, large portions of Barnegat Bay, Barnegat Inlet, and Island Beach State Park. The Pinelands Area (green line on Figure 13) that is governed by the Pinelands CMP and under the jurisdiction of the Pinelands Commission is outside of the NJBB CSRM Study area.

Jacques Cousteau National Estuarine Research Reserve

The Jacques Cousteau National Estuarine Research Reserve (JC NERR) is part of the National Estuarine Research Reserve System (NERRS) developed to protect the biologically, ecologically, economically, and aesthetically important estuarine areas along the coasts. It is one of the two national estuarine reserves created to promote the responsible use and management of the nation's estuaries through a program combining scientific research, education, and stewardship. The JC NERR encompasses approximately 116,000 acres in southeastern New Jersey, including a great variety of terrestrial, wetland and aquatic habitats within the Mullica River-Great Bay ecosystem (retrieved from https://jcnerr.org/about.html on 1/25/2019).

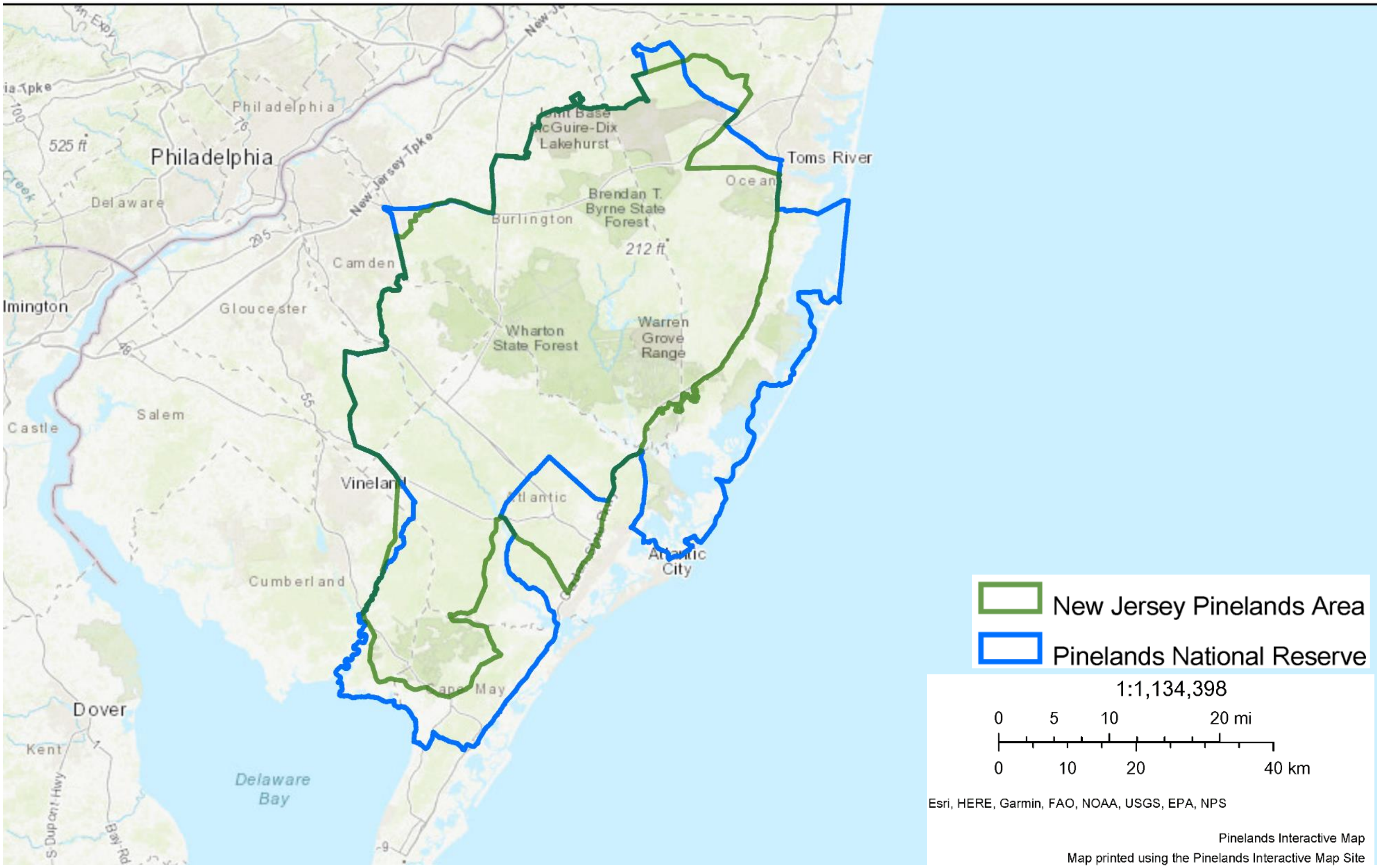


Figure 13: New Jersey Pinelands Map

4.8.2.1.7 Wild and Scenic Rivers

The National Wild and Scenic Rivers System was created by Congress in 1968 to preserve certain rivers with outstanding natural, cultural, and recreational values in a free-flowing condition for the enjoyment of present and future generations. The Act is notable for safeguarding the special character of these rivers, while also recognizing the potential for their appropriate use and development. It encourages river management that crosses political boundaries and promotes public participation in developing goals for river protection. The Great Egg Harbor River, was designated as a Wild and Scenic River on October 27, 1992, is located within the NJBB CSRM Study area. In the NJBB CSRM Study area, Wild and Scenic River status of the Great Egg Harbor River and tributaries are generally west of the Garden State Parkway. Key drainages that are part of the system include Patcong Creek and the Tuckahoe River near the confluence west of the Garden State Parkway (see Appendix F.11).

4.8.2.1.8 National Estuary Program

The Barnegat Bay Partnership (BBP), which comprises federal, state, and local government agencies, academic institutions, nongovernmental organizations, and businesses working together to restore and protect the Bay. The BBP recently revised its Comprehensive Conservation and Management Plan for Barnegat Bay-Little Egg Harbor Estuary (January 2021) which identifies the following goals:

- Water Quality – To protect and improve water quality throughout Barnegat Bay and its watershed by reducing the causes of water quality degradation to achieve swimmable, fishable, and drinkable water, and to support aquatic life.
- Water Supply – To ensure adequate water supplies and flow in the Barnegat Bay watershed for ecological and human communities now and in the future.
- Living Resources – To protect, restore, and enhance habitats in the Barnegat Bay and its watershed as well as ensure healthy and sustainable natural communities of plants and animals both now and in the future.
- Land Use – To improve and sustain collaborative regional approaches to responsible land use planning and open space preservation in the watershed that protect and improve soil function(s), water quality, water supply, and living resources.

4.8.2.1.9 Sedge Islands Marine Conservation Zone

A marine conservation zone was approved by the New Jersey Tidelands Resource Council to manage the submerged lands within the Sedge Islands estuarine complex within Barnegat Bay and Island Beach State Park, which is a sensitive marine habitat that is critical for the health of the bay and its resources. This conservation zone was designated to reduce the environmental impacts of personal watercraft and to better manage wildlife, recreation and traditional uses of the area.

4.8.3 Floodplains

Through Executive Order (EO) 11988, Federal agencies are required to evaluate all proposed actions within the 1% annual exceedance probability (AEP)(100-year) floodplain. Actions include any Federal activity involving 1) acquiring, managing, and disposing of Federal land and facilities, 2) providing Federally undertaken, financed, or assisted construction and improvements, and 3) conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, and licensing activities. In addition, the 0.2% AEP (500-year) floodplain should be evaluated for critical actions or facilities, such as storage of hazardous materials or construction of a hospital. The EO provides an eight-step process to evaluate activities in the floodplain that generally includes 1) determine if the proposed action is in the floodplain, 2) provide public review, 3) identify and evaluate practicable alternatives to locating in the 1% AEP floodplain, 4) identify the impacts of the proposed action, 5) minimize threats to life and property and to natural and beneficial floodplain values and restore and preserve natural and beneficial floodplain values, 6) reevaluate alternatives, 7) issue findings and a public explanation, and 8) implement the action. Proposed actions may have limited impacts such that the eight-step process may vary or be reduced in application, which is the case for this project.

FEMA defined Flood Zones are predominantly high-risk areas, designated by Zone AE, along the inland side of the barrier islands and the upland side of the bays. Base Flood Elevations associated with the AE Zones generally range from about 5 to 12 ft. NAVD88. There are several high-risk coastal areas that carry an additional hazard associated with storm waves, designated by Zone VE, which vary greatly in location and severity. Base Flood Elevations associated with the VE Zones generally range from 9 to 16 ft. NAVD88 but go as high as 29 ft. NAVD88.

More frequent flood events were analyzed for structure counts due to the high number of structures in the study area. There are approximately 31,000 structures below the elevation of the 5% AEP flood event as defined by the NACCS. For the 10% AEP and 20% AEP flood events, the number of structures is about 17,000 and 8,000 respectively.

Land elevations vary greatly throughout the study area. Generally, developed areas in the southern portion of the project area are on lands below 20-ft NAVD88. In these areas, the inland side of the barrier islands is generally at or below about 10-ft NAVD88 and the upland side of the bay is generally at or below about 20-ft NAVD88. The same is generally true in the northern portion of the project area, but there are more developed lands in the 20 to 30-ft NAVD88 range.

In the study area, there are approximately 183,000 structures with over $90 billion in damageable assets, critical infrastructure, and utilities. These structures are located in 84 separate municipalities across five counties. Of the total structures, approximately 95% are classified as residential structures. The other 5% are classified as non-high rise commercial, industrial, or public facilities.

4.8.4 Geology and Soils

4.8.4.1 Geomorphology

The study area is situated along the New Jersey coast, which is located within the New Jersey section of the Coastal Plain Physiographic Province of Eastern North America. In New Jersey, the Coastal Plain Province extends from the southern terminus of the Piedmont Physiographic Province southeastward for approximately 155 miles to the edge of the Continental Shelf. The boundary between the rock units of the Piedmont and unconsolidated sediments of the Coastal Plain Physiographic Provinces is known as the Fall Line, which extends southwest across the state from Perth Amboy through Princeton Junction to Trenton. It is termed the Fall Line due to its linearity and the distinct elevation change that occurs across this border between the more rugged, generally higher rock terrain of the Piedmont and generally lower terrain of the soil materials comprising the Coastal Plain. The locations of the Physiographic Provinces in New Jersey and Fall Line are shown on Figure 14.

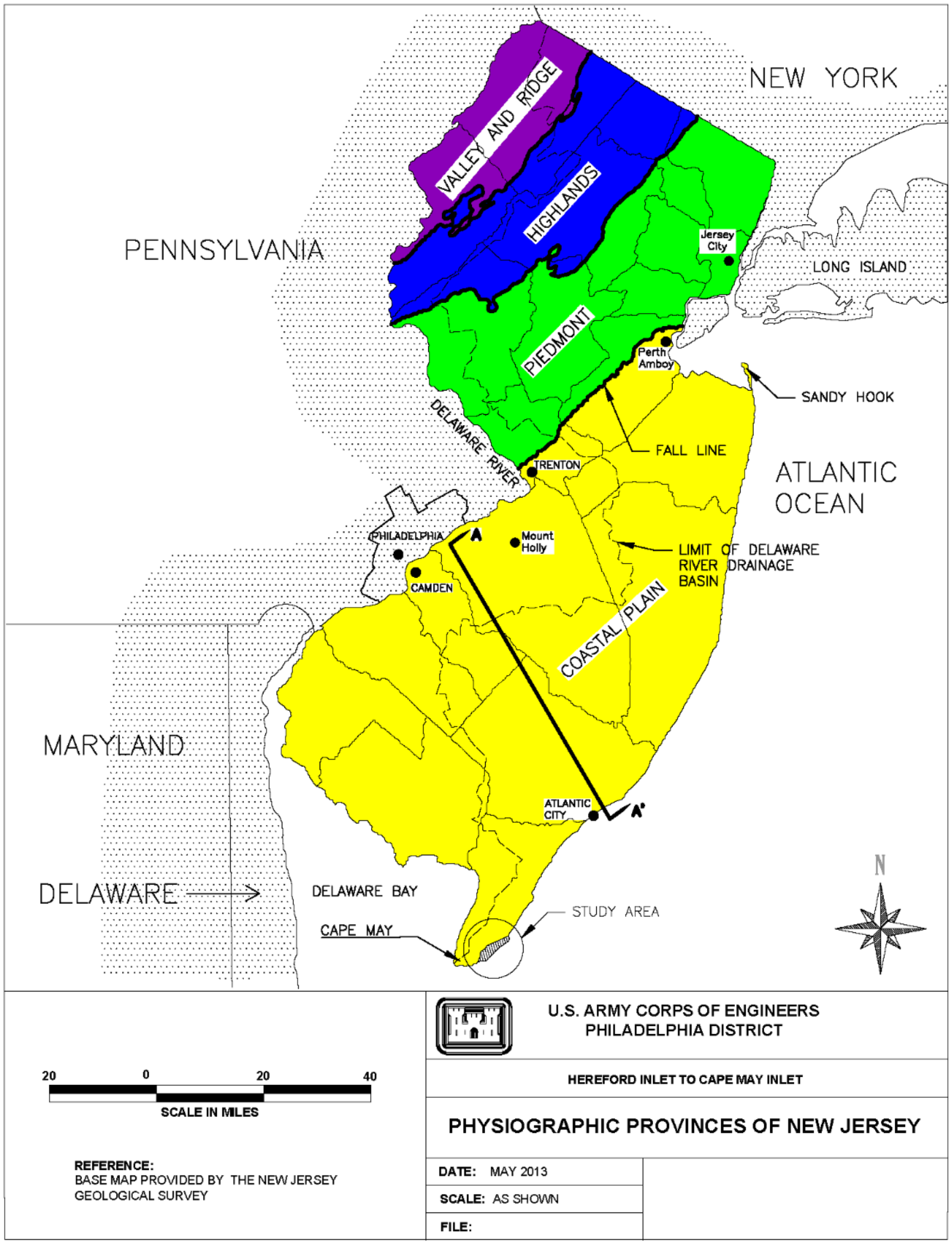


Figure 14: Physiographic Provinces of New Jersey

The Coastal Plain Province, lying southeast of the Fall Line, is part of the Atlantic Coastal Plain that extends along the entire eastern Atlantic Ocean coastline from Newfoundland to Florida. The Coastal Plain is the largest physiographic province in the state and covers approximately sixty percent of the surface area of New Jersey. This province encompasses an area of approximately 4,667 square miles, almost 3 million acres. More than half of the land area in the Coastal Plain is below an elevation of 50 feet above sea level (NGVD). The terrestrial portion of the Coastal Plain Province is bounded on the west and southwest by the Delaware River and Delaware Bay, on the north by the Fall Line and on the northeast by the Raritan Bay and Staten Island. The remaining portions of the Coastal Plain Province in New Jersey are bordered by the Atlantic Ocean. The Atlantic Coastal Plain has been further differentiated into the Inner and Outer Coastal Plain regions. The Inner Coastal Plain consists of lowlands and rolling hills underlain by Cretaceous deposits and is border to the north by the Piedmont Province. The Outer Coastal Plain is a region of low altitude where low-relief terraces are bounded by subtle erosional scarps, and consists of the unconsolidated Tertiary deposits of sand, silt, and gravels. The eastern boundary of the Coastal Plain includes many barrier bars, bays, estuaries, marshes, and meadowlands along the Atlantic coast extending from Sandy Hook in the north to Cape May Point at the southern tip of New Jersey.

4.8.4.2 Physiography

The New Jersey shoreline, which is included in the Coastal Lowlands can be divided into those sections where the sea meets the mainland (at the northern and extreme southern ends of the State) and where the sea meets the barrier islands (in the central to southern portion of the State). The Coastal Lowlands include as many as three scarp-bounded terraces, which are underlain by marine and estuarine deposits. The outer margin of the terraces is surrounded by the tidal marshes, bays, and the barrier islands. The barrier islands extend from Bay Head, down the coast for approximately 90 miles, to just north of Cape May Inlet and are generally continuous, except for the interruption by 10 inlets.

4.8.4.3 Barrier Islands

The New Jersey barrier islands, which include the study area, belong to a landform susceptible to comparatively rapid changes. The barrier islands range in width from around 1000 feet to 5,000 feet. Landward of the barrier beaches and inlets along the barrier islands are tidal bays, which range from 1 to 4 miles in width. These bays have been filled by natural processes until much of their area has been covered with tidal marshes. The remaining water area landward of the barrier islands consists of smaller bays connected by water courses called thorofares. Four geologic processes are considered to be responsible for the detritus (or loose material) in the bay area: (1) stream sedimentation, which contributes a small amount of upland material; (2) waves washing over the barrier islands during storms; (3) direct wind action blowing beach and dune sand into the lagoon; and (4) the work of tidal currents, which normally bring in more sediments in suspension from the ocean on flood tide than they remove on ebb tide. The vegetation of the lagoons, both in marshland and bays, serves to trap, and retain the sediments.

4.8.4.4 Drainage of the Coastal Plain

The land surface in the Coastal Plain of New Jersey is divided into drainage basins, based on the area that contributes runoff to streams and their tributaries in a particular region. A drainage divide marks the topographic boundary between adjacent drainage basins. A major drainage divide in the Coastal Plain separates streams flowing to the Delaware River on the west and to the Atlantic Ocean on the east and southeast.

The surficial drainage system of the New Jersey Coastal Plain was developed at a time when sea level was lower than at present. The subsequent rise in sea level has drowned the mouth of coastal streams where tidal action takes place. This tidal effect extends up the Delaware River to Trenton, New Jersey, a distance of 139 miles. The formation of the barrier islands removed all direct stream connection with the ocean between Barnegat Bay and Cape May Inlet. These streams now flow into the lagoons formed in the back of these barrier beaches and their waters reach the Atlantic Ocean by way of the thorofares and inlets, discussed above. The significance of these features to the drainage system in the study area is that the Coastal Plain streams, whose upper courses carry little sediment, lose that little sediment in their estuaries, and in the lagoons, and supply virtually no beach nourishment to the ocean front areas.

The material present within the coastal lagoons and tidal marshes consists primarily of alluvium, and salt-marsh deposits. The alluvium, which was deposited was derived from weathered upland soils of the Bridgeton and Cohansey Formations, consists of gray and brown sand, silt, pebble gravel, cobbles, minor peat, and shells. The salt-marsh deposits, which are comprised of organic muck and peat, silt clay and sand. Black, brown, and gray organic muck includes remains of salt-tolerant grasses. Silt and sand occur as deposits along tidal creek margins. These salt-marsh deposits were deposited largely as suspended sediment in turbid bays or rivers during high tides.

4.8.4.5 Regional Geology

The New Jersey Coastal Plain Physiographic Province consists of sedimentary formations overlying crystalline bedrock known as the "basement complex." From well drilling logs, it is known that the basement surface slopes at about 155 feet per mile to a depth of more than 5,000 to 6,000 feet near the coast. Geophysical investigations have corroborated well-log findings and have permitted determination of the profile seaward to the edge of the continental shelf. A short distance offshore, the basement surface drops abruptly but rises again gradually near the edge of the continental shelf. Overlying the basement are semi-consolidated sedimentary formations of Lower to Middle Cretaceous sediments. The beds vary greatly in thickness, increasing seaward to a maximum thickness of 2.5 miles then decreasing to 1.5 miles near the edge of the continental shelf. On top of the semi-consolidated beds lie unconsolidated sediments of Upper Cretaceous and Tertiary formations. These sediments range from relatively thin beds along the northwestern margin at the Fall Line, to around 4,500 feet beneath Atlantic City to over 40,000 feet in the area of the Baltimore Canyon Trough located around 50 miles offshore of Atlantic City.

Based on information provided by the New Jersey Geological Survey (NJGS) and United States Geological Survey (USGS), the wedge-shaped mass of unconsolidated sediments that comprise the New Jersey Coastal Plain discussed above are composed of sand, gravel, silt, and clay. The wedge thins to a featheredge along the Fall Line and attains a thickness of over 6,500 feet in the southern part of Cape May County, New Jersey. The system is comprised of relatively highly permeable sand and gravel layers separated by semi-permeable to impermeable silt and clay interlayers that form confining layers and restrict the vertical flow of groundwater. These sediments range in age from Cretaceous to Upper Tertiary (i.e., Miocene - 144 to 5 Ma) (Ma = mega annum = million years ago), and can be classified as continental, coastal or marine deposits. The Cretaceous and Tertiary age sediments generally strike on a northeast-southwest direction and dip gently to the southeast from ten to sixty feet per mile. The Coastal Plain is mantled by discontinuous deposits of Late Tertiary to Quaternary (geologically recent) sediments, which, where present are basically flat lying. The unconsolidated Coastal Plain deposits are unconformably underlain by a Pre-Cretaceous crystalline basement bedrock complex, which consists primarily of Precambrian and early Paleozoic age (>540 Ma to 400 Ma) rocks. Locally, along the Fall Line in Mercer and Middlesex Counties, Triassic age (circa 225 Ma) rocks overlie the crystalline basement rocks and underlie the unconsolidated sediments.

4.8.4.6 Surficial Geology

As indicated above, the Coastal Plain of New Jersey consists of beds of gravel, sand, silt, and clay, which dip gently towards the southeast. Fossil evidence indicates that these sediments range from the Cretaceous to Quaternary Period, with some more recent glacial period Quaternary sediments mantling the surface. The older and lower layers outcrop at the surface along the northwest margin of the Coastal Plain and pass beneath successively younger strata in the direction of their dip. Since the formations dip toward the southeast, this results in a series of successive generally parallel outcrops with a northeast-southwest strike, with successively younger layers outcropping at the surface towards the southeast and progressing southward along the shore.

The sea successfully advanced and retreated across the 155-mile width of the Coastal Plain during the Cretaceous through Quaternary Periods (144 Ma to present). Many sedimentary formations were deposited, exposed to erosion, submerged again, and buried by younger sediments. The types of sorting, the stratification, and the fossil types in the deposits indicate that deposition took place offshore as well as in lagoons and estuaries, and on beaches and bars. Considerable changes in sea level continued to take place during Pleistocene time. Glacial periods brought a lowering in sea level as water was locked up in the large terrestrial ice masses. As the sea level fell to a beach line thousands of feet seaward of the present shoreline, Pleistocene sediments were deposited in valleys cut into older formations.

Between Bay Head and Cape May City, the coastal lagoons, tidal marshes, and barrier beaches that fringe the coast have contributed to the sands of the present beaches. During Quaternary time, changes in sea level caused the streams alternately to spread deposits of sand and gravel along drainage outlets and later to remove, rework, and redeposit the material over considerable areas, concealing earlier marine formations. One of these, the Cape May Formation consisting largely of sand and gravel, was deposited during the last interglacial stage, when the sea level stood 33 to 46 feet higher than at present. The material was deposited along valley bottoms, grading into the estuarine and marine deposits of the former shoreline. In most places along the New Jersey coast, there is a capping of a few feet of Cape May Formation. This capping is of irregular thickness and distribution, but generally forms a terrace about 25 to 35 feet above sea level. The barrier beaches, being of relatively recent origin, are generally composed of the same material as that found on the offshore bottom.

4.8.4.7 Borrow Material for Berm Construction

Several offshore borrow areas are currently in use off the coast of New Jersey for beach nourishment and dune construction. Additional borrow areas have been studied but not permitted. Some borrow areas are located in inlets while others can be up to 7 miles offshore. Although most of these areas could be used for material for the project, only the near shore and inlet areas would be practical for use due to the distances and logistics involved.

There are numerous Confined Disposal Facilities (CDFs) along the back bay and New Jersey Intercoastal Waterway that have been used during past dredging events. These facilities are on a mix of federal, state, and local land. These CDFs contain sand, silt, and clay, however no complete inventory of them exists.

There are numerous quarries throughout the area that would be able to provide sand or other fill material by either truck, rail, or barge.

4.8.4.8 Soils

The soils within the study area are varied, ranging from deep fertile soils to droughty infertile soils with little humus or organic material present to organic tidal marshes, urban lands, and barrier island beach sands. In Monmouth County, the Natural Resources Conservation Service (NRCS) features 43 agronomic soil series and 114 types or subtypes. Soils associations encountered within the study area include the Klej-Galestown-Evesboro-Downer, Lakewood-Lakehurst-Evesboro-Atsion and Hooksan-Psamments-Udorthents along the coast. The NRCS recognizes 32 soil series, with 85 types or subtypes in Ocean County (USDA 1980). According to the Ocean County Soil Survey (1980), the dominant soil associations for the project area includes the Downer-Evesboro and Sulfaquents-Sulfihemists associations. The Downer-Evesboro association consists of well-drained and excessively drained, loamy, and sandy soils on uplands that are nearly level and gently sloping. The Sulfaquents-Sulfihemists association consists of poorly drained, mineral, and organic soils on tidal flats and marshes that are nearly level. Based on the project location within the Atlantic Coastal Plain province, fine to- medium sands from barrier formation processes or the underlying coastal plain are assumed to underlie the marsh deposits. Subsurface investigations performed in the area of the Barnegat Inlet South Jetty by USACE support this assumption. These subsurface investigations indicate that the area is underlain by fine-to-medium, dense-to-very dense sands with a layer of low density silts 4 to 6 feet thick at depths from 20 to 24 feet below ground surface (CH2M Hill 1997). However, note that this investigation was associated with a County-level survey for a specific region of the study area and is therefore limited in scope. Additionally, these County-level surveys typically include shallow boring depths and therefore may represent an incomplete characterization of soil thickness and associated regional extent. These low-density soils may extend deeper than the investigated depths, and may be more regional in extent. Additional research will be performed during subsequent project phases to better define subsurface conditions of the study area.

The southeast corner of Burlington County is within the study area that includes outer coastal plain soils within the lower Mullica River watershed composed predominantly of the Downer-

Sassafras-Woodstown association, which are mostly sandy loams and fine sandy loam subsoils and the Tidal Marsh association composed of organic silts subjected to daily flooding.

In Atlantic County, dominant soils within the study area are composed of the Appoquinimink-Transquaking-Mispillion (ATM)-Psamments-Hooksan-Urban Association, which contains nearly level, poorly drained tidal flats; nearly level excessively drained sandy fill land; and nearly level or gently sloping, excessively drained coastal beaches. The ATM soil series is located in areas near sea-level that are flooded twice daily by tidal waters and occupies about 16% of Atlantic County soil types. Psamments are located where several feet of sandy fill were placed on top of ATM soils to create developable land. Hooksan-Urban soils are located along the barrier beaches and includes areas that have been highly urbanized (Heyer, Gruel & Assoc., 2018).

In Cape May County, the barrier islands are composed of the heavily developed Coastal-Urban (CU) soil association and other fill lands (FL/FM) from tidal marshes converted to uplands. The tidal wetlands in the back-bay marsh areas are Tidal Marsh (TM) soil associations displaying various thicknesses of organic matter. Further inland and west, the dominant soil associations are the Downer-Sassafras-Fort Mott Association and Hammonton-Woodstown-Klej Association, which are high and intermediate landscape sandy loams and loamy sand soils found along the Garden State Parkway. A list of dominant soil associations within and near the study area are presented in Table 11.

Table 11: Dominant Soil Associations within New Jersey Back Bay Areas

Soil Association	County	Properties
Downer-Sassafras-Fort Mott	Cape May	Well-drained sandy loams or loamy sands in high landscape positions.
Downer-Hammonton-Sassafras	Atlantic	Nearly level or gently sloping, well drained to somewhat poorly drained soils that have a loamy subsoil in high or intermediate landscape positions.
Downer-Evesboro	Ocean	Nearly level and gently sloping, well drained and excessively drained, loamy, and sandy soils on uplands on broad, high, and intermediate landscape positions.
Manahawkin-Atsion-Berryland	Ocean	Nearly level, very poorly drained and poorly drained, organic, and sandy soils on lowlands.
Hammonton-Woodstown-Klej	Cape May	Nearly level, moderately well-drained and somewhat poorly drained soils that have dominantly loamy subsoil and a sandy substratum in intermediate landscape positions.
Sassafras-Aura-Woodstown	Atlantic	Nearly level or gently sloping, well drained and moderately well drained soils that have a loamy subsoil in high to intermediate landscape positions.
Sassafras-Downer-Woodstown	Monmouth, Burlington	Nearly level to steep, deep, well drained, and moderately well drained, loamy soils; on uplands.
Klej-Lakehurst-Evesboro	Atlantic	Nearly level to gently sloping, excessively drained to somewhat poorly drained soils that have a sandy sub-soil in high to intermediate landscape positions.
Pocomoke-Muck	Cape May	Nearly level, very poorly drained soils that have a loamy subsoil and a sandy substratum and soils that are organic throughout in low landscape positions.

Soil Association	County	Properties
Atsion-Muck-Pocomoke	Atlantic, Burlington,	Nearly level, poorly drained soils that have a sandy or loamy subsoil, and organic soils underlain mainly by sand that are organic throughout in low landscape positions.
Tidal Marsh	Cape May, Atlantic, Burlington	Nearly level, very poorly drained silty or mucky tidal flats that are subject to daily flooding.
Sulfaquents-Sulfihemists and Hooksan	Ocean, Monmouth	Nearly level, poorly drained, mineral, and organic soils on tidal flats and sand dunes and beaches (Hooksan).
Coastal beach- Urban Land	Cape May, Atlantic	Nearly level to strongly sloping barrier beaches and areas developed for residential and commercial uses.
Urban land-Fripp	Ocean	Urban land on nearly level and gently sloping excessively drained sandy soils; beaches on the barrier islands

4.8.5 Hazardous, Toxic and Radioactive Wastes (HTRW)

A desktop overview of the NJBB CSRM Study area was combined with District and personnel knowledge of the area to develop information regarding the potential for HTRW issues.

The barrier islands portion of the study area are predominately populated with residences, township supporting infrastructure (including water treatment plants), commercial, amusement parks/piers and some light industrial/marina-related facilities. There are fuel storage tanks related to the non-residential structures and marinas. Marinas may have pump out facilities with onsite temporary storage. Residential and most other facilities are likely heated using natural gas. There is a greater likelihood for fuel storage tanks (and septic tanks) in the more rural areas of the study area. There are small parks or natural areas within some townships on the barrier islands.

There are some larger natural areas, mostly in the southern portions of the study area (e.g., Island Beach State Park, E.B. Forsythe National Wildlife Refuge and the Cape May National Wildlife Refuge). These areas may also have storage tanks supporting facility structure and/or vehicles. There are limited heavy industrial facilities, including power plants, on the barrier islands. The Atlantic City-Ventnor-Margate-Longport area is heavily populated and could have more industrial-type facilities.

On the mainland portion of the study area, there are residential areas, township supporting infrastructure, and water treatment plants, commercial and industrial/marina-related facilities. There is increased potential for fuels and other materials storage tanks, and septic tanks use in rural areas. There is more industry on the mainland portion. The northern mainland area has more development than the middle mainland areas, although there are townships of considerable size (e.g., Little Egg Harbor, Pleasantville, Northfield and Somers Point) in the middle portion. There are power plants serving the mainland and barrier island areas.

The Oyster Creek Generating Station (Nuclear Power Plant) has been shut down but has not undergone decommissioning and remediation. The current plan is to decommission the plant, but retain the nuclear fuel on site. This facility is located in Lanoka Harbor, NJ and has a cooling water canal connected to Barnegat Bay.

The need for environmental data reviews (Phase I) and field investigation work (Phase II) will be highly dependent upon the locations and type(s) of flood management structures that are carried forward in the study.

4.8.6 Watersheds

The New Jersey Back Bays are part of the New Jersey Atlantic Coast Water Region (Figure 15), one of five watersheds in New Jersey delineated by NJDEP. The Region is comprised of five major watershed management areas (WMA). The New Jersey Atlantic Coast Water Region receives freshwater inputs from a number of river systems and smaller tributaries often originating as headwaters in the New Jersey Pinelands. These freshwater tributaries generally enter from the west where they meet tidally influenced polyhaline waters from the Atlantic Ocean that enter through the coastal inlets. The back bays are generally semi-enclosed estuaries bounded by the barrier islands and/or adjacent headlands. Five major watershed management areas (WMA) form the Atlantic Coast Water Region, however, the NJDEP now assesses water quality in individual sub watersheds as Assessment Units (AU's) at the USGS HUC 14 level. The northernmost area in the study area is Monmouth (WMA 12), which includes the Atlantic Ocean and inland bays along with two major river systems that are not in the NJBB CSRM Study area: the Navesink River and Shrewsbury River. Within the NJBB CSRM Study area, this area includes the Shark River and Manasquan River systems, which are connected to the Atlantic Ocean through the Shark River Inlet and Manasquan Inlet, respectively.

The Barnegat Bay Watershed Management Area (WMA 13) is very large and contains an estuarine drainage of 3,500 square kilometers (1,350 square miles), a surface area of 167 square kilometers (64 square miles), and a volume of 238 million cubic meters. This system includes Barnegat Bay and Little Egg Harbor Bay that form shallow lagoon estuaries that are fed by numerous streams including (from north to south): Metedeconk River, Kettle Creek, Toms River, Cedar Creek, Forked River, Oyster Creek, Manahawkin Creek, Mill Creek, and Tuckerton Creek. These rivers and streams provide freshwater influxes from the New Jersey Pinelands at a general rate of 10.2 cubic meters/second (360 cubic feet/second) with Toms River providing the greatest amount of that inflow followed by Cedar Creek (USFWS, 1997). WMA 13 is connected with the Atlantic Ocean through Barnegat Inlet to the north, Little Egg Harbor Inlet to the south, and also through the Bay Head-Manasquan Canal/Point Pleasant Canal and Manasquan Inlet at the northern end of the bay complex.

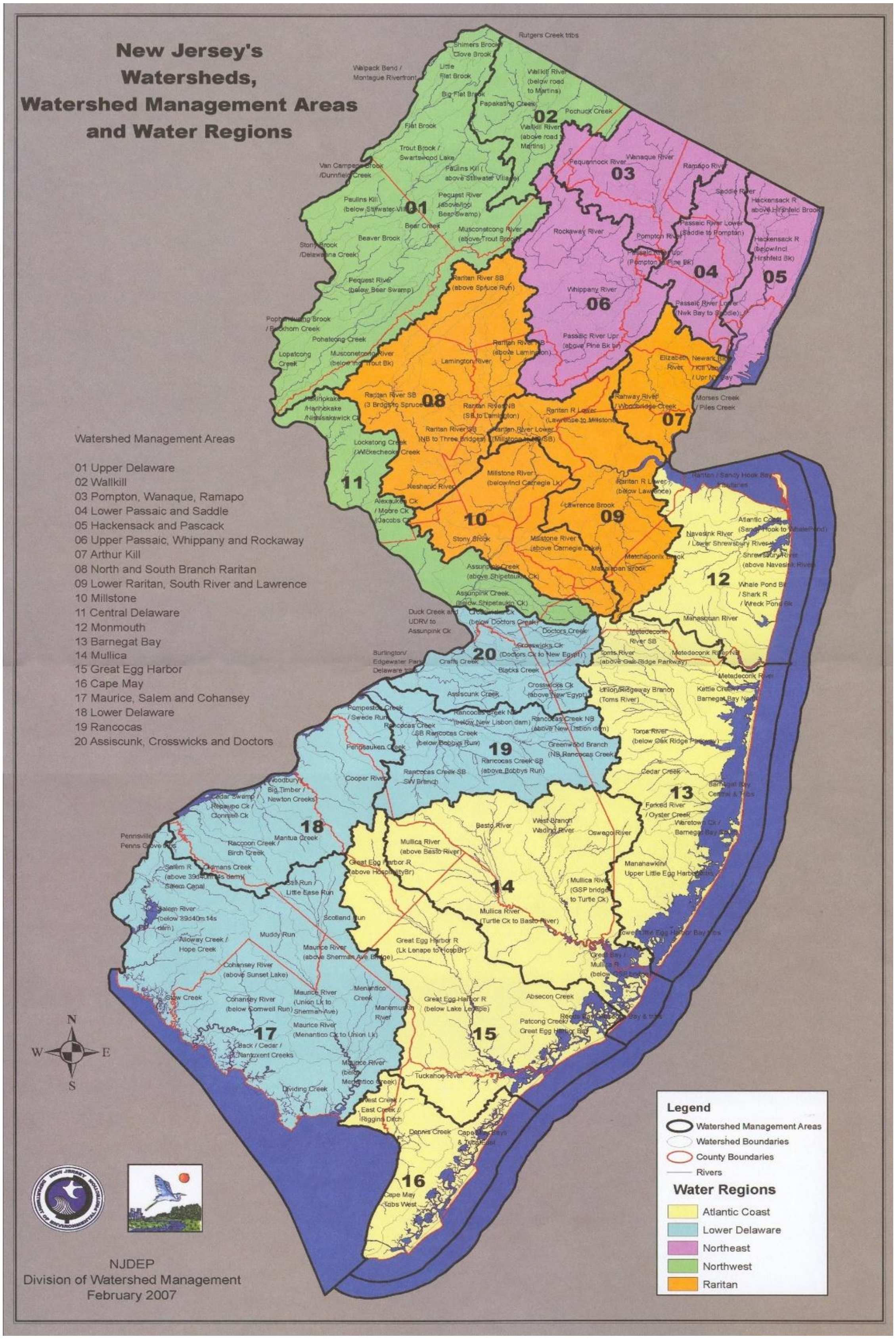


Figure 15: New Jersey's Watershed Management Areas (Source: NJDEP, 2007)

The Mullica River Basin (WMA 14) is a 1,471 square hectare (568 – square mile) area fed by a number of rivers and creeks originating from the heart of the New Jersey Pinelands including the Batsto River, Atsion (upper Mullica) River, Sleeper Branch, Nescocheague Creek, and Hammonton Creek. These major watersheds join at the head of tide near the town of Batsto to form the main stem of the Mullica River. The tidally influenced main stem from Batsto to the mouth at Great Bay is about 34 kilometers (21 miles) in length. A number of tributaries enter the main stem from the north, including Bull Creek, Wading River, and Bass River, with Landing Creek and Nacote Creek from the south. All of these tributaries are tidally influenced (USFWS, 1997). Great Bay is a polyhaline, well mixed estuary at the mouth of the Mullica River, and is fed tidally from the Atlantic Ocean through Little Egg Harbor Inlet to the east and Little Bay and Brigantine Inlet to the south.

The Great Egg Harbor River Basin (WMA 15) is composed of several embayment that extend behind Brigantine Island, Absecon Island, and Peck Beach. To the north, Reeds Bay and Absecon Bay receive freshwater inputs from mainly Absecon Creek. These bays are tidally connected to the Atlantic Ocean waters entering through Absecon Inlet and to a lesser extent from Little Bay and Brigantine Inlet to the north (WMA 14). Lakes Bay and Scull Bay are located south of the Atlantic City Expressway and west of Absecon Island. These bays are tidally influenced from the north and east via Beach Thorofare and Great Thorofare and from the south and east through Great Egg Harbor Inlet and Broad Thorofare. The dominant freshwater input into this area stems from two major river sources that originate in the New Jersey Pinelands to form an 875- square kilometer (338-square mile) area. These river sources are the Great Egg Harbor River and the Tuckahoe River. The Great Egg Harbor River is a 95-kilometer (59-mile) long river that is tidal for its lower 22.5 river kilometers (14 river miles) from the impoundment at May's Landing to its mouth where it joins the Middle and Tuckahoe Rivers at the head of Great Egg Harbor Bay. Smaller tributaries directly entering the estuary include the South River, Stephen Creek, Gibson Creek, and Middle River from the south, and Babcock Creek, Gravelly Run, English Creek, Lakes Creek, and Patcong Creek from the north. The Tuckahoe River is tidal for a distance of 22 river kilometers (13.5 river miles) upriver from the main stem of the Great Egg Harbor River (USFWS, 1997). These waters empty into the Great Egg Harbor Bay estuary, which receives polyhaline tidal waters from the Atlantic Ocean through the wide Great Egg Harbor Inlet. Peck Bay is connected to the south end of Great Egg Harbor Bay, and is located west of Ocean City/Peck Beach.

The Cape May Water Management Area (WMA 16) includes many smaller shallow bays and sounds that are inter-connected by an extensive system of tidal creeks and channels bounded by extensive salt marshes. There are four inlets in this area that connect the Atlantic Ocean to these bays. These inlets, from north to south, are Corson Inlet, Townsends Inlet, Hereford Inlet and Cape May Inlet. The bays from north to south are Corson Sound, Ludlam Bay, Townsend Sound, Stites Sound, Great Sound, Jenkins Sound, Grassy Sound, Richardson Sound, Sunset Lake, Jarvis Sound, and Cape May Harbor. There is a higher percentage of salt marsh in this wetland complex than in the bays to the north. The Cape May lagoons have a small drainage area, with most of the surface water in Cape May draining to the north into Great Egg Harbor estuary or to the west into Delaware Bay, and only a few small tributaries emptying directly into the Cape May lagoons (USFWS, 1997).

4.8.7 Water Quality

Water quality is a primary determinant of habitat quality for fish and wildlife, and also affects recreational opportunities in and the overall aesthetics of a water body. Water quality of the coastal waters of the New Jersey Atlantic Coast is comparable to that of similar coastal water bodies along the New York Bight and was indicative of similar coastal tidal river and estuary complexes along the Mid-Atlantic coast (USFWS, 1997). NJDEP (2017) summarizes that the coastal waters and estuaries of NJ were generally good for recreation and shellfish harvesting. However, there remain some areas where dissolved oxygen does not meet water quality criteria, which is a concern relative to aquatic life support particularly in Barnegat Bay. The quality of water in this coastal region is dependent largely on the influence of the major coastal freshwater rivers that flow into the bays that make up the study area reaches (e.g., the Mullica River empties in the Great Bay). Other factors that influence water quality over time include tides, time of year, ocean current fluctuations, nutrient enrichment, water depth, biotic communities, and other temporal and spatial variables. The results of prior studies conducted on the bays and estuaries within the study area indicate that the water quality has historically been impacted by pollutants such as nutrients, pathogens, heavy metals (cadmium, lead, and zinc) and fecal coliform bacteria. (USACE, 1998; BBEP, 2001; Zimmer and Groppenbacher, 1999). As a result, habitat for fish and wildlife has been degraded in many areas relative to historical pre-developed conditions. In recent years, however, improvements in water quality have been seen in the region resulting from implementation of the Clean Water Act, and state programs such as discharge permitting programs, coupled with improvements in wastewater treatment technology.

The U.S. EPA maintains a web-based information system that allows the user to access pollution information from a search based on a locality. A search was conducted on the “How’s My Waterway” maps for the NJBB CSRM Study area. Except for waters around Little Bay, Great Bay, Little Egg Harbor, and Southern Barnegat Bay, most of the waters were designated as polluted. These designations are based on State of NJ Water Quality Monitoring programs.

The NJBB CSRM Study area is within the Atlantic Coast Region (ACR) for water quality monitoring, assessment, and management by the NJDEP. The Atlantic Coast Region is further divided into smaller assessment units (AU’s) that are based on the USGS Hydrologic Unit Code (HUC) 14 watershed level. Section 305(b) of the Clean Water Act requires states to report attainment of designated water uses, including Aquatic Life – General, Aquatic Life – Trout, Recreation, Water Supply, and Shellfish. A multitude of parameters are used to assess the water quality and designated uses, including pathogens, nutrients, dissolved oxygen, and toxics. The ACR consists of 293 AUs covering 2,962 square miles of the coastal region, 5,812 miles of nontidal and tidal rivers, 6,632 acres of lakes/reservoirs, and 745 square miles of estuaries/bays and ocean waters. Use assessment results for the ACR’s 293 assessment units (AUs) showed that water quality is generally better in the ACR than water quality statewide. Both statewide and ACR assessment results showed that public water supply and recreation uses had the highest percentage of use support; moreover, the relative percentage of all AUs fully supporting applicable designated uses was generally higher in the ACR. Figure 16 shows the number of AUs that fully support applicable designated uses in each Water Region. The ACR has the highest number of fully supported designated uses (274 AU/use combinations) of the New Jersey’s Water Regions, followed by Lower Delaware (156), Northwest/Upper Delaware (146), Raritan (100), and Northeast (70) (NJDEP, 2017). Table 12 provides a breakdown of percentages of AUs that meet and do not meet designated uses within the ACR.

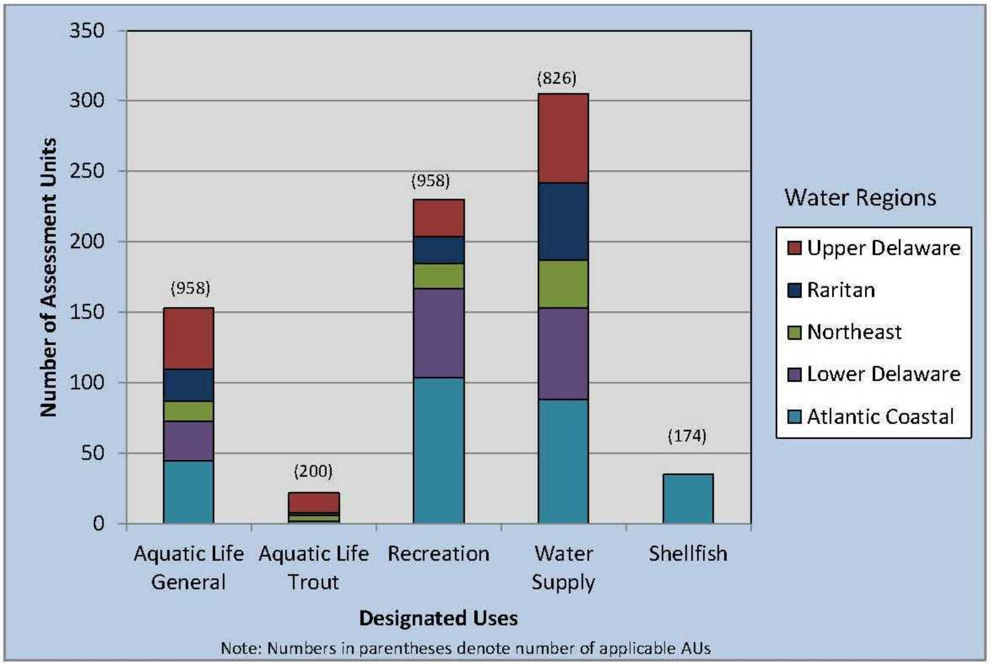


Figure 16: Number of AU's Fully Supporting Uses, Statewide (Source: NJDEP, 2017)

Table 12: Use Assessment Results for Atlantic Coastal Region (ACR), Number and Percentage of Assessment Units (AUs)

Designated Uses	Aquatic Life-General		Aquatic Life-Trout		Recreation	
Scope	# AUs	% AUs	# AUs	% AUs	# AUs	% AUs
Fully Supporting	45	15%	2	12%	104	35%
Not Supporting	184	63%	11	65%	76	26%
Insufficient Information	64	22%	4	24%	113	39%
Total AUs Applicable	293		17		293	
Notes:	The predominant parameter causing aquatic life use impairment is "cause unknown", followed by pH, and dissolved oxygen.		Only applies to trout maintenance waters in the freshwater Manasquan River, Toms River and Metedeconk River watersheds.		Not supporting %'s due to pathogenic impairments in heavily urbanized areas such as in Monmouth and Ocean County and new tributaries added in upper Barnegat Bay area and beach closure data.	

Designated Uses	Water Supply		Shellfish Harvest		Fish Consumption	
Scope	# AUs	% AUs	# AUs	% AUs	# AUs	% AUs
Fully Supporting	88	41%	35	27%	0	0%
Not Supporting	59	28%	78	60%	84	29%
Insufficient Information	67	31%	17	13%	209	71%
Total AUs Applicable	214		130		293	
Notes:	Water supply only applies to freshwater AU's. Impairments are predominantly due to arsenic concentrations that exceed established human health criteria even though the arsenic is naturally occurring.		Only shellfish waters classified as "approved" are assessed as fully supporting the designated use even though shellfish may be harvested from shellfish waters that are seasonal and special restricted.		Mercury and PCB in fish tissue are major causes of use impairment although, PCB in fish tissue along the Atlantic Coast is no longer on the 303(d) List because the waters from which the fish contamination arose are unknown. Other causes of use impairment found in fish tissue or subject to fish advisories are DDT and its metabolites, chlordane, dioxin, dieldrin and benzo (a) pyrene.	

Section 303(d) of the Federal Clean Water Act requires TMDLs (Total Maximum Daily Loads) to be developed for the pollutant(s) of concern in water bodies that cannot meet surface water quality standards after the implementation of technology-based effluent limitations. Waters of the State are regularly assessed to determine if surface water quality standards are attained. Waters that do not meet the applicable standards are placed on the 303(d) List of Water Quality Limited Waters (303(d) List). The 2014 303(d) List identifies 40 different causes of impairment for a total of 1,958 assessment unit (AU)/pollutant combinations (some AUs are impaired by multiple causes) statewide. Five of the top ten causes of water quality impairment (including total phosphorus (TP) are associated with the aquatic life use. TMDLs have been established where 74% of the use impairments were caused by pathogens, 56% of the use impairments by mercury, and 35% of the use impairments caused by TP. Table 13 provides a list of impaired AUs within each Watershed Management Area (WMA) within the ACR and demonstrates that the most impairments are for Aquatic Life-General.

Table 13: Number of Assessment Units (AUs) Listed within Each Watershed Management Area (WMA) within the Atlantic Coastal region as Impaired on the 2014 303(d) List

WMA	Aquatic Life General	Recreation	Water Supply	Shellfish Harvest	Fish Consumption
12 Monmouth	51	5	16	5	71
13 Barnegat	42	12	25	-	20
14 Mullica	50	-	18	-	34
15 Great Egg Harbor	39	-	14	1	4
16 Cape May	24	-	4	-	9
TOTAL AUs	206	17	77	6	138
Parameters:	Phosphorous, DO, Cause Unkn, TSS, pH, Turbidity, Copper, Nitrates	E. Coli, Enterococcus	Arsenic, Mercury, Lead	Total Coliform	PCB, Mercury, PAHs, DDT and Metabolites, Chlordane, Dieldrin, Dioxin,

4.8.7.1 Temperature and Salinity

The back bays generally exhibit the highest mean salinities and water temperatures within the project area. The higher salinities reflect the stronger influence of the ocean on dynamics of water within these bays and the absence of a major freshwater river. Similarly, warmer mean temperatures in this reach may also be accounted for by a stronger influence of oceanic (higher salinity) waters during the winter months when freshwater influences are likely to lower temperatures. Water temperature is driven primarily by seasonal shifts in weather and ambient air temperature. Summer water temperatures of New Jersey coastal waters averages between 20°C and 30°C. During winter months the average water temperature ranges from 0°C and 10°C (Zimmer and Groppenbacher, 1999). While these temperature ranges describe a majority of the water bodies along the coast, variables such as water depth, productivity, mixing, and influx of freshwater can all affect water temperatures in habitats across the study area.

Salinity is another key water quality indicator as it can significantly affect aquatic community structure in estuarine waters and related habitats. Salinity of coastal surface waters is driven both by cyclical tidal shifts and the non-cyclical pulses of freshwater flows from coastal rivers that empty into the bays and estuaries along the coast. Other factors influencing salinity in an estuary include evaporation, weather conditions affecting wind, distance from the mouth of the estuary, and river basin geomorphology (Kennish, 1992). On average, the salinity of much of the coastal waters ranges from 20-30 parts per thousand (ppt). However, similar to temperature, there is often a seasonal shift in salinity in New Jersey's coastal waters when rain and freshwater runoff brings salinities down during spring months (Zimmer and Groppenbacher, 1999).

4.8.7.2 Turbidity

Turbidity is a measure of the clarity of the water column, which is a function of suspended particles (Thurman, 1975) and is recorded as nephelometric turbidity units (NTUs). Turbid (cloudy) water can be caused by natural conditions (e.g., tidal flushing and resultant suspension of sediments), water from aquifer formations that is naturally elevated in total dissolved solids, or human activities, such as the release of suspended particles in urban runoff or wastewater discharges into the river. As a general trend, turbidity is somewhat lower in the winter months when biological productivity is lowest (Zimmer and Groppenbacher, 1999). Conversely high phytoplankton biomass and production during the warmer months of the year contribute to elevated turbidity readings. Other factors that may influence turbidity over the short term include storms, wind, and rain supplying energy that causes erosional processes that entrain suspended particles. Turbidity is also often elevated in areas near the mouth of estuaries, where tidal action and river flows result in great mixing.

4.8.7.3 Dissolved Oxygen

Dissolved oxygen (DO) is one of the most important water quality parameters, as most biota cannot survive without adequate DO levels. Dissolved oxygen concentrations in the water column are influenced by temperature, photosynthesis, respiration of aquatic life, aeration from physical processes, amount of organic matter, and pollutant inputs (USEPA, 1986). Generally, DO is highest in the winter months and lowest in summer months (Zimmer and Groppenbacher, 1999), as its solubility increases when temperature decreases. DO can vary greatly over time within a specific area due to changes in presence of other nutrients that stimulate productivity. Furthermore, DO is highly dependent on salinity as the latter affects the solubility of oxygen in water.

4.8.7.4 Nutrients

The level of nutrients in coastal waters as a measure of non-point source pollution is among one of the higher priority management issues for state and federal agencies (CBP, 2002). Two major nutrients (nitrogen and phosphorus) are monitored in water quality studies, although they may take many forms. Nitrogen is always present in aquatic systems although it exists in many forms simultaneously as ammonia (NH4+), nitrate (NO3-), nitrite (NO2-), and urea. It is the availability of the various nitrogen compounds that most influences the variety, abundance, and nutritional value of aquatic plants and eventually animals in an aquatic system (Goldman and Horne, 1983).

Many of New Jersey's coastal waters are experiencing high nutrient loadings that negatively impact water quality and biotic communities. For example, high nutrient inputs (especially nitrogen) can lead to a variety of adverse conditions (e.g., increased algal biomass and production, toxic or nuisance algal blooms, elevated turbidity, loss of submerged aquatic vegetation (SAV), exhausted DO levels, and a decline in biodiversity) that can severely impact the water quality of an estuary (BBEP, 2001). Kennish (2010) describes that the "nutrient enrichment of the Barnegat Bay-Little Egg Harbor Estuary is closely linked to a series of cascading environmental problems, notably increased growth of phytoplankton and benthic macroalgae (including both harmful and nuisance forms), loss of SAV, and declining shellfish resources. These problems have also led to deterioration of sediment and water quality, loss of biodiversity, and disruption of ecosystem health and function. Human uses of estuarine resources have also been impaired."

Many lagoonal estuaries with poor flushing and long residence times are more likely to retain nutrients longer in the system, which could lead to higher primary production rates, thus becoming more susceptible to eutrophication. Well-flushed estuaries demonstrate greater resilience to nutrient loading attributed to reduced residence time and greater exchange with less impacted coastal waters (Lancelot and Billen, 1984 as cited in Defne and Ganju, 2015). Barnegat Bay and Little Egg Harbor (BB-LEH) estuaries are the most studied concerning hydrodynamic modeling and residence times where Guo and Lordi (2000) estimated an average residence time at Barnegat Inlet based on velocity and salinity as occurring between 24 and 74 days (depending on season). Defne and Ganju (2015) performed systemic modeling using a combination of hydrodynamic and particle tracking modeling of the BB- LEH estuaries to determine a mean residence time of 13 days, but special variability was between 0 and 30 days depending on the initial particle location. This modeling also demonstrated that there is a pronounced northward subtidal flow from Little Egg Inlet in the south towards Point Pleasant Canal in the north attributed to frictional effects in the inlets. This effect resulted in better flushing of the southern half of the estuary and more particle retention (poor flushing) in the northern estuary.

4.8.8 Plankton

Plankton are collectively a group of interacting minute organisms adrift in the water column. Plankton are commonly broken into two main categories (with some exceptions): phytoplankton (plant kingdom) and zooplankton (animal kingdom), and both form the base of the food web in aquatic ecosystems. Phytoplankton are the primary producers in the aquatic freshwater, estuarine, and marine ecosystems, and are assimilated by higher organisms in the food chain. Phytoplankton production is dependent on light penetration, available nutrients, temperature, and wind stress. Phytoplankton production is generally highest in nearshore coastal waters. Seasonal shifts in species dominance of phytoplankton are frequent. Phytoplankton can be broken down into two major seasonal species associations. One is a spring-summer dinoflagellate dominated regime. October and November are periods of transition in the phytoplankton community. A second regime exists during the winter, which is predominantly diatoms. A two year baseline survey in Barnegat Bay and Little Egg Harbor reported that the most common phytoplankton species belonged to five major groups: diatoms (Bacillariophyceae), dinoflagellates (Dinophyceae), cryptophytes (Cryptophyceae), chlorophytes (Chlorophyceae), and chrysophytes (Chrysophyceae). Of these groups, diatoms made up approximately 50% of the total number of taxa, followed by dinoflagellates (Ren, 2015).

4.8.8.1 Zooplankton

Zooplankton provide an essential trophic link between primary producers and higher organisms. Zooplankton represent the animals (vertebrates and invertebrates) that are adrift in the water column, and are generally unable to move against major ocean currents. Many organisms may be zooplankton for their entire lifecycle (holoplankton), or at early stages in their respective life cycles (meroplankton) only to be able to swim against the currents (nektonic) in a later life stage, or become part of the benthic community. Zooplankton are generally either microscopic or barely visible to the naked eye. Zooplankton typically exhibit diurnal vertical migrations and seasonal variances in species abundance and distribution, which may be attributed to temperature, salinity, and food availability. In marine environments, seasonal peaks in abundance of zooplankton distinctly correlate with seasonal phytoplankton peaks. These peaks usually occur in the spring and fall. Zooplankton species that are characteristic of coastal areas include: *Acartia tonsa, Centropages humatus, C. furatus, Temora longicornis, Tortanus discaudatus, Eucalanus pileatus, Mysidopsis bigelowi* (mysid shrimp), and *Crangon septemspinosa* (sand shrimp). Zooplankton species within the geographic area generally fall within two seasonal groups. The copepod, *Acartia clausi*, is a dominant species during winter-spring, and is replaced in spring by *A. tonsa*. Peak densities usually occur in late spring to early summer following the phytoplankton bloom.

Howson (2016) reports that the zooplankton community in Barnegat Bay is characterized by strong spatial, seasonal and interannual trends in abundance and diversity. Spatial variability is most apparent between the northern and southern sections of the bay, with a characteristic suite of taxa and water quality parameters associated with each area. The northern bay was characterized by higher nitrogen and chlorophyll 'a', high abundances of copepods, ctenophores, and barnacle larvae, and the lowest species diversity of zooplankton and ichthyoplankton in the bay; whereas species diversity of both zooplankton and ichthyoplankton were higher in the lower bay.

4.8.8.2 Harmful Algal Blooms (HABs) and Bay Nettles

Excessive phytoplankton blooms in the NJBB are attributed to eutrophication of the waters in the bays stemming from excessive nutrients and poor flushing. Excessive growth of some phytoplankton species can generate harmful algal blooms (HABs), an increasing phenomenon worldwide, which are characterized based on their pigments as brown, yellow, and red tides. HABs can cause numerous ecological and/or human health problems due to the toxins produced by certain species and/or their potential bioaccumulation in the food web, or may cause hypoxia in the water column due to their decay and degradation (Gastrich, 2000). Toxic forms that are particularly dangerous to numerous organisms include macroalgae, shellfish, finfish, and humans. Secondary impacts of algal blooms include shading of benthic habitats, altered grazing patterns, and changes in trophic dynamics that are detrimental to estuarine function. HAB-forming species that have been recorded in the Barnegat Bay-Little Egg Harbor estuary, include *Aureococcus anophagefferens, Dinophysis* spp., *Gymnodinium* (*Karlodinium*) spp., *Heterosigma* sp., *Pseudo-nitzschia* sp. and *Prorocentrum* spp. (BBP, 2016).

Brown-tide blooms caused by the minute algal species, *Aureococcus anophagefferens* (Pelagophyceae), were first reported in New Jersey coastal bays in 1988. These blooms have typically been observed in dry years. A brown tide algal bloom can discolor the water brown and may cause negative impacts on shellfish, such as the ecologically and commercially important hard clam and scallop, as well as on seagrasses. Adverse shellfish impacts include a reduction in the growth of juvenile and adult hard clams and mussels, reduced feeding rates of adult hard clams and other shellfish, recruitment failures, and increased mortality of bay scallops. The dense shading of benthic habitats caused by these blooms may also contribute to the loss of seagrass beds, which serve as important habitat for finfish and shellfish (BBP, 2016).

Each summer, the New Jersey DEP Bureau of Marine Water Monitoring monitors for concentrations of chlorophyll 'a' (an indicator to determine the amount of algal biomass present) in New Jersey's coastal waters. Since chlorophyll 'a' is a plant pigment, high levels of chlorophyll ‘a’ in the water are typically associated with an algal bloom. To detect potential blooms, an airplane equipped with a remote sensor flies six days a week during clear, summer weather conditions over coastal NJ. These flights produce estimated chlorophyll ‘a’ concentrations that are made available for viewing through an interactive map. Developing algal blooms are monitored through this tool and Marine Water Monitoring will strategically deploy field staff to locations of concern. Samples are collected and brought back to the bureau laboratory for analysis to determine if a HAB species is present. Additionally, the phytoplankton-monitoring program provides surveillance of shellfish growing areas for possible toxin-producing algal species. A station network of over 45 sites is monitored for chlorophyll ‘a’ multiple times throughout the year. In addition, these samples are closely evaluated to determine if the concentration of any toxic algal species is present and at an unsafe level (retrieved from https://www.nj.gov/dep/bmw/phytoplankton.htm#/ on 12/20/2018). Through NJDEP and the Barnegat Bay Partnership, Barnegat Bay, Little Egg Harbor and Manahawkin Bay are regularly monitored to indicate if an algal bloom is occurring. Several years of monitoring demonstrates that overall chlorophyll ‘a’ concentrations are highest in the Barnegat Bay segment (generally from Barnegat Inlet in the south to the Metedeconk River in the north), but the blooms were generally localized (BBP, 2016).

Bay nettles (*Chrysaora chesapeakei*) are a stinging jellyfish that have become increasingly prevalent, and a nuisance, in Barnegat Bay and other coastal waterways in New Jersey. They can greatly affect recreational activities that involve human contact with the water where people can be stung by their tentacles. It is believed that sea nettle blooms are greatly influenced by a number of factors such as increases in the presence of manmade structures (pilings, floating docks, and bulkheads), which allow for a suitable substrate for the polyps to attach. Salinity can affect their populations where they prefer a narrow salinity range in lower salinity areas. A dry year or certain human activities that affect water use can affect their abundance and distribution in the bays. Other factors believed to contribute to increases in sea nettles are climate change (increases in temperature), eutrophication, and overfishing (https://www.barnegatbaypartnership.org/protect/threats-to-barnegat-bay/jellyfish/sea-nettles/ accessed on 1/4/2019).

4.8.9 Submerged Aquatic Vegetation

The New Jersey Back Bays contain a number of submerged aquatic vegetation and macroalgae species that occur in beds in the shallow lagoonal systems west of the barrier islands (Figure 17 to 20). A number of species of macroalgae can be found in various back bay habitats including jetties, sand beaches, enclosed bays, and tidal creeks. The productivity is primarily seasonal with the densest population occurring in June through August. Distribution and abundance of algae is closely related to seasonal temperature, salinity variations and nutrient levels coming from tributary streams. The predominant benthic algae are Rhodophyta (red algae) while Chlorophyta (green algae) comprise the largest number of intertidal algae species. Phaeophyta (brown algae) such as rockweed (*Fucus* spp.) may be found attached or floating free around rock jetties and pilings or washed onto the shore to make up part of the wrack line. Other common algae species include sea lettuce (*Ulva lactuca*), spaghetti grass (*Codium fragile*) and *Gracilaria* sp., a red alga that grows unattached among seagrass beds (Good, et al., 1978). Eutrophication can influence the abundance of some macroalgae where excessive growth of sea lettuce, and the Rhodophytes: *Agardhiella subulata, Ceramium* spp., and *Gracilaria tikvahiae* can form extensive organic mats that can be detrimental to essential estuarine habitats such as seagrass beds (Kennish et. al 2010).

Submerged aquatic vegetation (SAV) and/or “seagrass” beds exist in localized areas of the New Jersey Back Bay estuarine system, and are an essential food for a number of waterfowl species, habitat for finfish, shellfish and a number of other invertebrates, and provide sediment stabilization. SAV are rooted vascular flowering plants that exist within the photic zone of shallow bays, ponds, and rivers. The Barnegat Bay – Little Egg Harbor Estuary have the most extensive

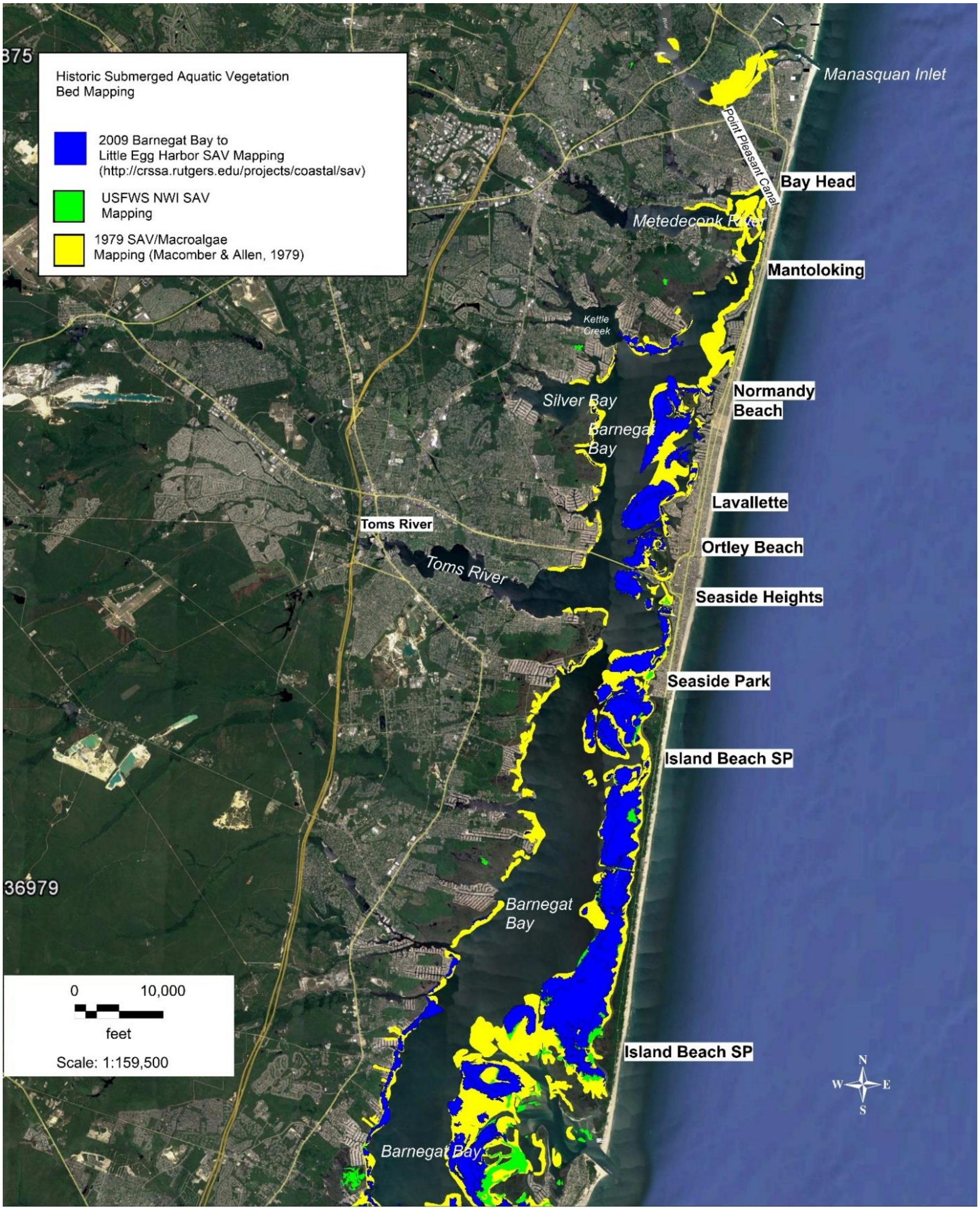


Figure 17: Historic Extents of Submerged Aquatic Vegetation and Macroalgae Beds of Barnegat Bay from Manasquan Inlet to Barnegat Inlet

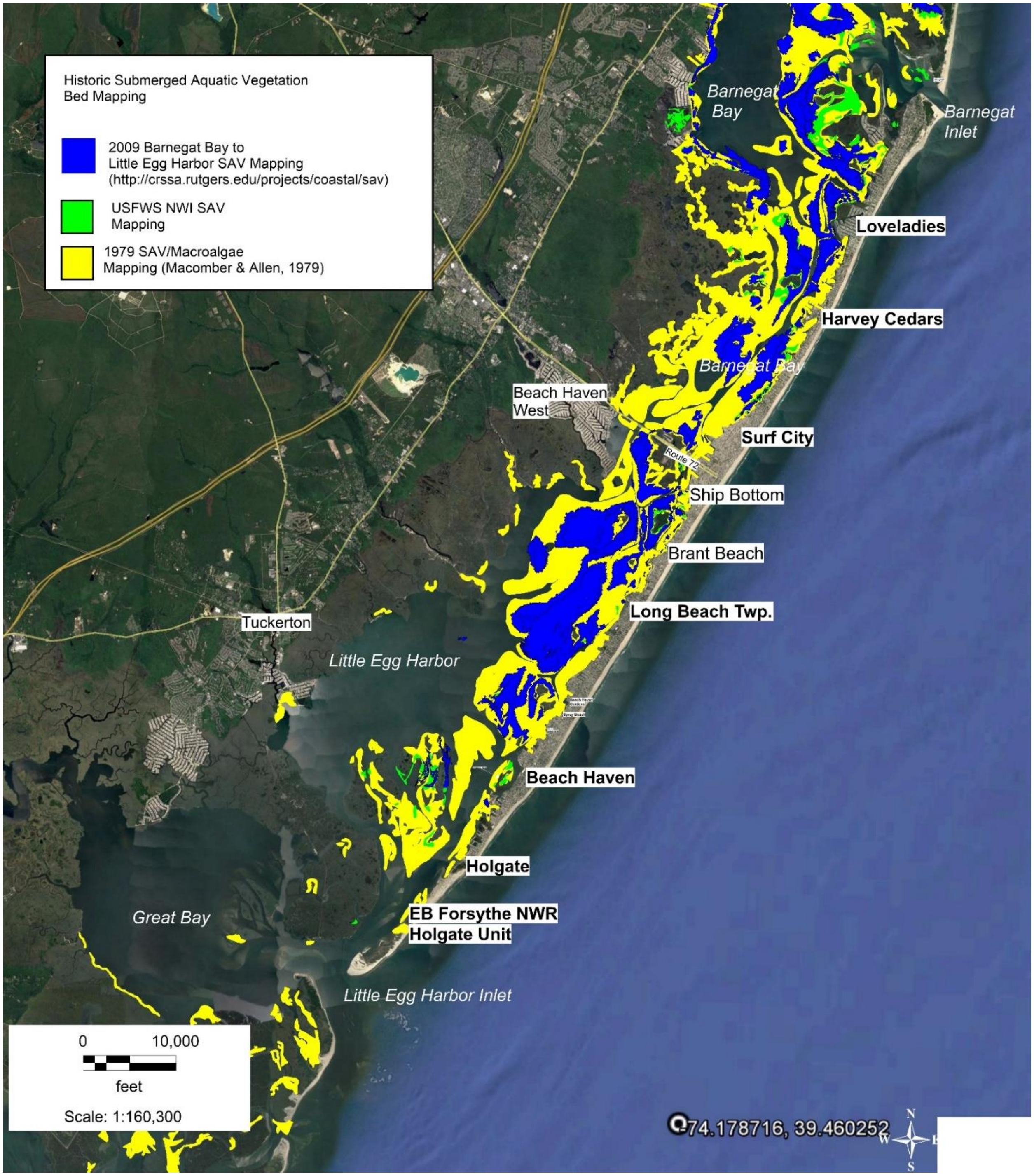


Figure 18: Historic Extents of Submerged Aquatic Vegetation and Macroalgae Beds of Barnegat Bay and Little Egg Harbor from Barnegat Inlet to Little Egg Inlet

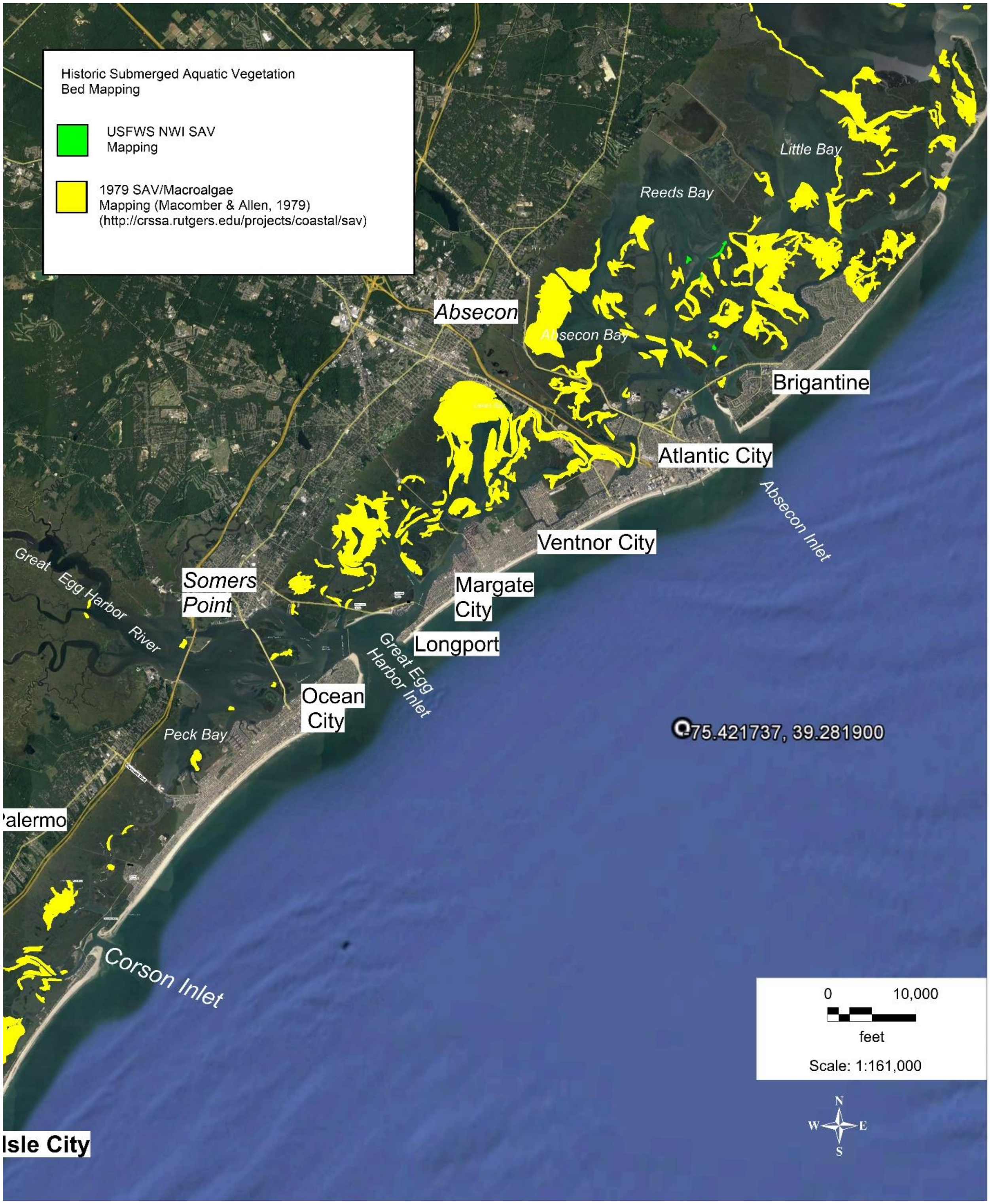


Figure 19: Historic Extents of Submerged Aquatic Vegetation and Macroalgae Beds from Little Egg Inlet to Corson Inlet

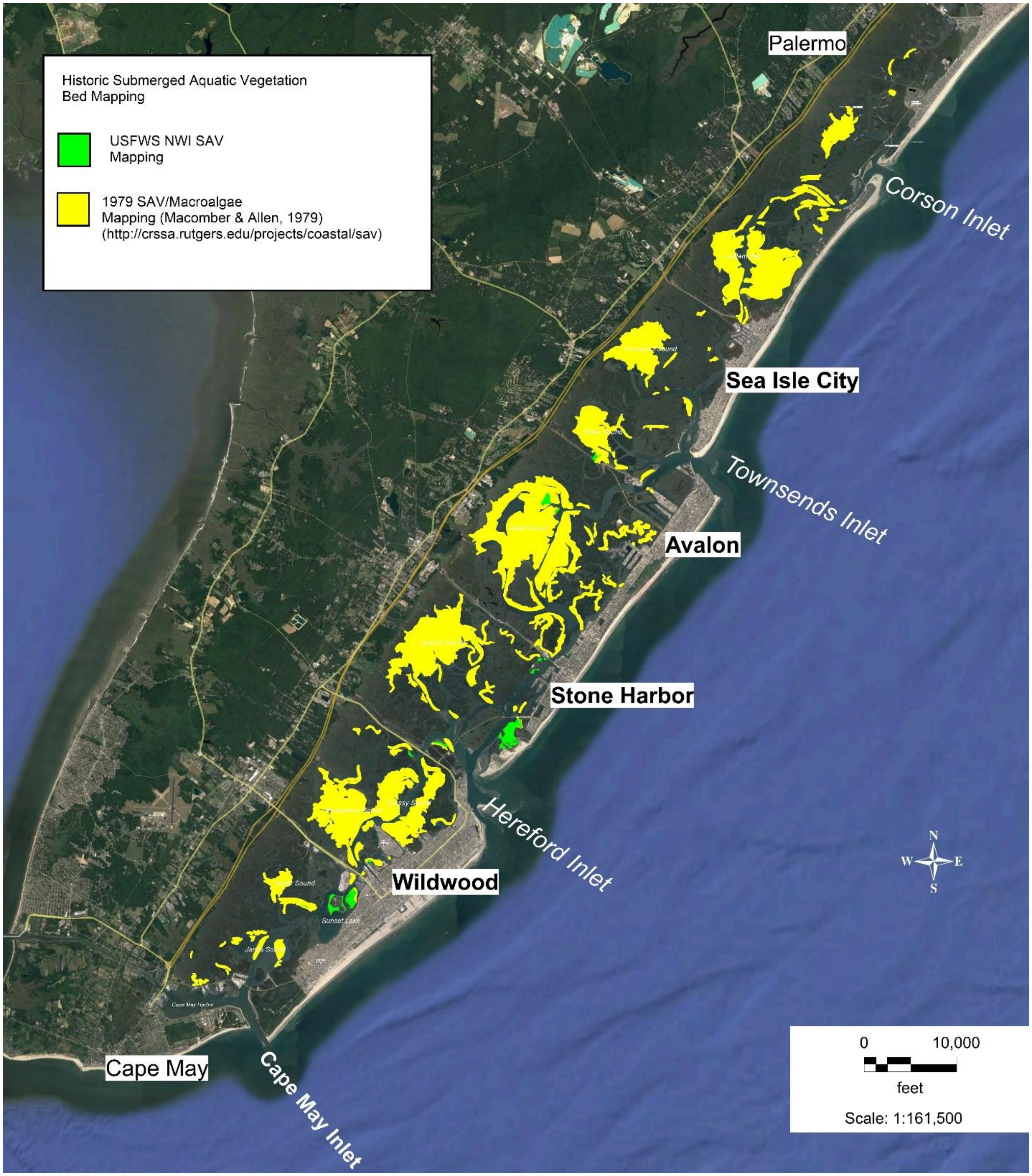


Figure 20: Historic Extents of Submerged Aquatic Vegetation and Macroalgae Beds from Corson Inlet to Cape May Inlet

beds and account for nearly 75% of the beds in New Jersey (Kennish et al. 2010). The most important species of SAV in New Jersey is eelgrass (*Zostera marina*), which is also the most common SAV that can form extensive beds important for fish, shellfish and other wildlife species. Other SAV species of ecological importance found in the more brackish waters of the estuary include widgeon grass (*Ruppia maritima*) and other more freshwater and slightly brackish species of pondweeds (*Zanichellia palustris* and *Potomogeton* spp.) and wild celery (*Vallisneria americana*) as reported in the Great Egg Harbor River, Tuckahoe River, Patcong Creek, and the Mullica River in USFWS (1997). SAV beds provide an important direct food source via the grazing chain, indirect food source via the detritus chain, a substrate for epiphytes, and cover and protective habitat. Although eelgrass is not used in fresh form by many organisms, Bellrose (1976) lists Atlantic brant *(Branta bernicla)* and black duck (*Anas rubripes*) as waterfowl known to feed extensively on eelgrass. Other waterfowl such as American widgeon (*Anas americana*), gadwall (*A. strepera*), mallard (*A. platyrhynchos*), canvasback (*Aythya valisineria*), greater scaup (*A. marila*), black scoter (*Melanitta nigra*), and surf scoter (*Melanitta perspicillata*) are also known to feed on the plant. Large numbers of fish are also typically associated with eelgrass beds, although most do not feed directly on the plants (Good, et al., 1978). Additionally, eelgrass beds have been recognized as an important habitat for juvenile and adult blue crabs (*Callinectes sapidus*), and the leaves are used by the bay scallop (*Argopecten irradians)* as a setting substrate, and are also associated with hard clam (*Mercenaria mercenaria*) beds.

Eelgrass beds are sensitive to a number of stressors in estuaries, which include nutrient enrichment, docks, dredging, and boat scarring. Lathrop and Haag (2011) conducted an aerial comparison of eel grass beds in Barnegat Bay and Little Egg Harbor in 2003 and 2009, and found that the general extent of eelgrass beds did not significantly change although a nearly 60% decline of the dense eelgrass beds occurred. Some changes were noted in the difference in seasons sampled in Barnegat Bay and Little Egg Harbor. Fertig et al. 2013 attribute declines in eelgrass populations and biomass in this area to increased Nitrogen loading within the watershed. Effects of high Nitrogen loading are accelerated algal growth, epiphytic infestation, light attenuation, and shading of the estuarine floor, which can heavily stress these plants.

4.8.10 Wetland and Tidal Flats

Wetland and aquatic habitat types dominate much of the study area (Figures 21 – 24). Aquatic habitats are principally associated with back water sound and bay areas such as Richardson Sound and Grassy Sound, Great Sound, Jenkins Sound, Townsend Sound, Corson's Sound, Great Egg Harbor, Peck Bay, Lakes Bay, Absecon Bay, Great Bay and Little Bay. In addition, nearshore and intertidal habitats are present within various channels and thorofares, while intertidal low marsh wetlands dominated by saltmarsh cordgrass (*Spartina alterniflora)* are the dominant vegetation feature. Common reed (*Phragmites australis*) marshes are also found throughout the area at higher elevations and around the edges of disturbed marsh areas. N.J.A.C. 7:7-9.15 defines intertidal and subtidal shallows as "all permanently or temporarily submerged areas from the spring high water line to a depth of four feet below mean low water. Spring high water and mean low water line delineations as well as visual observance aid in determining if intertidal subtidal shallows are present."

Intertidal mudflats or sand flats often border saltmarsh habitats, pocket beaches along developed shorelines, or locations where either erosion or marsh dieback has removed vegetation or depositional shoals have formed in areas that were previously subtidal.

These habitats are often rich in benthic food sources available to wading birds and shorebirds that forage at low tide.

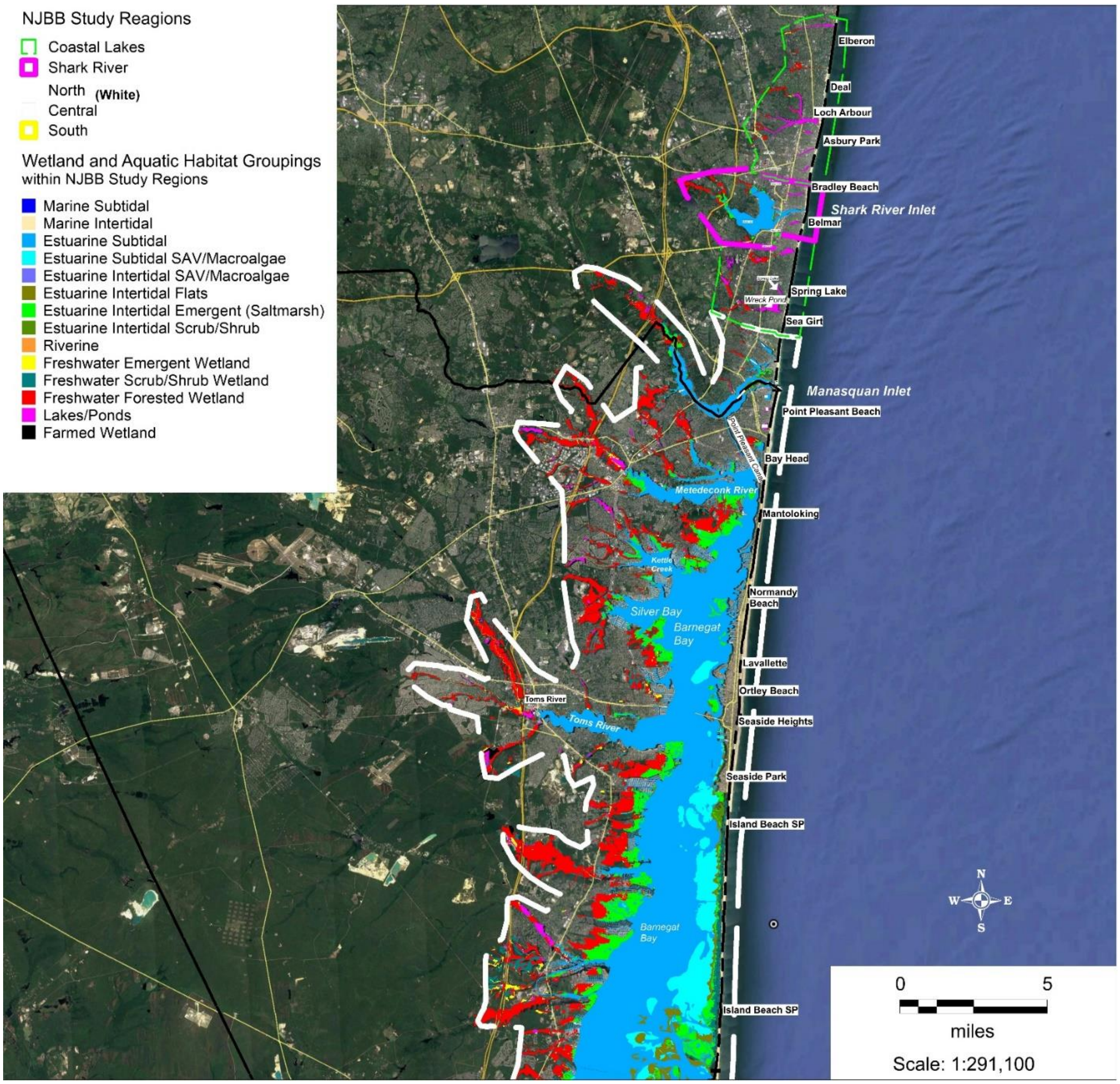


Figure 21: Coastal Lakes, Shark River and Northern Study Regions

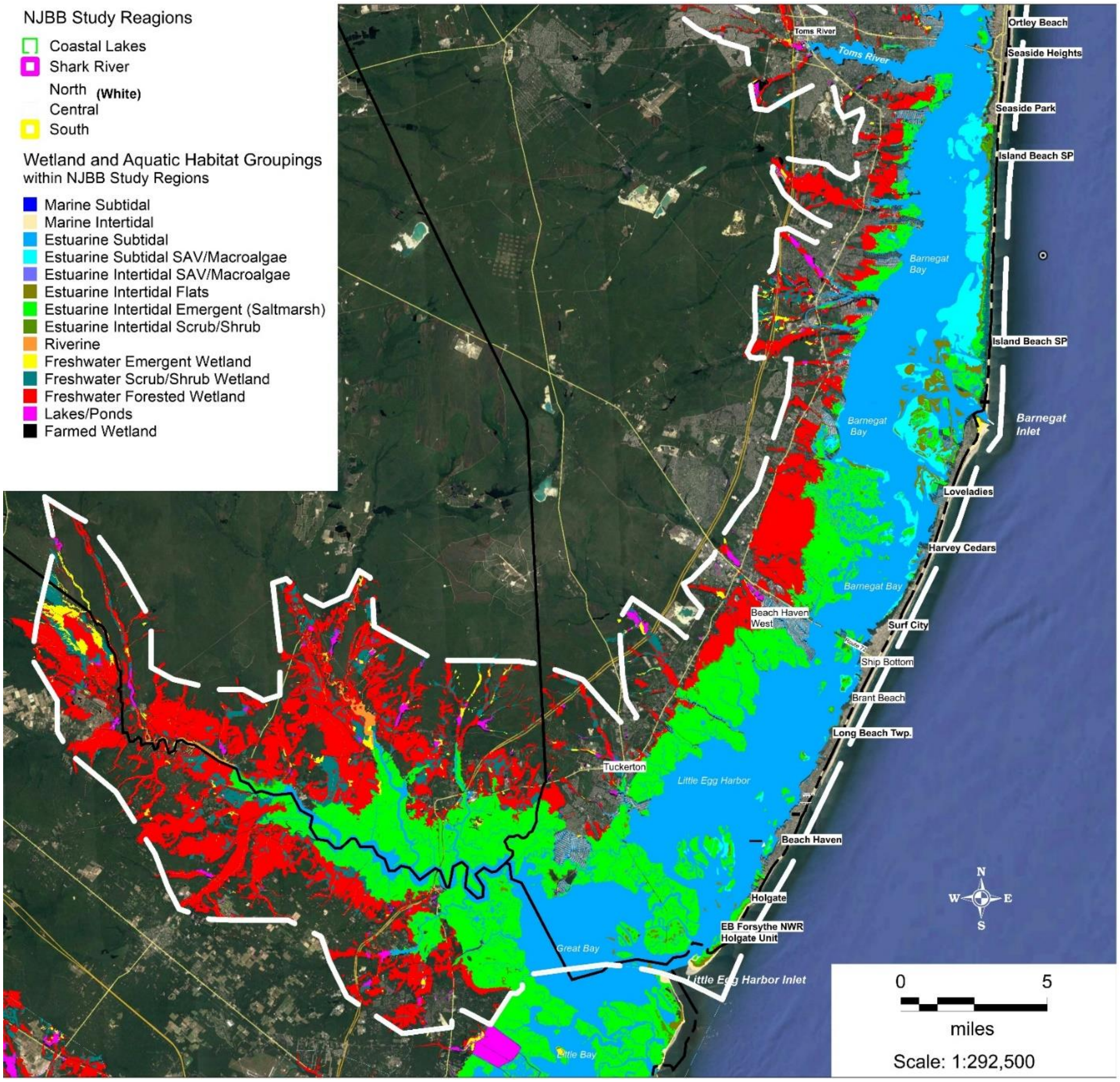


Figure 22: Northern Study Region

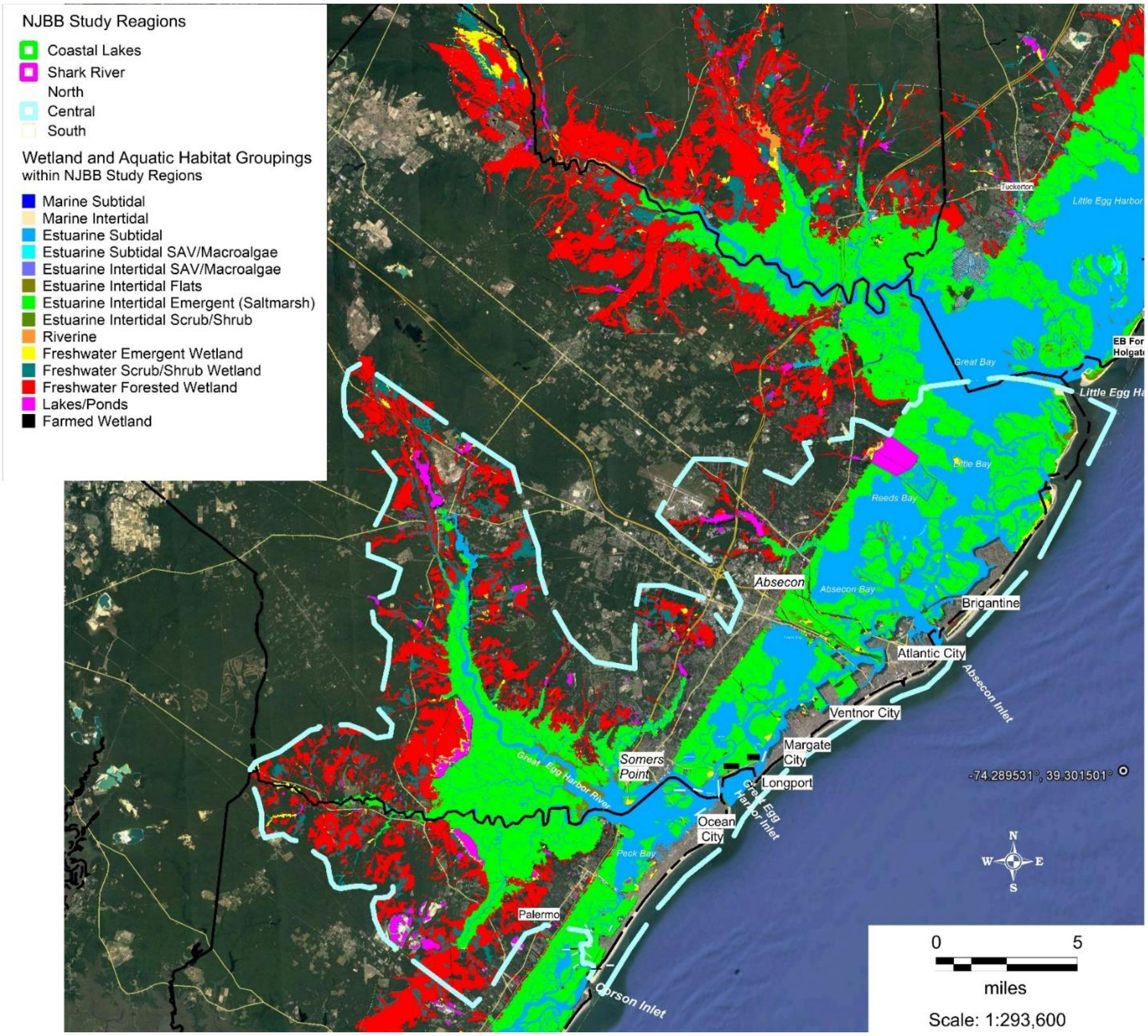


Figure 23: Central Study Region

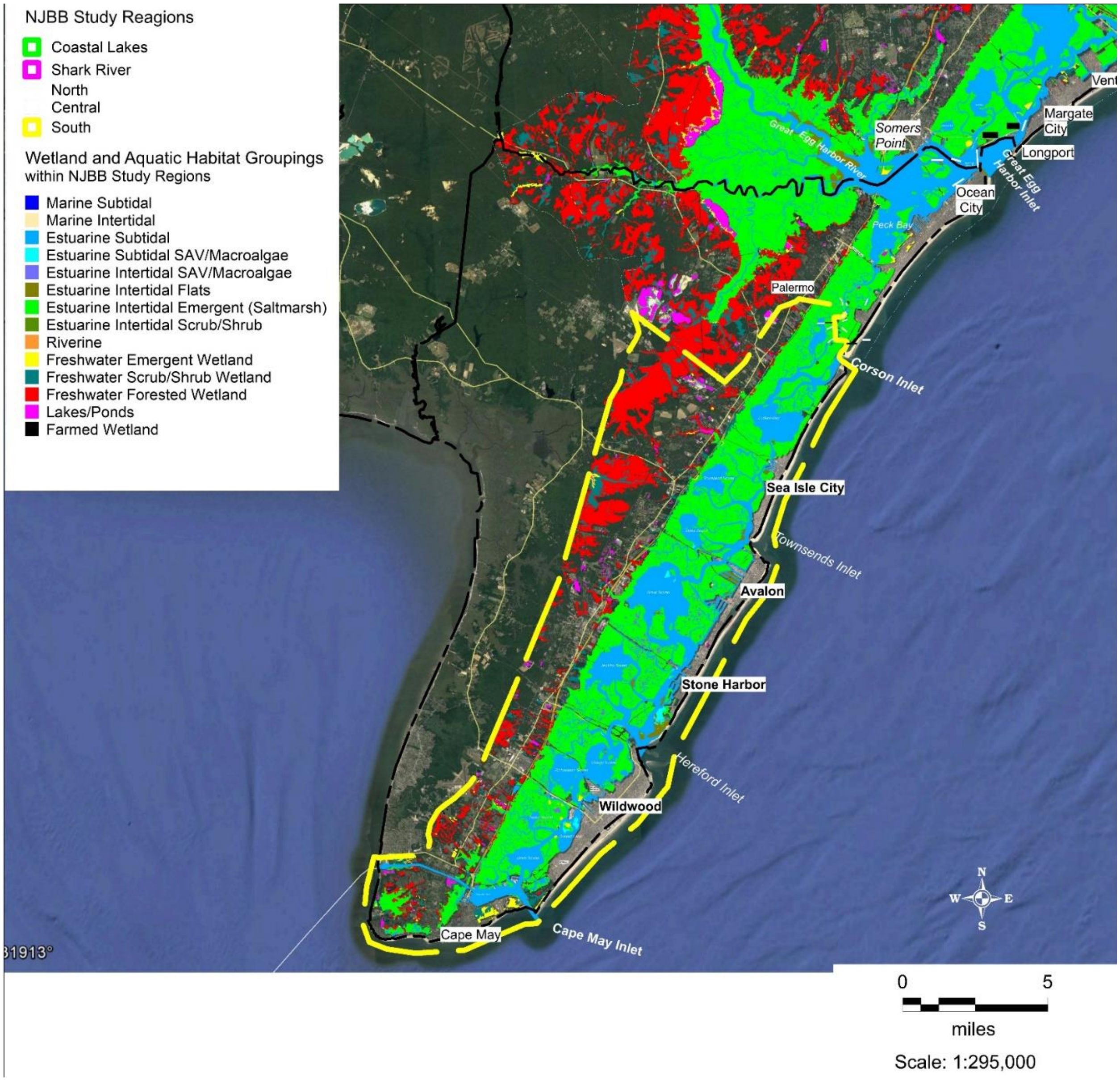


Figure 24: Southern Study Region

Estuarine emergent wetlands occur extensively throughout the back bays, channels, and inlets of the study area. The low marsh areas are typically dominated by saltmarsh cordgrass, the dominant saltmarsh plant species in the northeastern United States (Mitsch and Gosselink, 1993). This species grows in the intertidal zone between mean low water and mean high tide levels, so it is subject to daily tidal inundation. Wildlife species utilizing the low saltmarsh habitats include birds such as clapper rails (*Rallus longirostris*), common moorhen (*Gallinula chloropus*), waterfowl, and other species that feed on insects, crabs, and other invertebrates that this community supports. The low marsh and tidal channel complex provide significant habitat for numerous fish species that depend on estuaries for nursery and spawning grounds, as well as smaller resident fish such as mummichog, killifish and silversides (Mitsch and Gosselink, 1993; Tiner, 1985). Tidal flats are generally soft bottom (mud or sand) areas that are covered with water at high tide and exposed at low tide. Mudflats and sandflats are common special aquatic sites in the New Jersey Back Bays, and are important areas for algal growth, as producers of fish and wildlife organisms, and as nursery areas for many species of fish, mollusks, and other organisms.

High saltmarsh habitats are generally found near the mean high tide level, and are generally dominated by saltmarsh hay (*Spartina patens*), seashore saltgrass (*Distichlis spicata*), and glasswort (*Salicornia spp.)*. High saltmarsh provides habitat for many of the same species found in the low tidal marsh areas. However, since high saltmarshes are inundated far less regularly than the low saltmarshes, waterfowl such as black ducks and mallards may breed within this habitat. White-footed mice (*Peromyscus leucopus*) and meadow voles (*Microtus pennsylvanicus*) may use this habitat, as well as raptors (hawks and owls) that feed on the rodents throughout the year.

The critical, or upland, edge of the wetlands, is crucial for the survival of those coastal zone species that rely on this habitat for breeding, food, cover, and travel corridors. It also acts as a buffer from nonpoint source pollution and activities affecting wildlife. Scrub/shrub habitats are common at the transition from high marsh to uplands. Common vegetation includes switchgrass (*Panicum virgatum*), groundsel tree (*Baccharis halimifolia*), bayberry (*Myrica spp*.), eastern red cedar (*Juniperus virginiana*), hightide bush (*Iva frutescens*), seaside rose (*Rosa rugosa*) and poison ivy (*Toxicodendron radicans*). Common reed competes with these species for dominance in these areas. Scrub/Shrub communities are an important component of the open water/tidal marsh/upland transition, providing habitat for numerous species of birds and mammals that utilize these areas.

The invasive common reed dominates much of the remaining high tidal marsh areas within the study area. Since this species may invade areas and exclude other species, it can reduce the diversity of habitats and species within an area (Roman et al. 1984). This has happened historically within the study area, especially in areas that have been subject to diking and ditching for mosquito control purposes. Because of this, tidal wetland restoration projects often focus on control of common reed. Due to the tenacious nature of this species, control efforts are not always successful without repeated herbicide application (Marks et al. 1993). Common reed marshes are common throughout the area but are generally present at higher elevations than other tidal marsh communities. Common reed communities also tend to gradually encroach and fill in or restrict tidal channel flows. As a result, this habitat often provides marginal fish habitat except in mosquito ditches and other channels that are sufficiently inundated to support fish. Common reed provides some habitat benefits for certain species of wildlife. When interspersed with other habitats, such as open water and mudflat areas, the value of common reed habitat may be greater, since this interspersion provides breeding, foraging, and resting habitat for several species. However, if left unmanaged, the species quickly spreads creating a monoculture and limiting habitat diversity and productivity. The root mat and thick biomass of common reed communities also presents an impenetrable barrier to nesting terrapins and competing native vegetation.

Wetland communities are heavily influenced along salinity gradients of tidal salt and brackish tidal freshwater and non-tidal freshwater wetlands. These gradients are most prominent along the larger river systems in the NJBB CSRM Study area that include the Mullica River and Great Egg Harbor River, but do occur to a smaller extent within smaller drainages in Barnegat Bay (Metedeconk River, Toms River, Cedar Creek), Manasquan River, and small coastal drainages in Cape May County. However, in a large portion of the study area, the Garden State Parkway is situated on a man-made embankment of higher topography than the surrounding land which impacts the hydraulic conditions in the surrounding area thus resulting in distinct difference in wetland habitats on either side. Smaller areas of brackish tidal marsh complex occur adjacent to the Wading River, Bass River, Nacote Creek, Landing Creek, Mullica River mainstem, Tuckahoe River, Cedar Swamp Creek, Patcong Creek and Great Egg Harbor River mainstem and are dominated by narrow-leaved cattail (*Typha angustifolia*), big cordgrass (*Spartina cyosuroides*), common reed (*Phragmites australis*), and Olney three-square bulrush (*Scirpus americanus*). Freshwater intertidal wetlands are found in a few locations in the upper reaches of tidal influence in the Mullica River, Wading River, Tuckahoe River and Great Egg Harbor River. These freshwater tidal wetlands can be divided into different zones depending on degree of tidal inundation. The lower tidal zone is exposed only at low tide and consists of sparsely vegetated intertidal flats with riverbank quillwort (*Isoetes riparia*), bluntscale bulrush (*Scirpus smithii* var. *smithii*), the regionally rare Parker's pipewort (*Eriocaulon parkeri*), stiff arrowhead (*Sagittaria rigida*), grass-leaved arrowhead (*S. graminea*), and Hudson arrowhead (*S. subulata*). The mid-tidal zone includes wild rice (*Zinzania aquatica*), spatterdock (*Nuphar advena*) pickerelweed (*Pontedaria cordata*), three-square bulrush (*Scirpus pungens*), arrow arum (*Peltandra virginica*), water hemp (*Amaranthus cannabinus*), and dotted smartweed (*Polygonum punctatum*). Finally,the upper tidal zone is dominated by cattails (*Typha angustifolia* and *T. glauca*) and a diversity of other species including sensitive fern (*Onaclea sensibilis*), halberd-leaved tearthumb (*Polygonum arifolium*), arrowheads (*Sagittaria* spp.), river bulrush (*Scirpus fluviatalis*), sweet flag (*Acorus calamus*), smooth bur-marigold (*Bidens laevis*), orange jewelweed (*Impatiens capensis*), and rose-mallow (*Hibiscus moscheutos* var. *moscheutos*), as well as the invasive common reed and exotic purple loosestrife (*Lythrum salicaria*). Shrubs include knob-styled dogwood (*Cornus amomum*), buttonbush (*Cepahalanthus occidentalis*), and swamp rose (*Rosa palustris*). (USFWS, 1997).

There are several types of freshwater swamps and forests inland of the coastal areas within the NJBB CSRM Study area, of which many are located within the NJ Pinelands Reserve. Palustrine forested wetlands occur in headwater areas and bottomland river and stream edges within freshwater drainages. These swamps and forests include Atlantic white cedar, red maple (*Acer rubrum*), and black gum (*Nyssa sylvatica*), with pitch pine, gray birch (*Betula populifolia*), and sassafras (*Sassafras albidum*) as associates. In the Atlantic white cedar swamps, stands of white cedar are relatively dense. Tall pitch pines, red maple, black gum, and sweetbay (*Magnolia virginica*) sometimes form an understory, and the shrub layer contains highbush blueberry (*Vaccinium corymbosum*), dangleberry (*Gaylussacia frondosa*), swamp azalea (*Rhododendron viscosum*), sweet pepperbush (*Clethra alnifolia*), fetterbush (*Leucothoe racemosa*), and bayberry (*Myrica pensylvanica*). Along the Cape May peninsula, Atlantic white cedar (*Chamaecyparis thyoides*) swamps grade into hardwood swamps. Typical hardwood swamps are dominated by sweet gum (*Liquidambar styraciflua*) and red maple (*Acer rubrum*); the Cape May lowlands swamp community generally found at the headwaters of streams in Cape May is a hardwood swamp type with an unusually high species diversity. Typical tree species include red maple, sweet gum, pumpkin ash (*Fraxinus profunda*), and black gum (*Nyssa sylvatica*), with sweet bay (*Magnolia virginiana*) and American holly (*Ilex opaca*) trees and sweet pepperbush (*Clethra alnifolia*) shrubs in the understory. Southern species found in these swamps include basket oak, water oak, and willow oak (*Quercus michauxii, Q. nigra,* and *Q. phellos*), marsh St. John's-wort (*Triadenum walteri*), and swamp cottonwood (*Populus hetrophylla*). These swamps grade into mesic (moderately moist), southern coastal plain, mixed-oak forest, with southern red oak (*Quercus falcata*), willow oak, sweet gum, red maple, American beech (*Fagus grandifolia*), American holly, and flowering dogwood (*Cornus florida*). Oak-pine and pine-oak forests occur on the drier uplands with black, chestnut, scarlet, post, and white oaks (*Quercus velutina, Q. prinus, Q. coccinea, Q.stellata,* and *Q. alba*), pitch pine, and shortleaf pine (*Pinus rigida* and *P. echinata*) (USFWS, 1997).

The Emergency Wetlands Resources Act of 1986 (EWRA) (100 Stat. 3582) directs the Department of the Interior (through the U.S. Fish and Wildlife Service) to identify specific wetland sites that should receive priority attention for acquisition by federal and state agencies using Land and Water Conservation Fund monies. The study area includes six estuarine wetland complexes that have been identified as priority wetland sites pursuant to the EWRA because of national ecological significance. These wetland complexes (from north to south) are: the Barnegat Bay Complex (#6 Upper Barnegat Bay to Little Egg Inlet), Mullica River – Great Bay Estuary (#5), Brigantine Bay and Marsh Complex (#4), Great Egg Harbor Estuary (#3), New Jersey Pinelands (#2), and Cape May Peninsula (#1) (USFWS, 1997). Two of these wetlands within these complexes, Brigantine - Barnegat and Great Egg Harbor - Jarvis Sound, include "focus areas" identified by the Atlantic Coast Venture of the North American Waterfowl Management Plan as critical waterfowl wintering, migratory, or breeding habitat, with an emphasis on American black duck habitat.

These estuarine wetland complexes are characterized by productive salt marshes, shallow bays, numerous tidal ditches, and salt ponds. These features contribute to making these wetlands some of the most important for wintering American black ducks, Atlantic brant, bufflehead (*Bucephala albeola*), and other waterfowl. The substrate of most bays and sounds are exposed at low tide and the invertebrates present are heavily utilized by shorebirds, wading birds, gulls, terns, and waterfowl. The predominant vegetation in these wetlands is salt marsh cordgrass, an important species for the production of food chain organisms for fish, shellfish, birds, and other wildlife.

The Reedy Creek (#6 Upper Barnegat Bay to Little Egg Inlet), Malibu Beach (#3 (Great Egg Harbor Estuary) , Cape Island - Pond Creek, and Sewell Point wetlands have also been designated as priority wetland sites by the U.S. Fish and Wildlife Service. The Reedy Creek Wetlands are within the northernmost extent of Barnegat Bay in Ocean County and are part of the Edwin B. Forsythe National Wildlife Refuge (NWR). The Malibu Beach Complex in Egg Harbor Township, Atlantic County, consists of a 300-acre tract of coastal wetlands, tidal creeks and pools, and beach/dune system. This site has the potential to be managed as a prime shorebird nesting and feeding area. The federally listed (threatened) piping plover (*Charadrius melodus*), common tern (*Sterna hirundo*), and rufa red knot (*Calidris canutus rufa*) are among the beach nesting birds that have nested in the area. The Cape Island - Pond Creek priority wetland site is located in the southwestern tip of Cape May and contains ecologically valuable freshwater and estuarine marshes. Sewell Point contains important forested wetlands and is located in the southeastern portion of Cape May (USFWS, 1999).

4.8.11 Terrestrial Habitats

Upland terrestrial habitats within the NJBB CSRM Study area include vegetated primary and secondary dunes along the coastal barrier islands, inlets, and undeveloped back-bay areas. The primary dune is most susceptible to salt spray and wind and is dominated by American beachgrass (*Amophila breviligulata*), sea rocket (*Cakile edentula*), seaside goldenrod (*Solidago* *sempervierens*), seaside spurge (*Euphorbia polygonifolia*), and seabeach pursulane *(Susuvium maritimum*). The back side of the primary dunes and the secondary dunes are more protected, which provide suitable conditions for beach heather communities (*Hudsonia tomentosa*) and scrub thickets composed of bayberry (*Myrica pennsylvanica*), wax myrtle (*M. cerifera*), beach plum (*Prunus maritima*) and poison ivy (*Toxicodendron radicans*). Maritime forests in the study area occur in several locations along the barrier islands that support black cherry (*Prunus serotina*), sassafras (*Sassafras albidum*), red cedar (*Juniperus virginiana*), serviceberry (*Amelanchier canadensis*) and American holly (*Ilex opaca*). These habitats are important for millions of neo-tropical migratory songbirds.

Open-sandy (unvegetated) upland areas on islands and spits in the NJBB study area provide important habitat for colonial nesting birds. Further inland and along the western edges of the NJBB area, more open woodlands dominated by pitch pine (*Pinus rigida*) and scattered holly and oak trees and a shrub layer dominated by lowbush blueberry (*Vaccinium angustifolium*) and sheep laurel (*Kalmia angustifolia*). Developed areas are common with numerous impervious and paved surfaces from buildings, roadways, parking lots, and sidewalks. Vegetation in these areas is limited to grassy strips, fields, lawns, and ornamental plantings, and waste areas that may harbor a number of non-native plant species.

4.8.12 Wildlife

The NJBB are along the Atlantic Coastal Flyway that contain critical open water bay habitats, tidal flats, saltmarshes, scrub shrub, beaches, and overwash flats that support a multitude of resident and migratory birds that include shorebirds, waterfowl, wading birds, colonial nesting birds, raptors and neotropical migrants. Raptors that occur in the area include the red-shouldered hawk (*Buteo lineatus*), redtailed hawk (*B. jamaicensis*), peregrine falcon (*Falco peregrinus*), osprey (*Pandion haliaetus*), Cooper's hawk (*Accipiter cooperii*), barred owl (*Strix varia*), and short-eared owl (*Asio flammeus*) (New Jersey Division of Fish, Game and Wildlife, 1994, as cited in USFWS 1999). These species utilize tidal marshes for nesting and foraging throughout the year. Ospreys nest on platforms in numerous locations throughout the project area and “feed primarily on fish within the back bays” (USFWS, 1999). The short-eared owl is a temporary resident of high marsh areas, feeding primarily on small mammals and birds (USFWS, 1999). Northern harriers are also known to “nest and feed in the salt and brackish marshes” along the Intracoastal Waterway. The red-shouldered hawk and Cooper’s hawk migrate over the area in spring and fall (USFWS, 1999). Other raptors that could occur in the project area during migration include American kestrel (*Falco sparverius*), merlin (*E. columbarius*), sharp-shinned hawk (*Accipiter striatus*), broadwinged hawk (*Buteo platypterus*), and the bald eagle (*Haliaeetus leucacephalus*).

The New Jersey barrier beach/back barrier lagoon system provides important habitat for shorebirds during spring and fall migrations. Wetlands in the area also provided high quality habitats for a variety of migratory shorebirds. Shorebirds using beach areas and associated estuarine wetlands in the study area include the black rail (*Laterallus jamaicensis*), American oystercatcher (*Haematopus palliates*), semi-palmated plover (*Charadrius semipalmatus*), Wilson's plover (*C. wilsonia*), piping plover (*C. melodus*), lesser golden plover (*Pluvialis dominica*), black-bellied plover (*P. squatarola*), hudsonian godwit (*Limosa haemastica*), marbled godwit (*Limosa fedoa*), whimbrel (*Numenius phaeopus*), sanderling (*Calidris alba*), semi-palmated sandpiper (*C. pusilla*), purple sandpiper (*C. maritima*), western sandpiper (*C. mauri*), least sandpiper (*C. minutilla*), white-rumped sandpiper (*C. fuscicollis*), Baird's sandpiper (*C. bairdii*), pectoral sandpiper (*C. melanotos*), red knot (*C. canutus*), dunlin (*C. alpina*), greater yellowlegs (*Tringa melanoleuca*), eastern willet (*Catoptrophorus semipalmatus*), curlew sandpiper (*C. ferruginea*), stilt sandpiper (*C. himantopus*), spotted sandpiper (*Actitis macularia*), ruddy turnstone (*Arenaria interpres*), and short-billed dowitcher (*Limnodromus griseus*) (New Jersey Division of Fish, Game and Wildlife, 1994, as cited in USFWS, 1999).

Nesting wading birds that occur within the area include the great blue heron (*Ardea herodias*), little blue heron (*Egretta caerulea*), tricolored heron (*E. tricolor*), snowy egret (*E. thula*), black-crowned night heron (*Nycticorax nycticorax*), yellow-crowned night heron (*Nyctanassa violaceus*), cattle egret (*Bubulcus ibis*), great egret (*Casmerodius albus*), glossy ibis (*Plegadis falcinellus*), great black-backed gull (*Larus marinus*), herring gull (*L. argentatus*), laughing gull (*L. atricilla*), glossy ibis (*Plegadis falcinellus*), black-legged kittiwake (*Rissa tridactyla*), gull-billed tem (*Gelochelidon nilotica*), Forster's tem (*Sterna forsteri*), common tern (*S. hirundo*), least tern (*S. antillarum*), black skimmer (*Rynchops niger*), common loon (*Gavia immer*), red-throated loon (*G. stellata*), great connorant (*Phalacrocorax carbo*), and doublecrested cormorant (*P. auritus*) (New Jersey Division of Fish, Game and Wildlife, 1994, as cited in USFWS, 1999).

Estuarine marshes, bays, and channels within the area are important resting and feeding areas for migratory waterfowl on the Atlantic flyway. The bays and associated coves within the area provided habitat for tundra swan (*Cygnus columbianus*), mute swan (*Cygnus olor*), Canada goose (*Branta canadensis*), Atlantic brant (*Branta bernicla*), American black duck (*Anas rubripes*), gadwall (*Anas strepera*), American wigeon (*Mareca americana*), northern pintail (*Anas acuta*), bluewinged teal (*A. discors*), green-winged teal (*A. crecca*), northern shoveler (*A. clypeata*), redhead (*A. Americans*), lesser scaup (*Aythya affinis*), common goldeneye (*Bucephala clangula*), mallard, bufflehead, greater scaup, canvasback, long-tailed duck (*Clangula hyemalis*), wood duck (*Aix sponsa*), ruddy duck (*Oxyura jamaicensis*), red-breasted merganser (*Mergus serrator*), hooded merganser (*Lophodytes cucullatus*), common merganser (*M. merganser*), and canvasback (*Aythra valisneria*) (New Jersey Division of Fish, Game and Wildlife, 1994, as cited in USFWS 1999).

Dabbling ducks and bufflehead are fairly evenly distributed along the shorelines and tidal creeks of estuaries, while diving ducks occur mostly in more open water areas (USFWS, 1997). Inlet waterways are an important concentration area for many waterfowl species during harsh winters when other area water surfaces freeze. Breeding waterfowl in estuaries include American black duck, gadwall, mallard, and Canada goose. Salt marshes provide an important larval insect food source for newly hatched ducklings (USFWS, 1997).

A number of marine mammals (protected under the Marine Mammals Protection Act) are commonly observed in New Jersey Atlantic coastal waters. Cetaceans (whales and dolphins) may be present within the affected area. Some of the taxa likely to be seen include bottlenose dolphin (*Tursiops turncatus*), common dolphin (*Delphinus delphis*), common/harbor porpoise (*Phocoena phocoena*), short-finned pilot whale (*Globiocephala sieboldii macrorhyncus*) and fin whale (*Balaenoptera physalus*). The project area is within the range of a number of seals (Pinnipeds), which may be seen in the areas occasionally and/or frequently. Seals occur along the New Jersey coastline including the Back Bay Area's primarily between the months of November through April. The most common seal in New Jersey is the harbor seal (*Phoca vitulina*). Other species of seals found in the state include the larger gray seal (*Halichoerus grypus*), the harp seal (*Pagophilus groenlandica*), and on rare occasions, the hooded seal (*Cystophora cristata*). (http://conservewildlife.maps.arcgis.com/apps/MapJournal/index.html?appid=d2266f32c36449e

0b9630453e56c3888&webmap=564588c5cff04fa990aab644400475f9). There are two areas with significant seal colonies within the NJBB area. The Great Bay seal colony is the largest seal colony within New Jersey and the largest seal colony along the US East Coast south of Long Island, NY. It is regularly used as a haul-out site by 120+ individuals each winter. Up to 150 seals have been observed at this site at one time. The second location within the NJBB CSRM Study area is located at Barnegat Inlet, which is New Jersey's third largest seal colony. As many as four species of seal (grey, harbor, harp, and hooded) may occur within these colonies, with harbor seals being the most abundant (M. Davenport, Conserve Wildlife Foundation of NJ, personal communication).

Cetaceans such as dolphins and porpoises may occasionally venture into the shallower New Jersey Back Bays in search of prey. Some of the more common species include bottlenose dolphin and the harbor porpoise.

Non-marine mammals known to occur within upland habitats in the study area include raccoon (*Procyon lotor*), red fox (*Vulpes vulpes*), gray fox (*Urocyon cinereoargenteus*), gray squirrel (*Sciurus carolinensis*), striped skunk (*Mephitis mephitis*), meadow vole (*Microtus pennsylvanicus*), eastern cottontail (*Sylvilagus floridanus*), Virginia opossum (*Didelphis virginiana*), red bat (*Lasiurus borealis*), little brown bat (*Myotis lucifugus*) and white-tailed deer (*Odocoileus virginianus*) (New Jersey Division of Fish, Game and Wildlife, 1994, as cited in USFWS, 1999).

Mammals that would likely inhabit freshwater and brackish wetlands, rivers, and saltmarshes along the back bays of the study area include common muskrat (*Ondatra zibethicus*), raccoon, Virginia opossum, white-tailed deer, and river otter (*Lutra canadensis)* (USFWS, 1999).

Small mammals that could also utilize the upper saltmarsh and marsh transition areas include the meadow vole, meadow jumping mouse (*Zapus hudsonius*), and white-footed mouse (Daiber, 1982).

A number of mammals are likely to be found in terrestrial habitats including raccoon (*Procyon lotor*), red fox (*Vulpes vulpes*), gray fox (*Urocyon cinereoargenteus*), gray squirrel (*Sciurus carolinensis*), striped skunk (*Mephitis mephitis*), meadow vole (*Microtus pennsylvanicus*), eastern cottontail (*Sylvilagus floridanus*), Virginia opossum (*Didelphis virginiana*), red bat (*Lasiurus borealis*), little brown bat (*Myotis lucifugus*) and white-tailed deer (*Odocoileus virginianus*).

Several species of turtles and snakes could occur in upland areas of the barrier island complex within the study area including the snapping turtle (*Chelydra serpentina*), eastern mud turtle (*Kinosternon subrubrum*), stinkpot (*Sternotherus odoratus*), northern watersnake (*Natrix sipedon*), northern black racer (*Coluber constrictor*), and eastern garter snake (*Thamnophis sirtalis*). The distribution of these species is limited by the availability of fresh water, as they are intolerant of higher salinity. The northern diamondback terrapin (*Malaclemys terrapin terrapin*), a "species of special concern" is also known to inhabit marshes, tidal flats, and beaches within New Jersey estuaries.

4.8.13 Fisheries Resources

The presence of extensive estuarine wetlands, tidal creeks and inlets, mudflats and SAV beds within the New Jersey Back Bays allows the coastal waters of New Jersey to have a productive fishery. Many species utilize the estuaries behind the barrier islands for forage and nursery grounds. The finfish found along New Jersey coastal waters are principally seasonal migrants. Winter is a time of lower abundance and diversity as most species leave the area for warmer waters offshore and southward. During the spring, increasing numbers of fish are attracted to the New Jersey Coast, because of its proximity to several estuaries, which are utilized by these fish for spawning and nurseries (USACE 2002).

The great diversity of fish fauna found in the NJBB estuarine habitats includes both resident and transient species. Species habitat use is best understood in terms of life history, as many fish species occupy estuarine habitats only during certain life-stages. Several fish species are continuously present in coastal habitats, while others are present only during certain periods (e.g., during spring many fish species use specific habitats for spawning). Thus, the distribution and abundance of important indicator fish species vary both temporally and spatially (NOAA, 1994).

These estuarine environments are extremely important to a wide number of fish species because of the multitude of niche environments available to fish. Certain fish species utilize shallow water vegetated habitats for spawning while others migrate out to open water to distribute their eggs as planktonic forms. Similarly, some larval fish species migrate from open water as they develop and enter highly productive estuarine environments to grow and develop into juvenile stages. In this respect estuaries provide both ample amounts of both food and protection for larval and juvenile stages of fish (Able and Fahay, 1998).

High marsh and tidal mud flat areas have been shown to provide important year-round habitat for many groups of fishes including killifishes (*Fundulidae*), needlefishes (*Belonidae*), and silversides (*Atherinidae*) (Talbot and Able, 1984). In addition, larval and juvenile stages of numerous fish species such as herring (*Clupidae*), white perch (*Morone americana*), striped bass (*Morone saxatilis*), menhaden (*Brevoortia tyrannus*), and winter flounder (*Pseudopleuronectes americanus*) utilize high marsh and tidal mud flat environments during spring, summer, and fall seasons. The variable microhabitats found throughout these environments provide both protection and cover as well as food sources for early life stages of fish found throughout estuarine habitats and are important to the success of year classes of many of these species as nurseries, foraging areas, and cover habitat.

Habitats with restricted tidal flows such as marsh potholes and closed ponds often have associated fish assemblages that consist of low diversity and high abundance. For example, killifish are highly tolerant of wide variations in salinity and temperature and are known to dominate these types of habitats. High marsh habitat dominated by common reed has been shown to negatively affect the success and survival of larval and juvenile fish (Able and Hagan, 2000). Common reed habitats offer few niche habitats and associated biomass available as food sources. Conversely, low marsh areas dominated by *Spartina alterniflora* have been shown to provide high quality habitat for many fish species (Able and Hagan, 2000). Other vegetation types present in submerged aquatic vegetation beds such as eel grass and water celery provide both spawning habitats as well as nursery and feeding habitat for juvenile fish.

Certain fish such as striped bass travel through numerous habitat types along with daily tidal fluctuations (Tupper and Able, 2000). They may utilize low and high marsh channels during flood tides to areas where food is available in higher abundance, and then move back into deeper water and channels with the ebb tide. Adult migratory fish species exhibit this behavior throughout estuarine habitats and utilize numerous types of intertidal habitat types.

Many species of estuarine-dependent fish (fish species that spend some stage of life history within an estuary) exist within the study area. Estuarine-dependent species that comprise the majority of the ecologically, recreationally, and commercially important fisheries include Atlantic menhaden, weakfish (*Cynoscion regalis*), spot (*Leiostomus xanthurus*), Atlantic croaker (*Micropogonias undulatus*), northern kingfish (*Menticirrhus saxatilis*), silver perch (*Bairdiella chrysoura*), bluefish (*Pomatomus saltatrix*), summer flounder (*Paralichthys dentatus*) and winter flounder (Beccasio et al., 1980).

Species known to utilize estuaries along the Atlantic Coast of New Jersey include summer flounder (*Paralichtys dentatus*), black sea bass (*Centropristis striata*), striped bass, bluefish, winter flounder, tautog (*Tautoga onitiss*), weakfish, scup (*Stenotomus chrysops*), white perch, and Atlantic menhaden. In a study conducted at Peck Beach, 178 species of saltwater fishes were recorded. Of these, 156 were from the nearshore waters. Of the 124 species recorded in nearby Great Egg Harbor Inlet, 28 are found in large number in offshore waters. Eighty-seven species were found in the nearshore-ocean, bay and inlets adjacent to Peck Beach. Of these, 46 were located in the near shore waters. Sixty-two species were identified in Great Egg Harbor Inlet (USACE, 1989; USACE 2001).

During a comprehensive baseline finfish survey of the Hereford Inlet estuary of Cape May County (an area characterized by shallow sounds and extensive saltmarshes), a total of 105 species were collected within the tidal marsh embayment (Allen et al., 1978). Species collected in more than 10 percent of samples included bay anchovy (*Anchoa mitchilli*), sheepshead minnow (*Cyprinodon variegatus*), mummichog (*Fundulus heteroclitus*), striped killifish (*Fundulus majalis*), Atlantic silverside (*Menidia menidia*), tidewater silverside (*Menidia beryllina*), northern pipefish (*Syngnathus fuscus*), black sea bass, bluefish, spot, white mullet (*Mugil curema*), smallmouth flounder (*Etropus microstomus*), summer flounder, windowpane (*Scophthalmus aquosus*), and winter flounder.

Man-made structures within the study area such as groins and jetties add more habitat diversity within the study area for finfish. Juvenile and larval finfish such as black sea bass, summer flounder, winter flounder, and striped bass utilize these areas for feeding, protection from predators, and nursery habitat. However, extensive development in the New Jersey Back Bay communities has resulted in degraded fish habitats where shallows including SAV beds, saltmarshes, and tidal flats have been significantly altered or lost due to dredging, bulk heading, revetments, and other alterations along the NJBB shorelines.

The economic importance of New Jersey's marine fisheries is well documented. For 2012, it was estimated that the total economic impact of recreational fishing in New Jersey totaled over $1.1 billion (NMFS 2014). Fourteen recreational species of interest were identified by the New Jersey Department of Environmental Protection (NJDEP), including; scup, black sea bass, summer flounder, weakfish, bluefish, striped bass, red hake (*Urophycis chuss*), silver hake (*Merluccius bilinearis*), Atlantic mackerel (*Scomber scombrus*), Atlantic croaker, winter flounder, cunner (*Tautogolabrus adspersus*), Atlantic cod (*Gadus morhua*), and tautog.

Fifteen commercial species of fish generated over $1 million of revenue each in 2014 (NOAA 2015). In total, commercial landings in New Jersey were valued at $151,930,102 in 2014. Some of the highest grossing species include sea scallop (*Placopecten magellanicus*), Atlantic surf clam (*Spisula solidissima*), blue crab, longfin squid (*Doryteuthis pealeii*), skates, menhaden, summer flounder, scup, and black sea bass.

4.8.13.1 Essential Fish Habitat

Essential Fish Habitat (EFH) is defined in the Magnuson-Stevens Fishery Conservation and Management Act, (PL 94-265 as amended through October 11, 1996 and 1998) as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity". Regulations further clarify EFH by defining "waters" to include aquatic areas that are used by fish and may include aquatic areas that were historically used by fish where appropriate. A purpose of the act is to "promote the protection of essential fish habitat in the review of projects conducted under federal permits, licenses, or other authorities that affect, or have the potential to affect such habitat". An EFH assessment is required for a federal action that could potentially adversely impact essential fish habitat.

The back bays and coastal waters of New Jersey have been designated as EFH for a variety of life stages of fish managed under the New England Fishery Management Council, the Mid-Atlantic Fishery Management Council and National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS). Species designated in the NJBB area include Mid-Atlantic, New England, and coastal migratory pelagic species as well as a number of sharks and other highly migratory species (NMFS, 2016).

The NMFS and fishery management council roles in EFH are described in 67 FR 2343. Through Subpart J, fishery management councils must identify Fishery Management Plans (FMPs) EFH for each life stage of each managed species in the fishery management unit. The regulations also provide that councils: should organize information on the habitat requirements of managed species using a four-tier approach based on the type of information available, identify as EFH those habitats that are necessary to the species for spawning, breeding, feeding, or growth to maturity, describe EFH in text and must provide maps of the geographic locations of EFH or the geographic boundaries within which EFH for each species and life stage is found, identify EFH that is especially important ecologically or particularly vulnerable to degradation as "habitat areas of particular concern" (HAPC) to help provide additional focus for conservation efforts, and must evaluate the potential adverse effects of fishing activities on EFH and must include in FMPs management measures that minimize adverse effects to the extent practicable. Additionally, councils must identify other activities that may adversely affect EFH and recommend actions to reduce or eliminate these effects.

Through Subpart K, "NMFS will make available descriptions and maps of EFH to promote EFH conservation and enhancement. The regulations encourage Federal agencies to use existing environmental review procedures to fulfill the requirement to consult with NMFS on actions that may adversely affect EFH, and they contain procedures for abbreviated or expanded consultation in cases where no other environmental review process is available. Consultations may be conducted at a programmatic and/or project-specific level. In cases where adverse effects from a type of actions will be minimal, both individually and cumulatively, a General Concurrence procedure further simplifies the consultation requirements. The regulations encourage coordination between NMFS and the Councils in the development of recommendations to Federal or state agencies for actions that would adversely affect EFH. Federal agencies must respond in writing within 30 days of receiving EFH Conservation Recommendations from NMFS. If the action agency's decision is inconsistent with NMFS' EFH Conservation Recommendations, the agency must explain its reasoning and NMFS may request further review of the decision. EFH Conservation Recommendations are non-binding."

The coastal estuarine habitats of the project area have been designated as habitat for a number of managed species and their specific life history stages of concern. Some specific species and life stages that are designated for EFH in the New Jersey Inland Bays include summer flounder (larvae through adult), scup (juvenile), black sea bass (juvenile and adult), bluefish (juvenile and adult), and juvenile butterfish.

EFH assessments also examine the potential effects on prey species for the managed fish species potentially occurring within the area. Prey species are defined as being a forage source for one or more designated fish species. They are normally found at the bottom of the food web in a healthy environment. Prey species found in the project area estuaries include killifish, mummichogs, silversides and herrings.

To determine the extent of EFH within the NJBB CSRM Study area, the EFH Mapper was accessed at (https://www.fisheries.noaa.gov/resource/map/essential-fish-habitat-mapper). Federally managed fish species that may be found within the project area are listed in Table 14. Several of these species including the highly migratory species primarily inhabit marine offshore habitats throughout their lives and are not of major concern since they are largely outside of the project area. The remaining fish species can be found within inshore habitats during at least part of their life cycle. Not all areas of the New Jersey Back Bays are EFH for the species in Table 14. An "X" only indicates EFH present within one or more areas within the NJBB CSRM Study area. EFH in the NJBB CSRM Study area is defined in greater detail in Appendix F.2.

Table 14: NJBB EFH Life Stages Identified in EFH Mapper

Managed Species	Eggs	Larvae	Juveniles	Adults
Mid-Atlantic Species				
Atlantic butterfish *(Peprilus tricanthus)*	X		X	X
Atlantic mackerel (*Scomber scrombrus*)	X			
Atlantic surfclam *(Spisula solidissima)*			X	X
Black sea bass *(Centropristus striata)*			X	X
Bluefish *(Pomatomus saltatrix)*			X	X
Short finned squid *(Illex ilecebrosus)*	X	X		
Long finned inshore squid *(Loligo pealei)*	X		X	X
Scup *(Stenotomus chrysops)*			X	X
Spiny dogfish *(Squalus acanthias)*			X	X
Summer flounder *(Paralicthys dentatus)**HAPC***		X	X	X
New England Species*				
Atlantic cod *(Gadus morhua)*	X	X		
Ocean pout *(Macrozoarces americanus)*	X			X
Pollock (*Pollachius virens*)		X		
White hake (Urophycis tenuis)	X			
Windowpane flounder *(Scopthalmus aquosus)*	X	X	X	X
Winter flounder (*Pseudopleuronectes americanus*)** ****EFH for winter flounder does not occur south of Lat 39°22' N.**	X	X	X	X
Witch flounder (*Glyptocephalus cynoglossus*)	X			
Yellowtail flounder (*Limanda ferruginea*)	X	X	X	X
Silver hake/whiting (*Merluccius bilinearis*)	X	X	X	X
Red hake *(Urophycis chuss)*	X	X	X	X
Monkfish *(Lophius americanus)*	X	X		
Little skate (*Raja erinacea*)			X	X
Winter skate (*Raja ocellata*)			X	X
Clearnose skate (*Raja eglanteria*)			X	X
Atlantic sea herring (*Clupea harengus*)			X	X

Managed Species	Eggs	Larvae	Juveniles	Adults
Coastal Migratory Pelagic Species				
King mackerel *(Scomberomorus cavalla)*	X	X	X	X
Spanish mackerel *(Scomberomorus maculatus)*	X	X	X	X
Highly Migratory Species				
Bluefin Tuna (*Thunnus thynnus*)			X	X
Skipjack Tuna (*Katsuwonus pelamis)*				X
Yellowfin Tuna (*Thunnus albacares*)			X	
Shark Species				
Managed Species	**Neonates**		**Juveniles**	**Adults**
Sand tiger shark *(Odontaspis taurus)*	X		X	X
Atlantic angel shark *(Squatina dumerili)*	X		X	X
Common thresher shark (*Alopias vulpinus)*	X		X	X
Dusky shark *(Charcharinus obscurus)*	X			
Sandbar shark *(Charcharinus plumbeus)*	X		X	X
Sandbar shark *(Charcharinus plumbeus)* ***HAPC***	**X**		**X**	**X**
Smoothhound shark (Mustelus mustelus)	X		X	X
Tiger shark *(Galeocerdo cuvieri)*			X	X
White shark *(Carcharodon carcharias)*	X		X	X
***Digital mapping and location queries were unavailable, maps in NEFMC (2017) were utilized for life stage mapping of New England Fishery Management Species that occur in NJBB CSRM Study Area Waters**				

4.8.13.2 Habitat Areas of Particular Concern

Habitat Areas of Particular Concern (HAPC) are areas of EFH that are judged to be particularly important to the long-term productivity of populations of one or more managed species, or to be particularly vulnerable to degradation (NOAA, 1999a). Species-related HAPC's were identified in three areas within the study area. Additionally, submerged aquatic vegetation (SAV) beds in the back bays system are considered HAPC. A HAPC exists near the mouth of the Delaware Bay, which includes the entrance to the Cape May Inlet on the Delaware Bay side for the sand tiger shark (Carcharias taurus), and two HAPC areas exist for the sandbar shark (Charcharinus plumbeus) occurring in the lower Delaware Bay (including the entrance to Cape May Inlet) and the Great Bay estuary complex including Little Egg Inlet, Little Bay, Reed Bay, Absecon Bay, Lakes Bay, and Absecon Inlet along with the nearshore Atlantic Ocean along Brigantine Island and the northern half of Absecon Island. HAPCs occur within the study area for summer flounder (Paralicthys dentatus) in areas where "all native species of macroalgae, seagrasses, and freshwater and tidal macrophytes in any size bed, as well as loose aggregations, within adult and juvenile summer flounder EFH is HAPC."

4.8.13.3 Shellfish

N.J.A.C. 7:7-9.2 (Shellfish habitat) defines shellfish habitat "as an estuarine bay or river bottom which currently supports or has a history of production for hard clams (*Mercenaria mercenaria*), soft clams (*Mya arenaria*), eastern oysters (*Crassostrea virginica*), bay scallops (*Argopecten irradians*), or blue mussels (*Mytilus edulis*).

In order to be considered regulated shellfish habitat, a site must meet two parameters: habitat quality and water quality.

Habitat: Quality:

Shellfish habitat is defined as an area which meets one or more of the following criteria:

- The area has a current shellfish density equal to or greater than 0.20 shellfish per square foot;
- The area has a history of natural shellfish production or is depicted as having high or moderate commercial value in the Distribution of Shellfish Resources in Relation to the New Jersey Intracoastal Waterway (U.S. Department of the Interior, 1963), "Inventory of New Jersey's Estuarine Shellfish Resources" (Division of Fish, Game and Wildlife, Bureau of Shellfisheries, 1983-present); and/or the "Inventory of Delaware Bays Estuarine Shellfish Resources" (Division of Fish, Game and Wildlife, Bureau of Shellfisheries, 1993);
- The area is designated by the State as a shellfish culture area; or
- The area is designated as productive at N.J.A.C. 7:25-24, Leasing of Atlantic and Delaware Bay bottom for Aquaculture."

Extensive shellfish beds, which fluctuate in quality and productivity, are found in the back bays and shallow marine waters of the study area. Bivalves such as Atlantic surfclams, hard clams, and blue mussels and crustaceans such as blue crabs (*Callinectes sapidus*) are common commercial and recreational shellfish within the coastal waters of the study area. Additionally, the soft clam, bay scallop and Eastern oyster are also found at certain locations within the study area. Historic shellfish beds within the NJBB CSRM Study area are presented in Appendix F.1. The blue crab and the hard clam are two of the most important invertebrates of recreational and commercial value along the New Jersey Atlantic Coast estuaries and are common in the back bays and inlets (USACE 1999).

Hard Clams

Hard clams are an important commercial shellfish species that up until 2008 had on average of over 1 million pounds of meat with 2008 landings at 1,529,231 pounds at a value of over $6 million. Hard clams are typically found in the intertidal and subtidal zones of bays and lower estuaries. Shellfish distribution maps from 1963 (USFWS, 1963) demonstrate historic widespread occurrences of hard clams at various commercial and recreational densities throughout all of the study area. Factors that contribute to having a viable hard clam resource include salinity, dissolved oxygen levels, bottom conditions, and predator activity. Subsequent commercial and recreational shellfish surveys centered in Little Egg Harbor, Barnegat Bay and the Manasquan River were performed by the NJDEP Bureau of Shellfish in the mid 1980's and 2011-2012. The Barnegat Bay Partnership (BBP, 2016) reported from NJDEP Bureau of Shellfish surveys in 2011 and 2012 that there was an estimated standing stock of hard clams in Barnegat Bay and Little Egg Harbor of 224 million clams, down about 23% from surveys done in 1985/1986 (although there was a modest increase in Little Egg Harbor from a survey done in 2001). Declines in hard clam stocks are not attributed to any one factor, but may be caused by habitat degradation, siltation, harvest pressure, lack of management, varied water quality, and wetlands destruction (Fimlin, 2004). Based on the overall decline in hard clam stocks, the BBP has assessed that the indicator status for shellfish in Barnegat Bay as "degraded".

Hard Clam Aquaculture

In order to bolster the hard clam fishery in the New Jersey Back Bays, aquaculture is practiced in permitted areas. Flimlin (2004) reported that the aquaculture industry supported six hard clam hatcheries and three separate land based nursery systems, located mainly in southern Ocean, Atlantic, and northern Cape May counties with most of the leased grow-out areas located in the same general vicinity. It was estimated that there were about 50 active clam growers producing millions of high-quality clams each year. NJAAC (2011) reported that only a few hundred acres out of the 2,500 total leased acres along the Atlantic Coast bays were actively farmed for hard clams, but the leased acres were being severely underutilized. One area of notable lease expansion was in the Middle Island Channel Thoroughfare in Barnegat Bay, which attributes to having favorable conditions for shellfish production because of good tidal flow and a narrow channel that is less frequented by recreational users.

Blue Crabs: Blue crabs are abundant all along the New Jersey coast, and occur in tidal creeks and rivers and in shallow, saltwater bays. Based on both commercial and recreational data from 2005 through 2007, an average of over 19.2 million crabs are caught in any given year with the recreational harvest averaging over 6 million crabs per year (retrieved from https://www.nj.gov/dep/fgw/bluecrabresearch.htm on 2/1/2020).

4.8.13.4 Shellfish Growing Waters

N.J.A.C. 7:12 provides rules for NJDEP to implement procedures to classify shellfish waters and their boundaries to protect the health, safety, and welfare from the risks associated with the consumption of shellfish. Classifications of shellfish waters were developed in accordance with the guidelines of the National Shellfish Sanitation Program (NSSP), a Federal/State cooperative program. A number of factors determine the classification of shellfish waters, including ambient bacteriological water quality and point and non-point pollution sources. The classifications are Approved, Conditionally Approved, Conditionally Restricted, Restricted, Prohibited, and Suspended. The NJBB CSRM Study area includes a broad geographic area including Atlantic Ocean waters, large and small bays, tidal creeks with surrounding variable land uses that have point and non-point discharges, and marinas that would result in variable shellfish growing water classifications. These classifications are summarized by reach/unit in Table 15.

Table 15: Classifications of Shellfish Waters

			Classifications					
Unit	**Reach**	**Growing Area (acres)**	**Approved**	**Condition-ally Approved**	**Restricted (no harvest for direct market)**	**Pro-hibited**	**Sus-pended**	**Notes**
				Atlantic Ocean				
AONC	Monmouth Beach to Bayhead	46,664	68.5%			31.5%		A number of discharge pipes and outfalls of six wastewater treatment facilities are responsible for "prohibited" areas that also act as buffers for dilution.
AOCE	Bayhead to Beach Haven Terrace	78,443	91.5%			8.5%		A number of discharge outfalls of three wastewater treatment facilities are responsible for "prohibited" areas that also act as buffers for dilution.
AORE	Beach Haven Terrace to Absecon Inlet	38,549	100%					This area does not contain any actual or potential pollution sources.
AOSO	Absecon Inlet to Cape May Point	109,860	87.1%			12.9%		Four discharge outfalls for six wastewater treatment facilities are responsible for "prohibited" areas that also act as buffers for dilution.
				Barnegat Bay				
BB1	Northern Barnegat Bay (from Seaside Hts. to Bay Head)	11,000	39.3%	9% (Nov-Apr)	39.1%	12.6%		Waters of N. Barnegat Bay, Metedeconk River, Beaver Dam Ck, Cedar Bridge Ck, & N. Branch Ck. Bordered by Brick Twp., Bay Head, Mantoloking, Lavallette, Point Pleasant, Seaside Hts, Berkeley Twp., and Toms River.
BB2	Central Barnegat Bay – Toms River, Cedar Creek.	14,000	67.5%	7.5% (Nov-Apr)	14.3%	10.6%		Waters of Central Barnegat Bay, Toms River, Cedar Ck and Tributaries. Bordered by Seaside Pk., Seaside Hts., Island Hts., S. Toms River, Beachwood, Pine Beach, Ocean Gate, Berkeley Twp., and Lacey Twp.
BB3	Barnegat Inlet Area	40,062	82.7%	11.4% (Nov-Apr)	3.7%	2.2%		Waters of Barnegat Bay, Westecunk Creek, Dinner Pt. Ck., Mill Ck., Big Flat Ck., Double Ck., Oyster Ck. & Forked River. Bordered by Eagleswood, Stafford, Barnegat Ocean Township, Forked River, Long Beach Twp., Barnegat Light, Harvey Cedars, Surf City and Ship Bottom.
BB4	Southern Barnegat Bay	13,552	94.1%	3.7% (Nov-Apr)	0.7%	1.5%		Waters of S. Barnegat Bay, Little & Big Sheepshead Ck, Jimmies Ck, Little Thoro, Big Thoro, Tuckerton Ck, Jeremy Ck, Thompson Ck, Jesses Ck, and Parker Run. Bordered by Long Beach Twp., Beach Haven, Little Egg Harbor, Tuckerton and Eagleswood Twp.
				Northeast Waterbodies				
NE4	Shark River	800			66.7%		33.3%	All waters are restricted in Shark River with 266.7 acres of this area designated as "suspended" due to consistent data that indicate fecal coliform standards for Restricted are not met.
NE5	Manasquan River				55%	45%		Waters are prohibited upstream of the Rt. 70 Bridge across the Manasquan River and waters of Point Pleasant Canal, Lake Louise, The Glimmer Glass Bay, and Stockton Lake. Restricted waters are downstream of Rt. 70 through to the inlet.
				Southeast Waterbodies				

			Classifications					
Unit	**Reach**	**Growing Area (acres)**	**Approved**	**Condition-ally Approved**	**Restricted (no harvest for direct market)**	**Pro-hibited**	**Sus-pended**	**Notes**
SE1	Mullica River - Great Bay	17,932	72.8%	3.6% (Nov-Apr) 0.1% (Jan-Apr)	21.3%	2.2%		Waters of Great Bay and Mullica River. Tributaries include Roundabout Ck, Ballanger Ck. Big and Little Sheepshead Ck., Jimmies Ck, Little Thorofare, Motts Ck and Oyster Ck. Borders Galloway Twp., Port Republic City, Egg harbor City, Mullica Twp., Bass River Twp., and Little Egg Harbor Twp.
SE2	Reeds Bay - Absecon	14,343	86.6%	3.5% (Nov-Apr) 2.6% (Jan-Apr)	6.7%	0.6%		Waters of Absecon Bay, Reeds Bay, Little Bay, Grassy Bay, Absecon Channel, Brigantine Channel, Beach Thorofare, Bonita Tideway and St. George Thorofare. Borders Atlantic City, Brigantine City, Galloway Twp.,
SE3	Lakes Bay	15,140	50.3%	14.2% (Nov-Apr) 3.2% (Jan-Apr)	24.6%	7.7%		Waters of Lakes Bay, Shelter Island Bay, Scull Bay, Great Egg Harbor Bay and Peck Bay including tributaries of Great Egg Harbor River, Patcong Ck and Tuckahoe River.
SE4	Corson Sound - Ludlam Bay	1,408	72.2%	17.0% (Nov-Apr)	2.7%	2.5%		Waters of Peck Bay, Crook Horn Ck, Corson Sound, Corson Inlet, Upland Thoro., Beach Ck, Edward Ck, Devils Thoro., Weakfish Ck, Middle Thoro., Strathmere Bay, Ben Hands Thoro., Mill Ck, Marshalls Ck, Main Channel, Flat Ck, Burroughs Hole, Main Thoro., Whale Ck, and Run Ck. South of Ocean City, north of Sea Isle City, Upper Twp. and Dennis Twp. to west.
SE5	Ludlum Bay - Townsends Inlet	3,574	79.8%	3.0% (Nov-Apr) 1.1% (Jan-Apr)	9.1%	9.9%		Waters of Ludlam Bay, Townsends Sound, Stites Sound, Townsends Inlet, Devauls Ck, Maple Swamp, Big Elder Ck, Little Elder Ck, Swimming Ck, Ludlam Thoro, Sunks Ck, Mill Ck, Scraggy Ck, Ware Thoro, Mill Thoro, Townsend Channel, Clem Thoro, Granny Creek, Mud Thoro, Jonadab Ck, Uncle Aarons Ck, Kitts Thoro, Bottle Ck, Middle Thoro, North Channel, South Channel, Leonard Thoro, Ingram Thoro, Gravens Thoro, Cornell Hbr, Pennsylvania Hbr, Princeton Hbr, S Ck, Deep Ck, Rachael Gut, Salt Ck, Cat Run, Deep Thoro, and Paddy Thoro. Uppr Twp., Sea Isle City/Avalon, and Dennis/Middle Twp.
SE6	Hereford Inlet and Jenkins – Richardson Sound	7,083	42.1%	44% (Nov-Apr) 0.02% (Jan-Apr)	2.2%	11.8%		Waters of Great Sound, Jenkins Sound, Grassy Sound, Richardson Sound, Hereford Inlet, Gull Island Thoro, Cresse Thoro, Scotch Bonnet Ck, Nicols Channel, Dung Thoro, Drum Thoro, Jenkins Channel, Great Channel, Grassy Sound Channel, Old Turtle Thoro, and Taugh Ck. Avalon, Stone Harbor, N.& W. Wildwoods, & WW.
SE7	Sunset Lake to Cape May Harbor	2,525		24.8% (Jan-Apr)	31.7%	43.5%		Waters of Taylor Sound, Sunset Lake, Jarvis Sound, the Cape May Canal, Cape May Hbr, Cape May Inlet, Richardson Channel, Grassy Sound Channel, Shaw Cutoff, Sedge Ck, Stites Ck, Stingaree Ck, Swain Channel, Taylor Ck, Terrapin Thoro, Jones Cr, Old Turtle Ck, Jarvis Sound Thoro, Reubens Thoro, Punyard Ck, Haulover Ck, York Ck, Meadow Ck, Shell Thoro, Upper Thoro, Bennett Ck, Mill Ck, Skunk Sound, Ford Ck, Middle Thoro, Duck Gut, Mud Hen Gut, Lower Thoro, Old Lower Thoro, Schellenger Ck, Spicer Ck, and Cape Island Ck. WW & WW Crest, Lwr. Twp. and Cape May.

Source: https://www.nj.gov/dep/bmw/nsspreports.html

4.8.14 Invertebrates

The coastal habitats along the New Jersey coast including the back bays are home to a wide variety of both benthic and free swimming and floating invertebrates. Invertebrate groups found in various coastal habitats include Cnidaria (hydra, corals, anemones, jellyfish), Platyhelminthes (flatworms), *Nemertinea* (ribbon worms), Nematoda (roundworms), Polychaetes (bristle worms), Oligochaetes, *Bryozoa*, Mollusca (chitons, bivalves, snails, squids, etc.), Crustaceans (crabs, shrimp, amphipods), insects (Dipterans), Echinodermata (sea urchins, sea cucumbers, sand dollars, starfish), Urochordata (tunicates), and zooplankton, which may represent a number of different phyla at various life stages.

Benthic macroinvertebrate communities are commonly used as indicators of overall quality of water and benthic habitats. Indices measuring such parameters as abundance and species composition are well developed and often used in describing quality of habitats and also the potential food sources for higher consumers. In particular, benthic invertebrates make up the primary food source for both juvenile and adult fish species in shallow water environments found in estuarine habitats. Benthic invertebrate communities vary spatially and temporally (NOAA, 1994) as a result of factors such as sediment type, water quality, depth, temperature, predation, competition, and season. Thus, benthic invertebrate communities differ between habitat types. For example, the community within fine grain sediment found in deep water, low energy environment is likely to be dominated by a higher percentage of sessile organisms, while a shallow, high energy environment consisting of larger grain sediment may contain a higher percentage of mobile filter feeding invertebrates. The New Jersey back bays are rich in benthic taxa. A total of 276 taxa (220 of which were infaunal taxa) were collected in a recent benthic survey of the Barnegat Bay and Little Egg Harbor estuaries by Taghon *et* al. (2016), demonstrating a fairly diverse benthic community. However, five of these taxa made up 50% of the total abundance, which include polychaetes: *Mediomastus ambiseta and Streblospio benedicti;* amphipods*: Ampelisca abdita and A. verrilli*; and Oligochaeta.

Shallow water intertidal areas consisting of habitats such as high salt marshes, low salt marshes, mudflats, and estuarine wetlands dominated by common reed provide habitat for benthic invertebrate groups that are tolerant of a continuously changing environment such as *oligochaetes*, *polychaetes*, and nematodes. These habitats are frequently inhabited by the fiddler crab (*Uca spp*.), salt marsh snail (*Melampus bidentatus*), and ribbed mussels (*Geukensia demissus*). Other groups of benthic invertebrates that inhabit these habitats in lesser abundance include ceratopogonids, chironomids (green head flies, and mosquitos), mites, ostracods, isopods, and gastropods. High marsh habitats that are rarely affected by tidal influence generally contain lower abundances of aquatic invertebrates and a higher proportion of terrestrial taxa as a result. By comparison, habitats such as low saltmarsh and mosquito ditches are inundated most of the time and are home to a higher abundance of aquatic organisms. Similarly, the benthic macro invertebrate community may differ between vegetation types, such as within high marsh habitats dominated by common reed (*Phragmites*) vegetation versus low marsh habitat dominated by *Spartina alterniflora*. For example, low marshes dominated by *Spartina alterniflora* were shown to have greater abundance and species composition than high marshes dominated by *Phragmites* (Able, 2000; Angradi et. al., 2001).

Other notable benthic invertebrates common to estuarine and marine habitats within the New Jersey coast include mollusks such as bay scallop, hard clam, blue mussel, eastern oyster, moon snail (*Lunatia heros)*, and knobbed whelk (*Busycon carica*); crustaceans such as common rock crab (*Cancer irroratus*), blue crab snapping shrimp (*Crangon septemspinosa*), and grass shrimp (*Palaemontes spp*.); and an echinoderm: sea stars (*Asterias forbesi*).

The horseshoe crab (*Limulus polyphemus*) is a common, yet important, invertebrate inhabiting the New Jersey back bays and nearby Atlantic Ocean waters, and is notable for pharmaceutical applications, and their eggs are a critical food source for migratory shorebirds.

4.8.15 Special Status Species

Federally- listed threatened and endangered species and state-endangered species occur throughout the NJBB CSRM Study area (Table 16).

Federally Listed Species

Seabeach amaranth (*Amaranthus pumilus*) is a Federally listed threatened plant. The seabeach amaranth is an annual plant, endemic to Atlantic coastal plain beaches, and primarily occurs on over wash flats at the accreting ends of barrier beach islands and lower foredunes of non-eroding beaches. The species occasionally establishes small temporary populations in other areas, including bayside beaches, blowouts in foredunes, and sand and shell material placed as beachfill. Seabeach amaranth was found in New Jersey in 2000, after being absent from the state for over 80 years. In 2002, over 10,000 plants were present in the state, with the majority being found along the beaches in Monmouth County. Since that time, numbers in the state have been steadily declining with numbers dropping below 1,000 plants.

The Federally listed (threatened) and state listed (endangered) piping plover (*Charadrius melodus*) has historically nested along coastal beaches and inlets within the study area. Piping plover nests can be found above the high tide line on coastal beaches, on sand flats at the ends of sand spits and barrier islands, on gently sloping foredunes, in blowout areas behind primary dunes, and in washover areas cut into or between dunes. Plovers generally start to return to New Jersey in March with eggs being present on the beach as early as April. The nesting season generally concludes by mid-August once all chicks have fledged. Food for adult plover and chicks consists of invertebrates such as marine worms, fly larvae, beetles, crustaceans, or mollusks. Feeding areas include intertidal portions of ocean beaches, ocean washover areas, mudflats, sandflats, wrack lines (organic material left behind by high tide), shorelines of coastal ponds, lagoons, and salt marshes.

The federally threatened, rufa red knot (*Calidris canutus rufa*,) can be found in lower densities during the spring and fall migrations along Atlantic Coast beaches, and could occur within the project area. Red knots are also federally protected under the Migratory Bird Treaty Act and are listed as endangered by the State of New Jersey. Threats to the red knot include sea level change; coastal development; shoreline stabilization; dredging; reduced food availability at stopover areas; disturbance by vehicles, people, dogs, aircraft, and boats; and climate change. Red knots typically occur in New Jersey during their annual spring and fall migration. Small numbers of red knots may occur year-round in New Jersey, whereas large numbers rely on New Jersey's coastal stopover habitats during the spring (mid-May through early June) and fall (late-July through November) migration periods (USFWS 2015). In wintering and migration habitats, red knots may forage on bivalves, gastropods, and crustaceans (USFWS 2013; Harrington 2001).

Portions of the project area have the potential to serve as fall migratory stopover habitat for the red knot. During the fall migration, the red knot typically spends time foraging and resting within and above the intertidal zone. In 2014, the USACE contracted Tetra Tech Inc. to conduct a red knot survey along the coast of New Jersey to aid in identifying areas frequented by red knots during the fall migration. A total of 31 one-mile transects were surveyed over seven survey events from September to November of 2014. Only 20 red knots were observed during the surveys and those birds were only found in 3 of the transects. The survey report concluded that, overall, the results of the 2014 surveys indicated a low usage of the Corps Philadelphia beach nourishment Project Areas by red knots during the survey period (late September to late November). None of the transect surveys identified high concentrations of red knots using any part of the Project Areas as a focal point for foraging, roosting, or migration during the survey period.

On January 13, 2016, the U.S. Fish and Wildlife Service listed the northern long-eared bat (*Myotis septentrionalis*) as threatened under the Endangered Species Act (ESA). In an effort to conserve the northern long-eared bat, the U.S. Fish and Wildlife Service is using flexibilities under section 4(d) of the ESA to tailor protections to areas affected by white-nose syndrome during the bat's most sensitive life stages. The rule is designed to protect the bat while minimizing regulatory requirements for landowners, land managers, government agencies and others within the species' range. In areas of the country impacted by white-nose syndrome, incidental take is prohibited if it occurs within a hibernation site for the northern long-eared bat. It is also prohibited if it results from tree removal activities within a quarter-mile of a hibernaculum or from activities that cut down or destroy known occupied maternity roost trees, or any other trees within 150 feet of that maternity roost tree, during the pup-rearing season (June 1 through July 31). Occupied roost trees may be removed when necessary to address a direct threat to human life and property. In other cases, a permit for incidental take may be needed. Intentionally harming, harassing, or killing the northern long-eared bat is prohibited throughout the species' range, except for removal of northern long-eared bats from human structures, and when necessary to protect human health and safety.

The eastern black rail (*Laterallus jamaicensis*) was listed as Federally-threatened in October 2020. According to Conserve Wildlife New Jersey, black rail occurs in coastal salt and brackish marshes where they often nest in areas of elevated marsh that are flooded only during extremely high tides. Nests are typically located in marshes dominated by salt hay. These marshes also may contain spike grass, black rush, or marsh elder. Marshes containing salt hay provide characteristically thick mats of overlapping vegetation, beneath which the rails traverse on pathways of flattened vegetation. Black rails may seek cover within vegetation in adjacent upland fields and meadows during high tides. Black rails occupy similar habitats throughout the year. In the past three decades, black rails have been observed along the Atlantic Coast during the nesting season at Nummy Island, Marmora, Upper Township, Lester G. MacNamara Wildlife Management Area, Edwin B. Forsythe National Wildlife Refuge, and Manahawkin. Most breeding records of this species occur south of the Raritan River (Conserve Wildlife NJ, 2012).

The NOAA Fisheries has jurisdiction over four (4) Federally-designated sea turtles: the endangered leatherback (*Dermochelys coriacea*), Kemp's Ridley (*Lepidochelys kempii*), and green (*Chelonia mydas*) sea turtles, and the threatened loggerhead (*Caretta caretta*) sea turtle. These sea turtles may be found in New Jersey's continental shelf waters, inshore bays, and estuaries from late spring to mid-fall. Sea turtles feed primarily on mollusks, crustaceans, sponges and a variety of marine grasses and seaweeds. The endangered leatherback sea turtle may forage on jellyfish, as well. The northern diamondback terrapin (*Malaclemys terrapin*

terrapin) is listed as a State of New Jersey species of concern that occupies shallow bay waters, and nests on the sandy portions of bay islands as well as the barrier islands themselves. The diamondback terrapin is considered a candidate species, as its nesting habitat is dwindling.

The New York Bight population of the Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) was recently listed as endangered by the NOAA Fisheries. Atlantic sturgeon is anadromous, spending a majority of their adult life phase in marine waters, migrating up rivers to spawn in freshwater then migrating to brackish water in juvenile growth phases. The Atlantic sturgeon are known to spawn within the Delaware River and migrate along the coast of New Jersey, although the extent of the use of marine habitat by Atlantic sturgeon is not fully known. This species could be present within the project impact area. Studies have indicated that depth distribution appears seasonal, with sturgeon inhabiting the deepest waters during the winter and the shallowest during summer and early fall.

Species of Concern listed by NOAA Fisheries, and associated area of concern include the anadromous and highly migratory river herring (alewife and blueback herring) found in the Atlantic Ocean from Newfoundland to North Carolina, the pelagic and highly migratory Atlantic bluefin tuna found throughout the North Atlantic Ocean and adjacent seas, the Atlantic halibut found from Labrador to southern New England in the Northwest Atlantic Ocean, the dusky shark found in the Western Atlantic Ocean, the porbeagle shark found in the Northwest Atlantic Ocean, the anadromous rainbow smelt found in rivers and coastal areas of eastern North America from Labrador to New Jersey, and the sand tiger shark found in the Western Atlantic Ocean (http://www.nmfs.noaa.gov/pr/species/concern/).

State Listed Species

A variety of State-listed endangered and threatened species inhabit the beaches and marshes of the project area. Several birds-of-prey occur in the vicinity of the project area including the State-listed endangered Cooper's hawk, and the State-listed threatened northern goshawk *(Accipiter gentilis),* red-shouldered hawk, barred owl *(Strix varia),* and longeared owl *(Asia otus)* (USACE 1999).

Nesting populations of the State listed endangered northern harrier (*Circus cyaneus*) and black rail (*Laterallus jamaicensis*) nest in high emergent marshes. The State-listed endangered short-eared owl (*Asio flammeus*), and sedge wren (*Cistothorus latensis*) previously nested in Delaware bayshore marshes; however, their current breeding status in the project area is unknown. The State-listed threatened osprey (*Pandion haliaetus*) currently nests on trees, nesting platforms, and other structures within the project area. Nesting populations of the State- listed endangered sedge wren *(Cistothorus platens is)* occur in high emergent marshes.

The State-listed endangered least tern and black skimmer, and State-listed threatened yellow-crowned night heron utilize coastline habitats. Large colonies of State threatened least tern (*Sterna dougallii*), and black skimmer (*Rynchops niger*) use the Atlantic coast area along with any associated dunes (USACE 2002).

Table 16: Special Status Species in NJBB Coastal Areas

Species	Status	Habitat in NJBB
American Bittern (*Botaurus lentiginosos*) BR	SE	Brackish marshes
Bald Eagle (*Haliaeetus leucocephalus*) BR/NB	SE/ ST	Forest edges, open water
Northern Harrier (*Circus cyaneus*) BR	SE	Tidal marshes
Red knot (*Calidris canutus rufa*) NB	FT, SE	Sandy beaches, spits, marsh islands, tidal flats
Short-Eared Owl (*Asio flammeus*) BR	SE	Coastal marshes
Black-Crowned Night-Heron (*Nycticorax nycticorax*) BR	ST	Maritime forests, scrub-shrub, mixed *Phragmites* marshes
Yellow-Crowned Night-Heron (Nyctanassa violacea)	ST	Maritime forests, scrub-shrub on barrier and bay islands
Osprey (*Pandion haliaetus*) BR	ST	Coastal rivers, marshes, bays & inlets. Nest on dead trees, platforms, poles
Piping plover(*Charadrius melodus*)	FT, SE	Ocean beaches, inlets, washover areas, tidal flats
Eastern Black Rail (*Laterallus jamaicensis*) BR/NB	FT, SE/ST	High marshes
Black Skimmer (*Rynchops niger*)	SE	Sandy beaches, inlets, sandbars, offshore islands
Least Tern (*Sternula antillarum*)	SE	Sandy beaches, bay islands
Roseate Tern (*Sterna dougallii*)	FE/SE	Beaches w/ vegetated dunes
Sedge Wren (*Cistothorus platensis*)	SE	High marshes
Saltmarsh sparrow (*Ammospiza caudacuta*)	FR/SOC	Saltmarshes
Atlantic Loggerhead (*Caretta caretta*)	FT/SE	Marine/Estuarine Pelagic
Kemp's Ridley (*Lepidochelys kempii*)	FE/SE	Marine/Estuarine Pelagic
Atlantic Green Sea Turtle *(Chelonia mydas*)	FT/ST	Marine/Estuarine Pelagic
North Atlantic Right Whale (*Eubalaena glacialis*)	FE/SE	Marine pelagic
Blue Whale (*Balaenoptera musculus*)	FE/SE	Marine pelagic
Fin Whale (*Balaenoptera physalus*)	FE/SE	Marine pelagic
Humpback Whale (*Megaptera novaeangliae*)	FE/SE	Marine pelagic
Sei Whale (*Balaenoptera borealis*)	FE/SE	Marine pelagic
Sperm Whale (*Physeter microcephalus*)	FE/SE	Marine pelagic

Species	Status	Habitat in NJBB
Northern Long-Eared Bat (*Myotis septentrionalis*)	FT	Summertime roosts beneath the bark of live and dead trees.
Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*)	FE/SE	Marine/estuarine; Demersal/pelagic
Shortnose Sturgeon (*Acipenser brevirostrum*)	FE/SE	Marine/estuarine; Demersal/pelagic
Northeastern Beach Tiger Beetle (*Cincindela d. dorsalis*)	SE	Atlantic coast sandy beaches
Bronze Copper (butterfly) (*Lycaena hyllus*)	SE	Brackish marshes
Monarch butterfly (*Danaus plexippus*)	FCS/SOC	Widespread habitats- particularly in areas of abundance of milkweed (Asclepias syriaca)
Seabeach amaranth (*Amaranthus pumilus*)	FT/SE	Upper sandy beaches, accreting ends of inlets
Swamp pink (*Helonias bullata*)	FT/SE	Freshwater forested wetlands bordering small streams
Knieskern's beakrush (*Rhynchospora knieskernii*)	FT/SE	Early successional freshwater wetlands adjacent to slow moving streams

FT= Federally Threatened
FE= Federally Endangered
FCS=Federal Candidate Species
FR= Federal status under review
ST=State Threatened
SE= State Endangered
BR= Breeding Population Only
NB= Non-Breeding Population Only
SOC=Species of Concern in NJ

*Note: There are over 800 species of Special Status Plants in NJ. Due to the large study area, site specific species data searches will be conducted at subsequent phases of the feasibility study.

4.8.16 Coastal Lakes

The Coastal Lakes section of the study area is comprised of 16 freshwater/brackish water lakes. The lakes include: Lake Takanassee, Deal Lake, Sunset Lake, Wesley Lake, Fletcher Lake, Sylvan Lake, Silver Lake, Lake Como, Spring Lake, Wreck Pond, Stockton Lake, Glimmer Glass, Lake Louse, Little Silver Lake, Lake of the Lilies, and Twilight Lake. Most of the lakes have a connection to the ocean, but some are completely freshwater (Souza 2013). Twelve of the lakes are non-tidal and four are tidal. Historically, most of the coastal lakes were estuaries (Souza 2013).

The Coastal Lakes area of the study is highly urbanized with very limited natural resources and many of the lakes are considered eutrophic(NJDEP 2013). Today, the landscape defining the watersheds of the coastal lakes is primarily urban, and characterized by intensive residential and commercial development, including large contiguous swaths of impervious cover. Storm water and runoff generated from these areas is a major contributor to lake pollution. As a result, the water quality of almost all the coastal lakes has declined dramatically resulting in a loss of aesthetic attributes and recreation opportunities (Tiedemann 2013). All were severely impacted by Hurricane Sandy in 2013 (Souza 2013). Impacts from the storm included: direct scouring, impaired water quality (contaminants), sediment deposition, and habitat alteration.

Wreck Pond

Ecological communities around the Wreck Pond area include sand beach, dunes, sandy shoals, tidal wetlands and open water. The tidal wetlands found within the study area provide valuable habitat for numerous aquatic and terrestrial species. Coastal marshes provide foraging and nesting habitat for waterfowl and wading birds, as well as spawning and nursery habitat for juvenile fish and shellfish. The beach, dune and sandy shoal communities provide habitat for shore nesting and foraging species, including migratory shore birds. The diverse mosaic of habitats in and around Wreck Pond makes it a significant coastal resource for many aquatic and terrestrial species including several state and federally listed threatened and endangered species. However, limited connectivity, poor water quality and sedimentation issues have led to habitat degradation in the pond's recent history (USACE 2016).

The Wreck Pond area has been utilized by anadromous fish species, including alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), and catadromous species such as the American eel (*Anguilla rostrata*). A fall fish survey conducted in 2014 by the American Littoral Society indicates that young of year alewife are present within the pond or its upstream reaches. In addition, the open water community is currently connected to the Atlantic Ocean via an outfall pipe. The 2014 fish survey determined the presence of young of year alewife (*Alosa pseudoharengus*) within the pond and its upstream reaches, indicating that the outfall allows for some passage for migratory catadromous and anadromous fish species. In addition to alewife, the survey identified twenty-one other fish species, six crab species, two species of shrimp, one species of clam and one species of jellyfish that are all typically found in brackish and saline ecosystems within Wreck Pond (USACE 2016).

Wreck Pond is also included in the North Shore Coastal Ponds Complex Important Bird Area (IBA) designated by the National Audubon Society. IBA's are sites that support habitat necessary for breeding, overwintering or migration. The goal of the IBA Program is "to stop habitat loss by setting science-based priorities for habitat conservation and promoting positive action to safeguard vital bird habitats." Other coastal lakes that are also part of this IBA include Stockton Lake, Spring Lake, Lake Como, Silver Lake, Fletcher Lake and Lake Takanassee. The National Audubon Society considers the North Shore Coastal Pond Complex as a breeding and foraging site for Least Terns and Piping Plovers and a wintering site for waterfowl species such as northern shoveler (*Anas clypeata*), American wigeon (*Anas Americana*), redhead (Aythya Americana), common goldeneye (*Bucephala clangula*), common merganser (*Mergus merganser*), brant goose (*Branta bernicla*) and American black duck (*Anas rubripes*) and gulls species including Bonaparte's (*Chroicocephalus philadelphia*), ring-billed (*Larus delawarensis*), herring (*Larus argentatus*), and great blackbacked (*Larus marinus*) (National Audubon Society 2016).

Lake Como, Spring Lake and Deal Lake

Lake Como and Spring Lake are relatively small water bodies (35.5 acres and 13.7 acres, respectively) in the same vicinity as Deal Lake and Franklin Lake along the coastline of Monmouth

County. The watersheds of these lakes are highly urbanized and large relative to the size of the lakes (22.9 and 21.0 times the size of the lakes, respectively). The large urbanized watersheds of these lakes support the anecdotal evidence from local sampling programs that indicates these two water bodies are impaired due to eutrophication (NJDEP 2003).

Deal Lake is a large, dendritic water body (155 acres) in Monmouth County with a shape reminiscent of a four-legged octopus. Four tributaries join into two larger ones. The lake originated through flooding of the gradually sloping coastal lowlands and is separated from the Atlantic Ocean by a flume structure that permits lake outflow but prevents tidal inflow. The watershed is 26 times the area of the lake. Average depth is measured at 5.3 feet, with a range of up to 9 feet in the main basin. Total volume is estimated at 1,020,000 m^3, with total annual inflow estimated at 10,000,000 m^3/yr. Hydraulic retention time of the lake is approximately 37 days. The 3,990-acre watershed includes portions of Asbury Park City, Interlaken Boro, Allenhurst Boro, Loch Arbour Village, Deal Boro, Ocean Township, and Neptune Township (NJDEP 2003).

As of 1986, at least 135 storm drains empty directly into Deal Lake. Samples taken in 1986 and tested for fecal coliform and nitrates revealed that five of these drains contained sewage. One source was traced back to a house built in the 1950's with its lateral sewer line mistakenly connected into the storm drain. Other possibilities include pet waste washed in during rain events as well as infiltration from sewer main overload. In addition, 39 of the 135 storm drains were flowing constantly in 1986 suggesting a constant discharge into these drains. There are still a few small wetland areas scattered throughout the watershed, as well as some few remaining patches of forest; but the great majority of the land has been developed as either medium-to-high density residential with landscaping or commercial. Municipal and educational facilities are interspersed throughout the watershed. The educational complexes include multiple athletic fields. Two landfills exist within the watershed, as do one 9-hole and major portions of two 18-hole golf courses (NJDEP 2003).

There are some springs located at the headwaters of some tributaries, but they are not believed to be the major source of water. Runoff volume is considerable, mostly from the extensive labyrinth of storm sewers, with some overland flow directly to the lake. Lake use no longer includes swimming, but as with any coastal community the potential is there. Boating and fishing are the primary activities that currently take place in the lake (NJDEP, 2003).

Water Quality in Lakes

Benthic sampling involving the collection of sediment data, supporting in-situ water quality and benthic infauna samples from Wreck Pond and Deal Lake was conducted in 2014. Deal Lake was used as the reference waterbody for this study. All sampling stations within Wreck Pond were taken within the tidally influenced portion of the pond as were all of the Deal Lake sampling stations (USACE 2016).

Sediment samples taken in Wreck Pond primarily consisted of organic sand/silt while Deal Lake was comprised of an organic rich, reduced silty material. Based on water quality samples, Wreck Pond had a higher specific conductance and salinity, and is more affected by tidal inflow than Deal Lake; thus, making it more of a saline ecosystem. Both water bodies had pH and dissolved oxygen levels considered supportive of a variety of fish and benthic species (USACE 2016).

The benthic community within Wreck Pond is dominated by a variety of marine worms (*polychaetes*) with the majority comprised of tube building deposit feeders (*Nereidae*, *Lumbrineridae* and *Spionidae*). The predominance of these species is conducive to the organic sandy/silt composition of the pond's sediments. Ostracods, a type of crustacean, were also fairly common, being collected in six of the eight samples. Very few clams (*Gemma gemma*) were collected. The propensity of polychaetes and ostracods in Wreck Pond indicates that Wreck Pond is brackish in nature which is supported by the in-situ water quality data (USACE 2016).

The benthic community within Deal Lake was dominated by pollutant tolerant organisms (organisms capable of existing under anoxic, environmentally stressed conditions). In addition, the invertebrate community was found to be far less diverse, as demonstrated by the fact that many samples had much lower total numbers than samples collected from Wreck Pond.

Furthermore, the Deal Lake benthic assemblage was represented by a greater number of pollution tolerant species and by a fewer number of mollusks and ostracods (USACE 2016).

Thus, the benthic community of Wreck Pond was determined to be more robust and representative of a less stressful environment than the benthic community of Deal Lake. The primary factors that appear responsible for these differences are the more reduced nature of the Deal Lake sediments, the sandier nature of the Wreck Pond sediments, and the greater rate of tidal exchange and overall volumetric flushing of Wreck Pond as compared to Deal Lake (USACE 2016).

4.8.17 Cultural Resources

Several federal laws and regulations have been established to manage cultural resources, including the National Historic Preservation Act (NHPA) of 1966, the National Environmental Policy Act of 1970, the Archeological and Historic Preservation Act of 1974, the American Indian Religious Freedom Act of 1978, the Archeological Resource Protection Act of 1979, and the Native American Graves Protection and Repatriation Act of 1990. In addition, DoDI 4710.02, *Department of Defense Interactions with Federally-Recognized Tribes* (2006), governs DoD interactions with federally-recognized tribes and EO 13175, *Consultation and Coordination with Indian Governments* (2000), charges federal departments and agencies with regular and meaningful consultation with Native American tribal officials in the development of policies that have tribal implications. In order for a cultural resource to be considered significant, it must meet one or more of the following criteria for inclusion on the National Register of Historic Places (NRHP):

> *"The quality of significance in American history, architecture, archaeology, engineering, and culture is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association, and: 1) that are associated with events that have made a significant contribution to the broad patterns of our history; or 2) that are associated with the lives or persons significant in our past; or 3) that embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or 4) that have yielded, or may be likely to yield, information important in prehistory or history"* (36 CFR 60.4).

The NJBB CSRM Study will be especially challenging regarding potential impacts to historic properties eligible for or listed on the National Register of Historic Places (NRHP). This project involves the entire southern coast of New Jersey from Monmouth to Cape May Counties. In the early stages of alternative formulation, a baseline of known cultural resources was developed in GIS format. Data from the NJSHPO LUCY database, the NOAA Marine Cadaster, and layers from the USACE Philadelphia previous investigations database were combined and overlaid on the study areas to provide a baseline for NEPA analysis for cultural resources for the focused array of alternatives and was considered in decision-making for the TSP.

Background research within the general study area show many previously recorded archaeological sites, historic structures, historic districts, shipwrecks, and other cultural resources. The following is the current count of recorded historic properties eligible for or listed on the NRHP for each county in the study area:

Monmouth County – 377; Ocean County - 179; Burlington County – 331, one of which is a Paleo-Indian archaeological site; Atlantic County – 153; and Cape May County – 189.

In July of 2016, the initial scoping letter was sent to the NJSHPO and to the Tribes along with the other environmental agencies. The Delaware Tribe responded with a request for continued consultation; however, all the Tribes will be in continued consultation, as will the NJSHPO, as the project progresses.

The Area of Potential Effect (APE) is the geographic extent to which an undertaking may directly or indirectly cause changes in the character or use of historic properties (NHPA, 36 CFR 800.16[d]) (40 CFR 1508.8). The TSP elements, both structural and nonstructural will be considered a tentative Area of Potential Effect (APE). The actual APE will be refined and defined through further assessments and in consultation with the NJSHPO, the Tribes and other Consulting Parties as the project develops.

Prehistoric Context

Archaeologists recognize a sequence of regional cultural traditions in the eastern United States that can be viewed as responses to both continuity and change within environmental and cultural systems. Three major cultural patterns and time periods have been identified in the Pre-Contact Period: Paleoindian, Archaic, and Woodland.

Human occupation of the Middle Atlantic region began at the end of the Pleistocene epoch by highly mobile groups of hunter-gatherers described as Paleoindians. Theories of the earliest peopling of North America are divided between Clovis- first and pre-Clovis settlers. The Clovis culture is distinguished by the manufacture of fluted, lanceolate-shaped spear points that have been found from the Great Plains to the eastern seaboard. The earliest Clovis occupations in the Middle Atlantic region date to around 10,950 radiocarbon years before the present (RCYBP), represented by the Shawnee-Minisink Site on the Delaware River in Monroe County, Pennsylvania (Marshall 1985). Paleoindian groups practiced a range of subsistence strategies, including hunting big and small game, fishing, and collecting plants. Fish bones and seeds of hackberry and blackberry were recovered from Paleoindian levels at Shawnee-Minisink (Dent 1991:125). Cultural deposits dating up to several thousand years earlier than Clovis have been reported from the Meadowcroft Site in western Pennsylvania (Adovasio et al. 1999) and the Cactus Hill Site in Virginia (MacAvoy and MacAvoy 1997), although these early dates are rare and remain controversial. The Paleoindian period is considered to end around 10,000 BP (before present).

The adaptive strategies of groups during the Early Archaic period (c. 10,000 to 8000 BP) were more a continuation of established Late Paleoindian broad-spectrum subsistence practices than a dramatic shift to new routines. Bands remained nomadic but appear to have exploited more restricted territories than their Paleoindian predecessors, making more repetitive visits to fewer strategic locations (Anderson 2013). The addition of ground-stone implements to toolkits suggests that nuts and seeds had become an important component of Early Archaic diets. These adaptive modifications in subsistence practices were probably responses to increasingly dry conditions throughout the period and to the disappearance, by the end of the Paleoindian period, of the large herbivores that had been one component of early human diet and material culture. Climatic warming led to forest closure after 10,000 BP and increasing dominance of northern hardwoods over Boreal conifers, producing a more favorable habitat for such species as white-tailed deer and elk (Davis 1983, Snow 1980).

During the Middle Archaic period (c. 8000 to 4500 BP), indigenous peoples lived in more widely distributed locales, but settlement remained focused along major waterways, falls, and lakes, and groups had developed a reliance on aquatic resources. Rising sea levels by this period had opened rivers to anadromous and catadromous fish, permitting people to fish and exploit spring and autumn spawning runs at inland locations.

The Late Archaic period (circa 4500 to 3300 BP) is characterized by increased population (as evidenced by larger and more numerous sites), the onset of long-distance trade networks, and an increased focus on riverine settings for site locations. These factors relate to increased environmental stress caused by a shift toward a warmer, drier climate. Freshwater shellfish appeared in the mid-Hudson River during this period, and site assemblages from the Hudson Valley contain faunal evidence of beaver and muskrat (Funk 1992:10, Funk 1976:172). The manufacture and use of small notched point and narrow stemmed point types became common over broad regions of the Eastern Woodlands, tool styles that are found in the archaeological record for extended periods. Ceremonialism grew in importance, indicated by more elaborate, formalized burial practices and the presence of exotic raw materials as symbols of enhanced status and rank (Fiedel 1992).

The Early Woodland period (c. 3000 to 2000 BP) marks the inception of widespread ceramic vessel use, an important technological advance that revolutionized food preparation and storage strategies. While steatite had been a precursor of this new technology, it was a heavy material and geographically restricted in its distribution of source material. Not only could ceramic vessels be manufactured anywhere there was clay, its portability and diversity of form encouraged the transport of food and the storage of surpluses. The Early Woodland period, however, continued many of the cultural and adaptive traits of the Late Archaic period, notably the complexity of burial ceremonialism and the acquisition of certain exotic goods, such as high quality lithics, red ochre, shell beads, and copper. Several lines of evidence suggest that Early Woodland population levels in the Northeast declined compared with Late Archaic levels, perhaps a response to climatic cooling that adversely affected game numbers and flora availability (Fiedel 2001). This population decline (Dincauze referred to it as a “collapse” [1974:50-51]) may have been a critical factor in the adoption of ceramics and shellfish collecting as a means of increasing food supply through labor-intensive, yet efficient, activities.

An apparent population decline during the preceding Early Woodland period reversed during the early phase of the Middle Woodland period (c. 2000 to 1000 BP) as sea level and climates stabilized. It is from this point on that the first truly large shellfish middens occur in coastal southern New England and Long Island (Bernstein 1993), and an increase in the number of storage pits is noted in the archaeological record (DeBoer 1988, Snow 1980:282). The rich focus on burial ceremonialism and exotic goods of the Late Archaic and Early Woodland periods is not identified archaeologically during the Middle Woodland, an indication to some researchers that long-distance trade was contracting, perhaps due to increased competition for resources at the margins of ethnic group boundaries. There is, instead, an emphasis on exploiting local resources and exploring variations in ceramic styles. During this period, settlement patterns have a decidedly riverine focus.

Important cultural adaptations during the Late Woodland period (c1000 to 400 BP) have been archaeologically recognized on a wide scale in Pennsylvania and across much of eastern North America, and include the tending of cultigens (maize, beans, and squash), decrease in residential mobility, and use of the bow and arrow as a new and highly efficient hunting (and warring) weapon. These adaptations are perhaps all related to the region's population rise, with increased competition for resources and an intensification of local ethnic identity as manifested in greater variation in ceramic design.

Historic Context

Although there are no major ports along New Jersey's Atlantic coast, there has been a consistently high volume of ship traffic passing up and down the coast en route to the port cities in New York Bay and Delaware Bay throughout the historic period. The barrier beaches and inlets along the 127-mile New Jersey coastline offer little relief to mariners in distress. There were few options available to captains of vessels that were caught in squalls off the central portion of New Jersey's Atlantic coast. Cape May Inlet was one of only a few suitable harbors along New Jersey's Atlantic coast which ship captains could seek refuge during storm conditions. However, entering any inlet during a coastal storm was quite hazardous, and numerous vessels were lost at each of the New Jersey Atlantic Ocean inlets during storms.

Despite the increasing number of ship losses along the coast of New Jersey (and elsewhere along the Atlantic coast of the United States), federal funding of aids to navigation and lifesaving stations in New Jersey did not occur until the 19th century. The first aid to come from Congress was in 1823, when an allocation was made for the construction of a lighthouse at Cape May. A lighthouse had been constructed previously on Sandy Hook in 1761, but this was financed by New York merchants, and only later was the facility acquired by the Federal government. Following the construction of the Cape May Lighthouse, a series of lighthouses were constructed along the New Jersey shoreline during the 19th century.

The Federal government also financed Lifesaving stations. In the first quarter of the 19th century, volunteer lifesaving stations were scattered along the New Jersey shore. Typically, these were manned by small bands of local fishermen. The first federal appropriation for lifesaving stations occurred in 1848 when $10,000 was set aside to provide lifeboats and rockets for the protection of life and property on the New Jersey coast from Sandy Hook to Little Egg Harbor. This was the first federal appropriation to any state for such work. Eight lifeboat stations were constructed as part of this program. In the following year, another appropriation was made for six stations between Little Egg Harbor and Cape May. By 1872, stations had been established on the average of every five miles along the shore, and in 1886 the Federal Government inaugurated the policy of manning all stations with paid crews (Wilson 1964). Lifesaving Stations #39, #40, and #41 were each located around the Cape May vicinity. By 1900 there were 42 lifesaving stations on the New Jersey coast at an average of three miles apart.

Although there are no major commercial ports along New Jersey's Atlantic coast, there has been a consistently high volume of coastal ship traffic off the New Jersey Atlantic coast. Cape May Inlet is heavily used by both commercial fishing vessels that work out of Cape May Harbor and recreational fishing boats and sailing boats.

Cape May Inlet connects the Atlantic Ocean and Delaware Bay via the Cape May Canal. In 1942 the federal government undertook the construction of Cape May Canal. Work on the canal was assigned a high priority of World War II because the waterway could provide a short cut between Delaware Bay and the Atlantic Ocean for the Coast Guard and Navy anti-submarine surface vessels. This was important because of the intense U-boat activity at the entrance to the Delaware Bay. The canal was completed by 1944.

4.8.18 Socioeconomics

Communities along the New Jersey Back Bays (NJBB) include the counties of Atlantic, Burlington, Cape May, Monmouth, and Ocean. Major population centers exist in Atlantic City and other suburban areas. All of these areas have historically suffered extensive damage from nor'easters, hurricanes, and tropical storms. The impact of preparing for, mitigating, and recovering from these damages has placed a physical and emotional burden on both individuals and communities. Most recently, Superstorm Sandy in 2012 and Hurricane Irene in 2011 caused significant damages to homes and businesses. In this section, socioeconomic and other social effects data for the New Jersey Back Bays provides a context from which to evaluate potential effects of the Preferred Alternative.

4.8.18.1 Population and Housing

Recent population trends in the NJBB area are shown in Table 17. The NJBB CSRM Study area has held a steady population despite being hit by 2 major storms in 2011 and 2012. NJBB is below the national average in terms of population growth, but major storm impacts could partly explain this. Only small portions of Burlington and Monmouth are located within the study area (U.S. Census Bureau, 2020). Housing unit trends and population trends are similar (Table 18).

Table 17: Current Population Trends in the Study Area

Study Area Counties	2018	2017	2016	2015	2014	2013	2012
Atlantic	268,539	269,918	270,991	274,219	275,209	275,862	275,422

Burlington*	446,367	448,596	449,284	450,226	449,722	450,838	451,336
Cape May	93,705	93,553	94,430	94,727	95,344	95,897	96,304
Monmouth*	623,387	626,351	625,846	628,715	629,279	629,672	629,384
Ocean	591,939	597,943	592,497	588,721	586,301	583,414	580,470

Source: US Census (2020) *-Only a small percentage of these counties fall in the study area.

Table 18: Current Housing Unit Trends in the Study Area

Study Area Counties	2018	2017	2016	2015	2014	2013	2012
Atlantic	128,408	128,185	127,617	128,013	127,104	126,929	127,361
Burlington *	179,900	179,547	177,623	179,013	176,673	176,180	176,889
Cape May	99,427	99,246	98,900	99,233	98,630	98,531	98,653
Monmouth *	262,157	261,461	260,222	261,053	259,572	258,988	259,616
Ocean	284,918	283,679	280,508	282,205	278,980	278,766	279,564

Source: US Census (2020) *-Only a small percentage of these counties fall in the study area.

4.8.18.2 Structures

There are numerous coastal communities in the study area at risk from storm surge. The initial evaluation focused on the 500-year coastal floodplain for the study area. There are 172,988 structures within the study area. Many of the waterfront communities are at a significant risk from storm surge and inundation. Many of these communities provide employees, employers, and purchasing power that contribute to the economic health of the entire state of New Jersey. They are also equally critical to the regional economy that is supported by tourism, water recreation, as well as by industry and offices located in the area. The economies of the communities in this region are heavily intertwined; the health of one community is dependent on the health of all the communities in the area (e.g., the availability of housing in one community helps support businesses in another, etc.).

During Sandy, Atlantic City suffered severe damage to the "Boardwalk", a major tourist attraction in the region. The majority of restaurants and other businesses were small, family-owned businesses. Atlantic City lost much of its infrastructure that needed to be replaced in order for the city to get back on its feet. There was also the need to maintain an adequate amount of housing for people who work in local industries. Many of the residential and non-residential developments at risk from storm surge are focused on areas near the coast, barrier islands or bay system.

4.8.18.3 Critical Infrastructure

Critical infrastructure includes assets that are essential for the functioning of a society and an economy, including electricity, gas distribution, water supply, transportation, education, and community services (e.g., police, fire department, etc.). The New Jersey Back Bays study includes many critical infrastructure locations at risk in the study area (Table 19). Hospitals, roads, schools, police, and fire facilities play a central role in disaster response and recovery. Understanding which facilities are exposed, and the degree of that exposure, can help reduce or eliminate service interruptions and costly redevelopment.

Incorporating this information into development planning helps communities get back on their feet faster. When comparing the FEMA floodplain maps to the critical infrastructure locations, most of the critical infrastructure at risk are spread throughout the study area. Barrier Islands are at a significant risk. The New Jersey Back Bays are one of the most vulnerable areas of the U.S. to hurricanes because of their low-lying coastal location, large population, and critical economic infrastructure.

Table 19: Critical Infrastructure in the Study Area

CATEGORY	TYPE	COUNT
HEALTH CARE		
	Health Facilities	18
	Nursing Homes	48
	Receiving Hospital	6
	Pharmacies	150
EMERGENCY SERVICES		
	EMS Stations	153
	Fire Stations	142
	Law Enforcement	69
	Local Emergency Operations Center	2
	Local Public Safety	211

	National Shelter System	189
	Prisons	3
TRANSPORTATION		
	Airports	2
	AMTRAK Stations	2
	Bus Stations	18
	Ferries	1
	Port Facilities	160
	Road Bridges	419
	Railroad Bridges	25
	Railroad Stations	9
	Railroad Yards	1
	Roads (miles)	*4825.49*
	Evacuation Routes (miles)	*456.27*
	Railroad (miles)	*65.53*
SOCIAL		
	Places of Worship	82
	Historic Sites	2
EDUCATION		
	Colleges / Universities	14
	Day Care Centers	239
	Education	417
	Private Schools	49
COMMUNICATION		
	Cellular Stations	36
ENERGY		
	Electric Generating Units	57
	Electric Substations	33
	Gas Stations	167
	Natural Gas Compressor Stations	1
	Nuclear Power Plants	1
	Petroleum Pump Stations	55

	Power Generating Plants	19
WATER TREATMENT		
	Drinking Water Treatment Plants	357
	EPA Wastewater Treatment Plants	22
	Ice Plants	4
	Wastewater Treatment Plants	27
UTILITIES		
	Electric Transmission Lines (miles)	*201.17*
	Oil and Natural Gas Transmission Lines (miles)	*103.27*

Source: FEMA (2018)

4.8.18.4 Community Cohesion

Community cohesion is based on the characteristics that keep the members of the community together long enough to establish meaningful interactions, common institutions, and agreed-upon ways of behavior. These characteristics include race, education, income, ethnicity, religion, language, and mutual economic and social benefits. The study area is composed of communities with a long history and long established public and social institutions including places of worship, schools, and community associations. The economic anchors of the fishing and tourist industries remain firmly tied to their proximity to the coast; however, due to the absence of hurricane storm surge risk reduction measures in sections of the NJBB CSRM Study area, some local populations are forced to evacuate and/or relocate for extended time periods, thereby disrupting community cohesion, temporarily, and in some instances, permanently.

4.8.18.5 Other Social Effects

The USACE views "social well-being factors as constituents of life that influence personal and group definitions of satisfaction, well-being, and happiness. The distribution of resources; the character and richness of personal and community associations; the social vulnerability and resilience of individuals, groups, and communities; and the ability to participate in systems of governance are all elements that help define well-being and influence to what degree water resources solutions will be judged as complete, effective, acceptable, and fair" (USACE, 2013). It is the other social effects account that considers these elements and assures that they are properly weighted, balanced, and considered during the planning process under the USACE's Four Accounts Planning Framework.

In accordance with the USACE Institute for Water Resources handbook in Applying Other Social Effects in Alternatives Analysis (2013), seven social factors that describe the social fabric of a community were identified. The social factors identified and described in Table 20 are based on conventional psychological Human Needs Theory and Abraham Maslow's Hierarchy of Needs (USACE, 2013). This section, along with the socioeconomic data presented in the sections above, provides baseline conditions for the social communities in the entire study area.

Table 20: Social Factors

Social Factor	Description
Health and Safety	Refers to perceptions of personal and group safety and freedom from risks
Economic Vitality	Refers to the personal and group definitions of quality of life, which is influenced by the local economy's ability to provide a good standard of living
Social Connectedness	Refers to a community's social networks within which individuals interact; these networks provide significant meaning and structure to life
Identity	Refers to a community member's sense of self as a member of a group, in that they have a sense of definition and grounding
Social Vulnerability and Resiliency	Refers to the probability of a community being damaged or negatively affected by hazards, and its ability to recover from a traumatic event
Participation	Refers to the ability of community members to interact with others to influence social outcomes
Leisure and Recreation	Refers to the amount of personal leisure time available and whether community members are able to spend it in preferred recreational pursuits

4.8.18.5.1 Health and Safety (Stress, Loss-of-Life, Health Care, and Emergency Facilities)

Severe storm surge events threaten the health and safety of residents living within the study area. Loss of life, injury, and post-flood health hazards may occur in the event of catastrophic flooding. As shown in Table 19, there are 150 EMS stations, 69 police stations, and 142 fire stations located within the study area (FEMA, 2018). There are also 6 receiving hospitals, 18 medical facilities, 48 nursing homes, and 150 shelter locations. When facilities that provide critical care or emergency services are impacted by storm surge events, residents are at an even greater risk for experiencing negative health outcomes. Sandy reduced the accessibility and availability of health facilities and services and required additional first-responders (fire and police) to respond to emergencies. In addition to the damages of Sandy and Irene to hospitals, police stations, and fire stations, many employees providing related services lost their homes, reducing the staff that was available to operate health and safety services.

4.8.18.5.2 Economic Vitality

Growth in employment, business, and industrial activity is expected to follow economic trends in local, regional, and national economies. As stated above, the region's economic anchors of the fishing and tourist industries remain firmly tied to their proximity to the coast; however, without flood risk management alternatives, the stability of employment, business, and industrial activity associated with these economic drivers could be adversely affected over periods of time.

4.8.18.5.3 Social Connectedness

The degree to which communities are able to instill a shared sense of belonging and purpose among residents is in large part determined by the communities' civic infrastructure. The presence of social institutions, such as libraries, places of worship, and schools, provides residents an opportunity for civic participation and engagement, which allows residents to come together and work toward a common goal. In the NJBB CSRM Study area, there are 82 places of worship and over 700 places dedicated to education. The individuals working in these capacities are important due to their local knowledge and will assist in creating the most efficient and effective economic and social growth.

4.8.18.5.4 Social Vulnerability/Resiliency

The devastation left behind after Superstorm Sandy brought attention to social vulnerability and resiliency when evaluating water resources projects (USACE, 2013). Social vulnerability is a characteristic of groups or communities that limits or prevents their ability to withstand adverse impacts from hazards to which they are exposed.

Resiliency, in turn, refers to the ability of groups or communities to cope with and recover from adverse events. The factors that contribute to vulnerability often reduce the ability of groups or communities to recover from a disaster; therefore, more socially vulnerable groups or communities are typically less resilient.

Several factors have been shown to contribute to an area's vulnerability/resiliency, including poverty, racial/ethnic composition, educational attainment, and proportion of the population over the age of 65.

4.8.18.5.4.1 Racial/Ethnic Composition.

Race/ethnicity plays an important role in the everyday lives of Americans. Unequal access to social resources and language barriers may affect preparing for and recovering from storm surge events for certain groups. The majority of the population in the study area is white with varying degrees of diversity throughout (Table 21).

4.8.18.5.4.2 Poverty Rate.

High poverty rates negatively impact the social welfare of residents and undermine the community's ability to assist residents in times of need. Within the study area, a large percentage of the population below the poverty line is found in Atlantic County (Table 22).

Table 21: Population Characteristics of the Study Area

Population Characteristics (% of Population)	Atlantic	Burlington	Cape May	Monmouth	Ocean
Below 18 Years of Age	21.3%	20.8%	15.9%	21.2%	23.9%
65 Years or Above	17.9%	16.9%	26.0%	17.6%	22.7%

Race and Hispanic Origin					
White alone	65.3%	71.3%	88.6%	83.6%	90.7%
Black or African American alone	14.0%	17.1%	3.9%	7.4%	3.3%
Asian alone	8.1%	4.7%	1.2%	5.5%	2.0%
Some other race alone	8.9%	2.9%	2.9%	1.5%	2.3%
Two or more races	4.0%	4.0%	3.4%	2.0%	1.7%
Hispanic or Latino origin	19.2%	8.3%	7.9%	11.0%	9.5%

Source: US Census (2020)

There is not a large percentage of any county's population below the age of 18. Ocean County has the highest proportion with 23.9 percent of the population below the age of 18. The elderly is at an increased risk of life loss for various reasons during storm events, so it is important to pay attention to those above the age of 65. Cape May and Ocean counties both have over a fifth of their populations at an increased risk due to their age.

All of the counties in the NJBB CSRM Study area are majority white, but racial diversity varies widely amongst them. For instance, Ocean County is 90.7 percent white while Atlantic County is 65.3 percent white. These differences are important for communities historically underserved. Although Burlington County has a larger black or African American community than the other counties, Atlantic County is the most diverse county, with the largest percentage Asian, Other Race, and Hispanic origin populations and a 14% black or African American population. Hispanic or Latino origin is relatively low outside of Atlantic County, but it is an important consideration for language and cultural differences.

Table 22: Percentage in Poverty by Characteristic

Percentage in Poverty by Pop. Characteristics	Atlantic	Burlington	Cape May	Monmouth	Ocean
Below 18 Years of Age	19.2%	8.3%	13.1%	9.6%	16.3%
65 Years or Above	8.4%	4.1%	4.6%	5.9%	5.8%
Race and Hispanic Origin					
White alone	7.1%	4.4%	8.4%	5.8%	9.0%
Black or African American alone	27.4%	8.2%	N	13.8%	11.6%
Asian alone	10.7%	4.5%	N	3.9%	18.3%
Some other race alone	35.2%	21.6%	N	22.5%	N
Two or more races	N	14.0%	N	9.4%	21.5%

Hispanic or Latino origin	22.3%	13.2%	N	16.1%	13.8%

Source: US Census (2020)

The percentage of people in poverty by certain population characteristics can point to areas that need special attention. Again, Atlantic County draws the most concern. High proportions of the Black or African American and Other Races are in poverty. Those in poverty have the hardest time escaping these natural disasters. It is important that they have the utmost attention of government authorities to be best served during evacuations, basic needs, medical emergencies, and post-disaster recovery. Other races seem to have issues with poverty throughout the study area, and the Asian population in Ocean County suffers disproportionately from poverty. Poverty is likely to be exacerbated after a storm event, so efforts were made to address these concerns and not create any additional undue burden on their lives.

Table 23: Social Vulnerability

County	Social Vulnerability Index	Percentile in U.S.
Atlantic	3.63	92
Burlington	-4.49	4.9
Cape May	1.91	79.8
Monmouth	-4.70	4.3
Ocean	0.14	52.5

Source: University of South Carolina (2018)

4.8.18.5.5 Social Vulnerability Index

Every community must prepare for and respond to hazardous events, whether a natural disaster like a hurricane or a disease outbreak, or an anthropogenic event such as a harmful chemical spill. The degree to which a community exhibits certain social conditions, including high poverty, low percentage of vehicle access, or crowded households, may affect that community's ability to prevent human suffering and financial loss in the event of disaster. These factors describe a community's social vulnerability. According to USACE (2013) the Social Vulnerability Index (SoVI®) is a valuable tool that can be used to identify areas that are socially vulnerable and whose residents may be less able to withstand adverse impacts from hazards.

Social vulnerability is a key detail that has to be reviewed when addressing surge risk. The Social Vulnerability Index was computed as a comparative measure of social vulnerability for all counties in the United States, with higher scores indicating more social vulnerability than lower scores. Atlantic County was ranked to have the top Social Vulnerability Index score, while compared to Monmouth that had the lowest scores in the study area (Table 23). Atlantic County is more socially vulnerable than roughly 92 percent of counties in the United States, while Monmouth County is less socially vulnerable than roughly 4.3 percent of counties in the United States.

4.8.18.5.6 Leisure and Recreation

Having personal leisure time available and having access to recreational areas contributes to residents' quality of life and is therefore an important aspect of well-being.

Sandy and Irene are estimated to have contributed to a revenue loss of $40 to $50 million dollars per storm for the casinos. In-person gambling will effectively be zero during the duration of a storm, and tourist accommodations and gaming businesses may take time to fully recover. New Jersey's economy is tourism reliant, especially in Atlantic City, so the expected revenue loss for hotels would be high. Recreational fishing makes up a larger contribution to the gross state product for New Jersey than the commercial fishing sector, with estimates saying that recreational fishing adds over $1 billion per year to New Jersey's economy in value-added. The U.S. Department of Commerce estimated the loss from food services, drinking places, groceries, apparel, and fuel to be about $263.8 million for New Jersey following Hurricane Sandy, concentrated in Ocean and Monmouth Counties.

The losses from previous storms encapsulate the risk faced in the study area. The preferred alternative would mitigate these losses and provide a more sustainable path forward.

4.8.18.6 Environmental Justice

Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low- Income Populations, directs Federal agencies, "to the greatest extent practicable and permitted by law, to make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States and its territories and possessions… ."

To assess for potential disproportionate impacts, low-income and minority populations were identified within the study area using U.S. Census estimates. The PDT reviewed the demographic data and determined that, due to the large-scale CSRM measures evaluated, the current alternatives would not disproportionately impact minority populations and low-income populations.

There are also community cohesion and environmental justice concerns in minority populations and low-income populations in some of the communities. Atlantic County will be taken into consideration when investigating the details of nonstructural recommendations.

4.8.18.7 Recreation and Tourism

The U.S. Department of Commerce projected that the net decrease in direct spending would be $828.6 million for New Jersey's economy due to Hurricane Sandy. Hurricane Irene caused similar problems for New Jersey in 2011. The New Jersey Back Bays study area consists of a significantly impacted region.

Outstanding fishing and boating opportunities, walks along the Boardwalk, as well as family outings to the beach keep the economy strong and create jobs for both coastal residents and inland workers. Tourist spending on retail is likely to fall dramatically within the study area in the year following a major storm event. Spending on food services, drinking places, groceries, apparel, and fuel is likely to decline significantly in the study area. Vacation plans are canceled, repairs need to be made, casinos lose revenue, less fishing and boating occurs. Overall, a serious regional decline happens in the recreation and tourism industries.

4.8.19 Recreational Resources

Recreation and ecotourism services provided by waters of the New Jersey Back Bays, and adjacent marshes and beaches are a huge draw for tourism in the region. The New Jersey Back Bays support a number of sites with recreational bathing beaches along bayshores, inlets, and tidal rivers. Over 25 bathing beach locations in the back bays are monitored by local health departments for recreational beach water quality, which is reported to the NJDEP who issues beach advisories or closings if bacterial criteria are exceeded. Fishing is typically conducted along shoreline areas particularly where access to the water is available. Recreational fishing boats launch from private and public marinas and docks nearby to fish in deeper parts of the bays and creeks. Anglers in the back bays and tidal creeks typically target summer flounder (fluke), winter flounder, weakfish, bluefish, striped bass, kingfish, white perch and tautog. Other popular recreational activities in the back bays include clamming (hard clams), crabbing (blue crabs), hunting (waterfowl), sailing, boating, water skiing, jet skiing, paddling (canoes, kayaks, stand-up paddle boards), windsurfing, and bird watching.

4.8.20 Visual Resources and Aesthetics

Aesthetics refer to the sensory quality of the resources (sight, sound, smell, taste, and touch), especially with respect to judgment about their pleasurable qualities (Canter, 1993; Smardon et al. 1986). The aesthetic quality of the study area is influenced by the natural and developed environment. The New Jersey Back Bays contain extensive natural tidal marshlands and islands, tidal creeks and “guts”, and open-water embayment and lagoons on both the mainland (west side of the bays) and also along the western edges of some of the barrier islands. Likewise, the study area also contains heavily urbanized areas consisting of developed shorelines composed of homes, condominiums, businesses, marinas, boat ramps, some industrial activities, and power plants. Many of these developed shorelines include docks, wharves, and hardened shorelines with bulkheads, concrete revetments, and riprap.

Visual resources are the natural and man-made features that comprise the visual qualities of a given area, or “viewshed.” These features form the overall impression that an observer receives of an area or its landscape character. Topography, water, vegetation, man-made features, and the degree of panoramic view available are examples of visual characteristics of an area. The views of open water bays and saltmarsh landscapes are an important component of the viewshed within the NJBB CSRM Study area.

4.8.21 Air Quality

Pursuant to the Clean Air Act (CAA), the U.S. Environmental Protection Agency (EPA) adopts National Ambient Air Quality Standards (NAAQS) for the common air pollutants, and the states have the primary responsibility to attain and maintain those standards. Through the State Implementation Plan (SIP), The New Jersey Department of Environmental Protection – Division of Air Quality (NJDEP Division of Air Quality) manages and monitors air quality in the state. The goal of the SIP is to meet and enforce the primary and secondary national ambient air quality standards for pollutants. New Jersey air quality has improved significantly over the last 40 years, but still exceeds the current standards for ozone (O_3) throughout the state. Fine particles (PM_{10} or $PM_{2.5}$) standards have been attained in NJ since 2012 using the 2006 24-hr fine particulate standard. Additionally, New Jersey has attained the sulfur dioxide (SO_2) (except for a portion of Warren County), lead (Pb), and nitrogen dioxide (NO_2) and carbon monoxide (CO) standards. The NJDEP Division of Air Quality also regulates the emissions of hazardous air pollutants (HAPs) designated by the U.S. EPA.

The CAA requires that all areas of the country be evaluated and then classified as attainment or non-attainment areas for each of the National Ambient Air Quality Standards. Areas can also be found to be “unclassifiable” under certain circumstances. The 1990 amendments to the CAA required that areas be further classified based on the severity of non-attainment. The classifications range from “Marginal” to “Extreme” and are based on “design values”. The design value is the value that determines whether an area meets the standard. For the 8-hour ozone standard for example, the design value is the average of the four highest daily maximum 8-hour average concentrations recorded each year for three years. For 2016, the design value is 0.070 ppm. The ozone attainment classification with respect to the 8-hour standard is shown in Figure 25. Ground-level ozone is created when nitrogen oxides (NOx) and volatile organic compounds (VOC’s) react in the presence of sunlight. NOx is primarily emitted by motor vehicles, power plants, and other sources of combustion. VOCs are emitted from sources such as motor vehicles, chemical plants, factories, consumer and commercial products, and even natural sources such as trees. Ozone and the pollutants that form ozone (precursor pollutants) can also be transported into an area from sources hundreds of miles upwind. The entire state of New Jersey is in non-attainment and is classified as being either “Moderate” or “Marginal.” Marginal classifications have been designated for counties in the Southern New Jersey – Pennsylvania-Delaware-Maryland Area, which include Ocean, Burlington, Atlantic, and Cape May Counties within the NJBB CSRM Study area. Monmouth County is part of the Northern New Jersey-New York-Connecticut Area that have been reclassified from marginal to moderate non-attainment status in 2016 (NJDEP, 2017).

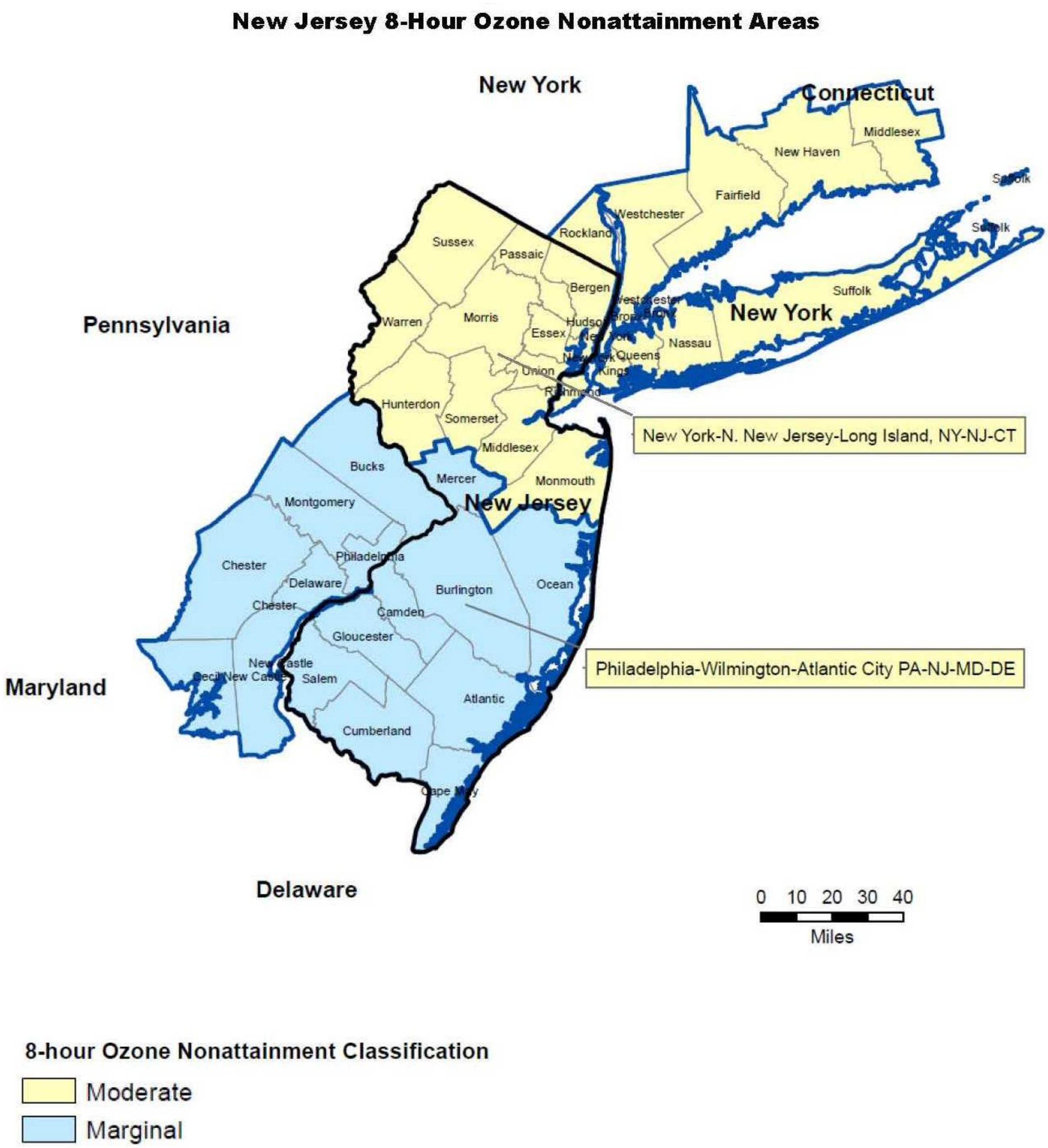


Figure 25: New Jersey Non-Attainment for Ozone (Source: NJDEP, 2017)

4.8.21.1 Greenhouse Gases

Greenhouse gases (GHGs) are gases that trap heat in the atmosphere. These emissions occur from natural processes and human activities. The accumulation of GHGs in the atmosphere can influence the earth's temperature. Predictions of long-term environmental impacts due to global climate change include sea level change, changing weather patterns with increases in the severity of storms and droughts, changes to local and regional ecosystems including the potential loss of species, and a significant reduction in winter snowpack. Federal agencies are, on a national scale, addressing emissions of GHGs by reductions mandated in federal laws and EOs, most recently, EO 13423, *Strengthening Federal Environmental Energy, and Transportation Management*. The Council on Environmental Quality (CEQ) has issued final guidance to assist Federal agencies in their consideration of the effects of GHG emissions and climate change when evaluating proposed Federal actions in accordance with the National Environmental Policy Act (NEPA) and the CEQ Regulations Implementing the Procedural Provisions of NEPA (CEQ Regulations) (CEQ, 2016). This guidance recommends that when addressing climate change, agencies should consider: (1) The potential effects of a proposed action on climate change as indicated by assessing GHG emissions (e.g., to include, where applicable, carbon sequestration); and (2) The effects of climate change on a proposed action and its environmental impacts. The CEQ guidance states: "it is now well established that rising global atmospheric GHG emission concentrations are significantly affecting the Earth's climate." In 1970, the mean level of atmospheric carbon dioxide (CO2) had been measured as increasing to 325 parts per million (ppm) from an average of 280 ppm pre-Industrial levels. Since 1970, the concentration of atmospheric carbon dioxide has increased to approximately 400 ppm (2015 globally averaged value). Since the publication of CEQ's first Annual Report, it has been determined that human activities have caused the carbon dioxide content of the atmosphere of our planet to increase to its highest level in at least 800,000 years (CEQ, 2016).

In the State of New Jersey, the New Jersey Global Warming Response Act of 2007 (GWRA), **N.J.S.A 26:2C-37,** establishes two GHG limits, one for 2020 and another for 2050. The GWRA requires two recommendations reports, one for each limit. The GWRA 2050 target requires New Jersey to reduce GHG emissions by 80 percent from 2006 levels by 2050. This limit is equivalent to 25.4 million metric tons (MMT) CO2 equivalent. The NJDEP has developed four scenarios to identify pathways to meet the GWRA target. In order to approach the 2050 GHG emission limit of 25.4 million metric tons, the following are a must: (a) energy efficiency measures for buildings, industry, and transportation; (b) electrification to avoid combustion wherever it is possible; (c) non-combustion electricity generating technology (e.g., renewables and nuclear); and (d) measures to increase and enhance natural sinks (NJDEP, 2016).

4.8.22 Climate and Climate Change

The NJBB area falls within the Coastal Zone, which is one of five climatic zones identified for the State of New Jersey. The New Jersey Atlantic Ocean coastal region experiences a moderate climate associated with the low elevations of the Coastal Plain and the presence of the large water bodies. Data obtained from the Office of the State Climatologist for 5 stations in the NJBB compiled from 1981-2010 are provided in Tables 24 and 25. The average annual temperature is approximately 54.6°F. The monthly averages for the coldest months of January and February are about 33.8 and 35.8°F, and the monthly averages for the warmest months of July and August range between 74.5°F and 75.7°F. Annual precipitation is approximately 42 inches that is evenly distributed throughout the year with monthly means ranging from 2.9 to 4.3 inches (NJ State Climatologist website retrieved on 2/24/2019 at http://climate.rutgers.edu/stateclim_v1/norms/monthly/index.html).

Table 24: New Jersey Back Bay Areas Monthly Temperature Range Normals (Deg F)

Mean Temperatures are in parentheses.

Based on Data from 1981-2010

STATION NAME	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
ATLANTIC CITY AP	24.5-41.5 (33.0)	26.4-44.3 (35.3)	32.7-51.8 (42.2)	41.8-61.7 (51.7)	51.0-71.3 (61.1)	61.2-80.6 (70.9)	66.9-85.5 (76.2)	65.2-83.7 (74.4)	57.4-77.0 (67.2)	45.6-66.6 (56.1)	37.2-56.3 (46.8)	28.4-46.0 (37.2)	44.9-63.9 (54.3)
ATLANTIC CITY MARINA	29.2-41.8 (35.5)	30.9-43.5 (37.2)	36.9-49.6 (43.3)	45.5-57.6 (51.6)	54.5-66.6 (60.6)	64.3-75.7 (70.0)	70.0-81.3 (75.6)	69.7-80.2 (75.0)	63.5-74.8 (69.1)	52.5-65.0 (58.7)	42.9-55.8 (49.4)	33.5-46.3 (39.9)	49.5-61.5 (55.5)
BRANT BEACH BECH HAVEN	26.2-41.1 (33.6)	28.2-42.7 (35.5)	34.1-49.1 (41.6)	42.8-57.5 (50.1)	52.7-67.7 (60.2)	62.3-76.9 (69.6)	69.0-83.4 (76.2)	68.2-82.4 (75.3)	61.8-76.1 (68.9)	50.5-65.9 (58.2)	41.0-55.6 (48.3)	31.5-45.4 (38.5)	47.4-62.0 (54.7)
CAPE MAY	27.9-42.3 (35.1)	29.2-44.3 (36.8)	35.2-51.4 (43.3)	43.8-60.8 (52.3)	52.7-70.4 (61.5)	62.5-79.4 (71.0)	67.7-84.5 (76.1)	66.8-83.4 (75.1)	60.7-77.8 (69.2)	49.9-67.1 (58.5)	41.1-56.8 (49.0)	31.9-46.8 (39.4)	47.5-63.8 (55.6)
TOMS RIVER	22.1-41.1 (31.6)	23.9-44.0 (34.0)	30.1-50.9 (40.5)	39.3-61 (50.2)	48.9-71.1 (60.0)	58.5-80.0 (69.2)	63.9-85.0 (74.5)	62.2-83.4 (72.8)	54.5-77.0 (65.7)	42.8-66.5 (54.6)	34.6-56.5 (45.5)	26.5-45.7 (36.1)	42.3-63.5 (52.9)
MEAN	(33.8)	(35.8)	(42.2)	(51.2)	(60.7)	(70.1)	(75.7)	(74.5)	(68.0)	(57.2)	(47.8)	(38.2)	(54.6)

Table 25: New Jersey Monthly Precipitation Normals (Inches)

Based on Data from 1981-2010													
STATION NAME	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
ATLANTIC CITY AP	3.2	2.9	4.2	3.6	3.4	3.1	3.7	4.1	3.2	3.4	3.3	3.7	41.8
ATLANTIC CITY MARINA	3.1	2.9	4.0	3.4	3.2	2.7	3.3	3.9	3.1	3.5	3.4	3.6	40.0
BRANT BEACH BECH HAVEN	3.3	2.9	4.0	3.3	2.8	3.1	3.9	3.7	2.8	3.7	2.9	3.4	39.5
CAPE MAY	3.3	2.8	4.3	3.5	3.5	3.4	3.7	3.6	3.3	3.7	3.3	3.5	41.9
TOMS RIVER	3.9	3.2	4.8	4.1	3.7	3.8	4.6	4.7	3.8	3.9	4.1	4.5	49.1
MEAN	3.4	2.9	4.3	3.6	3.3	3.2	3.9	4.0	3.2	3.6	3.4	3.7	42.4

Despite the historic moderate climate experienced within the Coastal Zone of New Jersey, the Earth's surface temperature has risen by 1.3 °F over the last century, which is attributed to the anthropogenic introduction of carbon dioxide and other greenhouse gases (NJDEP, 2013). In New Jersey, the New Jersey State Climatologist reports a statistically significant rise in average statewide temperature over the last 118 years. Also, during this period, New Jersey has experienced a significant increase of the departure from normal indicating that average annual temperatures are consistently greater than the longer term average. This temperature trend coincides with an increase in precipitation due to more moisture in the atmosphere. However, despite a trend toward more precipitation, the Northeast is seeing longer periods without rainfall and longer growing seasons (NJDEP, 2013 and O'Neill, 2009).

As stated in NJDEP (2013): "Sea levels are rising at a rate of 3.5 millimeters per year (Cooper *et al.* 2005), and this rate is projected to increase into the 21st Century (Climate Institute 2010, UCS 2013). The global average of sea level change is approximately 8 inches since the Industrial Revolution, but other areas of the world, particularly the East Coast and Gulf Coast are experiencing some of the highest rates of sea level rise (UCS 2013). Small increases in sea level dramatically affects the world's coastlines, physically, biogeochemically, and economically through impacts such as erosion, flooding, salinization, and habitat transformation for wildlife and plants (Climate Institute 2010, UCS 2013)."

Other impacts of climate change may include increased intensity of hurricanes; however, climate science projections for intensity and intense hurricane numbers suggest relatively large uncertainty at present (NOAA 2012). High magnitude storm events such as hurricanes and nor'easters could have extensive direct and indirect impacts to habitat, ranging from erosion from wave attack, saltwater intrusion from inundation, as well as water quality impacts from developed areas experiencing inundation from floodwaters. Additionally, temporary, and permanent impacts to habitat could occur across a broad temporal reference along the North Atlantic Coast. Some habitat areas could be exposed to different impacts based on the time of the year the storm occurs. Combined with sea level rise, extreme water levels may exacerbate coastal storm impacts to habitats over the long-term planning horizon (USACE 2014).

Climate change and sea level rise are significant issues affecting coastal areas in New Jersey. Climate change has potential devastating ecological, economic, and public health impacts in New Jersey (NJDEP, 2013 and IPCC, 2007).

5 Hydrodynamic Modeling Analysis

5.1 Introduction

Hydrodynamic modeling analyses and water surface elevations were determined using NACCS analyses and subsequent refinement in association with the USACE Engineer Research and Development Center (ERDC). Discussion in this chapter will discuss existing coastal storm risk, historical flooding considerations, storm surge modeling, total water level and crest elevations and high-frequency flooding (HFF) analyses.

5.2 Existing Coastal Storm Risk

5.2.1 Vertical Datum

In accordance with ER 1110-2-8160 the NJBB Feasibility Study is designed to North American Vertical Datum of 1988 (NAVD88), the current orthometric vertical reference datum within the National Spatial Reference System (NSRS) in the continental United States. The study area is subject to tidal influence and is directly referenced to National Water Level Observation Network (NWLON) tidal gauges and coastal hydrodynamic tidal models established and maintained by the NOAA. The current NWLON National Tidal Datum Epoch (NTDE) is 1983-2001.

More than one NWLON tidal gauge is required to reference tidal water levels to NAVD88 due to the vast size of the study area. The local NAVD88-MSL relationship at locations between gauges is estimated using NOAA VDatum models of the project region (EM 1110-2-6056). Hydrodynamic modeling completed for this study was performed in meters, MSL in the current NTDE. Water elevations are converted to ft., NAVD88 using NOAA VDatum.

5.2.2 Tides

The Atlantic Ocean adjacent to the study area experiences semi-diurnal tides, with a full tidal period that averages 12 hours and 25 minutes; hence there are nearly two full tidal cycles per day. The mean tidal range in the ocean is 4.0 ft. at Atlantic City. The rise and fall of the tide in the ocean lead to tidal flow through the inlets that causes a corresponding rise and fall of water levels in the back bays.

Figure 26 shows the locations of tide gauges within the study area. The green symbols are NOAA/NOS tide gauges: one in the ocean at Atlantic City and one in Delaware Bay at the western entrance to the Cape May Canal. The NOAA/NOS tide gauge at Atlantic City is the only open-ocean gauge in the study area and has a period of record of over 100 years. The mean tide range in the ocean gradually increases north of Atlantic City, to 4.7 ft. at Sandy Hook at the entrance to Raritan Bay and New York Harbor. The second green symbol in Figure 26 is the NOAA/NOS tide gauge at the Cape May Canal western entrance, with a mean range of 4.9 ft.

Figure 26 also displays the locations of tide gauges operated by the US Geological Survey (USGS) as red triangles. Data from these gauges indicate that the southern half of the study area, from Little Egg Harbor Inlet south to Cape May Inlet, experiences a mean tide range that is only slightly reduced relative to the mean range in the open ocean at Atlantic City, typically in the 3.5 to 4.0 foot mean range. This is due to the relatively shorter distance along the coast between inlets, and the relatively short distances from the open ocean, through the inlets, to the inland extent of the bays.

Figure 27(a) shows tides during typical non-storm conditions (6 through 9 October 2018) for the ocean at Atlantic City and at five USGS gauges located in the back bays south of Little Egg Inlet. The Atlantic City data are shown as the heavy black line. The data for the USGS back bay gauges are difficult to distinguish from the ocean tide signal at Atlantic City, other than a small phase lag; high and low tides in the back bays are comparable to those in ocean but occur later.

North of Little Egg Harbor Inlet the mean tide range in the back bays gradually decreases such that at Mantoloking, near the head of Barnegat bay, the mean range is about 0.9 ft. The reduction in mean tide range is due to the long, narrow, and shallow geometry of Barnegat Bay and the relatively greater distances between inlets; it is about 24 miles from Manasquan Inlet south to Barnegat Inlet, and then an additional 21 miles south to Little Egg Harbor Inlet. Additionally, the hydraulic connection between the head of Barnegat Bay and Manasquan Inlet is the Point Pleasant Canal, which is 2 miles long but only about 150 ft. wide. Figure 27(b) shows typical non-storm tides at back bay gauges in the northern part of the study area over the same four-day period in Figure 27(a). The tide in the ocean at Atlantic City is indicated by the bold black line. The additional tide curves are from gauges from Little Egg Inlet north to Mantoloking and show a continually diminishing tide range and increasing phase lag toward the head of Barnegat Bay.

Figure 26: USGS Tide Gauges (RED) and NOAA/NOS Tide Gauges (GREEN)

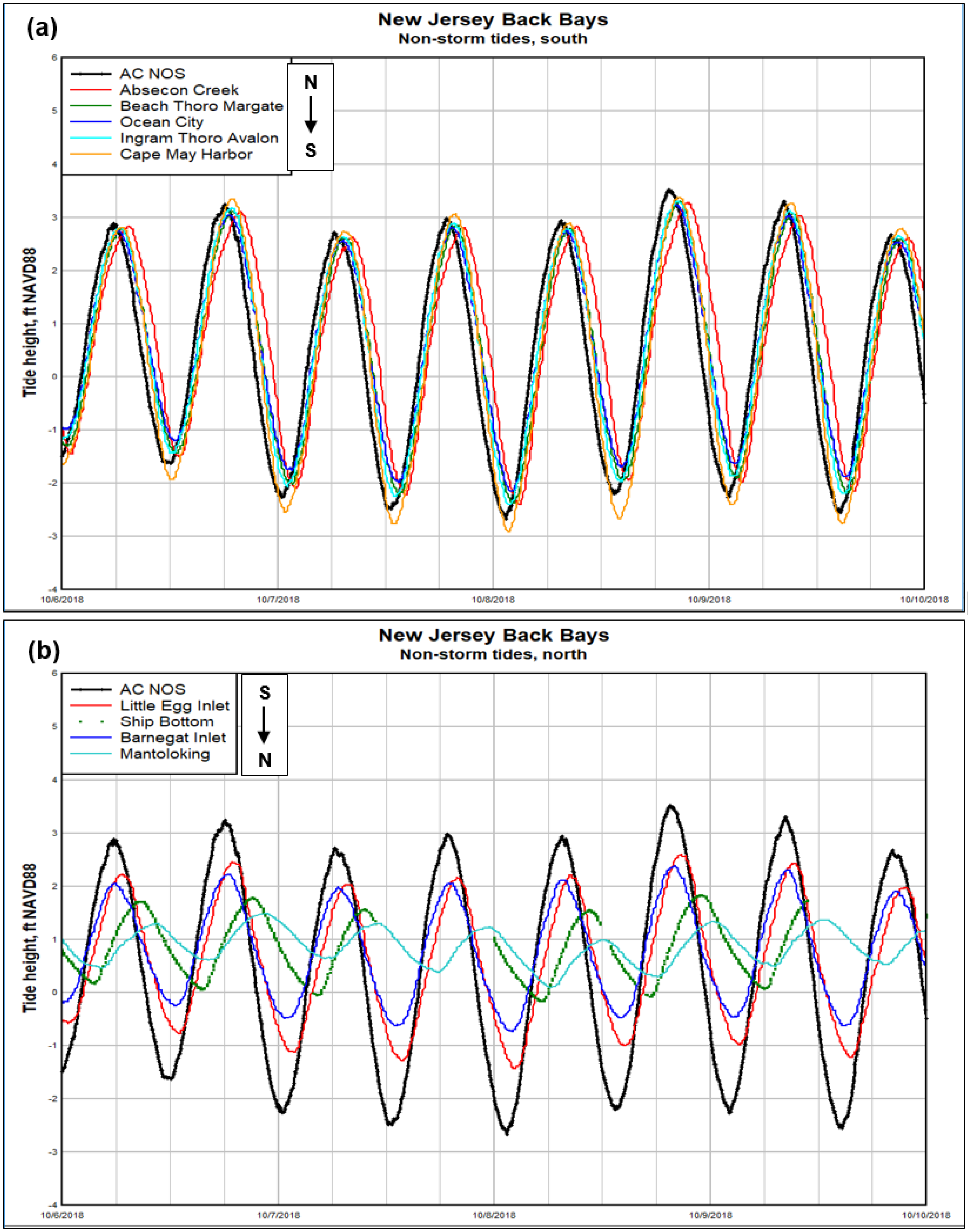


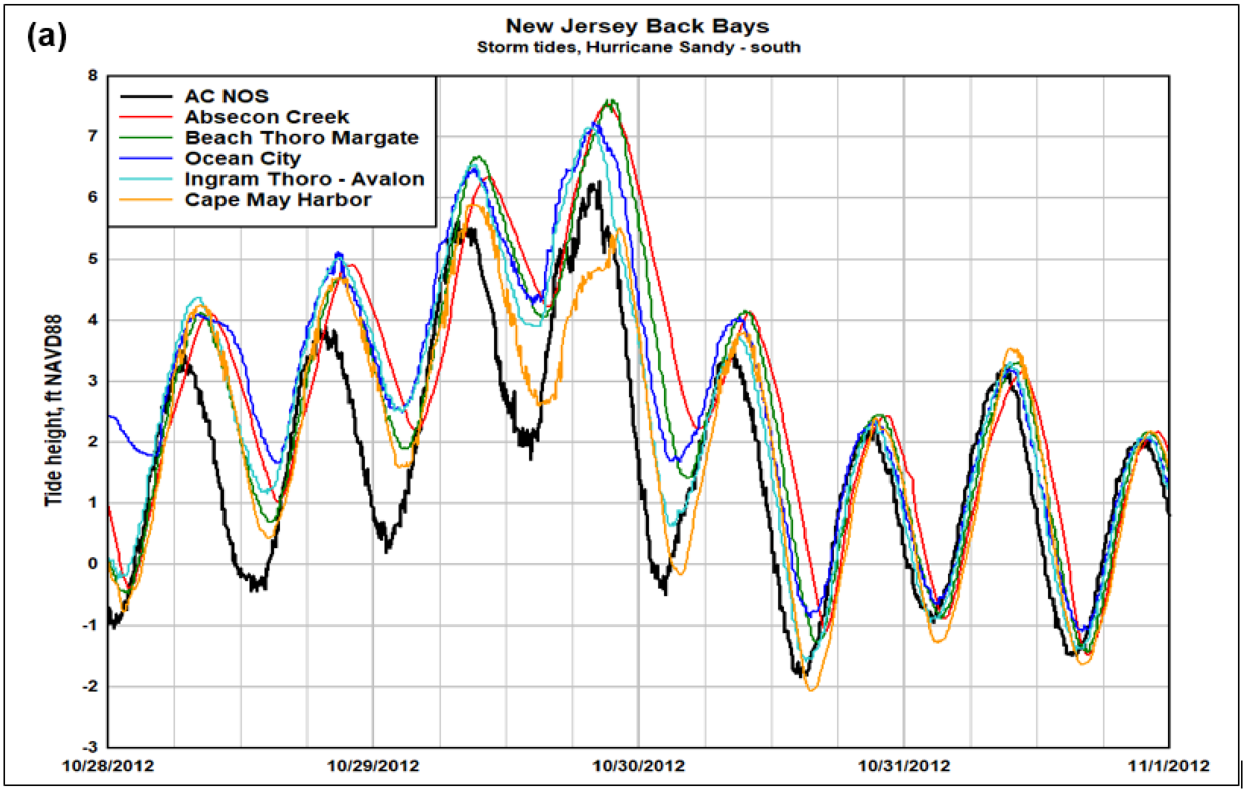
Figure 27: Non-storm tides for the South (a) and North (b) portions of the NJBB CSRM Study Area

5.2.3 Storm Surge

Storm surge is the increased water level above the predicted astronomical tide due to storm winds over the ocean and the resultant wind stress on the ocean surface. The principal factor that creates flood risk for the study area is storm surge that propagates into the back bays through the twelve inlets distributed along the New Jersey coast, between Shark River Inlet on the north and the Delaware Bay entrance to the Cape May Canal on the southwest. The magnitude of the storm surge is calculated as the difference between the predicted astronomic tidal elevation and the actual water surface elevation at any time. Any wind blowing over the ocean surface is capable of generating storm surge. However, the largest and most damaging storm surges develop as a result of either tropical cyclones (i.e., hurricanes) or extra-tropical cyclones ("nor'easters"). Although the meteorological origins of the two types of storms differ, both can generate large, low-pressure atmospheric systems with intense wind fields that rotate counter-clockwise (in the northern hemisphere). The relatively broad and shallow continental shelf along the study area allows the generation of larger storm surge values than are typically experienced on the US Pacific coast.

Just as Figure 28 depicted differences in tidal characteristics between the southern and northern portions of the study area during non-storm conditions, Figure 28 shows the differences between southern and northern areas during storm conditions, specifically those that occurred during Hurricane Sandy in October 2012. As depicted in Figure 28, the water level response of the southern back bays (Figure 28(a)) during Sandy broadly resembled the tide signal in the ocean at Atlantic City, although a number of the back bay gauges measured water levels higher than that observed at Atlantic City. Likewise, Figure 28(b) shows a larger degree of variability in storm surge response for the northern back bay areas, likely due to the effects of wind acting on the shallow, narrow Barnegat and Little Egg Harbor Bays. In particular note in Figure 28(b) that the tide level at Mantoloking near the head of Barnegat Bay stayed at near-normal values until late in the day on 29 October, when Sandy made landfall near Atlantic City. After Sandy's landfall, the change in wind direction over the back bays "pushed" accumulated storm surge from the southern end of the Little Egg Harbor-Barnegat Bay system to the north, inundating the back bay side of Mantoloking in a matter of a few hours.

Figure 27 and 28 were presented to illustrate the different non-storm and storm condition water level characteristcs of the southern portion of the back bay study area compared to the northern portion.



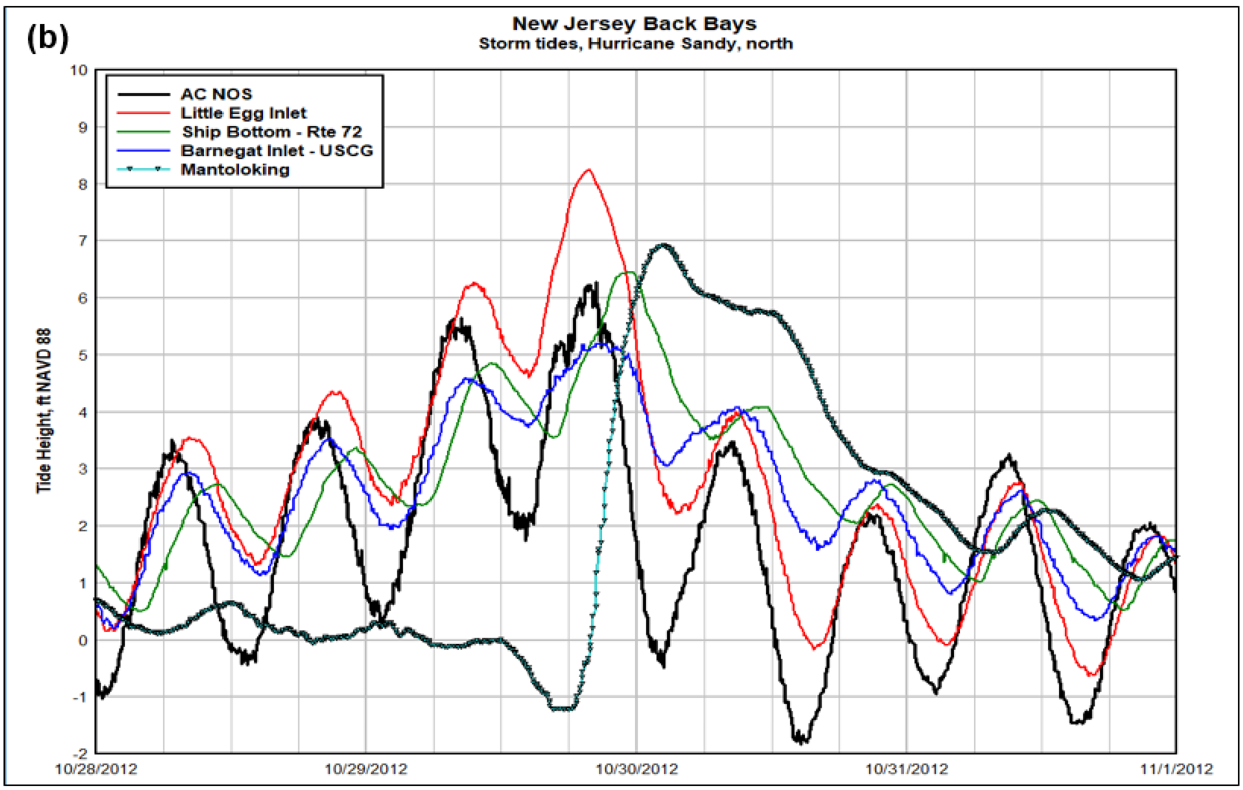


Figure 28: Storm water levels for the South (a) and North (b) portions of the NJBB CSRM Study Area

5.3 Historical Flooding

The back bays study area has experienced flooding from tropical storms (i.e., hurricanes) and extratropical storms (i.e., nor'easters) for as long as there has been development adjacent to the back bays. Hurricanes are characterized by winds of seventy-five miles per hour or greater and impact the Gulf and Atlantic seaboards in the late summer and autumn. Extratropical storms typically develop as strong, low pressure areas over land and move slowly offshore between approximately October through March. The winds, though not necessarily of hurricane force, blow onshore from a northeasterly or easterly direction for sustained periods of time and over very long fetches. Table 26 displays the Top 10 historical storms at Cape May, Atlantic City, and Sandy Hook NOAA tidal stations. Note that the historical water levels have not been adjusted for sea level rise.

Table 26: Top 10 Historical Storms at Cape May, Atlantic City, and Sandy Hook NOAA Tidal Stations

Cape May, NJ (since 1965)			Atlantic City, NJ (since 1911)			Sandy Hook, NJ (since 1932)		
Date	Type	Feet NAVD88	Date	Type	Feet NAVD88	Date	Type	Feet NAVD88
23-Jan-2016	E	5.96	11-Dec-1992	E	6.37	29-Oct-2012	T	10.42
29-Oct-2012	T	5.87	14-Sep-1944	T	6.23	12-Sep-1960	T	7.27
27-Sep-1985	T	5.79	29-Oct-2012	T	6.15	11-Dec-1992	E	7.26
29-Oct-2011	E	5.67	27-Sep-1985	T	5.96	28-Aug-2011	T	6.95
25-Oct-1980	E	5.64	31-Oct-1991	E	5.85	7-Nov-1953	E	6.87
11-Dec-1992	E	5.53	6-Mar-1962	E	5.83	6-Mar-1962	E	6.57
4-Jan-1992	E	5.52	9-Aug-1976	T	5.83	14-Sep-1944	T	6.57
3-Mar-1994	E	5.50	25-Nov-1950	E	5.63	13-Mar-2010	E	6.21
28-Aug-2011	T	5.37	29-Mar-1984	E	5.38	25-Nov-1950	E	6.17
14-Oct-1977	T	5.25	23-Jan-2016	E	5.23	12-Nov-1968	E	5.99

Note E: Extratropical; T: Tropical.

Recent storm surge events that have affected the back bays study area include floods associated with Tropical Storm Ida in November 2009, Hurricane Irene in August 2011, Hurricane Sandy in October 2012, and more recently, the nor'easter in January 2016.

The storm surge flooding that occurred in the NJ back bays during Hurricane Sandy and other coastal storm events results principally from the low elevation topography with densely populated residential and commercial areas and extensive low-lying roads and other public infrastructure. The intensity of the flooding ranges from nuisance flooding, typically associated with spring high tides, to severe, albeit less frequent flooding from hurricanes and major nor'easters. In addition, relative sea level in the study area has risen at a rate of 1.3 ft. per century, based on the period of record dating to 1911 at the NOAA/NOS Atlantic City tide gauge. Assuming that this trend continues or accelerates, both nuisance flooding and flooding from storm events will become more frequent and more damaging.

5.4 Storm Surge Modeling

5.4.1 NACCS

As part of the NACCS, the ERDC completed a coastal storm wave and water level modeling effort for the U.S. North Atlantic Coast. This modeling study provides nearshore wind, wave, and water level estimates and the associated marginal and joint probabilities critical for effective coastal storm risk management. This modeling effort involved the application of a suite of high-fidelity numerical models within the Coastal Storm Modeling System (CSTORM-MS) to 1050 synthetic tropical storms and 100 historical extra-tropical storms. Documentation of the numerical modeling effort is provided in Cialone et al. 2015 and documentation of the statistical evaluation is pr oved in Nadal-Caraballo et al. 2015. Products of the study are available for viewing and download on the Coastal Hazards System (CHS) website: https://chs.erdc.dren.mil/.

5.4.2 Modifications for NJBB

The USACE ERDC, Coastal and Hydraulics Lab (CHL) conducted a numerical modeling study to evaluate the effectiveness of SSBs in reducing water levels in the study area. ERDC-CHL leveraged the existing NACCS CSTORM-MS complete the numerical modeling study. As part of this numerical modeling study the existing condition water levels in the study area were updated from NACCS to ensure that the existing and with-project water levels were consistent and derived from a common model, set of storms, and statistical evaluation.

The ERDC-CHL numerical modeling study reused the CSTORM-MS developed for NACCS. While the original mesh boundary was maintained, Chesapeake Bay and coastal Long Island in the NACCS grid were subject to a “de-refining” procedure, which locally reduces a mesh resolution in areas that are distant from the area of interest. The model bathymetry was only updated to raise the barrier islands elevations from Manasquan to Lower Cape May Meadows to represent 2018 existing conditions with the recent construction of several USACE beach restoration projects that were not captured in the original NACCS model.

A total of 1.050 synthetic tropical cyclones were designed and simulated in the NACCS. However, not all of these storms affect the NJBB region. Using Gaussian process metamodeling (GPM) and a design of experiments (DoE) approach, ERDC-CHL selected a subset of the NACCS synthetic tropical cyclones to maximize coverage of the storm parameter and probability spaces and produce storm surges across the NJBB region while reducing the hydrodynamic modeling requirements. A set of approximately 60 tropical cyclones was selected for modeling in order to complete the frequency distributions of response for both the with- and without-project conditions. Although the subset of storms does not include extratropical storms (nor’easters) the combined frequency distributions for both tropical and extratropical storms is generated by ERDC-CHL using GPM.

5.4.3 NACCS Water Levels

Storm events are often defined according to their likelihood of occurring in any given year at a specific location. The most commonly used definition is the “100-year storm”. This refers to a storm with a “recurrence interval” or “return period” of 100 years and is equivalent to a storm that has a 1 in 100, or 1-percent chance of being equaled or exceeded in any year (i.e., 1-percent annual exceedance probability (AEP)).

A common misinterpretation is that a 100-year storm is likely to occur only once in a 100-year period. In fact, a second 100-year storm could occur a year or even a week after the first one. The term only means that the average interval between storms greater than the 100-year storm over a very long period (say 1,000 years) will be 100 years. However, the actual interval between storms greater than this magnitude will vary considerably.

The AEP describes the likelihood of a specified flood or storm event being exceeded in a given year. There are several ways to express the AEP. The AEP is expressed as a percentage. An event having a one in 100 chance of occurring in any single year would be described as the one percent AEP event. This is the current accepted scientific terminology for expressing chance of exceedance. The annual recurrence interval, or return period, has historically been used by engineers to express probability of exceedance.

Table 27 is presented to show the 1% AEP still water elevations for existing consitions as modeled during the NACCS. The salient point illustrated in Figure 29 is the relatively lower modeled flood elevations in the northern portion of the study area, Barnegat Bay, compared to the southern portion of the study area. Table 27 presents the AEP water levels at several locations throughout the study area.

Table 27: Water Level AEP in Study Area

Location	Save Point	Return Period (years)					
		1	10	20	50	100	500
		Annual Exceedance Probability Flood Event					
		100%	10%	5%	2%	1%	0.2%
Cape May	15566	3.9	7.1	7.9	9.2	10.4	12.9
Wildwood	11282	4.0	7.4	8.1	9.2	10.5	13.5
Avalon	13470	3.9	6.9	7.7	9.2	10.6	14.0
Strathmere	7531	4.1	7.0	7.8	9.2	10.4	13.9
Ocean City	11309	4.2	6.9	7.7	9.2	10.3	13.2
Atlantic City	11356	4.1	6.9	7.7	9.1	10.3	12.8
Mystic Island	11273	4.2	7.0	7.9	9.3	10.7	13.4
Lavallette	13694	2.9	5.2	6.1	7.6	8.8	11.2
Point Pleasant	13716	4.0	6.4	7.2	8.7	9.9	12.0
Belmar	13721	4.3	7.2	8.1	9.3	10.3	12.3
Asbury Park	3742	4.0	6.6	7.3	8.4	9.6	12.6

Note: All elevations are in ft. NAVD88, relative to NTDE (1983-2001)

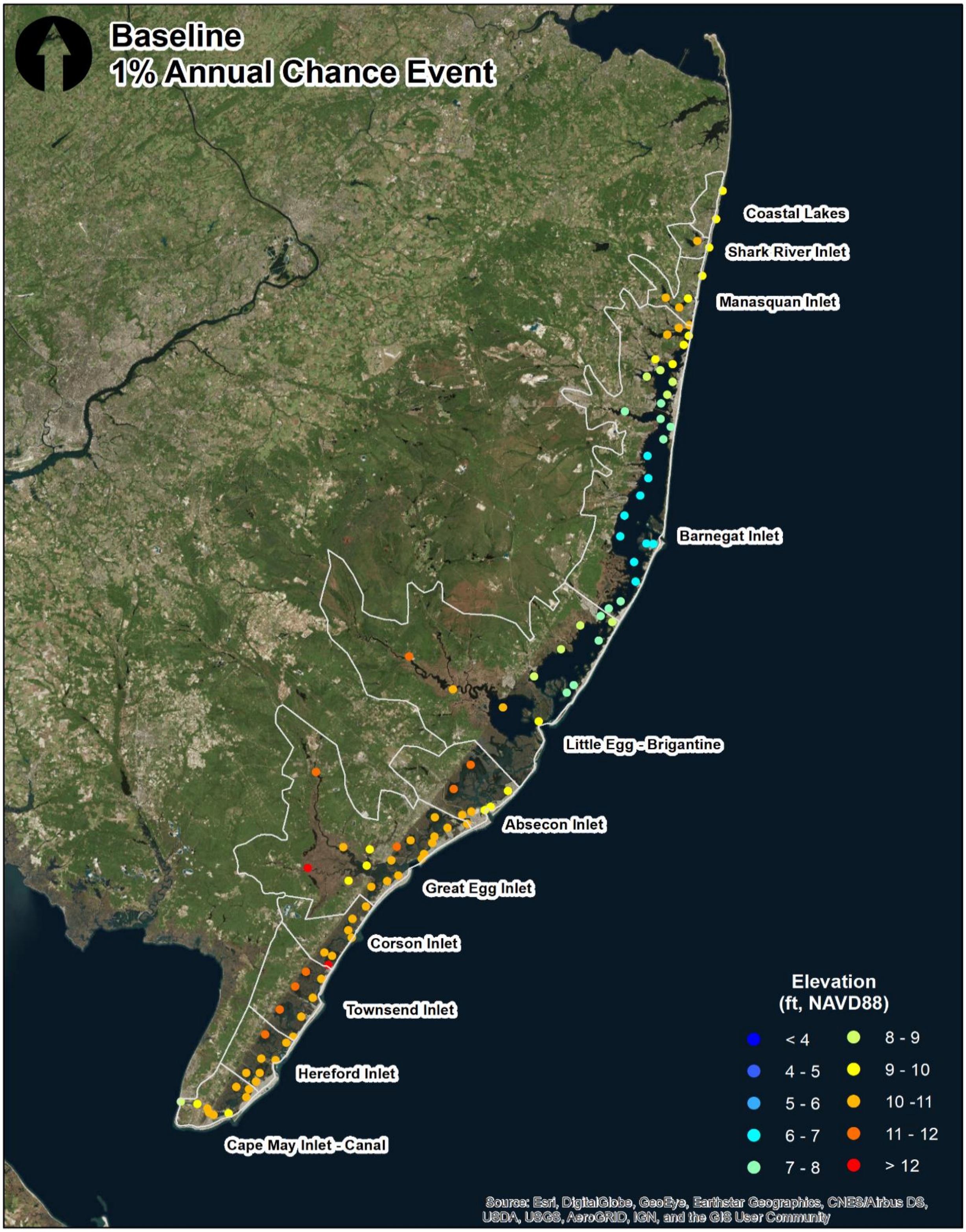


Figure 29: NACCS 1% AEP Peak Water Levels

5.5 High-Frequency Flooding

High-frequency flooding (HFF), also known as nuisance flooding, recurrent flooding, or sunny-day flooding, are flood events caused by tides and/or minor storm surge that occur more than once per year. High-frequency flooding mostly affects low-lying and exposed assets or infrastructure, such as roads, public storm-, waste- and fresh-water systems (Sweet et. al 2018) and is likely more disruptive (a nuisance) than damaging. However, the cumulative effects of high-frequency flooding may be a serious problem to residents who live and work in these low-lying areas. The number of high-frequency flood days is accelerating in the study area in response to RSLC.

Flooding from rainfall and inadequate storm water systems are closely related to high-frequency flooding but are treated separated in this study. It is common for municipalities in the study area to have gravity-based storm water systems that are unable to drain water when tidal level exceeds the elevation of the storm drain. When this happens, water starts ponding around the drain and may flood many of the same low-lying areas as high-frequency flooding. The frequency and impact of rainfall flooding will increase as the probability of the tide level exceeding storm drains will increases in response to RSLC. Some municipalities are addressing this problem by installing pump stations that are capable of draining water during elevated water levels.

For the NJBB CSRM Study, the term HFF is expanded to also include smaller storm inundation events in which the TSP's SSBs remain in an open position. Despite the TSP effectiveness at reducing and managing the risk to coastal storm events there are still residual damages associated with HFF. RSLC will render the existing patchwork network of bulkheads along the study area's shoreline less effective at preventing HFF, leaving the study area susceptible to greater depths and frequency of HFF. Since the TSP's SSBs and nonstructural management measures do not reduce water levels during a HFF event, the NJBB CSRM Study is exploring additional complementary management measures to address HFF, such as NS, NNBFs, bulkheads, critical infrastructure plans, and municipal partnership considerations. It is recognized that the long-term quality of life and sustainability of study area is dependent on managing the pernicious threat of HFF as well as the risk of coastal storms.

The primary focus of the NJBB CSRM Study is managing risk to severe storm surge events (i.e., Hurricane Sandy). A secondary focus of the NJBB CSRM Study is managing flooding risk associated with inadequate storm sewer systems and/or high-frequency flooding. This secondary analysis is being performed given USACE policy (ER 1165-2-21) which states that storm water systems are a local non-federal responsibility. Since nonstructural and SSB management measures may not provide comprehensive relief from these problems, complementary management measures are being investigated and may be recommended as part of a comprehensive Federal project or recommended for implementation. These recommendations could be potentially implemented at the Federal and/or local non-federal level.

5.5.1 National Weather Service Flood Stages

The National Weather Service (NWS) with the help of NOAA and USGS provide real time flood status of stream gauges and tidal stations. The National Weather Service (NWS) has established three coastal flood severity thresholds: minor, moderate, and major flood stages. The NWS minor and moderate flood stages are the most representative of high-frequency flooding events right now. However, all three flood stages will be evaluated since NWS major flood stage could eventually occur at frequency consistent with high-frequency flooding in the future in response to RSLC.

The definition of minor, moderate, and major flooding is provided herein by NWS. The definitions are taken from the NWS website for Atlantic City, NJ so that impacts are specific to Ocean and Atlantic County. However, impacts experienced described at this station are generally representative of the entire study area.

- **Minor Flooding** - Minimal or no property damage, but possibly some public threat;
- **Moderate Flooding** - widespread flooding of roadways begins due to high water and/or wave action with many roads becoming impassable in the coastal communities of Ocean County and Atlantic County. Lives may be at risk when people put themselves in harm's way. Some damage to vulnerable structures may begin to occur;
- **Major Flooding** - flooding starts to become severe enough to begin causing structural damage along with widespread flooding of roadways in the coastal communities of Ocean County and Atlantic County. Vulnerable homes and businesses may be severely damaged or destroyed as water levels rise further above this threshold. Numerous roads become impassable, and some neighborhoods may be isolated. The flood waters become a danger to anyone who attempts to cross on foot or in a vehicle.

An example of the flood inundation area associated with the three NWS Flood stages is shown in Figure 30 at Ventnor Heights, Chelsea Heights, and Absecon Island. The impact of minor flooding (orange) can be seen to be very limited to a few particularly low-lying areas. The impact of moderate flooding (red) is more widespread impacting some streets and properties and major flooding (purple) is widespread impacting several streets and blocks near the bay shoreline.

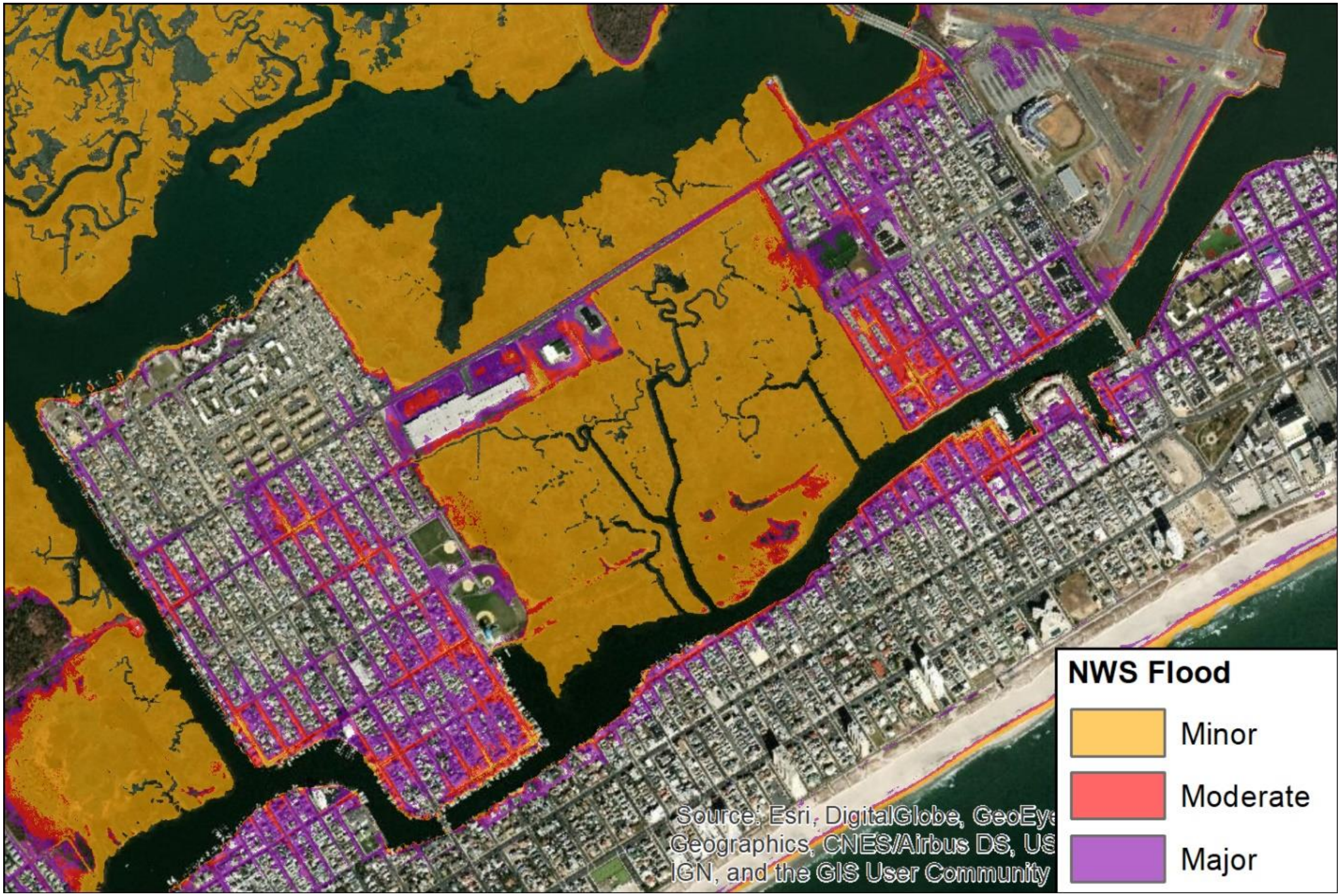


Figure 30: Floodplain associated with NWS Stages at Atlantic City, NJ

6 Future Without Project Condition*

6.1 Introduction

The forecast of the FWOP condition reflects the conditions expected during the period of analysis. The FWOP condition provides the basis from which alternative plans are formulated and impacts are assessed. Since impact assessment is the basis for plan evaluation, comparison and selection, clear definition and full documentation of the without-project condition are essential. Gathering information about historic and existing conditions requires an inventory. Gathering information about potential future conditions requires forecasts, which should be made for selected years over the period of analysis to indicate how changes in economic and other conditions are likely to have an impact on problems and opportunities. Information gathering and forecasts will most likely continue throughout the planning process.

The most likely FWOP condition is considered to be if no NJBB action is taken, and is characterized by CSRM projects and features, and socio-economic, environmental, and cultural conditions. This condition is considered as the baseline from which future measures will be evaluated with regard to reducing coastal storm risk and promoting resilience. The FWOP condition serves as the baseline for evaluating the anticipated performance of alternatives. It documents the need for Federal action to address the water resources problem. A base year of 2030 has been identified as the year when USACE projects associated with the NJBB CSRM Feasibility Study will be implemented or constructed.

Several trends have been identified for the NJBB Region which are projected to continue into the future and will likely affect the FWOP condition for this study. It is anticipated that the study area will continue to experience damages from coastal storms, and that the damages may increase as a result of more intense storm events. These coastal storm events will likely continue to effect areas of low coastal elevations within the study area with pronounced localized effects in some areas.

In the FWOP condition, it is anticipated that sea level is increasing throughout the study area, that shorelines are changing in response to sea level change, and historic erosion patterns will continue and accelerate. It is anticipated that there will continue to be significant economic assets within the NJBB region, and that population and development will continue to increase. Based on a desktop inventory of structures compiled for the HEC-FDA model, the NJBB CSRM Study area experiences a total of $1,808,610,000 in FWOP Average Annual Damages (AAD) over a 50 year period of analysis based on the intermediate rate of relative sea level change (RSLC).

Due to the likelihood of increasing water levels resulting from the rise in sea level over time, erosion rates will increase and impact the shorelines in the back bays. Increased erosive forces have the potential to undermine shorelines protected with structural management measures such as bulkheads having direct negative impacts on residents in bayfront communities. Unprotected shorelines could also be degraded, reducing the ability to attenuate waves and erosive forces, and losing valuable habitat. To maintain the shallow tidal marshes and islands, increases in sediment inflow into the back bays would be required to offset the increases in water levels as well as limit marsh loss and retreat. It is more likely that over time, increased water levels in the back bays will create more open water, reduce tidal marshes, inundate barrier islands, and steepen slopes near bulkheads and other back bay structures.

The FWOP condition no-action alternative would see no additional federal involvement in storm damage reduction as outlined within this study. Current projects and programs that the USACE conducts in conjunction with other Federal and non-Federal entities would continue and would be constructed by 2030.

The FWOP condition does consider those projects that have been completed (existing), are under construction, or have been authorized for construction and are anticipated to be constructed by 2030. Any proposed projects, which are not yet authorized for construction, are not considered part of the FWOP conditions for analysis.

6.2 Sea Level Change

6.2.1 Sea Level Change Guidance

Global sea level change (SLC) is often caused by the global change in the volume of water in the world's oceans in response to three climatological processes: 1) ocean mass change associated with long-term forcing of the ice ages ultimately caused by small variations in the orbit of the earth around the sun; 2) density changes from total salinity; and most recently, 3) changes in the heat content of the world's ocean, which recent literature suggests may be accelerating due to global warming. Global SLC can also be caused by basin changes through such processes as seafloor spreading. Thus, global sea level, also sometimes referred to as global mean sea level, is the average height of all the world's oceans.

Relative (local) SLC is the local change in sea level relative to the elevation of the land at a specific point on the coast. Relative SLC is a combination of both global and local SLC caused by changes in estuarine and shelf hydrodynamics, regional oceanographic circulation patterns (often caused by changes in regional atmospheric patterns), hydrologic cycles (river flow), and local and/or regional vertical land motion (subsidence or uplift). Relative SLC in the study area is higher than global SLC.

In accordance with ER 1100-2-8162, potential effects of relative sea level change (RSLC) were analyzed over a 50-yr economic analysis period and a 100-yr planning horizon. ER 1100-2-8162 requires planning studies and engineering designs consider three future sea level change scenarios (low, intermediate, and high) and consider how sensitive and adaptable the alternatives are to the range of SLC scenarios. The historic rate of SLC represents the "low" rate. The "intermediate" rate of SLC is estimated using the modified National Research Council (NRC) Curve I. The "high" rate of SLC is estimated using the modified NRC Curve III. The "high" rate exceeds the upper bounds of IPCC estimates from both 2001 and 2007 to accommodate the potential rapid loss of ice from Antarctica and Greenland, but it is within the range of values published in peer-reviewed articles since that time.

6.2.2 Historical and Projected SLC

Historical RSLC for this study (1.3 ft. per century) is based on NOAA tidal records at Atlantic City, NJ. USACE low, intermediate, and high SLC scenarios over the 100-yr planning horizon at Atlantic City, NJ are presented in Table 28 and Figure 31. Water level elevations at year 2030 are expected to be between 0.5 and 1.0 ft. higher than the current NTDE. Water elevations at year 2080 are expected to be between 1.15 and 4.02 ft. higher than the current NTDE.

Hydrodynamic modeling performed for this study was completed in the current NTDE. Therefore, the modeled water levels represent MSL in 1992. Future water levels are determined by adding the SLC values in Table 28. For example, a water level elevation of 10 ft. NAVD88 based on the current National Tidal Datum Epoch (1983-2001), will have an elevation in the year 2080 of 11.15, 11.84, and 14.02 ft. NAVD88 under the USACE low, intermediate, and high SLC scenario respectively (Table 28).

NJ Climate Adaptation Alliance convened a 2nd Science and Technical Advisory Panel (STAP) in 2019 to identify and evaluate the most current science on sea level rise projections and changing coastal storms, consider the implications for the practices and policies of local and regional stakeholders, and provide practical options for stakeholders to incorporate science into risk-based decision processes. The 2019 report titled "New Jersey's Rising Seas and Changing Coastal Storms: Report of the 2019 Science and Technical Advisory Panel" (Kopp et al. 2019) contains a detailed description of the basis for the STAP's projected SLR estimates. The STAP moderate emissions scenario falls between the USACE intermediate and high scenarios as shown in Table 28**Error! Reference source not found.**. The STAP high scenario is even higher than the USACE H igh scenario. During plan optimization all three USACE SLC scenarios and the STAP SLC scenarios will be considered.

Table 28: Relative Sea Level Change Projections for Study Area

Year	USACE - Low (ft., MSL[1])	USACE – Int. (ft., MSL[1])	USACE - High (ft., MSL[1])
1992	0.00	0.00	0.00
2000	0.11	0.11	0.13
2019	0.35	0.42	0.62
2030	0.50	0.63	1.03
2050	0.76	1.06	2.01
2080	1.15	1.84	4.02
2100	1.41	2.54	5.74
2130	1.81	3.50	8.87

[1]Mean Sea Level based on National Tidal Datum Epoch (NTDE) of 1983-2001

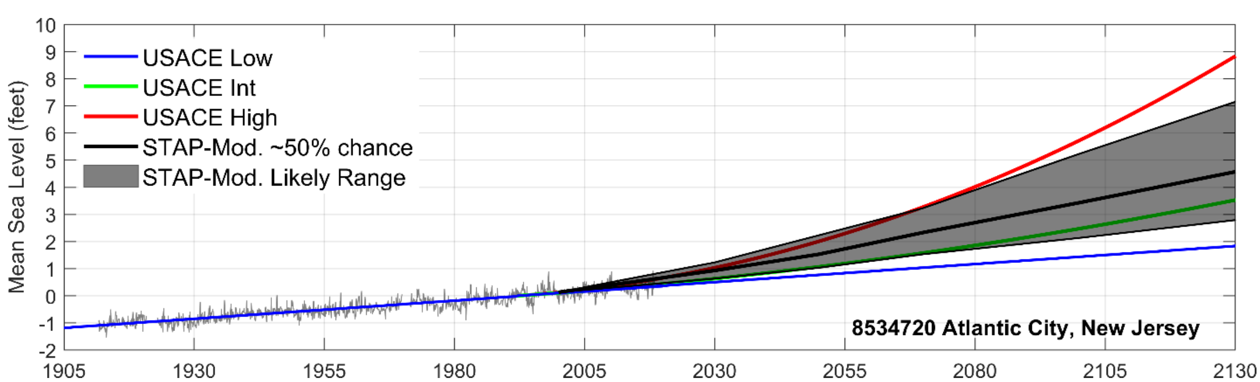


Figure 31: Relative Sea Level Change Projections for Study Area

6.2.3 Historical and Future High-Frequency Flooding

Atlantic City, NJ has the longest tidal record (1911-Present) out of any of NOAA or USGS stations and is therefore best suited for investigating how often high-frequency flooding has occurred in the past and how the rate of flooding has been affected by historical RSLC. The number of days in which the daily maximum water level equaled or exceeded the NWS flood stages was tabulated for every year since 1911. Future high-frequency flooding is estimated by repeating the last 25 years of NOAA tidal records (1992-2017) over and over again with the three USACE SLC projections added. An example of the approach using the USACE Low SLC scenario is shown in Table 29 with historical and future projected hourly water levels and a color-coded dot for any day in which the NWS flood stages were exceeded.

Annual NWS flood days from the analyses are tabulated in Figure 32. It is difficult to say or know what the tipping point (days per year) is for NWS minor, moderate, and major flooding before the impacts to roads and infrastructure are unacceptable. However, the analysis shows that major investments in high-frequency flood measures and storm water systems are likely to be required in the future for portions of the study area that could otherwise become inhabitable.

Table 29: High-Frequency Flood Occurrences (Per Year)

Year	NWS Minor Flood			NWS Moderate Flood			NWS Major Flood		
	Low	Int.	High	Low	Int.	High	Low	Int.	High
1930	1.1			0.0			0.0		
1955	1.7			0.2			0.1		
1980	3.6			0.5			0.2		
2005	14.5			0.7			0.0		
2015	26.5			2.2			0.5		
2030	54.7	73.2	139.8	4.7	5.9	21.1	0.1	0.3	1.0
2055	98.0	164.5	325.8	9.5	25.5	191.6	0.5	2.1	37.7
2080	153.8	282.6	356.2	23.1	100.9	349.9	1.5	11.1	298.3
2105	218.6	342.0	356.3	50.1	243.2	356.3	4.4	69.6	356.3
2130	258.5	350.6	352.3	78.1	327.3	352.3	5.8	182.3	352.3

Note: 10-year running mean filter applied to determine annual flood occurrences

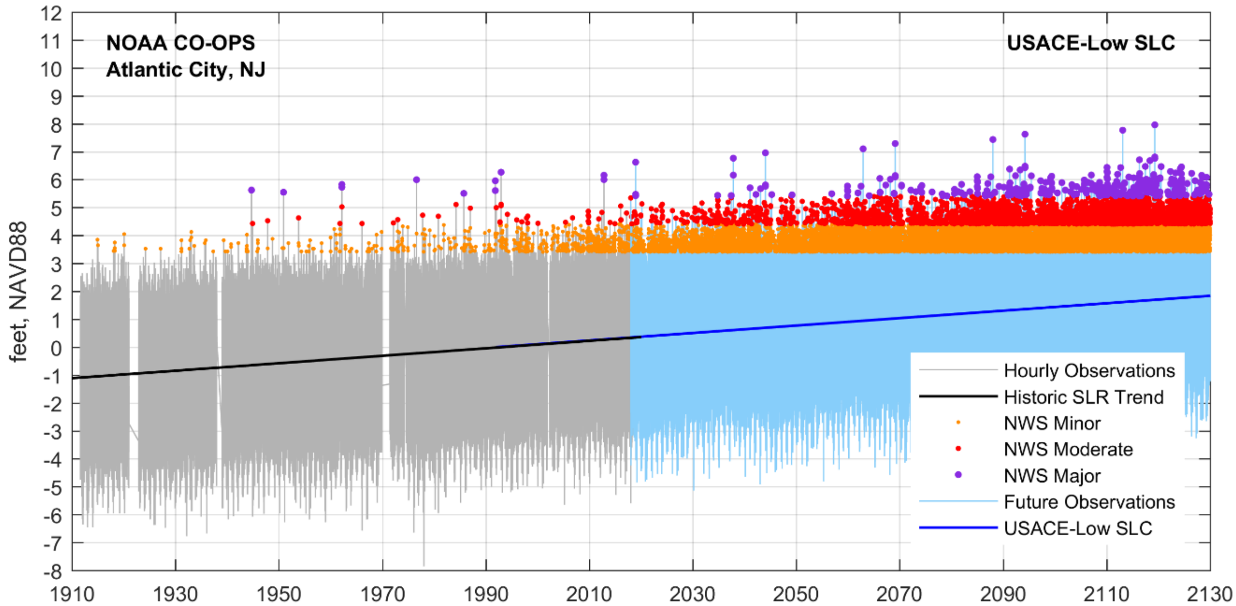


Figure 32: Historical and Future High-Frequency Flooding with USACE Low SLC

6.3 Economic and Social Without Project Condition

HEC-FDA links the predictive capability of hydraulic and hydrologic modeling with project area infrastructure information, structure and content damage functions, and economic valuations to estimate the total damages under various proposed alternatives while accounting for risk and uncertainty. The model output is then used to determine the net National Economic Development (NED) benefits of each project alternative in comparison with the No-Action Plan, or FWOP condition.

FWOP Condition damages are used as the base condition and potential project alternatives are measured against this base to evaluate project effectiveness and cost efficiency. FWOP condition damages are presented as Average Annual Damages (AAD) over a 50-year period of analysis with an FY2020 Project Evaluation and Formulation Rate (Discount Rate) of 2.75%.

The following model results for the FWOP condition analysis are based on HEC-FDA estimated structure, content, and vehicle damages with additional non-HEC-FDA benefit streams for transportation delay, non-transferrable income loss, emergency services, local costs foregone, boat damages, and critical infrastructure.

Current data for all HEC-FDA and non-HEC-FDA benefit streams reflect only primary, or direct, damage values. Future analysis will incorporate secondary, or indirect, damage from disruptions to critical infrastructure including interruptions to power plants, government operation centers, wastewater treatment facilities, utility lines, and communication centers.

6.3.1 Model Results

The NJBB CSRM Study area experiences a total of $1,778,000,000 in Without-Project AAD over a 50-year period of analysis with Intermediate RSLC. Table 30 below shows the breakdown of AAD by benefit stream and its relative contribution to the overall FWOP condition damage pool.

Table 30: FWOP Condition Damage Pool

Damage Type	Source	AAD	Relative %
Structures/Contents	HEC-FDA	$1,498,719,000	84.3%
Vehicles	HEC-FDA	$97,158,000	5.5%
Critical Infrastructure	Historic Damages	$63,856,000	3.6%
Emergency Services	Historic Damages	$41,059,000	2.3%
Income Loss	Historic Damages	$28,081,000	1.6%
Boat Damages	Historic Damages	$16,396,000	0.9%
Transportation Delay	Historic Damages	$2,701,000	0.2%
Local Costs Foregone	Historic Damages	$29,918,000	1.7%
TOTAL DAMAGES	**-**	**$1,777,888,000**	**100.0%**

While non-HEC-FDA benefit streams based on historic damages accounts are important for presenting the true vulnerability of the study area, they account for only 10.2% of total AAD damages. HEC-FDA modeled damages account for the remaining 89.8% of total AAD damages with structure and content damages comprising the majority of estimated impacts.

Figures 33 through 35 on the following pages show the heat map of FWOP damages across the 226 reaches in the NJBB CSRM Study area, where red indicates high damage potential and green indicates lower damage potential. Damages are concentrated on the barrier islands due to the islands' higher average Depreciated Replacement Values, density of structures, and increased vulnerability to inundation impacts. Of the 226 study area reaches, 72 fall on the barrier islands, but these reaches account for 76.8% of total AAD.

Absecon Island, Ocean City, and Wildwood Island (shown in red) are estimated to receive the most significant coastal storm related impacts over the 50-year period of analysis. Additional discussion of non-HEC-FDA category results for the FWOP condition are provided in the Economic Appendix.

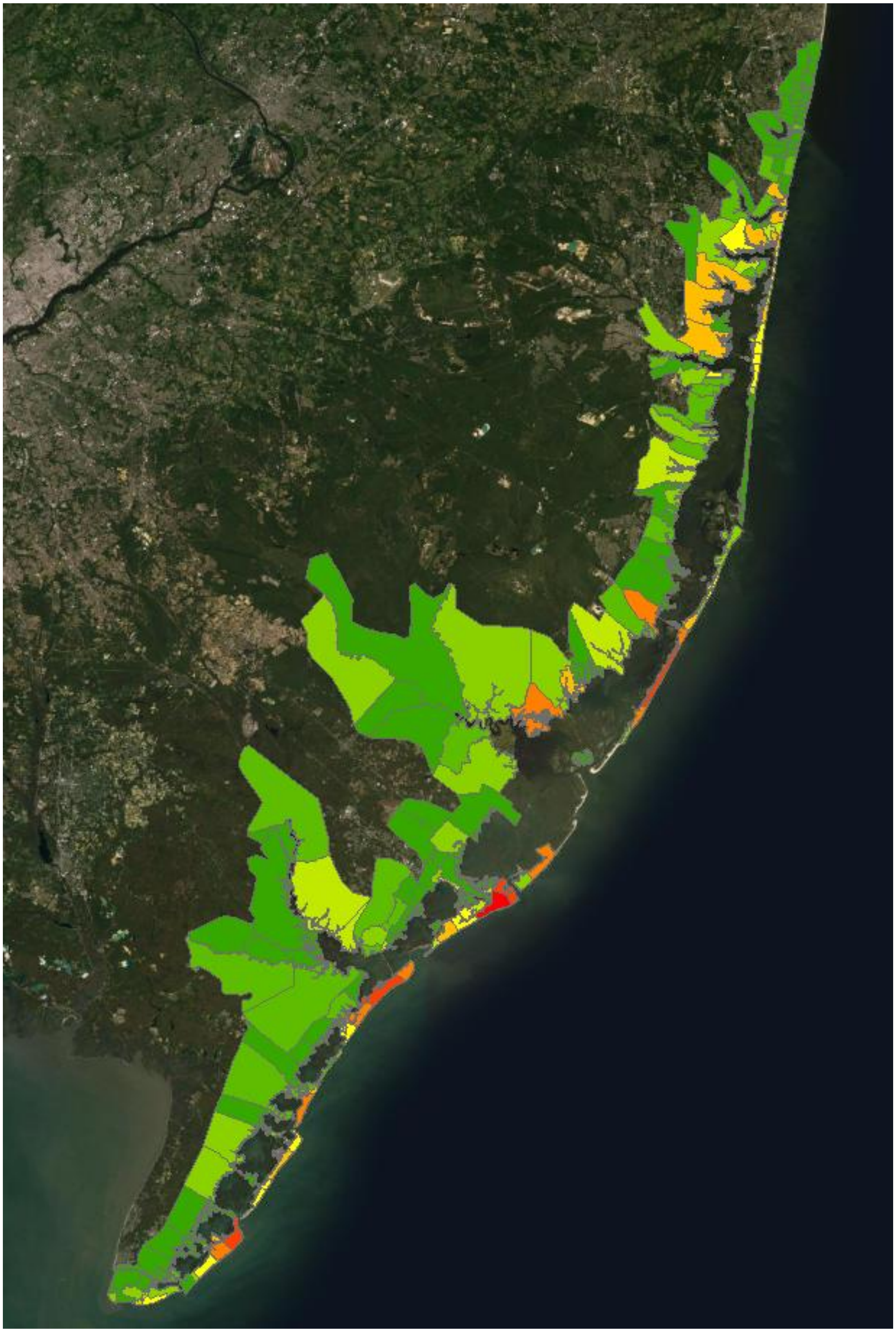


Figure 33: FWOP Damages--Heat Map (Full Study Area)

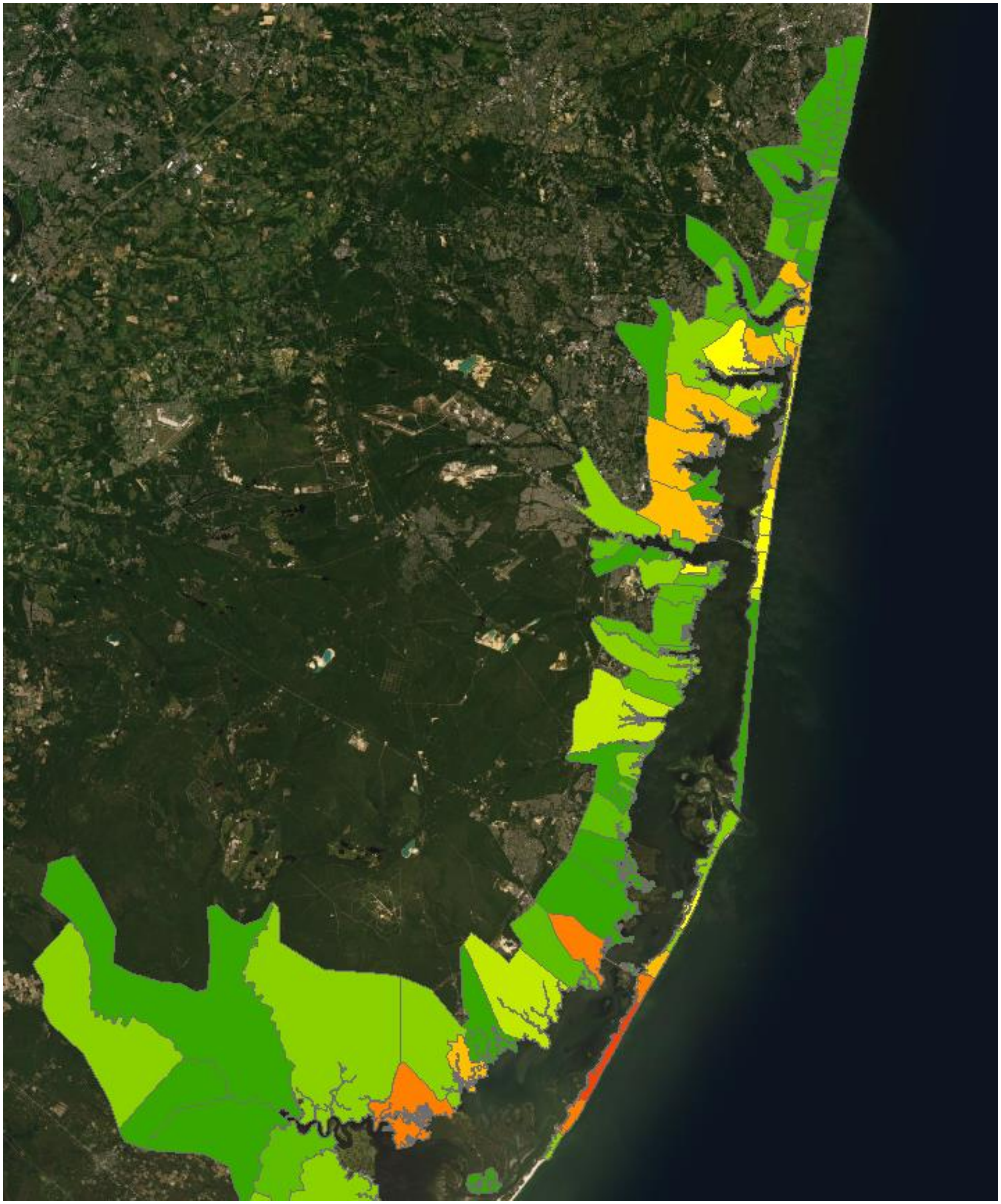


Figure 34: FWOP Damages--Heat Map (Burlington and Ocean and Monmouth)

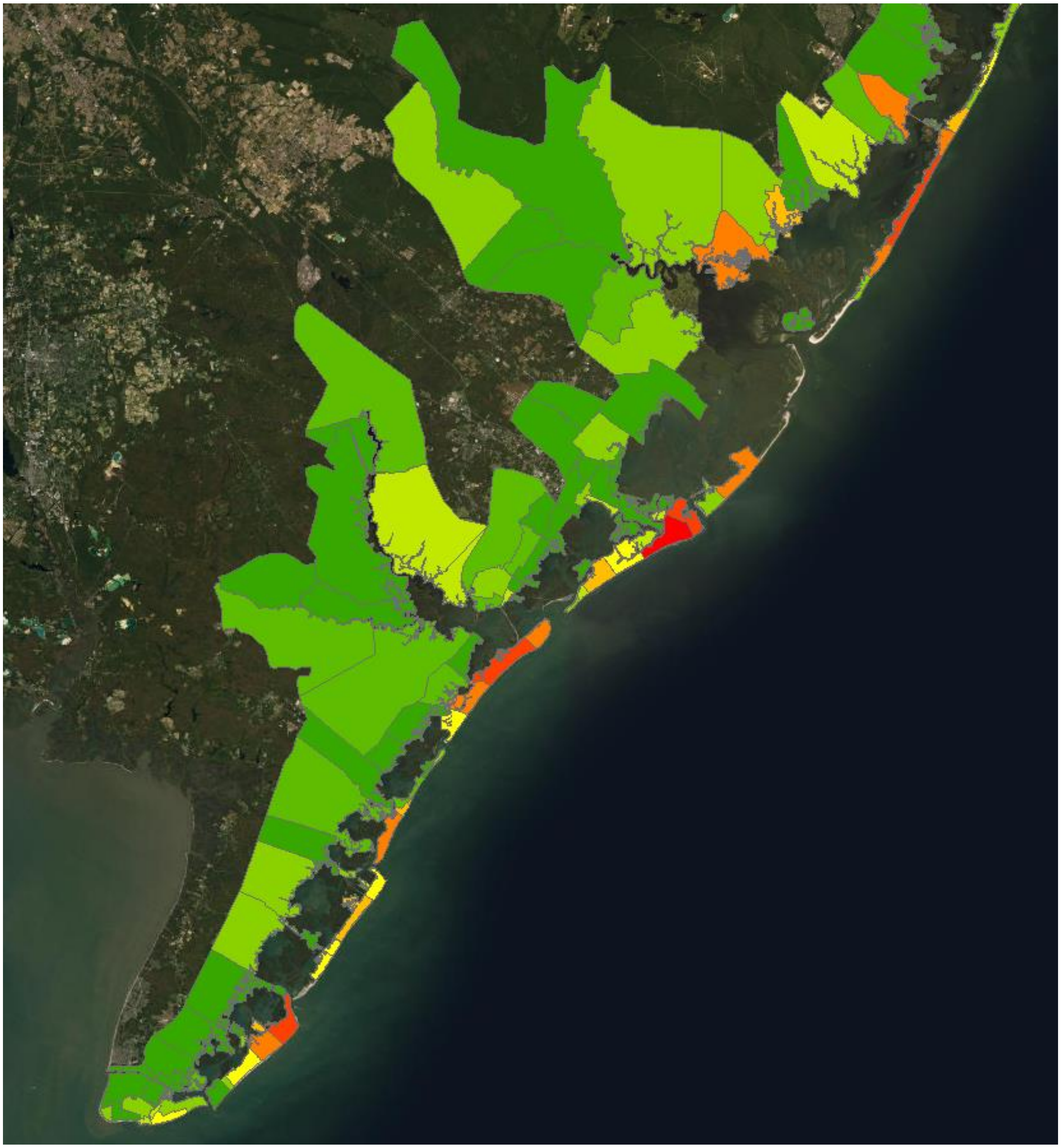


Figure 35: FWOP Damages--Heat Map (Cape May and Atlantic)

6.4 Environmental Without Project Condition*

6.4.1 Land Use

The FWOP/No Action alternative would involve no additional action from current USACE actions to mitigate against coastal storm risk along the NJBB CSRM Study area. Land use change has been significant in New Jersey from 1986 to 2012, with approximately 350,000 acres of forest and farmland converted to urban lands. However, many of the study area communities, especially along the barrier islands, are already heavily developed, and the remaining land areas are protected lands (parks, wildlife management areas), wetlands, and beaches. Therefore, the trend of conversion to urban land may not fully apply to the NJBB CSRM Study area.

It is assumed that no action would leave the communities within the study area more vulnerable to coastal storm risks from storm surge and inundation. Coastal storm risks coupled with sea level change have the potential to devastate communities, tourist areas, and associated transportation, commercial, industrial, health –related and educational activities, which could potentially have significant effects on land use. Low-lying areas would be increasingly susceptible to flooding, making these locations inaccessible at times to residents and visitors. It is expected that some localized measures (structural or nonstructural) would be implemented by residents, businesses, municipalities or the State to mitigate flooding. However, areas left unprotected over time may be uninhabitable following a major storm event or recurrent flooding. These areas could revert to open water, intertidal mudflat, or tidal marsh.

6.4.2 Floodplains

The FWOP/No Action alternative would involve no additional action by USACE to mitigate against coastal storm risk along the NJBB CSRM Study area. Therefore, it is expected that existing structures within the study area not protected by a certified and accredited flood protection system or elevated with appropriate freeboard will continue to be at risk to flooding or could become more at risk due to sea level change and climate change. Without local or non-Federal interventions, it is expected that nuisance flooding in low-lying areas will continue, where the potential impacts from tidal and/or rainfall flooding will likely increase and worsen over time with climate change and sea level change These areas would also become more susceptible to catastrophic flooding from storm surges.

6.4.3 Geology and Soils

The FWOP/No Action alternative would involve no additional action from USACE to mitigate against coastal storm risk along the NJBB CSRM Study area. No significant impacts are expected on the underlying geology or geologic processes. Continued sea level change would likely increase flooding and wave attack, resulting in increased soil erosion particularly on tidal marshes and mudflats in vulnerable locations. Sea level change rates may also exceed normal sediment accretion rates in the saltmarshes resulting in increased inundation and subsidence. Additionally, groundwater may become more susceptible to saltwater intrusion.

6.4.4 Water Quality

The FWOP/No Action alternative would involve no additional USACE actions to mitigate against coastal storm risk. With no action, water quality will remain undisturbed in its current conditions, considering existing trends and future conditions such as climate change and sea level change. It is reasonable to conclude that current water quality trends will continue without any significant interventions such as changes in land use or improvements through implementation of new water quality improvement programs such as TMDLs administered by Federal, State, and local agencies. BBP summarized status and trends for the Barnegat Bay system in their 2016 state of the bay report, and concluded that there is a negative trend association for nutrient loading, which was scored with a status of "below average" due to measurable increases in nutrient loading from the period of 1989-2011. The status of algal blooms in the Barnegat Bay estuary were scored as "degraded" (mainly in the northern portion of the bay), but no discernable trend was apparent. Dissolved oxygen, temperature, freshwater macroinvertebrates, and shellfish bed closures have not exhibited any trend changes, although their statuses ranged from "above average" to "good". These trends may be similar for the other inland bays with some local variations.

Climate change and sea level change introduce greater uncertainty of continued trends where changes in temperature, precipitation and flooding patterns, and chemical changes such as ocean acidification and increases in salinity could impose synergistic effects on the NJBB water quality. In the future, climate change and sea level change may have profound effects on the NJBB water quality. To illustrate effects of climate change and sea level change on water quality of the Barnegat Bay watershed (as well as the other NJ bay systems), the *Draft Comprehensive Conservation Management Plan for the Barnegat Bay Watershed* (BBP, 2019) states that "In the future, increased variability and unpredictability in stream flow will alter water quality and water supply within Barnegat Bay and its tributary watersheds. Various climate change stressors will change the loads and pathways of nutrients and other pollutants (including pathogens), potentially decrease dissolved oxygen concentrations in surface waters, and potentially affect monitoring programs and implementation of the nutrient TMDL now under development. More variable summer weather, including more frequent/intense storms, is likely to affect water quality, human use, and monitoring programs at public recreation beaches. This may also increase pollution impacts from boating activities and marinas throughout the bay."

6.4.5 Plankton

The FWOP/No Action alternative would involve no additional USACE actions to mitigate against coastal storm risk. In the No Action alternative, there is a potential for increased phytoplankton blooms (including Harmful Algal Blooms) associated with increases in nutrient loadings and estuarine eutrophication. BBP (2016) reports that algal blooms, which include macroalgae and phytoplankton, are considered to be in a "degraded" state within northern Barnegat Bay, but there are no discernable trends with algal blooms. This is attributed to the localized nature of algal blooms and the "spottiness" of chlorophyll 'a' concentration in the monitoring programs. Any significant interventions such as changes in land use or improvements through implementation of new water quality improvement programs such as TMDLs administered by Federal, State, and local agencies may have an effect on algal blooms. However, climate change and sea level change introduce greater uncertainty of continued trends where changes in temperature, precipitation and flooding patterns, and chemical changes could impose synergistic effects on the NJBB water quality where the bays' plankton may experience shifts in distribution and abundance.

6.4.6 Submerged Aquatic Vegetation

The FWOP/No Action alternative would involve no additional USACE actions to mitigate against coastal storm risk. In the No Action alternative, there is some uncertainty of future conditions of SAV and macroalgae coverages or density. BBP (2016) reports that the current condition of seagrasses in Barnegat Bay are "degraded" with no discernable trends. Any significant interventions such as changes in land use or improvements through implementation of new water quality improvement programs such as TMDLs administered by Federal, State, and local agencies may have an indirect effect on seagrasses/SAVs/macroalgae through either degradation or improvements in nutrient loads in the NJBB. However, climate change and sea level change introduce greater uncertainty of continued trends where changes in temperature, precipitation and flooding patterns, and chemical changes could impose synergistic effects on the NJBB water quality, algal blooms, and SAV/macroalgae distribution and abundance. Additionally, sea level change could potentially impact seagrass beds by increasing water depths resulting in reductions in light penetration, photosynthesis, and productivity (Strange, 2008; USACE, 2014).

6.4.7 Wetland and Tidal Flats

The FWOP/No Action alternative would involve no additional USACE actions to mitigate against coastal storm risk. In this scenario, existing conditions for wetland systems as described in the Affected Environment and existing trends described below are expected to continue unless there are significant interventions. BBP (2016) reports that tidal wetland areas in Barnegat Bay are in a degraded state due to losses from development, erosion from boat wakes, and degradation from other stressors such as sudden marsh die-backs and subsidence. More than 94% of tidal wetlands in Northern Barnegat Bay and 77% of tidal wetlands in Southern Barnegat Bay to be classified as moderate to severely stressed. Therefore, the current trend for wetland losses is negative and the trend for wetland conditions is unknown due to a limited sample period. Most of the other bay systems of the NJBB have similar issues, and it can be inferred that there are similar statuses and trends.

Predicted climate change impacts such as sea level change, have the potential to cause changes in the nature and character of the wetlands in the NJBB CSRM Study area. In general, wetlands both inside and outside of the NJBB CSRM Study area are at increased risk of degradation and loss from sea level change. Wetlands may erode further or be at increased risk of becoming too inundated to support vegetation while not keeping up with sediment accretion rates. Eventually, sea level change may cause estuarine and freshwater wetlands to retreat inland (USACE, 2017).

However, wetland retreat may not be possible in a lot of locations due to exiting heavy development and structures that would halt this process.

Another phenomenon related to sea level change and climate change is the formation of "ghost forests", which is the result of low-lying forests becoming susceptible to saltwater intrusion and inundation from coastal storms and higher tides due to sea level change. In these areas, the trees become stressed and eventually die or may suddenly die from an extreme event leaving dead snags and stumps while more brackish and saline vegetation move-in. Atlantic white cedar forested wetlands have become increasingly susceptible in areas such as along the Mullica River where this process has been observed for decades but is expected to increase significantly with sea level change and climate change.

As reported in USACE (2014), New Jersey's coastal wetlands and tidal mudflats are highly susceptible to the effects of sea level change. Tidal mudflats would experience increased inundation and/or their tidal regimes changed from intertidal to subtidal. Coastal wetlands can adapt and keep pace with sea level change through vertical accretion and inland migration, but must remain at the same elevation relative to the tidal range and have a stable source of sediment. Cooper et al. (2005) reported that coastal wetlands in New Jersey will generally be unable to accrete at a pace greater or equal to relative sea level rise (3.53 mm/year) and are extremely susceptible to permanent inundation. According to Lathrop and Love (2007), New Jersey's salt marshes appear to have been able to keep pace with historical rates of sea level rise, but if sea level rises faster than marsh accretion, tidal marshes could eventually be drowned and replaced by open water. Strange (2008) also reported that New Jersey's tidal salt marshes are keeping pace with current local rates of sea level rise of 4 mm/yr., but will become marginal with a 2 mm/yr. acceleration, and will be lost with a 7 mm/yr. acceleration except where they are near local sources of sediments (e.g., rivers such as the Mullica and Great Harbor rivers in Atlantic County). Coastal wetlands are forced to migrate inland due to a combination of sea level rise and vertical accretion forcing the saline marshes on the coastline to drown or erode and the upslope transitional brackish wetlands to convert to saline marshes. A significant portion of New Jersey's coastal wetlands are adjacent to human development or seawalls that block natural wetland migration paths and increase the likelihood of wetland loss from inundation (Cooper et al. 2005).

Two National Wildlife Refuges (Edwin B. Forsythe and Cape May) that are located within the NJBB system have been modeled for their coastal wetland habitat responses to sea level rise (SLR) using the Sea Level Affecting Marshes Model (SLAMM) (Warren Pinnacle Consulting, 2011 and 2012). This modeling simulates responses to multiple sea level rise scenarios by year and water surface elevation change and may be generally inferred for the entire NJBB CSRM Study area. SLAMM scenarios generally exhibit profound shifts in habitat with SLR where some losses and gains are offset between open water, tidal mudflats, and regularly flooded marshes. However, habitats at the upper fringes such as irregularly flooded marshes (high marshes composed of salt meadow hay and scrub shrub habitats) and freshwater wetlands (palustrine forested and palustrine emergent wetlands) would experience complete losses due to the increased inundations. Table 31 presents some key results of the modeling for both of these areas.

Table 31: Wetland Change Simulations at Two National Wildlife Refuges Within the NJBB System Utilizing the Sea Level Affecting Marshes Model (SLAMM)

SLR SCENARIO at Year 2100	General Effect on Wetland Habitats within Edwin B. Forsythe NWR (Barnegat Bay and Little Egg Harbor) and Cape May NWR
>=0.69 meters	Near complete loss of Irregularly flooded marsh habitat
	Irregularly flooded marshes converted to regularly flooded marshes
<1.5 meters	Regularly flooded marshes converted to open water or tidal flat
>1.5 meters	Gains of tidal flats are less pronounced as inundation of the newly-formed tidal flats is predicted.
2 meters	50%-55% of freshwater swamp loss and conversion to transitional salt marsh/regularly flooded marsh due to inundation
	Undeveloped and developed dry land inundated, but not as significantly impacted as wetlands
	Open water increased from current 23% coverage to 70% coverage

Source: USACE (2014) and Warren Pinnacle Consulting (2011 and 2012)

The potential for wetland conversions within the NJBB CSRM Study area were accessed on the Nature Conservancy's Coastal Resilience Website for marsh retreat zones. Figures 36 through 38 display existing marsh areas likely to be converted to unconsolidated shore or open water throughout the study area using a sea level rise of 2 ft. with a yearly sediment accretion of 4 mm/yr. over a 50-year period. Under this scenario, marsh conversions will be significant in the back-bay areas and tidal tributaries.

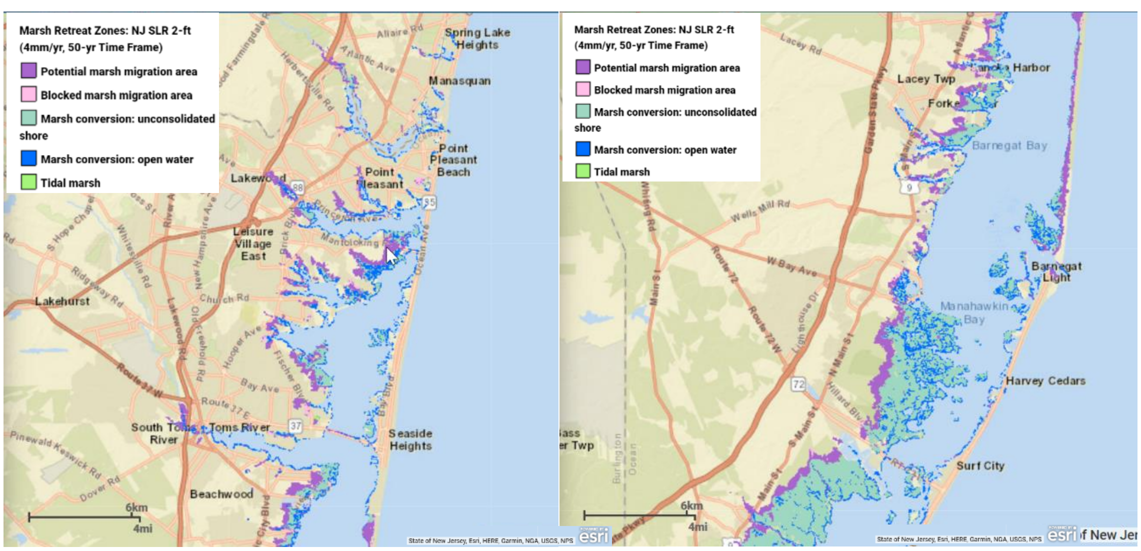


Figure 36: Northern Region 50-year Marsh Retreat Zones with 2-Ft. SLR - Rutgers CRSSA (retrieved from https://maps.coastalresilience.org/newjersey/#)

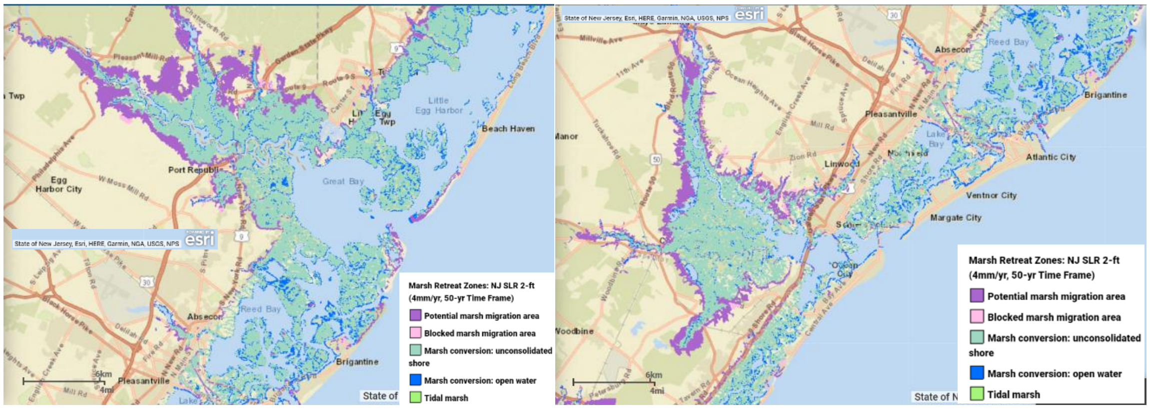


Figure 37: Northern and Central Regions 50-yr Marsh Retreat Zones with 2-Ft. SLR - Rutgers CRSSA (retrieved from https://maps.coastalresilience.org/newjersey/#)

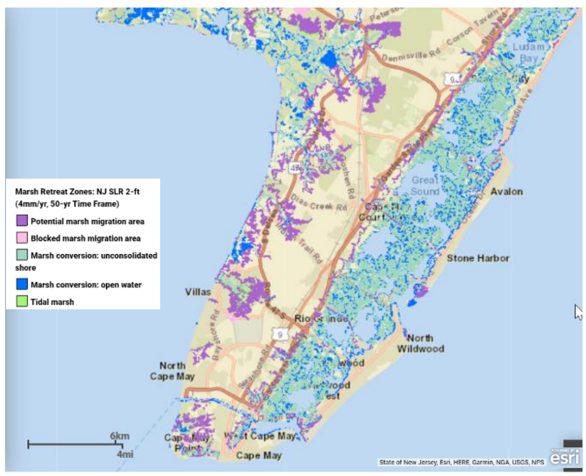


Figure 38: Southern Region 50-yr Marsh Retreat Zones with 2-Ft. SLR - Rutgers CRSSA (retrieved from https://maps.coastalresilience.org/newjersey/#)

6.4.8 Terrestrial Habitats

The FWOP/No Action alternative would involve no additional USACE actions to mitigate against coastal storm risk. In this scenario, it is assumed that continued beach nourishment along the Atlantic Coast beaches would maintain terrestrial habitats such as the upper beach, dunes, and lands behind these features along the developed barrier islands. Existing land use trends may increase development pressure on undeveloped terrestrial habitats and continue with conversions of some upland habitats to urban lands within areas zoned for development. Sea level rise may convert some lower lying upland areas into transitional wetlands and may result in die-back of low-lying forests by creating “ghost forests”.

6.4.9 Wildlife

The FWOP/No Action alternative would involve no additional action from USACE to mitigate against coastal storm risk. With no action, impacts to wildlife as described in the Affected

Environment section are expected. Projections for sea level change have the potential to adversely affect wildlife species based on losses of irregularly flooded marshes, freshwater wetlands, and some upland habitats. In locations where marshes and transitional areas have room to migrate, conversions of irregularly flooded marshes to regularly flooded marshes and regularly flooded marshes to intertidal mudflats may not necessarily adversely affect the species that depend on these habitats since these conversions (more or less) offset each other. However, irregularly flooded marshes, regularly flooded marshes, and intertidal mudflats and beaches that abut hardened shoreline structures in the back bays may be lost and converted to subtidal open water due to the inability of these habitats to retreat against a hardened shoreline. Conversion of intertidal mudflats and sandy shorelines to open water may have impacts on a number of bird species. Strange (2008) reported that inundation of tidal flats, marsh pannes, and pools as a result of rising seas would eliminate critical foraging opportunities for hundreds of species of shorebirds, passerines, raptors, and waterfowl, as the tidal flats of New Jersey's back-barrier bays, including the flats of Great Bay Boulevard Wildlife Management Area, North Brigantine Natural Area, and the Brigantine Unit of the Forsythe Refuge would be inundated more. In addition, as tidal flat area declines, increased crowding in remaining areas could lead to exclusion and mortality of many foraging birds (USACE, 2014). Strange (2008) further reports that SLR would affect (and possibly eliminate) the more vulnerable low-lying islands within the back bays that are habitat for several species of conservation concern including the northern diamondback terrapin, and nesting common terns, Forster's terns, black skimmers, and American oystercatchers (USACE, 2014). Several scenarios presented by Strange (2008) and USACE (2014) demonstrate that potential impacts of sea level change and loss of marsh habitats on birds include:

- Deeper tidal creeks and marsh pools will become inaccessible to short-legged shorebirds such as plovers.Long-legged waterbirds such as yellow-crowned night heron, which forages almost exclusively on marsh crabs (fiddler crab and others), will lose important food resources.
- High marsh nesting birds such as northern harrier, black rail (both state-listed as endangered), clapper rail, and willet may be most at risk from projected losses of high marsh habitat.
- Complete conversion of marsh to open water will affect the hundreds of thousands of shorebirds that stop in these areas to feed during their migrations.
- Waterfowl that forage and overwinter in area marshes (midwinter aerial waterfowl counts in Barnegat Bay alone average 50,000 birds) will likely be impacted by lost habitat as a result of sea level rise.
- Local populations of marsh-nesting bird species will be at risk where marshes drown. This will have a particularly negative impact on rare species such as seaside and sharp-tailed sparrows, which may have difficulty finding other suitable nesting sites.
- Species that nest in other habitat but rely on marshes for foraging, such as herons and egrets, will also be affected as marshes drown.

6.4.10 Fisheries Resources

The FWOP/No Action alternative would involve no additional USACE actions to mitigate against coastal storm risk. In this scenario, existing conditions for fisheries (finfish and shellfish) and

Essential Fish Habitat as described in the Affected Environment and existing trends will continue unless there are significant interventions. BBP (2016) reports that estuarine fish communities in the northern portion of Barnegat Bay (north of Cedar Creek) are fairly diverse (a total of 69 species of fish) with the most common species encountered in a variety of estuarine habitats and salinity ranges that include Atlantic silversides, bunker/menhaden, bay anchovy, juveniles of black drum (*Pogonias cromis*), silver perch, winter flounder and bluefish. Based on the application of diversity indices, BBP (2016) provides an "above average" indicator status for fish with no discernable trends. Shellfish resources (primarily the hard clam) as reported by BBP (2016) are in a degraded state and no discernable trend in abundance in Barnegat Bay and Little Egg Harbor due to limited sample intervals. It is assumed that other NJBB systems have similar statuses with some local variations for fish and shellfish resources. Climate change and sea level change introduce greater uncertainty of continued trends where changes in temperature, precipitation and flooding patterns along with chemical changes could impose synergistic effects on the NJBB water quality (salinity, nutrients, DO) and algal blooms could adversely impact fish and shellfish habitat. Changes in salinity and flow patterns could disrupt migratory fish patterns and recruitment of shellfish. Some fish such as Atlantic silverside, mummichog, and bay anchovy may actually benefit from SLR as marshes along protected shorelines that experience an increase in tidal flooding and a deepening and widening of tidal creeks become more abundant. However, continued SLR may adversely affect these species in marshes along hardened shorelines that convert to open water by decreasing protection from predators, nursery habitat and foraging areas (Strange, 2008; USACE, 2014).

6.4.11 Invertebrates

The FWOP/No Action alternative would involve no additional USACE actions to mitigate against coastal storm risk. In this scenario, existing conditions for invertebrates as described in the Affected Environment and existing trends will continue unless there are significant interventions. Climate change and sea level change introduce greater uncertainty of continued trends where changes in temperature, precipitation and flooding patterns along with chemical changes could impose synergistic effects on the NJBB water quality (salinity, nutrients, DO) and algal blooms could adversely impact benthic invertebrate communities cause shifts in benthic community structure (diversity, abundance, etc.). SLR is not expected to have significant effects on benthic invertebrates inhabiting subtidal habitat as this habitat would likely increase. Permanent losses of intertidal mudflats, sandy beaches, regularly flooded and irregularly flooded marshes due to SLR are more likely to affect the invertebrates that inhabit these areas through their entire lifecycle as well as those that depend on these habitats for a portion of their life cycle such as spawning horseshoe crabs.

6.4.12 Special Status Species

The FWOP/No Action alternative would involve no additional USACE actions to mitigate against coastal storm risk. In this scenario, impacts to Federal and State listed threatened and endangered species are likely. Climate change and sea level rise (SLR) may exacerbate conditions for some of these species. SLR may contribute to loss of intertidal foraging habitats critical for rufa red knots by converting them to open water. For piping plovers, SLR may directly impact beach habitats in areas where beach erosion is persistent, with beach migration and overwash curtailed by human development, limiting available nesting and foraging habitat. Continued implementation of beach nourishment projects may lessen this effect when implemented in accordance with reasonable and prudent measures to protect this species. The Federally threatened eastern black rail favors high marsh/irregularly flooded habitats for nesting and would experience significant losses of this habitat due to conversion to low marsh habitats. According to Cooper et. al (2005) seabeach amaranth is highly susceptible to the effects of SLR, and likely to be irreversibly damaged (USACE, 2014). NOAA Fisheries (2014) considered the effects of climate change on Atlantic sturgeon, and concluded that projections of rising sea temperatures of 3-4^{o} C by 2100 could, "over the long term, affect Atlantic sturgeon by affecting the location of the salt wedge in rivers, distribution of prey, water temperature and water quality. However, there is significant uncertainty, due to a lack of scientific data, on the degree to which these effects may be experienced and the degree to which Atlantic sturgeon will be able to successfully adapt to any such changes." NOAA Fisheries (2014) further concludes that for sea turtles, "the temperature changes are unlikely to be enough of a change to contribute to shifts in the range or distribution of sea turtles even though, theoretically, it is expected that as waters in the action area warm, more sea turtles could be present, or sea turtles could be present for longer periods of time." Additionally, it is uncertain that long-term habitat changes to SAV beds would have any indirect effects on species like green sea turtles that venture into the shallow areas to feed on marine algae and eelgrass. Sea level rise could also affect freshwater wetland systems by making them more vulnerable to saltwater intrusion especially from major storm events that may push saline water further into freshwater systems. This could potentially affect populations of the Federally listed swamp pink (*Helonias bullatta*) and Knieskern's beakrush (*Rhynchospora knieskernii*), which inhabit low-lying freshwater wetlands within the NJBB watersheds.

6.4.13 Coastal Lakes

The FWOP/No Action alternative would involve no additional action USACE actions to mitigate against coastal storm risk. In this scenario, impacts to the Coastal Lakes as described in the Affected Environment section are expected. No significant changes in land use are expected around these lakes as they are currently in very heavily developed areas. However, climate change and sea level rise (SLR) could have effects on these lakes as the freshwater lakes would be subject to shifts to warmer temperatures, increased precipitation events and associated stormwater input, drought events, and potential breaches and salinity intrusion from SLR. These factors could have profound adverse effects on the freshwater aquatic ecosystems as described in the Affected Environment Section.

6.4.14 Cultural Resources

The No Action/FWP Alternative would involve no additional action by USACE to mitigate against coastal storm risk. Climate change-driven sea level change and the potential for more frequent coastal storms are expected to continue over the next 50 years and into the future. Predicted climate change impacts, such as erosion of beaches and extended storm surge inundation, would continue and worsen over time. Climate change and associated sea level change would increase the depth and extent of storm surge inundation, as well as increase potential for more frequent nuisance flooding and increase the depth of water during nuisance flood events.

It is expected that sea level change and coastal storms would continue to increase along with population growth in the APE, potentially impacting historic properties. Effects upon historic properties would be cumulative and are expected to continue over time without further action or project implementation. Additional historic properties and archaeological sites would potentially be added to the county database with new investigations associated with future development and with buildings and structures reaching 50 years of age.

6.4.15 Recreational Resources

The FWOP/No Action alternative would involve no additional USACE actions to mitigate against coastal storm risk. In this scenario, impacts on recreation as described in the Affected Environment section are expected. Water-based recreation activities are not expected to change significantly under climate change and sea level (SLR) rise scenarios. However, SLR may increase vulnerability of land-based recreational facilities such as athletic fields to flooding. Sea level rise would subject the communities in the study area to increased vulnerabilities to coastal storms, and thus, any damages experienced by the communities from coastal storms would result in temporary and possibly long-term degraded tourism opportunities. Lesser known would be the potential for indirect losses of ecotourism opportunities resulting from diminishing wetland habitats due to SLR.

6.4.16 Visual Resources and Aesthetics

The FWOP/No Action alternative would involve no additional USACE actions to mitigate against coastal storm risk. In this scenario, no impacts to visual resources and aesthetics as described in the Affected Environment section are expected, and would be maintained in the study area. Sea level rise would subject the communities in the study area to increased vulnerabilities to coastal storms, and thus, any damages experienced by the communities from coastal storms would result in temporary and possibly long-term degraded aesthetics.

6.4.17 Air Quality

The FWOP/No Action alternative would involve no additional USACE actions to mitigate against coastal storm risk, and it is expected that current air quality trends will continue. The primary pollutant of concern in the study area is ground level ozone. It is expected that no action will continue the trends in ground level ozone, which are influenced by many factors including emissions of NOx and VOCs (ozone precursors), weather conditions and emission reductions brought about by control measures. Short term fluctuations are most likely due to weather conditions. The long-term trend shows ozone concentrations decreasing significantly due to State and Federal requirements to reduce emissions of NOx and VOCs (http://www.nj.gov/dep/dsr/trends/ accessed on 1/30/2019).

6.4.18 Greenhouse Gases

The FWOP/No Action alternative would involve no additional USACE actions to mitigate against coastal storm risk, and it is expected that current air quality trends will continue. New Jersey's estimated Greenhouse Gas (GHG) emissions have increased slightly in recent years, although

2015 levels remain below the 2020 Global Warming Response Act (GWRA) limit (which is equivalent to the 1990 level). To achieve the 2050 GWRA limit (of 80% below the 2006 value), NJ would need to reduce estimated GHG emissions by 78%, or about 2.2% per year on average, between 2014 and 2050. New Jersey expects to meet this goal in the future through several initiatives including the implementation of the State's Energy Master Plan (EMP) (http://www.nj.gov/dep/dsr/trends/ accessed on 1/30/2019).

6.4.19 Climate and Climate Change

The FWOP/No Action alternative would involve no additional action from current USACE actions to mitigate against coastal storm risk. This assumes that current CSRM projects along the Atlantic Coast are maintained. In this scenario, the trends described below will continue.

New Jersey is experiencing climate change with a long-term upward trend for temperature of 2.2°F per century. The statewide average temperature in 2012 was the highest since 1895. Additionally, nine of the ten warmest calendar years on record have occurred since 1990 with five of the warmest years occurring since 1998. (BBP, 2016; Broccoli et al. 2013). It is estimated by the Union of Concerned Scientists that the seasonal average temperatures across most of New Jersey will rise 7°F to 12° F above historic levels in winter and 6° F to 14° F in summer by the end of the century, which could lead to a dramatic increase in the number of days over 100° F. Increases in temperatures in temperate zones like New Jersey can lead to earlier springs, which can have severe impacts on native flora and fauna, which rely on temperature changes as a cue for important life history events (BBP, 2016).

Climate change may lead to increased ocean temperatures, ocean acidification, sea level rise, changes in currents, and upwelling and weather patterns, and has the potential to cause changes in the nature and character of the estuarine ecosystem (USACE, 2017). Climate change is expected to result in more intense and frequent extreme precipitation events by the end of the century, which would cause flooding, streambank erosion, and increases in the rate and amount of nutrients and sediments entering the estuary (BBP, 2016; IPCC, 2013). Cumulative losses of saltmarsh habitat due to sea level rise and other factors may reduce the ability to capture and hold carbon. Saltmarshes are considered to be carbon sinks. When these habitats are damaged or lost, carbon (i.e. CO_2) is emitted back into the atmosphere where it can contribute to climate change (https://oceanservice.noaa.gov/facts/bluecarbon.html accessed on 2/27/2019).

6.4.20 Noise

The FWOP/No Action alternative would involve no additional action from current USACE actions to mitigate against coastal storm risk. In this scenario, no impacts to noise as described in the Affected Environment section are expected. Assuming no significant changes in land use or the introduction of new activities that emit noise, it is expected that noise levels in the communities and wetland bay habitats would remain the same as current conditions. Climate change and sea level rise is not expected to be a significant factor in future noise impacts.

7 Plan Formulation

7.1 Plan Formulation Synopsis

A comprehensive CSRM risk management plan for the NJBB CSRM Study area has been developed to address the previously identified problems and opportunities and avoiding the constraints where possible as discussed in the Planning and Consideration Chapter. This plan will seek to reduce damages to homes and infrastructure from coastal storms including nor'easters and hurricanes. Plan formulation has focused on meeting the Federal objective of water resources project planning which is to contribute to the National Economic Development (NED) consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements. Plans will be formulated to present the most cost effective solution to the problems related to storm damage.

Plan formulation also considers the effects to each of the four evaluation accounts identified in the USACE Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (1983) (Principles and Guidelines) which include the NED, Regional Economic Development (RED), Environmental Quality (EQ), and Other Social Effects (OSE). The four Planning Criteria including effectiveness, efficiency, acceptability, and completeness identified in the Principles and Guidelines (1983) were also considered in plan formulation. The NJBB CSRM Study is guided by the principle of iterative planning, which encourages risk-informed decision making and the appropriate levels of detail for each round of alternatives formulation. Initial steps in the plan formulation process are broad-based analyses followed by more specific, detailed analyses during successive levels of the plan formulation process. Throughout the study, the study team will: a) Use existing data and tools as applicable including the NACCS Tier 2 evaluation and state and local datasets (county, municipal, nongovernmental organizations, and academic institutions; b) coordinate with and leverage other federal, state and NGO resilience projects, studies, and efforts; and c) integrate federal and state agency, public and stakeholder outreach comments as gathered through the series of NJBB outreach events.

The plan formulation phase follows the Corps of Engineers traditional 6-step planning process. The plan formulation process in the initial part of the study consisted of identifying the potential management measures based upon the study problems and opportunities, scoring those measures against the Problem/Opportunity matrix, scoring the measures against the four planning criteria for effectiveness, efficiency, acceptability, and completeness (ER 1105-2-100). These management measures were then ranked and grouped into three alternatives; 1-Preserve, 2-Accommodate, 3-Avoid based on the characteristics of that Alternative established in the NACCS. Their rank of each measure was based on their contributions to the Problem/Opportunity matrix combined with how well they scored against the four planning criteria.

The USACE six-step planning process is defined in the Planning Guidance Notebook (ER 1105-2-100). This process is a structured approach to problem solving which provides a framework for sound decision making.

The six steps are:

- Step 1 – Identifying Problems and Opportunities
- Step 2 – Inventorying and Forecasting Conditions
- Step 3 – Formulating Alternative Plans

- Step 4 – Evaluating Alternative Plans
- Step 5 – Comparing Alternative Plans
- Step 6 – Selecting a Plan

Each one of these steps is briefly defined below.

Step 1 - Identifying Problems and Opportunities.

Problems and opportunities statements will be framed in terms of the Federal objective and the specific study planning objectives. Problems and opportunities should be defined in a manner that does not preclude the consideration of all potential alternatives to solve the problems and achieve the opportunities. Problems and opportunities statements will encompass current as well as future conditions and are dynamic in nature. Thus, they can be, and usually are, re-evaluated and modified in subsequent steps and iterations of the planning process. Problems and Oppurtunities were identified and desribed in Chapter X of this feasibility report.

Step 2 – Inventory and Forecast.

The second step of the planning process is to develop an inventory and forecast of critical resources (physical, demographic, economic, social, environmental etc.) relevant to the problems and opportunities under consideration in the planning area. This information is used to further define and characterize the problems and opportunities. A quantitative and qualitative description of these resources is made, for both current and future conditions, and is used to define existing and FWOP conditions. Existing conditions are those at the time the study is conducted. The forecast of the FWOP condition reflects the conditions expected during the period of analysis between 2030 through 2080. The FWOP condition forecast provides the basis from which alternative plans are formulated and impacts are assessed. The Existing Conditions and Future Without Projet Conditions are contained in Chapter X of this report .

Step 3 - Formulation of Alternative Plans.

Alternative plans shall be formulated to identify specific ways to achieve planning objectives within constraints, so as to solve the problems and realize the opportunities that were identified in step 1. An alternative plan consists of a system of structural and/or nonstructural measures, strategies, or programs formulated to meet, fully or partially, the identified study planning objectives subject to the planning constraints. A management measure is a feature or an activity that can be implemented at a specific geographic site to address one or more planning objectives. Management measures are the building blocks of alternative plans and are categorized as structural and nonstructural. Equal consideration must be given to these two categories of measures during the planning process. An alternative plan is a set of one or more management measures functioning together to address one or more objectives. A range of alternative plans shall be identified at the beginning of the planning process and screened and refined in subsequent iterations throughout the planning process. However, additional alternative plans may be identified at any time during the process. Plans should be in compliance with existing statutes, administrative regulations, and common law or include proposals for changes as appropriate. Alternative plans shall not be limited to those the Corps of Engineers could implement directly under current authorities. Plans that could be implemented under the authorities of other Federal agencies, State and local entities and non-government interest should also be considered. The Formulation of plans from management measures is the bulk of this section of the report. This begins the screening process, and the metrics used to screen out solutions and select a plan are contained in this chapter of the report.

Step 4 – Evaluating Alternative Plans.

The evaluation of effects is a comparison of the with-project and without-project conditions for each alternative. The evaluation will be conducted by assessing or measuring the differences between each with- and without-project condition and by appraising or weighting those differences. The evaluation for a storm risk management study is centered around how much each measure reduces the impacts from the problems identified for the particular study, namely damage from storms.

Criteria to evaluate the alternative plans include all significant resources, outputs, and plan effects. They also include contributions to the Federal objective, the study planning objectives, compliance with environmental protection requirements, the P&G's four evaluation criteria (completeness, effectiveness, efficiency, and acceptability) and other criteria deemed significant by participating stakeholders.

(3) Four accounts are established in the Principles & Guidelines to facilitate the evaluation and display of effects of alternative plans include:

(a) The national economic development account displays changes in the economic value of the national output of goods and services.

(b) The environmental quality account displays non-monetary effects on ecological, cultural, and aesthetic resources including the positive and adverse effects of ecosystem restoration plans.

(c) The regional economic development account displays changes in the distribution of regional economic activity (e.g., income and employment).

(d) The other social effects account displays plan effects on social aspects such as community impacts, health and safety, displacement, energy conservation and others.

Step 5 - Comparing Alternative Plans.

In this step, plans (including the no action plan) are compared against each other, with emphasis on the outputs and effects that will have the most influence in the decision making process. A comparison of the outputs of the various plans must be made. Beneficial and adverse effects of each plan must be compared. These include monetary and non-monetary benefits and costs. Identification and documentation of tradeoffs will be required to support the final recommendation. The effects include those identified during the evaluation phase and any other significant effects identified in step 5. The comparison step can be defined as a reiteration of the evaluation step, with the exception that in this step each plan (including the no action plan) is compared against each other and not against the without-project condition. The output of the comparison step shall be a ranking of plans at the end of this chapter.

Step 6 - Selecting a Plan.

A single alternative plan will be selected for recommendation from among all those that have been considered. The recommended plan must be shown to be preferable to taking no action (if no action is not recommended) or implementing any of the other alternatives considered during the planning process. The culmination of the planning process is the selection of the recommended plan or the decision to take no action. The criteria for selecting the recommended plan differ, depending on the type of plan and whether project outputs are NED, NER, or a combination of both. The final section of this chapter will present a Tentatively Selected Plan (TSP) based on reasonably maximizing NED benefits.

7.2 Management Measure Inventory

The NACCS full array of CSRM management measures were used as the starting point for this study. Figure 39 provides diagrams of potential individual management measures for consideration in the NJBB CSRM Study, and Figure 40 shows an example of how some of the CSRM measures could be used across the NJBB CSRM Study area.

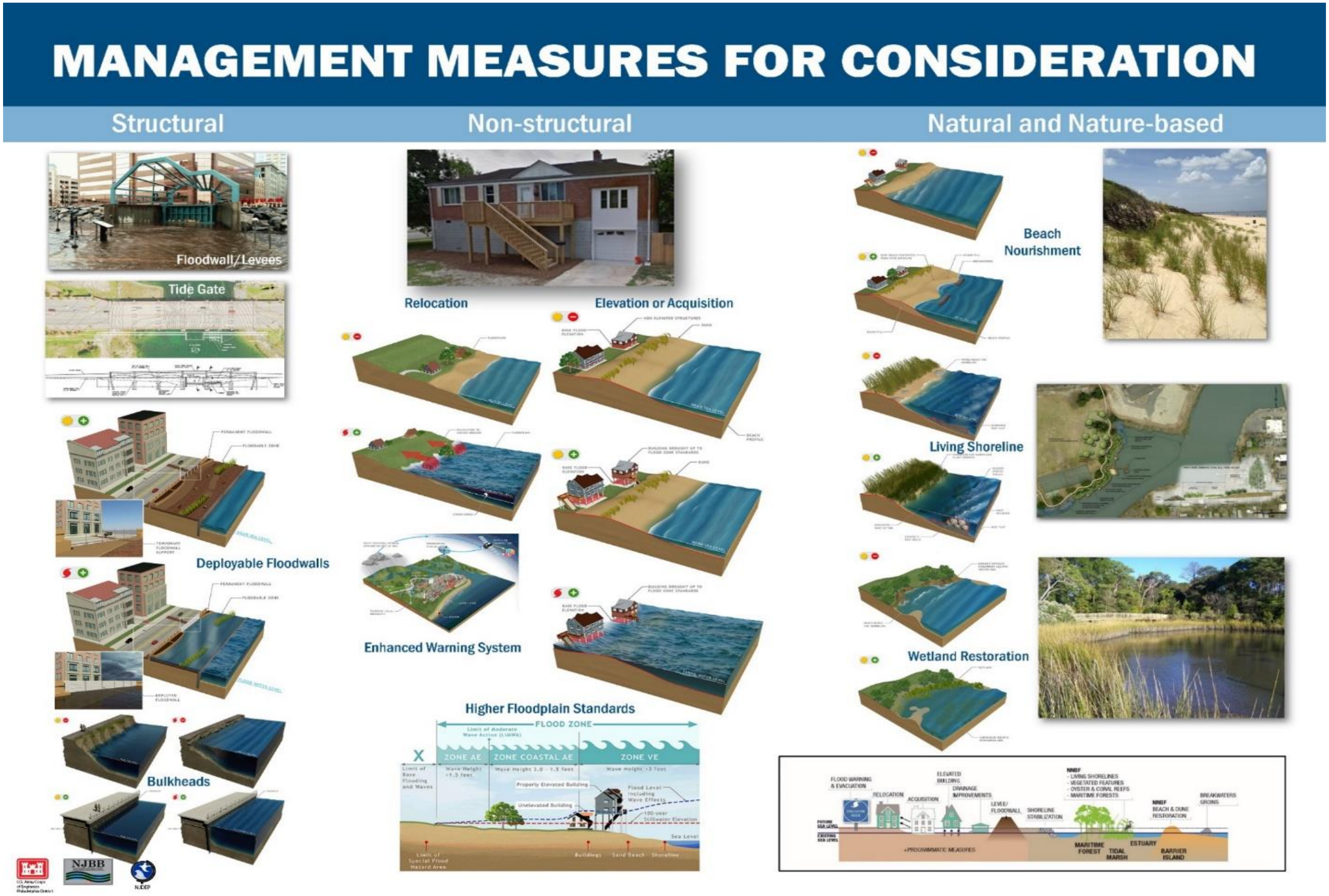


Figure 39: Management Measures for Consideration

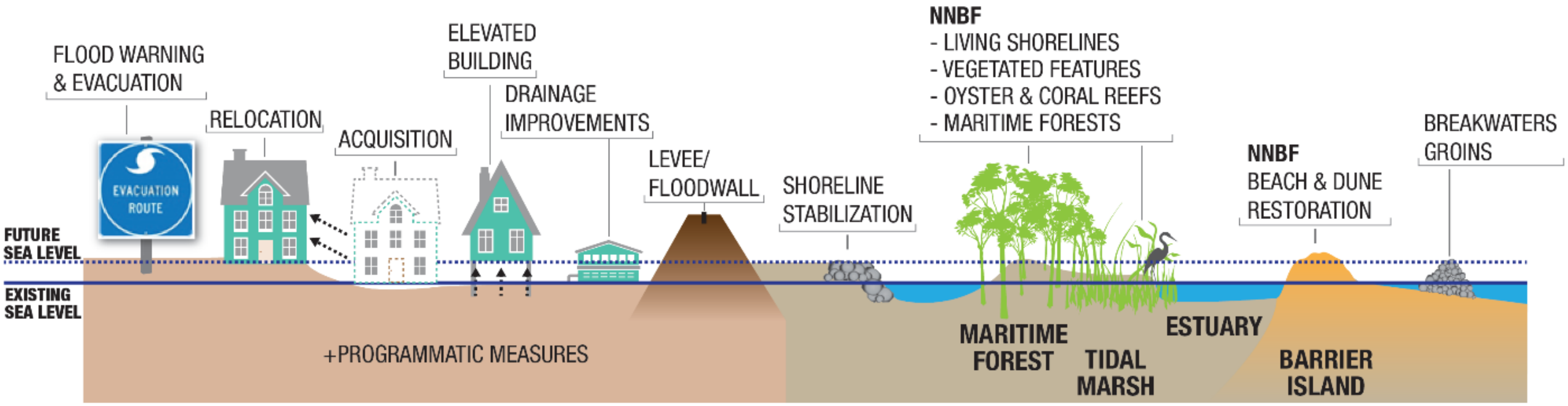


Figure 40: Examples of Management Measures across Coastal Landscape

7.2.1 No Action

The No Action plan provides no additional measures to provide flood risk management in the study area. The No Action plan represents the FWOP condition against which alternatives plans will be evaluated. No Action plan provides no additional measures to provide flood risk management in the study area. The No Action plan represents the FWOP condition against which alternatives plans will be evaluated. Without any action taken our models indicate that the study area will be subject to future storms, sea level rise and coastal flooding resulting in a projected $1,808,610,000 in Without-Project AAD over a 50-year period of analysis with Intermediate RSLC between 2030 and 2080.

7.2.2 Management Measures

The NACCS array of measures was refined for this study based on two Planning Charrettes composed of Federal, State, and local governments, academia and NGOs held on June 17, 2016 and June 21, 2016 to identify measures that are applicable only to the New Jersey back bays region.

In order to reduce without project damages in the study area the study team identified solutions listed below to measure against the problems and opportunities and the four planning criteria developed in the initial onset of the study. These measures were evaluated, scored, and ranked based on these criteria, the results of which are shown in Figure 41.

Measures that scored high were carried forward for further analysis, and measures that score low were eliminated from further evaluation. A total of 23 management measures listed below were considered in the initial plan formulation cycle of the NJBB CSRM Study.

Nonstructural Measures

- Managed Coastal Retreat
- Building Retrofit
- Hazard Mitigation Plans
- Emergency Evacuation Plans
- Early Warning Systems
- Public Education/Risk Communication

Structural Measures

- SSBs/CBBs
- Tide Gates
- Road Rail Elevation
- Levees
- Ringwalls
- Floodwalls
- Deployable Floodwalls

- Crown Walls
- Beach Restoration/Groins/Breakwaters
- Bulkheads
- Seawalls
- Revetments
- Storm System Drainage Improvements

Natural and Nature-Based Features

- Living Shorelines
- Reefs
- Wetland Restoration
- Living Breakwaters
- Horizontal Levees
- Shallows
- Surge Filters
- Submerged Aquatic Vegetation
- Green Stormwater Management

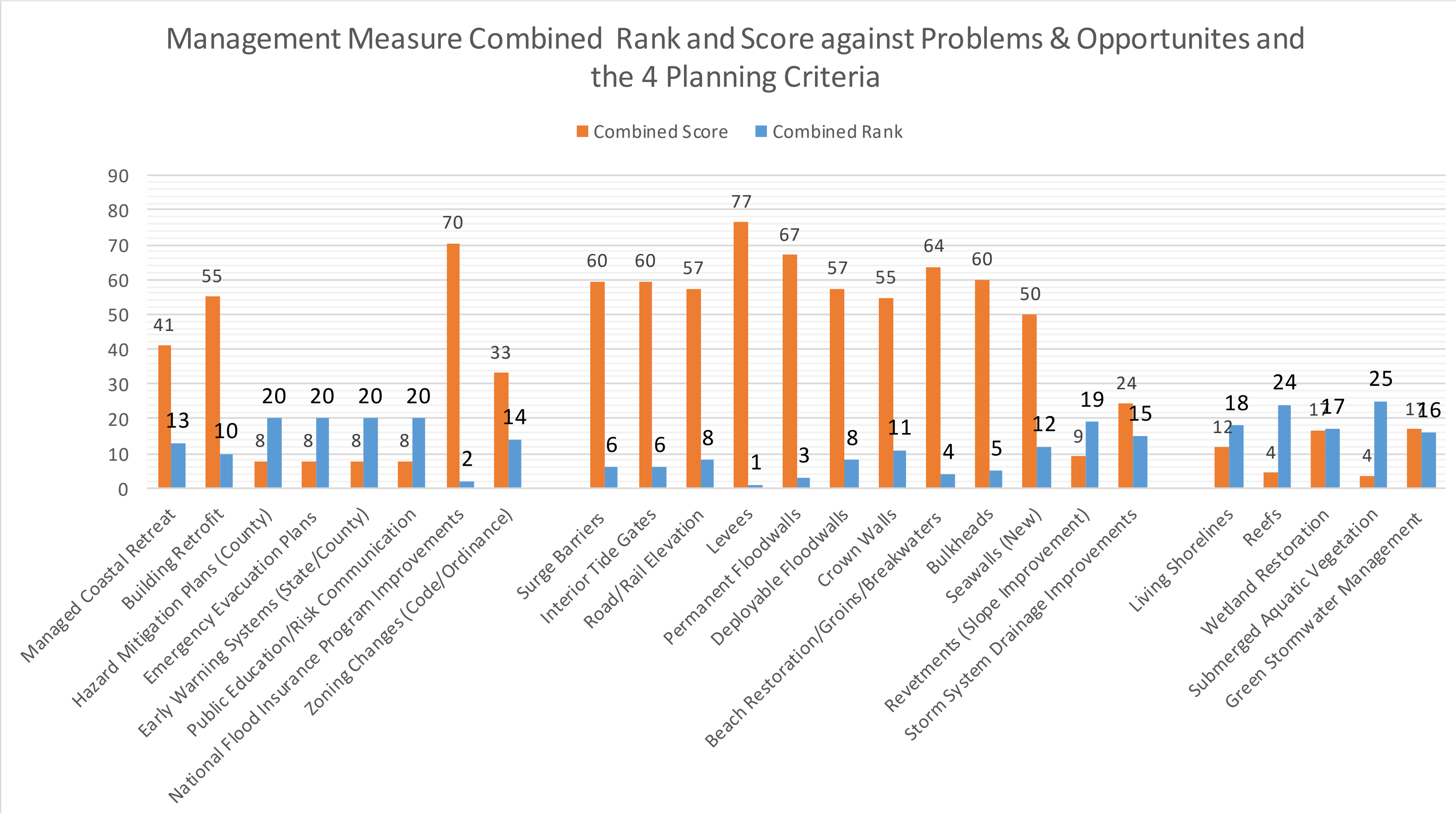


Figure 41: Management Measure Rank and Score Against the Problems and Opportunities and the 4 Planning Criteria

A summary of these ranked measures indicated that the highest ranked measures were largely structural management measures including include levees, floodwalls, beach restoration/groins/breakwaters and surge barriers (including SSB and CBB). The highest ranked nonstructural management measures include NFIP improvements and building retrofits. The highest ranked NNBF measures include wetland restoration and living shorelines. These ranked measures were further screened as discussed in subsequent sections of this chapter. A detailed explanation of the measure screening process is provided in the Plan Formulation Appendix.

7.2.2.1 Nonstructural Management Measures

Section 73 of the Water Resources Development Act of 1974 requires consideration of nonstructural alternatives (measures) in all flood risk management studies. They can be considered independently or in combination with structural management measures (Corps Planning Guidance Notebook PGN). Planning Bulletin (PB 2016-01) signed on 22 December 2015 further clarifies Corps policy on nonstructural management measures for the plan formulation phase on investigations and implementation. The Planning Bulletin clarifies that it is the policy of USACE to formulate a full array of alternatives consisting of nonstructural measures and structural measures and that not all nonstructural measures are required to meet USACE criteria for agency participation and cost share implementation. It further clarifies that a 100% voluntary participation for acquisition, relocation and permanent evacuation is not considered a complete plan and is not acceptable for USACE participation. USACE participation must include the option to use eminent domain, where warranted. Costs for relocation, and should include the provision of relocation assistance under P.L. 91-646.

The definition of nonstructural is to reduce human exposure to a flood hazard without altering the nature or extent of the hazard. Nonstructural CSRM management measures include acquisition and relocation, building retrofits, flood warning and evacuation planning, and programmatic considerations, such as land use and floodplain management and zoning. Additionally, conservation planning actions, including acquisition and the establishment of perpetual easements to increase the total acreage of undeveloped land and open space, to convert existing areas of privately owned and existing buildable properties into natural habitat along the coast could reduce risk by removing properties and people from potential direct damages from future coastal storm events (NRC 2014). The Project Development Team researched recent NGOs, university, and Corps of Engineers guidance to determine nonstructural alternatives to reduce the risk from coastal flood events. Some of the measures listed in the nonstructural, managed retreat section will need to be combined with another measure in order to be effective.

Nonstructural management measures in general are intended to reduce the consequences that flooding would have to assets exposed to flood peril, as opposed to a structural management measure that alters the characteristics or the probability of the flood peril to occur (USACE 2014b). Operation and maintenance costs of nonstructural measures are typically low and are usually sustainable over long-term planning horizons (USACE 2014c).

1. Managed Coastal Retreat

   This effort involves a series of different tools to reduce the level of development along a shoreline, reduce the number of repetitive losses, and limit the encroachment of private properties onto vulnerable shorelines through a series nonstructural efforts to be carried out at the municipal, state, and federal level. Specific tools from the Columbia School of Law report on managed coastal retreat are listed below. Some of these measures are more valuable along undeveloped shorelines where property and infrastructure are not as dense as it is along the New Jersey shoreline.

a. Setbacks-Setbacks require property owners to locate structures at some distance from the shoreline. Setbacks are successful in communities that are not 100% built out and fully developed, or in the planning of new communities since they reduce the contact of damaging flood waters, erosion, and waves. After the Ash Wednesday storm of 1962, the state of New Jersey established a building line or bulkhead line in coastal communities facing the Atlantic Ocean beyond which no structures could be built. New setback guidelines could be established for new construction, or re-construction that could reduce infrastructures exposure to storm events on the New Jersey Back Bay.

   There are two main methods of establishing a setback distance, set distance and projected erosion rates. Set distances establish a fixed distance from the shoreward edge of a property to some fixed tidal landmark. Projected erosion rates can be established from historic erosion rates multiplied by a factor based on the level of risk for that structure. North Carolina and Florida have erosion setback based on erosion rates. North Carolinas Administrative Code for Coastal Hazard establishes a setback distance from the first line of vegetation (beach vegetation) depending on the size of the structure. For structures less than 5,000 square ft. the setback distance is 30 times the rate of annual erosion, for structures over 10,000 square ft. the setback distance is established at 90 times the rate of erosion.

b. Rolling easements- A rolling easement can be a set distance from the established shoreline. They can be established to “roll” a set distance from the shoreline to allow communities to establish private property rights and public access to migrate landward with increased erosion and sea level rise. Rolling easement is a term used to refer to any public policy that protects lands in the public trust as the sea level “rolls” inland. A rolling easement grants the public access to a portion of the dry beach on a private property owner’s land and that rolls inland with the rising sea. This type of easement may also be important in areas of tidal encroachment that intersects with private property over time in order to protect public access to the shoreline as Defined in the Public Trust Doctrine. This public access enforcement principle was recently shot down in Severance vs. Patterson in the Texas Supreme Court in 2011 when the court ruled that unless a public easement was expressly included in the initial land grant, the state cannot rely on custom alone to secure public access.

   Setback and rolling easements not only allow for protection of coastal properties by reducing their exposure to coastal floods, they allow for long term managed coastal retreat and for the reduction in repetitive loss properties. It is important to note that a setback conveys no right to the public as it is a building site restriction. But an easement grants the public as certain access rights under the Public Trust Doctrine.

c. Exactions- An exaction is a condition tied to the granting of a development permit. The exaction requires the landowner to take some action or refrain from some action in order to mitigate the potential negative effects of the development. The California Coastal Commission uses exactions to limit future armoring of the shoreline that may be harmful to the broader area or region.

d. Mitigation fees - Mitigation fees are fees that are assessed to landowners who development actions burden or cause harm to other landowners and the public and can be used to fund further managed retreat strategies discussed in this section including buyouts, relocations, transfer development rights or green banks to fund local flood risk management project.

e. Building restrictions – Building restrictions fall into two categories, limited resilient building and conditional rebuilding. Limited resilient building requires that damaged structures be replaced by structures that are more resilient to wave, erosion and inundation damages or be moved further from the coast, Conditional rebuilding requires property owners agree to certain conditions before they are allowed to rebuild. Owners might be asked to purchase additional insurance, to remove structures that may be threatened by erosion, or inundation, or be limited in the number of times they can rebuild. This is a tool to reduce the number of repetitive loses and is currently being promoted and implemented by FEMA in certain regions of the New Jersey Shore in a new post Sandy context.

f. Zoning changes/overlay zoning/downzoning/un-inhabitability - Overlay zoning works in concert with existing zoning laws to apply an additional measure of approval for construction in high hazard coastal areas. Overlays can set development densities, building regulations, or setback requirements based on the location of the site in relation to flood sources. Downzoning reduces the use intensity of an existing zone by reducing densities or permitted use in the area. Specific downzoning techniques could change the classification of a zone from residential to conservation to reduce the development density. Un-inhabitability refers to the safety and livability of a coastal area in the face of coastal storms, sea level rise and erosion. Decisions have to be made in communities that have high rates of erosion and exposure to coastal storms on whether the community is inhabitable in the long run in the face of these extreme events.

g. Conservation easements – A conservation easement is a voluntary legal agreement between a landowner and an organization that limits specific activities in order to protect conservation values such as wildlife habitat, biodiversity, or open space. Although the typical use for a conservation easement is to improve wildlife habitat, they could have the additional benefit of reducing damage to property from coastal storms if they reduce development densities and preserve land that is undeveloped, but slated for future development.

h. Transfer Development Rights (TDRs) - TDRs are a market based mechanism intended to guide development toward preferred areas while limiting development in undesirable areas. The legal premise of the TDR ownership of the land is severable from the development rights. Developers in areas where development is desirable and encouraged can purchase the development rights from homeowners who are restricted in their development, in order to build in more desirable locations. Homeowners who are restricted from development through setback limits, or building restrictions, zoning changes, zoning overlays, can sell this development right to a developer in a separate onshore community in a high density setting. TDR programs have not yet been employed to mitigate hazards caused by sea level rise, but they have been used to achieve a wide range of land use goals including the protection of agricultural lands, preservation of wildlife habitats and coastal resources and control of development densities. According to one estimate from 2012, there are 239 TDR programs in 35 states under development.

i. Buyout programs (e.g., New Jersey Blue Acres) - Buyout programs are a specific type of acquisition program in which the government uses public funds to purchase title of privately held lands, demolishes existing structures on the land, and maintains the land in an undeveloped state for public use in perpetuity. Buyout programs can be conducted without the consent of the landowners by using eminent domain to acquire the lands, but most often buyout programs are conducted with voluntary sales from landowners who have recently experienced one of the disasters to which they are vulnerable. Buyout programs can be structured to provide financial incentives for owners who are uncertain about selling their property. Buyout programs can, reduce the exposure of people to dangerous conditions, reduce future disaster response costs by removing buildings and structures from the path of flooding, reduce future flood insurance payments, and assist homeowners by providing them with financial means to move from the floodplains and provide open space.

j. Relocations/utility/residential managed retreat often emphasizes movement away from the vulnerable coasts without identifying areas that are available for development. This is true of most of the tools in this category but is particularly true of buyout programs where landowners are selling their homes and divesting their entire interest in the land. Having a relocation plan is crucial for maintaining communities, for gaining public support, and for long-term economic development.

k. Eminent domain - Buyout programs are all voluntary programs, in which the homeowner has agreed to sell coastal property. However, the government can acquire shoreline properties using eminent domain, even without the consent of the owner, if the government pays the owner compensation and is pursuing a legitimate public purpose.

2. Building Retrofit

Building retrofit measures provide flood risk management to individual buildings. Retrofit measures include the following:

a. Elevation - raising the existing structure on fill or foundation elements such as solid perimeter walls, piers, posts, columns, or pilings.

b. Dry flood proofing - strengthening of existing foundations, floors, and walls to withstand flood forces while making the structure watertight.

c. Wet flood proofing - making utilities, structural components, and contents flood- and water resistant during periods of flooding within the structure.

d. Replace building - demolition of the structure and subsequent building of an equivalent structure within the same property boundary to the design elevation.

FEMA's NFIP regulations require that the lowest floor of new and substantially improved residential structures be elevated to or above the base flood elevation. However, non-residential structures may be flood proofed below that elevation, provided that the structure is watertight, with walls that are impermeable to floodwaters. Elevation of an existing structure is usually limited to smaller buildings and depends on a number of factors, including the foundation type, wall type, size of structure, condition, etc. Other measures such as elevation of critical systems and abandoning lowest occupied floor and wet proofing the abandoned floor may be used to reduce flood risk and increase resilience.

In addition, short-term adaption measures may be used to increase resilience such as installing backflow valves to prevent water from flowing back into a home through sanitary/storm sewer systems, elevation or anchoring of heavy equipment like washing machines, bringing outside furniture inside the home.

3. Coastal Storm Plans and Preparedness

a. Hazard Mitigation Plans

Hazard mitigation is the effort to reduce loss of life and property by lessening the impact of disasters. It is most effective when implemented under a comprehensive, long-term mitigation plan. State, tribal, and local governments engage in hazard mitigation planning to identify risks and vulnerabilities associated with natural disasters, and develop long-term strategies for protecting people and property from future hazard events. The State of New Jersey and all five counties in the study area have FEMA-approved hazard mitigation plans.

b. Emergency and Evacuation Plans

Emergency and evacuation planning is imperative for areas with limited access, such as barrier islands, high density housing areas, elderly population centers, cultural resources, and areas with limited transportation options. When a coastal storm threatens many of the communities in the study area, the limited number of bridges and causeways that connect the islands with the mainland become overcrowded, making evacuations from the barrier islands to the mainland difficult. Timely evacuation depends on well-defined emergency evacuation plans used in conjunction with accurate flood forecasting.

The State of New Jersey Office of Emergency Management completed a hurricane evacuation study in 2007 with the support of the USACE and FEMA that provides the State of New Jersey with updated local and regional hurricane evacuation clearance times. Hurricane evacuation clearance times are developed in a multi-step process. First the National Oceanic and Atmospheric Administration (NOAA) creates what they call a Sea, Lake and Overland Surges from Hurricanes (SLOSH) model that predicts where and how deep water will be based on the hurricane's intensity. Once the SLOSH model is analyzed to determine the different levels of inundation that would occur with various storms, evacuation zones are created that coincide with predicted ranges of hurricane impacts. These zones are then imported into a transportation model that overlays with census data and the evacuation network to predict how long it would take to clear that evacuation zone of all occupants, also known as a clearance time. These clearance times are then uploaded to the HURREVAC program for local emergency managers to use to track the storm and keep an eye on their predicted clearance times so that they can start the evacuation at the proper time.

The State has also developed a hurricane survival guide for their residents that highlight the importance of being prepared, having an evacuation plan, and knowing where to find pertinent evacuation information. Prior to an emergency, local or State emergency management officials notify neighborhoods of the need to evacuate or take other protective actions prior to the arrival of a storm event. This done via Emergency Alert System messages on local radio and TV. They may also alert entire areas via community notification systems such as “Reverse 911,” which sends messages to home telephones.

An updated hurricane evacuation study is in progress and updated clearance times are predicted to be released by the 2020 hurricane season. The updated study will include greater detail in the forecasting of storm surge inundation based on not only the hurricane’s intensity, but also its forward speed and direction. This increased level of forecasting will reduce over evacuating the populace while ensuring the most accurate storm surge inundation results.

c. Early Flood Warning Systems

A critical component of successful emergency and evacuation plans are early flood warning systems. Despite improved tracking and forecasting techniques, the uncertainty associated with the size of a storm, the path, or its duration necessitate that warnings be issued as early as possible.

The National Hurricane Center and National Weather Service are responsible for preparing hurricane and nor’easter forecasts and warnings respectively. Both agencies are able to predict storm surge in real-time and asses potential storm surge flooding while the track of the storm is still changing. A limiting factor in the accuracy of early forecasts are predictions of storm track and intensity.

In addition to NHC and NWS storm surge forecasts, the New Jersey Tide Telemetry System (NJTTS) is able to report observed tidal elevations and weather data at 20 tide gauges, 5 tide/weather stations, and 31 tidal crest-stage gauges in 13 New Jersey counties. The tide level at each of the tide gauges is automatically transmitted by NOAA and to specific critical decision-making centers. Additional work needs to be accomplished with Early Flood Warning Systems so local flood risk managers understand the severity of each event as it relates to their location based on the surge forecast and the regional topography. Descriptions such as “high”, “medium” and “low” risks for flooding, without definitions of what that means for local residents are not meaningful. Without two critical pieces of information, surge level compared to topography, a flood warning system may not communicate the specific level of risk to that community. More standardized systems, based on surge prediction networks, and local topography, and standardized elevation data can help local municipalities understand the risk for each surge event.

d. Public Education and Risk Communication

Hazard mitigation plans, emergency and evacuation plans, and early flood warning systems are of little value without communicating risk to local officials, community leaders, and decision-makers who are responsible for land use, evacuation planning, and implementation of mitigation measures. Public acceptability of coastal storm risk management measures, the difficulty individuals and communities have in understanding their own risk, and a lack of community engagement about coastal storm risk management options have all been cited as barriers to implementing good coastal management strategies.

Communities and residents often struggle navigating the complicated network of Federal, State, and local coastal programs. Hurricane Sandy generated huge public interest and awareness in flood risk management; however, it also led to several new initiatives and programs that may make communities feel overwhelmed and calloused to flood risk management opportunities.

4. National Flood Insurance Program Refinement

a. Increase homeowner participation

Residents that are uncertain about reducing risk to their belongings may be prone to attempt to remain in vulnerable areas during storm events, creating further risk. Knowing that personal property is insured, residents may be more comfortable with evacuating vulnerable areas at the approach of a storm. Flood insurance rates and regulations directly and indirectly impact property owners' decisions to reduce risk to their property through favorable construction practices.

b. Increase municipal participation in Community Rating System (CRS)

Community participation in the NFIP is conditional on meeting program guidelines. Participating communities must manage development within their floodplains in accordance with FEMA standards or risk removal from the program, which risks cancellation of all flood insurance policies within the community. Under the CRS, flood insurance premium rates are discounted to reward community actions that meet the three goals of the CRS, which are: (1) reduce flood damage to insurable property; (2) strengthen and support the insurance aspects of the NFIP; and (3) encourage a comprehensive approach to floodplain management. Participation in the CRS helps strengthen and enforce floodplain management policies.

c. Voucher system to assist lower income groups

One way to increase participation in the NFIP is a voucher system to provide assistance to lower income groups. Rising insurance rates and expanded flood plains have a greater burden on low income groups who may not be able to afford the increasing premiums associated with the Biggert-Waters Flood Insurance Reform Act.

5. Zoning Changes

   Effective local floodplain management could potentially reduce the risk of flood peril even before the next storm event occurs. Communities at risk of flood peril have the regulatory authority to address local land use, zoning, and building codes to avoid siting development in floodplains. Communities participating in the NFIP must incorporate flood resistant construction standards into building codes. Local ordinances have been established in in some municipalities to reduce impervious surfaces such as driveways and parking areas, promote uniform bulkhead elevations, and require buildings to have an additional 2-3 ft. of freeboard above the FEMA Base Flood Elevation (BFE). An interagency task force could help municipalities incorporate climate change and sea level change in their planning, zoning, and adaptation plans.

7.2.2.2 Structural Management Measures

Structural CSRM measures are engineering solutions to manage flood risk and reduce damage from coastal storms. Typical structural solutions include levees, floodwalls, beaches, and dunes, which are intended to physically limit flood water inundation from causing damage. Although many of the structural measures generally correspond to standard CSRM strategies, specific applications are not constrained to the usual solutions. Opportunities for innovative designs, technologies, materials, etc., should be considered when evaluating specific application of any of these measures.

7.2.2.2.1 Inlet Storm Surge Barriers

Storm surge barriers reduce risk to back bay environments and estuaries against storm surge, flooding, and waves. In most cases the SSB consists of a series of movable gates that stay open under normal conditions to allow navigation and tidal flow to pass but are closed during storm surge events. Storm surge barriers are often chosen as a preferred alternative during storm surge events and reduce the required length of flood protection management measures behind the barriers. Storm surge barriers range in scale from small/local gates reducing risk to a small coastal inlet to very large barrier “systems” reducing risk to a large estuary or bay and consist of a series of coastal dikes and gates. An example of the Seabrook Floodgate complex including a navigable sector gate and two vertical lift gates is provided in Figure 42.

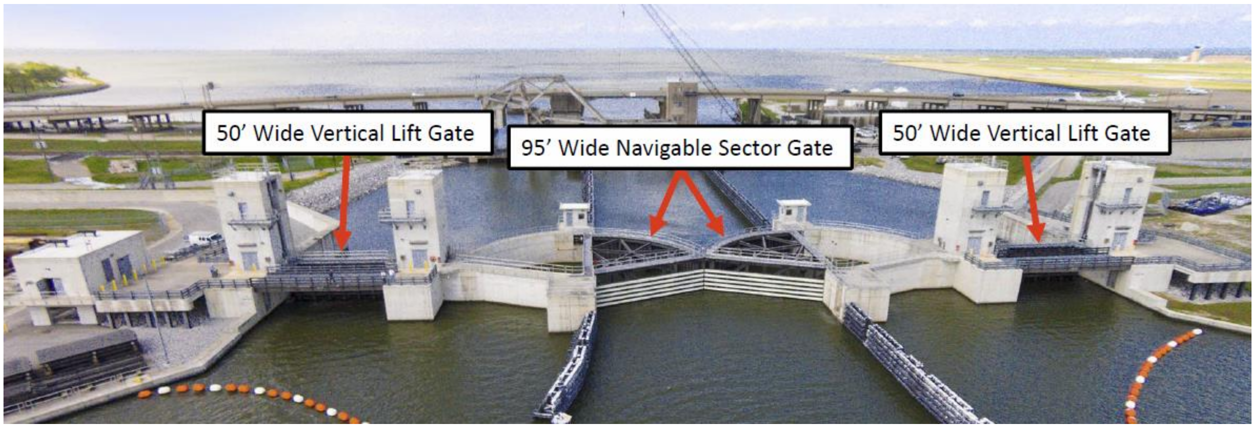


Figure 42: Seabrook Floodgate Complex

7.2.2.2.2 Cross-Bay Barriers

Cross-bay barriers across the interior of the bay are essentially the same as SSBs at the inlet. The difference between these two barriers include location, length and often features. For instance, many CBBs have sluice gates while SSBs do not, and CBBs typically have a greater length than do SSBs. Cross-bay barriers could be constructed across the interior of the bay and may be appropriate at locations where a SSB is not environmentally acceptable. Cross-bay barriers could be constructed adjacent existing roads, bridges, and causeways with dynamic navigable gates across the NJIWW and additional auxiliary flow gates to allow tidal flow to pass under normal conditions.

7.2.2.2.3 Raised Roads and Rails

Existing road and rail networks may be raised pending permeability properties to function as levees and reduce risk to storm surge flooding and also serve as evacuation routes during high tides and surges. Raised roads and rails can also enhance local evacuation plans and public safety by providing safer evacuation routes out of the area. Road and rail raising could also be more acceptable to residents in some communities since it reduces the need for structural alterations to individual buildings that may disrupt the owners' lives and affect perceptions of property value.

7.2.2.2.4 Levees

Levees are earthen embankments with an impervious core constructed along a waterfront to reduce risk to flooding. Levees may be constructed in urban areas or coastal areas; however, large tracts of real estate are usually required due to the levee footprint. If a levee is located in an erosive shoreline environment, armoring may be needed.

7.2.2.2.5 Ringwalls

Ringwalls are walls that encircle a specific area to reduce the risk of flooding for an individual or several structures.

7.2.2.2.6 Floodwalls (Permanent)

Floodwalls are vertical structures often constructed with steel or concrete that are used to reduce risk of flooding. Floodwalls are most frequently used in urban and industrial areas where smaller structure footprints are desired and there is limited space for large flood protection management measures. Two of the most common types of floodwalls are cantilevered I-walls and pile supported T-walls, both of these and other floodwall types will be considered in the study.

7.2.2.2.7 Deployable Floodwalls

Deployable floodwalls are vertical structures that can be rapidly deployed during a storm event to reduce the risk of flooding. Deployable floodwalls are particularly useful for flood risk management in smaller areas and are usually considered for areas where access to the waterfront is essential to the economy or character of a community. Often, traditional floodwalls, or levees are used to reduce risk to some portions of the waterfront, with intermittent closure structures like a deployable floodwall.

7.2.2.2.8 Crown Walls

Crown walls are a relatively small reinforced concrete walls constructed on top of a new or existing vertical structure (bulkhead, seawall, curb, or gravity wall) to reduce the risk of flooding. Crown walls are relatively small structures, 1 to 3 ft., which are drilled and grouted to connect to the existing concrete surface.

7.2.2.2.9 Beach Restoration/Groins/Offshore Breakwaters

Beach restoration also commonly referred to as beach nourishment or beachfill, typically includes the placement of sand fill to either replace eroded sand or increase the size (width and/or height) of an existing beach, including both the beach berm and dunes. Beach restorations reduce risk to storm surge flooding, waves, and erosion. Beach restoration is most applicable to areas with an existing beach. Additional erosion control measures such as groins and offshore breakwaters may be included in a beach restoration project to reduce erosion and increase the longevity of the project and reduce future renourishment requirements.

7.2.2.2.10 Bulkheads

Bulkheads are vertical structures with the primary purpose of retaining land and preventing the sliding of land at the shoreline and are impermeable to water and soil transport from in front of and behind the wall. Bulkheads are normally constructed in the form of a vertical wall built in concrete, stone, steel, or timber. The concrete, steel or timber walls can be piled and anchored walls, whereas the concrete and stone walls can also be constructed as gravity walls. Their use is limited to those areas where wave action can be resisted by such materials. In areas of intense wave action, massive concrete seawalls are generally required.

Bulkheads, unlike floodwalls and levees, are generally constructed at or near the existing grade and flood risk management is of secondary importance.

7.2.2.2.11 Seawalls

Seawalls are typically massive structures constructed along the shoreline whose primary purpose is interception of waves, prevention of upland erosion and reduction of wave-induced overtopping and flooding. If constructed with impermeable materials (not just stone) seawalls may also reduce flood risk to low-lying coastal areas.

7.2.2.2.12 Revetments

Revetments are sloped structures with the principal function of protecting the shoreline from erosion. Revetments typically constructed with cladding of stone, concrete, or asphalt to armor sloping natural shoreline profiles. Existing revetments may be retrofitted with an impermeable concrete L-wall at the top of the revetment to increase the elevation of the structure by 1 to 3 ft. and reduce flood risk.

7.2.2.2.13 Storm water System Drainage Improvements

Storm water system and drainage improvements carry water away via conveyance systems during times of heavy rainfall or high tidal water. Conveyance systems utilize measures such as pump stations, culverts, drains, and inlets to remove water from a site quickly and send it to larger streams. Storage facilities are used to store excess water until the storm or flood event has ended. As an example, ecological methods such as wetland development would be helpful in storing water. An alternative as evidenced at Lake Lily at Cape May Point is to lower the lake's water levels prior to storm events to provide additional storage capacity. Improvements may also include retrofitting existing culverts and outfalls with flap gates and tide valves to prevent back flow during storm surge events, clearing storm drains. Tide levels have the potential to increase coastal flooding during non-storm events through increased water level superimposed on normal tidal ranges from sea level rise. Plan formulation that focuses on tidal encroachment, not flooding from overland flow from rainfall events, should be evaluated as part of the formulation process as it is likely to increase with long term increases in sea level from climate change.

7.2.2.3 Natural and Nature-Based Features

Natural Features are created and evolve over time through the actions of physical, biological, geologic, and chemical processes operating in nature. Natural coastal features take a variety of forms, including reefs (e.g., coral and oyster), barrier islands, dunes, beaches, wetlands, and maritime forests. The relationships and interactions among the natural and built features comprising the coastal system are important variables determining coastal vulnerability, reliability, risk, and resilience. Conversely, Nature-Based Features are those that may mimic characteristics of natural features, but are created by human design, engineering, and construction to provide specific services such as coastal risk management. The built components of the system include nature-based and other structures that support a range of objectives, including erosion control and storm risk management (e.g., seawalls, levees), as well as infrastructure providing economic and social functions (e.g., navigation channels, ports, harbors, residential housing). An integrated approach to coastal resilience and risk management will employ the full array of measures, in combination, to support coastal systems and communities. NNBFs have been shown to reduce erosion and wave activity but have limited capacity to protect against elevated water levels since they are permeable and can be overtopped. The USACE partnered with our Engineering and Research Development Center to evaluate the effectiveness of NNBFs. Several reports are included in the NNBF Appendix.

7.2.2.3.1 Living Shorelines

Open and exposed shorelines are prone to erosion due to waves. Living shorelines are essentially tidal wetlands constructed along a shoreline to reduce coastal erosion. Living shorelines maintain dynamic shoreline processes, and provide habitat for organisms such as fish, crabs, and turtles. An essential component of a living shoreline is constructing a breakwater or sill offshore and parallel to the shoreline to serve as protection from wave energy that would impact the wetland area and cause erosion and damage or removal of the tidal plants.

7.2.2.3.2 Reefs

The development of artificial reefs in bays provides a means to reestablish and enhance reef communities. Artificial reefs provide shoreline erosion protection through the attenuation of wave energy. Artificial reefs are established for various reasons, amongst others: restore degraded or damaged natural reefs, provide three-dimensional habitat structure above the bottom, and provide fishing and scuba diving opportunities.

The NJBB CSRM Study is also considering modifications that can be made to structural management measures that can increase their habitat value including habitat benches to restore more natural slope along shorelines, and textured concrete to support colonization of algae and invertebrates.

7.2.2.3.3 Wetland Restoration

Wetlands may contribute to coastal flood risk management, wave attenuation and sediment stabilization. The dense vegetation and shallow waters within wetlands can slow the advance of storm surge somewhat and slightly reduce the surge landward of the wetland or slow its arrival time (Wamsley et al. 2010). Wetlands can also dissipate wave energy; potentially reducing the amount of destructive wave energy, though evidence suggests that slow-moving storms and those with long periods of high winds that produce marsh flooding can reduce this benefit (Resio and Westerlink 2008). The magnitude of these effects depends on the specific characteristics of the wetlands, including the type of vegetation, its rigidity and structure, as well as the extent of the wetlands and their position relative to the storm track.

Functionally restored wetlands act in the same manner as natural wetlands, though design features may be included to enhance risk management or account for adaptive capacity considering future conditions (e.g., by allowing for migration due to changing sea levels).

7.2.2.3.4 Living Breakwaters

Living Breakwaters are emergent breakwater structures designed to incorporate various forms of desired habitat. These breakwaters could include oyster beds, mudflats, nesting areas for birds, and/ or locations for emergent vegetation. These breakwaters could be designed to double as habitat features for shellfish, crustaceans, and fish.

7.2.2.3.5 Horizontal Levees

Horizontal levees are levees with an expansive slope (e.g., 1:30) that permit habitat to migrate upland while also possibly incorporating social uses (Figure 43). The creation of a more horizontal levee with less steep (1:20 - 1:30) sides would allow for areas of elevated vegetation and possible social amenity that are not possible on the standard 1:2 slope levee.

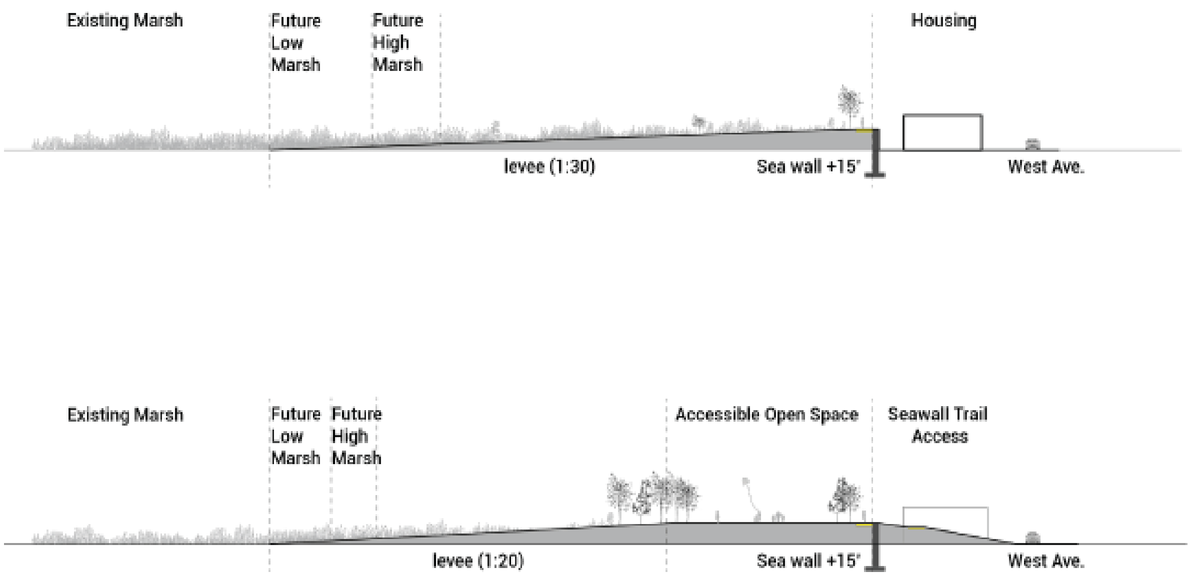


Figure 43: Horizontal levee renderings for 1:30 and 1:20 slopes

7.2.2.3.6 Shallows

Shallows are areas that were once deeper water, that are filled to an elevation that can accommodate sub-aquatic vegetation such as Eel Grass.

7.2.2.3.7 Surge Filters

The surge filter is a wetland complex designed or modified in order to create a thick collection or field of vegetation and soil. This field acts like a sponge or buffer, absorbing and dissipating wave energy as water passes through it.

7.2.2.3.8 Submerged Aquatic Vegetation (SAV) Restoration

Submerged aquatic vegetation (SAV) are grasses that grow to the surface of shallow water, but do not emerge from the water surface. SAV performs many important functions, including wave attenuation, buffer shorelines by stabilizing sediments with plant roots, water quality improvement, primary production, food web support for secondary consumers, and provision of critical nursery and refuge habitat for fisheries species.

7.2.2.3.9 Green Storm water Management

Green storm water management is a resilient approach that mimics nature to store and treat rainfall at its source. Green storm water management can be used to reduce runoff and increase the capacity of existing storm water systems and reduce the risk of flooding. Green storm water management includes management measures such as rain gardens, bioswales, permeable pavements, rainwater harvesting, downspout disconnection, planter boxes, and green roofs.

7.3 Management Measure Screening

Screening is the process of eliminating management measures from the initial CSRM management measure list discussed previously. The highest ranked measures carried forward from this measure inventory and screening were then refined into more detailed measures with greater location, engineering, and economic detail. These strategies will eventually be combined into individual alternative plans to be discussed later in this chapter, and ultimately the TSP in the following chapter.

Post measure-screening formulation resulted in the grouping of measures into four different strategies for managing coastal storm risk, including:

- Perimeter management measures (including floodwalls, levees, and seawalls) that limit the ingress of tidal floodwaters.
- Nonstructural management measures that do not alter the elevation of floodwaters (building retrofit).
- Storm surge barriers and CBBs that close to stop tidal exchange and limit storm surge during a coastal storm.
- Natural and nature-based features as either a stand-alone or a hybrid/complementary management measure to potentially limit the elevation of floodwaters and provide environmental benefits.

Each strategy was first evaluated independently for all relevant study area locations and then combined with other strategies to create NED optimizing and comprehensive multi-strategy alternatives. Figure 44 below shows the formulation approach, beginning with single strategy perimeter, nonstructural, and SSB/CBB alternatives and progressing to a full array of alternatives including multi-strategy approaches.

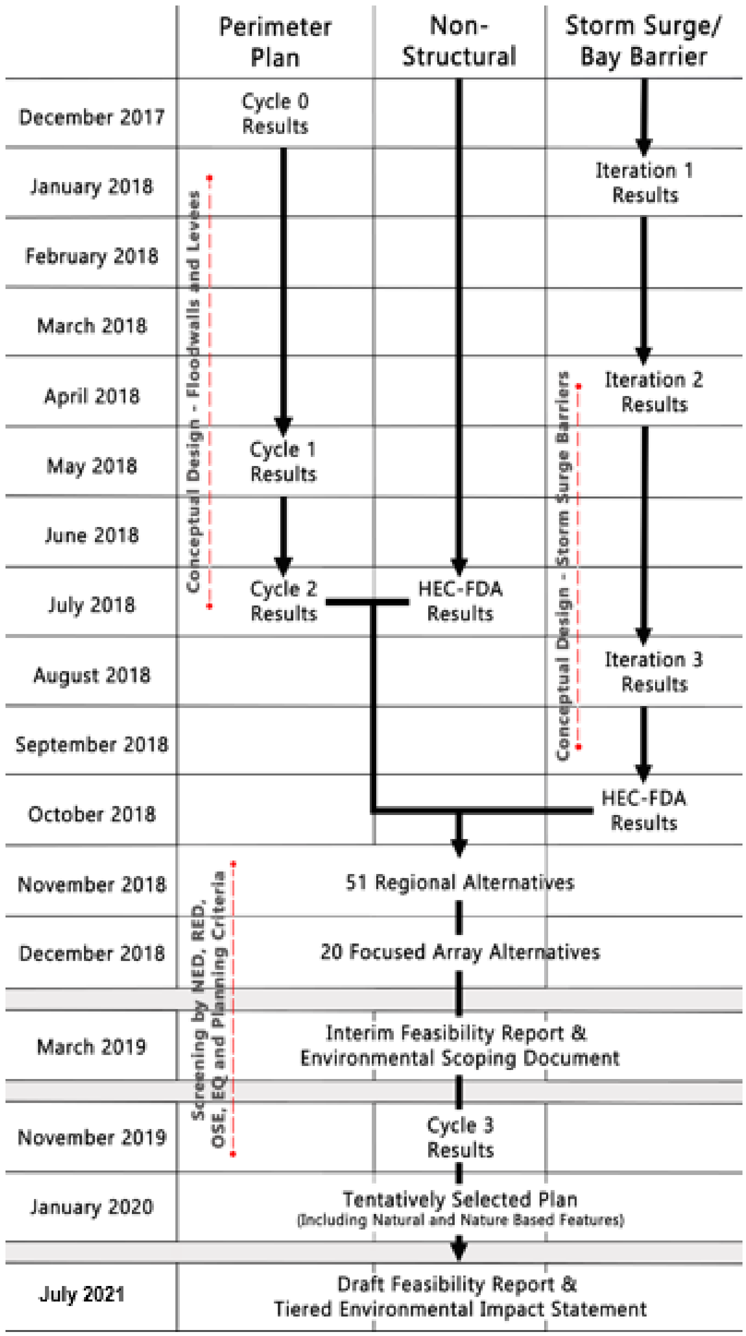


Figure 44: NJBB Component Plan Screening Process

A summary of the four different cycles of the NJBB alternative plan screening process is offered below. This Main Report only offers a detailed discussion of the latter cycles (i.e., Cycle 3) for each of the four different strategies. Detailed discussion of the initial cycles for each strategy are offered in the Plan Formulation Appendix as well as the Economic and Engineering Appendices.

- **Cycle 0** was a qualitative exercise where areas for perimeter measures were screened out because they had near zero damageable structures. No cost and no benefit analyses were performed.
- **Cycle 1** was the quantitative analysis for all the perimeter measures for mainland and barrier island (0% design level).
- **Cycle 2** (including two iterations as discussed in the March 2019 Interim Report) was the further quantitative analysis of the potentially economically viable sites (inclusive of all barrier islands).
  - -Alternatives: Reduced from 50 to 20
  - -Design: Iterations of 3 wall types; level of design ~ 5%
  - -Cost update - basic design and a cost formula
  - -SSB: 7 barriers screened out
  - -PP: LBI, Island Beach, and Strathmere screened out.
- **Cycle 3** (including three iterations performed subsequent to the Interim Report was the further quantitative analysis of the incrementally justified sites.
  - -Alternatives: Reduced from 20 to 8 with the ultimate selection of the TSP
  - -Design: Risk-based analysis including 16ft and 13ft wall heights; level of design ~ 15%
  - -Cost update - an improved design and cost formula
  - -SSB: Absecon Inlet screened out
  - -PP: Continuing analysis which still warrants further investigation

A discussion follows detailing the methodology and results of investigating each strategic grouping of measures in isolation.

7.4 Refined Management Measure Development

The refinement of management measures discussed in this section commences Step 3 – Formulating Alternative Plans of the USACE six-step planning process. This section identifies a system of structural, nonstructural and NNBF measures and strategies to meet the identified study planning objectives subject to the planning constraints.

7.4.1 Perimeter Plan Development

Evaluation of the perimeter plan (defined as a collection of perimeter measures that constitute and alternative or part of an alternative) was completed using four iterative cycles of analysis. The investigative cycles (Cycles 0 and 1) included an initial comprehensive qualitative analysis and an excel-based quantitative analysis. Cycles 2 and 3 included HEC-FDA based quantitative analysis. As the perimeter plan analysis progressed from Cycle 0 to Cycle 3, the level of risk and associated design/data uncertainty was reduced allowing for risk-informed comparison and evaluation of measures and alternatives. The results from the Cycle 3 level of screening are provided below. The results from the initial perimeter plan cycles of screening (Cycle 0-2) are provided in the Plan Formulation Appendix.

Cycle 0 identified 49 possible perimeter plan locations across the study area. These locations represent the base for future analysis. Cycle 1 incorporated all the areas identified in Cycle 0 and introduced cost inputs and benefit estimates. The inclusion of cost and benefit estimates allowed the PDT to assign preliminary AANBs and Benefit-Cost Ratios (BCRs) to each of the 49 locations identified in Cycle 0. The AANB results from Cycle 1 were used to screen locations for implementation of the perimeter plans with positive AANB estimates would progress to Cycle 2 analysis and locations with negative AANB estimates would not be considered further for implementation of the perimeter plan.

Thirteen perimeter plan locations were identified in Cycle 1 based on Benefit-Cost Ratios above 1.0 (apart from Strathmere with a BCR of 0.8), totaling 840,000ft in length (Table 32).

Table 32: Perimeter Plan Analysis - Cycle 1 Results

Location	Length	BCR
Cape May City	15,757	2.7
Wildwood Island	54,070	4.1
West Wildwood	11,727	2.5
Stone Harbor / Avalon	96,936	1.6
Sea Isle City	34,954	2.5
Strathmere	8,165	0.8
Ocean City	78,573	5.6
Absecon Island	97,409	8.7
Brigantine	48,590	2.6
Long Beach Island	206,561	1.6
Island Beach	186,140	1.9
Manasquan Inlet (North)	22,642	2.9
West Cape May	4,481	5.8

These thirteen locations were carried forward to the Cycle 2 analysis although Long Beach Island and Island Beach had negative AANB as well as other factors which make justification highly unlikely. Cape May City, Stone Harbor/Avalon and Brigantine could realistically attain justification with optimizations to measure placement or type and are therefore being carried forward for a total of 10 potential locations for consideration in Cycle 3.

7.4.1.1 Design Considerations and Assumptions

The Cycle 3 analysis for the perimeter plan consisted of the following elements, and built upon Cycle 0-2 elements, where indicated:

  - Levee - Type A
  - T-Wall - Type B (Concrete cantilever wall on piles, waterside construction)
  - T-Wall - Type C (Concrete cantilever wall, landside construction)
  - Wall - Type D (King pile combined with sheet pile wall).

- All structures (levee and walls) evaluated for increased water levels from Cycle 2
- Preliminary geotechnical and structural analysis to verify design
- Revised quantities
- Real estate (Permanent and Temporary Easement) Acreage estimates determined

Water levels for the 1% AEP were updated and wave overtopping was reanalyzed for this cycle, and it was determined that the approximate maximum required crest elevation for the flood protection structures is 16 feet NAVD88 (See the HH&C Sub appendix of the Engineering Appendix for design height calculations). The previous Cycle 2 analysis assumed a maximum required crest elevation of 13 feet NAVD88. A Cycle 3 design evaluation of the walls was completed using available geotechnical data for a stability analysis with proposed conditions to update the wall typical sections. No feature changes were necessary to the wall sections; however, pile numbers, size, depth, and spacing requirements were better defined. (See Geotechnical and Structural Appendices of the Engineering Appendix for the Cycle 3 analysis). Cycle 3 Quantities and Typical Sections for all 4 structure types were revised accordingly and are included in the Engineering Appendix/Drawings Annex.

7.4.1.1.1 Design Crest Elevations

Preliminary crest elevations for structural management measures (perimeter measures such as floodwalls and levees as well as for SSBs) are based on the 1% AEP water level with 50% assurance provided in the NACCS hazard curves. The 50% assurance implies that there is 50% chance, or coin flip, that the 1% AEP will have a water level greater. At the 90% assurance the crest elevations are designed to approximately the 4% AEP water level, however there is variability across the study area in the uncertainty and performance at the 90% assurance.

It is emphasized that there is no policy requirement that USACE projects be designed to the 1% AEP water level or any minimum performance standard. In subsequent phases of the NJBB Feasibility Study the performance of the measures will be optimized to maximize NED benefits, which could result in higher or lower performance. The decision to design structures to the 1% AEP water level at this stage of the study is consistent with the parametric designs in NACCS and ECB 2013-33 that required all Sandy rebuilding projects receiving funds for construction under the Sandy supplemental (Public Law 113-2) be meet a flood risk management standard of one foot above the best available and most recent base flood elevation. The 1% AEP water levels used for design are equal to or greater than observed water levels during Hurricane Sandy.

The relative contribution of each respective total water level component at three representative structure locations is provided in Table 33 and Table 34. The NJBB CSTORM and NACCS water level hazard curves include several of the total water level components: MSL, astronomical tide, storm surge, and wave setup. The water level hazard curves represent the join probability of all the components combined and the exact relative contribution of each component is not well defined. However, the relative contribution of each component is estimated here based on the well-known tidal amplitudes (MHW) and approximate estimates of wave setup based on the wave heights.

RSLC is included by adding 2 feet, based on the USACE Intermediate SLC scenario. The required freeboard for each structure was determined based on wave overtopping calculations and tolerable overtopping rate. Seasonal variations in sea level are included based on average seasonal fluctuation during peak hurricane season (August, September, October) observed NOAA tidal gage at Atlantic City. Inter-annual variations in sea level are not included in the TWL estimate or design crest elevations at this time and rarely exceed 0.5 feet.

Design and cost estimates of the perimeter plan floodwalls and levees (Table 33) are based on a crest elevation of 16 feet NAVD88.Due to the spatial variability in water levels, wave conditions, and wave overtopping there are some locations where the required crest elevation of the perimeter plan features could be lower than 16 feet NAVD88 and a few locations where the perimeter plan may need to be slightly higher.

Conceptual design and cost estimates of the SSBs are based on a crest elevation of 17 to 20 feet NAVD88 as shown in Table 34. Design crest elevations for the bay closures are set to the same elevation as the perimeter plan, 16 feet NAVD88.

In subsequent phases of the NJBB Feasibility Study the performance of the measures will be revisited and optimized to maximize NED benefits, which could result in higher or lower performance crest elevations. The performance and adaptability of the measures to all three SLC scenarios will be incorporated in the optimization process.

Table 33: Perimeter Plan Crest Elevations and Total Water Level Components

Component	Wildwood (feet)		Ocean City (feet)		Beach Haven (feet)	
MSL (feet, NAVD88)	-0.40	10.5[2]	-0.40	10.2[2]	-.40	7.9[2]
Astronomical Tide	1.8[1]		1.6[1]		1.2[1]	
Storm Surge	8.9		8.8		8.4	
Wave Setup	0.2		0.2		0.2	
RSLC	2.0		2.0		2.0	
Seasonal Variations	0.3		0.3		0.3	
Freeboard	3.3[3]		2.2[3]		3.0[3]	
Total Water Level (feet, NAVD88)	**16.1**		**14.7**		**13.2**	

Notes: [1]MHW shown; [2]Value from NACCS hazard curve in feet, NAVD88; [3]Freeboard based on wave overtopping of vertical wall.

Table 34: Storm Surge Barrier Crest Elevations and Total Water Level Components

Component	Great Egg Inlet (feet)		Absecon Inlet (feet)		Barnegat Inlet (feet)		Manasquan Inlet (feet)	
MSL (feet, NAVD88)	-0.40	10.6[2]	-0.40	10.0[2]	-0.40	8.8[2]	-0.40	9.3[2]
Astronomical Tide	1.6[1]		1.6[1]		1.6[1]		1.6[1]	
Storm Surge	9.4		8.8		7.6		8.1	
Wave Setup	0.0		0.0		0.0		0.0	
SSB Induced	1.0		1.0		1.0		1.0	
RSLC	2.0		2.0		2.0		2.0	
Seasonal Variations	0.3		0.3		0.3		0.3	
Freeboard	5.1[3]		6.1[3]		4.9[3]		7.8[3]	
Total Water Level (feet, NAVD88)	**19.0**		**19.4**		**17.0**		**20.4**	

Notes: [1]MHW shown; [2]Value from NACCS hazard curve in feet, NAVD88; [3]Freeboard based on wave overtopping of vertical wall.

7.4.1.2 Cost and Contingency Considerations and Assumptions

Perimeter plan costs utilized in preliminary Cycles were adapted from the NACCS and benefits were calculated using an excel-based model with preliminary structure inventory data and a simplified depth-percent damage curve. Cost estimates included $8,000 per linear foot of floodwall with additional costs added for miter gates, sluice gates, or road closures where applicable. The Cycle 3 perimeter plan strategy utilized the following cost and contingency considerations and assumptions. Costs for perimeter plan barriers were calculated using MII

(Second generation of Micro-Computer Aided Cost Estimating System [MCACES]). Unit cost information is presented below and is underlined where different than those costs used in the Cycle 2 strategy.

Unit Costs

- Floodwall:
    - Range between $10,121/linear ft. (lf) and $22,701/lf. Cost range is based on floodwall types discussed in above section and is dependent upon construction access for the different floodwall types. Construction from the land side can be performed from if no access limitations exist. Construction from the water side resulting from existing infrastructure or environmental mitigation activities will require water-based equipment and resulting cost differences
- Levee: $8,915/lf
- Miter Gate: $15,338,862 ea.
- Sluice Gate: $12,173,122 ea.
- Road Closure Gate: $4,037,103 ea.
- All costs adjusted based on an area factor and FY2020 Price Level
- Desktop estimate of interior pumping
- Real Estate: Perimeter plan costs are ~35% of construction costs and SSB are ~10% of construction costs
- Mitigation (Direct Impacts): 5% of project cost. Perimeter plan and SSB impacts costs are preliminary actual costs (based on habitat model analysis)
- Mitigation (Indirect Impacts): Perimeter plan costs are 0% of construction costs and SSB costs are 5% of construction costs
- Cultural: 1% of construction costs
- PED used 12% and S&A used 10% of construction costs
- Annual Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R) is 1% of First Costs for the perimeter plan measures and 2% of First Costs for SSBs

Contingency

- Cycle 3 Contingency is 40% of construction costs for a "10% design level"
- Contingency includes
    - Utility relocations
    - 300 Crossovers and ADA accessibility
    - HTRW
    - Demolition/reconstruction of docks and ramps

- Demolition/removal of bulkheads and revetments
- Local borrow area and disposal sites
- Accommodating navigation depths/vessel restrictions
- Drainage outlets spaced every 400 ft.

- Final Contingency for TSP was based on 'Crystal Ball' analysis and is 40% of construction costs.

7.4.1.3 Design Quantities and Layouts

The four typical sections used in this analysis were a levee section (Type A), a floodwall section to be constructed in areas below water level (Type B), a floodwall section to be constructed in areas above the mean tide zone (Type C), and a king pile combined with sheetpile wall (Type D). Typical Sections of each type are shown in Figures 45 through 49.

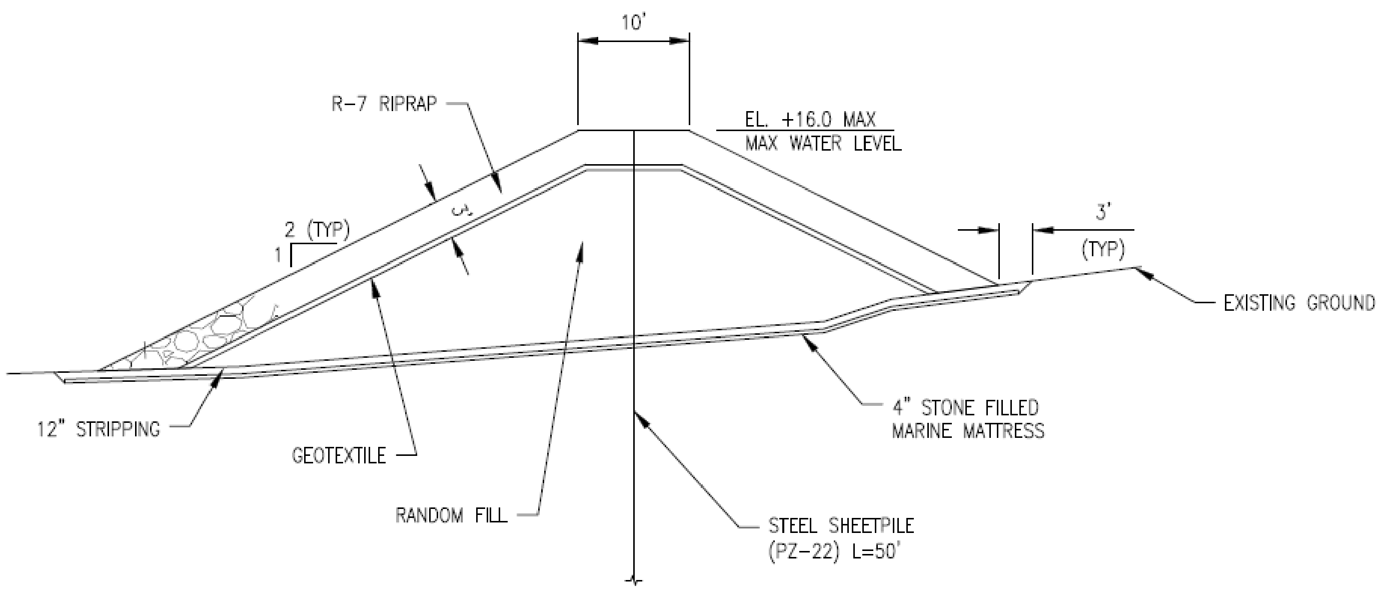


Figure 45: Typical Section – Levee – Type A

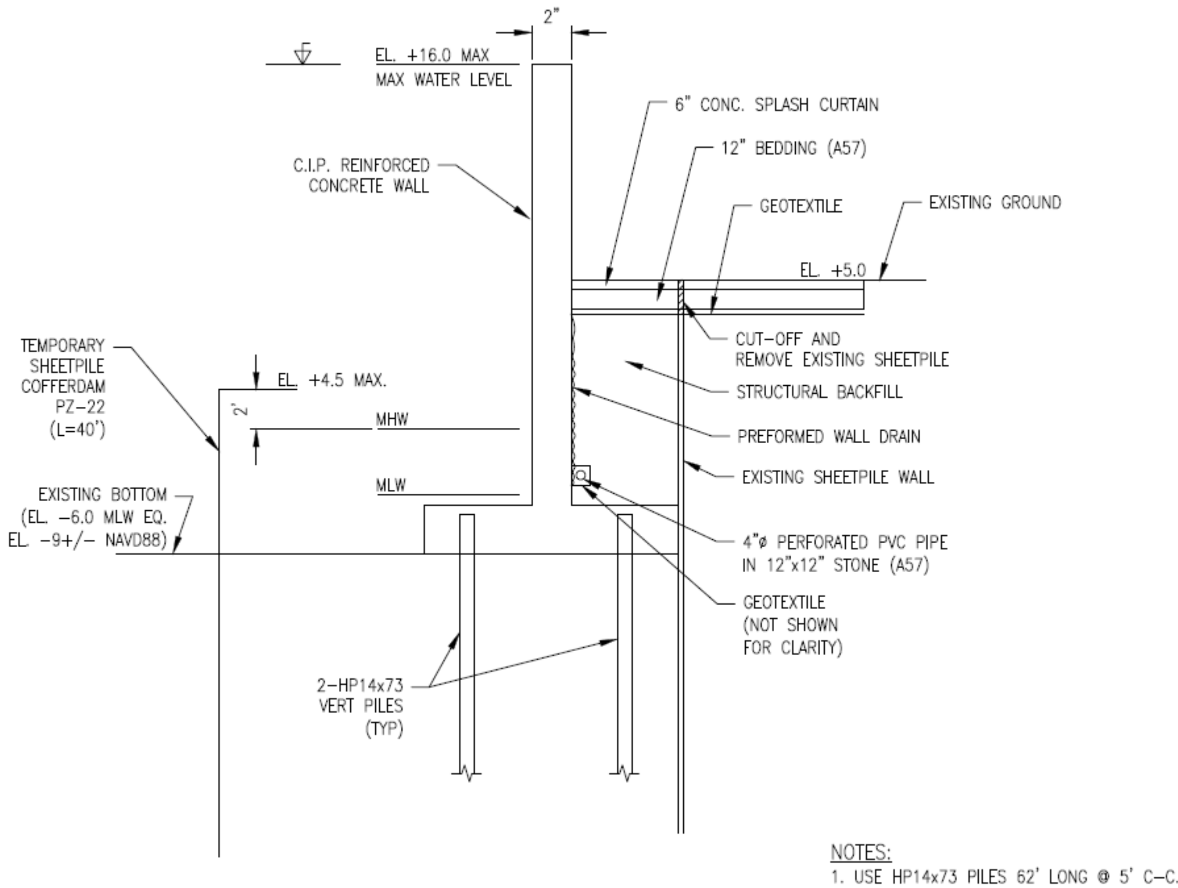


Figure 46: Typical Section – Concrete Cantilever Wall on Piles – Type B

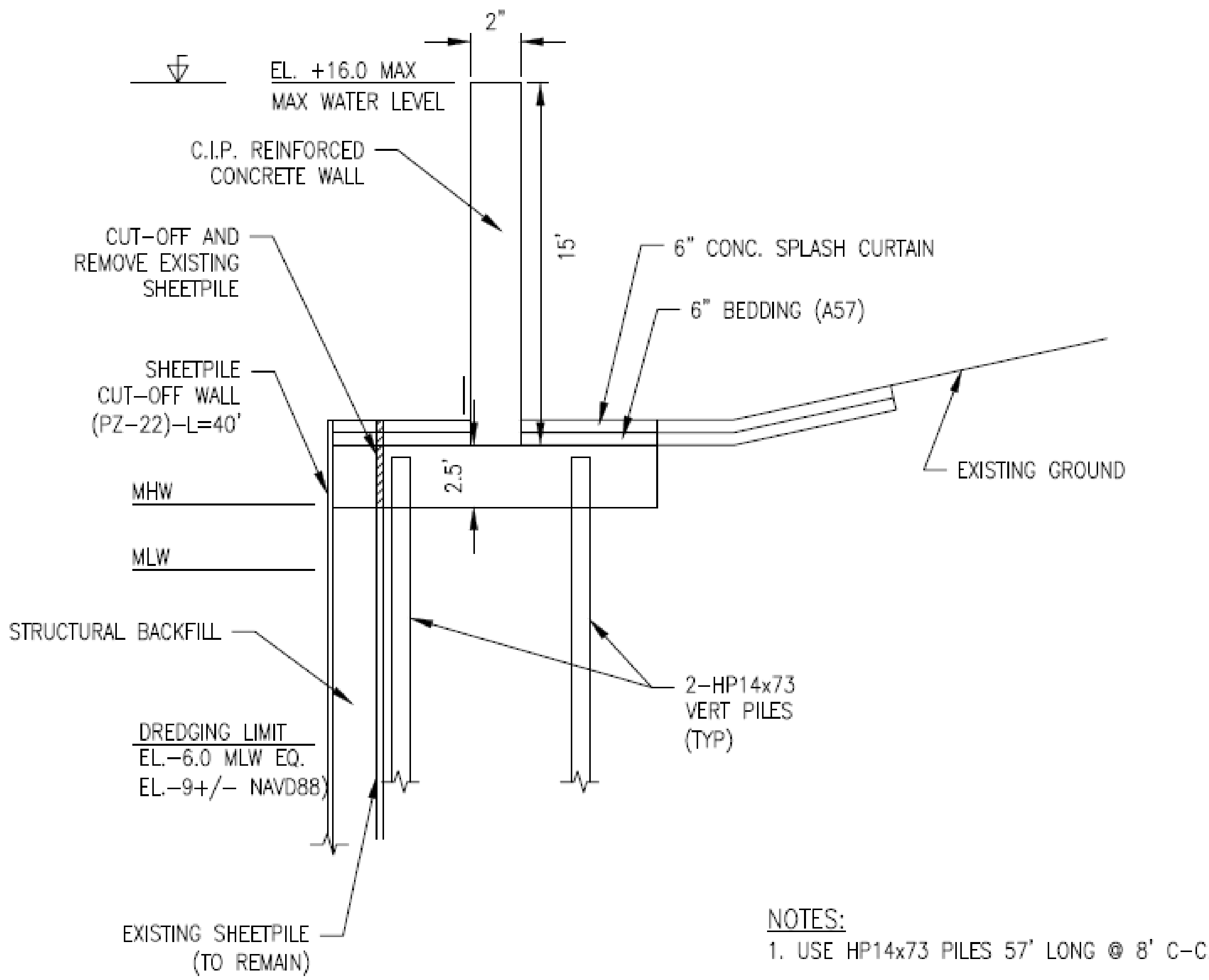


Figure 47: Typical Section – Concrete Cantilever Wall on Piles – Type B

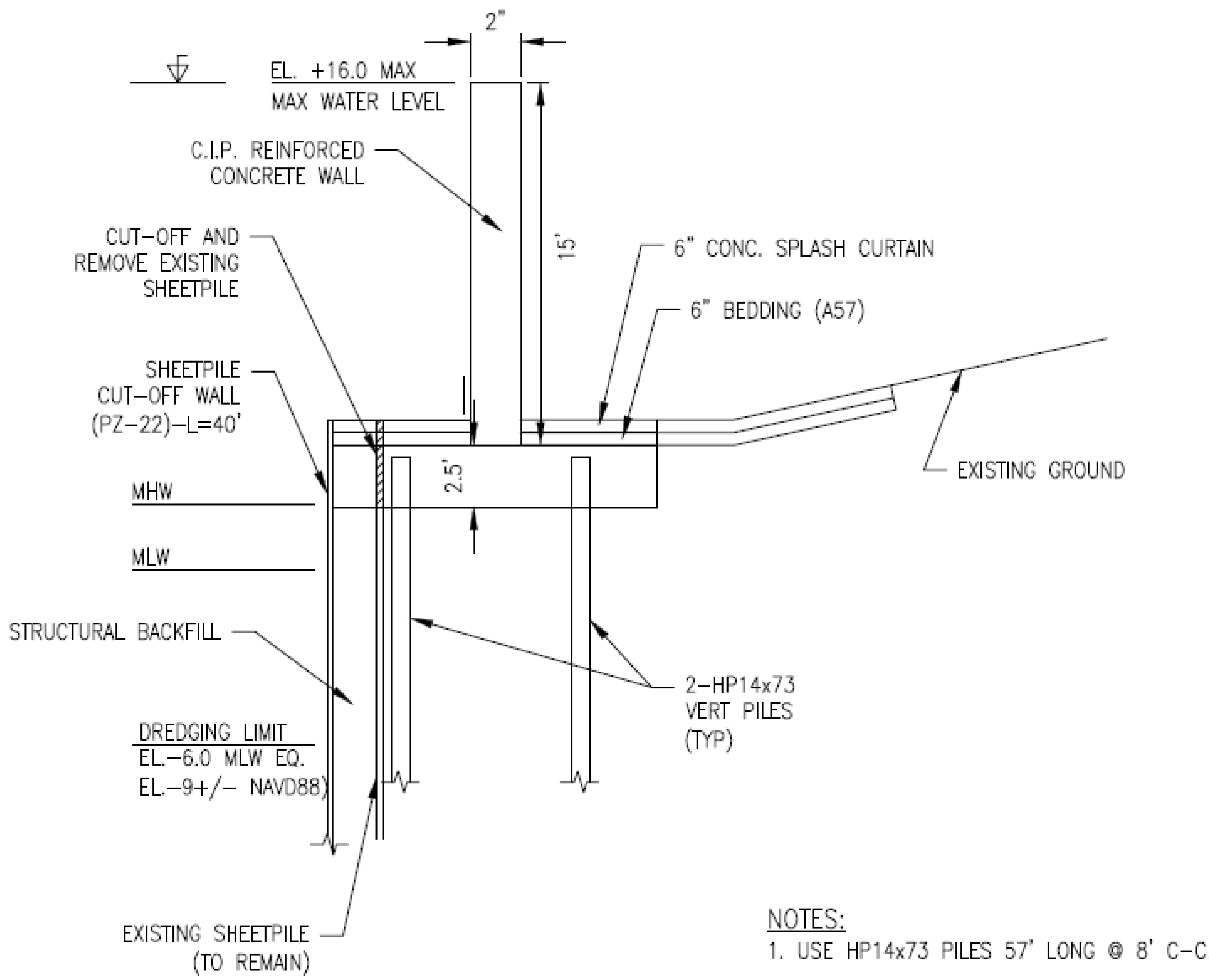


Figure 48: Typical Section – Concrete Cantilever Wall on Piles – Type C

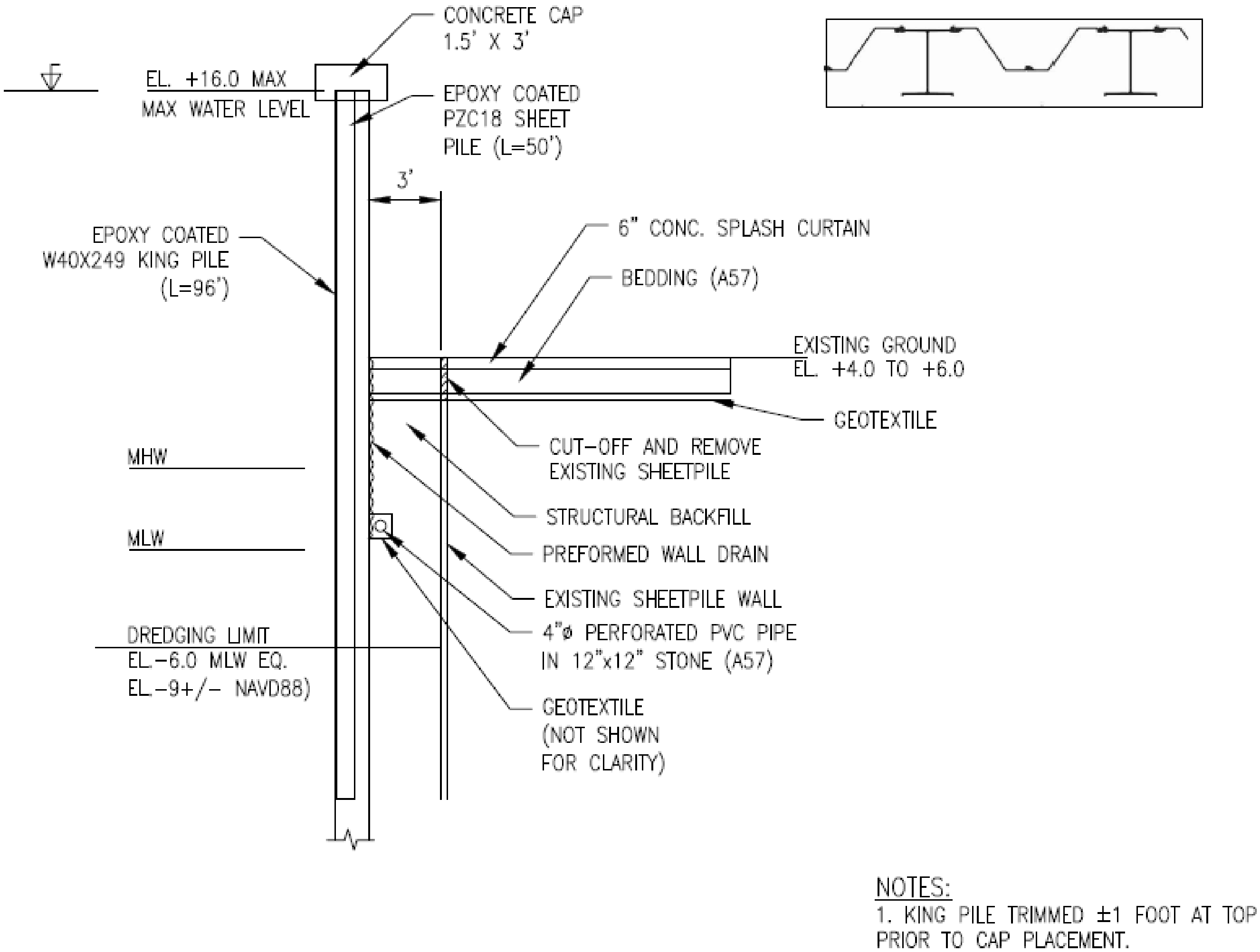


Figure 49: Typical Section – King Pile Combined with Sheetpile Wall - Type D

Levee sections were used in open space areas that transitioned from beach to water, or from undeveloped property to marshland, but generally avoided areas of coastal marsh or maritime forest for placement of the full levee section to minimize environmental impacts to these resources. If the alignment for the line of protection could not substantially avoid an environmentally sensitive area one of the floodwall types was utilized since its footprint is much smaller than the levee. Very short sections of levee between floodwalls were also avoided for the sake of continuity at the screening level. Layout assumed a landward toe tie-in to existing ground higher than mean high water (MHW), with a sloped bottom extending to the flood side toe at an approximate depth of mean low water (MLW). The levee section, 10' crest width with 2H:1V side slopes, includes a 3-foot-thick layer of riprap placed above a random fill interior. The riprap will protect the structure from, and reduce run-up by, wave action, and protect against erosion during overtopping. At the center of the levee section is a sheetpile wall to provide impermeability of the structure, and for cut-off protection against underseepage. Sections will be constructed on top of 4" thick, stone-filled marine mattresses with geotextile along the base to provide foundation support at the soil interface. Quantities include a 2 foot overbuild for expected settlement of the structure.

Both floodwalls Type B and Type C are assumed to be similar in composition but different in size, location of placement, and means and methods needed for construction. Both floodwalls are reinforced concrete T-Walls, with a stem thickness of 2 feet, base thickness of 2.5 feet, supported by (2) 50-foot-long HP14x73 piles spaced at 10 feet longitudinally. Construction of the Type B wall assumes placement just bayward of an existing bulkhead structure that will remain in place and provide support of excavation. The base of the Type B wall will extend down to a bed elevation of approximately -9 feet NAVD88, which is the expected maximum dredging depth for the New Jersey Intracoastal Waterway (NJICWW). A temporary cofferdam is required for construction of the wall which will be completed using water-based methods. The Type C wall will be constructed from land at a base depth above or close to the tidal zone. The wall dimensions are based upon constructing the concrete base above the lowest MHW level in the bay (0 feet +/- NAVD88) which results in a stem height of 10.5 feet. The unsupported stem height is estimated to be as high as 9.5 feet. The Type C wall assumes construction behind an existing bulkhead (condition unknown) or at the land edge. In either case, the installation of a sheetpile cut-off wall in front of the structure is assumed to be required for protection of soil below and beyond the base from scour. The depth, number, or size and spacing of piles for either of the floodwalls was not analyzed at this screening level, however, selection of these elements and their parameters was based upon other walls of similar type proposed in other studies.

7.4.2 Nonstructural Management Measure Development

7.4.2.1 Introduction

At this stage of the analysis, nonstructural economic analysis incorporates only building retrofits (elevations) to residential structures and wet)/dry floodproofing to residential and commercial structures due to availability of existing data such as structure inventory and cost information. Future analysis will include additional building retrofits such as managed coastal retreat including acquisition / relocation. Future recommendations will also be made regarding land use management and early flood warning elements.

Building retrofits, while effective in reducing the potential risk for storm damage to that specific structure, has no positive impact on reducing storm damage risk to surrounding property, vehicles, or infrastructure. Furthermore, emergency access and evacuation are not improved solely with the implementation of building retrofits and property owners should still evacuate vulnerable properties during storm events lest they become trapped by rising storm surge. While this section details the cost and benefits analysis for implementing only nonstructural management measures, a potential alternative may incorporate nonstructural as a supplemental measure to either perimeter measures, SSBs, or both.

7.4.2.2 Methodology

Nonstructural methods (Building Retrofit) protect the most vulnerable structures across the study area to an established Design Flood Elevation.

The target design elevation was developed considering past, present, and future conditions.

- Sea Level Rise – Intermediate curve 2080 expects the sea level rise to be 1.84 ft., rounded to 2 ft. (Table 35).

Table 35: Sea Level Rise Curve Table

Year	USACE - Low (ft, MSL[1])	USACE - Int (ft, MSL[1])	USACE - High (ft, MSL[1])
1992	0.00	0.00	0.00
2000	0.11	0.11	0.13
2019	0.35	0.42	0.62
2030	0.50	0.63	1.03
2050	0.76	1.06	2.01
2080	1.15	1.84	4.02
2100	1.41	2.54	5.74
2130	1.81	3.50	8.87

[1]Mean Sea Level based on National Tidal Datum Epoch (NTDE) of 1983-2001

The Target Design: Elevation: The elevation in which the structures first floor would be elevated above.

Target Design: Elevation = 1% AEP stage height + SLR + Wave

Note The Target Design Elevation differs throughout the study area. The target design elevation may change within the study as further analysis is being considered for determine the appropriate curve to use. Additional analysis on the effects of waves may change the Target Design Elevation.*

Future analysis is planned for understanding various methods for prioritizing the nonstructural portion of the plans. Structures will be looked at with various derivations of clustering. Some of the clustering or aggregation methods that will be considered are areas where a large number of nonstructural methods is recommended for a small area. Designations such as repetitive loss can be used to inform some of the most at risk structures from a historical damage's perspective. Implementing nonstructural in clusters can help reduce the mobilization cost for equipment needed attempting to lower project cost. Structures within political boundaries will also be considered as well as geographic boundaries. Considerations for historical structures can help inform the future aggregations.

7.4.2.3 Nonstructural Cost Estimates

Costs for the nonstructural management measures have been generalized to represent a prototypical structure within six subtypes. The subtypes help to apply a prototypical cost to a prototypical structure.

1) Single Story Light (1600 ft^2): This subtype is representative of a single story structure that has been constructed using light methods such as wood frame. Any of the structure types can fit into this subtype. The expectation is that most of the structures within this subtype will be residential. The estimated square footage of a prototypical structure of this subtype is 1600 ft^2.
2) Light (1600 ft^2) This subtype is representative of a multi-story structure that has been constructed using light methods such as wood frame. Any of the structure types can fit into this subtype. The expectation is that most of the structures within this subtype will be residential. The estimated square footage of a prototypical structure of this subtype is 1600 ft^2.
3) Heavy Small (1600 ft^2) This subtype is representative of a single or multi story structure that has been constructed using heavy methods such as brick and masonry. Any of the structure types can fit into this subtype. The expectation is that most of the structures within this subtype will be public. This subtype is used for structures with a first floor square footage up to 5000 ft^2. The estimated square footage of a prototypical structure of this subtype is 1600 ft^2.
4) Heavy Large (16000 ft^2) This subtype is representative of a single or multi story structure that has been constructed using heavy methods such as brick and masonry. Any of the structure types can fit into this subtype. The expectation is that most of the structures within this subtype will be public. This subtype is used for structures with a first floor square footage above 5000 ft^2. The estimated square footage of a prototypical structure of this subtype is 16000 ft^2.
5) Multipurpose Heavy Small (1600 ft^2) This subtype is representative of a single or multi story structure that has been constructed using heavy methods such as brick and masonry. Any of the structure types can fit into this subtype. This subtype accounts for complicated designs of structures that may act together on a site. The expectation is that most of the structures within this subtype will be industrial. This subtype is used for structures with a first floor square footage up to 5000 ft^2. The estimated square footage of a prototypical structure of this subtype is 1600 ft^2.
6) Multipurpose Heavy Large (16000 ft^2) This subtype is representative of a single or multi story structure that has been constructed using heavy methods such as brick and masonry. Any of the structure types can fit into this subtype. This subtype accounts for complicated designs of structures that may act together on a site. The expectation is that most of the structures within this subtype will be industrial. This subtype is used for structures with a first floor square footage up to 5000 ft^2. The estimated square footage of a prototypical structure of this subtype is 16000 ft^2.

Cost decision matrix were developed for residential, apartment, commercial, industrial, and public. These decision matrix help inform which cost to use for each of the categories designated in the CENSUS data. The cost decision matrix for each category is shown in the Nonstructural Appendix.

Costs were developed for each of the following methods and explained in further detail in the Nonstructural Appendix: Elevation, Dry Flood Proofing, Wet Flood Proofing, Addition, Basement Fill, Relocation, Buyout/Acquisition. If a structure is located on a barrier island **OR** on the waterfront there will be a 10% increase to the cost due to increased difficulties of implementation and construction. If a structure is located both on a barrier island **AND** on the waterfront, there will be a 20% increase to the cost due to increased difficulties of implementation and construction.

7.4.2.4 Structure Identification

Structures were identified based on applying a static foundation height that represents an average of all foundation heights. The identified structures represent a likely structure that would be contained with a data point. Structures that showed a First Floor Elevation below the 5% AEP stage height were considered for nonstructural management measures. Table 36 shows the breakdown a likely scenario including the first floor estimated compared to Target Flood Elevation, 5% AEP.

Table 36: Structure Identification based on Structure Type throughout the Study Area

Occupancy Type	# Recommended for Nonstructura	Total	% Recommended for Nonstructura
APT	367	1,669	22.00%
COM	2,899	6,558	44.20%
HIGH	21	117	17.90%
IND	22	62	35.50%
PUB	349	1,051	33.20%
SFR1-B	17,350	50,911	34.10%
SFR1-M	3,891	23,560	16.50%
SFRM-B	15,520	68,288	22.70%
SFRM-M	2,342	20,772	11.30%

7.4.2.5 Benefits Analysis

Nonstructural economic analysis is conducted using HEC-FDA with an FY18 Federal Discount Rate of 2.75% over a 50-year period of analysis. All single family residential 1-unit (SFR1) and single family residential multi-unit (SFRM) structures with first floor elevations below the 5% ACE event stage height were "elevated" to 15ft NAVD88 within the model (Table 37). This elevation height was selected only to remove any possibility of damage for these structures for any storm more frequent than the 1% ACE event. In reality, the exact elevation necessary for each structure (Design Flood Elevation) will fluctuate depending on the site-specific FEMA BFEs.

One limitation of HEC-FDA is the requirement of a static inventory for the entirety of the period of analysis. Structures cannot be added, removed, nor elevated within the model. To circumvent this limitation for nonstructural analysis, two separate HEC-FDA models are developed. One model has the Without-Project Condition from FY2030 to FY2080 and a separate model has the With-Project Condition (updated inventory) from FY2030 to FY2080. The difference in calculated AAD between the model results is the coastal storm damage reduction benefits of retrofitting 31,660 of the 182,930 structures in the inventory.

Additional damage categories such as infrastructure, vehicle damage, emergency costs, and transportation delays are not mitigated through nonstructural management measures and are included in the residual damage[1] category.

Table 37: Nonstructural Management Measure Evaluation – 5% ACE Event Floodplain

Item	Number	Unit Cost	Total Cost
SFR1 Elevations	20,338	$211,414	$4,299,737,932
SFRM Elevations	11,322	$245,147	$2,775,554,334
Total Initial Const.	***31,660***		***$7,075,292,266***
Period of Analysis			50
FY18 Discount Rate			2.75%
Capital Recovery Factor			0.037041
Total Average Annual Cost (AAC)			***$262,075,331***
Without AAD			$1,571,616,063
With AAD			$1,119,950,393
Reduced AAD			***$451,665,670***
AANB			***$189,590,339***
BCR			***1.72***
Residual Damage			***71.3%***

The nonstructural strategy when implemented across the study area, has a positive Average Annual Net Benefit, and passes the NED economic criteria. However, alternatives that only employ a nonstructural strategy will have an exceptionally high residual damage percentage. Residual damages stem from damage to non-elevated surrounding property, vehicle damage, infrastructure damage, emergency costs, and transportation delays.

[1] **Residual damages** are the expected damages to surrounding property and other damage categories including vehicle damage, infrastructure damage, emergency costs, and transportation delays that are not protected by the CSRM alternative as modeled in HEC-FDA. Residual damages are the damages expected in the study area even after construction of the proposed alternative

7.4.2.6 Refined Analyses to Support the TSP

Of the four nonstructural management measure groups discussed above only building retrofit measures are quantified for NED benefits. All structure occupancy types are considered for elevation or wet /dry floodproofing at this stage of the study.

Acquisition / relocation costs and identification criteria have been evaluated but have not been inserted into the HEC-FDA analysis. Comprehensive information on nonstructural methodology and implementation guides can be found in the Nonstructural Appendix.

For nonstructural management measures, the current selection criterion for identifying structures eligible for nonstructural selection remains broadly the same as the methodology outlined in Section C-5, though the estimated number of structures has changed due to adjustments to the inventory and nonstructural now includes non-residential structures. For residential and non-residential structures, eligibility is identified if the applied First Flood Elevation is lower than the 5% AEP event stage height for that reach (Year 2030). The 5% AEP event stage height was selected because it approximated maximizing potential nonstructural net benefits.

To reiterate a major nonstructural analysis limitation, because compiling a fully comprehensive structure inventory is resource and time prohibitive, structures are only assigned the mean occupancy type foundation height as opposed to their actual foundation height. As such, the actual structures that are being recommended for elevation cannot be identified. Instead, the results more generally show a total number of structures in a given area that are expected to be good candidates for elevation. Because the feasibility study will never have perfect information regarding the foundation heights of the structures in the study area, this issue will not be resolved until the implementation phase. In addition, the number of structures that have been elevated over time is increasing with local and FEMA efforts in these communities. This means that this management measure has a high degree of uncertainty.

The number of structures eligible for nonstructural and the average cost for nonstructural by structure type are documented by occupancy type in Table 38.

Table 38: Number of Structures Recommended for Nonstructural by Occupancy Type

Occupancy Type	Description	# Eligible	Total	% of Total Eligible	Methods Considered	Average Cost
APT	Apartment Building	367	1,669	22.0%	Wet Floodproof, Elevate	3,146,683
COM	Commercial	2,899	6,558	44.2%	Wet/Dry Floodproof, Elevate	504,986
HIGH	High-rise (5+ stories)	21	117	17.9%	Wet Floodproof, Elevate	3,146,683

IND	Industrial	22	62	35.5%	Wet Floodproof, Elevate	3,146,683
PUB	Public	349	1,051	33.2%	Elevate	979,185
SFR1-B	Single-Family Residential (One Story (Barrier island)	17,350	50,911	34.1%	Elevate	236,059
SFR1-M	Single-Family Residential (One Story Mainland)	3,891	23,560	16.5%	Elevate	236,059
SFRM-B	Single-Family Residential (Multi Story (Barrier island)	15,520	68,288	22.7%	Elevate	293,885
SFRM-M	Single-Family Residential (Multi Story (Mainland)	2,342	20,772	11.3%	Elevate	293,885
TOTAL		**42,761**	**172,988**	**24.7%**	-	-

As the assigned mean foundation heights for the non-single-family structures are very low (all less than 1.5 feet) and very few of the PUB, COM, and IND structures are already elevated out of the floodplain, a larger relative percentage are considered eligible for nonstructural.

Regardless, 91% of the structures recommended for elevations are single-family residential. Of the single-family structures as a whole, 23.9% of them are good candidates for nonstructural based on this methodology.

More information regarding the creation of the nonstructural costs can be found in the Cost Engineering Section of the Engineering Appendix (B.5) and the Nonstructural Appendix.

Future analysis will vary costs based on square footage, but currently, costs are fixed for both SFR1 and SFRM ($236,056 and $293,885 per structure, respectively). For PUB structures, (because of the high amount of heterogeneity in the data set) using a single cost was thought to be reductive. Currently, the depreciated replacement value (DRV) is used to create a separating equilibrium—structures with a DRV under $1 million get a cost of $334,577 and structures over $1 million get a cost of $3,146,683. Future work will refine this methodology and give bespoke costs based on individual structure attributes. For HIGH, APT, and IND, there exist costs for both wet floodproofing and elevation, but it was unclear if the structures in the inventory could be wet floodproofed; as such, to be conservative, only the higher elevation cost was used.

For COM, costs are based on the square footage of the structure. Square footage was known for 3,282 commercial structures. From these data, a linear model was constructed to predict the square footage for other commercial structures using improvement value. Once calculated, the model was used to assign square footages to the other commercial structures in the study area. These square footages were then used to assign per-structure nonstructural costs.

The Interest During Construction (IDC) and Average Annual Cost (AAC) are both calculated using the FY2020 Federal Discount Rate of 2.75%.

The nonstructural costs for all occupancy types, while applied post-selection in order to determine project cost, were not used in deciding which structures to treat. A nonstructural selection process that considers both costs and benefits will be completed prior to the final report, as will analysis that varies foundation height around a mean with the sample standard deviation, as opposed to the current methodology that uses the static mean.

Future analysis will also evaluate different vertical thresholds for structural eligibility identification (e.g., 10% AEP event stage height, 2% AEP event stage height) as well as identifying structures based on their contribution to net NED benefits. All methodologies will only estimate the number of structures of a given type in a given area that are promising candidates for nonstructural management measures. As mentioned earlier, final selection is only possible during implementation once specific characteristics of individual structures are determined.

As nonstructural management measures have a very high probability of being included in the final NED Plan, improving accuracy in the identification of eligible structures and the costs estimated to retrofit those structures is a high study priority and is expected to greatly inform the final decision criteria.

7.4.3 Storm Surge Barrier Management Measure Development

Storm surge barrier and CBB single strategy alternatives are presented by each of the five Regions (Figure 50) based on the relative hydraulic independence of the SSB alternatives configurations identified for these regions. Since many of the SSB alternatives are developed around leaving Corson Inlet and Little Egg Inlet without a barrier solution due to environmental concerns, these two inlets were natural boundaries between the South/Central and Central/North Regions. The SSB alternatives proposed within each Region are anticipated to not have a significant impact on the performance of a SSB proposed at a different Region due to the hydraulic independence of the regions and supported by the modeling results. The HEC-FDA model reaches were developed with the SSB alternatives in mind and are restricted to exactly one of the five Regions with no overlaps. This allows for HEC-FDA reach outputs to be aggregated at the Region level and then Region level results to be aggregated (if necessary) to calculate a study wide proposed alternative combination. All SSB alternatives are calculated using the FY2018 Federal Discount Rate of 2.75% with a 50-year period of analysis and Intermediate RSLC.

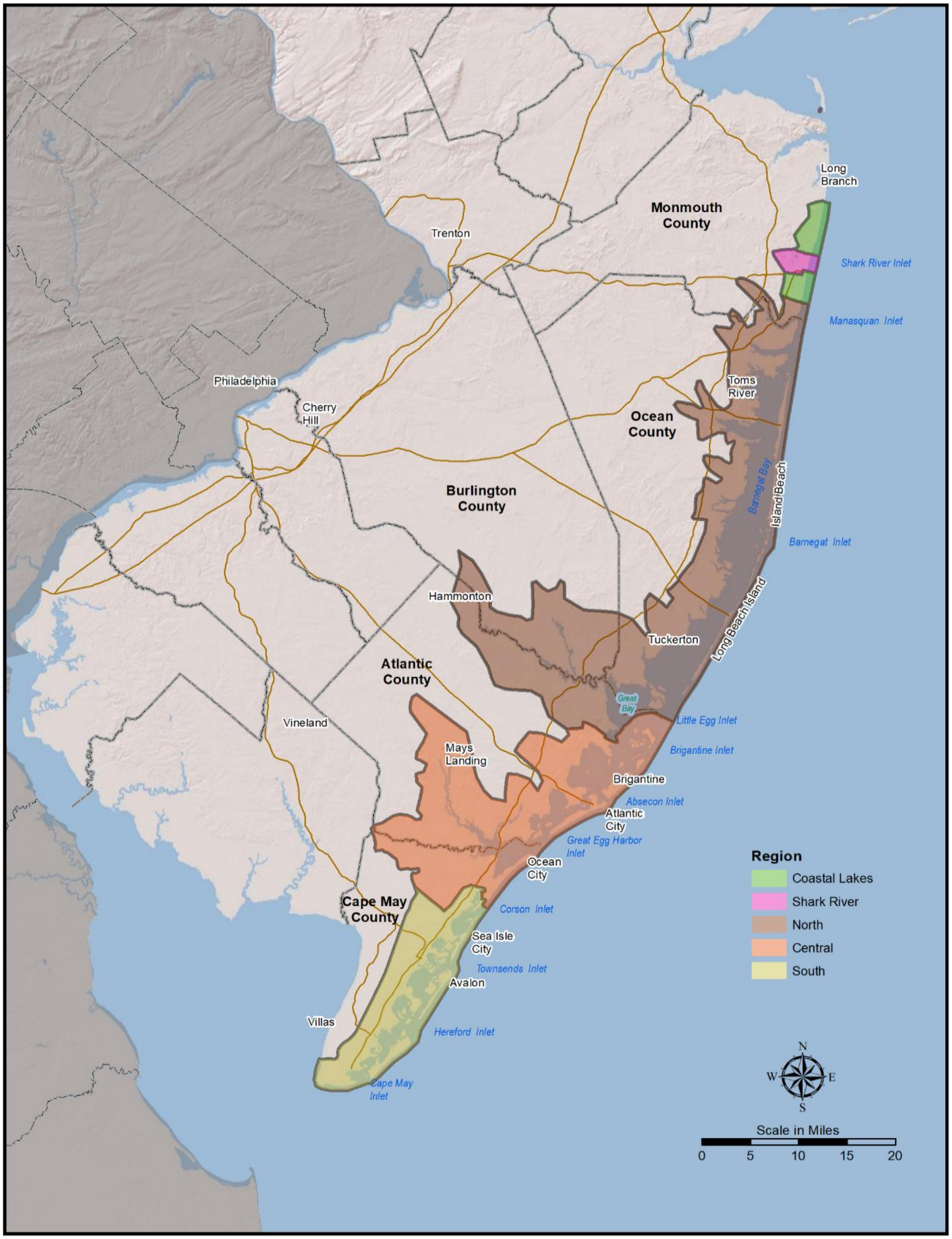


Figure 50: Study Area Regions

7.4.3.1 Hydrodynamic Modeling Approach

Due to the complex network of inlets and bays that control the flow of water between the ocean and back bays, NAP requested assistance from ERDC-CHL in evaluating the effectiveness of SSBs in reducing water levels in the NJBB CSRM Study area. More specifically, NAP wanted help determining how much SSBs reduce back-bay flooding? How effective SSBs are at reducing water levels if other inlets are open and if multiple SSBs could work as system? To answer these questions ERDC-CHL leveraged the existing NACCS CSTORM-MS.

ERDC-CHL performed three iterations of SSB modeling throughout the study area. The first iteration modeled a SSB at each individual inlet (one at a time). The second iteration modeled 15 alternatives, comprised of inlet and CBBs, to see how a system of barriers would reduce water levels. The third iteration modeled 8 alternatives with a larger storm set to establish hazard curves used for the HEC-FDA economic model.

A Draft Technical Report by Slusarczyk et al. (2020) provides a detailed description of the storm surge modeling effort and discussion of the modeling results and is included in the Engineering Appendix B.4. The storm surge modeling work was completed in two phases.

7.4.3.1.1 Phase 1

In Phase 1, an iterative modeling approach was devised that would allow a large number of SSBs and potential SSB combinations to be considered before converging on a smaller final set of SSB alternatives. The iterative modeling approach began with model simulations of one SSB at a time to improve understanding of the hydraulic influence of each inlet. The second iteration evaluated a large number of possible SSB combinations, before moving on to the final iteration of a smaller final set of alternatives. Model simulations for the final set of alternatives were used to develop frequency distributions of peak water levels that may be applied in economic analyses of flood damages. The iterative modeling approach was made feasible by utilizing a very small subset of 10 extreme cyclones for Iterations 1 and 2. A more robust set of 60 tropical cyclones was selected for Iteration 3 in order to develop the frequency distributions.

- Iteration 1: Model the hydraulic influence of each barrier island inlet by modeling one inlet at a time.
- Iteration 2: Model the effectiveness of large set of possible SSB combinations.
- Iteration 3: Model the effectiveness of final set of SSB alternatives and develop frequency distributions of peak water levels.

Workshops with the ERDC-CHL, the PDT, and non-Federal sponsor (NJDEP) were held on January 31, 2018 and April 13, to review the model results from Iteration 1 and Iteration 2 and selected the closure configurations to be brought forward in the study. Modeling results from Iteration 1 showed that individual closures can reduce back bay flooding, mainly in the bays closest to the closure location, but adjacent inlets typically allow flow into the bay resulting in limited reductions in the water level. Individual SSBs at Great Egg Inlet, Barnegat Inlet, and Shark River Inlet were most effective at reducing storm-induced water levels. Individual SSBs from Cape May to Corson Inlet were not as effective and would perform better as part of system of SSBs in reducing water levels. A SSB at Manasquan Inlet was effective for storms where the predominate wind direction was south, however, storms with north winds could push storm surge north into Barnegat Bay and Manasquan limiting the barriers effectiveness.

Iteration 2 focused on evaluating systems (multiple) of SSBs and CBBs. Many of the SSB alternatives were designed around leaving the most environmentally sensitive inlets open: Little Egg/Brigantine, Corson, and Hereford. The numerical modeling results show that many of the Iteration 2 alternatives are effective at reducing back bay water levels. However, some of the alternatives showed considerable sensitivity to the storm and wind directions and it was unclear what the net impact would be on the still water level hazard curves. Iteration 2 also showed that many of the CBBs have the potential to increase surge on the unprotected side of the closure as wind-blown water piles up against the closure. In some instances, the increases in surge were not limited to the immediate vicinity of the closure and significant impacts were observed 5 to 10 miles away from the barrier.

Iteration 3 focused on the 8 alternatives identified during the April 13, 2018 workshop that were selected based on their anticipated ability to generate the greatest NED benefits (flood damages reduce minus project costs) and be environmentally acceptable. Figures 51 and 52 show the locations of the SSBs in the 8 alternatives (N3+S3 and N7+S4 are each shown together, but treated as individual, hydraulically independent, alternatives in plan formulation). Several alternatives were included even though they were not likely to be environmentally acceptable to ensure that alternatives were not eliminated too early before a more thorough plan formulation evaluation is applied. In Iteration 3 still water level hazard curves were generated for 8 alternatives based on simulations for storm suite of 60 tropical cyclones. The still water level hazard curves were applied in HEC-FDA to calculate coastal storm damage reduction benefits.

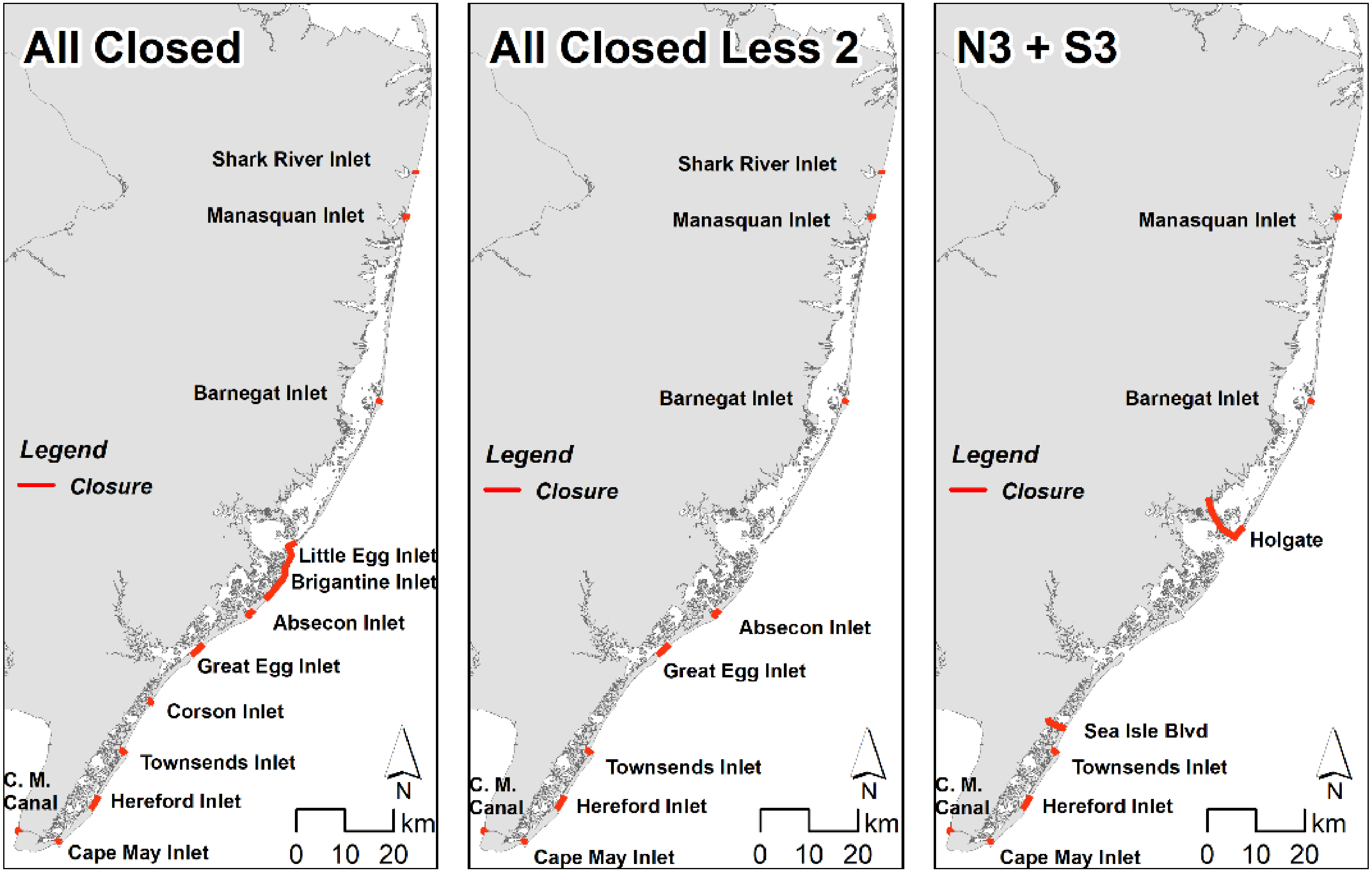


Figure 51: CSTORM-MS Phase 1 – Iteration 3 Storm Surge Barrier Alternatives

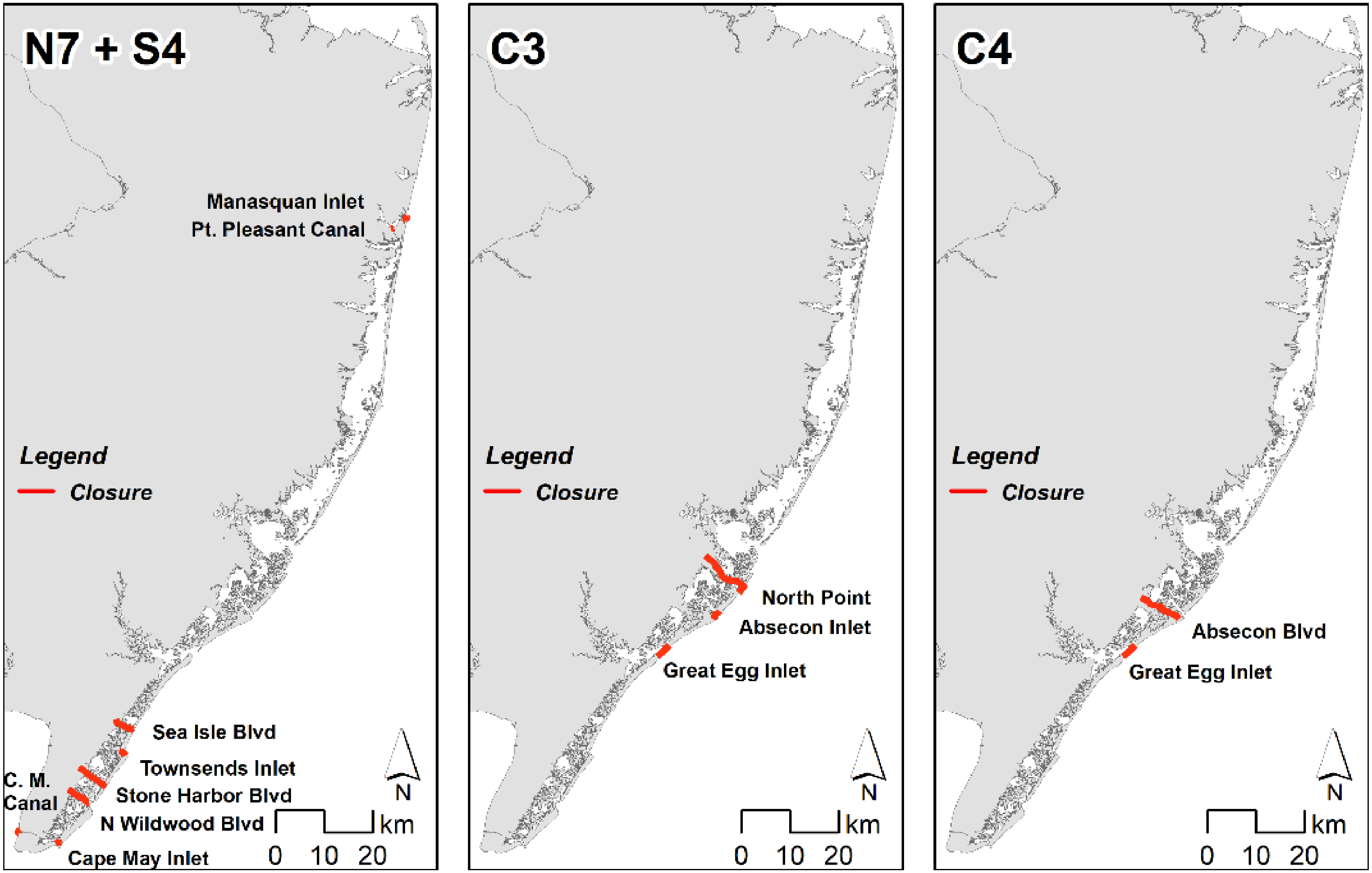


Figure 52: CSTORM-MS Phase 1 – Iteration 3 Storm Surge Barrier Alternatives

7.4.3.1.2 Phase 2

In Phase 2 the CSTORM model bathymetry was updated in Barnegat Bay and at several of the inlets with more recent survey data. After updating the model bathymetry, the same set of 60 tropical cyclones from Phase 1 – Iteration 3 was simulated in CSTORM and the hazard curves were updated. CSTORM simulations were also performed for the three primary SSB alternatives in the Focused Array of Alternatives (Figure 53):

- North: Closures at Manasquan and Barnegat Inlets.
- Central 1: Closures at Absecon and Great Egg Inlets.
- Central 2: Closure at Great Egg Inlet and CBBs at Absecon Blvd and Southern Ocean City.

In general, the model results and still water level hazard curves in Phase 2 are consistent with the findings from Phase 1 with small differences. Model results for North (closures at Manasquan and Barnegat Inlets) and Central 1 (closures at Absecon and Great Egg Inlets) alternatives closely mirror the results for All Closed Less 2 since it is the same set of closures in the North and Central Regions. All Closed Less 2 included additional closures in the South Region, but these closures have little impact on the results in the Central and North Regions. An example of the hazard curves at six locations (Figure 54) for Baseline, North, Central 1, and Central 2 alternatives is provided in Figure 55.

North alternative, peak still water levels (SWL) in upper Barnegat Bay and Manasquan River are 1.5 to 3 ft lower than the base conditions at the 100-year return period. In the Peak SWLs in lower Barnegat Bay are only 0 to 1 ft lower than the base conditions at the 100-year return period confirming earlier observations the peak SWLs in lower Barnegat Bay are dominated by flow from Little Egg Inlet.

Central 1 alternative, peak SWLs in the area dominated by Great Egg Inlet (most of Ocean City and Atlantic City) are 3 to 5 ft lower than the base conditions at the 100-year return period. Peak SWLs in the vicinity of Absecon Inlet are approximately 2 ft lower than the base conditions at the 100-year return period.

Central 2 alternative, with closures at Great Egg Inlet and CBBs at Absecon Blvd. and Southern Ocean City, produces similar results to Central 1 in the area dominated by Great Egg Inlet (most of Ocean City and Atlantic City) indicating that the benefits of the CBBs are more localized. Peak SWLs in the vicinity of Absecon Inlet are nearly the same as the base conditions.

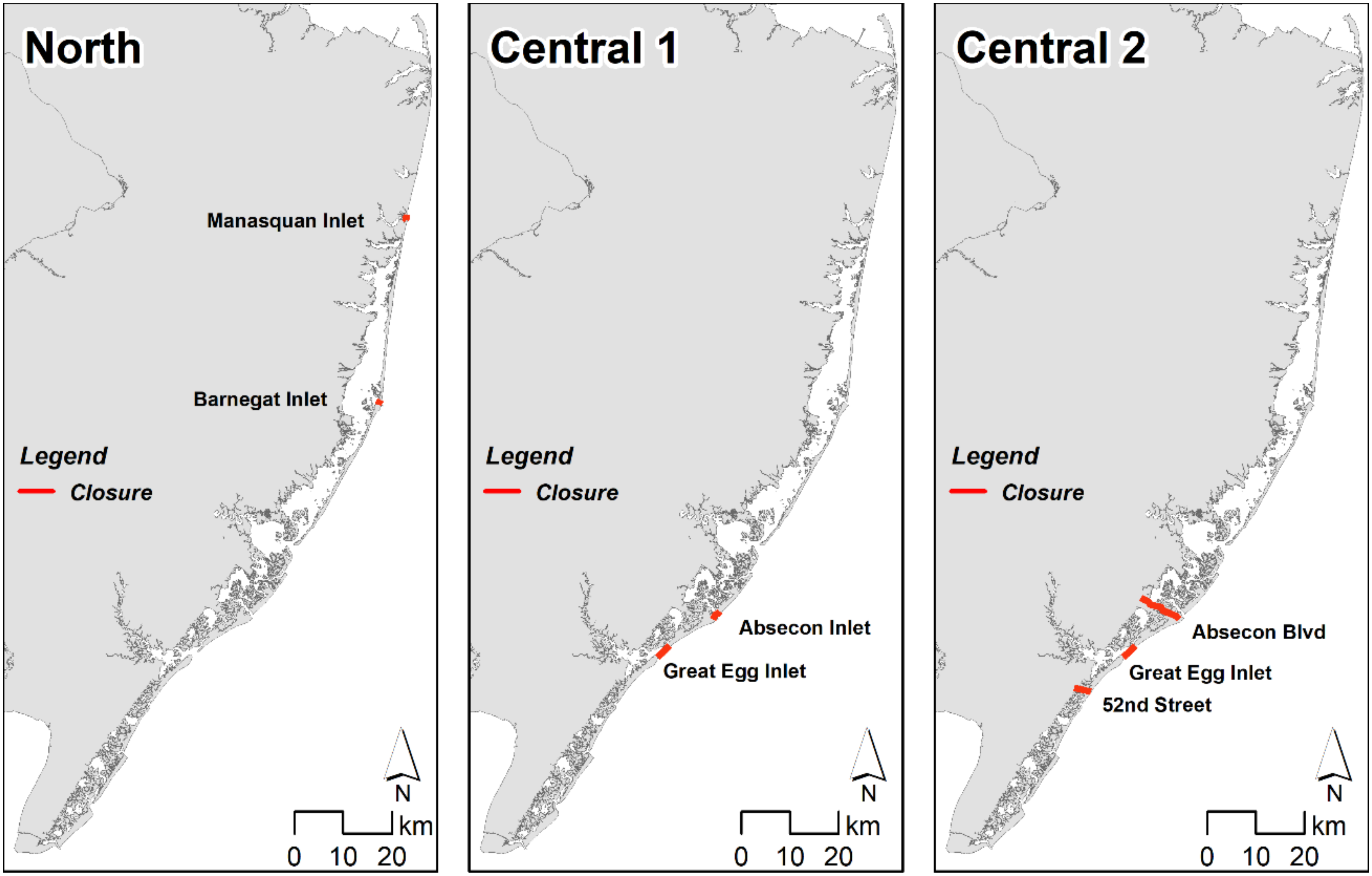


Figure 53: CSTORM-MS Phase 2 Storm Surge Barrier Alternatives

Figure 54: Example Hazard Curve Locations in Central and North Regions

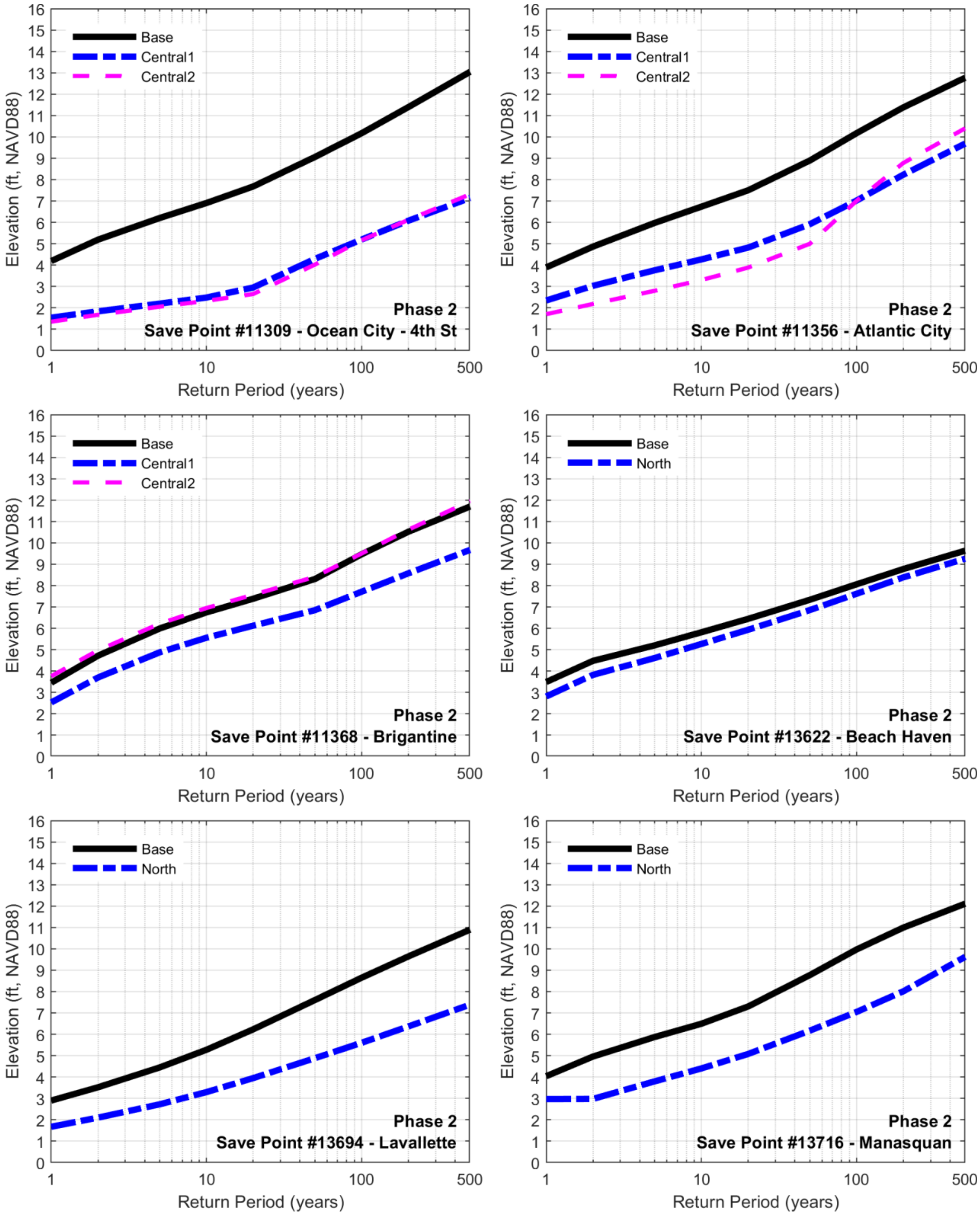


Figure 55: Storm Surge Barrier Hazard Curves (Phase 2)

7.4.3.2 Storm Surge Barrier Design

7.4.3.2.1 Cycle 2 Design

A SSB Cycle 2 screening level analysis was completed in December 2018 to initially investigate SSB options that would protect NJBB from coastal storm damages. Based on the ERDC models, 11 inlets and 8 CBBs were identified for screening level analysis. Preliminary alignments of SSB components were estimated in AutoCAD Civil 3D for each location. Quantities were then estimated at each location and were provided to Cost Engineering which then estimated construction costs for each SSB. Construction costs were then used in the HEC-FDA economic model to determine the National Economic Development (NED) benefits for each barrier. Barriers with low NED benefits were screened out while barriers with high NED benefits were added to a focused array of alternatives. The focused array was then investigated in more detail during the Cycle 3 analysis in order to reach a TSP. The following sections outline the process for determining SSB alignments and quantities for all 11 inlets and 8 CBBs. Drawings for all SSB, CBB and perimeter plan designs can be found in the Drawing Annex of the Engineering Appendix.

7.4.3.2.1.1 Storm Surge Barrier Parametric Cost Model

The cost model used in this study was developed by USACE New York District and is based on statistical data and major design considerations. Design considerations include barrier crest elevations, lengths, depths, and proportion of navigable and auxiliary flow features versus static elements. As seen in Table 39, cost engineers assembled a dataset of seventeen reference SSBs from around the world (Mooyart & Jonkman, 2017).

The parametric cost model equation differentiates barrier components into three categories: navigable gate area (NA), auxiliary flow gate area (AA), and impermeable barrier/dam area (DA). Length or area of "dynamic" span of SSBs refers to those portions of a barrier system which can be opened either to allow flow for navigation or auxiliary flow. The values include both the width/area of the openings and the structures associated with operation and housing of such features. By contrast, length and area of "static" span refers to that of the closed off wall or dam portions of barrier systems. The model estimates construction costs at a specified % confidence interval based on available reference data for existing barriers all over the world. An example of the 50% confidence interval parametric cost equation is as follows:

$$Construction\ Cost_{50\%} = (\$19{,}200 * NA) + (\$13{,}900 * AA) + (\$3{,}000 * DA)$$

The construction cost is a function of the cross sectional area of each barrier component. Specific barrier widths for auxiliary flow were not analyzed as part of the Cycle 2 screening level analysis and were evaluated in more detail during Cycle 3. The SSB design heights were selected to be 20' NAVD88 at the inlets and 13' NAVD88 along the CBBs. Since CBB locations are not as exposed to ocean waves and storm surge, the design heights requirements are not as high.

Table 39: Reference Set of Storm Surge Barriers

Reference Storm Surge Barrier	Country	Total Construction Duration [Years]	Initial Construction Cost [$, 2019Q1]	Average Height of Barrier (Sill to Crest) [FT]	Lengths Dynamic Features, Nav + Aux [FT]	Lengths Total (incl. dam) [FT]
Hollandsche Ijssel	Netherlands	4	$262,000,000	36	400	400
New Bedford	United States	4	$185,000,000	55	361	4495
Stamford	United States	4	$126,000,000	33	98	2854
Eider	Germany	6	$416,000,000	22	846	16076
Hull	United Kingdom	3	$29,000,000	35	134	134
Thames	United Kingdom	8	$2,521,000,000	42	1718	1718
Eastern Scheldt	Netherlands	17	$6,960,000,000	44	9206	25853
Maeslant	Netherlands	8	$1,010,000,000	82	2789	2789
Hartel	Netherlands	4	$219,000,000	31	763	820
Ramspol	Netherlands	5	$206,000,000	27	715	1348
Ems	Germany	3	$585,000,000	42	1516	2100
St. Petersburg	Russia	27	$9,948,000,000	24	7538	76280
IHNC	United States	3	$643,000,000	35	712	9449
Seabrook	United States	3	$192,000,000	34	325	469
Harvey Canal	United States	3	$368,000,000	24	282	394
GIWW	United States	4	$446,000,000	43	525	1706
MOSE	Italy	19	$7,540,000,000	46	5184	5184

7.4.3.2.1.2 Navigable and Auxiliary Flow Gates

A navigable gate was analyzed at every inlet and CBB to provide a navigable opening with unlimited vertical clearance. At this stage of the analysis, navigable gates were assumed to be sector gates due to their prevalence not only in the United States but all over the world. A sector gate contains two dynamic gates and two static gate housing structures. The dynamic gates remain in their housing structures, providing an open channel for navigation. The dynamic sector gates are horizontally closed during significant storm events. Due to the parametric cost model, the specific type of navigable gate does not affect the total construction cost. The parametric cost model references construction costs for a variety of navigable gate types. The specific type of navigable gate will need to be further evaluated and refined as the study continues.

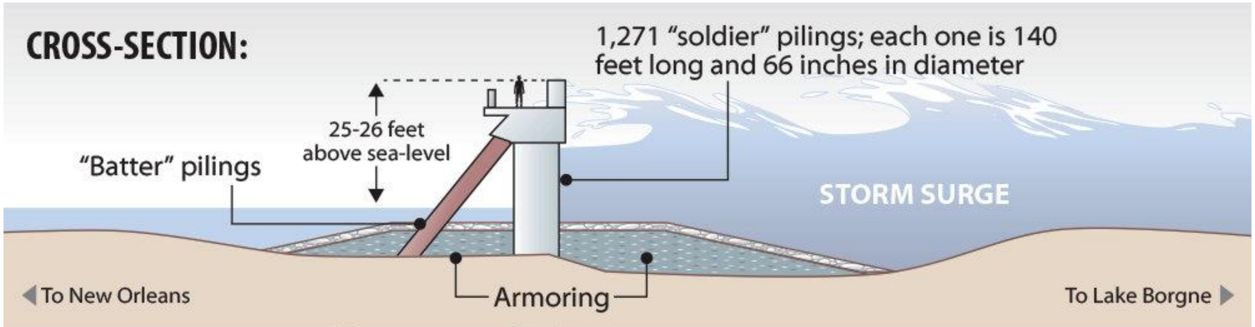
Along CBB alignments, sector gates were positioned across the NJIWW. At the inlets, sector gates were placed across federal navigation channels. To ensure channels were not restricted, the dynamic span of the sector gates was sized to provide a 10 foot buffer on either side of the NJIWW or federal navigation channel. The size of each dynamic gate and static housing structure was scaled off an existing SSB site in the United States, the Seabrook Flood Complex in New Orleans, LA, as previously discussed. Not all inlets or CBBs have a federal navigation channel or NJIWW. In these instances, sector gates were positioned along the deepest portion of the waterway in order to promote tidal flow during open conditions. Some inlets, such as Townsends Inlet, have no Federal Navigation Channel but do have existing bridges with drawbridges. Sector gates were aligned directly in front of these drawbridges to support large vessel navigation.

Auxiliary flow gates were positioned adjacent to navigable gates and throughout CBBs to maintain tidal flow. Auxiliary flow gates were placed throughout water depths that were deemed constructible and practical. For example, an area with water depths of only a foot may not generate enough flow in and out of a channel to justify the cost of an auxiliary flow gate. The minimum flow gate depth will need to be further investigated as the study continues. Auxiliary flow gates were assumed to be vertical lift gates because they are one of the more prevalent SSB gate types seen in the United States as well as overseas. Due to the parametric cost model, the specific type of auxiliary flow gate does not affect the total construction cost. The parametric cost model references construction costs for a variety of auxiliary flow gates including, but not limited to, vertical lift gates, segment gates, flap gates, and inflatable gates. The specific type of auxiliary flow gate will be further evaluated and refined as the study continues. The Seabrook Flood Complex (see Figure 55) was used as a template to initially size the vertical lift gates for this study. The dynamic portion of the gate is approximately 50 feet long, flanked by two housing structures that are each approximately 18 feet long. The length of movable gate was refined during Cycle 3 to minimize the flow restriction of the inlet. Vertical lift gates have limited vertical clearance but are capable of providing recreational navigation. For example, the Bayou Bienvenue vertical lift gate in New Orleans, LA (see Figure 56) has enough vertical clearance to allow recreational boats to pass to and from Lake Borgne. The bottom of the gate rests at approximately 33' NAVD88 in the open condition.

Figure 56: Bayou Bienvenue Vertical Lift Gate in New Orleans, LA

7.4.3.2.1.3 Impermeable Barriers

Impermeable barriers flank the dynamic SSB components in order to tie the barrier into the upland. Impermeable barriers were also positioned along portions of low lying marsh land across CBB alignments. The parametric cost equation does not estimate construction costs for a specific type of impermeable barrier, it applies a cost factor to a cross sectional area of static wall based on reference data for seventeen existing SSB sites. A site specific impermeable barrier type has not been selected at this stage but will be further investigated as the study continues. Figure 57 shows one example of an existing impermeable barrier at Lake Borgne in New Orleans, LA.



Dan Swenson, NOLA.com | The Times-Picayune

Figure 57: Lake Borgne Impermeable Barrier in New Orleans, LA

7.4.3.2.1.4 Levees, Floodwalls and Seawalls

In areas that are not in open water or on open marsh land, levees, floodwalls, and seawalls were used to tie barriers into high ground or existing adjacent oceanfront projects. Type A - levees were used in areas with little to no exposure to wave forcing. Type B and C - floodwalls were used in areas where the SSBs tie into the perimeter plan. In-water floodwalls were not used along low lying open marsh areas through CBB alignments. The in-water floodwall design assumes there are adjacent existing sheet piles with backfill. To be conservative, impermeable barriers (or the terminology for a feature that is impermeable and flanks a dynamic SSB component) were selected for open marsh areas. A more detailed wall design will be investigated for low lying open marsh areas as the study continues. Seawalls were selected for low lying areas, such as beaches, that are still susceptible to waves and erosion but may not need a structure as robust as an impermeable barrier. As the study continues, beach and dune restoration measures will be investigated for these areas. Estimated seawall costs were scaled off construction costs for the Absecon Seawall in Atlantic City, NJ (see Figure 58).

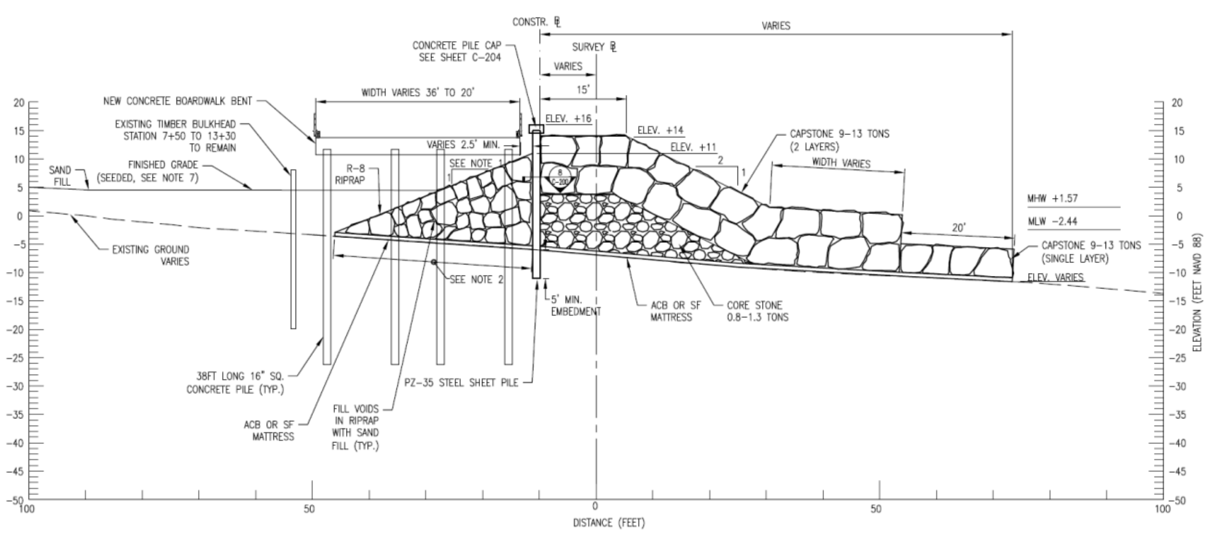


Figure 58: Typical Section – Absecon Seawall

7.4.3.2.2 Cycle 3 Design

The SSB Cycle 3 screening analysis expanded upon the Cycle 2 screening to refine the focused array of alternatives into a TSP. Cycle 3 evaluated the following SSB locations, Southern Ocean City CBB, Great Egg Harbor Inlet, Absecon Inlet, Absecon CBB, Barnegat Inlet and Manasquan Inlet. The following sections outline the additional analysis performed and process for determining SSB Cycle 3 quantities.

The preliminary design for Cycle 3 continues to utilize the parametric cost model from Cycle 2. This cost model was refined to increase the cost of the navigable area (NA) while decreasing the cost of the auxiliary flow (AA) area as well as the static dam area (DA):

$$Construction\ Cost_{50\%} = (\$20{,}200 * NA) + (\$11{,}800 * AA) + (\$2{,}200 * DA)$$

Similarly, to Cycle 2, the Cycle 3 preliminary SSB design assumes a combination of sector gates for navigation and vertical lift gates for auxiliary flow. The parametric cost model does not differentiate gate types. The equation only differentiates barriers by the three different sections: navigable, auxiliary, and static. As the study progresses actual quantities will need to be developed to refine the SSB cost estimate. It is also recommended to conduct a detailed multi-criteria gate type analysis to evaluate all of the existing gate types and rank them accordingly for each proposed site location.

The dynamic span of the vertical lift gate was increased from 50 feet to 150 feet in order to promote additional conveyance. The Hartel barrier located in Spijkenisse, Netherlands consists of two vertical lift gates approximately 162 feet and 322 feet in length, and is an example of vertical lift gate with longer spans (see Figure 59).

Figure 59: Hartel Barrier Vertical Lift Gates

Various other design parameters were evaluated during Cycle 3 such as barrier alignment, sector gate size, sill elevation, and number of gates. ERDC-CHL modeled various Cycle 3 SSB designs in their open gate conditions to evaluate indirect impacts on tides, velocity, salinity, and residence time through an Adaptive Hydraulic (AdH) Model (see Appendix B.4). Cycle 3 SSB drawings can be seen in the Engineering Appendix. Figure 60 is a rending for a potential SSB at Great Egg Harbor Inlet.

Figure 60: Great Egg Harbor Inlet – Storm Surge Barrier Rendering

7.4.3.2.3 Maritime Vessel Analysis

Maritime vessel analysis was conducted for this Draft Integrated Report to provide recommendations for minimum dimensions of navigable SSB gates. Recommendations for navigation gate widths are based on vessel traffic data specific to each potential SSB location. Based on the available vessel traffic data, a specific design vessel was selected for each inlet to recommend a minimum dimension for a SSB navigation gate. The maritime vessel analysis was performed for Great Egg Harbor Inlet, Absecon Inlet, Barnegat Inlet and Manasquan Inlet. There are proposed SSBs at each one of these inlets in the Focused Array of alternatives. Design vessels are selected for each inlet based on Nationwide Automatic Identification System (NAIS) data. A detailed description of the maritime vessel analysis is provided in the Engineering Appendix.

The purpose of this analysis is only to provide general gate width recommendations. The selected navigation gate dimensions could be larger or smaller depending on existing conditions at each site. Gates may be larger if additional conveyance is needed for environmental or ecological considerations or to maintain access to existing federal navigation channels. Gates may be smaller if navigable widths are already constrained by existing structures such as bridge piers. Vessel traffic locations were also analyzed in order to recommend practical navigation gate locations at each inlet. Preliminary navigable SSB gate widths are recommended for both one-way and two-way traffic. Minimum gate width calculations were performed based on guidelines in the USACE Engineering Manual (EM) 110-2-1613 Hydraulic Design of Deep-Draft Navigation Projects and World Association for Waterborne Transport Infrastructure (PIANC) Report No. 121 Harbor Approach Channels Design Guidelines.

Recommendations are preliminary and may be designed larger or smaller to meet specific criteria at each site. For example, some navigation gates may need to be larger to maintain access to federal channels or to provide additional conveyance to reduce effects on tidal prism. Some navigation gates may be reduced in size to meet existing navigation constraints such as bridge piers. Table 40 provides a summary of the preliminary findings. The dynamic spans of the Cycle 3 SSBs are greater than the minimum required main navigation opening, and the dynamic span of the vertical lift gates, 150 feet, is slightly narrower than the recommended minimum opening for the secondary navigation opening.

Table 40: Maritime Vessel Analysis Summary

Location	Main Navigation Design Vessel Beam (ft)	Main Navigation Minimum Opening (ft)	Seconday Navigation Design Vessel Beam (ft)	Seconday Navigation Minimum Opening (ft)
Great Egg Harbor Inlet	39	312	13	104
Absecon Inlet	43	344	20	160
Barnegat Inlet	33	264	20	160
Manasquan Inlet	39	312	N/A	N/A

The maritime vessel analysis does not focus on other critical design parameters including, but not limited to, environmental, ecological, and cost considerations. These other considerations will continue to be evaluated in more detail and used to determine the optimal dimensions of the SSBs. Guidance from both EM 1110-2-1613 and PIANC Report No. 121 recommend ship maneuvering simulations (numerical models) be carried out in the detailed design phase to refine the preliminary design widths and to quantify the safety and risk level of the final channel width. Additional factors that need to be considered in a vessel analysis include, but are not limited to, future design vessels, one-way vs. two-way traffic, wind and wave effects, visibility, navigation aids, currents, speed of design ship, project costs and vessel traffic intensity.

7.4.3.2.4 Cycle 3 Results

Cycle 3 quantities, as shown in Table 41 were measured from the SSB Cycle 3 Screening drawings (see the Engineering Appendix). Various design parameters (gate alignment, sill elevation, number of gates, etc.) were investigated for each barrier location to evaluate indirect impacts on tides, velocities, salinity, and residence time through the ERDC-CHL AdH Model. The A1 alignments were selected for the Cycle 3 screening prior to receiving the AdH Model results but were shown to promote more flow compared to other model runs and were assumed to have the smallest environmental impacts.

Perimeter measures that tie SSBs into high ground include seawalls, floodwalls, and levees. Floodwalls are divided into four different wall types including the following:

- Levee - Type A
- T-Wall Type B (Concrete cantilever wall on piles, waterside construction)
- T-Wall Type C (Concrete cantilever wall, landside construction)
- Wall Type D (King pile combined with sheet pile wall).

The alignments, as well as other design parameters, may be refined after the TSP Phase in order to optimize the design and minimize indirect impacts.

Table 41: Storm Surge Barrier Cycle 3 Quantities

Barrier Components	Storm Surge Barrier Locations					
	Manasquan Inlet - A1	Barnegat Inlet - A1	Absecon Inlet - A1	Great Egg Harbor Inlet - A1	Absecon Bay Closure - A1	Ocean City Bay Closure - A1
Navigable Gate Pier Area (SF)	14411	14893	27865	19149	4787	3457
Navigable Gate Moveable Area (SF)	13005	13440	25200	17280	4320	3120
Navigable Gate Total Area (SF)	27416	28333	53065	36429	9107	6577
Aux. Flow Gate Pier Area (SF)	0	12504	5310	19230	0	0
Aux. Flow Gate Moveable Area (SF)	0	54327	20250	84900	0	0
Aux. Flow Gate Total Area (SF)	0	66831	25560	104130	0	0
Impermeable Barrier Area (SF)	0	18365	7033	20716	14772	2906
Seawall Length (FT)	2366	795	2569	1275	0	0
Sluice Gate (SF)	0	3456	0	0	4272	768
Floodwall Type A Length (FT)[3]	7280	0	0	974	27524	9467
Floodwall Type B Length (FT)	0	0	0	0	5193	1205
Floodwall Type C Length (FT)	0	897	0	0	5503	2919
Floodwall Type D Length (FT)	0	0	0	0	18194	0
Levee/Seawall Outfall	12	1	3	3	45	15
Floodwall Outfall	0	2	0	0	72	10
Road Closure (EA)	0	1	0	0	4	0

Notes:

1. *Navigable gate total area and auxiliary flow gate total area is the cross sectional surface area of the dynamic (moveable) span of barrier plus the cross sectional surface area of the housing structure associated with the gate.*
2. *The impermeable barrier area is the cross sectional surface area of the impermeable barrier.*

7.4.3.1 Storm Surge Barrier (SSB) Costs

Detailed SSB designs and cost estimation methodology can be found in the Engineering Appendix, but this section will cover the final cost estimates used for the economic analysis. Detailed cost estimates were calculated for all eleven possible SSBs and eight possible CBBs evaluated in Cycle 2 and Cycle 3. Estimates are based on barriers with navigable sector gates and vertical life gates to allow tidal flow outside of storm events. Cost estimates are shown in Table 42 and Table 43 with values for initial construction, contingency, and interest during construction, and OMRR&R.

Table 42: Storm Surge Barrier Cost Estimates ($1000s)

Region	Barrier	Init. Const.	Contingency	Total Const.	Construction Duration (months)	IDC	Subtotal AAC	OMRR&R	Total AAC
South	Cape May Canal	$389,412	$145,232	$534,644	55	$67,387	$22,300	$8,250	$30,549
South	Cape May Inlet	$1,203,163	$448,721	$1,651,884	113	$427,769	$77,032	$25,500	$102,532
South	Hereford Inlet	$1,001,373	$373,463	$1,374,836	66	$207,944	$58,628	$21,222	$79,850
South	Townsends Inlet	$785,109	$292,807	$1,077,916	56	$138,333	$45,051	$16,638	$61,689
Boundary	Corson Inlet	$686,898	$256,179	$943,077	61	$131,834	$39,816	$14,556	$54,372
Central	Great Egg Harbor Inlet	$2,838,878	$1,058,762	$3,897,641	126	$1,125,444	$186,060	$60,175	$246,235
Central	Absecon Inlet	$2,065,920	$770,487	$2,836,407	127	$825,513	$135,641	$43,789	$179,430
Boundary	Brigantine to Little Egg Inlet	$4,390,448	$1,637,421	$6,027,869	143	$1,975,383	$296,448	$93,066	$389,514
North	Barnegat Inlet	$1,251,230	$466,647	$1,717,878	105	$413,364	$78,943	$26,519	$105,462
North	Manasquan Inlet	$605,604	$225,861	$831,465	81	$154,341	$36,515	$12,833	$49,348
Shark	Shark River Inlet	$430,712	$160,635	$591,347	48	$65,048	$24,313	$9,125	$33,439
TOTAL ESTIMATED AMOUNT		$15,648,749	$5,836,214	$21,484,962	-	$5,532,359	$1,000,746	$331,673	$1,332,419

Table 43: Cross-Bay Barrier Cost Estimates ($1000s)

Region	Barrier	Initial Construct.	Contingency	Total Const.	Duration (months)	IDC	Subtotal AAC	OMRR&R	Total AAC
South	Wildwood Blvd	$641,899	$238,183	$880,082	55	$110,927	$36,708	$13,248	$49,956
South	Stone Harbor Blvd	$828,572	$306,461	$1,135,034	56	$145,663	$47,438	$16,782	$64,220
South	Sea Isle Blvd	$426,966	$158,037	$585,003	50	$67,032	$24,152	$8,692	$32,844
Central	Southern Ocean City Bay	$307,798	$113,822	$421,620	49	$47,344	$17,371	$6,234	$23,605
Central	Absecon	$720,765	$265,805	$986,570	50	$113,045	$40,731	$14,381	$55,112
Central	North Point	$2,256,894	$840,313	$3,097,206	133	$944,003	$149,690	$47,431	$197,121
North	Holgate	$2,459,847	$915,349	$3,375,197	125	$966,853	$160,834	$51,543	$212,376
North	Point Pleasant Canal	$233,064	$86,919	$319,984	49	$35,932	$13,183	$4,934	$18,117
TOTAL ESTIMATED AMOUNT		$7,875,807	$2,924,890	$10,800,696	-	$2,430,798	$490,107	$163,245	$653,351

7.4.4 Natural and Nature-Based Features Measure Development

Natural and nature-based features assist in the incorporation of natural approaches to develop regional climate change and sea level rise adaptation planning strategies and solutions in the NJBB CSRM Study area. The NJBB CSRM Study has incorporated NNBFs to help meet the project objectives and provide CSRM attributes in adherence to Section 1184 of the Water Resources Development Act of 2016 requires the Secretary of the Army, with the consent of the non-federal sponsor, to consider NNBFs when studying the feasibility of projects for flood risk management. Other policy drivers for incorporating NNBF are outlined below:

- Executive Order 13690: "Where possible, an agency shall use natural systems, ecosystem processes, and nature-based approaches when developing alternatives for consideration,"
- Executive Order 11998, Section 1, which directs Federal agencies to take action to restore and preserve the natural and beneficial values served by floodplains; and
- Consistent with Federal Government Policy Priorities and best practices which promote integration of green infrastructure for coastal flood risk management following Hurricane Sandy (e.g., Hurricane Sandy rebuilding Strategy Recommendations 19-22).

Further, NNBFs have been identified and integrated into the NJBB Draft Integrated Report in association with the USACE Engineering and Research Development Center (ERDC) Engineering With Nature®-Landscape Architecture (EWN-LA) initiative. One of the goals of this initiative is to align natural and engineering processes to deliver economic, environmental, and social benefits efficiently and sustainably through collaborative processes.

As described by the EWN® initiative, NNBF "are landscape features that are used to provide engineering functions relevant to flood risk management, while producing additional economic, environmental, and/or social benefits. These features may occur naturally in landscapes or be engineered, constructed and/or restored to mimic natural conditions. A strategy that combines NNBF with nonstructural and structural management measures represents an integrated approach to flood risk management that can deliver a broad array of ecosystem goods and services to local communities."

The CSRM value provided by NNBF (and by features that hybridize NNBF and structural approaches) does differ from the value provided by traditional structural management measures. NNBFs have the advantage of providing multiple kinds of benefits and, because they incorporate dynamic natural processes, are in some cases capable of adapting to changing environmental conditions. Marshes, for instance, can accrete, potentially keeping pace with relative sea-level rise (RSLR). However, NNBF typically perform best when paired with nonstructural management measures such as buyouts and relocation, as NNBF require migration space over time to perform their natural adaptations.

These NNBFs have been evaluated and selected for their potential to combine CSRM value with additional ecological and social benefit into the storm surge/crossbay barrier, perimeter measure, and nonstructural management measures. The 'Engineering With Nature + Landscape Architecture: New Jersey Back Bays' Report, which is provided in the Natural and Nature-Based Features Appendix, identifies NNBFs in each of the four NJBB Regions within the context of the structural and nonstructural management measures.

In addition to the larger-scale NNBFs discussed above, stand-alone NNBFs are also being considered as well as in combination with structural management measures. For instance, plan formulation analyses suggest that NNBFs would meet the project objectives when placed in combination with the following structural management measures:

- Unarmored shorelines adjacent to infrastructure;
- Complementary to structural management measures such as floodwalls and levees; and
- Specific modifications to structural management measures including habitat benches to restore more natural slope along shorelines and textured concrete to support colonization of algae and invertebrates.

7.5 Plan Formulation Analysis

7.5.1 Overview

This section continues the discussion addressing Steps 3, 4, and 5 including Formulating, Evaluating and Comparing Alternative Plans of the USACE six-step planning process. As discussed in a previously, management measures are the building blocks of alternative plans. An alternative plan is a set of one or more management measures functioning together to address one or more objectives. A range of alternative plans are identified in this section and subsequently screened and refined during conduct of the planning process. Thorough analysis in this section ensures that the plans are in compliance with existing statutes, administrative regulations, and common law.

Alternative plans have been subsequently evaluated and compared including a comparison of the with-project and without-project conditions for each alternative. Plans (including the no action plan) have been compared against each other, with emphasis on the outputs and effects that will have the most influence in the decision-making process. Beneficial and adverse effects of each plan have been compared. This comparison includes monetary and non-monetary benefits and costs.

Specifically, measures were combined into alternative plans through a hybrid plan screening process which considered the four accounts established in the Principles & Guidelines risk and uncertainty management, residual risk, construction costs, economic benefits, environmental acceptability, and implementation, as well as the four planning criteria analyses in ER 1105-2-100. This screening process facilitates the effective evaluation and display of effects of alternative plans. Residual risk is defined as the coastal storm risk that remains in the floodplain even after a proposed coastal storm risk management project is constructed and implemented. Physical damages, as well as potential life loss consequences, can remain even after the project is implemented due to a variety of causes. Residual risk has been calculated for the study area for all measure types to the study area perimeter identified by the 0.2% AEP floodplain plus intermediate SLC scenario. The residual damages only account for assets in the HEC-FDA inventory (structures and vehicles) and does not include traditional infrastructure (roads, utilities, bridges).

A series of criteria analyzed to describe, evaluate, and compare potential CSRM solutions including the various benefits of the different regional alternatives across the five regional groups in the study area. Alternatives were evaluated to narrow the array down to the alternatives that had the highest benefits. These analyses were quantitatively evaluated and compared in accordance each of the four evaluation accounts identified in the Principles and Guidelines (1983) which include the NED, Regional Economic Development (RED), Environmental Quality (EQ), and Other Social Effects (OSE). The four Planning Criteria including effectiveness, efficiency, acceptability, and completeness identified in the Principles and Guidelines (1983) were also qualitatively assessed in plan formulation. Each of the criteria used for screening are defined in Table 44 below.

Table 44: Alternative Screening Criteria Matrix

Criteria	Definition	Screening Threshold
National Economic Development (NED)	Increases in the net value of the national output of goods and services, expressed in monetary units) through the reduction in wave, erosion, and inundation damage.	AANB greater than $0.
Environmental Quality (EQ)	Beneficial effects in the EQ account are favorable changes in the ecological, aesthetic, and cultural attributes of natural and cultural resources. Adverse effects in the EQ account are unfavorable changes in the ecological, aesthetic, and cultural attributes of natural and cultural resources.	Through use of best professional judgment by the PDT and coordination with other state and Federal resource agencies, the PDT analyzed the potential environmental impacts of the alternatives. Alternatives that had environmental impacts with a high certainty of hindering implementation failed the EQ criteria and were removed for further consideration.
Completeness	Completeness is the extent to which a given alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects.	Using best professional judgment, the PDT qualitatively assessed each alternative to determine if it met the completeness criteria. Generally, alternatives with higher geographical distribution of risk management and lower residual risk were considered more complete.
Efficiency	Efficiency is the extent to which an alternative plan is the most cost-effective means of alleviating the specified problems and realizing the specified opportunities.	Using best professional judgment, the PDT qualitatively assessed each alternative to determine if it met the efficiency criteria. Generally, alternatives with higher Benefit Cost Ratios were considered more efficient

		because each dollar spent resulted in more benefits accrued.
Effectiveness	Effectiveness is the extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities."	Using best professional judgment, the PDT qualitatively assessed each alternative to determine if it met the effectiveness criteria. Generally, plans with lower residual risk were considered more effective.
Acceptability	Acceptability is the workability and viability of the alternative plan with respect to compatibility with existing laws, regulations, and public policies.	Using best professional judgment, the PDT qualitatively assessed each alternative to determine if it met the acceptability criteria. Plans that passed the EQ screening were generally considered acceptable at this stage in the planning process. Future acceptability analysis will focus on land use policies and real estate constraints in addition to environmental policies.

A summary of these analyses indicates that each individual measure type has key advantages and disadvantages (Figure 61). As discussed in subsequent sections, an approach consisting of multiple measures will likely help to balance some of the disadvantages of a single measure plan.

Nonstructural Measures	**General**: Life Safety - Moderate rate of flooding. Independent failure points (each structure is independent).
	Key Advantages: Reduces risk to most vulnerable structures in study area. No OMRR&R.
	Key Disadvantages: Does not reduce risk to infrastructure or other structures, so residual risk remains high.
Perimeter Measures	**General**: Life Safety - High flood depths, rapid rate of flooding. Multiple/Scattered failure points.
	Key Advantages: Reduces risk to infrastructure within the perimeter footprint during storm events with water elevations below the barrier elevation. This could reduce nuisance flooding within the perimeter footprint.
	Key Disadvantages: No risk management outside of the footprint of the perimeter structure. Impacts to viewshed would be high and real estate would need to be required to construct the perimeter structures. Low storage capacity for overtopping, breach, gate failure.
Storm Surge Barrier Measures	**General**: Life Safety - Lower flood depths and moderate rate of flooding, extended evacuation window. Centralized failure points.
	Key Advantages: Reduces risk to infrastructure within the area that is hydrologically connected to ocean tides through the inlet. High storage capacity for overtopping, breach, individual gate failure.
	Key Disadvantages: No risk management during higher frequency events when the gates are left open. Average Annual OMRR&R costs are also very high. Considerable OMRR&R.
Natural Nature Based Feature Measures	**General**: Standalone or Complementing/Hybrid feature
	Key Advantages: Environmental benefits and residual risk management.
	Key Disadvantages: Undertermined CSRM benefit properties.

Figure 61: Advantages vs. Disadvantages

7.5.2 Regional Alternatives Based on Economic Evaluation

The management measure screening and refined measure development as discussed in previous sections were combined into multi-strategy alternatives in two iterations following the principle of iterative planning towards the development of CSRM solutions. The first iteration addresses the formulation of alternatives for the fifty-one alternatives in the focused array considered in the Cycle 0-2 screening process presented in the March 2019 NJBB Interim Report which is available at https://www.nap.usace.army.mil/Missions/Civil-Works/New-Jersey-Back-Bays-Study/. The second iteration addresses the formulation of alternatives for the 20 alternatives considered in the Cycle 3 screening process. This chapter discusses the economic evaluation of potential alternatives inclusive of individual measures (Note that a more complete economic evaluation of NNBFs will be performed during future phases of the study).

The following tables show potential single and multi-strategy alternatives inclusive of the fifty-one regional alternatives presented in the Interim Report (March 2019) based on economic evaluation alone. This evaluation and comparison of alternative plans has resulted in the selection of alternatives highlighted in green which represent the focused array of alternatives (20 alternatives) that maximize net benefits. All alternatives are shown to provide transparency on the transition from isolated single strategy alternatives to a preliminary focused array of complete and implementable hybrid multi-strategy alternative plans. Individual maps for each of these alternative plans can be found in the Economics Appendix.

The regional alternatives were separated into the five regional groups that were each assigned a number to describe their location: (1) Entire Study Area, (2) Shark River, (3) Area between Manasquan Inlet and Little Egg Inlet; referred to as "North Region", (4) Area south of Little Egg Inlet and north of Corson Inlet, referred to as "Central Region", and (5) Areas south of Corson Inlet, referred to as "South Region". Within each region, the alternatives were assigned a letter to describe the strategies implemented: (A) nonstructural strategy only, (B) perimeter plan strategy only (including locations that passed cycle 1 and cycle 2 analyses), (C) perimeter plan only in locations that passed cycle 2, (D) perimeter plan in locations that passed cycle 2 with nonstructural (plus permutations for perimeter locations that passed cycle 1), (E) SSBs with nonstructural and/or perimeter plan, (F) SSBs with nonstructural and/or perimeter plan and CBBs, and finally (G) SSBs with nonstructural and/or perimeter plan and a different combination of CBBs.

Table 45 provides a brief description of each of the fifty-one alternatives formulated during the economic evaluation for Cycle 0-2. Individual maps are provided for each of the alternatives in the Economics Appendix.

Table 45: Comprehensive List of Fifty-One Regional Alternatives (Cycle 0-2)

REGION	ALTERNATIVES	DESCRIPTION
STUDY WIDE	1A	Nonstructural ONLY
	1B	Perimeter plan (justified) ONLY
	1C	SSB ALL INLETS
	1D	SSB ALL INLETS minus Little Egg Harbor Inlet
SHAR	2A	Nonstructural ONLY

	2B	Perimeter Plan ONLY
	2C	SSB ONLY
NORTH REGION	3A	Nonstructural ONLY
	3B	Perimeter Plan ONLY
	3C	Perimeter Plan (Cycle 2) ONLY
	3D	Perimeter Plan (Cycle 2) + Nonstructural
	3E(1)	SSB ONLY
	3E(2)	SSB + Nonstructural
	3E(3)	SSB + Nonstructural + Perimeter Plan
	3F(1)	SSB + CBB (Holgate)
	3F(2)	SSB + CBB (Holgate) + Nonstructural
	3G	SSB + CBB (Point Pleasant Canal)
CENTRAL REGION	4A	Nonstructural ONLY
	4B	Perimeter Plan ONLY
	4C	Perimeter Plan (Cycle 2) ONLY
	4D(1)	Perimeter Plan (Cycle 2) + Nonstructural
	4D(2)	Perimeter Plan (Cycle 1 and 2) + Nonstructural
	4E(1)	SSB ONLY
	4E(2)	SSB + Nonstructural
	4E(3)	SSB + Nonstructural + South Ocean City Perimeter Plan
	4E(4)	SSB + Nonstructural + South Ocean City CBB
	4F(1)	SSB + CBB (North Point)
	4F(2)	SSB + CBB (North Point) + Nonstructural
	4F(3)	SSB + CBB (North Point) + Nonstructural + South Ocean City Perimeter Plan
	4F(4)	SSB + CBB (North Point) + Nonstructural + South Ocean City CBB
	4G(1)	SSB + CBB (Absecon Blvd)
	4G(2)	SSB + CBB (Absecon Blvd) + Nonstructural
	4G(3)	SSB + CBB (Absecon Blvd) + Nonstructural + South Ocean City Perimeter Plan
	4G(4)	SSB + CBB (Absecon Blvd) + Nonstructural + South Ocean City CBB
	4G(5)	SSB + CBB (Absecon Blvd) + NS Brigantine + South Ocean City No-Action
	4G(6)	SSB + CBB (Absecon Blvd) + NS Brigantine + South Ocean City Nonstructural
	4G(7)	SSB + CBB (Absecon Blvd) + NS Brigantine + South Ocean City Perimeter Plan
	4G(8)	SSB + CBB (Absecon Blvd) + NS Brigantine + South Ocean City CBB
	4G(9)	SSB + CBB (Absecon Blvd) + PM Brigantine + South Ocean City No-Action

	4G(10)	SSB + CBB (Absecon Blvd) + PM Brigantine + South Ocean City Nonstructural
	4G(11)	SSB + CBB (Absecon Blvd) + PM Brigantine + South Ocean City Perimeter Plan
	4G(12)	SSB + CBB (Absecon Blvd) + PM Brigantine + South Ocean City CBB
SOUTH REGION	5A	Nonstructural ONLY
	5B	Perimeter Plan ONLY
	5C	Perimeter Plan (Cycle 2) ONLY
	5D(1)	Perimeter Plan (Cycle 2) + Nonstructural
	5D(2)	Perimeter Plan (Cycle 1 and 2) + Nonstructural
	5E(1)	SSB ONLY
	5E(2)	SSB + Nonstructural
	5F	SSB + Nonstructural + CBB (Sea Isle Blvd)
	5G	SSB + Nonstructural + CBB (Sea Isle Blvd, Wildwood Blvd, Stone Harbor Blvd)

7.5.3 National Economic Development (NED) Criteria Screening

7.5.3.1 Fifty-One Regional Alternatives

HEC-FDA economic modeling for these plans was performed iteratively during the screening process to develop multi-strategy alternatives. HEC-FDA model runs were first performed for perimeter measures and nonstructural management measures independently to determine their respective economic feasibility in each reach. A second round of HEC-FDA model runs was performed after the hydrodynamic modeling of SSBs was completed to calculate benefits for barrier and CBB management measures.

These HEC-FDA analyses were then combined to develop the preliminary focused array of alternative plans that optimized net benefits for multi-measure combination alternatives. A third round of HEC-FDA model runs, inclusive of updated water levels for different return frequencies and consideration of additional benefit categories as well as refinements to the inventory totals, first floor elevation assessment, depreciated replacement value computation, content-to-structure value ratio assignment, depth-percent damage function specificity, non-HEC-FDA benefits inclusion, was subsequently performed to further refine multi-measure results. These analyses composed the basis of the final focused array of alternative plans and the TSP.

Additional details regarding the creation of the structure inventory, the methodology for identifying structures and their valuation as well as first floor elevation, the application of functions to compare water level depth to structure damage, and the final hydraulic engineering inputs for HEC-FDA can be found in the Economics Appendix.

Table 46 provides the economic analysis and screening against the NED criteria for each measure combination for the fifty-one alternatives based on the Cycle 0-2 screening using the FY2018 Price Level. Each Region is presented independently in separate tables with results for AANB, Benefit-Cost Ratio, residual damages, and projected annual operations, maintenance, repair, replacement, and rehabilitation (OMRR&R). Alternatives met the NED criteria and were considered economically justified if the AANB were greater than zero.

Any alternatives shaded in GREEN denotes success of meeting the NED criteria, and inclusion in the Final Array of Alternatives.

Table 46: Economic Analysis Results for Fifty-One Regional Alternatives – Study Wide (Baseline) (FY2018 Price Level)

ITEM	Initial Const.	AAC	Ave. Ann. Benefits (AAB)	AANB	BCR	Residual	OMRR&R
1A	$7,075,292,000	$262,075,000	$451,666,000	$189,590,000	1.72	71.26%	$0
1B	$5,229,038,000	$281,177,000	$738,568,000	$457,392,000	2.63	53.01%	$52,290,000
1C	$21,484,962,000	$1,332,419,000	$1,478,075,000	$145,656,000	1.11	5.95%	$331,673,000
1D	$15,457,093,000	$942,905,000	$1,219,060,000	$276,155,000	1.29	22.43%	$238,606,000

Annual Operations & Maintenance is the annual cost for operating and maintaining a CSRM measure most notably a SSB in the NJBB CSRM Study.

Each of the study wide single-measure alternatives have positive AANB and a BCR greater than 1. The nonstructural alternative only plan (1A) and cycle 2 perimeter only plan (1B) have exceedingly high residual damages at 71% and 53%, respectively. Only incorporating nonstructural strategies across the study area, such as in Alternative 1A, does not inhibit vehicle damage, infrastructure damage, emergency costs, or transportation delays. Alternative 2A incorporates physical barriers to reduce the ingress of flood waters and is effective at reducing CSRM damages for the communities within the footprint of perimeter plans but does not reduce risk to structures outside the footprint of the perimeter plans.

Installing storm barriers in the study area with SSBs (Alternative 1C) and closing all inlets except Little Egg Harbor Inlet (Alternative 1D) also have positive AANBs and BCRs.

While these plans provide valuable context for the Region-specific evaluations, none are considered acceptable or implementable based on the discussion above as well as other alternatives which have more favorable cost and benefit analysis results which will be discussed in subsequent sections.

The economic assessment presented below in Table 47 contains both the results for the Shark River Inlet HEC-FDA reaches and the Coastal Lakes HEC-FDA reaches. To reiterate, the Coastal Lakes Region covers only the coastal lakes not already included in either the North or Shark River & Coastal Lakes Regions. The results are aggregated here due to the exceptionally minor influence of either Region on the overall study area.

Both the perimeter plan (2B) and SSB (2C) alternatives are economically unviable and were eliminated from further analysis. Only nonstructural (2A) has a positive AANB and meets the NED criteria.

Table 47: Shark River and Coastal Lakes Region - NED Screening (FY2018 Price Level)

ITEM	Initial Const.	AAC	AAB	AANB	BCR	Residual	OMRR&R
2A	$24,468,000	$906,000	$1,133,000	$227,000	1.25	88.47%	$0

2B	$512,216,000	$25,747,000	$3,771,000	-$21,976,000	0.15	61.63%	$5,122,000
2C	$591,347,000	$33,439,000	$6,149,000	-$27,289,000	0.18	37.44%	$9,125,000

Table 48 contains the results for the North Region and indicates that eight different plans are economically viable.

Table 48: North Region - NED Screening (FY2018 Price Level)

ITEM	Initial Const.	AAC	AAB	AANB	BCR	Residual	OMRR&R
3A	$3,629,095,000	$134,425,000	$203,011,000	$68,586,000	1.51	62.97%	$0
3B	$6,726,209,000	$437,164,000	$276,635,000	-$160,529,000	0.63	49.54%	$67,262,000
3C	$461,554,000	$22,731,000	$26,258,000	$3,528,000	1.16	95.21%	$4,616,000
3D	$3,898,614,000	$150,042,000	$214,874,000	$64,831,000	1.43	60.81%	$4,616,000
3E(1)	$2,549,342,000	$154,810,000	$308,828,000	$154,018,000	1.99	43.67%	$39,351,000
3E(2)	$3,837,663,000	$202,530,000	$362,691,000	$160,160,000	1.79	33.84%	$39,351,000
3E(3)	$4,838,353,000	$268,041,000	$399,903,000	$131,861,000	1.49	27.06%	$53,997,000
3F(1)	$5,924,539,000	$367,186,000	$434,515,000	$67,329,000	1.18	20.74%	$90,894,000
3F(2)	$6,354,659,000	$383,118,000	$455,972,000	$72,854,000	1.19	16.83%	$90,894,000
3G	$1,151,448,000	$67,465,000	$42,502,000	-$24,963,000	0.63	92.25%	$17,766,000

As shown in **Error! Reference source not found.**Table 49 the Central Region has multiple plans t hat meet NED criteria. Alternative 4A, which only employs the nonstructural strategy meets the NED criteria, but has high residual damages (79%). Alternatives 4B and 4C (perimeter plan only) meet the NED criteria, but both are improved by Alternatives 4D(1) and 4D(2). Alternative 4D(1) adds nonstructural and maximizes AANB while Alternative 4D(2) adds nonstructural and a perimeter plan to Brigantine Island. Alternative 4D(2) reduces residual damages with only a 2.6% decrease in AANB.

Alternative 4E(1) meets the NED criteria, yet is improved with the inclusion of other measure types in 4E(2), 4E(3), 4E(4).

The inclusion of the North Point CBB in Alternative 4F severely dropped AANB in comparison with another SSB alternative. Alternative 4F increased Average Annual Benefits (AAB) by 14.5% but required a 46.3% increase in AAC.

Alternative 4G(1) meets the NED criteria, but is improved by adding either nonstructural or perimeter measures to Brigantine Island and nonstructural, perimeter, or CBB management measures to South Ocean City (Alternatives 4G(6) – 4G(8) and 4G(10) – 4G(12)).

At the current level of analysis, any of Alternatives 4D(1), 4D(2), 4G(7), 4G(8), or 4G(12) could be considered the maximizing NED alternative.

Table 49: Central Region - NED Screening (FY2018 Price Level)

ITEM	Initial Const.	AAC	AAB	AANB	BCR	Residual	OMRR&R
4A	$1,954,627,000	$72,401,000	$148,963,000	$76,562,000	2.06	78.81%	$0
4B	$3,619,705,000	$201,070,000	$562,047,000	$360,976,000	2.80	20.04%	$36,197,000
4C	$2,904,784,000	$164,102,000	$530,764,000	$366,662,000	3.23	24.49%	$29,048,000
4D(1)	$3,336,914,000	$180,109,000	$557,779,000	$377,671,000	3.10	20.65%	$29,048,000
4D(2)	$3,822,130,000	$208,568,000	$576,257,000	$367,689,000	2.76	18.02%	$36,197,000
4E(1)	$6,734,047,000	$425,665,000	$570,170,000	$144,506,000	1.34	18.89%	$103,964,000
4E(2)	$7,140,707,000	$425,665,000	$585,964,000	$160,299,000	1.38	16.64%	$103,964,000
4E(3)	$7,169,796,000	$446,873,000	$592,968,000	$146,094,000	1.33	15.64%	$107,923,000
4E(4)	$7,173,761,000	$449,940,000	$595,793,000	$145,853,000	1.32	15.24%	$110,198,000
4F(1)	$9,831,254,000	$622,785,000	$652,920,000	$30,135,000	1.05	7.12%	$151,395,000
4F(2)	$10,219,820,000	$637,178,000	$669,220,000	$32,041,000	1.05	4.80%	$151,395,000
4F(3)	$10,248,909,000	$643,324,000	$677,241,000	$33,918,000	1.05	3.66%	$155,354,000
4F(4)	$10,252,874,000	$646,390,000	$680,097,000	$33,706,000	1.05	3.25%	$157,629,000
4G(1)	$4,884,211,000	$301,347,000	$594,284,000	$292,937,000	1.97	15.46%	$74,556,000
4G(2)	$5,272,777,000	$315,740,000	$610,169,000	$294,429,000	1.93	13.20%	$74,556,000
4G(3)	$5,301,866,000	$321,885,000	$617,831,000	$295,946,000	1.92	12.11%	$78,516,000
4G(4)	$5,305,831,000	$324,952,000	$620,672,000	$295,720,000	1.91	11.70%	$80,790,000
4G(5)	$5,132,009,000	$310,526,000	$611,147,000	$300,622,000	1.97	13.06%	$74,556,000
4G(6)	$5,520,576,000	$324,918,000	$627,032,000	$302,114,000	1.93	10.80%	$74,556,000
4G(7)	$5,549,665,000	$331,064,000	$634,694,000	$303,630,000	1.92	9.71%	$78,516,000
4G(8)	$5,553,629,000	$334,130,000	$637,535,000	$303,405,000	1.91	9.30%	$80,790,000
4G(9)	$5,617,225,000	$338,985,000	$634,873,000	$295,888,000	1.87	9.68%	$81,706,000
4G(10)	$6,005,792,000	$353,378,000	$650,758,000	$297,380,000	1.84	7.42%	$81,706,000
4G(11)	$6,034,880,000	$359,524,000	$658,420,000	$298,897,000	1.83	6.33%	$85,665,000
4G(12)	$6,038,845,000	$362,590,000	$661,261,000	$298,671,000	1.82	5.93%	$87,939,000

As shown in Table 50, in the South Region, the nonstructural only alternative (5A) meets the NED criteria though with 68% residual damages. Alternatives 5B and 5C (perimeter plan only) also meet the NED criteria, but both are improved by Alternatives 5D(1) and 5D(2). Alternative 5D(1) adds nonstructural and maximizes AANB while Alternative 5D(2) adds nonstructural and a perimeter measure to Seven Mile Island.

Alternatives 5E(1) and 5E(2) meet the NED criteria, but with significantly fewer AANB than other alternatives. Adding the Sea Isle Blvd CBB (5F) drops residual damages but fails to meet the NED criteria. Avoiding a SSB at Hereford Inlet with the inclusion of two CBBs (5G) also fails to meet the NED criteria.

At the current level of analysis, Alternatives 5D(1) or 5D(2) could be considered the maximizing NED alternative.

Table 50: South Region - NED Screening (FY2018 Price Level)

ITEM	Initial Const.	AAC	AAB	AANB	BCR	Residual	OMRR&R
5A	$1,467,103,000	$54,343,000	$98,558,000	$44,216,000	1.81	68.27%	$0
5B	$3,424,391,000	$181,379,000	$231,893,000	$50,514,000	1.28	25.35%	$34,244,000
5C	$1,862,700,000	$94,344,000	$181,546,000	$87,202,000	1.92	41.55%	$18,627,000
5D(1)	$2,286,822,000	$110,054,000	$206,462,000	$96,408,000	1.88	33.53%	$18,627,000
5D(2)	$3,428,552,000	$180,266,000	$237,575,000	$57,310,000	1.32	23.52%	$33,066,000
5E(1)	$4,639,279,000	$274,620,000	$290,854,000	$16,233,000	1.06	6.37%	$71,610,000
5E(2)	$4,680,566,000	$276,150,000	$292,784,000	$16,634,000	1.06	5.74%	$71,610,000
5F	$5,265,569,000	$308,994,000	$298,195,000	-$10,799,000	0.97	4.00%	$80,302,000
5G	$5,924,476,000	$344,010,000	$293,924,000	-$50,086,000	0.85	5.38%	$89,110,000

7.5.3.2 Preliminary Focused Array of Regional Alternatives (Twenty Alternatives)

This section details the screening results (based on Cycle 3 screening) of the Focused Array of Alternatives (twenty alternatives). Table 51 provides a description of each of the 20 alternatives comprising the preliminary focused array of alternative plans formulated during the economic evaluation for Cycle 3. Table 52 below shows the updated economic analysis results for the Focused Array. Economic examination uses a 50-year period of analysis with the FY2021 Federal Discount Rate of 2.5% and an FY2021 Price Level. Results are formulated with an Intermediate Relative Sea Level Change (RSLC).

Economic results for individual alternatives in the focused array are also presented in alphanumeric graphics for the North, Central and South Regions below in Figures 62, 63 and 64, respectively.

Table 51: Comprehensive List of 20 Regional Focused Array of Alternative Plans (Cycle 3)

Region	Overview	Alternative	NONSTRUC	PERIMETER	SSB	BC
SHARK RIVER & COASTAL LAKES	2A	2A	X			
NORTH	3A	3A	X			
	3D	3D	X	X		
	3E	3E(2)	X		X	
		3E(3)	X	X	X	
CENTRAL	4A	4A	X			
	4D	4D(1)	X	X		
		4D(2)	X	X		

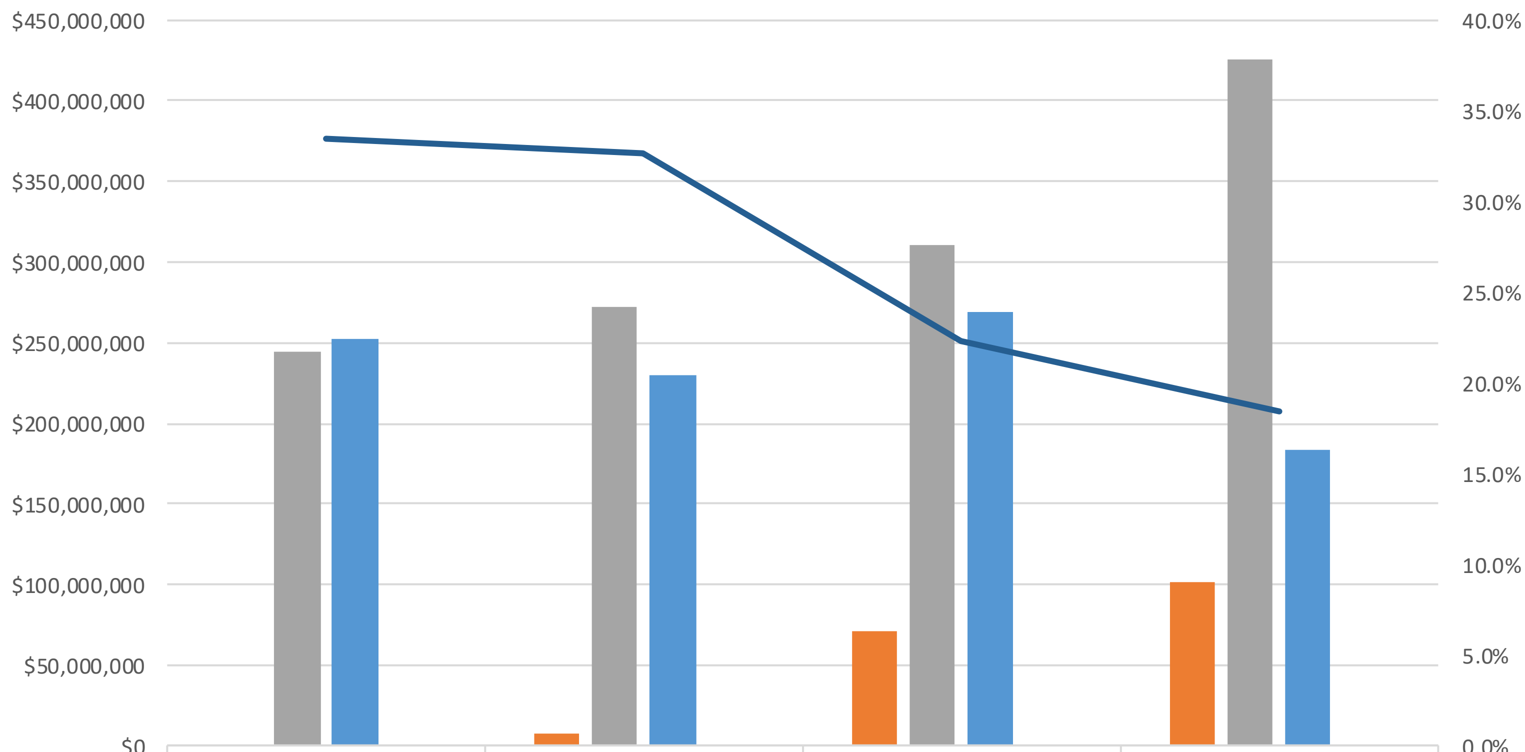
		4E(2)	X		X	
	4E	4E(3)	X	X	X	
		4E(4)	X		X	X
		4G(6)	X		X	X
		4G(7)	X	X	X	X
	4G	4G(8)	X		X	X
		4G(10)	X	X	X	X
		4G(11)	X	X	X	X
		4G(12)	X	X	X	X
	5A	5A	X			
SOUTH	5D	5D(1)	X	X		
		5D(2)	X	X		

Table 52: Focused Array of Alternatives (FY 2021 Price Level)

Alternative	Initial Const.	AAC	EAD Without[1]	EAD With[1]	EAD Reduced[1]	AANB	BCR	Residual
2A	$43,222,000	$1,533,000	$10,256,000	$6,836,000	$3,420,000	$1,887,000	2.2	66.7%
3A	$6,862,188,000	$243,460,000	$761,942,000	$245,034,000	$516,908,000	$273,448,000	2.1	32.2%
3D	$7,428,935,000	$272,025,000	$761,942,000	$239,073,000	$522,870,000	$250,845,000	1.9	31.4%
3E(2)	$6,252,584,000	$310,325,000	$761,942,000	$167,943,000	$593,999,000	$283,674,000	1.9	22.0%
3E(3)	$8,182,228,000	$424,189,000	$761,942,000	$137,836,000	$624,106,000	$199,917,000	1.5	18.1%
4A	$3,746,596,000	$132,923,000	$676,805,000	$305,983,000	$370,823,000	$237,900,000	2.8	45.2%
4D(1)	$6,923,867,000	$332,440,000	$676,805,000	$98,512,000	$578,294,000	$245,854,000	1.7	14.6%
4D(2)	$8,126,813,000	$393,378,000	$676,805,000	$85,011,000	$591,794,000	$198,416,000	1.5	12.6%
4E(2)	$6,415,617,000	$373,066,000	$676,805,000	$107,705,000	$569,100,000	$196,034,000	1.5	15.9%
4E(3)	$6,737,405,000	$393,078,000	$676,805,000	$93,804,000	$583,001,000	$189,923,000	1.5	13.9%
4E(4)	$6,458,924,000	$386,122,000	$676,805,000	$99,277,000	$577,529,000	$191,407,000	1.5	14.7%
4G(6)	$6,456,450,000	$363,493,000	$676,805,000	$84,082,000	$592,723,000	$229,230,000	1.6	12.4%
4G(7)	$6,778,238,000	$383,505,000	$676,805,000	$70,181,000	$606,624,000	$223,119,000	1.6	10.4%
4G(8)	$6,499,757,000	$376,549,000	$676,805,000	$75,654,000	$601,152,000	$224,603,000	1.6	11.2%
4G(10)	$7,659,396,000	$424,432,000	$676,805,000	$70,582,000	$606,223,000	$181,791,000	1.4	10.4%
4G(11)	$7,981,184,000	$444,444,000	$676,805,000	$56,681,000	$620,124,000	$175,680,000	1.4	8.4%
4G(12)	$7,702,703,000	$437,488,000	$676,805,000	$62,154,000	$614,652,000	$177,164,000	1.4	9.2%
5A	$3,252,801,000	$115,404,000	$359,606,000	$136,984,000	$222,622,000	$107,218,000	1.9	38.1%
5D(1)	$4,846,058,000	$217,466,000	$359,606,000	$73,900,000	$285,705,000	$68,239,000	1.3	20.6%
5D(2)	$7,583,011,000	$361,475,000	$359,606,000	$50,869,000	$308,737,000	($52,738,000)	0.9	14.1%

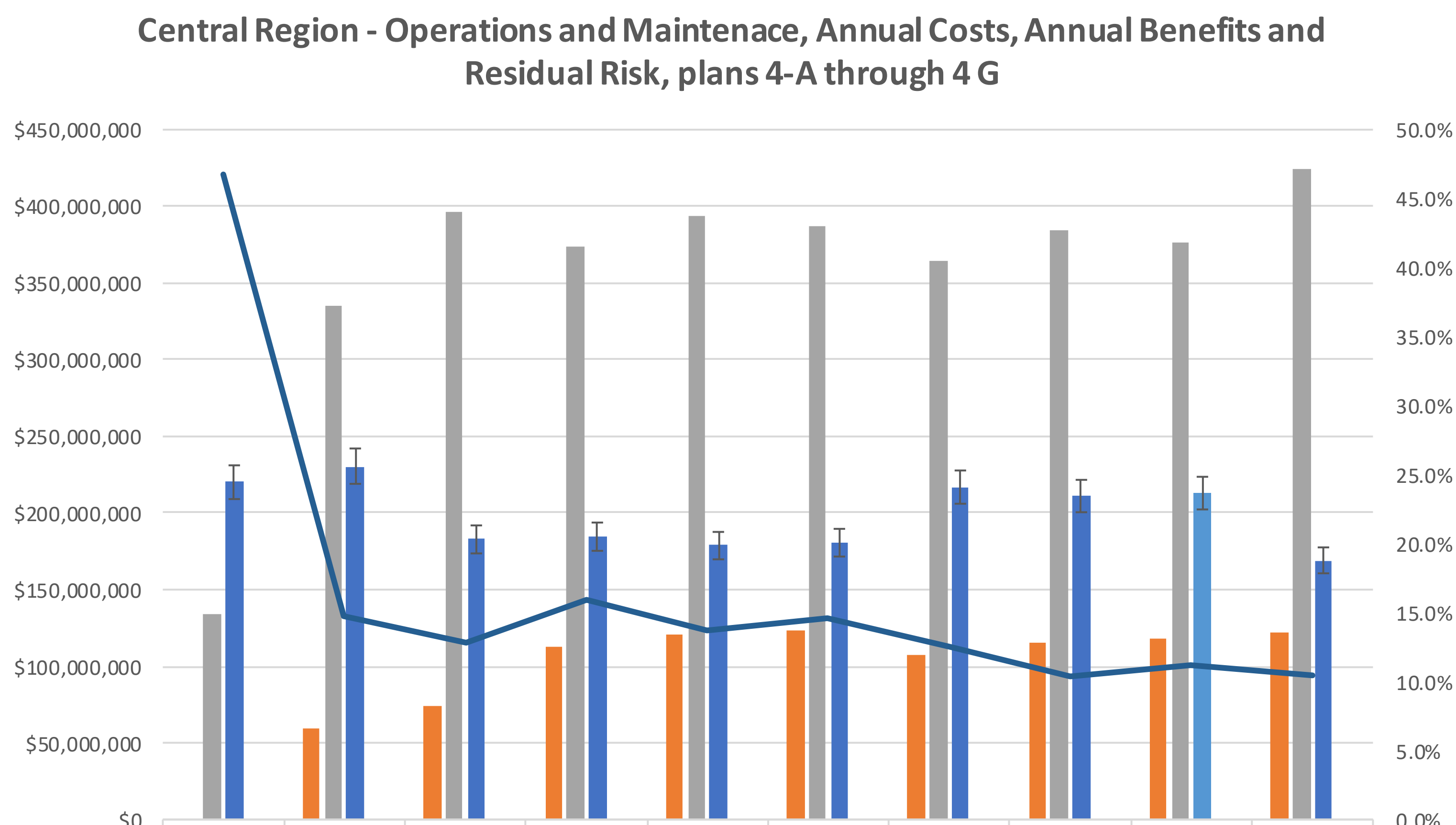
1. EAD stands for "Equivalent Annual Damages." This is the terminology used in HEC-FDA. EAD and AAD are identical and are used interchangeably.

North Region- Operations and Maintenace Costs, Annual Costs, Annual Benefits, Residual Risk



	3A	3D	3E(2)	3E(3)
OMRR&R	$0	$7,569,000	$70,404,000	$101,463,000
AAC	$244,196,000	$272,771,000	$310,793,000	$425,901,000
AANB	$252,392,000	$229,633,000	$268,881,000	$183,009,000
BCR	2.03	1.84	1.87	1.43
Residual Risk	33.5%	32.7%	22.3%	18.4%

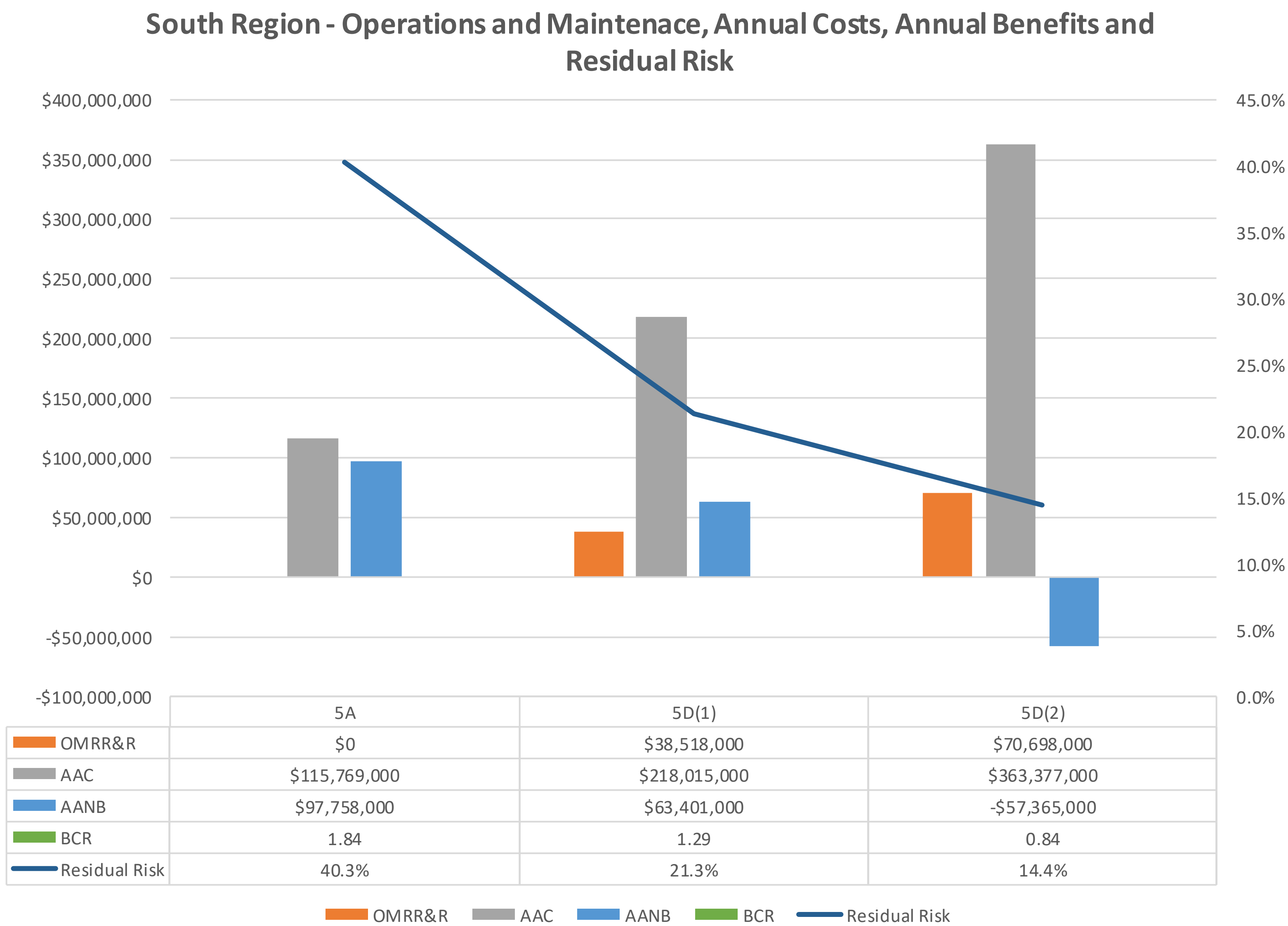
Figure 62: Economic results for individual alternatives in the North Region



	4A	4D(1)	4D(2)	4E(2)	4E(3)	4E(4)	4G(6)	4G(7)	4G(8)	4G(10)
OMRR&R	$0	$59,258,00	$74,085,00	$113,216,0	$120,725,0	$123,444,0	$107,399,0	$114,908,0	$117,627,0	$122,226,0
AAC	$133,339,0	$335,194,0	$396,354,0	$373,805,0	$393,823,0	$386,676,0	$363,814,0	$383,831,0	$376,684,0	$424,973,0
AANB	$220,044,0	$230,503,0	$182,728,0	$184,495,0	$178,672,0	$180,578,0	$216,836,0	$211,015,0	$212,921,0	$169,063,0
BCR	2.65	1.69	1.46	1.49	1.45	1.47	1.60	1.55	1.57	1.40
Residual Risk	46.8%	14.8%	12.7%	15.9%	13.7%	14.5%	12.5%	10.4%	11.2%	10.5%

OMRR&R AAC AANB BCR Residual Risk

Figure 63: Economic results for individual alternatives in the North Region



	5A	5D(1)	5D(2)
OMRR&R	$0	$38,518,000	$70,698,000
AAC	$115,769,000	$218,015,000	$363,377,000
AANB	$97,758,000	$63,401,000	-$57,365,000
BCR	1.84	1.29	0.84
Residual Risk	40.3%	21.3%	14.4%

Figure 64: Economic results for individual alternatives in the North Region

Costs for each of the twenty alternatives in the Focused Array were updated to the FY2021 Price Level and their development is further explained in the Cost Section of the Engineering Appendix (B.5). The summary costs for the individual measure components of each alternative are shown below in Table 53 and Table 54. Nonstructural costs are provided in Table 55 and further explained in the Nonstructural Appendix.

The methodology for nonstructural evaluation is slightly changed in Cycle 3 compared to Cycle 2, primarily due to the adjustments made to the inventory. These changes are detailed following Table 55. The application of perimeter measures and SSB management measures remain the same as Cycle 2, though the results have been updated and refined.

The results shown in Table 53 are presented as deterministic values but are actually the means for a distribution of outcomes. Due to limitations with HEC-FDA 1.4.2, results by iteration are not accessible, though the summary statistics display the quartile values of the distribution. While future work will more fully describe what the distribution of the iteration results looks like, it is important to acknowledge the uncertainty associated with the current values. Uncertainty in key inputs such as foundation height, depreciated replacement value, depth-percent damage functions, and water surface profiles implies that the outputs take a range of values rather than a deterministic variable. HEC-FDA Monte Carlo modeling provides a range of future scenarios that can be combined with the triangle distribution of non-HEC-FDA benefit streams to estimate the overall distribution of AAD future results for each proposed alternative.

Using the distributions of NED results by alternative can inform the TSP decision-making process by attaching uncertainty to what are often considered deterministic values. Instead of asserting that the selected plan is necessarily the NED plan, the plan can instead be selected with a level of confidence attached to it. Additionally, TSP identification should be achieved not only with NED results by alternative, but with acknowledgment of other relevant decision metrics such as residual risk, adaptability to sea level change, reliability, and life safety.

Table 53: Storm Surge Barrier Cost Estimates (FY 2021 Price Level)

Region	Description	Construction Duration (Months)	Initial Construction	Interest During Construction*	**Total First Construction Cost**	Annual OMRR&R**	**Average Annual Cost (AAC)**
North	Manasquan Inlet SSB	95	$1,146,890,852	$117,760,238	**$1,264,651,090**	$22,937,817	**$67,526,957**
North	Barnegat Inlet SSB	122	$2,517,077,609	$336,630,759	**$2,853,708,368**	$50,341,552	**$150,957,764**
Central	Absecon Inlet SSB	111	$2,367,232,830	$286,387,909	**$2,653,620,739**	$47,344,657	**$140,906,168**
Central	Great Egg Harbor SSB	137	$3,524,739,775	$533,544,429	**$4,058,284,204**	$70,494,796	**$213,582,011**
Central	Absecon Blvd Bay Closure	65	$2,064,490,714	$143,619,476	**$2,208,110,190**	$41,289,814	**$119,143,489**
Central	Ocean City Bay Closure	50	$532,290,857	$28,099,164	**$560,390,021**	$10,645,817	**$30,404,080**

* Interest During Construction is developed in accordance with ER 1105-2-100 and BPG 2020-01. Calculation is based on the mid-period of construction duration with a federal discount rate of 2.5%. Information on construction duration can be located in the Cost Section of the Engineering Appendix (B.5).

** Operations, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R) is a broad category meant to capture the ongoing costs to the non-Federal sponsor after initial construction of the project is completed. OMRR&R is estimated based on the type of measure proposed and the initial construction cost of that measure.

Table 54: Perimeter Plan Cost Estimates (FY 2021 Price Level)

Region	Description	Construction Duration (Months)	Initial Construction	Interest During Construction*	**Total First Construction Cost**	Annual OMRR&R**	**Average Annual Cost (AAC)**
North	Manasquan Inlet (North)	26	$787,837,592	$21,359,327	**$809,196,918**	$7,878,376	**$36,409,087**
North	Partial Long Beach Island	111	$3,232,691,144	$391,091,085	**$3,623,782,229**	$32,326,911	**$160,094,432**
Central	Absecon Island	126	$3,748,279,447	$518,814,993	**$4,267,094,440**	$37,482,794	**$187,932,253**
Central	Ocean City	89	$2,419,530,025	$232,013,029	**$2,651,543,054**	$24,195,300	**$117,683,556**
Central	Brigantine Island	55	$1,543,246,736	$89,846,169	**$1,633,092,905**	$15,432,467	**$73,012,150**
Central	Partial Southern Ocean City	33	$781,566,480	$26,991,634	**$808,558,115**	$7,815,665	**$36,323,853**
South	Cape May City	18	$545,709,170	$10,200,400	**$555,909,570**	$5,457,092	**$25,057,383**
South	Wildwood Island	62	$1,741,972,080	$114,739,769	**$1,856,711,849**	$17,419,721	**$82,883,773**
South	West Wildwood	13	$375,455,619	$5,055,515	**$380,511,134**	$3,754,556	**$17,170,639**
South	Stone Harbor / Avalon	110	$3,349,372,453	$401,346,248	**$3,750,718,701**	$33,493,725	**$165,736,778**
South	Sea Isle City	40	$1,153,935,372	$48,480,209	**$1,202,415,581**	$11,539,354	**$53,934,191**
South	West Cape May	5	$192,045,530	$990,484	**$193,036,014**	$1,920,455	**$8,726,530**

Table 55: Nonstructural Totals and Cost Estimates by Alternative (FY 2021 Price Level)

Alternative	SFRM	SFR1	COM	HIGH	APT	IND	PUB	TOTAL	Total Cost ($)	IDC ($)	AAC ($)
2A	66	49	13	-	-	-	7	**135**	$43,221,713	$270,136	$1,533,438
3A	8,773	13,073	1,072	-	95	8	131	**23,152**	$6,862,188,220	$42,888,676	$243,459,594
3D	8,478	12,593	1,050	-	95	8	129	**22,353**	$6,641,097,899	$41,506,862	$235,615,659
3E(2)	3,308	5,023	464	-	25	1	48	**8,869**	$2,588,615,639	$16,178,848	$91,839,992
3E(3)	1,183	3,487	98	-	1	1	15	**4,785**	$1,285,568,647	$8,034,804	$45,609,944
4A	4,522	5,079	1,050	18	87	10	129	**10,895**	$3,746,595,950	$23,416,225	$132,923,304
4D(1)	971	1,110	220	1	8	2	28	**2,340**	$756,057,663	$4,725,360	$26,823,731
4D(2)	405	594	164	1	7	2	16	**1,189**	$415,757,013	$2,598,481	$14,750,402
4E(2)	577	1,279	30	1	2	1	7	**1,897**	$523,644,774	$3,272,780	$18,578,089
4E(3)	132	48	13	1	-	-	3	**197**	$63,865,516	$399,159	$2,265,848
4E(4)	41	46	12	1	-	-	3	**103**	$34,660,093	$216,626	$1,229,685
4G(6)	1,143	1,795	86	1	3	1	20	**3,049**	$867,219,908	$5,420,124	$30,767,592
4G(7)	698	564	69	1	1	-	16	**1,349**	$407,440,649	$2,546,504	$14,455,350
4G(8)	607	562	68	1	1	-	16	**1,255**	$378,235,226	$2,363,970	$13,419,188
4G(10)	577	1,279	30	1	2	1	8	**1,898**	$526,919,258	$3,293,245	$18,694,263
4G(11)	132	48	13	1	-	-	4	**198**	$67,139,999	$419,625	$2,382,021
4G(12)	41	46	12	1	-	-	4	**104**	$37,934,577	$237,091	$1,345,859
5A	4,501	3,040	764	3	185	4	82	**8,579**	$3,252,801,000	$20,330,006	$115,404,239
5D(1)	1,275	743	269	-	27	-	20	**2,334**	$836,940,299	$5,230,877	$29,693,319
5D(2)	248	319	76	-	2	-	11	**656**	$224,520,371	$1,403,252	$7,965,628

- Construction duration is assumed to be three months for any particular structure.

Based on the economic analyses discussed above, a subset of focused array of alternatives with an emphasis on highest AANB was identified prior to continued plan formulation as discussed in the following sections of this chapter. Table 56 identifies alternatives with higher NED quantities (including AANB, AAC, OMRR&R and residual risk), to be considered as the TSP (highlighted in green) and alternatives with higher NED quantity ranges where further analyses is warranted in future phases of the study (highlighted in yellow).

Table 56: Focused Array of Alternatives highlighting alternatives with no table economic analyses

Alternative	Description	Initial Const.	OMRR&R	AAC	AAB	AANB	BCR	Residual Risk
Shark River & Coastal Lakes								
2A	NS Only	$41,531,000	$0	$1,538,000	$3,157,000	$1,619,000	2.05	68.7%
North Region								
3A	NS Only	$6,592,603,000	$0	$244,196,000	$496,588,000	$252,392,000	2.03	33.5%
3D	NS + PP (Manasquan (North))	$7,137,113,000	$7,569,000	$272,771,000	$502,404,000	$229,633,000	1.84	32.7%
3E(2)	NS + SSB (Manasquan Inlet & Barnegat Inlet)	$6,007,313,000	$70,404,000	$310,793,000	$579,674,000	$268,881,000	1.87	22.3%
3E(3)	NS + PP (Southern Long Beach Island) + SSB (Manasquan Inlet & Barnegat Inlet)	$7,861,217,000	$101,463,000	$425,901,000	$608,910,000	$183,009,000	1.43	18.4%
Central Region								
Alt.		**Initial Const.**	**OMRR&R**	**AAC**	**AAB**	**AANB**	**BCR**	**Residual Risk**
4A	NS Only	$3,599,771,000	$0	$133,339,000	$353,383,000	$220,044,000	2.65	46.8%
4D(1)	NS + PP (Ocean City & Absecon Island)	$6,652,242,000	$59,258,000	$335,194,000	$565,697,000	$230,503,000	1.69	14.8%
4D(2)	NS + PP (Ocean City, Absecon Island & Brigantine Island)	$7,807,982,000	$74,085,000	$396,354,000	$579,082,000	$182,728,000	1.46	12.7%
4E(2)	NS + SSB (Absecon Inlet & Great Egg Harbor Inlet)	$6,163,914,000	$113,216,000	$373,805,000	$558,300,000	$184,495,000	1.49	15.9%
4E(3)	NS + PP (Southern Ocean City) + SSB (Absecon Inlet & Great Egg Harbor Inlet)	$6,473,071,000	$120,725,000	$393,823,000	$572,495,000	$178,672,000	1.45	13.7%
4E(4)	NS + SSB (Absecon Inlet & Great Egg Harbor Inlet) + CBB (Southern Ocean City)	$6,205,516,000	$123,444,000	$386,676,000	$567,254,000	$180,578,000	1.47	14.5%
4G(6)	NS + SSB (Great Egg Harbor Inlet) + CBB (Absecon Blvd)	$6,203,154,000	$107,399,000	$363,814,000	$580,650,000	$216,836,000	1.60	12.5%
4G(7)	NS + PP (Southern Ocean City) + SSB (Great Egg Harbor Inlet) + CBB (Absecon Blvd)	$6,512,312,000	$114,908,000	$383,831,000	$594,846,000	$211,015,000	1.55	10.4%
4G(8)	NS + SSB (Great Egg Harbor Inlet) + CBB (Absecon Blvd & Southern Ocean City)	$6,244,757,000	$117,627,000	$376,684,000	$589,605,000	$212,921,000	1.57	11.2%
4G(10)	NS + PP (Brigantine Island) + SSB (Great Egg Harbor Inlet) + CBB (Absecon Blvd)	$7,358,895,000	$122,226,000	$424,973,000	$594,036,000	$169,063,000	1.40	10.5%
4G(11)	NS + PP (Brigantine Island & Southern Ocean City) + SSB (Great Egg Harbor Inlet) + CBB (Absecon Blvd)	$7,668,053,000	$129,735,000	$444,991,000	$608,231,000	$163,240,000	1.37	8.4%
4G(12)	NS + PP (Brigantine Island) + SSB (Great Egg Harbor Inlet) + CBB (Absecon Blvd & Southern Ocean City)	$7,400,497,000	$132,454,000	$437,844,000	$602,991,000	$165,147,000	1.38	9.1%
South Region								
5A	NS Only	$3,125,440,000	$0	$115,769,000	$213,527,000	$97,758,000	1.84	40.3%
5D(1)	NS + PP (Sea Isle City, West Wildwood, Wildwood Island, Cape May City & West Cape May)	$4,655,959,000	$38,518,000	$218,015,000	$281,416,000	$63,401,000	1.29	21.3%
5D(2)	NS + PP (Sea Isle City, Seven Mile Island, West Wildwood, Wildwood Island, Cape May City & West Cape May)	$7,285,507,000	$70,698,000	$363,377,000	$306,012,000	-$57,365,000	0.84	14.4%

NS = Nonstructural, PP = Perimeter Plan, SSB = Storm Surge Barrier, BC = Cross-Bay Barrier

Alternative NED maximizing plans where further analysis is warranted (yellow rows)

NED reasonably maximizing plan to be considered as the TSP (green rows)

A detailed discussion graphically comparing different economic and cost variables for each individual region as well as the presentation of individual maps of the preliminary focused array of alternatives are provided in the Plan Formulation Appendix.

7.5.4 Regional Economic Development (RED) Screening Status

Regional Economic Development (RED) is the change in the distribution of regional economic activity that results from each alternative plan. Typically, income and employment are considered in the determination of RED benefits. The evaluation of regional effects will be carried out using nationally consistent projections of income, employment, output, and population. Following is a discussion of RED benefits in the NJBB CSRM Study area. Investigation of potential OSE impacts and benefits will be conducted in the next study phase.

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

RED Benefits from Construction

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

- *Direct effects* are the impacts direct federal expenditure have on industries that directly support the new project. Labor and construction materials are considered the direct components of a project.
- *Indirect effects* represent changes to secondary industries that support the direct industry. For example, rock quarries used in making cement could be considered indirect pieces of a project.
- *Induced effects* are changes in consumer spending patterns caused by changes in employment and income within the direct and indirect industries. The additional income earned by workers may be spent in numerous different ways within the region.

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

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

The percentage of spending captured (i.e., the direct effects) at each level is reported by county below in Table 57:

Table 57: Local Capture by County

	Cape May	Atlantic	Burlington	Ocean	Monmouth
Local	71%	75%	83%	76%	81%
State	89%	87%	88%	87%	87%
US	95%	95%	95%	95%	95%

Though it is a transfer (and, as such, not an NED benefit), the federal funding spent in a community represents a benefit when it is captured locally. For example, 83% of the federal spending in Burlington County is captured by local interests within the county, providing them tangible RED benefits. As such, the local capture is equal to the monetary direct effect of federal spending.

Secondary impacts, which include indirect and induced impacts, are multiplier effects on top of the direct impacts. Indirect impacts include payments to industries that support the directly affected industries, while induced effects occur when workers associated with the direct and indirect industries spend their salaries in the impact area, creating additional jobs and income. The secondary impact multipliers are listed below in Table 58 for each county and should be applied to the initial federal outlay (i.e., multiplying the multiplier by the initial outlay yields the secondary impact).

Table 58: Indirect and Induced Impact Multipliers

	Cape May	Atlantic	Burlington	Ocean	Monmouth
Local	.41	.59	.76	.55	.67
State	.85	.83	.92	.83	.83
US	1.76	1.76	1.76	1.76	1.76

It should be intuitive that the secondary impacts increase as the scale (locality, state, U.S.) becomes larger, since more of the impacts are internalized within the larger area, thereby continuing to provide compounding benefits.

Spending in the study area will also spur job growth. On average, each $125,000 spent in the study area will directly create one job and indirectly create half of another. On the national level, that amount of spending would create a total of 2.2 jobs. This implies that both the nonstructural and structural alternatives considered in this study would create thousands of jobs locally, regionally, and nationally. Many of these jobs would be full-time, as Operations, Maintenance, Repair, Rehabilitation, & Replacement (OMRR&R) spending will need to continue after the project is completed.

RED Losses from Business Interruption

The above discusses the direct and secondary benefits of federal spending in the NJBB CSRM Study area, but a USACE project could also potentially prevent regional economic losses—a separate benefit stream. Back bay flooding can cause physical damages to the over 6,500 commercial and industrial structures in the study area, which can in turn lead to business interruption. Some of the major sectors that may be impacted include healthcare and tourism. Preventing the physical damage can prevent the business interruption.

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

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

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

While RED is one of the four accounts established to facilitate evaluation and display of effects of alternative plans, it is not anticipated that regional economic impacts will assist in deciding between alternative plans. Therefore, the RED account will be reviewed more comprehensively after identification of the TSP.

7.5.5 Environmental Quality (EQ) Criteria Screening

Alternatives that met the NED screening criteria were carried forward to be screened against the Environmental Quality (EQ) criteria. The potential environmental impacts of the various alternatives were assessed qualitatively using the best professional judgment of the PDT and through coordination with state and Federal resource agencies. Potential impacts of the implementation of alternatives to water quality, estuary circulation, sedimentation and scour, air quality, endangered species, fisheries, aquatic life, wetland habitat, aquatic habitat, and upland terrestrial habitat were considered and scored using a ranked ordinal scale to describe the magnitude of the impacts and risk related to their implementation. The EQ scores for different habitats and resources were averaged to calculate an EQ Index Score (Table 59). If any alternative received a score of 0 for any habitat or natural resource impact, the alternative failed the EQ criteria.

Table 59: EQ Index Score

Score	Description	Risk Category
0	EXTREME RISK. Environmental Impacts are severe making alternative non-implementable and/or is not likely to receive statutory approvals for compliance. A score of zero on any criteria negates entire alternative.	HIGH
1	VERY HIGH RISK. Environmental Impacts are significant with either the magnitude, duration of impact, and/or a very high vulnerability of resources. Alternative would have very high level of controversy. Statutory approvals would require extensive reviews that are likely to impact schedule and budget. Alternative would require very high compensatory mitigation and associated costs likely to adversely affect project costs.	
2	HIGH RISK. Environmental Impacts are substantial to moderate with either the magnitude, duration of impact, and/or a high vulnerability of resources. Alternative would have a higher level of controversy. Statutory approvals would require extensive reviews that are likely to impact schedule and budget. Alternative would require high compensatory mitigation and associated costs likely to have an adverse effect on project costs.	
3	MODERATE RISK. Environmental Impacts are moderate with either the magnitude, duration of impact, and/or a moderate vulnerability of resources. Alternative would have a moderate level of controversy. Statutory approvals could require additional reviews that could impact schedule and budget. Alternative would require compensatory mitigation and associated costs could impact project costs.	MEDIUM
4	MINOR RISK. Environmental Impacts are minor with either the magnitude, duration of impact, and/or a minor vulnerability of resources. Alternative would have little or no level of controversy. Statutory approvals are routine but could require additional reviews that could impact schedule and budget based on complexity. Alternative would require some compensatory mitigation and associated costs would likely have little impact to project costs.	
5	LOW RISK. Environmental Impacts are neutral with either the magnitude, duration of impact, and/or no vulnerability of resources. Alternative would have little or no level of controversy. Statutory approvals are routine. Alternative would require no compensatory mitigation.	LOW

6	**VERY LOW RISK. Environmental impacts are beneficial and provide a net ecological uplift. Alternative would have very little or no level of controversy. Statutory approvals would be routine. No compensatory mitigation required.**	

At this stage in the analysis, the indirect impacts to environmental resources from SSBs have not been fully modeled. Therefore, there is a high degree of uncertainty around the impacts of those measures. Similar to the planning process, the EQ screening of alternatives will be an iterative process that will be refined as more data and model results are available. Alternatives that passed this iteration of EQ screening may not pass future iterations of screening as the PDT's understanding of impacts improves. Table 60 provides the preliminary analysis and screening against the EQ criteria. Each Region is presented independently with a pass or fail designation for the EQ criteria. Alternatives that successfully met the EQ screening are shaded GREEN and are included from the final array of alternatives.

STUDY WIDE – EQ Screening

Alternatives 1C and 1D both failed to meet the EQ criteria and were eliminated from further consideration. Alternative 1C included SSBs at every inlet in the study area, and 1D included SSBs at every inlet in the study area, except for Little Egg Harbor Inlet. Endangered species impact and wildlife habitat impacts at Little Egg Inlet, Corson Inlet, and Hereford Inlet drove the decision to eliminate these alternatives. A SSB at Little Egg Harbor Inlet would impact at least 10 miles of critical habitat for the endangered Piping Plover within the Edwin B. Forsythe National Wildlife Refuge. Little Egg Inlet also provides uniquely undisturbed habitat to a wide range of wildlife because is also the only unmodified inlet between Montauk, New York and Gargathy Inlet, Virginia. Corson Inlet is an inlet with significant beach nesting bird habitat and contains a State Natural Area at Strathmere. The area of Hereford Inlet is within a CBRA zone and a Federal coastal storm risk project in the area would not comply with CBRA. A SSB at Hereford Inlet would result in significant impacts to critical habitat for Piping Plover at Stone Harbor Point.

Table 60: EQ Screening for Individual Regions

Alternative	EQ Index Score	EQ Pass/Fail
1A*	4.2	Pass
1B	3.3	Pass
1C	1.6	Fail
1D	2.1	Fail

*Environmentally preferred alternative for study-wide area

SHARK RIVER AND COASTAL LAKES REGION – EQ Screening

Alternative 2A employs the nonstructural strategy in the Shark River & Coastal Lakes Region and passed the EQ screening analysis (Table 61). It is the only alternative remaining under consideration for inclusion in the preliminary focused array of alternative plans. Building retrofit is the least impactful measure under consideration environmentally.

Table 61: Shark River and Coastal Lakes Region

Alternative	EQ Index Score	EQ Pass/Fail
2A*	4.2	Pass

*Environmentally preferred alternative

NORTH REGION – EQ Screening

In the North Region of the study area (Table 62), Alternative 3F(1) and 3F(2) did not pass the EQ criteria. Impacts resulting from the Holgate CBB were the primary drivers behind the failure of these alternatives. The Holgate CBB would negatively impact piping plover habitat in addition to high wetland and aquatic habitat impacts within the Edwin B. Forsythe National Wildlife Refuge.

Table 62: Northern Region

Alternative	EQ Index Score	EQ Pass/Fail
3A*	4.2	Pass
3C	3.3	Pass
3D	3.3	Pass
3E(1)	2.1	Pass
3E(2)	2.1	Pass
3E(3)	2.0	Pass
3F(1)	1.2	Fail
3F(2)	1.2	Fail

*Environmentally preferred alternative

CENTRAL REGION – EQ Screening

In the Central Region of the study area (Table 63), Alternative 4F(1) through 4F(4) did not pass the EQ criteria. Impacts resulting from the North Point CBB were the primary drivers behind the failure of these alternatives. The North Point CBB includes the construction of a seawall along the beach in a sensitive piping plover habitat within a State Natural Area and would pass through environmentally sensitive wetland habitat within the Edwin B. Forsythe National Wildlife Refuge.

Table 63: Central Region

Alternative	EQ Index Score	EQ Pass/Fail
4A*	4.2	Pass
4B	3.3	Pass
4C	3.3	Pass
4D(1)	3.3	Pass
4D(2)	3.3	Pass
4E(1)	2.1	Pass
4E(2)	2.1	Pass
4E(3)	2.1	Pass
4E(4)	2.0	Pass
4F(1)	2.0	Fail
4F(2)	2.0	Fail
4F(3)	2.0	Fail
4F(4)	1.9	Fail
4G(1)	2.0	Pass
4G(2)	2.0	Pass
4G(3)	2.0	Pass
4G(4)	2.0	Pass
4G(5)	2.0	Pass
4G(6)	2.0	Pass
4G(7)	2.0	Pass
4G(8)	2.0	Pass
4G(9)	2.0	Pass
4G(10)	2.0	Pass
4G(11)	2.0	Pass
4G(12)	2.0	Pass

*Environmentally preferred alternative

SOUTH REGION – EQ Screening

In the South Region of the study area (Table 64), Alternative 5E(1) and 5E(2) did not pass the EQ criteria. Impacts resulting from the Hereford Inlet SSB were the primary drivers behind the failure of these alternatives. Hereford Inlet is within a Coastal Barrier Resources Act (CBRA) zone and a Federal coastal storm risk project in the area would not comply with CBRA. A SSB at Hereford Inlet would result in significant impacts to critical habitat for Piping Plover at Stone Harbor Point.

Table 64: South Region

Alternative	EQ Index Score	EQ Pass/Fail
5A*	4.2	Pass
5B	3.3	Pass
5C	3.3	Pass
5D(1)	3.3	Pass
5D(2)	3.3	Pass
5E(1)	2.0	Fail
5E(2)	2.0	Fail

*Environmentally preferred alternative

Based on the environmental quality analyses discussed above, a summary table is provided which summarizes the EQ index score and pass/fail ranking for each of the focused array of alternatives (Table 65). Note that all alternatives identified with NED-maximizing plans to be considered as the TSP (highlighted in green) as well as NED-reasonably maximizing plans where further analysis is warranted and in future phases of the study (highlighted in yellow) received an EQ pass score.

Table 65: Focused Array of Alternatives highlighting alternatives with EQ Index Scores and Pass/Fail Ranking

Alternative	Description	EQ Index Score	EQ Pass/Fail
Shark River			
2A	NS Only	4.2	Pass
North Region			
3A	NS Only	4.2	Pass
3D	NS + PP (Manasquan (North))	3.3	Pass
3E(2)	NS + SSB (Manasquan Inlet & Barnegat Inlet)	2.1	Pass
3E(3)	NS + PP (Southern Long Beach Island) + SSB (Manasquan Inlet & Barnegat Inlet)	2.0	Pass
Central Region			
Alt.			
4A	NS Only	4.2	Pass
4D(1)	NS + PP (Ocean City & Absecon Island)	3.3	Pass
4D(2)	NS + PP (Ocean City, Absecon Island & Brigantine Island)	3.3	Pass
4E(2)	NS + SSB (Absecon Inlet & Great Egg Harbor Inlet)	2.1	Fail
4E(3)	NS + PP (Southern Ocean City) + SSB (Absecon Inlet & Great Egg Harbor Inlet)	2.1	Fail
4E(4)	NS + SSB (Absecon Inlet & Great Egg Harbor Inlet) + BC (Southern Ocean City)	2.0	Fail
4G(6)	NS + SSB (Great Egg Harbor Inlet) + BC (Absecon Blvd)	2.0	Fail
4G(7)	NS + PP (Southern Ocean City) + SSB (Great Egg Harbor Inlet) + BC (Absecon Blvd)	2.0	Pass
4G(8)	NS + SSB (Great Egg Harbor Inlet) + BC (Absecon Blvd & Southern Ocean City)	2.0	Pass
4G(10)	NS + PP (Brigantine Island) + SSB (Great Egg Harbor Inlet) + BC (Absecon Blvd)	2.0	Pass
4G(11)	NS + PP (Brigantine Island & Southern Ocean City) + SSB (Great Egg Harbor Inlet) + BC (Absecon Blvd)	2.0	Pass
4G(12)	NS + PP (Brigantine Island) + SSB (Great Egg Harbor Inlet) + BC (Absecon Blvd & Southern Ocean City)	2.0	Pass
South Region			
5A	NS Only	4.2	Pass
5D(1)	NS + PP (Sea Isle City, West Wildwood, Wildwood Island, Cape May City & West Cape May)	3.3	Pass
5D(2)	NS + PP (Sea Isle City, Seven Mile Island, West Wildwood, Wildwood Island, Cape May City & West Cape May)	3.3	Pass
	NS = Nonstructural, PP = Perimeter Plan, SSB = Storm Surge Barrier, BC = Bay Closure		
	Alternative NED-maximizing plans where further analysis is warranted		
	NED reasonably maximizing plan to be considered as the TSP		

*Non-structural alternatives 2A, 3A, 4A, and 5A are environmentally preferred alternatives

7.5.6 Other Social Effects Analysis

Alternatives that met the NED and EQ screening criteria were carried forward to be screened against the Other Social Effects (OSE) criteria. The other Social Effects (OSE) account is a means of displaying and integrating into water resource planning information from perspectives that are not reflected in the other accounts. The categories of effects in the OSE account include the following: Urban and community impacts; life, health, and safety factors; displacement; long-term productivity; and energy requirements and energy conservation. At this stage in the study, the OSE account is not being used as an alternative screening tool, but it does provide context on social and infrastructure vulnerability that the PDT will continue to consider throughout the planning process as it progresses.

An OSE qualitative analysis was performed on alternatives that met the NED, RED and EQ accounts to ensure that any decisions based on economics and engineering would also consider life/safety, critical infrastructure, and disproportionate negative impacts to socially vulnerable populations. At this stage of the analysis, the information used included the NACCS Social Vulnerability Exposure and Risk Indices, NACCS geodatabases of critical infrastructure, and mapped emergency evacuation routes. The NACCS defines exposure as the presence of people, infrastructure, and/or environmental resources in areas subject to coastal flooding. The NACCS Social Vulnerability Exposure Index was created by compiling data from the U.S. 2010 Census and 2011 American Community Survey on age, income, and other characteristics. Key variables that defined social vulnerability exposure include percentage of people age 65 or older, percentage of people age 5 and younger, percentage of all people whose income in the past 12 months is below poverty threshold, and percentage of people with limited proficiency in English. Based on the data to reflect OSE, each alternative was qualitatively assessed against HFF, social risk and vulnerability, infrastructure exposure, and community cohesion, and observations were recorded (Table 66)(Alternative plans shaded in green represent the TSP). As the study progresses, the data and information used to assess OSE will be refined and will be used to further evaluate alternatives within the preliminary focused array of alternative plans.

Table 66: Other Social Effects Alternative Qualitative Assessment

Alternative	Nuisance Flooding	Social Risk and Vulnerability	Infrastructure Exposure	Community Cohesion
SHARK RIVER AND COASTAL LAKES REGION				
2A	No reduction in inundation during higher frequency events	There is risk that elevating structures might create a false sense of security during a storm event reducing compliance with evacuation orders. People sheltering in place will increase their personal risk and could also increase risk to emergency responders	No reduction of exposure of critical infrastructure and evacuation routes	Residual risk to infrastructure and properties that don't qualify for elevation could reduce the robustness of coastal communities. Additionally, there might be community opposition to selective elevating of structures and the needed real estate easements.
NORTH REGION				
3A	No reduction in inundation during higher frequency events	There is risk that elevating structures might create a false sense of security during a storm event reducing compliance with evacuation orders. People sheltering in place will increase their personal risk and could also increase risk to emergency responders	No reduction of exposure of critical infrastructure and evacuation routes	Residual risk to infrastructure and properties that don't qualify for elevation could reduce the robustness of coastal communities. Additionally, there might be community opposition to selective elevating of structures and the needed real estate easements.
3D	No reduction in inundation during higher frequency events, except behind the Manasquan North floodwall.	There is risk that elevating structures might create a false sense of security during a storm event reducing compliance with evacuation orders. People sheltering in place will increase their personal risk and could also increase risk to emergency responders	No reduction of exposure of critical infrastructure and evacuation routes, except behind the Manasquan North Floodwall.	Residual risk to infrastructure and properties that don't qualify for elevation could reduce the robustness of coastal communities. Additionally, there might be community opposition to selective elevating of structures and the needed real estate easements. Along the Manasquan North floodwall, there is potential for reduction in bayside views and access by floodwalls. There will also likely be difficulties in obtaining real estate easements required to construct walls. .
3E(1)	SSBs will manage risk from low frequency storms in the area of influence around Manasquan and Barnegat inlets, but will not address the risk to communities from higher frequency events.	SSBs will manage risk from low frequency coastal storms but will not address the risk to communities from higher frequency events. No CSRM is implemented in the vicinity of Tuckerton.	Exposure of critical infrastructure and evacuation routes is lessened around Manasquan and Barnegat Inlets during low frequency events when the SSB is closed. However, infrastructure is vulnerable in the southern vicinity of Tuckerton	As of now, the full extent of the indirect impacts of a SSB are not understood. There is risk that these structures could result in environmental degradation, which can have negative impacts on the recreational and aquaculture industries in the study area. The omission of CSRM in the vicinity of Tuckerton could have a negative impact on this community in the future
3E(2)	SSBs will manage risk from low frequency storms in the area of influence around Manasquan and Barnegat inlets, but will not address the risk to communities from higher frequency events.	SSBs will manage risk from low frequency coastal storms but will not address the risk to communities from higher frequency events. There is risk that elevating structures might create a false sense of security during a storm event reducing compliance with evacuation orders around Tuckerton. People sheltering in place will increase their personal risk and could also increase risk to emergency responders	Exposure of critical infrastructure and evacuation routes is lessened around Manasquan and Barnegat Inlets during low frequency events when the SSB is closed. However, infrastructure is vulnerable in the southern vicinity of Tuckerton where nonstructural measures will be implemented.	As of now, the full extent of the indirect impacts of a SSB are not understood. There is risk that these structures could result in environmental degradation, which can have negative impacts on the recreational and aquaculture industries in the study area. Residual risk to infrastructure and properties that don't qualify for elevation could reduce the robustness of coastal communities. Additionally, there might be community opposition to selective elevating of structures and the needed real estate easements.
3E(3)	SSBs will manage risk from low frequency storms in the area of influence around Manasquan and Barnegat inlets, but will not address the risk to communities from higher frequency events. Southern LBI will experience less nuisance flooding due to the construction of a floodwall.	SSBs will manage risk from low frequency coastal storms but will not address the risk to communities from higher frequency events, except in southern LBI where a floodwall will be constructed. There is risk that elevating structures might create a false sense of security during a storm event reducing compliance with evacuation orders around Tuckerton.	Exposure of critical infrastructure and evacuation routes is lessened around Manasquan and Barnegat Inlets during low frequency events when the SSB is closed and in LBI due to the presence of a floodwall. However, infrastructure is vulnerable in the southern vicinity of Tuckerton where nonstructural measures will be implemented.	As of now, the full extent of the indirect impacts of a SSB are not understood. There is risk that these structures could result in environmental degradation, which can have negative impacts on the recreational and aquaculture industries in the study area. Residual risk to infrastructure and properties that don't qualify for elevation could reduce the robustness of coastal communities. Additionally, there might be community opposition to selective elevating of structures and the needed real estate easements. In southern LBI, there is potential for reduction in bayside views and access by floodwalls. There will also likely be difficulties in obtaining real estate easements required to construct walls.
CENTRAL REGION				

Alternative	Nuisance Flooding	Social Risk and Vulnerability	Infrastructure Exposure	Community Cohesion
4A	No reduction in inundation during higher frequency events	There is risk that elevating structures might create a false sense of security during a storm event reducing compliance with evacuation orders. People sheltering in place could increase both their personal risk and the risk to emergency responders.	No reduction of exposure of critical infrastructure and evacuation routes	Residual risk to infrastructure and properties that don't qualify for elevation could reduce the robustness of coastal communities. Additionally, there might be community opposition to selective elevating of structures and the needed real estate easements.
4D(1)	Floodwalls and Levees would reduce inundation in barrier island (except Brigantine Island) communities during higher frequency events.	There is risk that elevating structures might create a false sense of security during a storm event reducing compliance with evacuation orders in Brigantine, Somers Point, Linwood, Northfield, Pleasantville, and Absecon. People sheltering in place could increase both their personal risk and the risk to emergency responders.	Exposure of critical infrastructure and evacuation routes is lessened on the barrier islands, except for Brigantine. Infrastructure and evacuation routes remain vulnerable on the mainland and Brigantine.	Potential for reduction in bayside views and access by floodwalls in Ocean City and Absecon Island. Real estate easements required to construct walls could be difficult to obtain. Residual risk to infrastructure and properties that don't qualify for elevation could reduce the robustness of coastal communities in Brigantine, Somers Point, Linwood, Northfield, Pleasantville, and Absecon. Additionally, there might be community opposition to selective elevating of structures and the needed real estate easements.
4D(2)	Floodwalls and Levees would reduce inundation in barrier island communities during higher frequency events.	There is risk that elevating structures might create a false sense of security during a storm event reducing compliance with evacuation orders in Somers Point, Linwood, Northfield, Pleasantville, and Absecon. People sheltering in place could increase both their personal risk and the risk to emergency responders.	Exposure of critical infrastructure and evacuation routes is lessened on the barrier islands. Infrastructure and evacuation routes remain vulnerable on the mainland. .	Potential for reduction in bayside views and access by floodwalls in Ocean City, Absecon Island, and Brigantine. Real estate easements required to construct walls could be difficult to obtain. Residual risk to infrastructure and properties that don't qualify for elevation could reduce the robustness of coastal communities in Somers Point, Linwood, Northfield, Pleasantville, and Absecon. Additionally, there might be community opposition to selective elevating of structures and the needed real estate easements.
4E(2)	SSBs will manage risk from low frequency storms in the area of influence around Great Egg Harbor and Absecon Inlets, but will not address the risk to communities from higher frequency events.	SSBs will manage risk from low frequency coastal storms but will not address the risk to communities from higher frequency events. Additionally, communities on the mainland Little Egg Inlet remain vulnerable as these inlets will not be closed. There is risk that elevating structures might create a false sense of security during a storm event reducing compliance with evacuation orders in mainland communities adjacent to Little Egg Inlet.	Exposure of critical infrastructure and evacuation routes is lessened around Great Egg Harbor and Absecon Inlets during low frequency events when the SSB is closed. However, infrastructure is vulnerable when the SSBs are open.	As of now, the full extent of the indirect impacts of a SSB are not understood. There is risk that these structures could result in environmental degradation, which can have negative impacts on the recreational and aquaculture industries in the study area. Residual risk to infrastructure and properties that don't qualify for elevation could reduce the robustness of coastal communities in Southern Ocean City and Absecon. Additionally, there might be community opposition to selective elevating of structures and the needed real estate easements.
4E(3)	SSBs will manage risk from low frequency storms in the area of influence around Great Egg Harbor and Absecon Inlets, but will not address the risk to communities from higher frequency events. The floodwall in Southern Ocean City will reduce inundation from higher frequency events.	SSBs will manage risk from low frequency coastal storms but will not address the risk to communities from higher frequency events. Additionally, communities on the mainland around Corson Inlet and Little Egg Inlet remain vulnerable as these inlets will not be closed. There is risk that elevating structures might create a false sense of security during a storm event reducing compliance with evacuation orders in mainland communities adjacent to Little Egg Inlet and Corson Inlet. People sheltering in place could increase both their personal risk and the risk to emergency responders.	Exposure of critical infrastructure and evacuation routes is lessened around Manasquan and Barnegat Inlets during low frequency events when the SSB is closed. However, infrastructure is vulnerable when the SSBs are open. The floodwall in Southern Ocean City could improve risk management for critical infrastructure in this area.	T As of now, the full extent of the indirect impacts of a SSB are not understood. There is risk that these structures could result in environmental degradation, which can have negative impacts on the recreational and aquaculture industries in the study area. However, SSBs will reduce coastal storm risk in mainland communities during low frequency events when the barrier is closed. Residual risk to infrastructure and properties that don't qualify for elevation could reduce the robustness of coastal communities on the mainland adjacent to Corson and Little Egg Inlet. Additionally, there might be community opposition to selective elevating of structures and the needed real estate easements. Potential for reduction in bayside views and access by floodwalls in Southern Ocean City. Real estate easements required to construct walls could be difficult to obtain.

Alternative	Nuisance Flooding	Social Risk and Vulnerability	Infrastructure Exposure	Community Cohesion
4E(4)	SSBs will manage risk from low frequency storms in the area of influence around Great Egg Harbor and Absecon Inlets, but will not address the risk to communities from higher frequency events. The floodwall in Southern Ocean City will reduce inundation from higher frequency events.	SSBs will manage risk from low frequency coastal storms but will not address the risk to communities from higher frequency events. Additionally, communities on the mainland around Corson Inlet and Little Egg Inlet remain vulnerable as these inlets will not be closed. There is risk that elevating structures might create a false sense of security during a storm event reducing compliance with evacuation orders in mainland communities adjacent to Little Egg Inlet and Corson Inlet. People sheltering in place could increase both their personal risk and the risk to emergency responders.	Exposure of critical infrastructure and evacuation routes is lessened around Great Egg and Absecon Inlets during low frequency events when the SSB is closed. However, infrastructure is vulnerable when the SSBs are open. The floodwall in Southern Ocean City could improve risk management for critical infrastructure in this area. .	As of now, the full extent of the indirect impacts of a SSB and CBBs are not understood. There is risk that these structures could result in environmental degradation, which can have negative impacts on the recreational and aquaculture industries in the study area. However, SSBs will reduce coastal storm risk in mainland communities during low frequency events when the barrier is closed. Residual risk to infrastructure and properties that don't qualify for elevation could reduce the robustness of coastal communities on the mainland adjacent to Little Egg Inlet. Additionally, there might be community opposition to selective elevating of structures and the needed real estate easements.
4G(5)	SSBs will manage risk from low frequency storms in the area of influence around Great Egg Harbor but will not address the risk to communities from higher frequency events. Nonstructural measures to the north of the Absecon Bay Blvd will reduce risk to structures from nuisance flooding but will not impact other critical infrastructure such as roads. No CSRM is provided to communities around Corson Inlet.	SSBs and CBBs will manage risk from low frequency coastal storms but will not address the risk to communities from higher frequency events. Additionally, communities around Corson Inlet remain vulnerable as this inlet will not be closed. There is risk that elevating structures north of the Absecon Bay Blvd closure might create a false sense of security during a storm event reducing compliance with evacuation orders. People sheltering in place could increase both their personal risk and the risk to emergency responders.	Exposure of critical infrastructure and evacuation routes is lessened around Great Egg Inlet and south of the Absecon Blvd CBB during low frequency events when the SSB is closed. However, infrastructure is vulnerable when the SSBs are open. The construction of the CBB will elevate Absecon Blvd, which will reduce exposure of the evacuation route to coastal storm risk. North of the CBB and around Corson Inlet, there is no risk management to critical infrastructure or evacuation routes. Modeling would need to be completed to confirm that the CBB doesn't induce flooding north of the structure from Little Egg Inlet. .	As of now, the full extent of the indirect impacts of a SSB and CBBs are not understood. There is risk that these structures could result in environmental degradation, which can have negative impacts on the recreational and aquaculture industries in the study area. However, SSBs will reduce coastal storm risk in mainland communities such as Somers Point, Linwood, and Northfield during low frequency events when the barrier is closed. Residual risk to infrastructure and properties that don't qualify for elevation could reduce the robustness of coastal communities north of the Absecon Blvd CBB. No CSRM on around Corson Inlet can have negative impacts on these communities. .
4G(6)	SSBs will manage risk from low frequency storms in the area of influence around Great Egg Harbor but will not address the risk to communities from higher frequency events. Nonstructural measures to the north of the Absecon Bay Blvd and around Corson Inlet will reduce risk to structures from nuisance flooding but will not impact other critical infrastructure such as roads.	SSBs and CBBs will manage risk from low frequency coastal storms but will not address the risk to communities from higher frequency events. There is risk that elevating structures north of the Absecon Bay Blvd closure and around Corson Inlet might create a false sense of security during a storm event reducing compliance with evacuation orders. People sheltering in place could increase both their personal risk and the risk to emergency responders.	Exposure of critical infrastructure and evacuation routes is lessened around Great Egg Inlet and south of the Absecon Blvd CBB during low frequency events when the SSB is closed. However, infrastructure is vulnerable when the SSBs are open. The construction of the CBB will elevate Absecon Blvd, which will reduce exposure of the evacuation route to coastal storm risk. North of the CBB and around Corson Inlet, there is no risk management to critical infrastructure or evacuation routes. Modeling would need to be completed to confirm that the CBB doesn't induce flooding north of the structure from Little Egg Inlet.	As of now, the full extent of the indirect impacts of a SSB and CBBs are not understood. There is risk that these structures could result in environmental degradation, which can have negative impacts on the recreational and aquaculture industries in the study area. However, SSBs will reduce coastal storm risk in mainland communities such as Somers Point, Linwood, and Northfield during low frequency events when the barrier is closed. Residual risk to infrastructure and properties that don't qualify for elevation could reduce the robustness of coastal communities north of the Absecon Blvd CBB and around Corson Inlet.
4G(7)	SSBs will manage risk from low frequency storms in the area of influence around Great Egg Harbor but will not address the risk to communities from higher frequency events. Nonstructural measures to the north of the Absecon Bay Blvd and around Corson Inlet will reduce risk to structures from nuisance flooding but will not impact other critical infrastructure such as roads. The floodwall in Southern Ocean City will reduce inundation from higher frequency events. .	SSBs and CBBs will manage risk from low frequency coastal storms but will not address the risk to communities from higher frequency events. There is risk that elevating structures north of the Absecon Bay Blvd closure and around Corson Inlet might create a false sense of security during a storm event reducing compliance with evacuation orders. People sheltering in place could increase both their personal risk and the risk to emergency responders.	Exposure of critical infrastructure and evacuation routes is lessened around Great Egg Inlet and south of the Absecon Blvd CBB during low frequency events when the SSB is closed. However, infrastructure is vulnerable when the SSBs are open. The construction of the CBB will elevate Absecon Blvd, which will reduce exposure of the evacuation route to coastal storm risk. The floodwall in Southern Ocean City could improve risk management for critical infrastructure in this area. North of the CBB and around Corson Inlet, there is no risk management to critical infrastructure or evacuation routes. Modeling would need to be completed to confirm that the CBB doesn't induce flooding north of the structure from Little Egg Inlet.	As of now, the full extent of the indirect impacts of a SSB and CBBs are not understood. There is risk that these structures could result in environmental degradation, which can have negative impacts on the recreational and aquaculture industries in the study area. However, SSBs will reduce coastal storm risk in mainland communities such as Somers Point, Linwood, and Northfield during low frequency events when the barrier is closed. Residual risk to infrastructure and properties that don't qualify for elevation could reduce the robustness of coastal communities north of the Absecon Blvd CBB and around Corson Inlet. There is potential for reduction in bayside views and access by floodwalls in Southern Ocean City. Real estate easements required to construct walls could be difficult to obtain.

Alternative	Nuisance Flooding	Social Risk and Vulnerability	Infrastructure Exposure	Community Cohesion
4G(8)	SSBs and CBBs will manage risk from low frequency storms in the area of influence around Great Egg Harbor but will not address the risk to communities from higher frequency events. Nonstructural measures to the north of the Absecon Bay Blvd will reduce risk to structures from nuisance flooding but will not impact other critical infrastructure such as roads.	SSBs and CBBs will manage risk from low frequency coastal storms but will not address the risk to communities from higher frequency events. There is risk that elevating structures north of the Absecon Bay Blvd closure might create a false sense of security during a storm event reducing compliance with evacuation orders. People sheltering in place could increase both their personal risk and the risk to emergency responders.	Exposure of critical infrastructure and evacuation routes is lessened around Great Egg Inlet and south of the Absecon Blvd CBB during low frequency events when the SSB and CBBs are closed. However, infrastructure is vulnerable when the SSBs are open. The construction of the Absecon Blvd CBB will elevate Absecon Blvd, which will reduce exposure of the evacuation route to coastal storm risk. North of the CBB, there is no risk management to critical infrastructure or evacuation routes. Modeling would need to be completed to confirm that the CBB doesn't induce flooding north of the structure from Little Egg Inlet.	As of now, the full extent of the indirect impacts of a SSB and CBBs are not understood. There is risk that these structures could result in environmental degradation, which can have negative impacts on the recreational and aquaculture industries in the study area. However, SSBs will reduce coastal storm risk in mainland communities such as Somers Point, Linwood, and Northfield during low frequency events when the barrier is closed. Residual risk to infrastructure and properties that don't qualify for elevation could reduce the robustness of coastal communities north of the Absecon Blvd CBB.
4G(9)	P SSBs will manage risk from low frequency storms in the area of influence around Great Egg Harbor but will not address the risk to communities from higher frequency events. Nonstructural measures to the north of the Absecon Bay Blvd on the mainland will reduce risk to structures from nuisance flooding but will not impact other critical infrastructure such as roads. The floodwall around Brigantine will reduce inundation from higher frequency events. No CSRM is provided to communities around Corson Inlet.	SSBs and CBBs will manage risk from low frequency coastal storms but will not address the risk to communities from higher frequency events. Additionally, communities around Corson Inlet remain vulnerable as this inlet will not be closed. There is risk that elevating structures on the mainland north of the Absecon Bay Blvd closure might create a false sense of security during a storm event reducing compliance with evacuation orders. People sheltering in place could increase both their personal risk and the risk to emergency responders.	Exposure of critical infrastructure and evacuation routes is lessened around Great Egg Inlet and south of the Absecon Blvd CBB during low frequency events when the SSB is closed. However, infrastructure is vulnerable when the SSBs are open. The construction of the CBB will elevate Absecon Blvd, which will reduce exposure of the evacuation route to coastal storm risk. The floodwall around Brigantine could improve risk management for critical infrastructure in this area. On the mainland north of the Absecon Blvd CBB and around Corson Inlet, there is no risk management to critical infrastructure or evacuation routes. Modeling would need to be completed to confirm that the CBB doesn't induce flooding north of the structure from Little Egg Inlet.	As of now, the full extent of the indirect impacts of a SSB and CBBs are not understood. There is risk that these structures could result in environmental degradation, which can have negative impacts on the recreational and aquaculture industries in the study area. However, SSBs will reduce coastal storm risk in mainland communities such as Somers Point, Linwood, and Northfield during low frequency events when the barrier is closed. Residual risk to infrastructure and properties that don't qualify for elevation could reduce the robustness of coastal communities on the mainland north of the Absecon Blvd CBB. There is potential for reduction in bayside views and access by floodwalls in Brigantine. Real estate easements required to construct walls could be difficult to obtain. No CSRM on around Corson Inlet can have negative impacts on these communities.
4G(10)	SSBs will manage risk from low frequency storms in the area of influence around Great Egg Harbor but will not address the risk to communities from higher frequency events. Nonstructural measures to the north of the Absecon Bay Blvd on the mainland and around Corson Inlet to the south will reduce risk to structures from nuisance flooding but will not impact other critical infrastructure such as roads. The floodwall around Brigantine will reduce inundation from higher frequency events.	SSBs and CBBs will manage risk from low frequency coastal storms but will not address the risk to communities from higher frequency events. There is risk that elevating structures on the mainland north of the Absecon Bay Blvd closure and to the south around Corson Inlet might create a false sense of security during a storm event reducing compliance with evacuation orders. People sheltering in place could increase both their personal risk and the risk to emergency responders.	Exposure of critical infrastructure and evacuation routes is lessened around Great Egg Inlet and south of the Absecon Blvd CBB during low frequency events when the SSB is closed. However, infrastructure is vulnerable when the SSBs are open. The construction of the CBB will elevate Absecon Blvd, which will reduce exposure of the evacuation route to coastal storm risk. The floodwall around Brigantine could improve risk management for critical infrastructure in this area. On the mainland north of the Absecon Blvd CBB and around Corson Inlet, there is no risk management to critical infrastructure or evacuation routes. Modeling would need to be completed to confirm that the CBB doesn't induce flooding north of the structure from Little Egg Inlet.	As of now, the full extent of the indirect impacts of a SSB and CBBs are not understood. There is risk that these structures could result in environmental degradation, which can have negative impacts on the recreational and aquaculture industries in the study area. However, SSBs will reduce coastal storm risk in mainland communities such as Somers Point, Linwood, and Northfield during low frequency events when the barrier is closed. Residual risk to infrastructure and properties that don't qualify for elevation could reduce the robustness of coastal communities on the mainland north of the Absecon Blvd CBB and to the south around Corson Inlet. There is potential for reduction in bayside views and access by floodwalls in Brigantine. Real estate easements required to construct walls could be difficult to obtain.

Alternative	Nuisance Flooding	Social Risk and Vulnerability	Infrastructure Exposure	Community Cohesion
4G(11)	SSBs will manage risk from low frequency storms in the area of influence around Great Egg Harbor but will not address the risk to communities from higher frequency events. Nonstructural measures to the north of the Absecon Bay Blvd on the mainland and around Corson Inlet to the south will reduce risk to structures from nuisance flooding but will not impact other critical infrastructure such as roads. The floodwalls around Brigantine and southern Ocean City will reduce inundation from higher frequency events.	SSBs and CBBs will manage risk from low frequency coastal storms but will not address the risk to communities from higher frequency events. There is risk that elevating structures on the mainland north of the Absecon Bay Blvd closure and to the south around Corson Inlet might create a false sense of security during a storm event reducing compliance with evacuation orders. People sheltering in place could increase both their personal risk and the risk to emergency responders.	Exposure of critical infrastructure and evacuation routes is lessened around Great Egg Inlet and south of the Absecon Blvd CBB during low frequency events when the SSB is closed. However, infrastructure is vulnerable when the SSBs are open. The construction of the CBB will elevate Absecon Blvd, which will reduce exposure of the evacuation route to coastal storm risk. The floodwalls around Brigantine and southern Ocean City could improve risk management for critical infrastructure in this area. On the mainland north of the Absecon Blvd CBB and around Corson Inlet, there is no risk management to critical infrastructure or evacuation routes. Modeling would need to be completed to confirm that the CBB doesn't induce flooding north of the structure from Little Egg Inlet.	As of now, the full extent of the indirect impacts of a SSB and CBBs are not understood. There is risk that these structures could result in environmental degradation, which can have negative impacts on the recreational and aquaculture industries in the study area. However, SSBs will reduce coastal storm risk in mainland communities such as Somers Point, Linwood, and Northfield during low frequency events when the barrier is closed. Residual risk to infrastructure and properties that don't qualify for elevation could reduce the robustness of coastal communities on the mainland north of the Absecon Blvd CBB and to the south around Corson Inlet. There is potential for reduction in bayside views and access by floodwalls in Brigantine and southern Ocean City. Real estate easements required to construct walls could be difficult to obtain.
4G(12)	SSBs will manage risk from low frequency storms in the area of influence around Great Egg Harbor but will not address the risk to communities from higher frequency events. Nonstructural measures to the north of the Absecon Bay Blvd on the mainland will reduce risk to structures from nuisance flooding but will not impact other critical infrastructure such as roads. The floodwall around Brigantine will reduce inundation from higher frequency events.	SSBs and CBBs will manage risk from low frequency coastal storms but will not address the risk to communities from higher frequency events. . There is risk that elevating structures on the mainland north of the Absecon Bay Blvd closure might create a false sense of security during a storm event reducing compliance with evacuation orders. People sheltering in place could increase both their personal risk and the risk to emergency responders.	Exposure of critical infrastructure and evacuation routes is lessened around Great Egg Inlet and south of the Absecon Blvd CBB during low frequency events when the SSB is closed. However, infrastructure is vulnerable when the SSBs are open. The construction of the Absecon Blvd CBB will elevate Absecon Blvd, which will reduce exposure of the evacuation route to coastal storm risk. The floodwall around Brigantine could improve risk management for critical infrastructure in this area. On the mainland north of the Absecon Blvd CBB there is no risk management to critical infrastructure or evacuation routes. Modeling would need to be completed to confirm that the CBB doesn't induce flooding north of the structure from Little Egg Inlet.	As of now, the full extent of the indirect impacts of a SSB and CBBs are not understood. There is risk that these structures could result in environmental degradation, which can have negative impacts on the recreational and aquaculture industries in the study area. However, SSBs will reduce coastal storm risk in mainland communities such as Somers Point, Linwood, and Northfield during low frequency events when the barrier is closed. Residual risk to infrastructure and properties that don't qualify for elevation could reduce the robustness of coastal communities on the mainland north of the Absecon Blvd CBB. There is potential for reduction in bayside views and access by floodwalls in Brigantine. Real estate easements required to construct walls could be difficult to obtain.
SOUTH REGION				
5A	No reduction in inundation during higher frequency events	There is risk that elevating structures might create a false sense of security during a storm event reducing compliance with evacuation orders. People sheltering in place could increase both their personal risk and the risk to emergency responders.	No reduction of exposure of critical infrastructure and evacuation routes	Residual risk to infrastructure and properties that don't qualify for elevation could reduce the robustness of coastal communities. Additionally, there might be community opposition to selective elevating of structures and the needed real estate easements.
5D(1)	No reduction in inundation during higher frequency events in Strathmere and 7 Mile Island. Floodwalls and Levees would reduce inundation during higher frequency events in Cape May, the Wildwoods, and Sea Isle City.	There is risk that elevating structures might create a false sense of security during a storm event reducing compliance with evacuation orders. People sheltering in place could increase both their personal risk and the risk to emergency responders.	Exposure of critical infrastructure and evacuation routes is lessened in the Wildwoods, Cape May, and Sea Isle City. Exposure to critical infrastructure is not lessened in Strathmere and 7 Mile Island. Infrastructure and evacuation routes remain vulnerable on the mainland.	Residual risk to infrastructure and properties that don't qualify for elevation in Strathmere, and 7 Mile Island could reduce the robustness of those coastal communities. Additionally, there might be community opposition to selective elevating of structures and the needed real estate easements. Along the floodwalls in Sea Isle City, the Wildwoods, and Cape May, there is potential for reduction in bayside views and access by floodwalls. There will also likely be difficulties in obtaining real estate easements required to construct walls.

Alternative	Nuisance Flooding	Social Risk and Vulnerability	Infrastructure Exposure	Community Cohesion
5D(2)	No reduction in inundation during higher frequency events in Strathmere. Floodwalls and Levees would reduce inundation during higher frequency events in Cape May, the Wildwoods, 7 Mile Island and Sea Isle City.	There is risk that elevating structures might create a false sense of security during a storm event reducing compliance with evacuation orders in Strathmere. People sheltering in place could increase both their personal risk and the risk to emergency responders.	Exposure of critical infrastructure and evacuation routes is lessened in the Wildwoods, Cape May, 7 Mile Island and Sea Isle City. Exposure to critical infrastructure is not lessened in Strathmere. Infrastructure and evacuation routes remain vulnerable on the mainland.	Residual risk to infrastructure and properties that don't qualify for elevation could reduce the robustness of coastal communities. Additionally, there might be community opposition to selective elevating of structures and the needed real estate easements.
Note: Alternative plans shaded in green represent the NED/Additional Decision Criteria Maximizing Plan. .				

7.5.7 Planning Criteria Screening Analyses

After alternatives were screened using the NED, RED, EQ and OSE system of accounts criteria, the remaining alternatives were qualitatively assessed and screened against the four planning criteria. Reference ER 1105-2-100, Section 2-3, c (2), states, "As a general rule projects must be formulated to reasonably maximize benefits to the national economy, to the environment or to the sum of both. Each alternative plan shall be formulated in consideration of four criteria described in the Principles and Guidelines (1983): completeness, efficiency, effectiveness, and acceptability."

A summary of findings for each of the planning criteria by measure type is provided below. A detailed presentation of the results of these analyses are provided in the Plan Formulation Appendix.

Completeness is the extent to which an alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of planned effects (ER 1105-2-100):

- Nonstructural plans ranked medium or low as these plans do not reduce residual risk or protect structures and infrastructure.
- Perimeter Plans ranked low because there is a potential increase incremental life loss consequence in the case of structure failure although floodwalls and levees are adaptable to sea level rise as additional nonstructural or perimeter measures can be implemented over time without adding expensive adaptability costs to initial construction.
- Storm surge barriers and CBBs ranked low because of the risk associated with the very high uncertainty of indirect impacts to water quality and circulation.

Efficiency is the extent to which a plan is most cost effective and if resources are used efficiently (ER 1105-2-100):

- Nonstructural plans ranked high, with high BCRs and lower environmental impacts because construction footprint is of limited area extent. Net benefits might be higher relative to other measures as mitigation costs are refined.
- Perimeter Plans ranked low, because floodwalls and levees have the potential for elevated mitigation or real estate costs as the design is adapted in the future.
- Storm surge barriers and CBBs ranked low because there is high uncertainty for elevated mitigation for indirect effects of SSBs.

Effectiveness is the extent to which an alternative plan alleviates the specified problems (the most effective plans make significant contributions to all planning objectives) (ER 1105-2-100):

- Nonstructural plans ranked medium because nonstructural solutions do not reduce risk to infrastructure.
- Perimeter Plans ranked low, because floodwalls and levees increase "with project" incremental life loss in case of failure of the structure. Perimeter structural measures are at risk of structural failure when wave overtopping exceeds the design standard and have limited storage capacity behind the

measures to accommodate the water overtopping the wall before damages are incurred.

- Storm Surge Barriers and CBBs ranked high because they provide an adaptable approach to flood risk management and have flexibility with operation and maintenance. SSBs, in contrast to perimeter structural measures, are not as susceptible to structural failure from wave overtopping and are able to disperse and store the water overtopping the barriers over a much larger area throughout the bays. While it is possible that a failure of the SSB at a floodwall or levee would be a rapid failure, a more likely potential scenario considers a slower rise in water level associated with a gate being unable to close, or a gate opening prematurely, or if another failure occurred allowing a slower flow of water into the bay. As a result, the water level in the bay would have to rise before the land flooded, and additional evacuations would be possible.

Acceptability considers the workability and viability of alternatives with regard to State and local entities, and compatibility with existing laws (ER 1105-2-100):

- Nonstructural plans ranked medium because of the elevated risk associated with uncertainty about compliance with state and local laws.
- Perimeter plans ranked low because of the risk associated with very high uncertainty whether or not the high direct impacts of a floodwall would be acceptable to resource agencies.
- Storm surge barriers and CBBs ranked low because of the associated with the very high uncertainty of indirect impacts to water quality and circulation.

Table 67 provides the specifics associated with the analysis and screening of the twenty alternatives in the focused array against the four planning criteria. The alternatives were ranked using high, medium, and low, rather than pass/fail. The focused array of alternatives is presented in this table by the Shark River & Coastal Lakes, North, Central and South regions of the study area. Alternatives that successfully meet the planning criteria as well as the system of accounts criteria discussed previously will be considered as part of the TSP. These alternatives are highlighted in green. Alternatives to be potentially considered for additional analyses based on the NED analysis are highlighted in yellow.

Table 67: Planning Criteria Screening Analyses of the Focused Array of Alternatives

NJBB TSP IPR Focused Array Comparison		Planning Criteria			
		Effectiveness	Efficiency	Acceptability	Completeness
Shark River & Coastal Lakes					
2A	All Nonstructural	Medium - will reduce damages to buildings (i.e., structure and content), but does not reduce risk to infrastructure (e.g., roads, utilities, etc.)	High (BCR>1) - environmental impacts likely lowest compared to other measures because of construction within the footprint; therefore, net benefits may be highest relative to other measures as mitigation costs are refined	Medium - There is risk due to uncertainty of implementability of nonstructural measures due to remaining questions about compliance with state and local laws.	Low - Very high residual risk (69%); as we refine the analysis and community participation rates, residual risk may increase for non-. Nonstructural measures do not reduce risk to infrastructure.
North Region (Manasquan to Little Egg Inlet)					
3A	All Nonstructural	Medium - will reduce damages to buildings (i.e., structure and content), but does not reduce risk to infrastructure (e.g., roads, utilities, etc.)	High (BCR = 2) - environmental impacts likely lowest compared to other measures because construction is within the footprint; therefore, net benefits may be highest relative to other measures as mitigation costs are refined	Medium - There is risk due to uncertainty of implementability of nonstructural measures due to remaining questions about compliance with state and local laws.	Low - Provides CRSM to both mainland and barrier islands. Nonstructural measures do not reduce risk to infrastructure. As we refine the analysis and community participation rates, residual risk may increase for nonstructural.
3D	Limited Perimeter (Manasquan Inlet) + Non - Structural	Low - Nonstructural measures such as building elevation will reduce damages to structures (i.e., structure and content), but do not reduce risk to infrastructure on the mainland. Behind the	Medium (BCR>1) - has the potential for elevated mitigation or real estate costs as	Low - There is risk that the project may not be implementable due to environmental laws. This	Low - Provides CRSM to both mainland and barrier islands. Perimeter measures not adaptable to sea level rise and may cause a

NJBB TSP IPR Focused Array Comparison		Planning Criteria			
		Effectiveness	Efficiency	Acceptability	Completeness
		Manasquan North floodwall, the floodwall will manage risk for both high and low frequency events; however, perimeter measures would result in increased "with project" incremental life loss in the case of failure of the structure. This potential structure failure coupled with the potential for increased community complacency (i.e., if people don't evacuate based on the presence of the perimeter wall) could contribute to increased “with project” incremental life loss consequences. In addition, the perimeter plan is not adaptable to sea level rise, which could further exacerbate life loss potential.	design is refined for the perimeter plan. Net benefits for the nonstructural component may highest relative to other measures as mitigation costs are refined; environmental impacts are likely lowest compared to other measures because construction is within the footprint	risk is based in the very high uncertainty whether the high direct impacts of a floodwall would be acceptable to resource agencies. There is also risk due to uncertainty of implementing nonstructural measures due to remaining questions about compliance with state and local laws.	potential for increased community complacency (i.e., if people don't evacuate based on the presence of the perimeter wall); thereby, potentially increasing with project incremental life loss consequences in the case of structure failure. Nonstructural measures do not reduce risk to infrastructure. As we refine the analysis and community participation rates, residual risk may increase for nonstructural.
3E(2)	Barnegat Inlet and Manasquan Inlet SSB + Nonstructural	High - SSBs will reduce coastal storm risk during low frequency events but will likely not reduce risk from more frequent storm events. SSBs provide an adaptable approach to flood risk management; flexibility with operation and maintenance (i.e., timing and frequency of gate opening/closing). Less potential for elevated incremental life loss (as compared to a perimeter measure) if overtopped. Nonstructural measures such as building elevation will reduce damages to buildings (i.e., structure and content), but do not reduce risk to other infrastructure	Medium (BCR>1) - high uncertainty for elevated mitigation for indirect effects of SSBs. Net benefits for the nonstructural component may be highest relative to other measures as mitigation costs are refined; environmental impacts are likely lowest compared to other measures because construction is within the footprint	Low - There is risk that the project may not be implementable due to environmental laws. This risk is based in the very high uncertainty of indirect impacts to water quality and circulation from SSBs. There is risk due to uncertainty of implementing nonstructural measures due to remaining questions about compliance with state and local laws.	Low - Provides CSRM benefits to both barrier islands and mainland communities, but likely only during low frequency events. Implementation and maintenance of SSBs may be cost prohibitive. Nonstructural measures do not reduce risk to infrastructure. As we refine the analysis and community participation rates, residual risk may increase for nonstructural.
3E(3)	Barnegat Inlet and Manasquan Inlet	Low - SSBs will reduce coastal storm risk during low frequency events but will likely not reduce risk from	Low (BCR>1) - high uncertainty for	Low - There is risk that the project may not be	Low - Lowest residual risk plan in this region (18%). Provides CSRM to

NJBB TSP IPR Focused Array Comparison		Planning Criteria			
		Effectiveness	Efficiency	Acceptability	Completeness
	SSB + Nonstructural + Southern LBI Perimeter	more frequent storm events. SSBs provide an adaptable approach to flood risk management; flexibility with operation and maintenance (i.e., timing and frequency of gate opening/closing). Less potential for elevated incremental life loss if overtopped (as compared to the perimeter measure). Nonstructural measures such as building elevation will reduce damages to buildings (i.e., structure and content), but do not reduce risk to other infrastructure on the mainland. In southern LBI, the floodwall will manage risk for both high and low frequency event; however, perimeter measures would result in increased with project incremental life loss in the case of failure of the structure. This potential structure failure coupled with the potential for increased community complacency (i.e., if people don't evacuate based on the presence of the perimeter wall) could contribute to increased "with project" incremental life loss consequences. In addition, the perimeter plan is not adaptable to sea level rise, which could further exacerbate life loss potential.	elevated mitigation for indirect effects of SSBs. Perimeter plan component has the potential for elevated mitigation or real estate costs as design is refined. Net benefits for the nonstructural component may be highest relative to other measures as mitigation costs are refined; environmental impacts are likely lowest compared to other measures because construction is within the footprint	implementable due to environmental laws. This risk is based in the very high uncertainty of indirect impacts to water quality and circulation from SSBs and high uncertainty whether the high direct impacts of a floodwall would be acceptable to resource agencies. There is also risk due to uncertainty of implementing nonstructural measures due to remaining questions about compliance with state and local laws.	both mainland and barrier islands. Perimeter measures not adaptable to sea level rise and may cause a potential for increased community complacency (i.e., if people don't evacuate based on the presence of the perimeter wall); thereby, potentially increasing with project incremental life loss consequences in the case of structure failure. Implementation and maintenance of SSBs may be cost prohibitive. Nonstructural measures do not reduce risk to infrastructure. As we refine the analysis and community participation rates, residual risk may increase for nonstructural.
Central Region (Brigantine to Corson's Inlet)					
4A	All Nonstructural	Medium - will reduce damages to buildings (i.e., structure and content), but does not reduce risk to infrastructure (e.g., roads, utilities, etc.)	High (BCR>2) - environmental impacts likely lowest compared to other measures because construction is within the footprint; net benefits may be highest relative to other plans as	Medium - There is risk due to uncertainty of implementability of nonstructural measures due to remaining questions about compliance with state and local laws.	Low - High residual risk (47%). Provides CRSM to both mainland and barrier islands. Nonstructural measures do not reduce risk to infrastructure. As we refine the analysis and community participation rates, residual risk may increase for nonstructural.

NJBB TSP IPR Focused Array Comparison		Planning Criteria			
		Effectiveness	Efficiency	Acceptability	Completeness
			mitigation costs are refined		
4D(1)	All Perimeter Less Brigantine + nonstructural	Low - Nonstructural measures such as building elevation will reduce damages to buildings (i.e., structure and content), but do not reduce risk to other infrastructure on the mainland. In Ocean City and Absecon Island, the floodwalls will manage risk for both high and low frequency events; however, perimeter measures would result in increased "with project" incremental life loss in the case of failure of the structure. This potential structure failure coupled with the potential for increased community complacency (i.e., if people don't evacuate based on the presence of the perimeter wall) could contribute to increased "with project" incremental life loss consequences. In addition, the perimeter plan is not adaptable to sea level rise, which could further exacerbate life loss potential.	Low (BCR>1) - perimeter plan has the potential for elevated mitigation or real estate costs as the design is refined. Net benefits for the nonstructural component may be highest relative to other measures as mitigation costs are refined; environmental impacts are likely lowest compared to other measures because construction is within the footprint	Low - There is risk that the project may not be implementable due to environmental laws. This risk is based in the very high uncertainty whether the high direct impacts of a floodwall would be acceptable to resource agencies. There is also risk due to uncertainty of implementing nonstructural measures due to remaining questions about compliance with state and local laws.	Low - Provides CSRM benefits to both barrier islands (Except Brigantine) and mainland communities. Perimeter measures not adaptable to sea level rise and may cause a potential for increased community complacency (i.e., if people don't evacuate based on the presence of the perimeter wall); thereby, potentially increasing with project incremental life loss consequences in the case of structure failure. Nonstructural measures do not reduce risk to infrastructure. Plan has low residual risk. As we refine the analysis and community participation rates, residual risk may increase for nonstructural.
4D(2)	All Perimeter + Nonstructural	Low - Nonstructural measures such as building elevation will reduce damages to buildings, but do not reduce risk to other infrastructure on the mainland. In Ocean City, Absecon Island, and Brigantine, the floodwalls will manage risk for both high and low frequency events. Perimeter measures would result in high potential for incremental life loss associated with based on complacency (i.e., if people don't evacuate) and because water levels would increase in case of a failure. Perimeter plan is	Low (BCR>1) - perimeter plan has the potential for elevated mitigation or real estate costs as the design is refined. Net benefits for the nonstructural component may be highest relative to other measures as	Low - There is risk that the project may not be implementable due to environmental laws. This risk is based in the very high uncertainty whether the high direct impacts of a floodwall would be acceptable to resource agencies. There is also risk due to uncertainty of	Medium - Provides CSRM benefits to both barrier islands and mainland communities. Perimeter measures not adaptable to sea level rise and may cause a potential for increased community complacency (i.e., if people don't evacuate based on the presence of the perimeter wall); thereby, potentially increasing with project incremental life loss consequences in the case of

NJBB TSP IPR Focused Array Comparison		Planning Criteria			
		Effectiveness	Efficiency	Acceptability	Completeness
		not adaptable with sea level rise and could exacerbate life loss potential.	mitigation costs are refined; environmental impacts are likely lowest compared to other measures because construction is within the footprint	implementing nonstructural measures due to remaining questions about compliance with state and local laws.	structure failure. Nonstructural measures do not reduce risk to infrastructure. Plan has low residual risk. As we refine the analysis and refine community participation rates, residual risk may increase for nonstructural.
4E(2)	Absecon Inlet and Great Egg SSB + Nonstructural	High - SSBs will reduce coastal storm risk during low frequency events but will likely not reduce risk from more frequent storm events. SSBs provide an adaptable approach to flood risk management; flexibility with operation and maintenance (i.e., timing and frequency of gate opening/closing). Less potential for elevated incremental life loss if overtopped (relative to perimeter measures). Nonstructural measures such as building elevation north of Corson's Inlet and in the vicinity of Absecon, will reduce damages to buildings, but do not reduce risk to infrastructure	Low (BCR>1) - high uncertainty for elevated mitigation for indirect effects of SSBs. Net benefits for the nonstructural component be highest relative to other measures as mitigation costs are refined; environmental impacts are likely lowest compared to other measures because construction is within the footprint	Low - There is risk that the project may not be implementable due to environmental laws. This risk is based in the very high uncertainty of indirect impacts to water quality and circulation from SSBs. There is also risk due to uncertainty of implementing nonstructural measures due to remaining questions about compliance with state and local laws.	Low - Provides CSRM benefits to both barrier islands and mainland communities, but likely only during low frequency events. Implementation and maintenance of SSBs may be cost prohibitive. Nonstructural measures do not reduce risk to infrastructure. Plan has low residual risk. As we refine the analysis and refine community participation rates, residual risk may increase for nonstructural.
4E(3)	Absecon Inlet and Great Egg SSB + Southern Ocean City Perimeter +Nonstructural	Low- SSBs will reduce coastal storm risk during low frequency events but will likely not reduce risk from more frequent storm events. SSBs provide an adaptable approach to flood risk management; flexibility with operation and maintenance (i.e., timing and frequency of gate opening/closing). Less potential for elevated incremental life loss if overtopped (relative to perimeter measures). Nonstructural measures such as building elevation	Low (BCR>1) - high uncertainty for elevated mitigation for the SSBs for indirect effects. Perimeter plan has the potential for elevated mitigation or real estate costs as the design is refined. Net	Low - There is risk that the project may not be implementable due to environmental laws. This risk is based in the very high uncertainty of indirect impacts to water quality and circulation from SSBs and very high uncertainty	Low - Provides CSRM benefits to both barrier islands and mainland communities, but only during low frequency events. The floodwall in Ocean City will provide CRSM during high-frequency events. Perimeter measures not adaptable to sea level rise and may cause a potential for increased community complacency

NJBB TSP IPR Focused Array Comparison		Planning Criteria			
		Effectiveness	Efficiency	Acceptability	Completeness
		north of Corson's Inlet and in the vicinity of Absecon, will reduce damages to buildings, but do not reduce risk to infrastructure. The floodwall in southern Ocean City will manage risk from high and low frequency events; however, perimeter measures would result in increased "with project" incremental life loss in the case of failure of the structure. This potential structure failure coupled with the potential for increased community complacency (i.e., if people don't evacuate based on the presence of the perimeter wall) could contribute to increased "with project" incremental life loss consequences. In addition, the perimeter plan is not adaptable to sea level rise, which could further exacerbate life loss potential.	benefits for the nonstructural component may be highest relative to other measures as mitigation costs are refined; environmental impacts are likely lowest compared to other measures because construction is within the footprint	whether the high direct impacts of a floodwall would be acceptable to resource agencies. There is also risk due to uncertainty of implementing nonstructural measures due to remaining questions about compliance with state and local laws.	(i.e., if people don't evacuate based on the presence of the perimeter wall); thereby, potentially increasing with project incremental life loss consequences in the case of structure failure. Nonstructural measures will manage risk to structures, but not infrastructure. Plan has low residual risk. As we refine the analysis and refine community participation rates, residual risk may increase for nonstructural.
4E(4)	Absecon Inlet and Great Egg SSB + Southern Ocean City CBB + Nonstructural in Absecon	High - SSBs will reduce coastal storm risk during low frequency events but will likely not reduce risk from more frequent storm events. SSBs provide an adaptable approach to flood risk management; flexibility with operation and maintenance (i.e., timing and frequency of gate opening/closing). Less potential for elevated incremental life loss if overtopped (relative to perimeter measures). Nonstructural measures such as building elevation north of Corson's Inlet and in the vicinity of Absecon, will reduce damages to buildings, but do not reduce risk to infrastructure.	Low (BCR>1) - high uncertainty for elevated mitigation for the SSBs and CBB from indirect effects. Net benefits for the nonstructural component may be highest relative to other measures as mitigation costs are refined; environmental impacts are likely lowest compared to other measures because construction is within the footprint	Low - There is risk that the project may not be implementable due to environmental laws. This risk is based in the very high uncertainty of indirect impacts to water quality and circulation from SSBs. There is also risk due to uncertainty of implementing nonstructural measures due to remaining questions about compliance with state and local laws.	Low - Provides CSRM benefits to both barrier islands and mainland communities, but likely only during low frequency events. Implementation and maintenance of SSBs may be cost prohibitive. Nonstructural measures will manage risk to structures, but not infrastructure. Plan has low residual risk. As we refine the analysis and refine community participation rates, residual risk may increase for nonstructural.

NJBB TSP IPR Focused Array Comparison		Planning Criteria			
		Effectiveness	Efficiency	Acceptability	Completeness
4G(6)	Absecon Blvd CBB + Great Egg Harbor Inlet SSB + Nonstructural in Brigantine and Absecon + Nonstructural in Southern Ocean City	High - SSBs and CBBs will reduce coastal storm risk during low frequency events but will likely not reduce risk from more frequent storm events. SSBs provide an adaptable approach to flood risk management; flexibility with operation and maintenance (i.e., timing and frequency of gate opening/closing). Less potential for elevated incremental life loss if overtopped (relative to perimeter measures). Nonstructural measures such as building elevation north of the Absecon Blvd CBB will manage risk to structures, but not other critical infrastructure.	Low (BCR>1) - high uncertainty for elevated mitigation for the SSB and CBB from indirect effects. Net benefits for the nonstructural component may be highest relative to other measures as mitigation costs are refined; environmental impacts are likely lowest compared to other measures because construction is within the footprint	Low - There is risk that the project may not be implementable due to environmental laws. This risk is based in the very high uncertainty of indirect impacts to water quality and circulation from SSBs and CBBs. There is also risk due to uncertainty of implementing nonstructural measures due to remaining questions about compliance with state and local laws.	Low - Provides CSRM benefits to both barrier islands and mainland communities. Nonstructural measures do not reduce risk to infrastructure. Very low residual risk. Nonstructural measures do not reduce risk to other critical infrastructure. As we refine the analysis and refine community participation rates, residual risk may increase for nonstructural. Implementation and maintenance of SSBs and CBB may be cost prohibitive.
4G(7)	Absecon Blvd CBB + Great Egg Harbor Inlet SSB + Nonstructural in Brigantine and Absecon + Nonstructural and Perimeter in Southern Ocean City	Low - SSBs and CBBs will reduce coastal storm risk during low frequency events but will likely not reduce risk from more frequent storm events. SSBs provide an adaptable approach to flood risk management; flexibility with operation and maintenance (i.e., timing and frequency of gate opening/closing). Less potential for elevated incremental life loss if overtopped (relative to perimeter measures). Nonstructural measures such as building elevation north of the Absecon Blvd CBB will manage risk to structures, but not other critical infrastructure. The floodwall along southern Ocean City will manage risk from both high and low frequency events; however, perimeter measures would result in increased with project incremental	Low (BCR>1) - high uncertainty for elevated mitigation for the SSBs for indirect effects. Perimeter plan has the potential for elevated mitigation or real estate costs as the design is refined. Net benefits for the nonstructural may be highest relative to other measures as mitigation costs are refined; environmental	Low - There is risk that the project may not be implementable due to environmental laws. This risk is based in the very high uncertainty of indirect impacts to water quality and circulation from SSBs and CBBs and very high uncertainty whether the high direct impacts of a floodwall would be acceptable to resource agencies. There is also risk due to uncertainty of	Low - Provides CSRM benefits to both barrier islands and mainland communities. Perimeter measures not adaptable to sea level rise and may cause a potential for increased community complacency (i.e., if people don't evacuate based on the presence of the perimeter wall); thereby, potentially increasing with project incremental life loss consequences in the case of structure failure. Nonstructural measures do not reduce risk to infrastructure. Very low residual risk. As we refine the analysis and

NJBB TSP IPR Focused Array Comparison		Planning Criteria			
		Effectiveness	Efficiency	Acceptability	Completeness
		life loss in the case of failure of the structure. This potential structure failure coupled with the potential for increased community complacency (i.e., if people don't evacuate based on the presence of the perimeter wall) could contribute to increased "with project" incremental life loss consequences. In addition, the perimeter plan is not adaptable to sea level rise, which could further exacerbate life loss potential.	impacts are likely lowest compared to other measures because construction is within the footprint	implementing nonstructural measures due to remaining questions about compliance with state and local laws.	refine community participation rates, residual risk may increase for nonstructural. Implementation and maintenance of SSBs and CBB may be cost prohibitive.
4G(8)	Absecon Blvd CBB + Great Egg Harbor Inlet SSB + Nonstructural in Brigantine and Absecon + South Ocean City CBB	High - SSBs and CBBs will reduce coastal storm risk during low frequency events but will likely not reduce risk from more frequent storm events. SSBs provide an adaptable approach to flood risk management; flexibility with operation and maintenance (i.e., timing and frequency of gate opening/closing). Less potential for elevated incremental life loss if overtopped (relative to perimeter measures). Nonstructural measures such as building elevation north of the Absecon Blvd CBB will manage risk to structures, but not infrastructure.	Low (BCR>1) - high uncertainty for elevated mitigation for the SSBs and CBB. Net benefits for the nonstructural component may be highest relative to other measures as mitigation costs are refined; environmental impacts are likely lowest compared to other measures because construction is within the footprint	Low - There is risk that the project may not be implementable due to environmental laws. This risk is based in the very high uncertainty of indirect impacts to water quality and circulation from SSBs and CBBs. There is also risk due to uncertainty of implementing nonstructural measures due to remaining questions about compliance with state and local laws.	Low - Provides CSRM benefits to both barrier islands and mainland communities. Nonstructural measures do not reduce risk to other critical infrastructure. Very low residual risk. As we refine the analysis and refine community participation rates, residual risk may increase for nonstructural. Implementation and maintenance of SSBs and CBB may be cost prohibitive.
4G(10)	Absecon Blvd CBB + Great Egg Harbor SSB + Brigantine Perimeter + Nonstructural in Absecon + Nonstructural in	Low - SSBs and CBBs will reduce coastal storm risk during low frequency events but will likely not reduce risk from more frequent storm events. SSBs provide an adaptable approach to flood risk management; flexibility with operation and maintenance (i.e., timing and frequency of gate opening/closing). Less potential for elevated	Low (BCR>1) - high uncertainty for elevated mitigation for the SSBs for indirect effects. Perimeter plan has the potential for elevated mitigation or	Low - There is risk that the project may not be implementable due to environmental laws. This risk is based in the very high uncertainty of indirect impacts to water quality	Low - Provides CSRM benefits to both barrier islands and mainland communities. Perimeter measures not adaptable to sea level rise and may cause a potential for increased community complacency (i.e., if people don't evacuate based on the

NJBB TSP IPR Focused Array Comparison		Planning Criteria			
		Effectiveness	Efficiency	Acceptability	Completeness
	Southern Ocean City	incremental life loss if overtopped (relative to perimeter measures). Nonstructural measures such as building elevation north of the Absecon Blvd Bay and north of Corson's SSB will manage risk to structures, but not other critical infrastructure. The floodwall along Brigantine will manage risk from both high and low frequency events; however, perimeter measures would result in increased with project incremental life loss in the case of failure of the structure. This potential structure failure coupled with the potential for increased community complacency (i.e., if people don't evacuate based on the presence of the perimeter wall) could contribute to increased "with project" incremental life loss consequences. In addition, the perimeter plan is not adaptable to sea level rise, which could further exacerbate life loss potential.	real estate costs as the design is refined. Net benefits for the nonstructural component may be highest relative to other measures as mitigation costs are refined; environmental impacts are likely lowest compared to other measures because construction is within the footprint	and circulation from SSBs and CBBs and very high uncertainty whether the high direct impacts of a floodwall would be acceptable to resource agencies. There is also risk due to uncertainty of implementing nonstructural measures due to remaining questions about compliance with state and local laws.	presence of the perimeter wall); thereby, potentially increasing with project incremental life loss consequences in the case of structure failure. Nonstructural measures do not reduce risk to infrastructure. Very low residual risk. As we refine the analysis and refine community participation rates, residual risk may increase for nonstructural. Implementation and maintenance of SSBs and CBB may be cost prohibitive.
4G(11)	Absecon Blvd CBB + Great Egg Harbor SSB + Brigantine Perimeter + Nonstructural in Absecon + Nonstructural and Perimeter in Southern Ocean City	Low - SSBs and CBBs will reduce coastal storm risk during low frequency events but will likely not reduce risk from more frequent storm events. SSBs provide an adaptable approach to flood risk management; flexibility with operation and maintenance (i.e., timing and frequency of gate opening/closing). Less potential for elevated incremental life loss if overtopped (relative to perimeter measures). Nonstructural measures such as building elevation north of the Absecon Blvd Bay and north of Corson's SSB will manage risk to structures, but not other critical infrastructure. The floodwall along Brigantine and around southern Ocean City will manage risk from both high and low frequency events; however, perimeter measures	Low (BCR>1) - high uncertainty for elevated mitigation for the SSBs for indirect effects. Perimeter plan has the potential for elevated mitigation or real estate costs as the design is refined. Net benefits for the nonstructural component may be highest relative to other measures as mitigation costs are	Low - There is risk that the project may not be implementable due to environmental laws. This risk is based in the very high uncertainty of indirect impacts to water quality and circulation from SSBs and CBBs and very high uncertainty whether the high direct impacts of a floodwall would be acceptable to resource agencies. There is also risk due to uncertainty of	Low - Provides CSRM benefits to both barrier islands and mainland communities. Perimeter measures not adaptable to sea level rise and may cause a potential for increased community complacency (i.e., if people don't evacuate based on the presence of the perimeter wall); thereby, potentially increasing with project incremental life loss consequences in the case of structure failure. Nonstructural measures do not reduce risk to other critical infrastructure. Lowest residual risk plan in this region (8%).

NJBB TSP IPR Focused Array Comparison		Planning Criteria			
		Effectiveness	Efficiency	Acceptability	Completeness
		would result in increased with project incremental life loss in the case of failure of the structure. This potential structure failure coupled with the potential for increased community complacency (i.e., if people don't evacuate based on the presence of the perimeter wall) could contribute to increased "with project" incremental life loss consequences. In addition, the perimeter plan is not adaptable to sea level rise, which could further exacerbate life loss potential.	refined; environmental impacts are likely lowest compared to other measures because construction is within the footprint	implementing nonstructural measures due to remaining questions about compliance with state and local laws.	As we refine the analysis and refine community participation rates, residual risk may increase for nonstructural. Implementation and maintenance of SSBs and CBB may be cost prohibitive.
4G(12)	Absecon Blvd CBB + Great Egg Harbor SSB + Brigantine Perimeter + Nonstructural in Absecon + South Ocean City CBB	Low - SSBs and CBBs will reduce coastal storm risk during low frequency events but will likely not reduce risk from more frequent storm events. SSBs provide an adaptable approach to flood risk management; flexibility with operation and maintenance (i.e., timing and frequency of gate opening/closing). Less potential for elevated incremental life loss if overtopped (relative to perimeter measures). Nonstructural measures such as building elevation north of the Absecon Blvd Bay and north of Corson's Inlet closure will manage risk to structures, but not other critical infrastructure. The floodwall along Brigantine will manage risk from both high and low frequency events; however, perimeter measures would result in increased with project incremental life loss in the case of failure of the structure. This potential structure failure coupled with the potential for increased community complacency (i.e., if people don't evacuate based on the presence of the perimeter wall) could contribute to increased "with project" incremental life loss consequences. In addition, the perimeter plan is not	Low (BCR>1) - high uncertainty for elevated mitigation for the SSBs for indirect effects. Perimeter plan has the potential for elevated mitigation or real estate costs as the design is refined. Net benefits for the nonstructural component may be highest relative to other measures as mitigation costs are refined; environmental impacts are likely lowest compared to other measures because construction is within the footprint	Low - There is risk that the project may not be implementable due to environmental laws. This risk is based in the very high uncertainty of indirect impacts to water quality and circulation from SSBs and CBBs and very high uncertainty whether the high direct impacts of a floodwall would be acceptable to resource agencies. There is also risk due to uncertainty of implementing nonstructural measures due to remaining questions about compliance with state and local laws.	Low - Provides CSRM benefits to both barrier islands and mainland communities. Perimeter measures not adaptable to sea level rise and may cause a potential for increased community complacency (i.e., if people don't evacuate based on the presence of the perimeter wall); thereby, potentially increasing with project incremental life loss consequences in the case of structure failure. Nonstructural measures do not reduce risk to infrastructure. Lowest residual risk plan in this region. As we refine the analysis and refine community participation rates, residual risk may increase for nonstructural. Implementation and maintenance of SSBs and CBB may be cost prohibitive.

NJBB TSP IPR Focused Array Comparison		Planning Criteria			
		Effectiveness	Efficiency	Acceptability	Completeness
		adaptable to sea level rise, which could further exacerbate life loss potential.			
South Region (Strathmere to Cape May)					
5A	All Nonstructural	Medium - will reduce damages to buildings (i.e., structure and content), but does not reduce risk to infrastructure (e.g., roads, utilities, etc.)	High (BCR > 2) - environmental impacts likely lowest compared to other measures because construction is within the footprint; therefore, net benefits may be highest relative to other measures as mitigation costs are refined	Medium - There is risk due to uncertainty of implementability of nonstructural measures due to remaining questions about compliance with state and local laws.	Low - High residual risk (40%). Provides CRSM to both mainland and barrier islands. Nonstructural measures do not reduce risk to infrastructure. As we refine the analysis and refine community participation rates, residual risk may increase for nonstructural.
5D	All Perimeter Less Seven Miles/Strathmere nonstructural	Low - will reduce damages to buildings (i.e., structure and content), but do not reduce risk to other infrastructure on the mainland. In Cape May City, Wildwood Island and Sea Isle City, the floodwalls will manage risk for both high and low frequency events; however, perimeter measures would result in increased with project incremental life loss in the case of failure of the structure. This potential structure failure coupled with the potential for increased community complacency (i.e., if people don't evacuate based on the presence of the perimeter wall) could contribute to increased "with project" incremental life loss consequences. In addition, the perimeter plan is not adaptable to sea level rise, which could further exacerbate life loss potential.	Low (BCR>1) perimeter plan has the potential for elevated mitigation or real estate costs as the design is refined. Net benefits for the nonstructural component may be highest relative to other measures as mitigation costs are refined; environmental impacts are likely lowest compared to other measures because construction is within the footprint	Low - There is risk that the project may not be implementable due to environmental laws. This risk is based in the very high uncertainty whether the high direct impacts of a floodwall would be acceptable to resource agencies. There is also risk due to uncertainty of implementing nonstructural measures due to remaining questions about compliance with state and local laws.	Low - Provides CSRM benefits to both barrier islands and mainland communities. Perimeter measures not adaptable to sea level rise and may cause a potential for increased community complacency (i.e., if people don't evacuate based on the presence of the perimeter wall); thereby, potentially increasing with project incremental life loss consequences in the case of structure failure. Nonstructural measures do not reduce risk to infrastructure. As we refine the analysis and refine community participation rates, residual risk may increase for nonstructural.

NJBB TSP IPR Focused Array Comparison		Planning Criteria			
		Effectiveness	Efficiency	Acceptability	Completeness
5D(2)	All Perimeter Less Seven Mile + Nonstructural	Low - will reduce damages to buildings (i.e., structure and content), but do not reduce risk to other infrastructure on the mainland. In Cape May City, Wildwood Island, Seven Mile Island, and Sea Isle City, the floodwalls will manage risk for both high and low frequency events; however, perimeter measures would result in increased with project incremental life loss in the case of failure of the structure. This potential structure failure coupled with the potential for increased community complacency (i.e., if people don't evacuate based on the presence of the perimeter wall) could contribute to increased "with project" incremental life loss consequences. In addition, the perimeter plan is not adaptable to sea level rise, which could further exacerbate life loss potential.	Low (BCR>1) - perimeter plan has the potential for elevated mitigation or real estate costs as the design is refined. Net benefits for the nonstructural component may be highest relative to other measures as mitigation costs are refined; environmental impacts are likely lowest compared to other measures because construction is within the footprint	Low - There is risk that the project may not be implementable due to environmental laws. This risk is based in the very high uncertainty whether the high direct impacts of a floodwall would be acceptable to resource agencies. There is also risk due to uncertainty of implementing nonstructural measures due to remaining questions about compliance with state and local laws.	Low - Provides CSRM benefits to both barrier islands and mainland communities. Perimeter measures not adaptable to sea level rise and may cause a potential for increased community complacency (i.e., if people don't evacuate based on the presence of the perimeter wall); thereby, potentially increasing with project incremental life loss consequences in the case of structure failure. Nonstructural measures do not reduce risk to infrastructure on the mainland. This plan has the lowest residual risk (14%) in the region. As we refine the analysis and refine community participation rates, residual risk may increase for nonstructural.

7.5.8 Additional Decision Metrics

7.5.8.1 Project Performance

A series of additional decision metrics were developed to assist in the formulation of the focused array of alternatives. These additional decision metrics are discussed below and include:

- Project performance
- Sea level change and adaptive capacity
- Sea level change resiliency
- Reliability and fragility
- Real estate costs
- Life safety risk

In accordance with ER 1105-2-101 *Risk Assessment for Flood Risk Management Studies*, the following performance considerations for the measures included in the focused array of alternatives are provided in Table 68.

The AEP is the probability that a certain threshold (crest elevation or first floor elevation) may be exceeded at a location in any given year considering the full range of possible storm events and project performance.

Long-term exceedance probability (LTEP) is the probability that a certain threshold (crest elevation or first floor elevation) is exceeded at least once during a specified period. For Table 68, the LTEP is calculated as if the water surface profile stage heights in Year 2080 with Intermediate SLC remained constant. The LTEP for the study 50-year period of analysis (Year 2030 to Year 2080) is actually lower than the LTEP specified in the table as every year before Year 2080 has lower mean stage heights.

Assurance is the probability that a target stage will not be exceeded during the occurrence of a flood of specified exceedance probability considering the full range of uncertainties.

Nonstructural and perimeter measures within the focused array of alternatives are both designed to meet the same project performance and therefore share the same AEP, LTEP, and Assurances. The expected AEP for either measure is 0.91%, or in other words, there is a 0.91% probability in any given year that the measure will be exceeded by a coastal storm event and any structures with a FFE less than the height of the perimeter measure will be inundated. At the 90% assurance level, this probability rises to 2.37%.

The LTEP over a 50-year period of analysis is 36.8% for the nonstructural and perimeter measures. This means there is an estimated 36.8% probability the measure will be exceeded at least once over the 50-years of analysis. The Assurance by Event shows when considering the uncertainties in the hydraulic variables, there is a 0.1% probability the measure will be exceeded by a 10% AEP event, but a 45.4% probability the measure will be exceeded by a 1% AEP event.

Evaluating the project performance of SSBs is less straightforward compared to evaluating nonstructural and perimeter structural measures due to the differences in how the measures respond to storm events that exceed the design crest elevations. Perimeter structural measures are at risk of structural failure when wave overtopping exceeds the design standard and have limited storage capacity behind the measures to accommodate the water overtopping the wall before damages are incurred. Storm surge barriers, in contrast to perimeter structural measures, are not as susceptible to structural failure from wave overtopping and are able to disperse and store the water overtopping the barriers over a much larger area throughout the bays. This same fundamental difference in storage capacity will be a key determining factor in qualitatively assessing life safety consequences in the event of a measure failure.

Table 68: Project Performance at Year 2080 (USACE Int. SLC)

Plan	AEP		LTEP			Assurance by Event				
	Expected	90% Assurance	10YR Period	30YR Period	50YR Period	10%	2%	1%	0.4%	0.2%
Nonstructural	0.91%	2.37%	8.8%	24.1%	36.8%	99.9%	85.0%	54.6%	17.9%	6.1%
Perimeter	0.91%	2.37%	8.8%	24.1%	36.8%	99.9%	85.0%	54.6%	17.9%	6.1%
SSB, FFE 14'	0.01%	0.01%	0.1%	0.3%	0.5%	99.9%	99.9%	99.9%	99.9%	99.9%
SSB, FFE 12'	0.01%	0.06%	0.1%	0.3%	0.5%	99.9%	99.9%	99.9%	99.9%	99.8%
SSB, FFE 10'	0.09%	0.27%	0.9%	2.8%	4.6%	99.9%	99.9%	99.9%	97.7%	80.2%
SSB, FFE 08'	0.48%	0.95%	4.7%	13.5%	21.5%	99.9%	99.9%	91.8%	38.9%	12.4%

To accurately compare the project performance of perimeter and SSB measures, the plans can be evaluated on how effectively they mitigate coastal storm risk for representative structures behind those measures. The SSB performance in Table 68 is based on the 4G(8) SSB alternative in the Central Region. Starting with a representative structure at a First Floor Elevation (FFE) of just 8ft NAVD88, there is a 0.48% annual probability that the structure will be inundated, but a 0.91% annual probability of inundation for the same structure behind a perimeter measure.

For that same representative structure at 8ft NAVD88, there is a 21.5% probability of being inundated behind a SSB at least once in a 50-year period of analysis compared to 36.8% probability for the same structure behind a perimeter measure. In terms of Assurance at a 1% AEP event, the representative structure has only an 8.2% probability of being inundated behind a SSB compared to the 45.4% probability behind a perimeter measure.

7.5.8.2 Sea Level Change and Adaptive Capacity

ER 1110-2-8162 requires the performance of alternatives to be evaluated under all three USACE SLC scenarios to determine the alternatives overall potential performance. Not only is it possible that RSLC could be lower or greater than the USACE Intermediate SLC scenario, it is also possible that the plans will have a service life well beyond 50 years. Therefore, it is important to consider the sensitivity of the project performance to RSLC and the adaptive capacity of the alternatives.

Perimeter structural alternatives, such as 4D(1), present certain project risks when accounting for SLC that are not found with SSBs. For example, if a perimeter measure is designed and constructed to maintain project performance with a given SLC rate and that rate is exceeded during the life of the project, then the project may encounter a difficult choice between low project performance or requiring an expensive reconstruction to a higher design elevation. This risk can be mitigated in two ways, but both must be undertaken before the base year. This includes initially constructing the perimeter measure for the higher SLC rate or initially constructing the measure with certain design features, wider levee base or deeper floodwall piles, which allow for a future adaptation if the SLC rate is different than expected during formulation.

Both methods present disadvantages. Constructing an initially larger perimeter feature mitigates the risk of reduced project performance due to SLC, but likely decreases net benefits and increases the risk of selecting an inefficient design. If a larger and more expensive design is constructed, there is the risk that SLC does not increase at the higher rate and a smaller, less expensive design would have maintained the desired project performance. The same risk is apparent if constructing an initially larger base or deeper piles for a SLC rate that does not come to fruition. Furthermore, the additional costs for these adaptability approaches must be incurred at the base year and can jeopardize economic justification.

The adaptive capacity of the SSB structure is low, as it is not feasible to increase the height of vertical lift gate or sector gate, however additional nonstructural or perimeter measures can be implemented over time in adjustment to the SLC rate being experienced without adding expensive adaptability costs to initial construction. Even under the High SLC curve, the initial SSB design proposed for the TSP can be adapted to maintain project performance over a 100-year planning horizon.

Figure 65 shows the LTEP (over a 25-year period) for perimeter / nonstructural measures and several SSB scenarios. Once again, the project performance at representative structures (i.e., FFE of 8ft NAVD88) is useful in evaluating how the performance is affected by RSLC and how adaptive actions could be taken to maintain performance over a 100-year period.

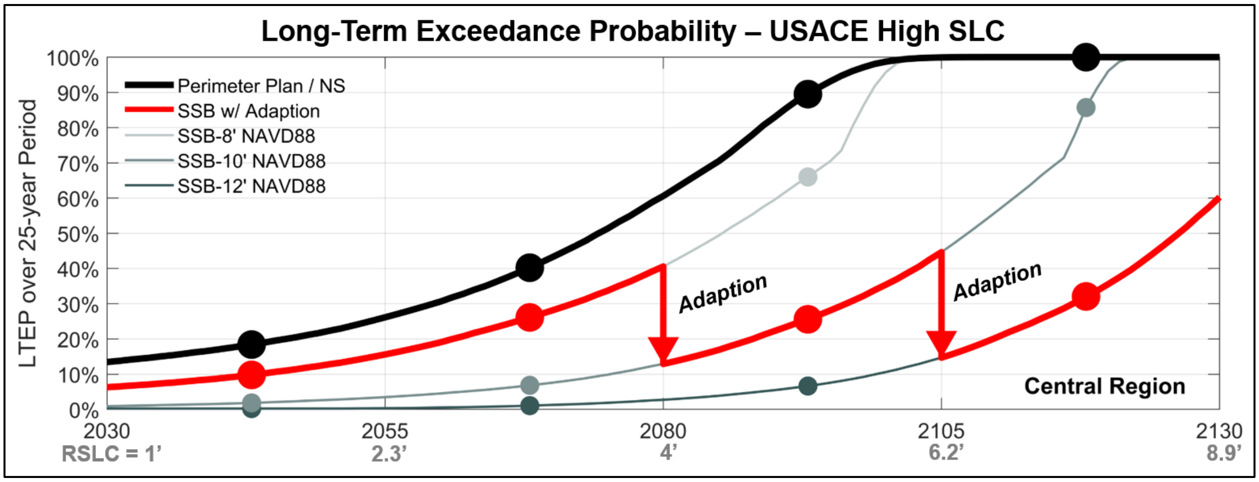


Figure 65: Long-Term Exceedance Probability for Perimeter and SSB

For the current perimeter measure formulated and designed using the Intermediate SLC curve, LTEP increases steadily over time until approaching 60% at the end of the 50-year period of analysis and 99.9% in Year 2105. This means any structure with a FFE less than the design elevation of the perimeter measure has between a 60% annual probability to a 99.9% annual probability of being inundated in the 25-year period following 2080. This LTEP risk can be mitigated but requires significant upfront costs to provide that adaptability.

For the current SSB measure formulated and designed using the Intermediate SLC curve, LTEP for a structure with a FFE at 8ft NAVD88 eclipses 40% in 2080. However, SSBs can be adapted in several ways including adjusting the closure operation frequency or incrementally adding smaller perimeter or nonstructural measures in the Year 2080. Instead of necessitating construction of a perimeter measure at 10ft NAVD88 or elevating all the structures in the inventory to 10ft NAVD88 in Year 2030, those costs can be deferred 50 years past the base year and only implemented in the event of High SLC without any change to current design or formulation. Perimeter and/or nonstructural measures can be incrementally added to the SSB measure throughout the 100-year planning horizon to maintain project performance under the High SLC curve without any additional upfront costs.

Essentially the SSB measure allows for adaptation to high SLC rates while providing reduced vulnerability to coastal storm damage for the study area over the full 100-year planning horizon.

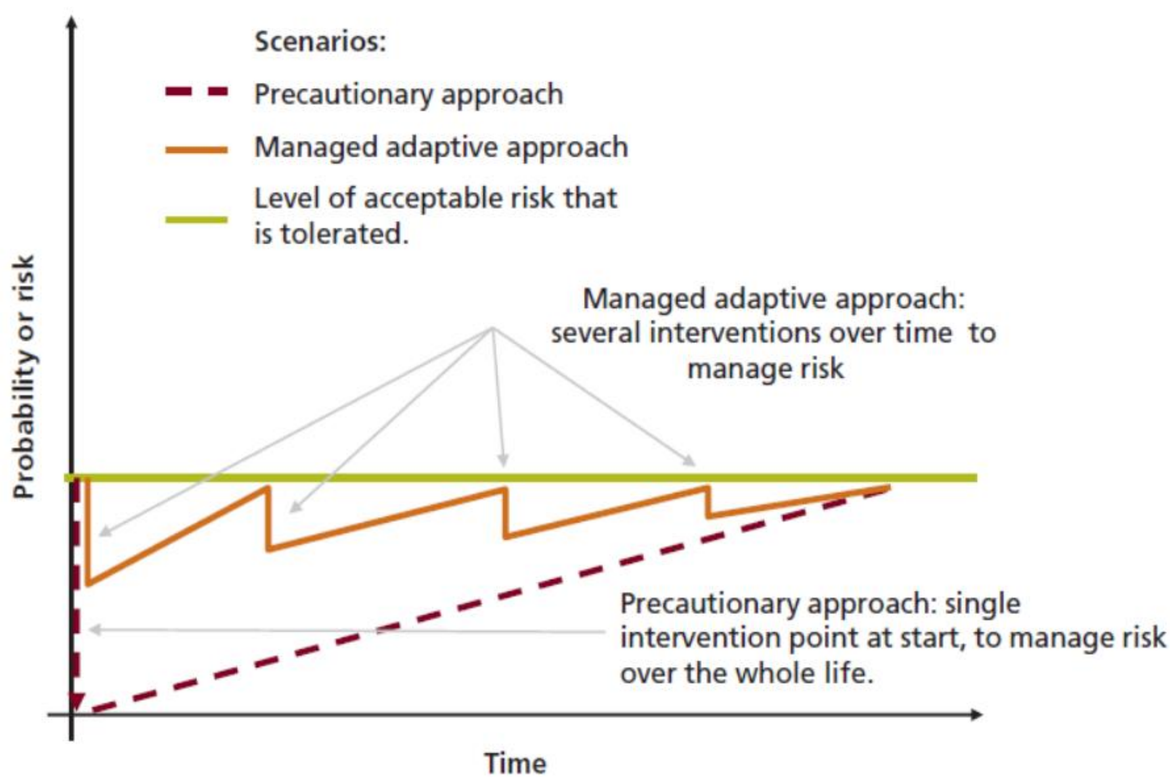
7.5.8.3 Sea Level Change Resiliency

Sea level change is incorporated into the formulation, evaluation, comparison, and selection of proposed alternatives in accordance with ER 1105-2-100, ER 1100-2-8162 *Incorporating Sea Level Change in Civil Works Programs*, and EP 1100-2-1 *Procedures to Evaluate Sea Level*

Change: Impacts, Responses, and Adaptation. Sea level change is integrally included in the economic and engineering analyses including the impacts of sea level change on forecasted FWOP condition and understanding the robustness, resiliency, and potential adaptability of proposed CSRM alternatives.

Current formulation and analysis incorporate the intermediate sea level change curve in accordance with ER 1100-2-8162. The TSP, National Economic Development (NED) Plan, and Nonstructural Only Plan are also evaluated under the Low and High sea level change curves to gage their robustness under a range of future conditions. The results of that analysis are displayed in the Economics Appendix and in the TSP Consideration and Implications Chapter of the Main Report.

Future sea level change analysis will investigate the potential resiliency of proposed alternatives in terms of project performance and possible decision timing strategies. Decision timing strategies are different approaches in managing sea level change risk over the period of analysis. Figure 66 below shows the overview for Anticipatory (i.e., Precautionary), Adaptive, and Reactive project strategies.



** Source: EP 1100-2-1, (Courtesy of DEFRA 2009)*

Figure 66: Conceptual Comparison of Project Alternative Strategies

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

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

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

Future analysis will also review possible combinations of the above three strategies. The USACE process requires the inclusion of a wide range of factors in evaluating and comparing the alternative plans. In most cases a portfolio of mixed strategies will be the best overall approach.

Table 69 below shows a qualitative inventory of resources for the NJBB CSRM Study area and their relative susceptibility to sea level change over the period of analysis. The assessed inventory is identified using the Year 2080 0.2% AEP event floodplain with Intermediate sea level change. The qualitative analysis is intended to identify the density of impacted resources, including critical infrastructure (schools, roads, water supply, community buildings, etc.), impacted property, and ecosystems.

The matrix is a starting point to gage the sensitivity of the study area to sea level change and facilitate quantitatively identifying thresholds and tipping points in the next study phase. Quantitative evaluation criteria (i.e., decision metrics) are necessary to properly evaluate the vulnerability to sea level change, select the appropriate resiliency strategy, and identify the Recommended Plan.

Table 69: Qualitative Matrix of Inventory Assets and Susceptibility to Sea Level Change

Critical Resources	Density of Resource[1]	Relevant Notes	Risk from SLC[2]
Structures (e.g., residential, commercial, industrial)	2	Mostly residential. In some locations, highly developed between main evacuation route and back bay. Significant number of structures are vulnerable to SLC in existing conditions and exceptionally vulnerable during period of analysis.	3
Infrastructure (e.g., roads, water/sewer lines)	2	State highways, secondary roads, power, and service lines are present throughout the study area.	2
Critical infrastructure (e.g., police, fire, schools, wastewater treatment)	3	1,785 critical infrastructure assets within the study area. A significant portion are at risk of damage and disruption from SLC	3
Evacuation routes	1	Coastal evacuation routes are present in the study area	2
Environment and habitat	3	Substantial losses of coastal wetlands and aquatic habitats	3

1. Density of resource scale is relative and ranges from 1-3 where 1 is lowest density and 3 is highest density.
2. Risk from SLC scale is relative and ranges from 1-3 where 1 represents the lowest risk and 3 represents the highest risk from SLC.

7.5.8.4 Reliability and Fragility

Storm surge barriers and perimeter measures also differ in their probability of failure and consequences of failure. While this section qualitatively addresses these distinctions, a comprehensive risk assessment is required to quantitatively compare the structural and life safety risks of the measures. The risk assessment will be completed before release of the final report.

For perimeter measures, the length and characteristics of the proposed design present potential failure modes and potential failure consequences not apparent for SSBs. 4D(1) requires approximately 189,843 linear feet of hardened structure with 24 miter gates and/or road closures. The failure of any one section of floodwall or multiple scattered gates/closures could compromise the integrity and effectiveness of the entire perimeter network.

The lack of storage in the event of an overtopping or breach or gate failure coupled with high flood depths and rapid rate of flooding presents significant potential structural and life safety consequences. The risk from inundation is transformed from a moderate rate of flooding with days of warning time to a sudden catastrophic event with limited to no warning time.

Plan 4G(8) still requires the construction of some floodwall length, but considerably less than required in Plan 4D(1). There are certain potential failure modes unique to SSBs not present with floodwalls or levees, but these failure points are centralized at the location of the barrier. Additionally, the high storage capacity afforded with SSB measures mitigate consequences of an overtopping or breach event by moderating the rate of flooding and extending the evacuation window.

HEC-FDA allows the introduction of floodwall fragility curves to properly assess the economic project performance of the proposed plans. While this will not provide insight on life safety concerns nor fully identify the economic risk for perimeter measures, it can partially quantify the risk to adjust estimated NED AANBs. The implementation of these fragility curves is planned for future work before release of the final report.

7.5.8.5 Real Estate Costs

A detailed real estate cost estimate for the NJBB CSRM Study is still under development and is expected to be completed in 2021. A real estate cost sensitivity analysis using ROM MCACES was conducted in November 2019, considering an individual section of floodwall along Long Beach Island and a SSB section at Barnegat Inlet.

This analysis indicated significant real estate acquisition costs associated with floodwall construction. Specifically, the per-parcel estimated just compensation real estate payment number of $481,000 per parcel (includes the perpetual easement, damages to the remainder, additional 3-year TWAEs on the parcels, and the expected contingency) was detrimental to retaining perimeter plan elements in the TSP other than as a tie in for SSB/CBBs. Floodwall justification was further limited by aesthetic/view concerns associated with the floodwall height, and significant loss of access to the water from the property resulting in near 100% condemnation rate based on experience with beach-side landowners. Additional administrative costs associated specifically with eminent domain actions as outlined in the ROM MCACES begin at $174,000 to cover the initial process fees, commissioners' fees, and trial administrative fees.

Also, the parcels reviewed for the ROM MCACES floodwall exercise were single family residential only. There are several restaurants and marinas in the section of floodwall reviewed, all of which would effectively be put out of business without access to the water. Those costs were not included in the ROM MCACES described here.

As for the SSB/CBBs reviewed for the Barnegat Inlet SSB ROM MCACES exercise, the vast majority of land required for the construction is publicly owned, either by the localities or the NFS, and therefore RE costs will have less of a detrimental impact to overall constriction cost estimates.

7.5.8.6 Life Safety Risk

In compliance with ER 1105-2-100 and ER 1105-2-101 *Risk Assessment for Flood Risk Management Studies*, a comprehensive life safety risk assessment of the Recommended Plan is scheduled to occur during the Design and Implementation phase of the study. The assessment will run concurrently with enhancements to the level of design, as well as improvements to the level of certainty in construction cost estimates. The scope and detail of data collection and model assessment (analytical rigor) in the study are scalable, including assessments of the potential for life loss. The level of detail will depend on the decision being made, what is necessary to address uncertainty in the results, complexity of the problem, and cost of addressing the risks.

An abbreviated qualitative life safety risk assessment of the most likely alternatives for structural measures only is detailed in this section. This risk assessment includes a description of the various types of safety risks, a qualitative assessment of key life safety metrics, and an outline of the Tolerable Risk Guidelines (TRGs) as recommended by USACE Planning Bulletin (PB) 2019-04 *Incorporating Life Safety into Flood and Coastal Storm Risk Management Studies*. For more information on how the life loss was calculated see the "Life Safety Risk Assessment for the New Jersey Back Bay Feasibility Study" in the Engineering Appendix.

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

Residual risk is the coastal storm risk that remains in the floodplain even after a proposed CSRM project is constructed and implemented. Physical damages, as well as potential life loss consequences, can remain even after the project is implemented due to a variety of causes. The current dune system on the oceanward side of the barrier islands protect the residents from direct storm surge.

However, oceanward direct storm surge is not the only source of flooding for the study area. As storm events increase in magnitude, inundation occurs from back bay flooding. The back bay flooding is the primary focus of this study, and the recommended plan will be connected to the existing dune systems to form a more complete line of protection.

While life loss modeling over the full region will be evaluated during the Design and Implementation phase, the Central Region of the NJBB CSRM Feasibility Study is being used as a representative section to show the relative differences in life loss potential of the structural alternatives. There are twenty-one municipalities that would be at least partially included in the Central Region of this study.

Population at Risk (PAR) provides a brief overview of the vulnerable population within the study area (Table 70). For this study, PAR is displayed for the entire study area. While homes in this region are a combination of permanent resident and rental properties, the assumption was made that the residences were occupied at the U.S. Census Bureau (Population Estimates Program, V2019) rates for occupant per structure.

Table 70: Population at Risk (PAR)

	Future without Project	Perimeter Plan	Storm Surge Barrier
Residential Structures in Central Region	45,291	45,291	41,291
Residential Structures within the Line of Protection	0	31,666	38,202
Population at Risk	101,654	101,654	101,654

The PAR is a good indication of who lives in the area at risk, but to determine the life loss potential, other factors including the warning times, evacuation rates, depth of water, and the associated fatality rates must be utilized.

Once the number of people evacuating are removed from the PAR, the threatened population is what remains. The threatened population is used with the depth of water models and fatality rates to determine loss of life estimates.

Depth of water was modeled for the FWOP condition, and both structural alternatives using water levels modeled for the year 2080 and a line of protection with a 0.01 AEP. Since no one was evacuating in this analysis, water depths were taken at the first-floor elevation of each structure. Loss of life was evaluated for both Non-Breach (project works as designed) and Breach (failure of project) situations. During future life loss assessments, all water levels will be evaluated, but for the purposes of this screening level assessment a water level with a 0.01 AEP or water to the top of the wall, shows the greatest impact between breach and non-breach scenarios. Table 71 shows the threatened population by depth of water for each alternative.

Table 71: Threatened Population by Water Depth (0.01 AEP)

1st Floor Depth	Future Without Project	Perimeter Plan	Storm Surge Barrier
0 ft	16,766	37,106	40,715
<2ft	11,900	12,388	11,228
2-6ft	12,517	4,547	3,514
6-13ft	548	289	31
>13ft	-	-	-
Vert Evac Utilized	16,719	4,121	2,963
Total	58,451	58,451	58,451

There are many factors that are used to determine fatality rates, including proximity to assistance, response capabilities, age of population, air temperature, and many others. For the purposes of the screening, fatality rates are based solely on depth of water and only include loss of life due to exposure to the water (see Table 72). There is no life loss included for heart attacks, car accidents, or other causes of death related to the flooding.

Table 72: Fatality Rates by Water Depth

Fatality Rates	Probability
0-2ft	0%
2-13ft	0.02%
13-15ft	12%
>15ft	91%

Life loss from non-breach assumes that all features of the alternatives are working as designed. Life loss from non-breach is generally limited to locations outside of the protected area or low-lying areas with ponded water. and as mentioned earlier in this basic assessment is based on the fatality rates and flood depths at residences during non-breach conditions caused by an event with an AEP of 0.01 (see Table 73).

Table 73: Non-Breach Life Loss by Alternative for 0.01 AEP Event

1st Floor Depth	Future Without Project	Perimeter Plan	Storm Surge Barrier
0 ft	0.00	0.00	0.00
<2ft	0.00	0.00	0.00
2-6ft	2.50	0.91	0.70
6-13ft	0.11	0.06	0.01
>13ft	0.00	0.00	0.00
Total	2.61	0.97	0.71

Life loss from breach is the most commonly considered life loss by the public. Life loss from breach is caused by project failure. Breach life loss is calculated in the same way as non-breach (using first floor water depths at each structure). Incremental life loss is used to show the loss of life caused only by the breach, by subtracting the non-breach life loss value out because it would have occurred with or without the breach. The only change is if a failure occurs with adequate warning time (see Warning Times above for a description) and an additional evacuation is possible (see Table 74).

Table 74: Incremental Life Loss by Alternative and Depth for 0.01 AEP Event

1st Floor Depth	Future Without Project	Perimeter Plan	Storm Surge Barrier (Rapid Failure)	Storm Surge Barrier (Slow Failure)
0 ft	0.00	0.00	0.00	0.00
<2ft	0.00	0.00	0.00	0.00
2-6ft	0.00	1.59	1.80	1.03
6-13ft	0.00	0.05	0.10	0.06
>13ft	0.00	0.00	0.00	0.00
Total	0.00	1.64	1.90	1.09

Since the perimeter plan consists of flood walls and levees, connected to the existing dune systems, wrapped around the protected area, with water already stored in the ocean and bay, any failure of a wall or levee would be a rapid failure since there would be little warning and the residents would be close to the failure. The SSB connects the existing dunes with levees and floodwalls along the oceanward side of the barrier island, and these floodwall sections include mechanical gates that would close to keep water out of the bays. It is possible that a failure of the SSB plan at a floodwall or levee would be a rapid failure. However, if a gate couldn't close, if a gate opened prematurely, or if another failure occurred where the water flowed into the bay, the water level rise would be slower as the water level in the bay would have to rise before the land flooded, and additional evacuations would be possible.

This single life loss elevation with and without breach of the line of protection is a representative sample of the full life loss assessment for comparison purposes at the worst-case condition. By utilizing the same water and line of protection elevations it creates the largest contrast in breach/non-breach values, since any overtopping would increase water on the protected side and increase non-breach life loss. Breach after overtopping is another calculation that will be run during the LifeSim modeling. This would result in a higher water level, but again the differential water levels between breach and non-breach would not be as great.

Transferred and transformed risks are also components of a future with-project life safety risk assessment. Transferred risk is the result of an action taken in one region shifting the risk burden to another region in the system. For the structural plans considered, transferred risk is not a significant concern. An effective coastal floodwall or SSB will keep flood waters out of the vulnerable area without increasing the risk for any neighboring area.

Transformed risk is a new risk of flooding that emerges or increases as a result of mitigating another risk. The magnitude and nature of the risk of flooding is different when a floodwall, SSB, or natural conditions are compared. A floodwall or levee may transform the flood risk from one risk that may be gradual and observable before emergency action would be necessary for the originally protected properties to flood risk that may be sudden and catastrophic. If a floodwall breaches or levee fails, then the sudden increase in flood waters in vulnerable areas can increase the potential for life loss. However, failure of a SSB closure, while still life threatening, would create a slower increase in water levels allowing for additional evacuations.

For a structural plan, transformed risk is a significant concern and the comprehensive life safety risk assessment will need to investigate the impact of transformed risk on estimated statistical life loss. Transformed risks can be mitigated with drafting emergency action plans (EAPs) for vulnerable areas being protected by the project. An EAP, as part of a larger floodplain management plan, will cover warning times, warning effectiveness, flood arrival time, and fatality rate thresholds.

The comprehensive life safety risk assessment will also fully cover the four TRGs detailed in USACE PB 2019-04 *Incorporating Life Safety into Flood and Coastal Storm Risk Management Studies*. An outline and qualitative assessment of the TRGs is completed below. Like all planning objectives, the extent to which the TRGs objectives can be met will vary based on the conditions in the study area and the efficiency and effectiveness of measures that contribute towards meeting the objectives.

TRG 1 – Understanding the Risk

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

When levees and floodwalls are designed to USACE standards and properly maintained, they have a high reliability of working and a low probability of failure, often with probabilities of failure in the $1x10^{-6}$ range. Mechanical gates have higher probabilities of failure than static features, like levees and floodwalls, because of the multiple moving parts. If enough parts break, the system stops working. Regular maintenance is performed on the gates to keep the system running as designed, but the probability of failure is likely 1-2 orders of magnitude higher than a floodwall or levee.

The Life Risk Matrix below (Figure 67) shows the framework for quantitatively determining whether the life safety risk is tolerable for the study area. The full quantitative effort will be completed during the comprehensive life safety risk assessment in the next study phase.

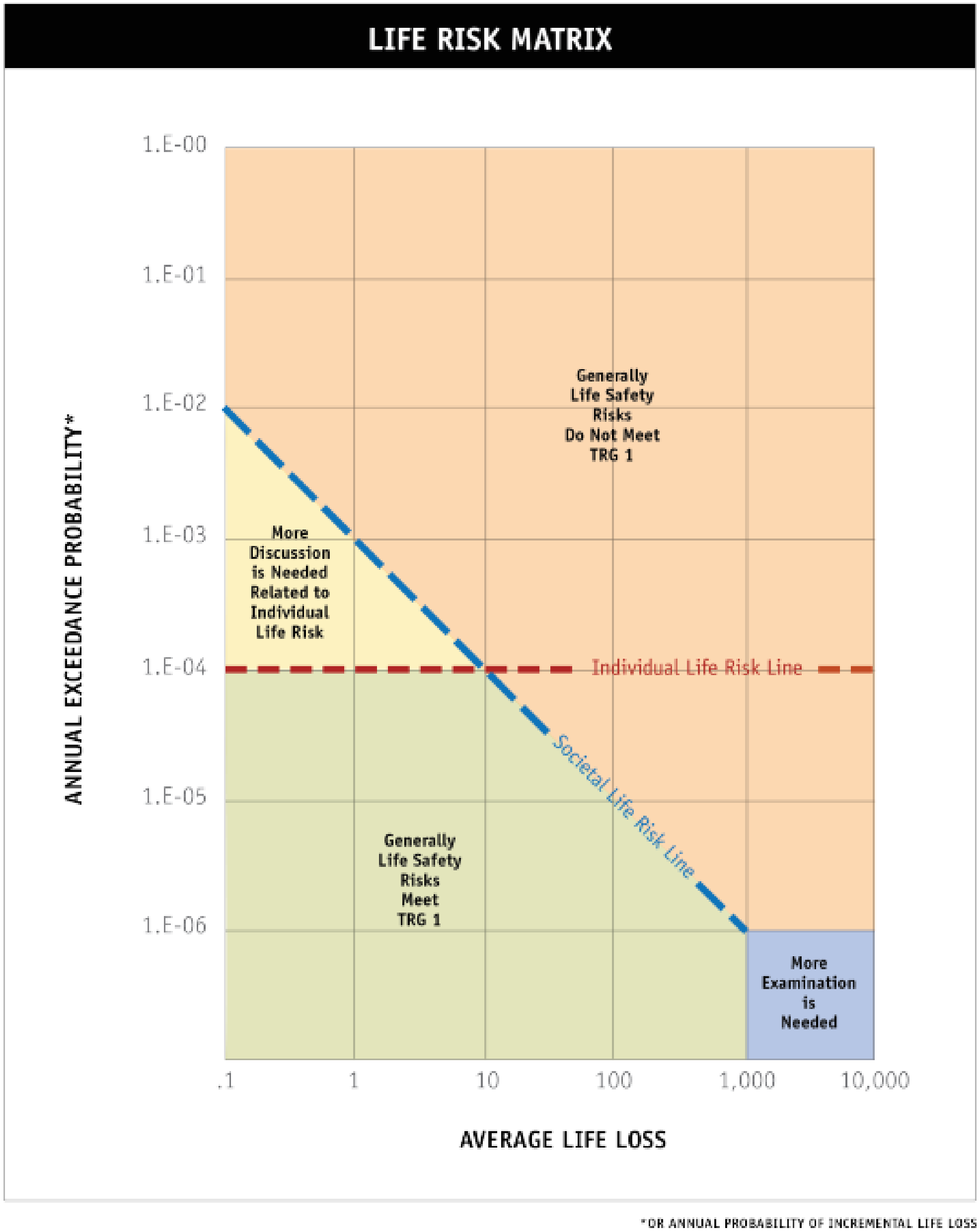


Figure 67: Life Risk Matrix (PB 2019-04)

TRG 2 – Building Risk Awareness

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

TRG 3 – Fulfilling Daily Responsibilities

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

TRG 4 – Actions to Reduce Risk

The fourth guideline is determining if there are cost effective, socially acceptable, or environmentally acceptable ways to reduce risks from an individual or societal risk perspective. The comprehensive life safety risk assessment will investigate whether complementary risk management measures are feasible or appropriate for the study area. This can include complementary nonstructural measures that would work in tandem with the structural alternatives to reduce risk.

In summary, This qualitative assessment considering life loss and population at risk for the various types of risk including residual risk, transferred risk, transformed risk, and incremental risk has assisted in informing if the future with-project condition provides a tolerable level of safety for the study area. Overall, there is a divergence in life safety risk between perimeter and SSB/bay closure measures. This is a contributing reason for identifying the TSP in addition to the NED Plan. Specifically, for SSBs, and Bay Closures, a potential breach is less catastrophic as the bay itself acts as a natural storage area. Closure of the barriers during low tide prior to the storm event provides a massive storage area to mitigate impacts from barrier failures. Overtopping or breaching water would first need to fill this storage before vulnerable structures or populations are inundated. This greatly reduces the life safety risk in comparison to lengthy perimeter measures.

While qualitative assessments of the measure types suggest SSBs have reduced life safety risk over perimeter measures, which in turn has influenced the decision to propose 4G(8) for the Central Region as part of the TSP over other alternatives, the final decision for the Recommended Plan will only be reached once the quantitative risk assessment is completed. Further, while the current qualitative life safety risk assessment only considered structural measures, a quantitative risk assessment will also consider both structural and nonstructural alternatives.

7.5.9 Summary

The formulation of the focused array of alternatives and the TSP as identified in the next chapter was based on a qualitative screening analysis. This screening analysis considered the NED, RED, EQ and OSE Accounts as established in the Principles and Guidelines as well as the four planning criteria analyses in ER 1105-2-100. This screening analysis also addressed additional decision metric screening including life safety, residual risk, project performance and adaptive capacity of alternatives due to SLC support the formulation of the focused array of alternatives and the TSP.

While the AANB of the NED reasonably maximizing plan to be considered as the TSP are lower than some other plans, the NED reasonably maximizing plan also meets the metrics set forth by the RED, EQ and OSE Accounts as well as the Planning Criteria. In addition, the TSP was the most reasonably maximizing plan in terms of life safety, residual risk, project performance and adaptive capacity of alternatives due to SLC, as well as reliability and fragility.

A qualitative analysis of additional decision metrics indicates that alternative plans that include SSB and CBB are more justified than plans that include perimeter measures and to a less extent nonstructural measures.

Life Safety

This qualitative assessment considering life loss and population at risk for the various types of risk including residual risk, transferred risk, transformed risk, and incremental risk has assisted in informing if the future with-project condition provides a tolerable level of safety for the study area. Overall, this assessment indicates SSBs and CBBs have reduced life safety risk over perimeter measures, which in turn has influenced the decision to propose an alternative inclusive of SSB and CBB measures for the Central Region (Alternative 4G(8)) as part of the TSP over other alternatives. Specifically, for SSBs and CBBs, a potential breach is less catastrophic as the bay itself acts as a natural storage area. Closure of the barriers during low tide prior to the storm event provides a massive storage area to mitigate impacts from barrier failures. Overtopping or breaching water would first need to fill this storage before vulnerable structures or populations are inundated. This greatly reduces the life safety risk in comparison to lengthy perimeter measures.

Residual Risk

While the TSP's mean AANB is $21,251,000 (3.3%) less than that of the NED Plan, the TSP provides an estimated 1.3% additional decrease in residual damages, and thus a factor in the decision to select the TSP. While the nonstructural alternative is economically justified, the alternative has an exceptionally high residual damage percentage. These residual damages stem from damage to non-elevated surrounding property, vehicle damage, infrastructure damage, emergency costs, and transportation delays.

Project Performance

Project performance considers annual exceedance probability (AEP), long-term exceedance probability (LTEP), and assurance as previously discussed. While

Nonstructural and perimeter measures within the TSP and NED plans are both designed to meet the same project performance and therefore share the same AEP, LTEP, and Assurances. Evaluating the project performance of SSBs is less straightforward compared to evaluating nonstructural and perimeter structural measures due to the differences in how the measures respond to storm events that exceed the design crest elevations. Perimeter structural measures are at risk of structural failure when wave overtopping exceeds the design standard and have limited storage capacity behind the measures to accommodate the water overtopping the wall before damages are incurred. Storm surge barriers, in contrast to perimeter structural measures, are not as susceptible to structural failure from wave overtopping and are able to disperse and store the water overtopping the barriers over a much larger area throughout the bays.

Sea Level Change and Adaptive Capacity

it is important to consider the sensitivity of the project performance to RSLC, the adaptive capacity of the alternatives, and performance over the 100-year planning horizon. Generally, NJBB analyses suggest that SSB and CBB measures have greater adaptive capacity to RSLC than do perimeter or nonstructural measures. Further, SSB measures allow for adaptation to all three SLC scenarios while providing reduced vulnerability to coastal storm damage for the study area over the full 100-year planning horizon. This result lends supports the decision to incorporate SSBs and CBBs in the TSP.

Perimeter structural alternatives, such as 4D(1), present certain project risks when accounting for SLC that are not found with SSBs or adaptive nonstructural. For example, if a perimeter measure is designed and constructed to maintain project performance with a given SLC rate and that rate is exceeded during the life of the project, then the project may encounter a difficult choice between low project performance or requiring an expensive reconstruction to a higher design elevation.

Comparatively, the inherent adaptive capacity of the SSB structure is low, as it is not feasible to increase the height of vertical lift gate or sector gate; however, additional complementary nonstructural measures can be implemented over time in adjustment to the SLC rate being experienced without adding expensive adaptability costs to initial construction. Even under the High SLC curve, the initial SSB design proposed for the TSP can be adapted to maintain project performance over a 100-year planning horizon.

Reliability and Fragility

Storm surge barriers and perimeter measures also differ in their probability of failure and consequences of failure. For perimeter measures, the length and characteristics of the proposed design present potential failure modes and potential failure consequences not apparent for SSBs. 4D(1) requires approximately 189,843 linear feet of hardened structure with 24 miter gates and/or road closures. The failure of any one section of floodwall or multiple scattered gates/closures could compromise the integrity and effectiveness of the entire perimeter network.

The lack of storage in the event of an overtopping or breach or gate failure, coupled with high flood depths and rapid rate of flooding, presents significant potential structural and life safety consequences. The risk from inundation is transformed from a moderate rate of flooding with days of warning time to a sudden catastrophic event with limited to no warning time.

Plan 4G(8) still requires the construction of some floodwall length, but considerably less than required in Plan 4D(1). There are certain potential failure modes unique to SSBs not present with floodwalls or levees, but these failure points are centralized at the location of the barrier. As such, they are easier to mitigate and monitor for. Additionally, the high storage capacity afforded with SSB measures mitigate consequences of an overtopping or breach event by moderating the rate of flooding and extending the evacuation window.

However, the final decision for the Recommended Plan will only be reached once a quantitative risk assessment is completed.

8 The Tentatively Selected Plan

The TSP has been identified in this section in accordance with Step 6 – Selecting a plan of the USACE six-step planning process. This recommended plan is justified as it is preferable to taking no action or implementing any of the other alternatives considered during the planning process of the NJBB CSRM Study.

The Tentatively Selected Plan (TSP) as identified for the intermediate SLC scenario (Figure 68) reasonably maximizes benefits and includes:

- Storm surge barriers at Manasquan Inlet, Barnegat Inlet, and Great Egg Harbor Inlet;
- Cross-bay barriers or interior bay closures at Absecon Boulevard, and southern Ocean City; and
- Elevation and floodproofing of 18,800 structures. These nonstructural solutions are considered for 11% of the study area and are concentrated in the vicinity of the Shark River Inlet, and in southern Ocean County specifically along the mainland shoreline south of Beach Haven West and on Long Beach Island. Nonstructural solutions are also concentrated in northern Atlantic County on the mainland shoreline and on Brigantine, and in large portions of Cape May County.
- Perimeter measures including floodwalls, levees and seawalls which tie SSBs and CBBs into adjacent higher ground.

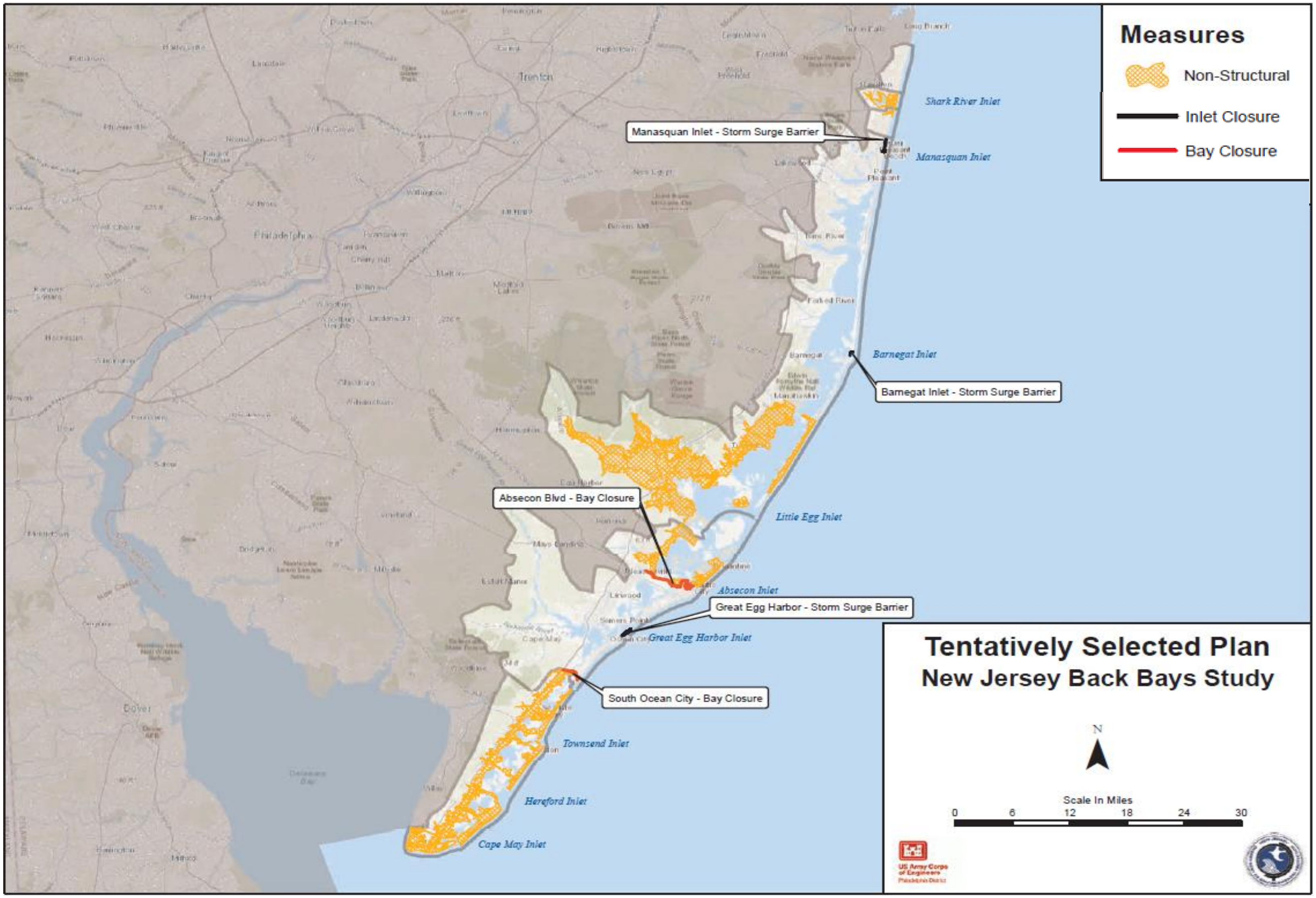


Figure 68: The Tentatively Selected Plan

Plan views and layouts for the Manasquan Inlet SSB are provided in Figures 69 and 70. Plan views and layouts for the SSBs at Barnegat Inlet and Great Egg Harbor Inlet City can be found in Figures 71 through 74. Plan views and layouts for the CBBs at Absecon Boulevard and southern Ocean City can be found in Figures 75 through 78. Detailed maps of the TSP by Region are provided in the Plan Formulation Appendix, and additional information and drawings are provided in the Engineering Appendix.

The TSP was selected based on a number of decision criteria including the four system of accounts, planning criteria and additional decision metrics as summarized in Chapter 7.5.8. This discussion stated that while the AANB of the TSP are lower than the actual NED plan, the TSP meets the metrics set forth by the RED, EQ and OSE Accounts as well as the Planning Criteria. In addition, the TSP was the best performing plan in terms of life safety, residual risk, project performance and adaptive capacity of alternatives due to SLC, as well as reliability and fragility.

The total cost of the TSP is $16.07B with annual OMRRR of $196M (using the Intermediate SLC curve, FY2021 Price Level). The TSP reasonably-maximizing NED Plan and is expected to provide mean AANB of $612M with a Benefit-to-Cost ratio of 1.8 and 22% in Residual Damages. The TSP is identified to reasonably maximize net NED benefits while accounting for project performance, SLC adaptability, and risk to life safety. While the initial construction cost of the TSP is $16.07B, the AAD Prevented are $1.42B which justify the construction costs over the project life. Table 75 presents a summary of the detailed economic and cost information for the TSP (FY2021 Price Level).

Table 75: TSP economic and cost information

FWOP AAD	$1,808,610,000
Future with Project Average Annual Damages (AAD)	$393,372,000
Total Reduced AAD	$1,415,238,000
Initial Construction	$16,067,536,000
OMRR&R	$195,710,000
Average Annual Cost (AAC)	$803,107,000
Average Annual Net Benefits (AANB)	$612,131,000
Benefit-Cost Ratio	1.8
Residual Damages	22%

The TSP considers an SSB closure frequency at the 20% AEP water level. This closure frequency which remains constant over time allows the forecasted water level for operation to change over time in response to RSLC and the average number of closure operations per year (0.2) to remain fixed. An additional barrier closure is expected to occur and an annual basis for maintenance/training. In subsequent phases on the NJBB CSRM Study the cost, benefits, and impacts of closure operations will evaluated in greater detail to refine the SSB closure criteria, which is likely evolve during the feasibility study, PED, and even during the life of the SSBs.

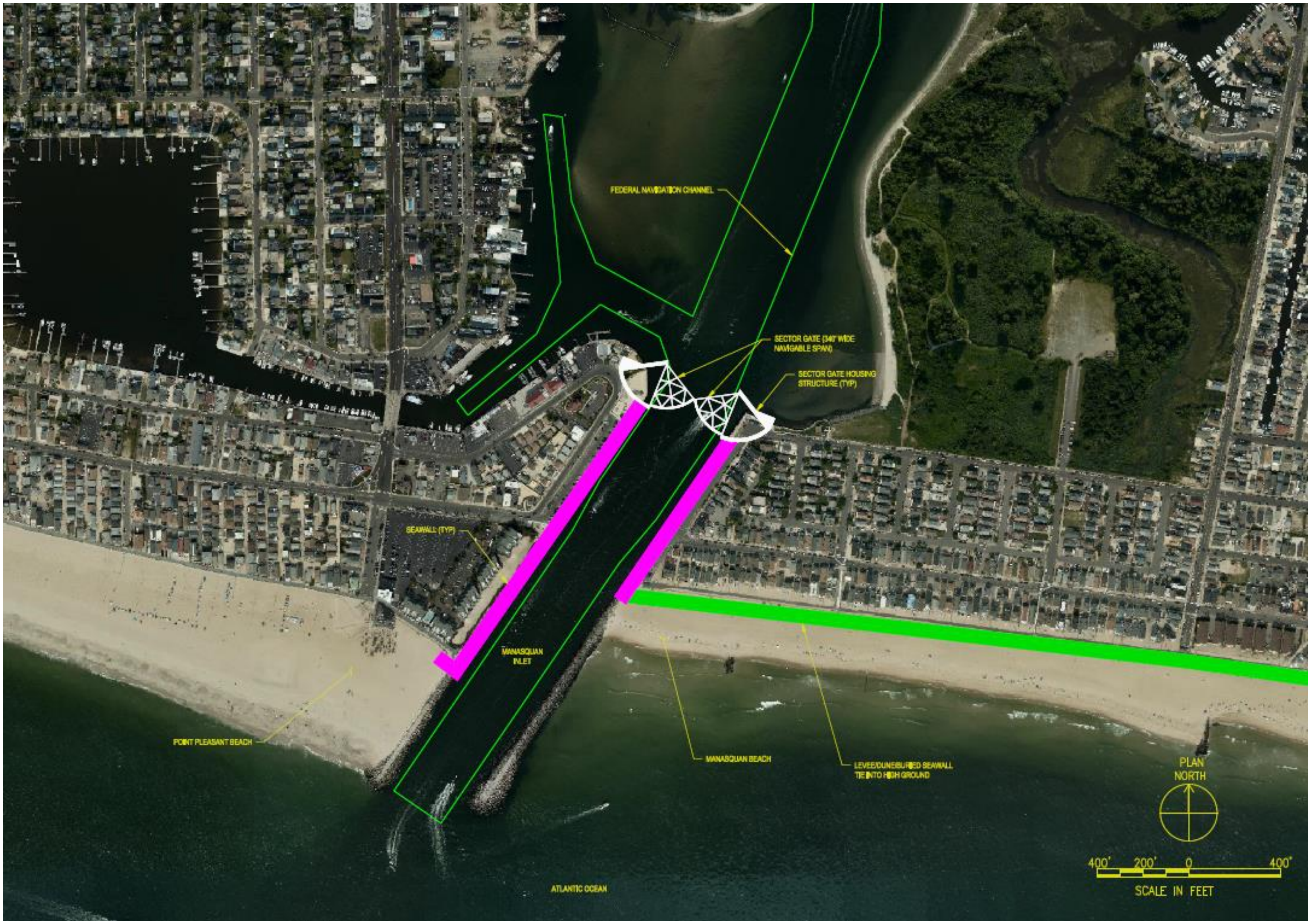


Figure 69: Manasquan Inlet storm surge barrier plan view

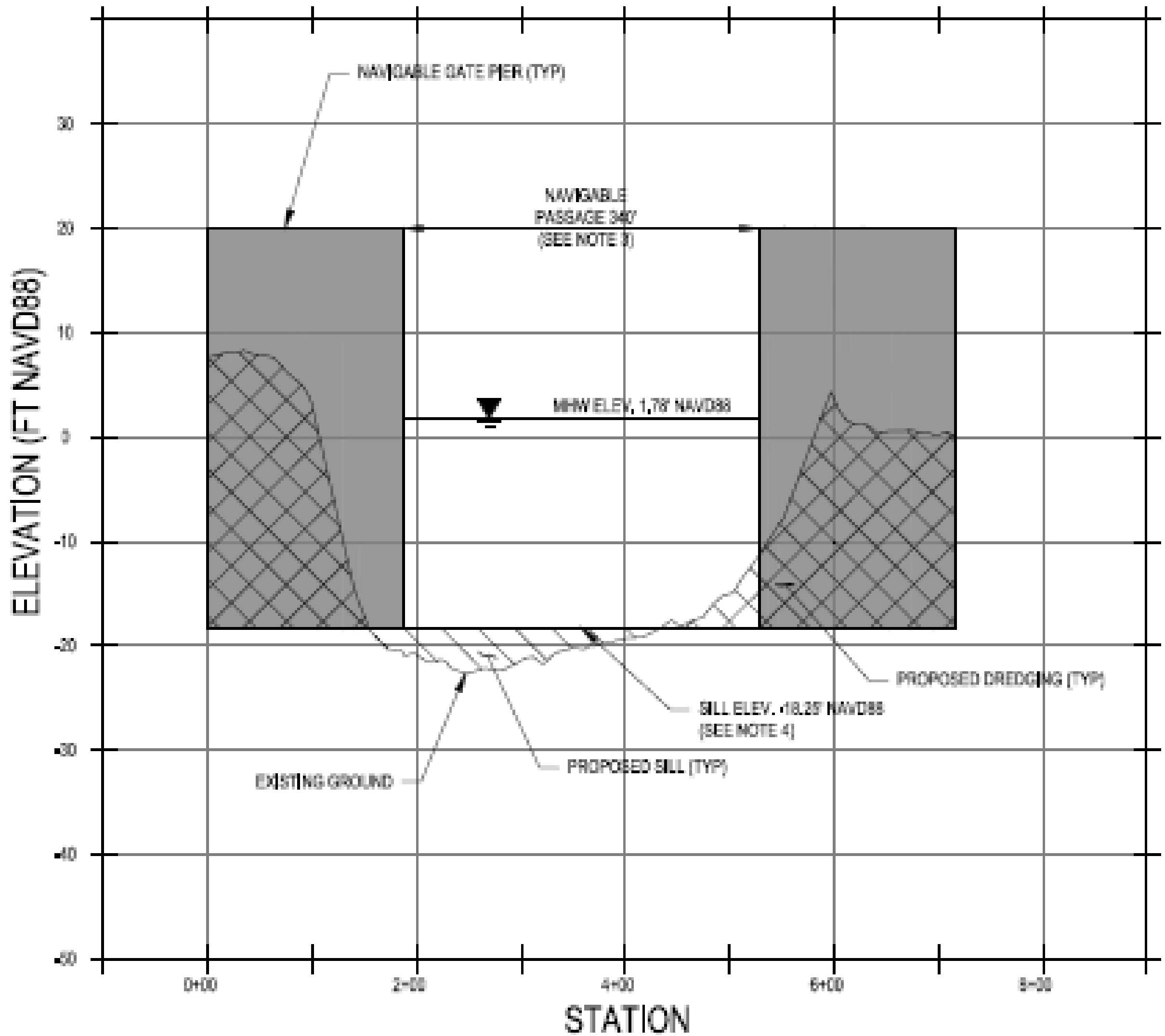


Figure 70: Manasquan Inlet storm surge barrier layout

Figure 71: Barnegat Inlet storm surge barrier plan view

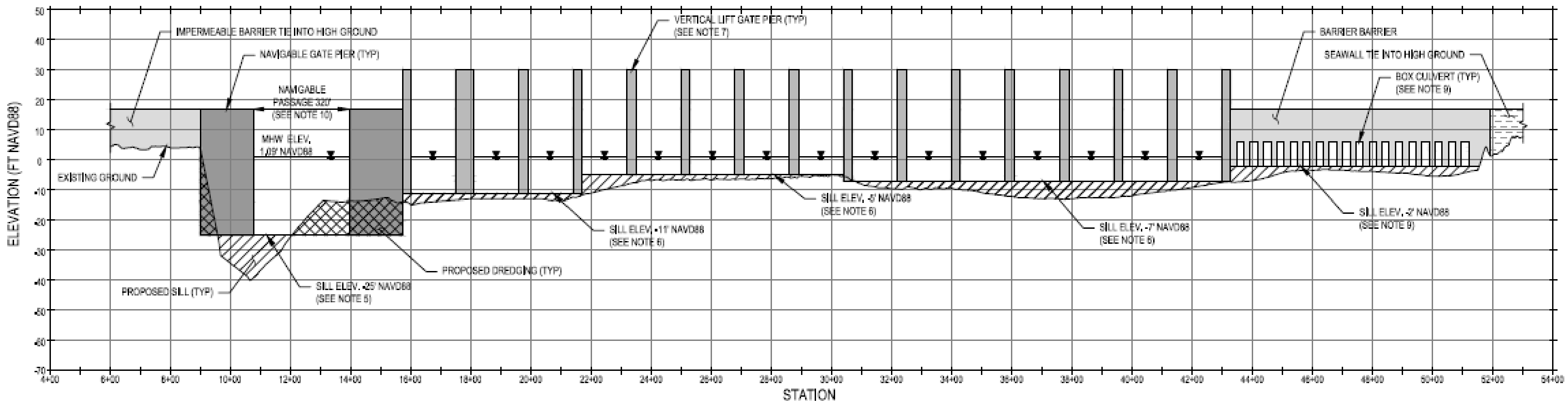


Figure 72: Barnegat Inlet storm surge barrier layout

Figure 73: Great Egg Harbor Inlet storm surge barrier plan view

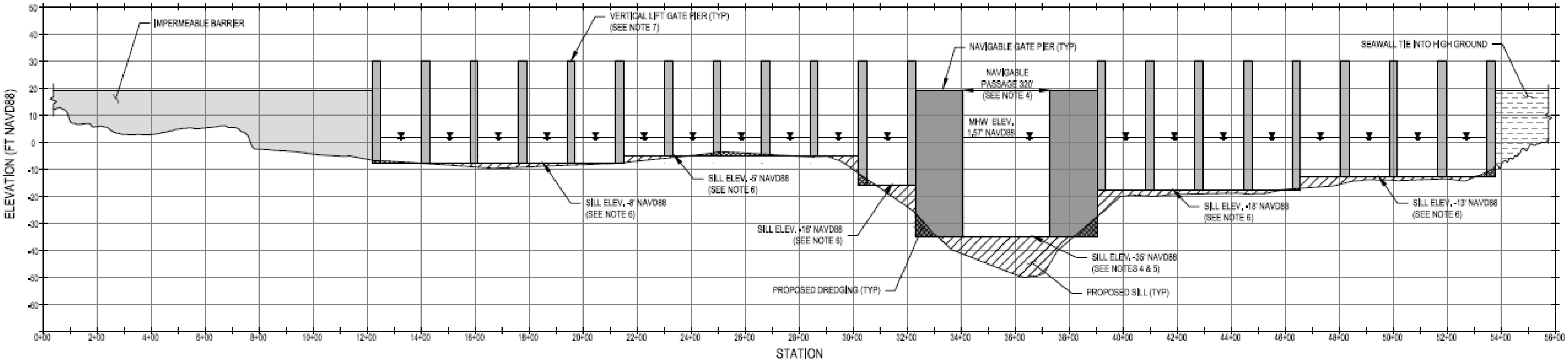


Figure 74: Great Egg Harbor Inlet storm surge barrier layout

Figure 75: Absecon cross-bay barrier plan view

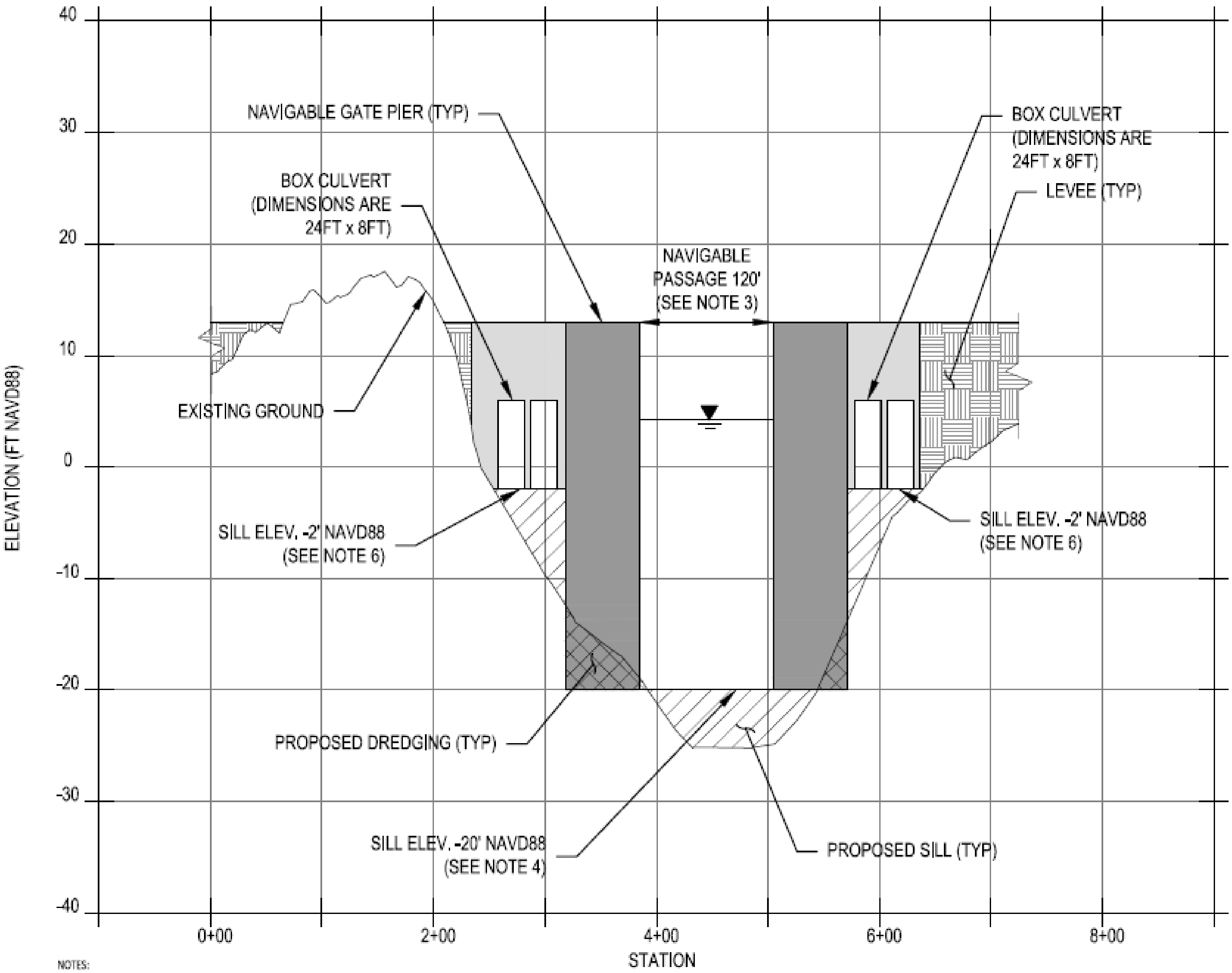


Figure 76: Absecon cross-bay barrier layout

Figure 77: Southern Ocean City cross-bay barrier plan view

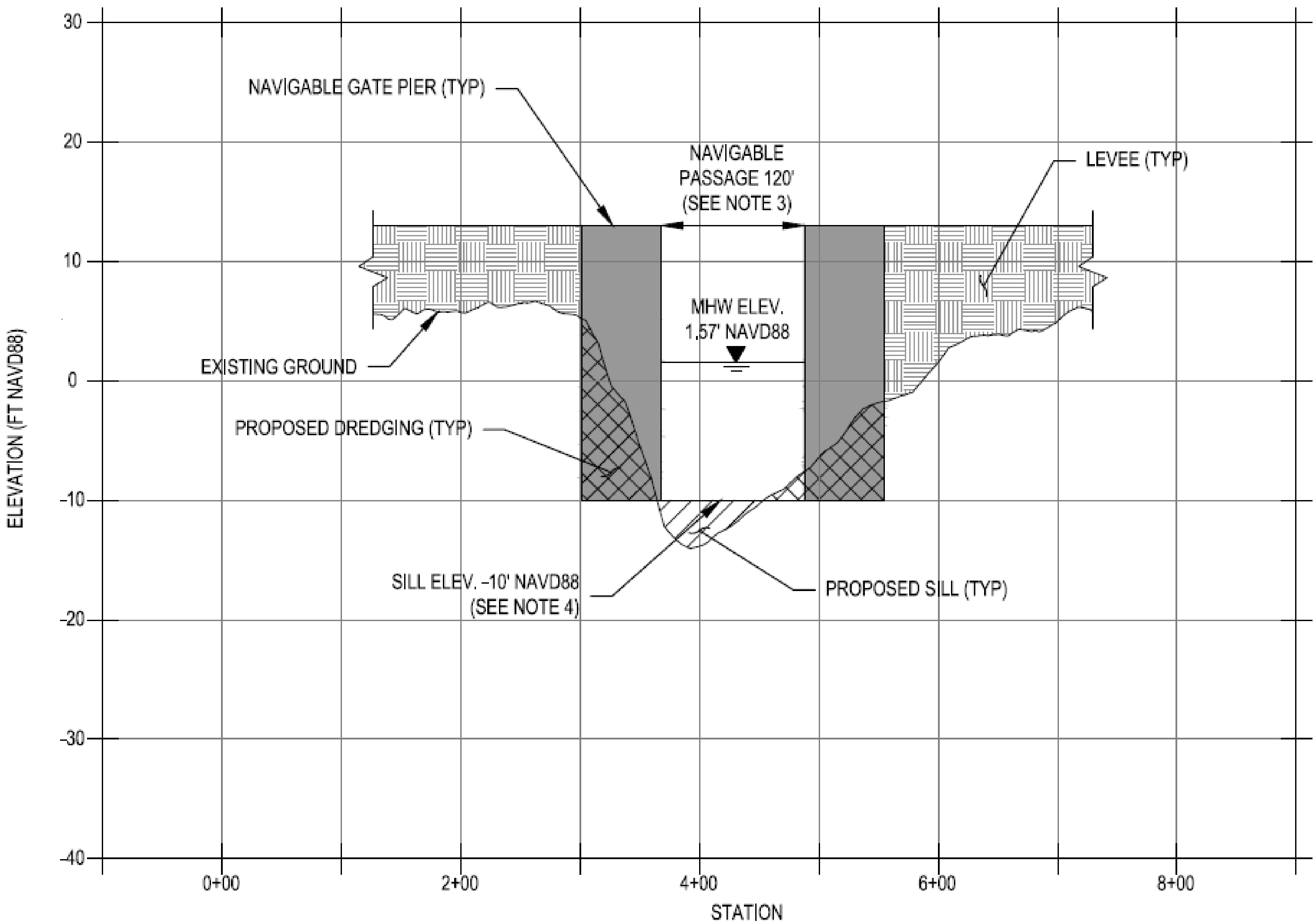


Figure 78: Southern Ocean City cross-bay barrier layout

Nonstructural solutions in the TSP include elevation and flood proofing of residential structures only at this stage of the study.

Nonstructural solutions considered the 5% AEP floodplain and included the following structure types:

- 17,150 structures are 1- or 2-story residential
- 1,308 structures are commercial
- 373 structures are something else (public, industrial, high rise, or apartment).

A separation of structures identified for nonstructural solutions for the TSP by study region includes:

- 135 structures in the Shark River and the Coastal Lakes Regions (Alternative 2A)
- 8869 structures in the North Region (3E-2)
- 1255 structures in the Central Region (4G-8)
- 8579 structures in the South Region (5A)

A separation of structures identified for nonstructural solutions for the TSP by County includes:

- 135 structures in Monmouth County
- 8567 structures in Ocean County
- 66 structures in Burlington County
- 1491 structures in Atlantic County
- 8579 structures in Cape May County

When flood proofing was considered, 90% of the time wet flood proofing was the recommended treatment and 10% of the time dry flood proofing was the recommended treatment. For non-residential structures, the elevation of structures considered the target design elevation which is equivalent to BFE + 3ft. Future analysis will include additional building retrofits such as flood proofing and ring levees for commercial, public, and industrial structures, as well as managed coastal retreat including acquisition / relocation.

Levees and floodwall elements in the TSP are limited to locations where storm surge and CBBs tie into adjacent higher ground.

The TSP is based upon detailed analyses but represents a step in the phased, iterative planning process. Additional more detailed analyses will be performed going forward during the conduct of the study which will likely result in revisions to the TSP and associated economic and other account calculations. These revisions may occur before the ADM Meeting which is currently scheduled for January 2022. These continued analyses will help to reduce the uncertainty and risk associated with risk management solutions.

8.1 Alternative TSP Plans and Assessments

8.1.1 Introduction

Alternative TSP plans are also herein offered in this Draft Integrated Report based upon USACE's greater consideration of the assessment of comprehensive benefits across four distinct categories: National Economic Development (NED), Regional Economic Development (RED), Other Social Effects (OSE), and Environmental Quality (EQ). The *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (P&G) (USACE, 1983) established the four accounts to display the effects of plans while maximizing potential benefits relative to project costs. Though the P&G stated that determining RED and OSE benefits was discretionary, the memorandum from the Assistant Secretary of the Army entitled "Comprehensive Documentation of Benefits in Feasibility Study" (USACE, 2021) directed USACE "to identify, analyze and maximize all benefits in the NED, RED, and OSE."

Alternative study area-wide plans to the TSP offered herein include:

- A NED benefit maximizing plan
- A nonstructural only plan
- A comprehensive benefit-maximizing plan across all four accounts (NED, RED, OSE and EQ).
- Note that a locally preferred plan has not yet been identified but can be identified in the future if non-benefit maximizing plan is proposed by a non-Federal entity.

Additional analyses will be performed in future phases of this study to further comprehensively document benefits across the four benefit categories towards identification of a recommended plan.

Separate analyses are also provided for four study aspects including:

- Natural and nature-based features
- Critical Infrastructure measures
- Separable and complementary measures
- Coastal Lakes Region

Detailed assessment of these analyses will also be performed prior to final identification of the recommended plan to assess CSRM opportunities offered by NNBFs, critical infrastructure measures, and separable and complementary measures. While the type of SSB, gates, and shoreline-based measures (floodwall, levee and seawall, and nonstructural) have been identified in this report as part of the TSP, the development of critical infrastructure risk management measures offers an alternative, focused assessment of opportunities that could be implemented as part of a tiered phased, scalable approach. The identification of complementary measures, or measures that provide risk management in the residual floodplains of structural measures, will help to address higher frequency flooding events, and provide a uniform level of risk management throughout the region in question. Additional analyses will also be performed to identify the specific path forward for inclusion of the Coastal Lakes in the recommended plan.

8.1.2 NED Plan

A detailed assessment of focused array of alternatives with an emphasis on highest AANB was performed. Using FY21 price levels, the NED plan is expected to provide mean AANB of $632,478,000 with a Benefit-to-Cost ratio of 1.8 and 23% in Residual Damages. For comparison purposes, the TSP is expected to provide mean AANB of $612,131,000 with a Benefit-to-Cost ratio of 1.8 and 22% in Residual Damages. This analysis indicated that the TSP is a reasonably maximizing plan and is in departure from the NED maximizing plan (Figure 79). Table 76 identifies alternatives included in the TSP (highlighted in green) and alternatives with AANB with higher ranges (highlighted in yellow).

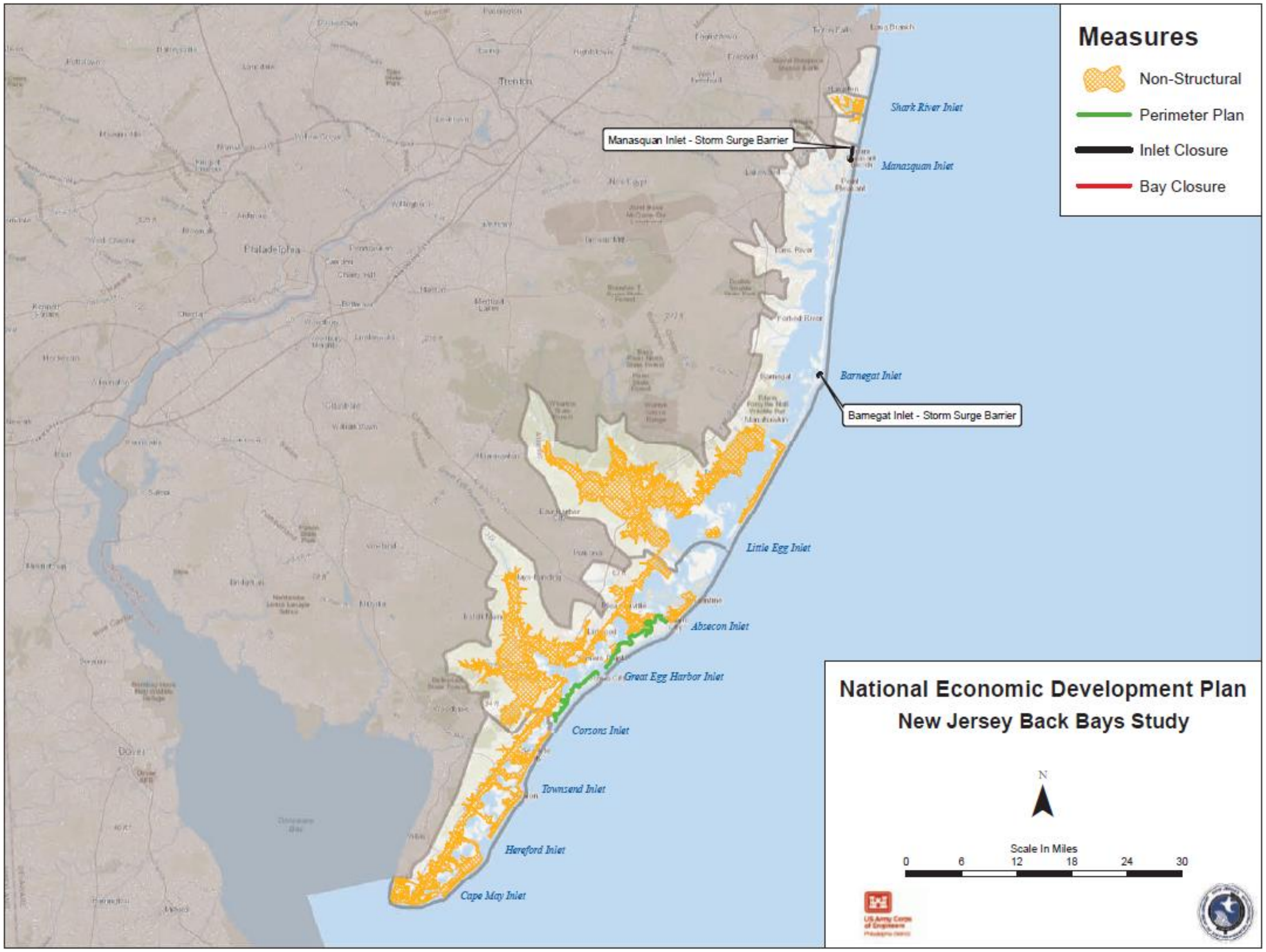


Figure 79: NED Plan for the Study Area

Table 76: Focused Array of Alternatives highlighting alternatives with no table economic analyses

Alternative	Description	Initial Const.	OMRR&R	AAC	AAB	AANB	BCR	Residual Risk
Shark River & Coastal Lakes								
2A	NS Only	$41,531,000	$0	$1,538,000	$3,157,000	$1,619,000	2.05	68.7%
North Region								
3A	NS Only	$6,592,603,000	$0	$244,196,000	$496,588,000	$252,392,000	2.03	33.5%
3D	NS + PM (Manasquan (North))	$7,137,113,000	$7,569,000	$272,771,000	$502,404,000	$229,633,000	1.84	32.7%
3E(2)	NS + SSB (Manasquan Inlet & Barnegat Inlet)	$6,007,313,000	$70,404,000	$310,793,000	$579,674,000	$268,881,000	1.87	22.3%
3E(3)	NS + PM (Southern Long Beach Island) + SSB (Manasquan Inlet & Barnegat Inlet)	$7,861,217,000	$101,463,000	$425,901,000	$608,910,000	$183,009,000	1.43	18.4%
Central Region								
Alt.		**Initial Const.**	**OMRR&R**	**AAC**	**AAB**	**AANB**	**BCR**	**Residual Risk**
4A	NS Only	$3,599,771,000	$0	$133,339,000	$353,383,000	$220,044,000	2.65	46.8%
4D(1)	NS + PP (Ocean City & Absecon Island)	$6,652,242,000	$59,258,000	$335,194,000	$565,697,000	$230,503,000	1.69	14.8%
4D(2)	NS + PP (Ocean City, Absecon Island & Brigantine Island)	$7,807,982,000	$74,085,000	$396,354,000	$579,082,000	$182,728,000	1.46	12.7%
4E(2)	NS + SSB (Absecon Inlet & Great Egg Harbor Inlet)	$6,163,914,000	$113,216,000	$373,805,000	$558,300,000	$184,495,000	1.49	15.9%
4E(3)	NS + PP (Southern Ocean City) + SSB (Absecon Inlet & Great Egg Harbor Inlet)	$6,473,071,000	$120,725,000	$393,823,000	$572,495,000	$178,672,000	1.45	13.7%
4E(4)	NS + SSB (Absecon Inlet & Great Egg Harbor Inlet) + CBB (Southern Ocean City)	$6,205,516,000	$123,444,000	$386,676,000	$567,254,000	$180,578,000	1.47	14.5%
4G(6)	NS + SSB (Great Egg Harbor Inlet) + CBB (Absecon Blvd)	$6,203,154,000	$107,399,000	$363,814,000	$580,650,000	$216,836,000	1.60	12.5%
4G(7)	NS + PP (Southern Ocean City) + SSB (Great Egg Harbor Inlet) + CBB (Absecon Blvd)	$6,512,312,000	$114,908,000	$383,831,000	$594,846,000	$211,015,000	1.55	10.4%
4G(8)	NS + SSB (Great Egg Harbor Inlet) + CBB (Absecon Blvd & Southern Ocean City)	$6,244,757,000	$117,627,000	$376,684,000	$589,605,000	$212,921,000	1.57	11.2%
4G(10)	NS + PP (Brigantine Island) + SSB (Great Egg Harbor Inlet) + CBB (Absecon Blvd)	$7,358,895,000	$122,226,000	$424,973,000	$594,036,000	$169,063,000	1.40	10.5%
4G(11)	NS + PP (Brigantine Island & Southern Ocean City) + SSB (Great Egg Harbor Inlet) + CBB (Absecon Blvd)	$7,668,053,000	$129,735,000	$444,991,000	$608,231,000	$163,240,000	1.37	8.4%
4G(12)	NS + PP (Brigantine Island) + SSB (Great Egg Harbor Inlet) + CBB (Absecon Blvd & Southern Ocean City)	$7,400,497,000	$132,454,000	$437,844,000	$602,991,000	$165,147,000	1.38	9.1%
South Region								
5A	NS Only	$3,125,440,000	$0	$115,769,000	$213,527,000	$97,758,000	1.84	40.3%
5D(1)	NS + PP (Sea Isle City, West Wildwood, Wildwood Island, Cape May City & West Cape May)	$4,655,959,000	$38,518,000	$218,015,000	$281,416,000	$63,401,000	1.29	21.3%
5D(2)	NS + PP (Sea Isle City, Seven Mile Island, West Wildwood, Wildwood Island, Cape May City & West Cape May)	$7,285,507,000	$70,698,000	$363,377,000	$306,012,000	-$57,365,000	0.84	14.4%

NS = Nonstructural, PP = Perimeter Measure, SSB = Storm Surge Barrier, CBB = Cross-Bay Barrier

Alternative NED maximizing plans where further analysis is warranted

NED reasonably maximizing plan to be considered as the TSP

Table 77: Comprehensive assessment of benefits for each region

Region	TSP	NED	Maximize Across Four Accounts	Nonstructural Plan	Environmental Quality	Locally Preferred Plan
Shark River and Coastal Lakes Region	2A - NS Only	Same as TSP	Same as TSP	Same as TSP	NS and NNBF	NA
North Region	3E(2) - NS + SSB (Manasquan Inlet & Barnegat Inlet)	Same as TSP	Same as TSP	3A - NS Only	NS and NNBF	NA
Central Region	4G(8) - NS + SSB (Great Egg Harbor Inlet) + CBB (Absecon Blvd & Southern Ocean City)	4D(1) - NS + PP (Ocean City & Absecon Island)	4G(8)	4A - NS Only	NS and NNBF	NA
South Region	5A - NS Only	Same as TSP	5A - NS Only	5A - NS Only	NS and NNBF	NA
Total Costs	$16,067,536,000	$16,492,814,000	$15.4 - 15.8 B	$13,947,220,783	TBD	TBD
Net Benefits	$612,131,000	$632,478,000	$581 - $598 M	$606,163,000	TBD	TBD

While there is clear identification of the TSP based on NED alone in the Shark River & Coastal Lakes, North and South Regions as discussed previously and summarized in Table 76, the distinction between the TSP and the NED maximizing plan in the Central Region is limited. The NED Plan departure in the Central Region includes Alternative 4D(1) which is a nonstructural/perimeter plan (Ocean City and Absecon). This is different from the TSP Plan including Alternative 4G(8) which includes SSB, NS and CBB measures (Figure 80). Other NED reasonably maximizing plans in the Central Region include alternative 4A, and alternative 4D(2).

While the selection of Alternative 4G(8) as the TSP in the Central Region was based on several decision criteria as discussed previously, the primary reason for selection of Alternative 4G(8) was that while the AANB of the TSP are lower than the actual NED plan, the TSP was the best performing plan in terms of life safety, residual risk, and adaptive capacity. Also note that the departure in AANB between these two alternatives was less than 5%. This departure, however, may necessitate the development of a locally preferred plan (LPP) in the future or an NED waiver.

A qualitative assessment of the comprehensive benefits for each region was performed given the USACE 2021 guidance (Table 77). This preliminary analysis highlights the differences between the different plans including similar costs and benefits for the TSP, NED and maximizing benefit plan while the nonstructural only plan has relatively lower costs. On a region by region basis, the TSP and the maximizing benefit plan are nonstructural measures only in the Shark River & Coastal Lakes (Alternative 2A) and South Regions (Alternative 5A). In the North Region, Alternative 3E(2) including nonstructural and SSBs at Manasquan Inlet and Barnegat Inlet is the maximizing benefit plan, as well as the TSP and the NED. In the Central Region, given the departure between the TSP and the NED Plan, the maximizing benefit plan is still being quantitatively determined. Since the NJBB CSRM Study reached a TSP prior to the development of this guidance, additional analyses will be performed to further comprehensively document benefits across the four categories in association with Draft Integrated Report public and stakeholder comments.

Reasons for the selection of the TSP over the NED plan in the Central Region are its minimal difference between AANB, lower residual risk and a higher benefit to cost ratio. Planning guidance indicates that an exception to the NED plan must be approved at the Assistant Secretary of the Army level before the release of the draft report, but recent Planning Bulletins indicate that a certain level of judgment, and the application of risk and uncertainty is allowable where the difference between plans is minimal. Initial economic results show that the difference in benefits between high performing plans is small, with the NED plan in the Central Region having $246,000 in AANB while the TSP has $225,000 in AANB which differs by only $21,000. The TSP in the Central Region also has lower residual risk and lower initial construction costs when compared to the NED plan.

Presentation of the TSP as the non-maximizing NED Plan is made with the understanding that significant risk and uncertainty is present in the economic analysis of the TSP due to the level of detail and that these uncertainties will be addressed in future post-TSP analyses to inform the optimization phase following the ADM Meeting.

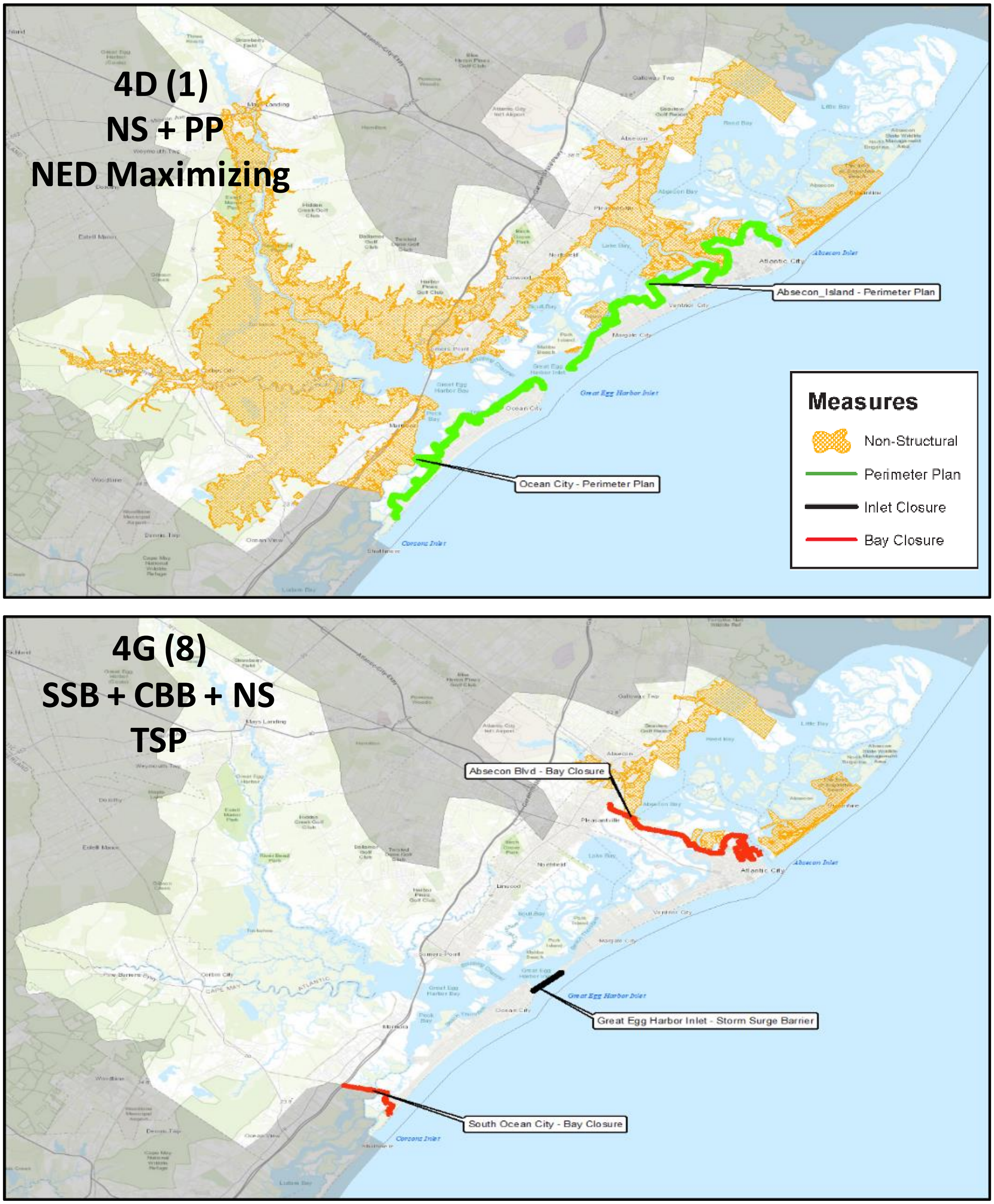


Figure 80: Central Region Alternatives 4D(1) (NED maximizing) and 4G(8) TSP

8.1.3 Nonstructural Plan

A study area wide nonstructural-only plan has also been identified (Figure 81) which includes significantly more structures (42,800) than that of the NED Plan which includes 19,900 structures. While this nonstructural only plan is not the most justified of the other plans presented, a summary of this plan is offered here for comparative study area wide opportunities. As previously discussed in detail, the nonstructural economic analysis incorporates only building retrofits (elevations) to residential structures. Building retrofits, while effective in reducing the potential risk for storm damage to that specific structure, has no positive impact on reducing storm damage risk to surrounding property, vehicles, or infrastructure. Using FY21 price levels, the nonstructural plan is expected to provide mean AANB of $606,163,000 with a Benefit-to-Cost ratio of 2.2 and 39% in Residual Damages This nonstructural only alternative plan has higher residual damages as compared to the TSP and other alternative plans. An additional significant feature of this this study wide nonstructural plan is that there are no associated OMRR&R costs.

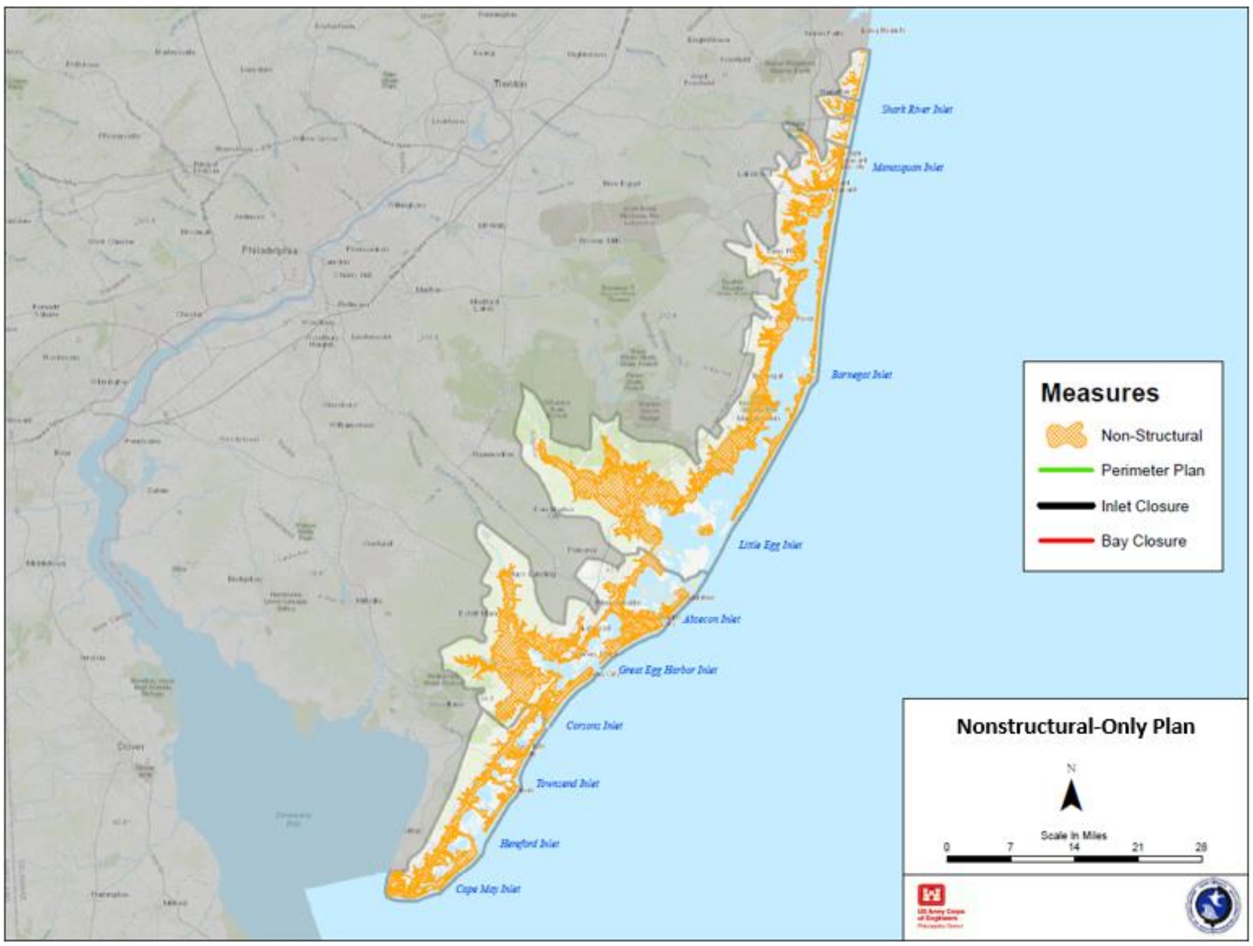


Figure 81: Study area wide nonstructural Plan

8.1.4 Natural and Nature-Based Features Analyses

Natural and nature-based features assist in the incorporation of natural approaches to develop regional climate change and sea level rise adaptation planning strategies and solutions in the NJBB CSRM Study area. Large-scale features under consideration include wetland/marsh island creation, storm surge filters and horizontal levees.

An initial suite of opportunities for integration into the TSP are identified for each of the NJBB Regions. NNBF opportunities are demonstrated in maps outlining location specific concepts. The features shown on the map are drawn to locate the general area an NNBF might be considered and are not representative of a specific design. A complete discussion of the entire range of NNBF strategies considered can be found in the Natural and Nature-Based Features Appendix inclusive of key design concepts which are documented in the latter sections of that Appendix.

Within the Coastal Lakes Region, due to the highly variable conditions of the various lakes, very few generalizable NNBF responses are possible within this region (Figure 82). The reduction of flood risk is something that must be considered on a lake-by-lake basis. However, the opportunity of terracing or lining lakes with vegetation that could serve as stormwater filters, habitat, and increased recreational amenities is one overall strategy that may be applicable. Other possibilities include the creation of islands within the river itself in order to reduce storm effects to the surrounding coastlines.

Figure 82: Natural and Nature-Based Features within the Shark River/Coastal Lakes Region

As the largest region of the study, and a collection of somewhat similar conditions throughout the region, the North Region provides the opportunity to study a series of strategies that could be repeatedly deployed at large scale, calibrated to specific conditions. For this report, Barnegat Bay is used as an example for this approach, demonstrating the range of NNBF strategies that could be used at a bay-wide scale to address some of the more ubiquitous conditions there (Figure 83). Since the Holgate CBB and the Little Egg-Brigantine SSB are not included in the TSP, importance is placed on the performance of the Tuckerton Peninsula/Great Bay Boulevard wetland complex and the system of sedge islands to the northeast of the peninsula. Two possible NNBFs are included in this area, including possibilities for the Tuckerton Peninsula and the modifications of the sedge islands to enhance their performance as a surge filter.

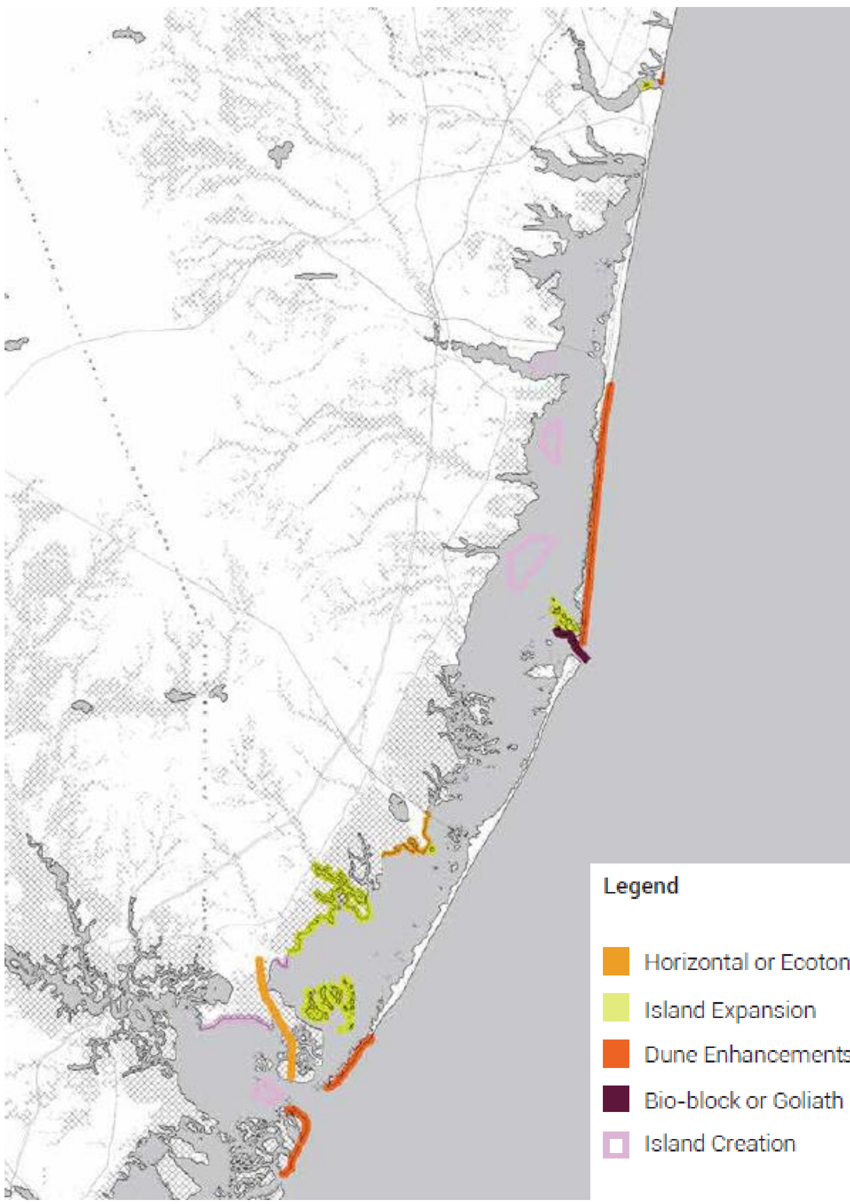


Figure 83: Natural and Nature-Based Features within the North Region

One of the significant challenges of the Central Region is the flooding of urban areas from the bay during periods of high water. In addition to the aforementioned SSB and CBBs, there is likely to be some consideration of flood wall or levee construction to protect urban populations on the barrier islands (Figure 84). Horizontal levee opportunities exist in Ocean City. Many previously wetland creation and bayfloor shallowing opportunities exist in this region particularly in and around Reed's Bay given inclusion of the Absecon CBB in the TSP.

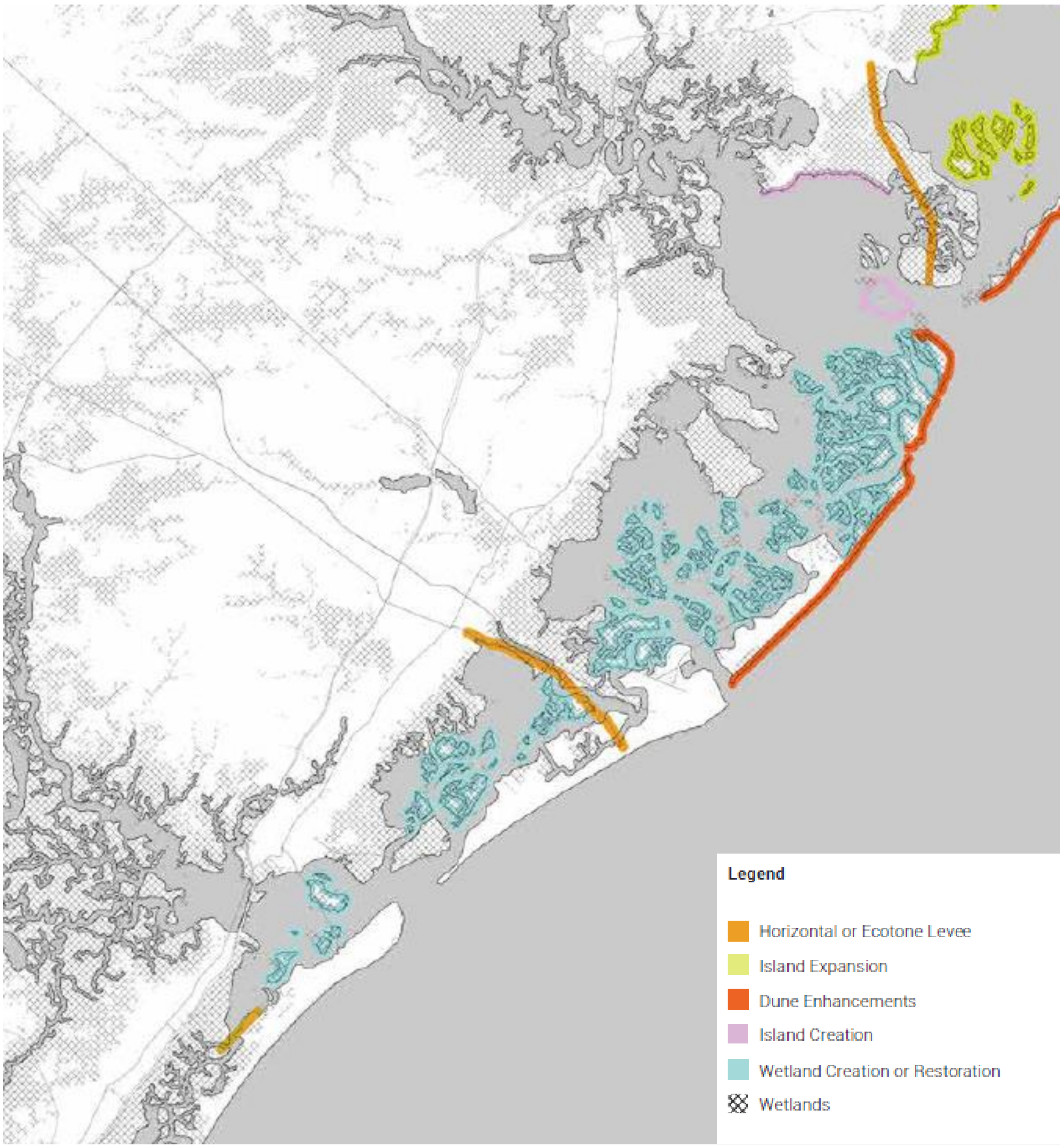


Figure 84: Natural and Nature-Based Features within the Central Region

Due to the infeasibility of structural CSRM measures in the TSP in the South Region, this region will likely require significant investments to enhance wetlands to complement nonstructural strategies in order to provide enhanced storm protection (Figure 85). NNBFs similar to those described for Ocean City above or the wetland enhancement projects described elsewhere in this section may be applicable to the South Region. Dune enhancement and beach nourishment is also possible in this region as a method of protecting barrier island communities. An additional opportunity is the Seven Mile Island Innovation Lab which is a collaborative project between the USACE, the Wetlands Institute, and the State of New Jersey. It is developing innovative methods of sediment management that have significant potential to contribute to CSRM.

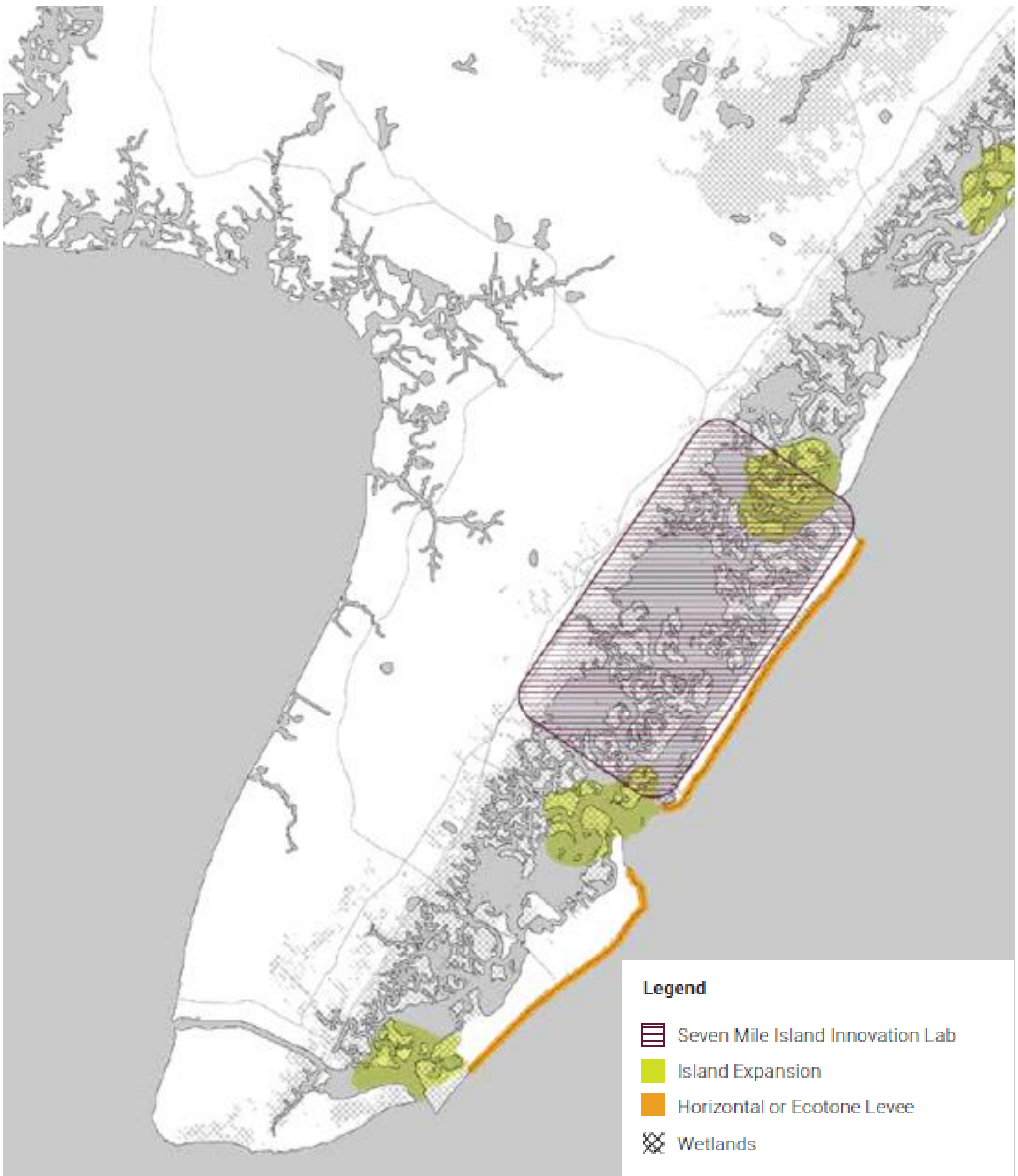


Figure 85: Natural and Nature-Based Features within the South Region

Smaller stand-alone measures under consideration include living shorelines, reefs, wetland restoration and submerged aquatic vegetation. NNBFs are also being considered in combination with structural measures including critical infrastructure as well as in areas with undeveloped shorelines adjacent to SSBs or floodwalls/levees to pre-emptively address erosion near these structures. Specifically, NNBFs would meet the project objectives when placed in combination with the following structural measures:

- Unarmored shorelines adjacent to infrastructure;
- Complementary to structural measures such as floodwalls and levees; and
- Specific modifications to structural measures including habitat benches to restore more natural slope along shorelines and textured concrete to support colonization of algae and invertebrates.

Ongoing analyses are being performed as part of the study process to assess the role of NNBF measures to manage the risk from both erosion and inundation. Additional analyses are being conducted to determine if NNBFs help to meet the project objectives and provide CSRM attributes in relation to costs along several accounts not limited to economic benefits.

8.1.5 Critical Infrastructure Analysis

The existing HEC-FDA model already captures physical losses to critical infrastructure assets, such as hospitals, fire departments, and police stations. Non-physical losses that occur due to the impairment of critical infrastructure—for instance, the economic losses incurred when a community loses power or wastewater services—are not currently accounted for within HEC-FDA. This is due to the difficulty in tying water levels to consequences for these secondary effects. Additionally, damages to roads, ports, utilities, telecommunication lines, water supply infrastructure, and other resources that do not have rigorously defined depth-percent damage curves are not currently included in HEC-FDA (or are included only using generic depth-percent damage curves).

Within the existing analysis, critical infrastructure losses are treated outside of HEC-FDA using historical loss data from FEMA, NJT, and DOT to derive AEP-damage curves that map the return frequencies of events to damages. This methodology, while mathematically sound, suffers due to a lack of data. During the next study phase, this methodology will be overhauled by instead mapping the consequences of flooding for each type of infrastructure asset to dollar losses based on flood depth (i.e., deriving bespoke stage-damage curves). It is currently possible, however, to identify the vulnerable critical infrastructure assets within the study area and gauge their level of risk to coastal storm events.

To date, there are approximately 1,785 critical infrastructure assets within the study area. Of these, 656 of them are or may be vulnerable to inundation by 2080 under the Intermediate SLC rate. The data are from the HSIP Gold 2015 geodatabase from National Geospatial Intelligence Agency and the vulnerability determination was made evaluating whether the asset would be in the 2080 1% AEP floodplain. To display these data visually, the various types of critical infrastructure were weighted using the risk scores used in *Planning Appendix C* of the NACCS. The weights ranged from 5 (for bus stations and ferries) to 30 (for fire stations, hospitals, and wastewater infrastructure). A list of the types of vulnerable infrastructure in the study area, their counts, and their risk scores is shown in Table 78. The weights were used to generate the reach-based heat map seen below in Figure 86, while the points themselves, color-coded based on risk score, are displayed in Figure 87.

Table 78: Vulnerable Critical Infrastructure Counts

Type of Infrastructure	Count	Risk Score
Airport	1	15
Amtrak Station	2	15
Bus Station	8	5
Cell Tower	16	10
Colleges	2	15
Electric Power	10	25
Emergency Medical Services	57	25
Ferry	1	5
Fire Station	53	30
Gas Station	61	20
Hospital	3	30
Law Enforcement	29	25
National Shelter	36	20
Natural Gas Compressor	1	15
Nursing Home	4	25
Petroleum Pumping Station	43	10
Pharmacy	41	15
Place of Worship	25	15
Private School	11	10
Public School	41	15
Railroad Bridge	11	20
Railroad Station	3	20
Railroad Yard	1	20
Road/Bridge	170	20
Substation Electric	13	20
Urgent Care	3	20
Wastewater Infrastructure	10	30
Grand Total	**656**	

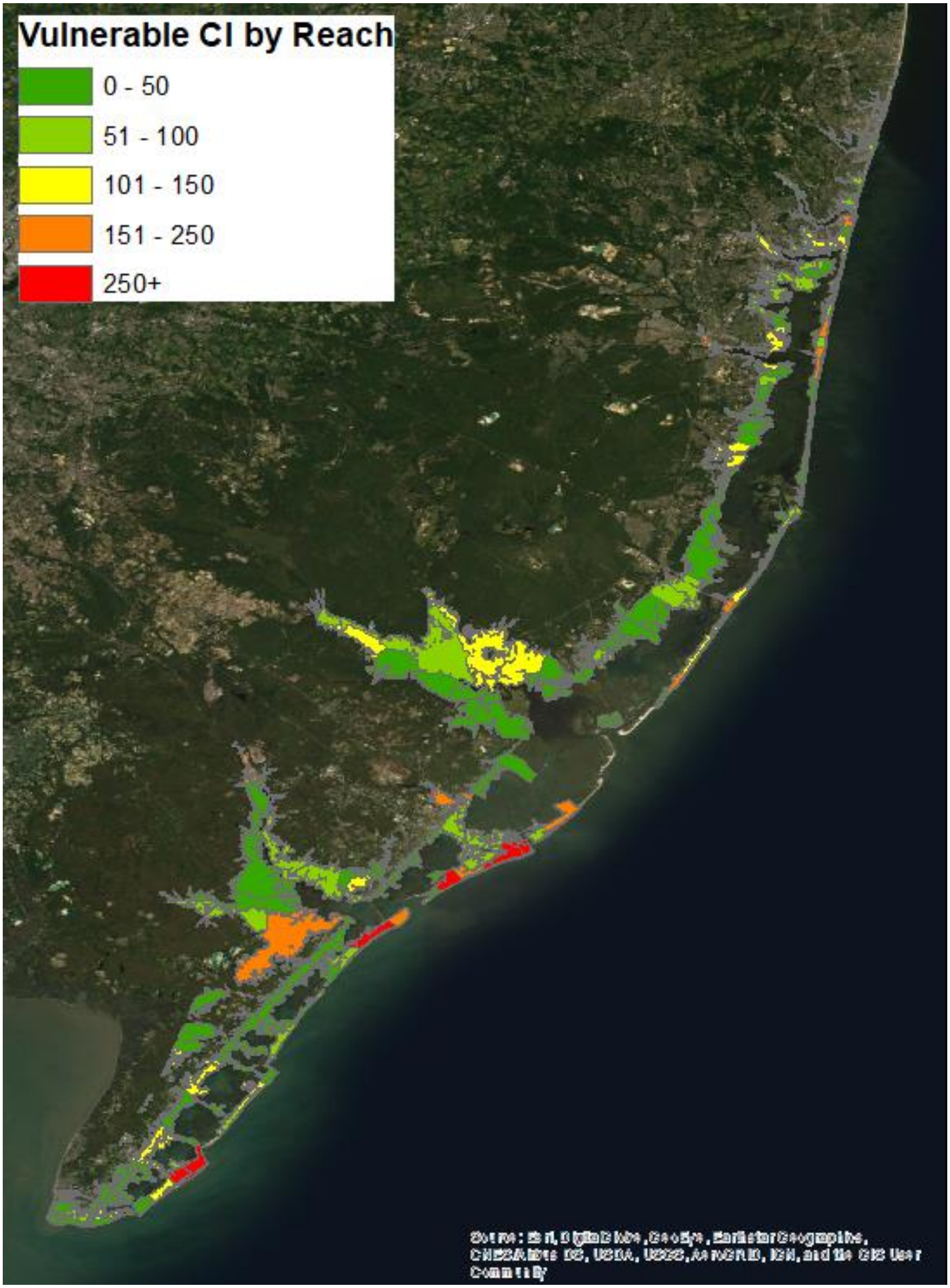


Figure 86: Heat Map of Vulnerable Critical Infrastructure by Reach

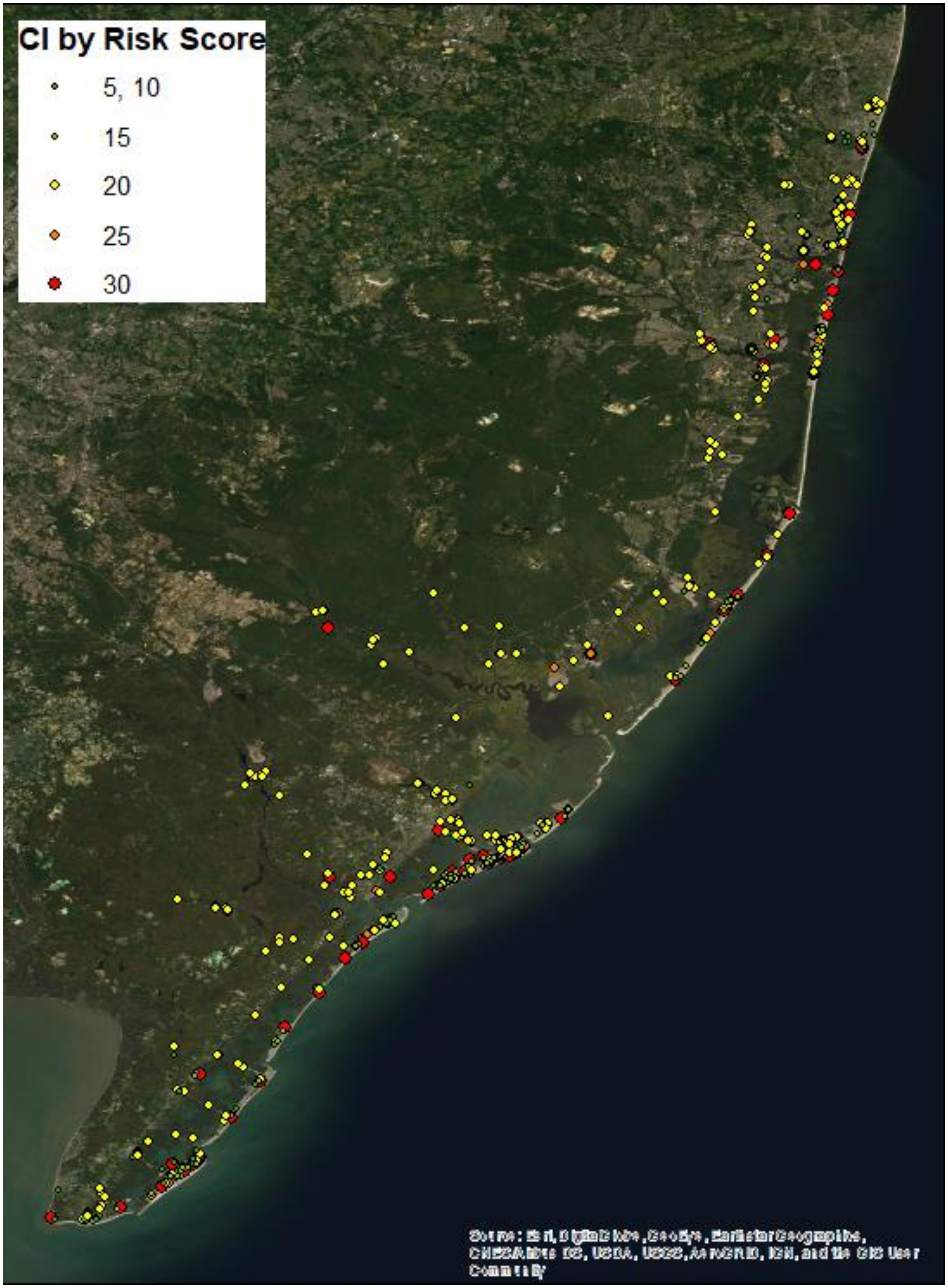


Figure 87: Depiction of all Vulnerable Critical Infrastructure Assets in Study Area

As can be seen in the heat map, the highest concentrations of vulnerable critical infrastructure (weighted by risk score) are in Atlantic City, Ocean City, and Wildwood—places that, not coincidentally, also have high risk for other flood damages. In fact, the critical infrastructure heat map looks very similar to the FWOP damages heat map (see Figure 39, Economics Appendix), though it shows less vulnerability along Long Beach Island, which has relatively fewer critical infrastructure assets.

Moving forward, the vulnerable critical infrastructure assets will be examined in more detail. The structure values for the critical infrastructure assets will first be reassessed using RSMeans construction cost estimate database industrial dollar per square foot estimates and their corresponding content-to-structure value ratio (CSVR)s will be updated. For assets where damage may lead to secondary NED losses, like a power plant becoming flooded and its customers losing power, a deep dive will be performed to determine both vulnerability and consequences. For many types of assets, including wastewater plants, hospitals, and electric plants, these secondary damages may be quantified using a methodology derived from the FEMA manual *Benefit-Cost Sustainment and Enhancement*. Other options for determining consequences involve collaborating with the utilities to determine the consequences of flooding, thereby allowing for the construction of bespoke depth-percent damage curves on a utility-by-utility basis.

This critical infrastructure plan which could be implemented as part of a tiered implementation strategy of scaled, incrementally implementable integrated USACE construction opportunities would help to buy down life, health and safety risk and be comprised of hybrid solutions which may include perimeter plan, smaller SSBs, nonstructural (elevation, floodproofing, ring levees, evacuation planning, acquisition and relocation), and NNBFs. This critical infrastructure plan would help to address communities at risk on a more incremental basis towards reducing risk of coastal flooding to and including critical infrastructure of significant institutional and residential significance, and will consider risk management associated with higher frequency (10, 20, and 50 yr. events).

Components of the critical infrastructure plan could be incrementally justified and employed to identify "shorter term, lower levels of protection" type measures that could be implemented more readily in the short term to help citizens recover from storms more quickly, keeping the larger scale portions of the project still in the mix.

Such a critical infrastructure plan would assist in addressing environmental justice as part of the plan formulation and NEPA process. Environmental justice is the fair treatment and meaningful involvement of all people, regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Environmental justice is defined in Executive Order (E.O.) 12898 as:

> *" Each Federal agency must make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health, environmental, economic and social effects of its programs, policies, and activities on minority and low-income populations, particularly when such analysis is required by NEPA. The EO emphasizes the importance of NEPA's public participation process, directing that each Federal agency shall provide opportunities for community input in*

the NEPA process. Agencies are further directed to identify potential effects and mitigation measures in consultation with affected communities."

The E.O. requires agencies to work to ensure effective public participation and access to information. Thus, within its NEPA process and through other appropriate mechanisms, each federal agency should, translate crucial public documents, notices, and hearings, relating to human health or the environmental for limited English speaking populations when it is practical and appropriate."

Environmental justice is part of an equity-focused resilience planning process the NJBB CSRM Study employs to consider the needs of socially vulnerable populations. The NJBB outreach program inclusive of stakeholder, public and environmental resource agency meetings help to promote meaningful and supportive engagement of socially vulnerable groups.

From an economic perspective, critical infrastructure damage is quantified as the structural (i.e., building) damage calculated within HEC-FDA and the non-building damage (i.e., assets that don't have depth-percent damage curves) empirically modeled outside of HEC-FDA. Future work will identify secondary damages that stem from the damage to infrastructure and to address critical infrastructure separately from the rest of the inventory to potentially determine smaller plans that could have outsized benefits.

8.1.6 Separable and Complementary Measures Analysis

HFF includes flood events caused by non-storm inundation events including tides, winds, seasonal water level fluctuations or combinations thereof that occur more than once per year. This type of flooding is also known as nuisance flooding, recurrent flooding, or sunny-day flooding. For the NJBB CSRM Study, the term HFF is expanded to also include smaller storm inundation events in which the TSP's SSBs remain in an open position. Despite the TSP effectiveness at reducing and managing the risk to coastal storm events there are still residual damages associated with HFF. RSLC will render the existing patchwork network of bulkheads along the study area's shoreline less effective at preventing HFF, leaving the study area susceptible to greater depths and frequency of HFF. Since the TSP's SSBs and nonstructural measures do not reduce water levels during HFF event the NJBB CSRM Study is exploring additional complementary measures to address HFF, such as NS, NNBFs, bulkheads, critical infrastructure plans, and municipal partnership considerations. It is recognized that the long-term quality of life and sustainability of study area is dependent on managing the pernicious threat of HFF as well as the risk of coastal storms.

Separable and complementary measures to manage coastal flooding risk associated with higher frequency flooding events offers an alternative opportunity to complement the TSP. Separable measures are those measures that can provide a level of risk management to an area without relying on other measures, and therefore can potentially be applied on a smaller regional or local scale under a different authority which is not being considered for this study given the large study area. Individually justified separable measures or combined measures in the form of alternative plans can be considered.

Complementary measures are those measures that provide risk management in the residual floodplains of structural measures in order to provide a uniform level of risk management throughout the region in question. For example, engineering constraints may limit the location of a structural measure such that a portion of a neighborhood is left unprotected. Provision of complementary measures, typically nonstructural, low elevation floodwalls or NNBFs, will provide a similar level of risk management when combined with other management measures as offered by the TSP, thus allowing for a more holistic approach to regionwide flood risk management.

An example of the potential complementary measure opportunity in Ocean City, NJ associated with a 20% AEP storm event where the SSBs remain open, is shown in Figure 88 for 2030 and 2080 (USACE Intermediate SLC scenario). The extend and depth of flooding for the 20% AEP is already significant in 2030 with nearly 50% of the barrier island inundated by 0 to 2 feet, and smaller but still significant portion of the island inundated by 2 to 4 feet. The extend and depth of inundation in 2080 increase in association with RSLC. The HFF inundation maps of Ocean City highlight the severity of flooding event at the 20% AEP and need for additional HFF measures.

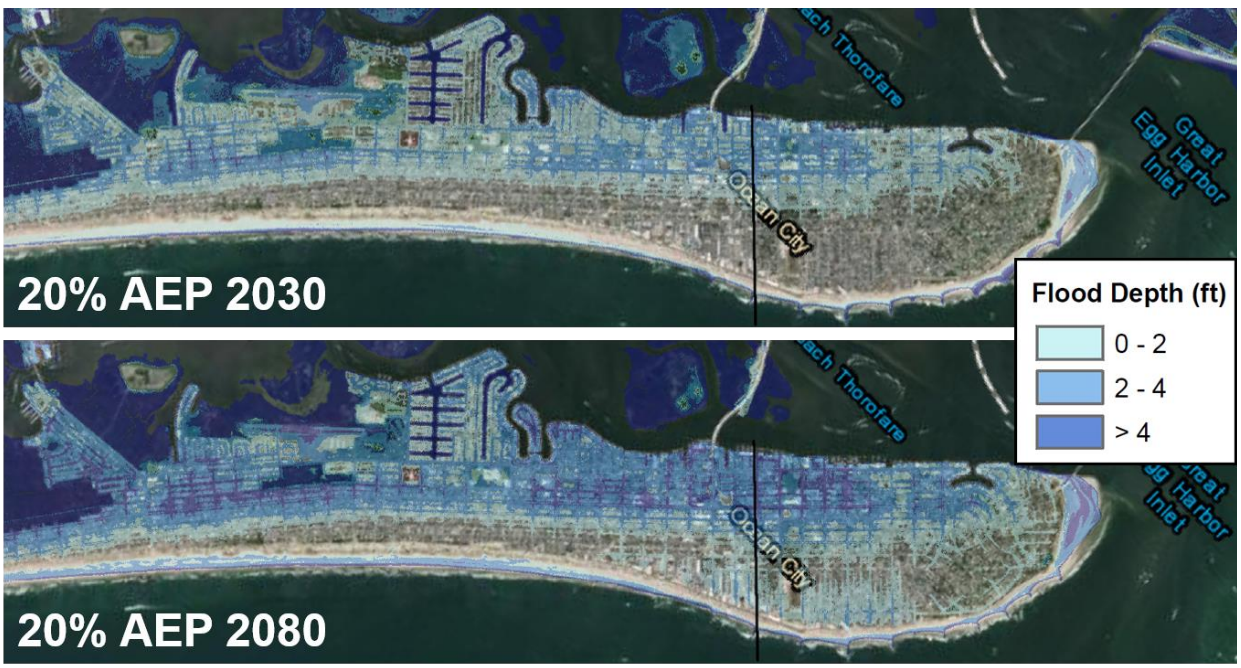


Figure 88: HFF Inundation in Ocean City, NJ (Central Region)

8.1.6.1 Nonstructural

NS measures such as elevation, buyout/relocation, wet/dry floodproofing are well suited as complementary measures to the TSP in regions with SSBs. Any structures that would be damaged by HFF could be elevated above the flood plain. Over time, as the forecasted water level at which the SSB closes increases, additional structures could be included in the NS plan to accommodate the increase flood elevations with increasing damages. In Central and North Regions with SSBs wet/dry floodproofing may be more suitable for addressing HFF since the depth of inundation is limited to the 20% AEP. In larger storm events the SSBs would be closed greatly reducing the upper limit of water levels in the region. An additional benefit of HFF NS measures is that also help reduce residual flood damages from the largest of storm events, that even with the SSBs closed there remains a risk of elevated water levels and damages to the most vulnerable and low-lying assets.

8.1.6.2 Natural and Nature-Based Features

NNBFs have been proven to be relatively effective at reducing wave and flooding impacts during HFF events where the water levels are lower and the NNBFs are less likely to be submerged and thus more effective at attenuating wave energy. For these reasons it is possible that many of the NNBFs measures developed by EWN Team, such as island creation, marsh restoration, living shorelines, and horizontal levees, would be better suited for reducing damages during HFF events than more severe storm events.

8.1.6.3 Shore Based Measures (Bulkheads)

An evaluation of tidal records at Atlantic City, NJ shows that HFF in the study area has increased over the last 100 years due to RSLC and is going to experience a dramatic acceleration in HFF in response to RSLC (even under the historic rate of RSLC). It is difficult to assess what is a tolerable frequency and depth of flooding before the impacts to roads and infrastructure are unacceptable. The analysis of HFF shows that major investments in bulkheads and storm water systems (i.e., pump stations) are likely to be required in the future for the portions of the study area to remain inhabitable. However, based on the PDTs experience in other back bay studies, such as Nassau County, NY, it does not expect that a floodwall/bulkhead designed to the 20% AEP would be economically justified under USACE guidelines. In previous studies the relatively high cost of the floodwalls designed to the 20% AEP has not been supported by the damages prevented. However, it will be imperative the State, Counties, local municipalities, and individual property owners, increase the elevation of shore based measures over time or else HFF may overwhelm roads and storm water systems on a regular basis.

8.1.6.4 Municipal Partnership Considerations

Addressing HFF will require a comprehensive approach involving collaboration at all levels of government from the Federal government down to local municipalities. There are already existing opportunities and examples of partnerships with local municipalities such as the NJDEP grants and loans to support flood hazard risk management and shore protection projects. Grant programs such as this may provide an incentive for municipalities and individual homeowners to build NNBFs, elevate bulkheads, and improve storm water infrastructure to help lessen the impacts of HFF. Other innovative programs such as municipal level grant procurement frameworks and special taxing districts may help provide the necessary incentives and funding to help address HFF. Many local municipalities already have ordinances in place that require construction of new bulkheads to be built to specific elevation that may over time help reduce HFF.

8.1.7 Coastal Lakes Region Analysis

Within the Coastal Lakes Region which consists of sixteen bodies of water commonly referred to as "coastal lakes" (Figure 89), eight of these lakes are included in the TSP, including:

- Sylvan Lake (Bradley Beach/Avon-by-the-Sea)
- Silver Lake (Belmar)
- Stockton Lake (Sea Girt/Manasquan)
- Glimmer Glass (Manasquan)
- Lake Louise (Pt Pleasant Beach)
- Little Silver Lake (Pt Pleasant Beach)
- Lake of the Lilies (Pt Pleasant Beach)
- Twilight Lake (Bay Head)

Four of the lakes are ordinary tidewater bodies with direct, open channel tidal connections to the ocean through Manasquan Inlet or upper Barnegat Bay. These four lakes and adjacent land and structures are included in the TSP and will be evaluated for coastal flood risk using HEC-FDA similar to the other portions of the study area. This includes the consideration of the application of NACCS stage-frequency data at appropriate data save points to inventories of structures surrounding each water body. The Manasquan Inlet SSB and nonstructural measures, but not perimeter measures at this time, offer CSRM capabilities as part of the TSP. This group of four "lakes" and their tidewater connection are highlighted in green text in Figure 89 and consist of:

- Stockton Lake (Manasquan Inlet)
- Glimmer Glass (Manasquan Inlet)
- Lake Louise (Manasquan Inlet)
- Twilight Lake (upper Barnegat Bay)

There are also four "lakes" that do not have direct open channel connections to the ocean. However, because of a combination of topography and/or underground hydraulic connections (i.e., "plumbing"), they will be evaluated using the same general methodology described above and are included in the TSP. Coastal storm risk will be managed as part of the TSP at Sylvan Lake and Silver Lake primarily though nonstructural measures, and at Little Silver Lake and Lake of the Lillies primarily through the Manasquan Inlet SSB. These four lakes are highlighted in orange text in Figure 89.

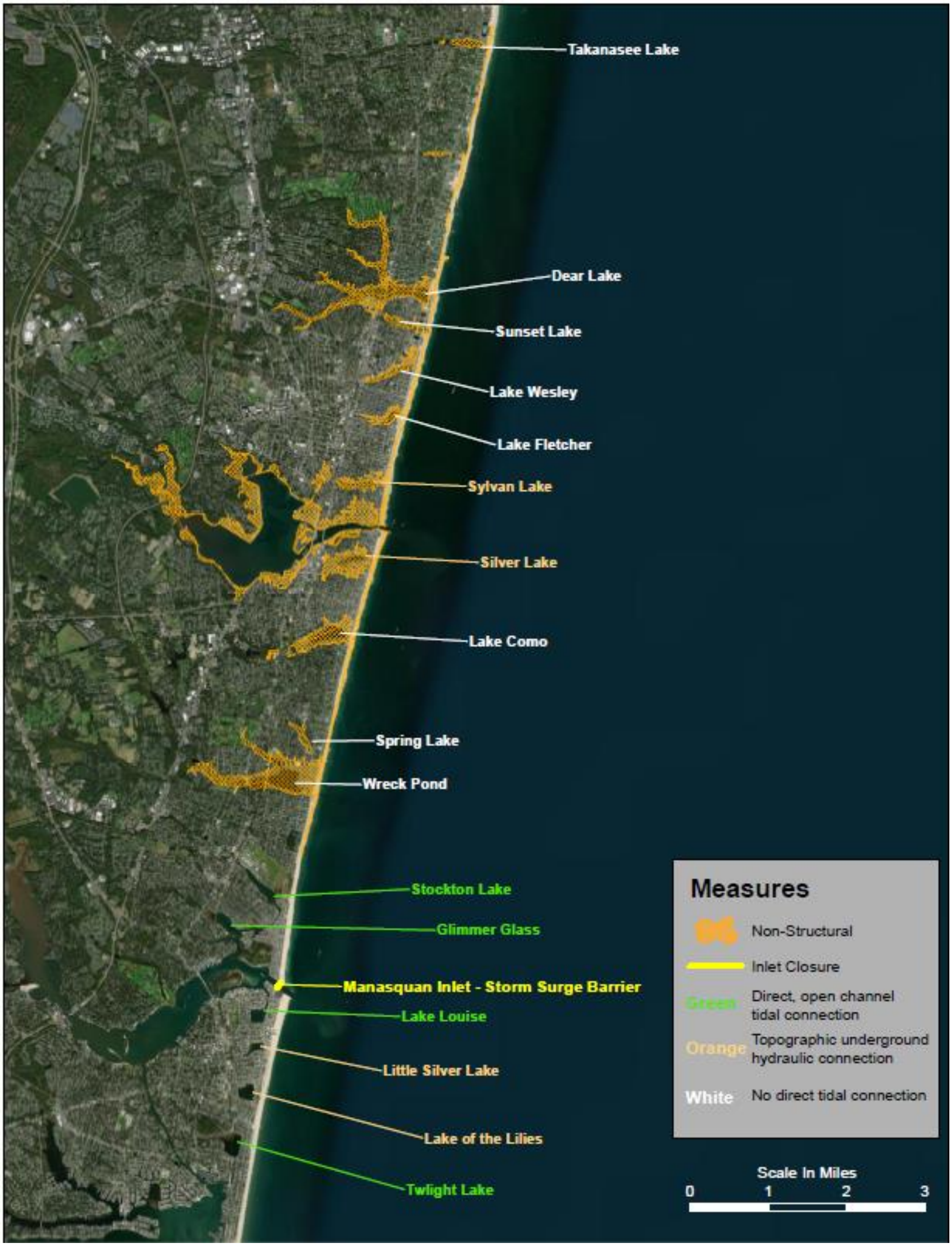


Figure 89: Coastal Lakes within the NJBB CSRM Study Area

Future analyses may be warranted for the Coastal Lakes Region. The remaining eight "coastal lakes" are highlighted in white, which will not be included in the TSP, include:

- Lake Takanassee
- Deal Lake
- Sunset Lake
- Wesley Lake
- Fletcher Lake
- Lake Como
- Spring Lake
- Wreck Pond

These lakes are not directly connected to tidal inlets; hence they are subject to a different type of flood risk than the eight lakes previously discussed and will consequently require an alternate method of analysis. Potential flood pathways for these lakes include fluvial flooding due to precipitation over each lake's watershed, ocean wave and storm surge overtopping of the barrier beach, and ocean storm surge flooding that "backs up" from the ocean into the lake through the underground drainage pipes.

For these eight coastal lakes that are functionally independent from back bay flooding and are only impacted by coastal flooding, the inventory is still analyzed for nonstructural measures, but there are no proposed structural measures for the coastal lakes themselves. In other words, the structures around the coastal lakes are included in the study, but not the lakes themselves.

Since these eight coastal lakes are not part of the TSP, a possible alternative study approach is the USACE Continuing Authorities Program or a General Reevaluation Study for the Sea Bright to Manasquan Inlet CSRM project. Any of these potential future study paths would require approval from USACE higher authority, and endorsement by the non-federal sponsor, NJDEP.

8.2 TSP Considerations and Implications

A series of considerations and consequences of the TSP are addressed below for the following topics:

- Sea level change
- SSB hydraulics and operations
- Managed adaptive approach
- Environmental consequences.

While these considerations and consequences were not used in the actual formulation of the TSP, they are important variables in developing an overall framework to critique the TSP and ultimate implementation of the TSP.

8.2.1 Sea Level Change

8.2.1.1 Comparison of SLC Scenarios for Identified Plans

A discussion comparing the current NED Plan, identified TSP, and Nonstructural-Only Plan under the three USACE SLC scenarios (Low, Intermediate and High curves) are provided below. Table 79 below shows the summary breakdown of the current NED Plan, identified TSP, and Nonstructural-Only Plan under the Intermediate SLC curve scenario. Table 80 provides the results for the Low SLC scenario curve and Table 81 provides the results for the High SLC curve scenario.

Table 79: Comparison of TSP, NED, and Nonstructural Plans (Intermediate RSLC)

Intermediate RSL-C	Tentatively Selected Plan (TSP) / Total Benefits Plan	National Economic Development (NED) Plan	Nonstructural Plan
FWOP AAD	$1,808,610,000	$1,808,610,000	$1,808,610,000
Future With-Project AAD	$393,372,000	$417,176,000	$710,695,000
Total Reduced AAD	**$1,415,238,000**	**$1,391,434,000**	**$1,097,915,000**
Total Initial Construction	$16,067,536,000	$16,492,814,000	$13,947,220,000
OMRR&R	$195,710,000	$134,957,000	$0
Average Annual Cost (AAC)	**$803,107,000**	**$758,956,000**	**$491,752,000**
Average Annual Net Benefits	**$612,131,000**	**$632,478,000**	**$606,160,000**
Benefit-Cost Ratio	**1.8**	**1.8**	**2.2**
Residual Damages	21.7%	23.1%	39.3%
Eligible Nonstructural	18,800	19,900	42,800
Shark River / Coastal Lakes	**2A**	**2A**	**2A**
North Region	**3E(2)**	**3E(2)**	**3A**
Central Region	**4G(8)**	**4D(1)**	**4A**
South Region	**5A**	**5A**	**5A**

Table 80: Comparison of TSP, NED, and Nonstructural Plans (Low RSLC)

Low RSL-C	Tentatively Selected Plan (TSP) / Total Benefits Plan	National Economic Development (NED) Plan	Nonstructural Plan
FWOP AAD	$1,437,190,000	$1,437,190,000	$1,437,190,000
Future With-Project AAD	$311,424,000	$503,602,000	$577,117,000
Total Reduced AAD	**$1,125,766,000**	**$933,588,000**	**$860,073,000**
Total Initial Construction	$16,067,536,000	$13,324,776,000	$13,947,220,000
OMRR&R	$195,710,000	$73,279,000	$0
Average Annual Cost (AAC)	**$803,107,000**	**$559,106,000**	**$491,752,000**
Average Annual Net Benefits	**$322,659,000**	**$374,482,000**	**$368,321,000**
Benefit-Cost Ratio	**1.4**	**1.7**	**1.7**
Residual Damages	21.7%	35.0%	40.2%
Eligible Nonstructural	18,800	28,500	42,800
Shark River / Coastal Lakes	**2A**	**2A**	**2A**
North Region	**3E(2)**	**3E(2)**	**3A**
Central Region	**4G(8)**	**4A**	**4A**
South Region	**5A**	**5A**	**5A**

Table 81: Comparison of TSP, NED, and Nonstructural Plans (High RSLC)

High RSL-C	Tentatively Selected Plan (TSP) / Total Benefits Plan	National Economic Development (NED) Plan	Nonstructural Plan
FWOP AAD	$3,874,279,000	$3,874,279,000	$3,874,279,000
Future With-Project AAD	$1,196,560,000	$1,121,338,000	$1,767,230,000
Total Reduced AAD	**$2,677,719,000**	**$2,752,941,000**	**$2,107,049,000**
Total Initial Construction	$16,067,536,000	$18,701,058,000	$13,947,049,000
OMRR&R	$195,710,000	$101,769,000	$0
Average Annual Cost (AAC)	**$803,107,000**	**$793,933,000**	**$491,752,000**
Average Annual Net Benefits	**$1,874,612,000**	**$1,959,008,000**	**$1,615,297,000**
Benefit-Cost Ratio	**3.3**	**3.5**	**4.3**
Residual Damages	30.9%	28.9%	45.6%
Eligible Nonstructural	18,800	28,000	42,800
Shark River / Coastal Lakes	**2A**	**2A**	**2A**
North Region	**3E(2)**	**3A**	**3A**
Central Region	**4G(8)**	**4D(1)**	**4A**
South Region	**5A**	**5D(1)**	**5A**

A summary of the alternatives selected for both the NED plans and the TSPs for each SLC rate can be found below in Table 82.

Table 82: TSP and NED Plan by SLC Rate

	Shark River & Coastal Lakes		North Region		Central Region		South Region	
SLC Rate	TSP	NED	TSP	NED	TSP	NED	TSP	NED
Low (Historic)	2A	2A	3E(2)	3E(2)	4G(8)	4A	5A	5A
Intermediate	2A	2A	3E(2)	3E(2)	4G(8)	4D(1)	5A	5A
High	2A	2A	3E(2)	3A	4G(8)	4D(1)	5A	5D(1)

As Table 82 shows, the NED plan often depends on the SLC curve selected. The TSP, which was formulated under the Intermediate SLC curve and based on both AANB and other criteria, such as adaptive capacity, fragility, and life safety risk, does not change based on the SLC curve selected. The increase or decrease of SLC increases or decreases the magnitude of AANBs, but only one plan—5D(2)—changes sign (it goes from negative AANBs to positive under the High curve). As such, the selection of SLC curve is not the determinant of economic viability for the project. There are two changes to the NED plan under the High curve in the North and the South regions, though, as well as a change to the NED plan under the Low curve in the Central Region. For these, the NED plan switches from one economically justified plan to another economically justified plan.

In the North under the High Curve, the NED plan switches from 3E(2) (SSB and nonstructural) to 3A (nonstructural). This result, while surprising, is an artifact of how the SSBs were modeled within HEC-FDA. In the face of higher SLC, there may be changes to closure frequency or increased nonstructural implementation that are not captured within the HEC-FDA analysis. These additional measures would likely make 3E(2) the NED plan, despite the HEC-FDA results suggesting that 3A is the NED plan. Future analysis will verify this, while a qualitative discussion of adaptability and sea level change can be found later in this Section.

In the South under the High curve, the NED plan switches from 5A (nonstructural) to 5D(1) (perimeter plus nonstructural). While it is true that perimeter measures prevent more damage as there is more sea level change, these results need to be considered in context. There are major limitations in using the results under the High SLC curve, as HEC-FDA is not a life cycle model and does not allow for inventory changes over time. As the sea level rises, some structures will begin to take high amounts of repetitive damage. In reality, some of these structures will be elevated or not be rebuilt, but within HEC-FDA, they are assumed to remain in the inventory and take damage until the end of the study timeframe. When HEC-FDA interfaces a static inventory with water levels that have been raised by SLC, the model may overestimate damages by assuming indefensible repetitive damages. Some of the damages reduced by the perimeter plan in the South under the High SLC curve are those repetitive damages; as such, it is possible that, even under the High curve, the nonstructural plan is still the NED plan. Future work will seek to remove erroneous repetitive damages to verify the NED plan for the South under the High curve.

8.2.1.2 Sea Level Adaptability

The following section provides a snapshot of the ongoing sea level change strategies analysis for the three remaining measure types in the study: floodwalls, SSBs, and nonstructural (elevation/acquisition/floodproofing). The currently identified NED Plan contains both nonstructural and floodwalls and the TSP contains both nonstructural and SSBs. The Nonstructural Only Plan contains only nonstructural measures.

For the SSB measure, the closure criteria are currently unknown and must be defined and optimized in the next study phase. For the purposes of this sea level change analysis, the closure criteria are assumed to be indexed to the 20% AEP event stage in Year 2030 (approximately 6.9ft NAVD88). For Criterion 1, the SSB would maintain the 20% AEP event stage over the period of analysis. With sea level change, the actual stage for the 20% AEP increases over time (approximately 8ft NAVD88 in Year 2080 with Intermediate SLC), but the rate at which the SSB closes remains constant. For Criterion 2, the SSB would maintain the 6.9ft NAVD88 stage as the closure criterion over the period of analysis. As the stage criteria is constant, the actual rate of closure for the SSB would increase. Both approaches have pros and cons and will be further developed in the next study phase. For the purposes of this analysis, the SSB is assumed to implement Criterion 1 with complementary nonstructural necessary to maintain project performance (Figure 90).

The qualitative description provides an overview of the sea level change strategies considered for each measure type and Table 83 provides a list of pros and cons for each strategy. In the next study phase, the pros and cons will be quantitatively defined as appropriate and used to facilitate a trade-off analysis.

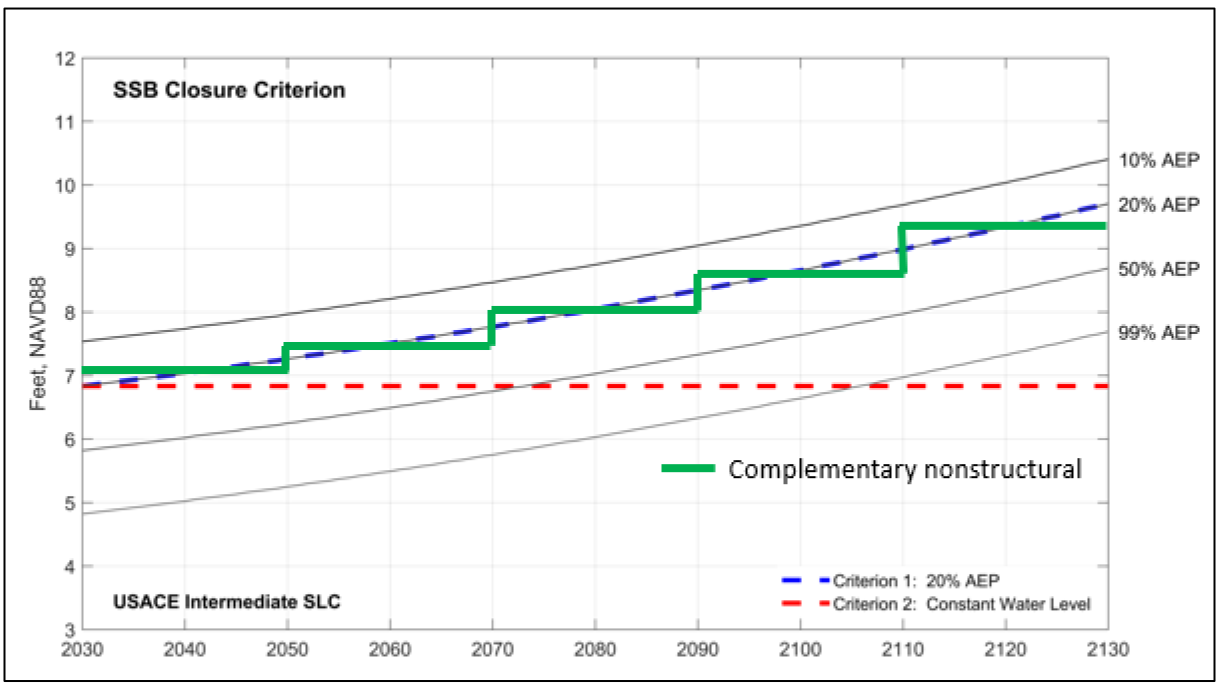


Figure 90: Storm Surge Barrier Closure Criteria Comparison – 100-Year Planning Horizon

Measures Strategy Comparison: Qualitative Description

Floodwalls (Protect)

- Anticipatory – Optimize floodwall height and base for High SLC rate
- Managed Adaptive – Optimize floodwall height for Low/Int SLC rates with overly wide base
- Reactive – Optimize floodwall height and base for Low/Int SLC rates

Storm Surge Barriers (Protect/Accommodate)

- Anticipatory – Optimize barrier components to High SLC rate and implement all nonstructural complementary measures for the entire period of analysis by the Base Year
- Managed Adaptive – Optimize barrier components to High SLC rate and implement nonstructural complementary measures periodically over the period of analysis to maintain project performance
- Reactive – Optimize barrier components to High SLC. No complementary measures.

Nonstructural (Accommodate/Retreat)

- Anticipatory – Implement nonstructural measures (elevate/acquire/floodproof) for all structures that will be eligible over the period of analysis using High SLC rate by the Base Year.
- Managed Adaptive – Implement nonstructural measures incrementally over the period of analysis as structures become vulnerable based on the experienced SLC rate
- Reactive – Implement nonstructural measures for only structures eligible by Base Year. No plans to elevate/acquire/floodproof further structures.

Table 83: Measures Strategy Comparison: Anticipatory, Managed Adaptive, Reactive

	Anticipatory	Managed Adaptive	Reactive
Floodwalls	**Pros** (1) No future actions necessary to preserve project effectiveness and performance (2) Minimizes residual risk (3) Maximizes RED/OSE benefits by keeping inundation out of study area	**Pros** (1) More easily adaptable to future SLC scenarios. Wider base can accommodate taller floodwall heights to maintain effectiveness and performance. Resilient. (2) Lower initial wall height commensurate with current study area vulnerabilities (3) Potentially more societally implementable	**Pros** (1) Less expensive than Anticipatory (Precautionary) or Adaptive approaches. No risk of unnecessary construction or real estate expenses (2) No future expenses planned to elevate or modify floodwall (3) Project is robust in dealing with Low/Int SLC potential impacts

	Cons (1) Requires larger initial investment in real estate, environmental mitigation (larger footprint), and construction materials (2) Potential efficiency loss. Benefits for larger wall height may only be realized late in the period of analysis (or not at all) depending on uncertain SLC future (3) Potential societal implementation issues due to taller wall height	**Cons** (1) Significant initial cost investment for over-building wider base. Benefits may not be realized if wall height is not elevated in the future. (2) Requires a second (or third) expensive future investment to construct a taller floodwall on the pre-built wider base (3) Requires future actions to maintain robustness and performance across all 3 SLC curves. Risk that future decision-makers will not be able to act in time to mitigate future SLC impacts (4) Initial performance less than floodwall optimized for High SLC (residual risk/life safety)	**Cons** (1) Project is not resilient to changes in future SLC scenarios. High SLC rates would dramatically reduce performance and effectiveness. Significant risk of residual damages and life safety under High SLC curve (2) Project is not easily adaptable for future scenarios. Project would need to be effectively rebuilt (significant construction and real estate burdens) to maintain performance and effectiveness. (3) Initial performance less than floodwall optimized for High SLC (residual risk/life safety)

	Anticipatory	Managed Adaptive	Reactive
Storm Surge Barriers	**Pros** (1) Project is robust against all 3 SLC future scenarios (2) Anticipatory complementary measures (floodwall or nonstructural) preserve project effectiveness across all SLC scenarios (3) Constant closure criteria remove necessity to periodically re-evaluate optimal operation plans (4) Provides RED/OSE benefits by keeping inundation waters out of the study area	**Pros** (1) Complementary measures can be implemented over time to mitigate SLC impacts when SSB gates are open. (2) Closure criteria can be variable to shift with uncertain SLC futures. Adaptive complementary measures implemented to maintain project effectiveness (3) Costs for complementary	**Pros** (1) Less expensive than Anticipatory (Precautionary) or Adaptive approaches. No risk of unnecessary complementary measure construction costs (2) No future expenses for complementary measures (3) Project is still robust in dealing with low frequency storm events

		measures incurred only when necessary to combat SLC. If SLC rate is lower than anticipated, no unnecessary costs (4) Incremental implementation allows costs for complementary measures to be spread out over the period of analysis (5) Provides RED/OSE benefits by mitigating major storm events	
	Cons (1) Significant cost to provide complementary structural (floodwall) or nonstructural (elevation/floodproofing) at Base Year that will remain robust throughout entire period of analysis (2) Potential efficiency loss. High initial cost on robust complementary measures may not produce benefits until later in the period of analysis or not realized at all	**Cons** (1) Requires future investments in complimentary measures to maintain project performance and effectiveness (2) Requires future actions to maintain robustness and performance across all 3 SLC curves. Risk that future decision-makers will not be able to act in time to mitigate future SLC impacts (3) Initial performance less than floodwall or nonstructural complementary measures optimized for High SLC (residual risk/life safety)	**Cons** (1) Study area receives significant residual damages from SLC impacts; particularly under the High SLC rate. (2) Project is neither robust nor resilient to potential SLC futures

	Anticipatory	Managed Adaptive	Reactive
Nonstructural	**Pros** (1) No future actions necessary to	**Pros** (1) Efficiency improvement. Structures can be	**Pros** (1) Less expensive than

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

8.2.2 Storm Surge Barrier Hydraulic and Operation Considerations

8.2.2.1 Hydraulic Effects

Storm surge barriers are a combination of static impermeable barriers and dynamic gates that may be closed during storm events to reduce storm surges in the back bays. During normal conditions the gates will remain open allowing for tidal exchange between the ocean and bays. However, even under normal conditions when the gates are open, the gate housings, piers, and impermeable barriers will reduce the cross-sectional area across the inlet. The reduction in cross-sectional area causes an increase in velocities through the open gates and has the potential to reduce tidal exchange between the ocean and bays. A reduction in tidal exchange could lead to other physical impacts including changes in back bay tidal ranges, salinity, sediment transport, and other physical factors. These physical impacts may in turn affect water quality, wetlands, ecological processes, and living resources (Orten et al. 2019).

The USACE Philadelphia District requested the ERDC CHL to perform hydrodynamic and salinity modeling with the Adaptive Hydraulics (AdH) model and particle tracking model (PTM) of proposed storm surge protection measures at several inlets from the Atlantic Ocean. The two-dimensional (2D) AdH model has been developed based on the available data and known primary influences on the physics within the system. The model includes freshwater inflows, tides, salinity, and wind in an effort to reproduce the field for water surface elevation, velocity magnitude and direction, and salinity over a wide range of conditions. The AdH model was validated to available field data for all including a data collection effort performed in February 2019 to collect salinity and discharge/velocity data at three major inlets over a 13-hour tidal cycle – Barnegat, Little Egg, and Great Egg. A detailed description of the model setup and validation are presented as well as the results of several proposed alternatives is provided in Draft Technical Reports by McAlpin & Ross (2020) and Lackey et al. (2020).

AdH modeling was conducted for the TSP and five other alternatives/variations to understand the potential physical impacts of the SSBs and well as the sensitivity of the physical impacts to current design choices: bottom sill elevation, number of gates, location/alignment. One of the strengths of the AdH model is its ability to resolve the detailed geometry of the SSBs with really small grid elements. Figure 91 shows an alignment of the SSB at Barnegat Inlet. Figure 92 shows an example of the SSB design (A1) at Barnegat Inlet and the model resolution.

The modeling results show the SSBs cause an increase in velocities in vicinity of the structures, the greater the reduction in cross-sectional area the greater the increase in velocities. The alignment of the SSB was also found to be important and shifting the alignment away from the strongest currents at an inlet can reduce the overall impacts. Many of the alternative design configurations evaluated with shallower sills or with reduced number of vertical lift gates caused a greater reduction in cross-section area and subsequently the greatest increases in velocities. An example of the impact of the SSB designs on the near-field velocities is shown in Figure 93 for Barnegat Inlet. The velocity patterns and magnitudes at the proposed structure locations are greatly changed, as expected, but the impact to velocity magnitudes away from the structures is very little. The velocity at the inlets and structures should be reviewed for impacts to navigation as well as potential sedimentation impacts. However, the changes produced by modifying the flow at the inlets is fairly localized.

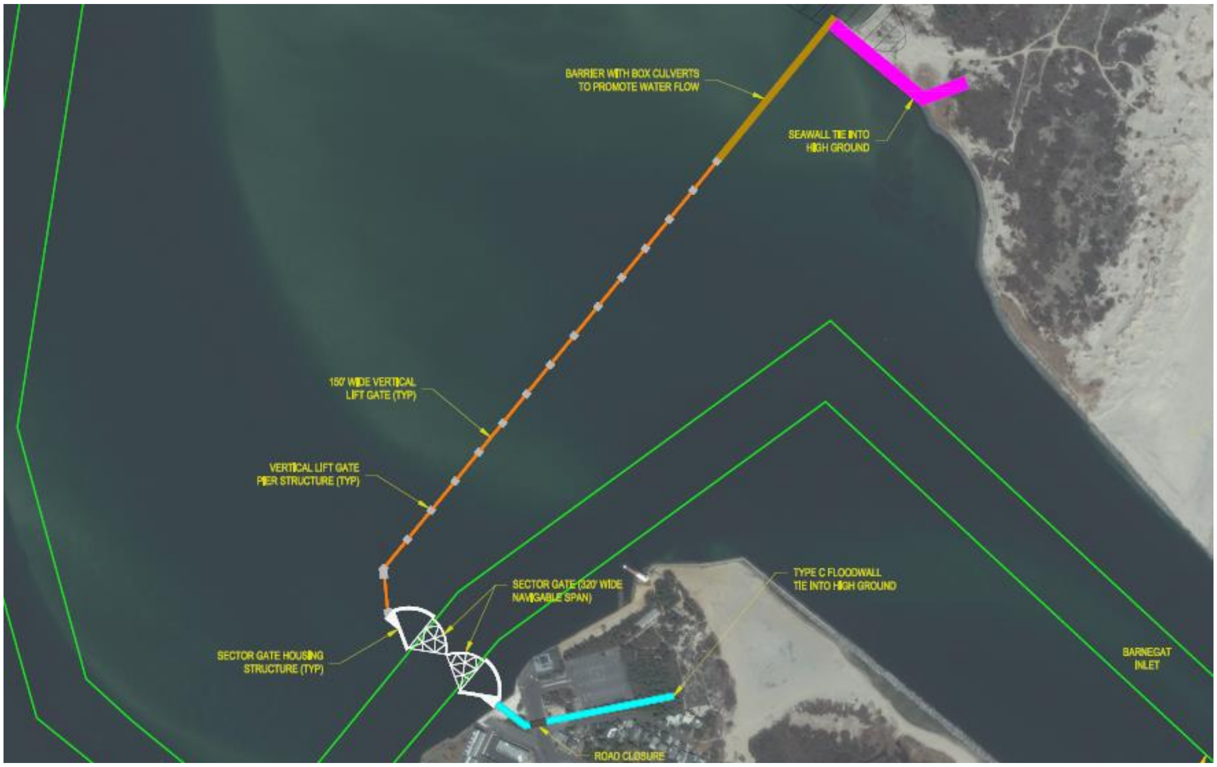


Figure 91: Barnegat Inlet SSB alignment.

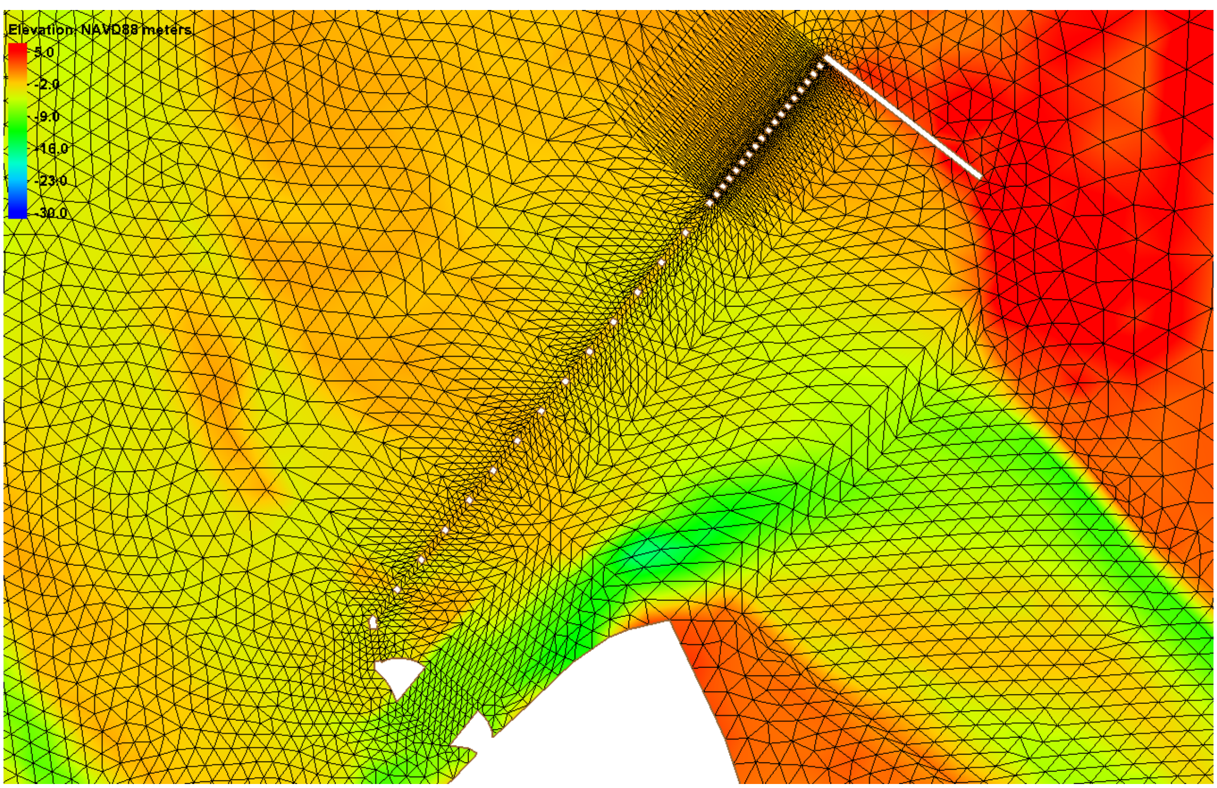


Figure 92: AdH Model Representation of Storm Surge Barrier at Barnegat Inlet (A1)

One of the primary questions is what impact the SSBs have on the exchange of water between the ocean and bay. The volume of water that enters and leaves an inlet during an average tidal cycle is called the tidal prism. The tidal prism may also be thought of as the surface area of a bay multiplied by the average tidal range. The TSP is estimated to have relatively no impact on the tidal prism at Manasquan River, and reduce the tidal prism in Barnegat Bay and Great Egg Harbor by 2.5% and 4.8% respectively. The impacts of the TSP extend beyond the immediate bays at which the closures are located with reductions in tidal prism less than 1.6% elsewhere. The modeling results proved to be sensitive to the design configurations with tidal prism reductions two to three times greater in design variations with less gates or shallower sills. The impacts to tidal amplitudes are not evenly distributed throughout the bays with individual reductions in tidal amplitude ranging from 1.3% to 8.3% through Barnegat Bay and 0.1% to 4.5% in Great Egg Harbor for the TSP.

Overall, the impact of the SSBs on salinities is small, and the mean salinity does not vary by more than 2 ppt for any given location and alternative. The variation at specific times may be larger but overall, the impact is small. Given the well mixed nature of the inlets, ocean salinity is pushed into the back bay areas and allowed to move easily throughout the area. The restrictions created by the alternative structures and the reduction in tidal prism are not large enough to significantly impact the salinity at the analysis locations.

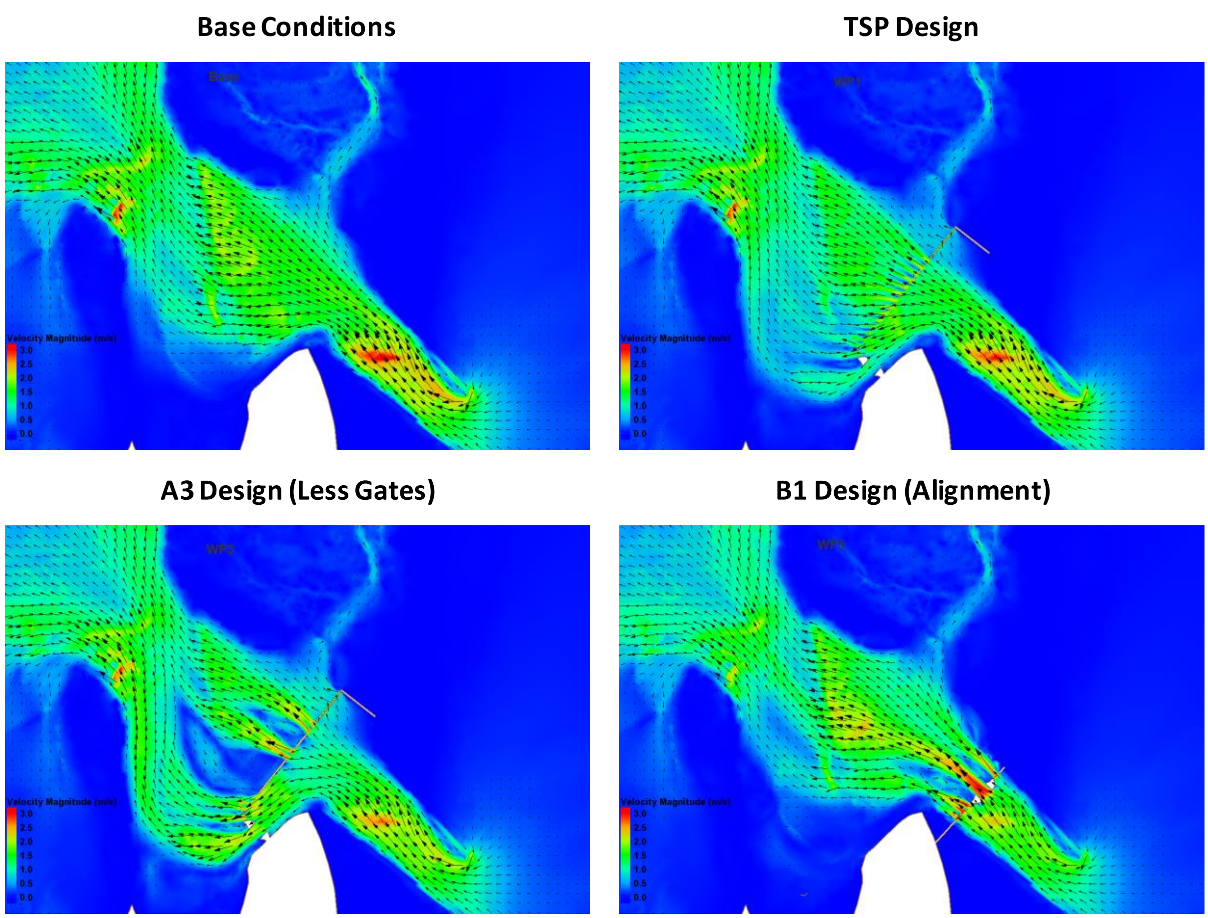


Figure 93: Flood Velocities for Barnegat Inlet Storm Surge Barrier Concepts

One of the other major concerns is the potential impact of SSBs on flushing, residence time, eutrophication, and water quality. Some areas in the study area, such as Barnegat Bay, already suffer from eutrophication, and poor water quality (USGS). Detailed water quality models and investigations of residence time for Barnegat Bay have already been completed. Defne and Ganju (2014) use a combination of hydrodynamic and particle tracking modeling to identify the mechanisms controlling flushing and residence time in Barnegat Bay. Defne and Ganju (2014) also explain the link between residence time and eutrophication:

> *Estuarine eutrophication is a fundamental consequence of anthropogenic nutrient loading to the coast (Bricker et al. 1999). Typical symptoms include phytoplankton blooms (Paerl 1988), macroalgae proliferation (Valiela et al. 1997), seagrass dieback (Duarte 2002), and hypoxia (Rabalais and Turner 2001). Ultimately, eutrophication impairs the ecological function of estuaries in terms of biodiversity, habitat quality, and trophic structure.*
>
> *One primary physical control on eutrophication is estuarine flushing and ultimately residence time (González et al. 2008), which is defined as the time elapsed until a water parcel leaves a water body through one of its outlets. Estuaries with poor flushing and long residence times tend to retain nutrients within the system leading to high primary productivity rates (Lancelot and Billen 1984). Conversely, well-flushed estuaries are more resilient to nutrient loading due to reduced residence time and greater exchange with less impacted coastal waters.*

The AdH hydrodynamic model results were applied to a PTM to evaluate the impact of the SSBs have on residence time in the NJBB CSRM Study area. Overall, the PTM results, Figure 94 showed that the structures had little discernable changes to residence time with modeled differences general within the uncertainty range from innate model randomness caused by diffusion. Model results show that the TSP in general increases in residence time in South and Central Regions by 2 to 5 days and reduces residence time in North Region by 1 to 2 days. Up to now the focus of the AdH and PTM has been on the physical impacts of SSBs during normal conditions when the gates are open. Additional work may be required in the future to assess the impact of the SSB during storm events.

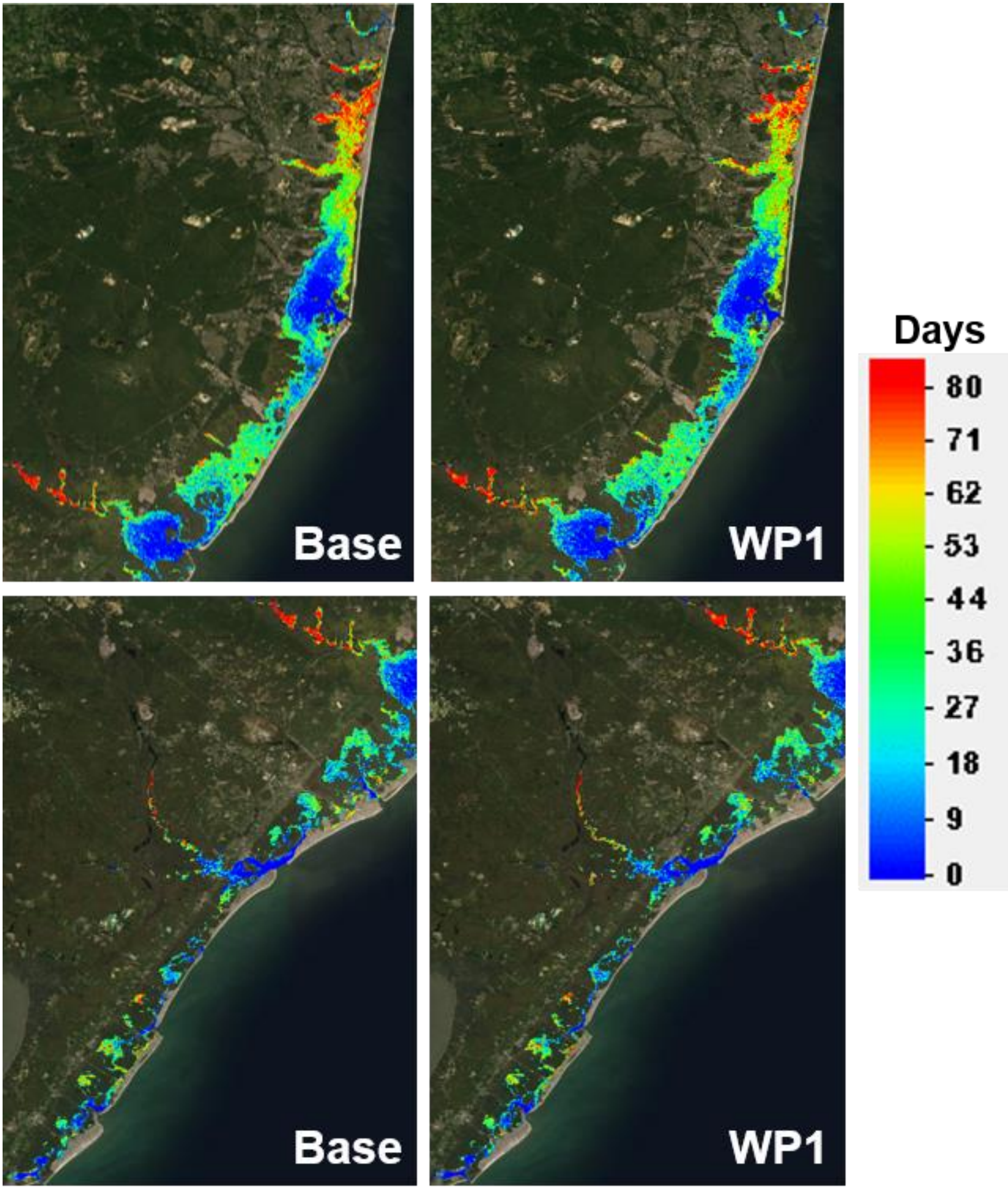


Figure 94: Modeled Residence Time (PTM)

8.2.2.2 Operations

The criteria for closing SSBs are highly variable across the United States and World. The frequency of closure operations ranges from as often as once a month (New Bedford, MA) to only once a decade (Maeslant Barrier, Netherlands). The reason for the large variability in the frequency of closure operations is because the cost, benefits, and impacts of a closure are unique to each SSB and must evaluated to determine the appropriate criteria for each location. For NJBB SSBs the closure criterion is the forecasted water level for which operation of a SSB is authorized to reduce flood risk for the region behind it. The following list provides a short overview of the key factors to consider in selecting the SSB closure criteria:

- Operational Costs – incremental cost associated with each SSB closure operation. Regardless of the closure frequency a well trained and experienced staff is required to operate the SSB.
- Environmental Impacts – indirect impacts associated with closure operation such as water quality degradation associated with a temporary reduction in water exchange and flushing. While closure impacts are temporary, a sudden drop in flushing and water quality has the potential to increase the likelihood and severity of harmful algal blooms and cause lasting damage to fish and fauna. Therefore, it is preferable from an environmental impact perspective to minimize the frequency of closure operations.
- Navigation Impacts – closure operations will temporary close the inlets and prevent commercial, recreational, and US Coast Guard vessels from passing through the inlets. It is important for SSB operations to provide advance notice of potential closure operations based on forecasted water levels, so vessels are not caught out in the ocean. One of the drawbacks of a relatively low water level criterion is that the number of potential storms forecasted to be above or near the water level criterion 12 to 48 hours could be significant, resulting a far greater number of potential closure warnings than a slightly higher water level criterion.
- Reliability – reliability of closure operations may be negatively affected by relatively high closure frequency with more opportunities for something to go wrong such as a gate not closing. Likewise, a relatively low closure frequency may reduce the reliability of closure by reducing opportunities for the staff to gain experience operating the SSB during storm conditions that often pose unique challenges not experienced during routine training operations such as high wind and wave conditions, road closures, power outages, etc.
- Flood Damages – potential damages to low-lying and exposed assets or infrastructure during flood events below the closure criteria are important consideration in selecting the closure criteria. The primary purpose of the SSBs is to reduce flood damages form storm events and considering the considerable investment there will be tremendous public and politically pressure to use the SSBs to prevent flood damages.
- HFF Measures – complementary measures to reduce potential flood damages from HFF, such as NS, NNBFs, bulkheads, critical infrastructure plans, and municipal partnership considerations may allow less frequent closure operations. The feasibility and cost of different HFF measures may affected by the closure criteria. Smaller and less expensive HFF measures may be feasible with a relatively low water level criterion, with larger and more expansive HFF measures required as the water level criterion for closure increases.

In subsequent phases on the NJBB CSRM Study the cost, benefits, and impacts of closure operations will evaluated in greater detail to refine the SSB closure criteria, which is likely evolve during the feasibility study, PED, and even during the life of the SSBs.

At this stage of study, the PDT considered a closure criterion between the 10% AEP (once every 10 years) and 99% AEP (once every year) and two different approaches (static vs adaptable criterion) to addressing RSLC. As noted above it is too early to determine the optimal closure criterion until a tradeoff analysis has been performed for all the cost, benefits, and impacts. Based on the PDTs knowledge of the study area the PDT expects the sweet spot to likely to fall between a 50% AEP and 20% AEP and focused on the 20% AEP at stage of the study. Two different closure criterions were considered:

- Criterion 1 – Constant closure frequency at the 20% AEP water level. This criterion allows the forecasted water level for operation to change over time in response to RSLC and the average number of closure operations per year (0.2) to remain fixed.
- Criterion 2 – Constant forecasted water level at 6.7 ft NAVD88 (20% AEP in 2030) at Atlantic City, NJ. This criterion allows the frequency of closure operations to increase in response to RSLC.

A visual display of the two closure criterion over a 100-year service life is shown in Figure 95. The solid green line shows a more realistic scenario for Criterion 1 where the forecasted water level for operation is updated every 20 years in response to RSLC.

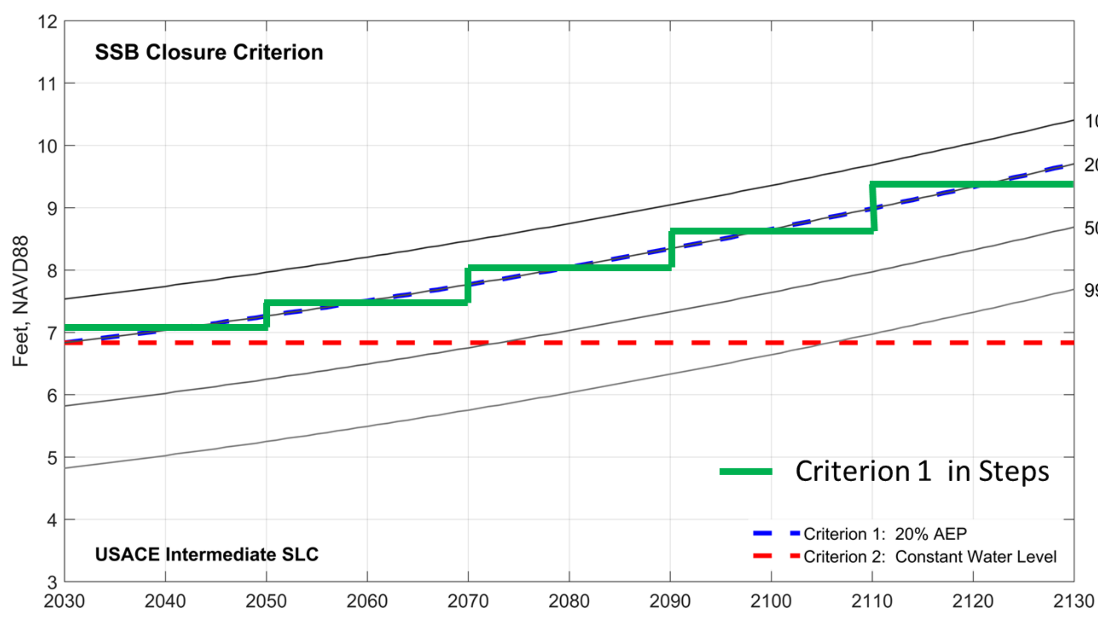


Figure 95: Storm Surge Barrier Closure Criterion

At this stage of the study, the PDT selected Criterion 1 based on the more predictable environmental impacts and the RSLC adaptability that the criterion promotes. Criterion 1 supports adaptable HFF measures such as expanding the NS plan over time to include any structures that fall below the forecasted water level for operation and the gradual increase over time in elevation and extent of shore based measures (such as bulkheads). The PDT also felt that a fixed closure frequency may not be suitable for a High SLC scenario that may eventually result in closure operations as often as once a month.

8.2.2.1 Impacts of Closures

During large storm events the SSB gates will close to prevent storm surge from entering the bays and causing flooding. The gate closures will temporarily stop the exchange of water between the ocean and the bays. In the Central Region, the SSB at Great Egg Inlet and two CBBs will effectively eliminate any exchange of water between the ocean and bays. In the North Region, the south inlet of Barnegat Bay will remain open and water will still be exchanged between the ocean and bay. Indirect impacts associated with closures and a temporary reduction in water exchange and flushing include a reduction in water quality. While closure impacts are temporary, a sudden drop in flushing and water quality has the potential to increase the likelihood and severity of harmful algal blooms and cause lasting damage to fish and fauna.

The frequency and duration of closure operations will have a significant impact on the impacts of the closure operations. It is likely that the gates will be closed at a minimum of once per year for testing. The exact details of closure operations for storm events are still being determined and will be refined as the study progresses. At this point, the PDT anticipates a closing the SSB gates for storm events about once every 5 years (20% AEP). The PDT also expects to adjust the water level threshold over time in response to RSLR so that the frequency of closure operations, about once every 5 years, remains constant over the life of the project.

It is common to close SSBs at some point before the water levels reach the closure criterion (20% AEP water level). Closing the SSBs earlier reduces the bay water levels increasing the storage capacity of the bays to handle additional water from wave overtopping, rainfall, potential breaches, and water flowing through the SSB gates which are not necessarily designed to be 100% watertight. However, coordination with the USCG and sufficient warning time is required before closure operations to avoid stranding vessels in the ocean.

The duration of closure operations will depend on the selected closure criterion (20% AEP) and the observed water level at which the closure operation will begin and the storm events. Hurricanes typically have a relatively narrow peak and may require a shorter closure duration than a nor’easter. At this point in the study, it is expected that closure durations will typically be between 4 to 12 hours. Longer closure durations are certainly possible but would not be an outlier and not normal.

A detailed evaluation of the cost, benefits, and impacts of closure operations will be performed in subsequent phases of the study to refine the closure operations. This detailed evaluation may include additional hydrodynamic modeling and water quality under conditions with the SSBs closed.

8.2.3 Managed Adaptive Approach

Table 84 provides an example for a possible managed adaptive approach for the TSP. For this decision timing strategy, the nonstructural measures in Shark River & Coastal Lakes, North, and South Regions are implemented incrementally over the period of analysis. Using a 5% AEP event floodplain as the eligibility threshold stage, nonstructural measures (elevation/acquisition/floodproofing) are implemented over ten-year increments as sea level change causes more structures in the study area to become vulnerable and fall below the eligibility threshold stage.

For the Central Region, the SSB components would be constructed to provide CSRM benefits up to the Year 2080 1% AEP event floodplain stage with High SLC rate. The SSB closure criteria would be indexed to the 20% AEP event stage. Depending on the sea level change curve rate, the 20% AEP changes through time. Complementary nonstructural measures in the Central Region would be indexed to the same 20% AEP event floodplain stage and implemented over ten-year increments. This managed adaptive approach ensures a constant project performance level with clear closure criteria guidelines and minimizes coastal storm impacts for both high-frequency and low-frequency events. Table 85 breaks out the incremental complementary nonstructural implementation for the Central Region.

For the TSP, there are 35,000+ structures in the Shark River & Coastal Lakes, North, and South Regions vulnerable to the 5% AEP event and considered eligible for nonstructural measures. Depending on the rate of sea level change, by Year 2080, the managed adaptive strategy would implement nonstructural measures for thousands of more structures. It is important to note that while ER 1110-2-8162 requires the use of the three USACE sea level change curves, the actual rate of future sea level change in the study area most likely does not align perfectly with any of the three curves and is probably found somewhere between the Low and High curves. The adaptive approach mitigates this uncertainty as the implementation team would be able to constantly update their sea level change measurements periodically over the period of analysis and optimize the new eligibility threshold criteria.

For the Central Region, approximately 1,900 structures are vulnerable to the Year 2030 20% AEP event floodplain and would be eligible for complementary nonstructural measures. As the 20% AEP event stage changes through time, adjusting the closure criteria stage for the SSB, more complementary nonstructural measures would be implemented to maintain project performance.

Table 86 shows the same managed adaptive approach for the Nonstructural Only Plan. The managed adaptive approach for the NED Plan is identical to the Nonstructural Only Plan except that fewer nonstructural implementations are necessary due to floodwalls in the Central Region.

Table 84: TSP – Cumulative Nonstructural Across 3 SLC Curves – 5% AEP (20% AEP in Central)

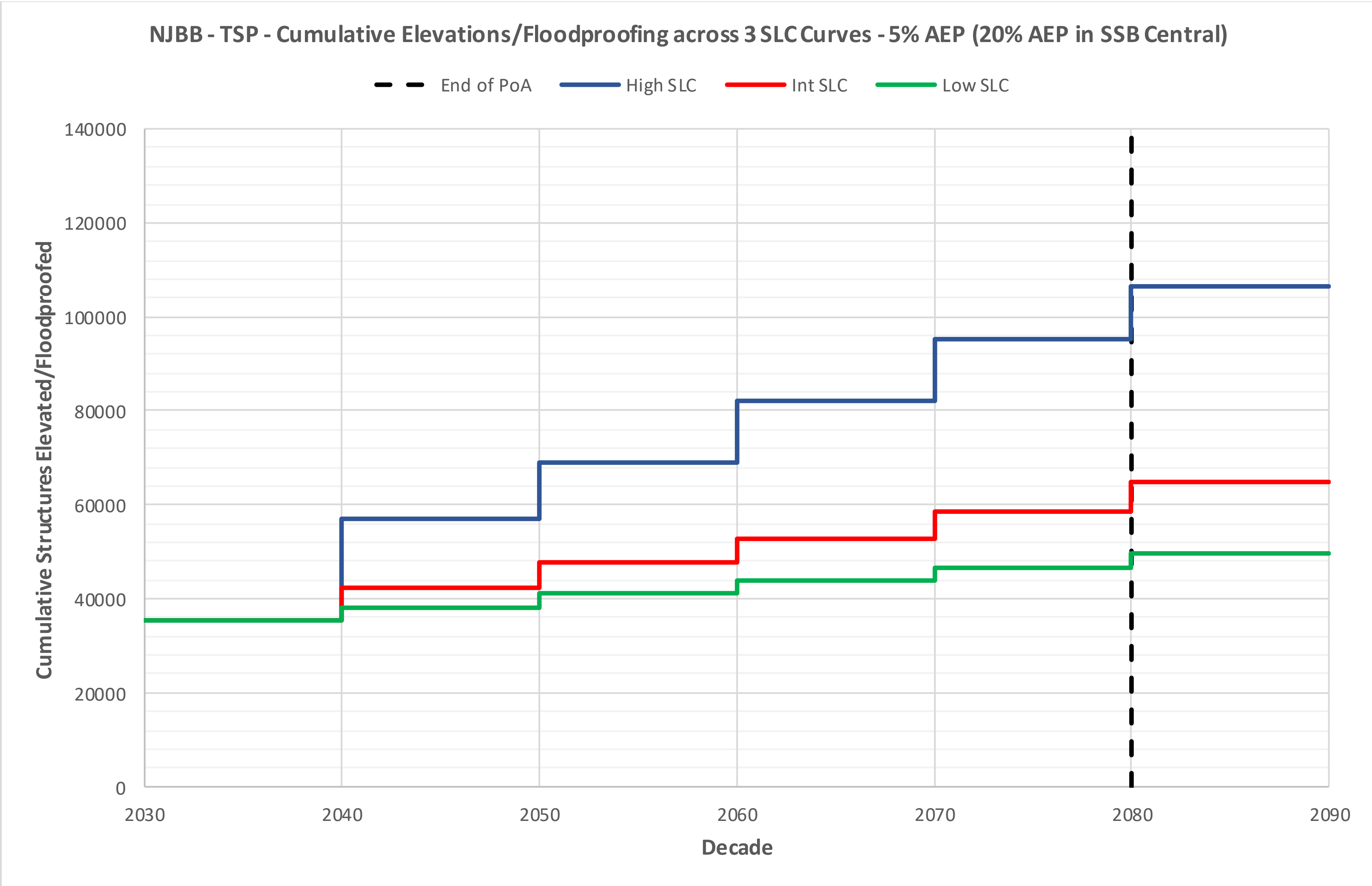


Table 85: TSP Central Region – Cumulative Nonstructural Across 3 SLC Curves – 20% AEP

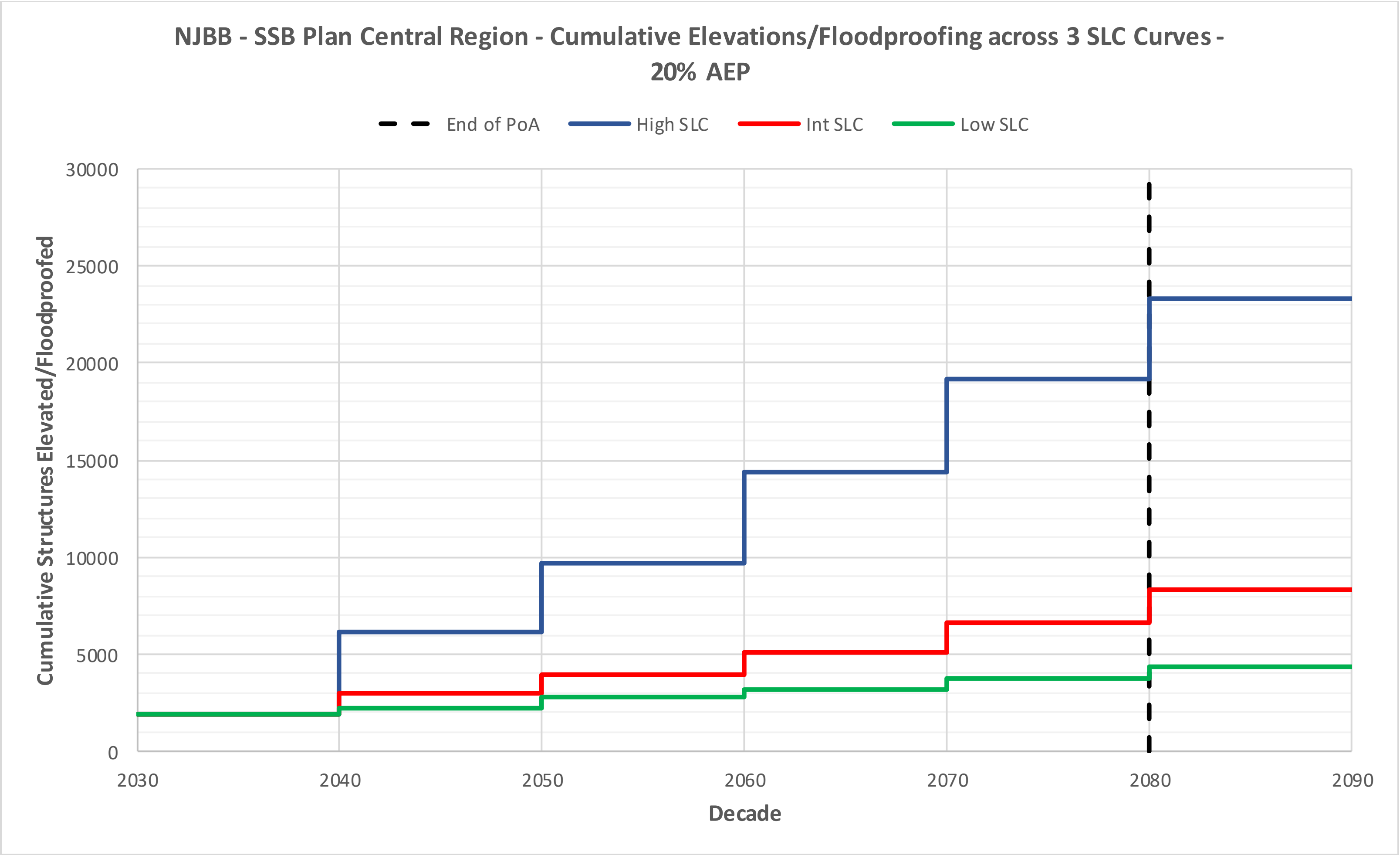
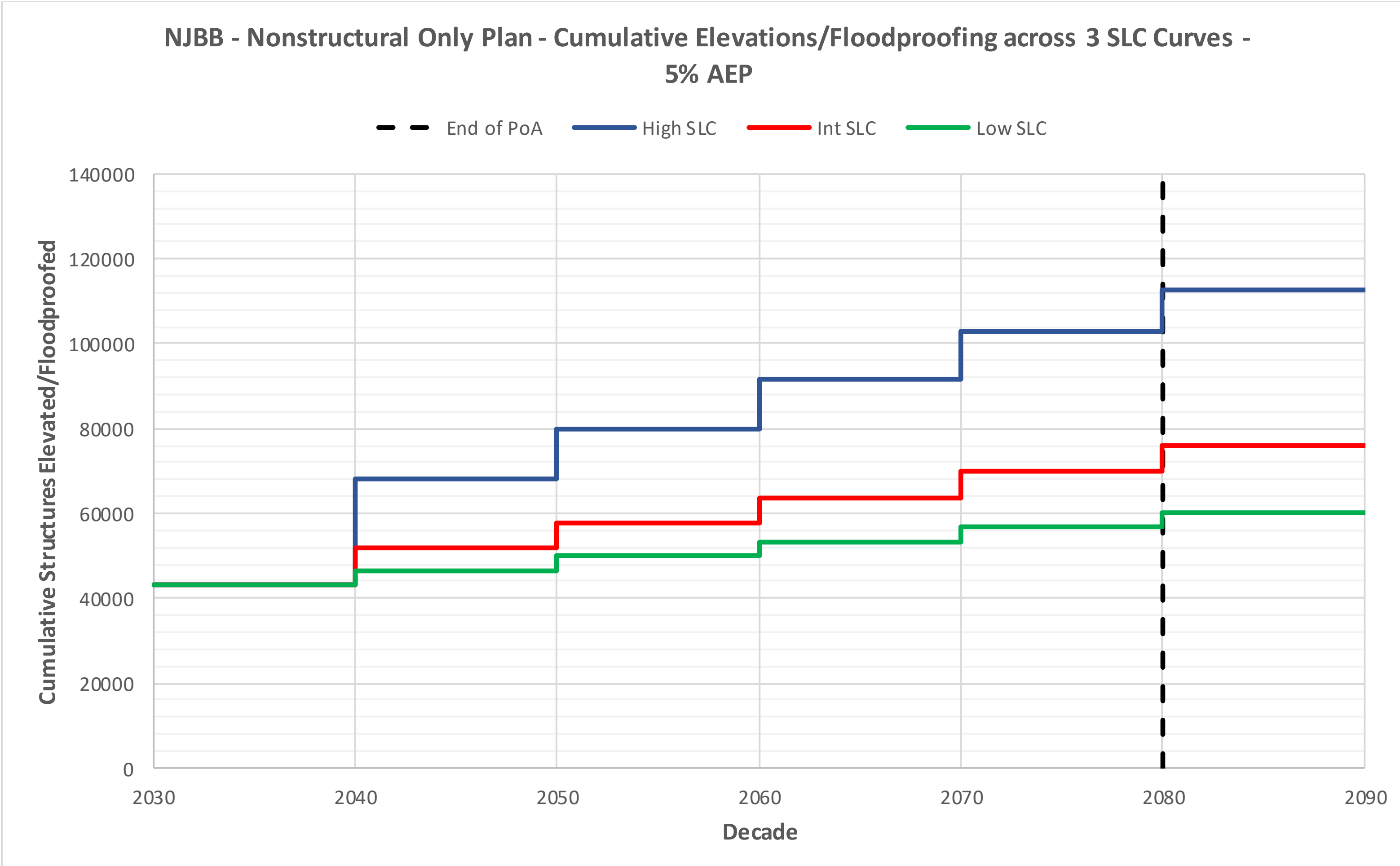


Table 86: Nonstructural Only Plan - Cumulative Nonstructural Across 3 SLC Curves – 5% AEP



8.2.4 Environmental Consequences*

8.2.4.1 General

Based on a comprehensive plan formulation that evaluated and screened over 51 structural and nonstructural and combinations thereof, this section evaluates the Tier 1 environmental consequences of the TSP (Figure 96). The No Action/FWOP condition is evaluated in Section 6.4. In addition, measures that address HFF, protection of critical infrastructure, and complementary NNBFs are being carried forward for further evaluation. At this time, no specific HFF and protection of critical infrastructure are identified. It is assumed that combinations of localized perimeters, non-structural, and NNBF would be utilized for HFF and critical infrastructure. The TSP alternatives are divided into three main regions: north, central, and south. Other regions include the Shark River Inlet and bay and the Coastal Lakes Region, which were evaluated separately. The North Region is generally from Manasquan Inlet south to Little Egg Inlet, which includes the entire Barnegat Bay and Little Egg Harbor and tributaries. The Central Region spans from Little Egg Inlet to Corson Inlet, which includes all of the bays, sounds and thoroughfares in that region and the Great Egg Harbor River and Great Egg Harbor Inlet. The South region spans from Corson Inlet south through Cape May Inlet and Cape May Canal, and includes all of the inlets, bays, sounds, and thoroughfares within that segment of the New Jersey coast.

8.2.4.2 Action Area

The action area is defined as all areas that may be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action. It encompasses the geographic extent of environmental direct, indirect, and cumulative impacts (i.e., the physical, chemical, and biotic effects) that will result from the action is within the entire NJBB CSRM Study Area.

For the NJBB CSRM Study, the action area is all areas directly and indirect affected by the TSP, presented in Figure 96. The TSP includes the following project components:

- Three SSBs
  - Manasquan Inlet
  - Barnegat Inlet
  - Great Egg Harbor Inlet
- Two CBBs
  - Absecon Blvd
  - South Ocean City
- Nonstructural measures
  - 18,800 structures eligible for elevation and floodproofing

Additionally, the action area considers the effects of the following options, which have not yet been eliminated.

- Nonstructural measures only (elevation and floodproofing for 23,152 structures) in the North Region (Alternative 3A; see Figure 97).

- Nonstructural measures only alternative (elevation and floodproofing for 10,895 structures) in the Central Region (Alternative 4A; see Figure 98).
- Nonstructural measures for (elevation and floodproofing for 1,189 structures) and perimeter plan alternative in the Central Region (Alternative 4D1; see Figure 98).
- Nonstructural measures for (elevation and floodproofing for 2,340 structures) and perimeter plan alternative in the Central Region (Alternative 4D2; see Figure 98**Error! Reference source not found.**).
- Nonstructural (656 structures) and perimeter plan alternative in the South Region (Alternative 5D2; see Figure 99).

Note that nonstructural measures consist of elevating or floodproofing already existing structures in previously developed areas. Detailed alignments of the inlet closures, CBBs, and perimeter plans are presented in the Economics Appendix. Three SSBs at inlets (Manasquan Inlet, Barnegat Inlet, Great Egg Inlet) and two SSBs across the bay (Absecon Blvd and Southern Ocean City) are included in the TSP. The selected SSBs reduce storm surge from propagating into the bays from the ocean during storm events, lowering flood elevations. The CBBs reduce storm surge from propagating into Central Region from adjacent inlets (Absecon Inlet, Little Egg Inlet, and Corson's Inlet) that would remain open and unaltered in the TSP. Storm surge barriers span the inlet opening with a combination of static impermeable barriers and dynamic gates that are only closed during storm events. Each SSB includes a navigable sector gate, to provide a navigable opening with unlimited vertical clearance and a series of auxiliary flow gates, vertical lift gates, to maintain tidal flow during non-storm conditions. Engineering drawings, layouts, and cross-sections, for the SSBs are included in the Engineering Appendix. Storm surge barrier gate types and alignments are considered tentative and may change in future phases of the study with more detailed engineer analyses and designs.

Navigable sector gates span the full width of the federal navigation channel with a 10-foot buffer on either side with opening spans ranging from 120 feet at the CBBs to 340 feet at Manasquan Inlet. Auxiliary flow gates have an opening span of 150 feet and are located along the SSB in water depths that are deemed constructible and practical. In shallow water, where vertical lift gates are impractical, shallow water gates (SWG) consisting of 24-foot x 8-foot box culverts with sluice gates are used. Bottom sill elevations for the navigable and auxiliary flow gates are designed at or near the existing bed elevations to promote tidal flow and are well below the federally authorized depths at the federal navigation channels.

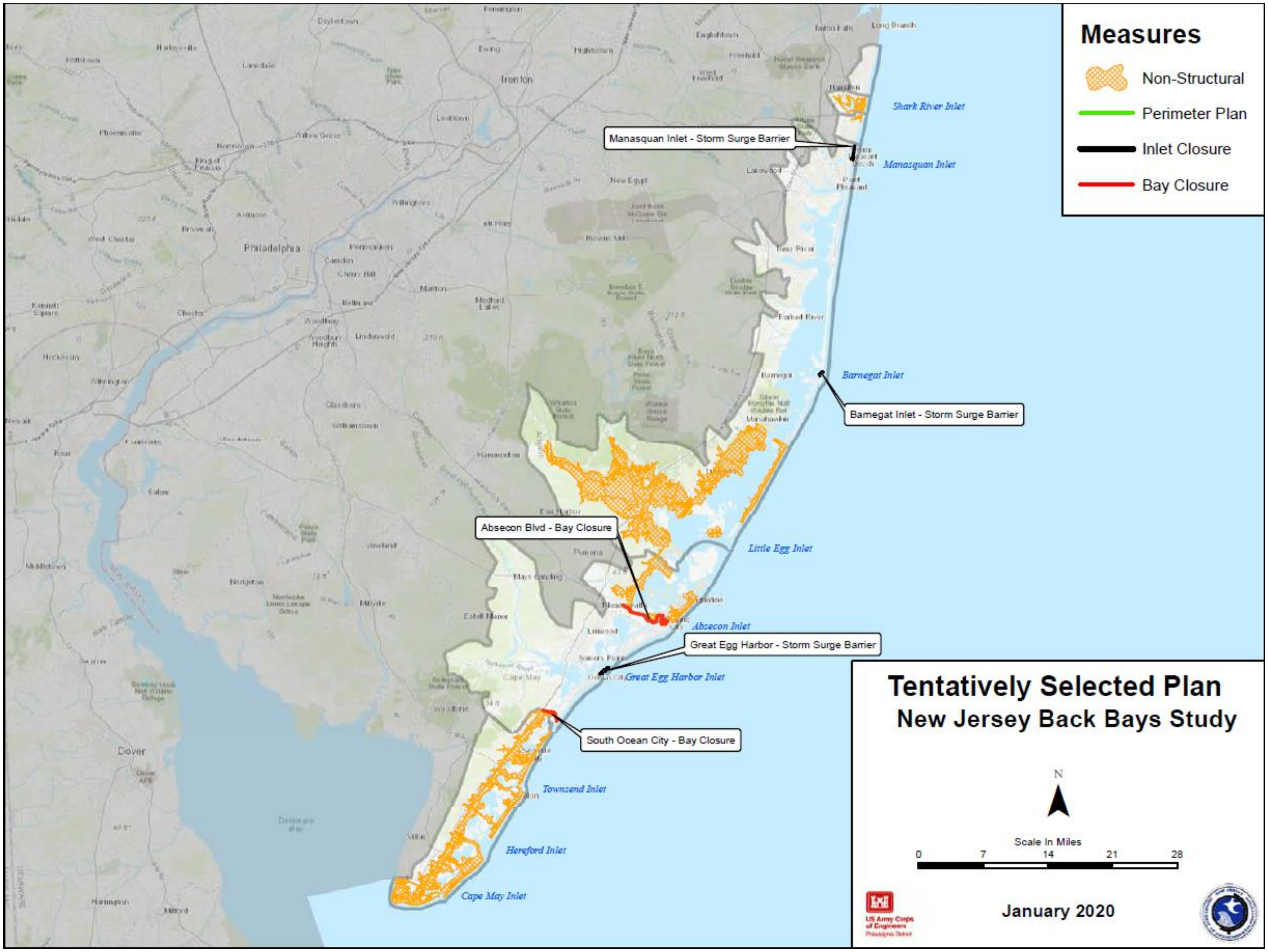


Figure 96: TSP for the NJBB CSRM Study

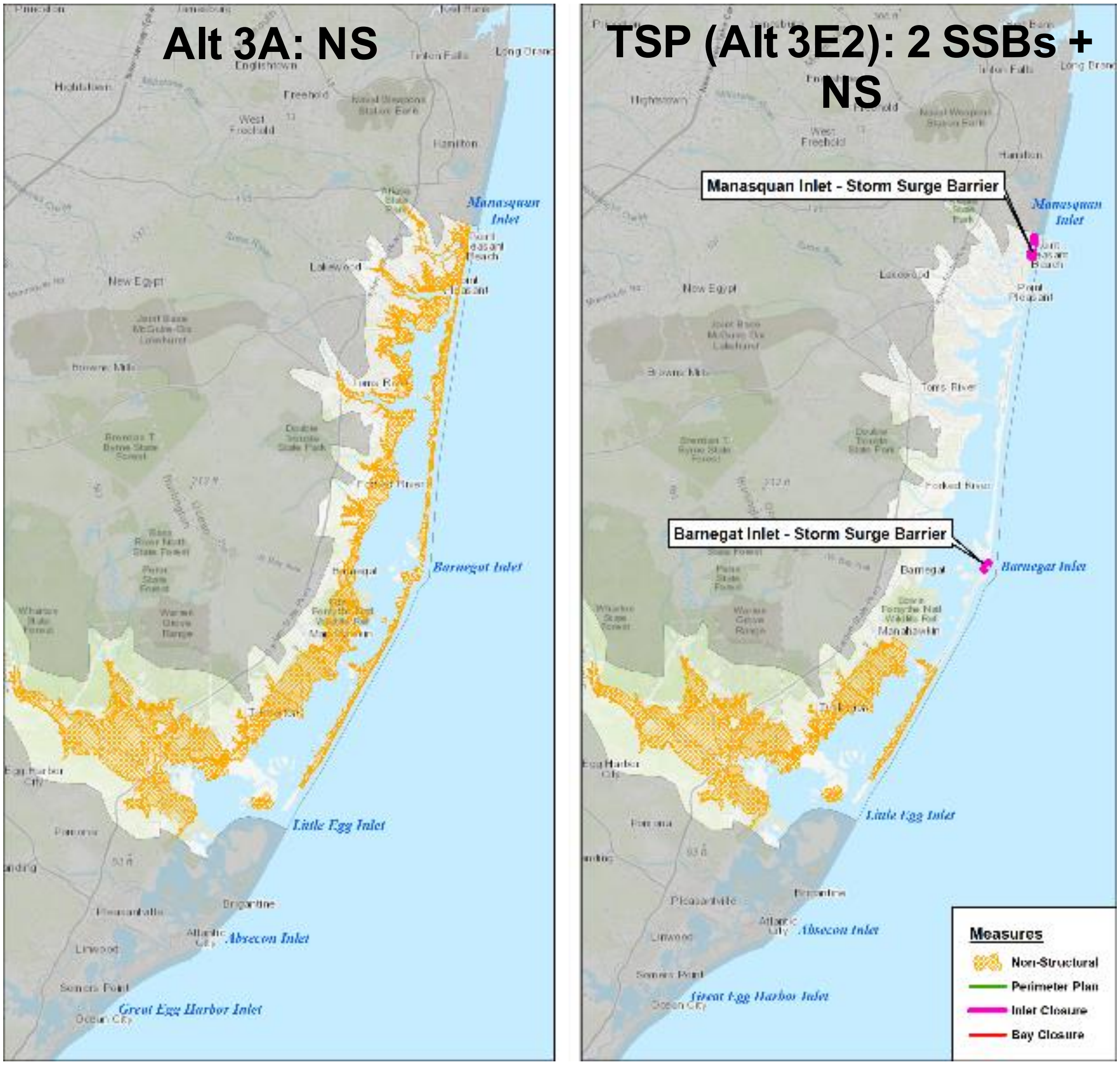


Figure 97: Comparison of the Nonstructural Alternative and the TSP in the North Region

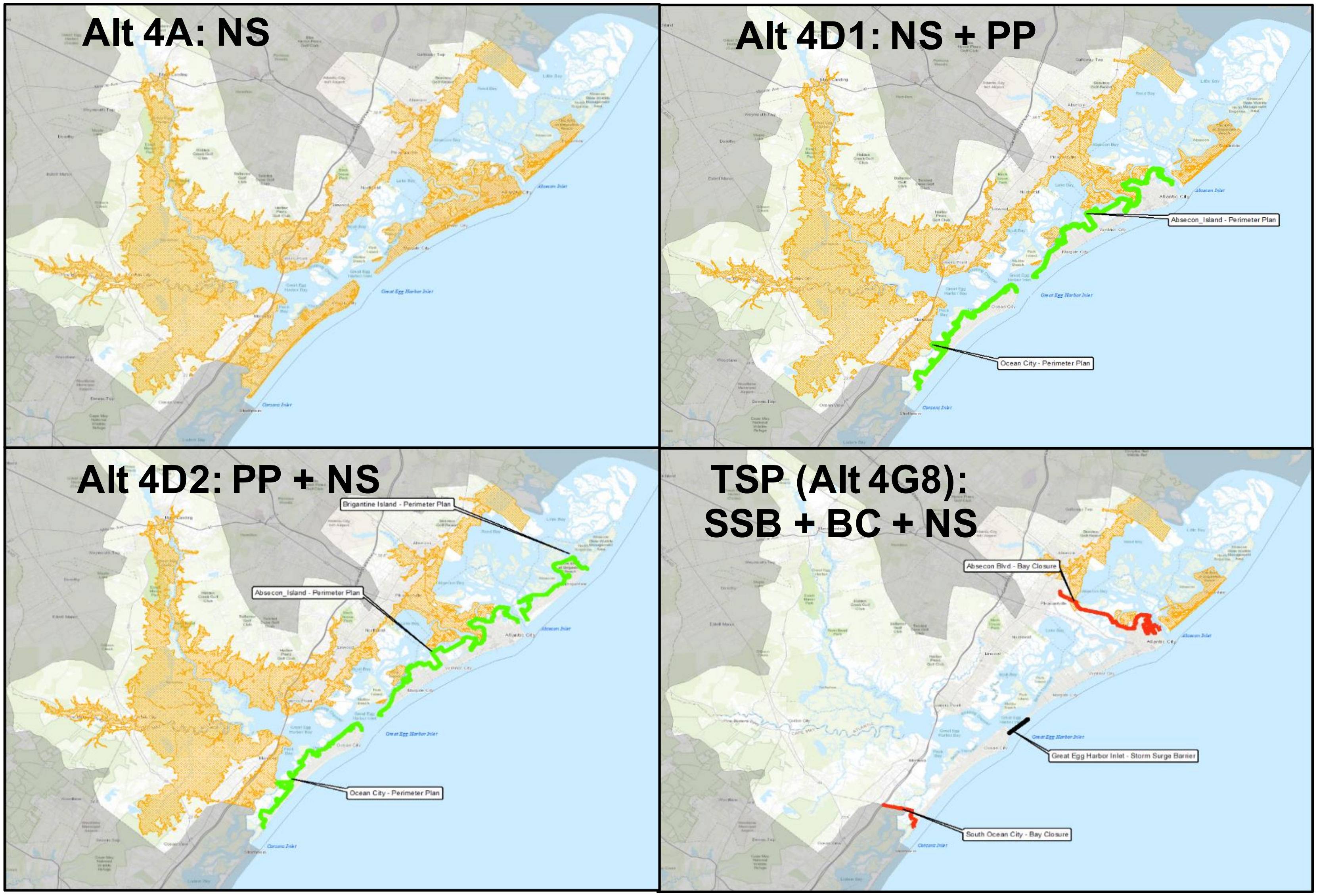


Figure 98: Comparison of the Nonstructural and Perimeter Plan Alternatives and the TSP in the Central Region

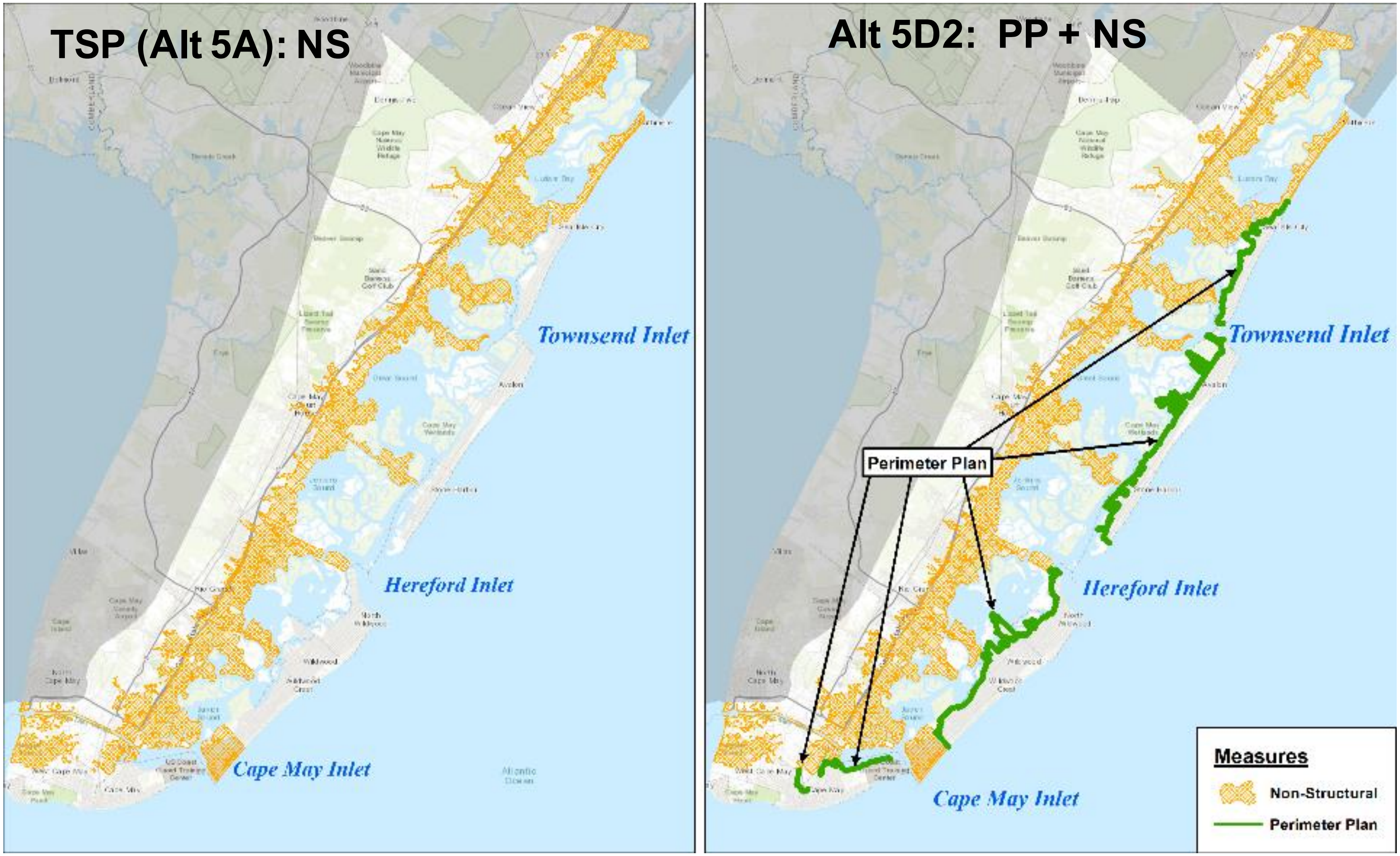


Figure 99: Comparison of the TSP and the Perimeter Plan and Nonstructural Alternative in the South Region

Impermeable barriers are open water structures that flank the navigable and auxiliary flow gates to tie the barrier into high ground or existing CSRM features (i.e., dunes or seawalls). Site specific impermeable barrier types have not been selected at this stage of the study but will be further investigated as the study continues. Several of the SSBs, particularly the CBBs, include levees, floodwalls, and seawalls along roads, shorelines, and low-lying areas to tie into high ground or existing CSRM features (i.e., dunes or seawalls). The crest elevation of the SSBs is between 17 and 20 feet NAVD88. A summary of the SSB components is provided in Table 87.

Table 87: TSP – Storm Surge Barrier Components

Storm Surge Barrier	Navigable Gate	Auxiliary Flow Gates	Impermeable Barrier	Perimeter Barrier
Manasquan Inlet Inlet Closure	1 Sector Gate Length = 340 FT Crest Elev = 20 FT Sill Elev = -18.25 FT	None	None	Levee = 7,280 FT Seawall = 2,366 FT
Barnegat Inlet Inlet Closure	1 Sector Gate Length = 320 FT Crest Elev = 17 FT Sill Elev = -25 FT	15 Vertical Lift Gates Length = 150 FT each Crest Elev = 17 FT Sill Elev = -5 to -11 FT 18 Shallow Water Gates Length = 24 FT each Crest Elev = 17 FT Sill Elev = -4 FT	Length = 798 FT Area = 18,365 SF	Floodwall = 897 FT Seawall = 795 FT 1 Road Closure Gate
Great Egg Inlet Inlet Closure	1 Sector Gate Length = 320 FT Crest Elev = 19 FT Sill Elev = -35 FT	19 Vertical Lift Gates Length = 150 FT each Crest Elev = 19 FT Sill Elev = -5 to -18 FT	Length = 863 FT Area = 20,716 SF	Levee = 974 FT Seawall = 1,275 FT
Absecon Blvd. Bay Closure	1 Sector Gate Length = 120 FT Crest Elev = 13 FT Sill Elev = -20 FT	4 Shallow Water Gates Length = 24 FT each Crest Elev = 13 FT Sill Elev = -2 FT	Length = 869 FT Area = 14,772 SF	Levee = 27,524 FT Floodwall = 28,890 FT 4 Road Closure Gates 5 Mitre Gates
Southern Ocean City Bay Closure	1 Sector Gate Length = 120 FT Crest Elev = 13 FT Sill Elev = -10 FT	None	None	Levee = 9,467 FT Floodwall = 4,124 FT 1 Mitre Gate 1 Sluice Gate

8.2.4.3 Pre-construction

Prior to construction, investigations may include wetland delineations, benthic and finfish sampling remote sensing surveys for submerged cultural resources, archaeological investigations, subsurface geotechnical investigations, and HTRW sampling, if required. These investigations are being developed.

8.2.4.4 Construction

In-water construction activities for the construction of SSBs and CBBs include installation and removal of temporary cofferdams, temporary excavations and dredging, fill and rock placement, concrete work, and pile driving. On land construction activities include clearing, grading, excavations, backfilling, movement of construction equipment, concrete work, pile driving, and soil stockpiles.

8.2.4.5 Operation and Maintenance

The purpose of Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R) is to sustain the constructed project. The most significant OMRR&R is associated with the SSBs. At this point of the study, it is estimated that SSBs and CBBs would be closed for a 5-yr and higher storm surge event, with an average of one closure operation every five years. In the next phase of the study the SSB operations plan and closure criteria will be developed. OMRR&R for SSBs typically include monthly startup of backup generators/systems, annual closure of surge barrier gates pre-hurricane season, dive inspections, gate adjustments/greasing, gate rehab and gate replacement.

8.2.4.6 Nonstructural Measures

The TSP includes Nonstructural solutions, such as elevating structures and floodproofing, in areas where the SSBs will not significantly reduce flood elevations. These areas are concentrated in the Shark River & Coastal Lakes Region, in Ocean and Atlantic Counties (between Route 72 and Absecon Blvd.) and Cape May County. A total of 18,800 structures located within the 5% AEP floodplain (20-year return period) in these areas are targeted for nonstructural solutions under the TSP; this includes 135 structures in the Shark River & Coastal Lakes Region; 8,869 structures in the North Region; 1,255 structures in the Central Region; and 8,579 structures in the South region.

In addition, to the TSP, two alternatives that are completely nonstructural are still under consideration.

- Nonstructural measures only (elevation and floodproofing for 23,152 structures) in the North Region (Alternative 3A; see Figure 97).
- Nonstructural measures only alternative (elevation and floodproofing for 10,895 structures) in the Central Region (Alternative 4A; see Figure 98).

Additionally, the number of structures under consideration for nonstructural measure changes with the perimeter plan options considered.

8.2.4.6.1 Pre-construction

Prior to construction a detailed investigation and refinement of the eligibility and suitable treatments of individual structures for nonstructural measures would be conducted.

8.2.4.6.2 Construction

Nonstructural measures involve a significant construction effort whether it be from building retrofits such as elevation (including raising a structure on fill or foundation elements such as solid perimeter walls, pier, posts, columns, or pilings) or buyout/ relocations that are likely to involve demolition, grading, and soil stabilization/revegetation. The majority of the construction would occur within the footprint of the existing structure and would most likely be in upland urbanized settings.

8.2.4.6.3 Operations and Maintenance

There is no operations and maintenance associated with nonstructural solutions.

8.2.4.7 Perimeter Measures

The two CBB alternatives in the TSP at Absecon Boulevard and Southern Ocean City contain perimeter measures. However, perimeter measures not identified as the TSP are still being considered in the Central and South Regions, including floodwalls and levees to be constructed on the western side of the barrier islands along residential bayfronts. These structures would tie into existing dunes at the northern and southern ends of the barrier islands (Figure 100). Figure 101, and Figure 102 show typical sections which have been used in the perimeter plan design to date.

Options. The following are the perimeter measures still under consideration. The number of structures under consideration for nonstructural measures is noted for each perimeter measure option.

- Nonstructural measures for (elevation and floodproofing for 1,189 structures) and perimeter plan alternative in the Central Region (Alternative 4D1; see Figure 98). Nonstructural measures for (elevation and floodproofing for 2,340 structures) and perimeter plan alternative in the Central Region (Alternative 4D2; see Figure 98).
- Nonstructural (656 structures) and perimeter plan alternative in the South Region (Alternative 5D2; see Figure 99).

The location, length, and construction duration for the perimeter measures for these options are presented in Table 88.

Table 88: Location, Length, and Construction Duration for Perimeter Measures

Alternative	Location	Barrier	Construction
		Length (LF)	Duration (Months)
4D1	Ocean City	78,732	89
	Absecon Is.	111,111	126
4D2	Ocean City	78,732	89
	Absecon Is.	111,111	126

	Brigantine	48,699	55
5D2	Cape May City	15,825	18
	Wildwood Is.	54,171	62
	West Wildwood	11,726	13
	Sea Isle City	35,167	40
	West Cape May	4,480	5

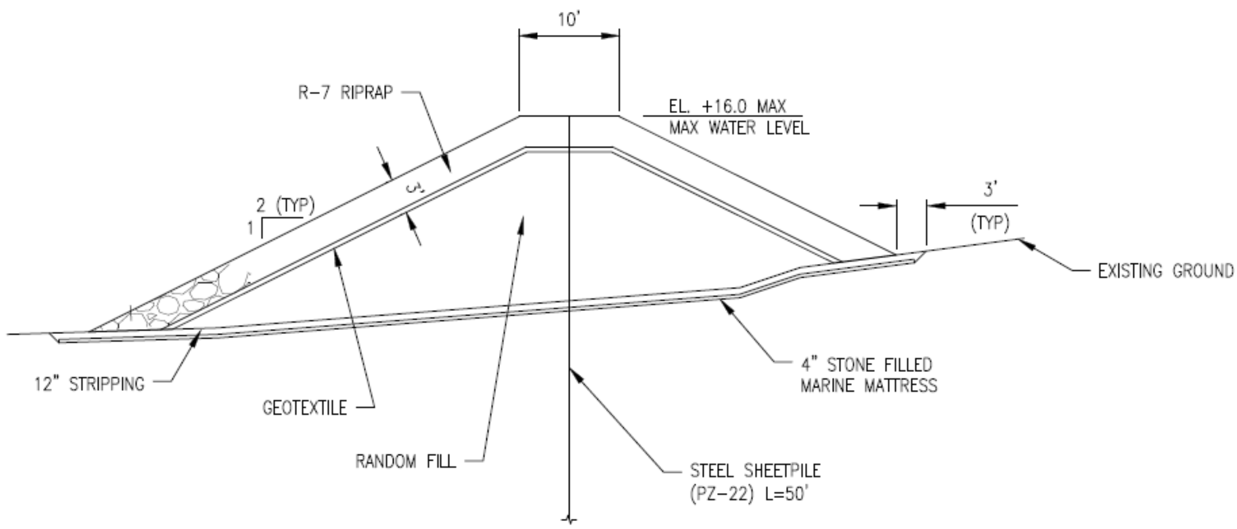


Figure 100: Typical Section – Levee – Type A

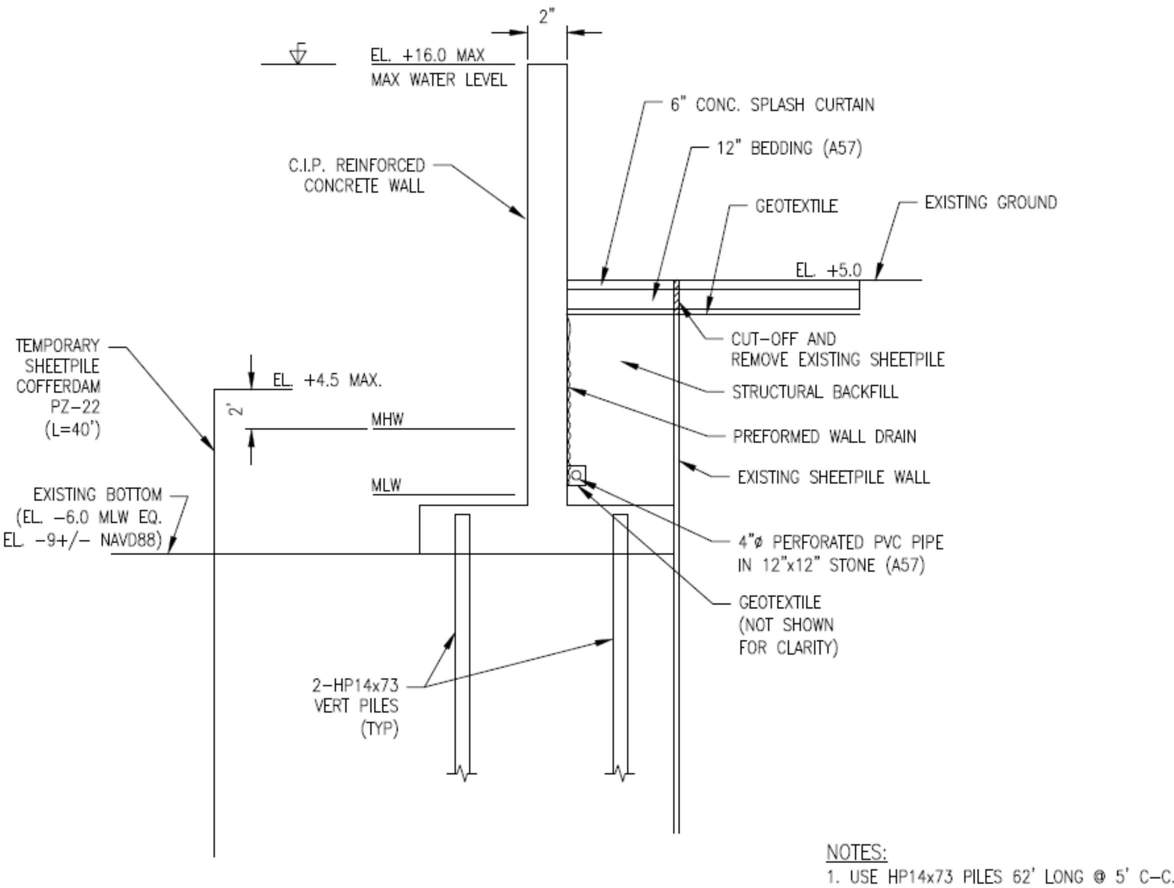


Figure 101: Typical Section – Concrete Cantilever Wall on Piles – Type B

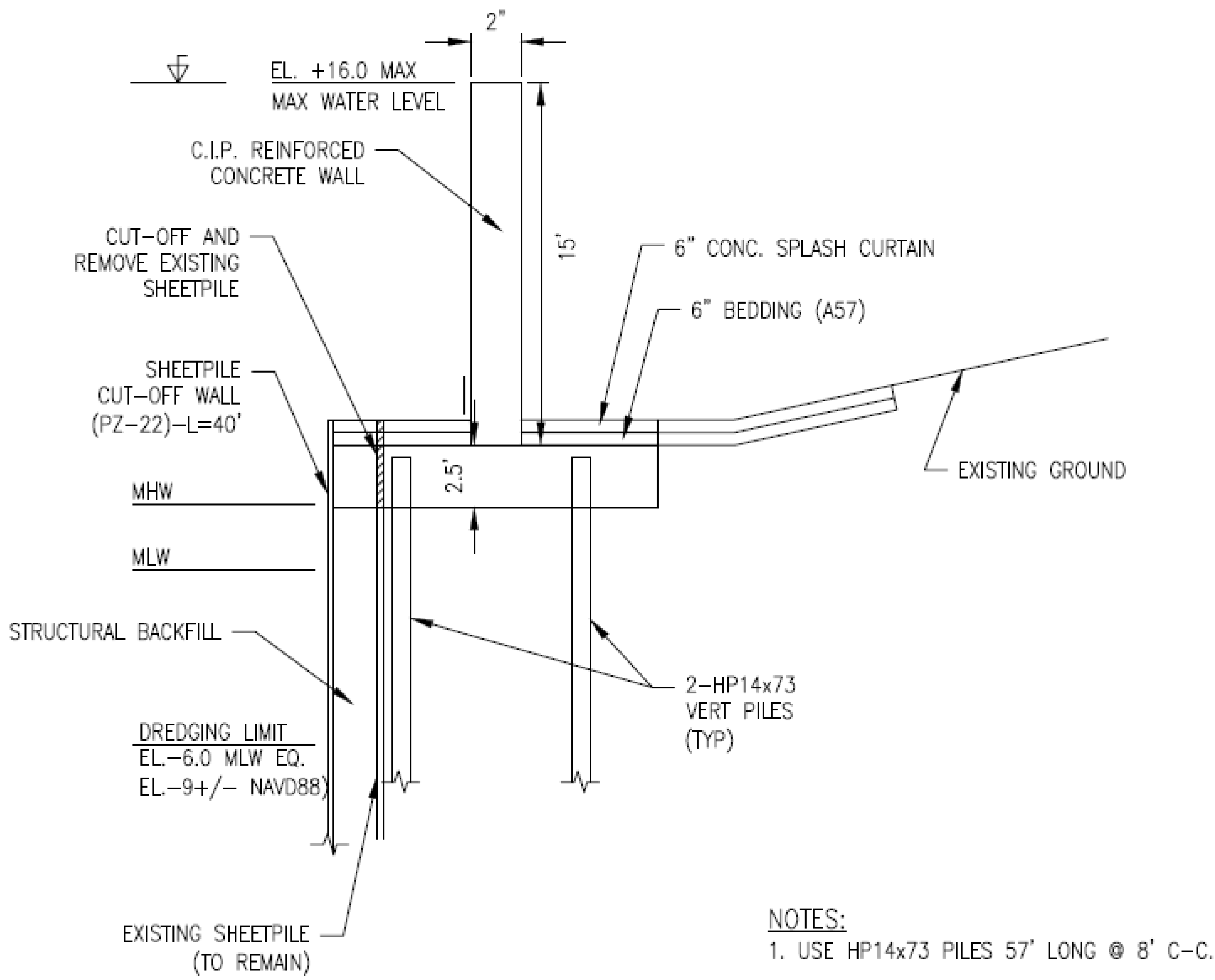


Figure 102: Typical Section – Concrete Cantilever Wall – Type C

8.2.4.7.1 Pre-Construction

Prior to construction, investigations may include, wetland delineations, fish and wildlife surveys, subsurface geotechnical investigations, and HTRW sampling, if required. These investigations are being developed.

8.2.4.7.2 Construction

In-water construction activities for the construction of levee and floodwalls include installation and removal of temporary cofferdams, temporary excavations, fill and rock placement, concrete work, and pile driving. On land construction activities include clearing, grading, excavations, backfilling, movement of construction equipment, concrete work, pile driving, and soil stockpiles.

8.2.4.7.3 Operation and Maintenance

Miter gates will also be installed in associated with the perimeter measures and operated across smaller channels that require navigable access. These gates would remain open during normal conditions and would be closed during significant storm events. Regular maintenance is performed on the gates to keep the system running as designed.

8.2.4.8 Inlet Storm Surge Barrier (SSB) Features

Manasquan Inlet (Alternative 3E(2) - A1 alignment): one pair of navigable sector gates at the western end of the inlet, seawalls along both inlet jetties, and an approximately 7,200-ft. long levee/dune structure along the upper beach on the north side of the inlet.

Barnegat Inlet (Alternative 3E(2) - A1 alignment): a floodwall at Barnegat Light State Park and road closure that tie into one pair of navigable sector gates located on the bay side southwest of Barnegat Inlet, fifteen (15) auxiliary flow vertical lift gates and their abutments spanning the bay west of Barnegat Inlet jetties, box culverts in shallows on north end of the structure that tie into the western end of the north jetty near Sedge Island, and a seawall along north jetty that ties into existing dunes of Island Beach State Park.

Great Egg Harbor Inlet (Alternative 4G(8) - A1 alignment): a levee/dune structure along the existing dune on the north end of Ocean City, an impermeable barrier that crosses the northern beach and joins ten (10) auxiliary flow vertical liftgates and their abutments in the inlet, one (1) pair of navigable sector gates near center of the inlet, eight (8) auxiliary flow vertical liftgates and their abutments that join a seawall constructed along the north side of the inlet at Longport.

8.2.4.9 Cross-Bay Barrier Features

Absecon Boulevard (Alternative 4G(8)): Continuous floodwall along the southern side of Absecon Inlet extending along the waterfronts of Clam Creek, Gardner's Basin, Snug Harbor, Delta Basin, State Marina, Clam Thorofare to Huron Avenue and Absecon Avenue. Miter gates across Penrose Canal and Venice Lagoon. Floodwall continuing west along Absecon Boulevard to Beach Thorofare. Navigable sector gate across Beach Thorofare. Levee along north side of Absecon Blvd. with Miter Gates across Duck, Newfound and Johnathan Thorofare's. A sluice gate and road closure at junction of Absecon Blvd. and Delilah Road. Levee continues on north side of Delilah Road with road closure at NJ Transit Railway and levee tie-in near Iowa Avenue in Absecon.

Southern Ocean City (Alternative 4G(8)): Floodwall begins at the dune near the southern end of Central Avenue and extends around homes along 59th Street and along West Avenue to 56th Street and Road Closure at Bay Avenue. Floodwall continues along the marsh sides of Safe Harbor Drive, W. 55th Street and Ensign Drive to W. 52nd St. At 52nd Street a levee extends westward along the railroad embankment with a navigable sector gate at Crook Horn Creek, miter gate at Edward Creek and sluice gate at an unnamed tidal creek at the western end of the levee. Levee then ties into the Garden State Parkway embankment.

8.2.4.10 Nonstructural (NS) Measures

The TSP also includes nonstructural (building raising), and combinations, thereof. Additional NS alternatives such as building acquisition and flood-proofing are also considered, but not defined at this time. Nonstructural locations are throughout the study area and are generally presented in Figure 97 and Table 89 and 90.

8.2.4.11 Natural and Nature Based Features

NNBFs in the form of standalone features or as a complementary feature to a structural feature would include but not be limited to living shorelines, reefs, wetland restoration, submerged aquatic vegetation (SAV), and modifications to structural measures including habitat benches to restore more natural slope along shorelines and textured concrete to support colonization of algae and invertebrates. Additionally, large scale NNBFs are being evaluated that include surge filters (marsh islands), protective islands, horizontal levees, and others as presented in Table 91 and in King et. al 2020.

Table 89: Tentatively Selected Plan

NJBB REGION	ALT	EQ Risk Index Score	CSRM Measures		
			NONSTRUCTURAL Building Raising for structures with first floor w/in 20-yr floodplain	**STORM SURGE BARRIER** Combinations of Inlet Navigable Sector Gates, Auxiliary Lift Gates, Impermeable Barriers, Floodwalls and Levees	**CROSS-BAY BARRIER** Combinations of Navigable Sector Gates, Auxiliary Lift Gates, Miter Gates, Sluice Gates, Impermeable Barriers, Floodwalls and Levees
SHARK RIVER & COASTAL LAKES	2A*	4.2 Minor Risk	Portions of Belmar, Bradley Beach, Neptune City & Shark River Hills		
NORTH (Manasquan Inlet to Little Egg Harbor Inlet)	3E(2)	2.1 High Risk	All communities on southern LBI (Cedar Bonnet Island and south), western shore of Barnegat Bay at Beach Haven West and south, Mystic Island, and along lower Mullica River Basin	1.Manasquan Inlet 2.Barnegat Inlet	
CENTRAL (Little Egg Harbor Inlet to Corson Inlet)	4G(8)	2.0 High Risk	Brigantine, Absecon, Pleasantville, West A.C.,	1.Great Egg Harbor Inlet	1.Absecon Blvd 2.Southern Ocean City (52nd Street)
SOUTH (Corson Inlet to Cape May Inlet)	5A*	4.2 Minor Risk	All Atlantic Coast and bayside communities from Ludlam Island (Upper Twp.) south to Cape May and W. Cape May		

*Environmentally preferred alternative

Table 90: Alternatives with Perimeter Measures Requiring Further Consideration

NJBB REGION	ALT	EQ Risk Index Score (see Table xx)	CSRM Measures	
			NONSTRUCTURAL Building Raising for structures with first floor w/in 20-yr floodplain	**PERIMETER MEASURES** Floodwalls, Levees, Miter Gates, Road Closures
CENTRAL (Little Egg Harbor Inlet to Corson Inlet)	4D(1)	3.3 Moderate Risk	Brigantine, Absecon, Pleasantville, West A.C., Northfield, Linwood, Estell Manor, Mays Landing, Somers Point, Marmora, Palermo	Along Absecon Inlet and western side of Atlantic City, Ventnor, Margate, Longport, and all of Ocean City.
	4D(2)	3.3 Moderate Risk	Absecon, Pleasantville, West A.C., Northfield, Linwood, Estell Manor, Mays Landing, Somers Point, Marmora, Palermo	Along Absecon Inlet and western side of Brigantine, Atlantic City, Ventnor, Margate, Longport, and all of Ocean City.
SOUTH (Corson Inlet to Cape May Inlet)	5D(2)	3.3 Moderate Risk	All bayside communities from Ludlam Island (Upper Twp.) south to Cape May and W. Cape May; Strathmere and Cape May Inlet along Atlantic Coast.	Western side of Sea Isle City, Seven Mile Island, all Wildwoods, and southern shore along Cape May Harbor in Cape May.

Table 91: CSRM Measures Carried Forward for Further Analysis

Region	Natural and Nature - Based Features (NNBF)	High Frequency Flooding (HFF) Structural Measures	Critical Infrastructure (CI) Measures	Other
Coastal Lakes/Shark River	1.Tide-gate improvements 2.Lake shoreline enhancement (terracing) 3.Island Expansion 4. Dune Enhancements	Lower profile Perimeter Measures and/or combinations with NNBF Features	Lower profile Perimeter Measures and/or combinations with NNBF Features	Recommend a dune structure along Atlantic Coast Beaches be pursued
North	1.Lagoon Community Protective Islands 2. Tuckerton Peninsula Barrier (a) Horizontal Levee (b) Living Breakwater (c) Marsh augmentation 3. Beach Haven Surge Filter 4. Barnegat Bay Shallows 5. Barnegat Bay Strategies – mudflat expansions, marsh elevations, ditch filling, maritime forest restoration	Lower profile Perimeter Measures and/or combinations with NNBF Features	Lower profile Perimeter Measures and/or combinations with NNBF Features	
Central	1. Ocean City Horizontal Levee/Wall	Lower profile Perimeter Measures and/or combinations with NNBF Features	Lower profile Perimeter Measures and/or combinations with NNBF Features	

Region	Natural and Nature - Based Features (NNBF)	High Frequency Flooding (HFF) Structural Measures	Critical Infrastructure (CI) Measures	Other
South	2. Seven Mile Island Innovation Lab	Lower profile Perimeter Measures and/or combinations with NNBF Features	Lower profile Perimeter Measures and/or combinations with NNBF Features	

8.2.4.12 General Impact Assumptions

Some generalized assumptions are that no action (future without project) will continue existing trends unless significant changes are implemented such as regulatory changes, development, land use, etc. with awareness of current knowledge of climate change and sea level rise as a major driving force.

For structural measures considered, the perimeter measures were not identified as the TSP during plan formulation, but comparatively would have had significant direct impacts particularly on wetlands and shallow aquatic habitats within the footprint of floodwalls and levees over long linear distances. Additionally, PPs are expected to have significant impacts on visual resources mainly due to their heights. Because three of the plans that included perimeter measures were not eliminated from further consideration, they remain in the impact analysis. Additionally, consideration of measures to reduce HFF remain in the study and will be further evaluated following the release of the draft EIS. Components of the perimeter plan such as floodwalls and levees may remain as HFF alternatives and are assumed to have similar impacts as the PPs presented in the focused array of alternatives. HFF perimeter components would likely be less extensive or have different dimensions than the PPs and are assumed to have smaller footprint effects than the PPs. Nevertheless, localized footprint impacts of HFF plans using perimeter components are assumed to be similar to the PPs previously screened out.

Storm Surge Barriers and CBBs in the TSP would also have significant direct impacts on aquatic habitats, but comparatively less than the perimeter measures. However, potential indirect impacts of these structures (particularly inlet SSBs) on hydrodynamics, water quality, shifts in flora and fauna abundance, distributions and migrations are potentially significant with a higher degree of uncertainty. At this time, the high uncertainty of the indirect impacts associated with these structures associated coupled with the application of environmental mitigation warrants additional evaluation as a TSP feature. The TSP structural elements also have potential to impact significant cultural resources, which require further investigations into all features within their Area of Potential Effect. Subsequent study phases will also further investigate for any potential Hazardous, Toxic, and Radioactive Wastes (HTRW).

Nonstructural (NS) measures are a component for all of the focused array of alternatives either as a standalone alternative or in various combinations with other structural components. NS measures such as building raising may have some temporary adverse direct and indirect effects related to earth disturbance but are not significant. However, impacts on cultural resources (particularly if building modifications are on historic structures or in a historic district) and community are potentially significant.

Natural and Nature-Based Features must have a direct coastal storm risk management (CSRM) function for flooding and/or function as a scour protection feature of a traditional structural CSRM feature while providing some degree of ecological uplift. NNBFs are expected to have temporary and minor impacts on aquatic resources and water quality during their construction but would have a long-term beneficial effect on aquatic and some terrestrial habitats and the flora and fauna that inhabit these habitats.

At this time, the Tier 1 DEIS has not identified any alternatives as actionable. Actionable project features are components that can be implemented at the completion of the feasibility study without further evaluation and would receive the appropriate environmental compliance/approvals. However, low risk items could become implementable by the completion of the Feasibility Study and Record of Decision. Actionable items will be re-evaluated in the Final Tier 1 EIS and non-actionable items would be carried out into the Tier 2 phases for additional analyses and evaluation.

8.2.4.13 Land Use

8.2.4.13.1 Perimeter – Floodwalls, Levees and Miter Gates (4D(1), 4D(2) and 5D(2)

8.2.4.13.2 Storm Surge Barriers/Cross-bay barriers (TSP Features for 3E(2) and 4G(8)

The structural alternatives identified in the TSP and perimeter measures under consideration, in the long-term, are expected to maintain current land uses by providing greater stability to areas susceptible to coastal flooding. However, the construction of these structures would require the acquisition of real estate easements from a large number of residential, commercial, and municipal properties. The perimeter protection plans would affect the most properties, followed by the CBBs, with the least amount of property affected by the SSBs. However, these acquisitions would not significantly affect overall land use of the affected areas.

For the TSP SSBs and CBBs, Table 92 shows the types of land uses within or close to the footprint of the TSP structural features. Areas most extensively developed such as at the Absecon Boulevard (Atlantic City) and Southern Ocean City CBBs and the Manasquan Inlet SSB have the most diversity of Land Use/Land Cover (LULC) cover types within the immediate footprint (0 meters), 100 meters and 1,000 meters from the structures. Tables 92 and 93 present the TSP alternatives and the structural features that may interact with protected land uses or have comprehensive management plans that affect land use as discussed in the affected environment section.

Table 92: Land Use/Land Cover Types (New Jersey) Encountered within Buffer Zones (meters) Per TSP Structure

CAT.	NJ LAND USE/LAND COVER TYPES	STORM SURGE BARRIERS (SSBs)									CROSS-BAY BARRIERS (CBBs)					
		Manasquan Inlet			Barnegat Inlet			Great Egg Harbor Inlet			Absecon Boulevard			Southern Ocean City to 52nd Street		
		0 m	100 m	1000 m	0 m	100 m	1000 m	0 m	100 m	1000 m	0 m	100 m	1000 m	0 m	100 m	1000 m
URBAN LAND	1110 Residential, High Density		X	X		X	X	X	X	X	X	X	X	X	X	X
	1120 Resid., Single Unit, Med. Density		X	X		X	X	X	X	X		X		X	X	X
	1130 Residential Single Unit Low Density			X					X	X			X			
	1140 Residential Rural Single Unit									X			X			
	1200 Commercial/Services	X	X	X	X	X	X				X	X	X			X
	1211 Military Installations		X	X							X	X	X			
	1214 No Longer Military												X			
	1300 Industrial			X							X	X	X			
	1400 Transp./communication/utilities	X	X	X	X	X	X					X	X	X	X	X
	1410 Major Roadway										X	X	X		X	X
	1419 Bridge Over Water									X	X	X	X			
	1461 Wetland Rights of Way															
	1462 Upland Rights of Way Developed												X			
	1600 Mixed Urban or Built-Up Land			X												
	1700 Other Urban or Built-Up Land		X	X		X	X				X	X	X	X	X	X
	1710 Cemetery												X			
	1741 Phragmites Dominant Urban Area											X	X			
	1750 Managed Wetland (Lawn/Greenspace)												X			
	1800 Recreation Land		X	X	X	X	X			X	X	X	X			X
	1804 Athletic Fields (Schools)			X								X	X			
	1810 Stadium, Theaters, Cult.Ctrs., & Zoos			X												
FO	4110 Deciduous Forest 10-50% Crown												X			

CAT.	NJ LAND USE/LAND COVER TYPES	STORM SURGE BARRIERS (SSBs)									CROSS-BAY BARRIERS (CBBs)					
		Manasquan Inlet			Barnegat Inlet			Great Egg Harbor Inlet			Absecon Boulevard			Southern Ocean City to 52nd Street		
		0 m	100 m	1000 m	0 m	100 m	1000 m	0 m	100 m	1000 m	0 m	100 m	1000 m	0 m	100 m	1000 m
	4120 Deciduous Forest >50% Crown												X			X
	4220 Coniferous Forest			X												
	4312 Mixed Forest															X
	4410 Old Field <25% Brush Cover	X	X	X						X	X	X	X			
	4420 Deciduous Brush/Shrubland										X	X	X			
	4430 Coniferous Brush/Shrubland										X	X	X			
	4312 Mixed Forest (>50% conifer)															X
	4322 Mixed Forest (>50% deciduous)															X
	4440 Mixed Dec/Conif. Brush/Shrubland										X	X	X	X	X	X
WATERS	5300 Artificial Lakes												X		X	X
	5410 Tidal Rivers, Inland Bays & Other	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	5412 Tidal Mudflat											X	X			
	5420 Dredged Lagoon			X			X			X	X	X	X			
	5430 Atlantic Ocean		X	X			X		X	X					X	X
WETLANDS	6111 Saline (low marsh)			X			X				X	X	X	X	X	X
	6112 Saline High Marsh			X							X	X	X	X	X	X
	6130 Vegetated Dune Communities	X	X	X	X	X	X	X	X	X	X	X	X	X		
	6141 Phragmites Dominant Coastal Wetlands			X			X				X	X	X			X
	6210 Deciduous Wooded Wetlands										X	X	X			X
	6231 Deciduous Scrub/Shrub Wetlands			X			X					X	X			X
	6232 Conif. Scrub/Shrub Wetlands			X								X	X			
	6233 Mixed Scrub/Shrub Wetlands			X			X	X	X	X		X	X		X	X
	6234 Mixed Scrub/Shrub Wetlands (conif.)											X	X	X	X	X

CAT.	NJ LAND USE/LAND COVER TYPES	STORM SURGE BARRIERS (SSBs)									CROSS-BAY BARRIERS (CBBs)					
		Manasquan Inlet			Barnegat Inlet			Great Egg Harbor Inlet			Absecon Boulevard			Southern Ocean City to 52nd Street		
		0 m	100 m	1000 m	0 m	100 m	1000 m	0 m	100 m	1000 m	0 m	100 m	1000 m	0 m	100 m	1000 m
	6240 Herbaceous Wetlands			X							X	X	X			
	6241 Phragmites Dominant Interior Wetlands			X							X	X	X	X	X	X
	6251 Mixed Wooded Wetlands (Deciduous)															X
	6252 Mixed Wooded Wetlands (coniferous)														X	X
BARREN LAND	7100 Beaches	X	X	X	X	X	X		X	X	X	X	X		X	X
	7200 Bare Exposed Rock	X	X	X	X	X	X	X	X	X	X	X	X			
	7430 Disturbed Wetlands (Modified)										X	X	X			
	7440 Disturbed Tidal Wetlands			X												
	7500 Transitional Areas										X	X	X			
	TOTAL # OF LULC COVER TYPES WITHIN BUFFER AREA	7	13	29	7	10	16	6	9	14	25	34	42	11	16	26

Table 93: Protected Lands or Areas with Comprehensive Management Plans that Regulate or Guide Land Use Within or Adjacent to the NJBB Focused Array of Alternatives

ALT	Feature	NJ Coastal Zone	NJ Pine-lands Boundary	National Reserves/Wild and Scenic Rivers and Wilderness Areas	National Wildlife Refuges	CBRA Sites (Existing)	CBRA Sites (Draft Revised)	National Estuary Program	State Parks/State Wildlife Mgt. Areas/Natural Areas
2A *TSP	Nonstructural	X							
3E(2) *TSP	Manasquan Inlet SSB	X							
	Barnegat Inlet SSB	X		-Pinelands National Reserve (Barnegat Inlet)		-NJ-05P (OPA)	-NJ-05P (OPA)	-Barnegat Bay Partnership	-Island Beach S.P. -Barnegat Lt. S.P.
	Nonstructural	X	X	- Pinelands National Reserve - Jacques Cousteau NERR	-E.B. Forsythe NWR	-NJ-06 -NJ-07P (OPA)	-NJ-06 -NJ-07P (OPA)	-Barnegat Bay Partnership	-Manahawkin W.M.A. -Wharton S.F. -Bass River S. F
4D(1)	Perimeter	X				NJ-08P (OPA)	NJ-19P (OPA) NJ-08P (OPA)		Corson's Inlet S.P.
	Nonstructural	X	X	1. Pinelands National Reserve 2. Great Egg Harbor National Wild and Scenic River	1. E.B. Forsythe NWR 2. Cape May NWR	NJ-07P (OPA) NJ-08P (OPA)	NJ-19P (OPA) NJ-07P (OPA) NJ-08P (OPA)		Belleplain S.F. N. Brigantine S. Nat. Area Absecon W.M.A. Tuckahoe W.M.A.
4D(2)	Perimeter	X				NJ-08P (OPA)	NJ-19P (OPA) NJ-08P (OPA)		N. Brigantine St. Nat. Area Corson's Inlet S.P.
	Nonstructural	X	X	1. Pinelands National Reserve 2. Great Egg Harbor National Wild and Scenic River	1. E.B. Forsythe NWR 2. Cape May NWR	NJ-07P (OPA) NJ-08P (OPA)	NJ-19P (OPA) NJ-07P (OPA) NJ-08P (OPA)		Belleplain S.F. Absecon W.M.A. Tuckahoe W.M.A.
4G(8) *TSP	SSB	X		-Great Egg Harbor National Wild and Scenic River*			-NJ-19P (OPA)		
	CBB- Absecon Blvd.	X							-Absecon WMA
	CBB-S. Ocean City (52nd St.)	X		-Pinelands National Reserve		-NJ-08P* (OPA)	-NJ-08*		-Corson's Inlet S.P.

ALT	Feature	NJ Coastal Zone	NJ Pine-lands Boundary	National Reserves/Wild and Scenic Rivers and Wilderness Areas	National Wildlife Refuges	CBRA Sites (Existing)	CBRA Sites (Draft Revised)	National Estuary Program	State Parks/State Wildlife Mgt. Areas/Natural Areas
							-NJ-08P* (OPA)		-Cape May Coastal Wetlands WMA
	Nonstructural	X		-Pinelands National Reserve	-E.B. Forsythe NWR	-NJ-07P (OPA)	-NJ-07P (OPA)		-N. Brigantine S. Nat. Area -Absecon W.M.A.
5A *TSP	Nonstructural	X		-Pinelands National Reserve		-NJ-09 -NJ-09P (OPA) -NJ-10P (OPA) -NJ-11P (OPA)	-NJ-08 -NJ-09 -NJ-09P (OPA) -NJ-10P (OPA) -NJ-11P (OPA) -NJ-20P (OPA)		-Strathmere Natural Area -Cape May Wetlands WMA -Stone Harbor Point -Cape Island WMA -Cape May Point S.P. -Higbee Beach WMA
5D(2)	Perimeter	X			Cape May NWR	NJ-09	NJ-09		Cape May Wetlands WMA
	Nonstructural	X		Pinelands National Reserve	Cape May NWR	NJ-09 NJ-09P (OPA) NJ-11P (OPA)	NJ-08 NJ-09P (OPA) NJ-11P (OPA)		Strathmere Natural Area Stone Harbor Point Cape Island WMA Higbee Beach WMA

Northern Region | Central Region | Southern Region

*Feature is not located in area, but could have potential indirect impact on area or could occur within a buffer area.

8.2.4.13.3 Nonstructural Measures (TSP Features for 2A, 3E(2), 4G(8) and 5A)

For this alternative, Building Retrofit, which includes building elevation (raising existing structures) emerged from the focused array of alternative as a nonstructural means for CSRM in the NJBB. However, other retrofit measures that will be considered include dry floodproofing, wet floodproofing, ringwalls and rebuilding, which are discussed in greater detail in Section 9.2.2. Building retrofits such as elevation would help protect only individual structures from storm surge. This could disrupt land uses temporarily during construction, as these measures are being constructed. However, the land use disruption would likely be limited to those specific structures being protected, and this alternative should not cause many permanent impacts to land use.

Other measures, such as buyout programs and relocations, fall under the category of "managed coastal retreat", as described in Section 9.2.2 or are also considered as "floodplain acquisitions". This type of program, if implemented on a widespread basis, could have significant impacts on land use. A buyout program would utilize public funds to purchase the title of privately held land, and existing structures are then demolished. The land is left in an undeveloped state for public use in perpetuity. This could change the land use from an urban use to a publicly accessible open space for recreation or conservation. Depending on the scale of implementation, this could occur structure by structure, by street or block, or an entire neighborhood.

8.2.4.13.4 Natural and Nature-Based Features (TSP Features Warranting Further Analysis)

NNBFs are not expected to have significant effects on existing land uses as these measures are primarily water-based and would likely be compatible and consistent with existing water uses. Exceptions would be conversions of open water to intertidal types of habitat/land covers. At this time, no specific NNBFs and locations have been identified. However, the identification of NNBFs and their locations will be evaluated for their compatibility with existing land uses in subsequent phases.

8.2.4.14 Floodplains

8.2.4.14.1 Impacts Common to All Structural Alternatives

8.2.4.14.1.1 Perimeter – Floodwalls, Levees and Miter Gates (4D(1), 4D(2) and 5D(2)

8.2.4.14.1.2 Storm Surge Barriers/Cross-bay barriers (TSP Features for 3E(2) and 4G(8)

The structural plans in the TSP are typically large-scale projects that would protect a large number of structures, which is a beneficial and significant impact. The high cost of constructing, operating, and maintaining these structures usually reflects the size and complexity of the system, including the SSBs, CBBs, miter gates, road closures, number of pumps needed for interior drainage, real estate needs for berms, floodwalls, levees and closures, easements, and rights-of-way, engineering, and design, etc. After a community experiences several flood events, the damages prevented can easily justify the costs for such a project. If properly inspected, maintained, and operated, the flood protection system can last and function as designed during its project life.

However, flood protection systems can fail, be overtopped, and/or flood due to interior drainage, which would be an adverse and significant impact to those on the protected side. In these possible flood scenarios, rather than having minor damage, there could be significant damage within the protected area. Although a temporary impact, recovery could take several years for an individual and the community, especially if citizens do not have flood insurance. In addition to having flood insurance and floodplain regulations in place for new development and substantially damaged or improved structures within the protected area, other things to consider which could influence the severity of the impacts, include outreach and education to citizens on the need for evacuation of the protected area and removing or elevating valued items in advance of a storm event; locating critical structures outside the protected area in case of flooding; and preventing unwise development within the protected area that may aggravate interior flooding due to rainfall (USACE, 2017).

8.2.4.14.2 Nonstructural Measures (TSP Features for 2A, 3E(2), 4G(8) and 5A)

For this alternative, Building Retrofit, which includes building elevation, (raising existing structures) emerged as a nonstructural means for CSRM in the NJBB. However, other retrofit measures that will be considered include dry floodproofing, wet floodproofing, ringwalls and rebuilding, which are discussed in greater detail in Section 9.2.2.

Building retrofit measures will help reduce flood insurance premiums and keep neighborhoods and communities sustainable and resilient after a flood, which is a beneficial and significant positive impact to those living and working in a floodplain and the local municipality. FEMA recognizes elevation, acquisition, and relocation in reducing the cost or eliminating the need for flood insurance for residential and commercial structures. For commercial structures only, flood proofing is recognized by FEMA, where a flood proofed building has been designed and constructed to be watertight. Depending on the nonstructural method used and level of protection, a residential or commercial structure could possibly stay flood-free during its design life. An advantage of nonstructural measures when compared to structural measures is the ability of nonstructural measures to be sustainable over the long term with minimal costs for operation, maintenance, repair, rehabilitation, and replacement. If an existing structure does not meet FEMA's regulations, is substantially damaged in any way, or is substantially improved, as may apply with a nonstructural measure, then the structure will need to be brought into compliance with FEMA's and the municipality's floodplain regulations (USACE, 2017).

8.2.4.14.3 Natural and Nature-Based Features (NNBFs) (TSP Features Warranting Further Analysis)

NNBFs could provide beneficial impacts in many ways, such as reducing flood impacts and providing valuable habitat, recreational areas, and urban landscape diversity. These types of features can be long lasting or temporary as necessary. While the measures will not significantly reduce flood risks during major storms, they may make a difference for small and localized flood events and can aid in dissipating wave energies and scour on flood structures (King et. al 2020).

8.2.4.15 Geology and Soils

8.2.4.15.1 Impacts Common to All Structural Alternatives

8.2.4.15.1.1 Perimeter – Floodwalls, Levees and Miter Gates (4D(1), 4D(2) and 5D(2)

8.2.4.15.1.2 Storm Surge Barriers/Cross-Bay Barriers (TSP Features for 3E(2) and 4G(8)

Because of the depth of overlying soils and sediments within the affected areas, construction of the structural measures, which include pile driving, is not expected to affect bedrock competency, aquifers, or cause long-term changes in seismic activity that would be damaging for structures. Short-term effects would involve vibrations from heavy construction equipment including pile or vibratory hammers, which could affect structures that include nearby residential homes, attached decks and commercial buildings and shops. Therefore, appropriate seismic monitoring will be implemented in locations susceptible to vibration utilizing seismographs at locations on or at the base of the representative structures to obtain the highest peak particle velocities. Representative structures would be defined as one of each foundation type (pile foundation, masonry, concrete, and slab on grade).

Construction activities would also impact soils through compaction, disturbance, and mixing of discrete soil strata in all areas involved in construction including staging areas that involve clearing, grading, excavations, backfilling, and the movement of construction equipment. These impacts can be minimized by implementing Best Management Plans (BMPs) for sediment and soil erosion control to minimize earth disturbance impacts.

The structural measures within the focused array of alternatives involve structures affecting primarily the shoreline areas of the bays, inlets, open water, beaches, and tidal marsh. No disturbance of soils in areas classified as prime farmland would occur; therefore, no adverse significant impact on the agricultural use of soil is expected.

Importation of earthen materials including rock, sand, backfill materials, and topsoil, would be obtained from existing approved commercial quarries, sandpits, offshore borrow areas and other approved sources.

8.2.4.15.2 Nonstructural Measures (TSP Features for 2A, 3E(2), 4G(8) and 5A)

Nonstructural measures involve a significant construction effort whether it be from building retrofits such as elevation (including raising a structure on fill or foundation elements such as solid perimeter walls, pier, posts, columns, or pilings) or buyout/ relocations that are likely to involve demolition, grading, and soil stabilization/revegetation. All of these activities would involve earth disturbances similar to some of the effects discussed for construction of the structural measures. Soil disturbances can be readily managed by implementing appropriate BMPs.

8.2.4.15.3 Natural and Nature-Based Features (TSP Features Warranting Further Analysis)

NNBFs, similar to the other structural and nonstructural measures, would involve construction impacts during the time of implementation. The degree of the impact is largely dependent on the feature and its method of construction. For instance, some NNBFs like wetland restoration or reef construction may require the aquatic placement of fill materials that would disturb existing substrates (soil or sediments), and likewise generate localized, but temporary, turbidity in the water column. These effects are expected to be temporary. After construction is completed, these areas would become stabilized with vegetation and/or with other biogenic processes. NNBFs are not expected to result in any adverse impacts on underlying geology (bedrock, aquifers), but are likely to result in minor changes in topography and bathymetry depending on the measure being implemented.

8.2.4.16 Water Quality

8.2.4.16.1 Structural Measures

8.2.4.16.1.1 Perimeter – Floodwalls, Levees and Miter Gates (4D(1), 4D(2) and 5D(2)

8.2.4.16.1.1.1 Direct Impacts

The direct impacts of the implementation of floodwalls, levees, and miter gates on water quality would result in temporary increases in turbidity and total suspended solids in the vicinity during construction. Minor and temporary increases in turbidity are expected during construction from activities such as the installation and removal of temporary cofferdams, temporary excavations, fill and rock placement, and vibrations during the driving of sheet piles. Other activities such as earth disturbances resulting from construction access activities, staging/storage areas and upland excavations and soil stockpiles have the potential to generate turbidity as a non-point source. In accordance with Section 402 of the Clean Water Act, a sediment/erosion control plan will be submitted to the county conservation districts for their review and approval. Compliance with the approved sediment/erosion control plan/earth disturbance permit will result in minimal sedimentation/turbidity. Several measures such as rock entrances, silt fencing, physical runoff control as well as other best management practices will be implemented to reduce direct impacts to water quality. Areas disturbed during construction would be subsequently stabilized upon completion of construction activities and turbidity is expected to return to normal levels.

8.2.4.16.1.1.2 Indirect Impacts

The generation of turbidity during construction would have temporary impacts on fish respiration, filter feeders, sight feeders, and may inhibit photosynthesis of nearby SAV beds. These impacts would be more severe on sessile organisms because they will not be able to avoid the turbidity generated during construction. However, this effect is expected to be minor and of short duration until construction activities cease. Miter gates will be installed and operated across smaller channels that require navigable access. These gates would remain open during normal conditions and would be closed during significant storm events. Some localized, but minor changes in hydrodynamics around the gates are expected, however, no significant changes in water quality are expected while the gates are open. Miter gate closures during storms may temporarily affect water quality in a localized area by inhibiting circulation and mixing.

With any of the perimeter measures, pump stations would be required to collect interior drainage from significant precipitation events. These pump stations, for the most part, would receive urban run-off from impermeable surfaces from buildings, streets, and parking lots that may contain typical urban non-point source pollutants such as sediments, bacteria, nutrients, and oil and grease. The pumps would not necessarily increase these stormwater discharges; however, they may focus these discharges more at fewer points based on the pump station location and outfall discharge points rather than the current stormwater drainage systems. Current stormwater discharges may either have discharges directly into the bays at the street ends or through combined sewers. Stormwater systems vary by community and would require further investigation to determine the appropriate locations and design for the interior drainage pumps and outfalls.

8.2.4.16.1.1.3 Cumulative Impacts

The cumulative impacts of floodwalls and levees on water quality are not expected to be significant because the generation of turbidity during construction would be of short duration and limited to within work the segments. However, the cumulative effects of turbidity may be increased if there are other similar activities ongoing and nearby that generate turbidity such as dredging, earth disturbance, non-point storm water discharges, etc.

8.2.4.16.1.2 Inlet Storm Surge Barriers/Cross-Bay Barriers (TSP Features for 3E(2) and 4G(8)

8.2.4.16.1.2.1 Direct Impacts

Due to the size of the features, the construction of SSBs and CBBs are expected to last from months to years, although discharges are not likely to be constant during these periods. Therefore, the direct impacts of the construction of inlet SSBs and CBBs on water quality are temporary increases in turbidity and total suspended solids in the vicinity during construction. Minor and temporary increases in turbidity are expected during construction from activities such as the installation and removal of temporary cofferdams or other structures for dewatering, temporary excavations, dredging, fill and rock placement, concrete work, and vibrations during the driving of sheet piles. Should any dredging/fill placement be required an evaluation of the Clean Water Act Section 404(b)(1) guidelines will be conducted prior to undertaking any work and the procedures in the "The Management and Regulation of Dredging Activities and Dredged Material in New Jersey's Tidal Water" for Section 401 Water Quality Certification compliance will be implemented. BMPs and containment/contingency plans will be required to address potential for fuel, lubricant, or coolant spills or leaks from construction equipment. Other activities such as earth disturbances resulting from construction access activities, staging/storage areas and upland excavations and soil stockpiles have the potential to generate turbidity as a non-point source. In accordance with Section 402 of the Clean Water Act, a sediment/erosion control plan will be submitted to the county conservation districts for their review and approval. Compliance with an approved sediment/erosion control plan/earth disturbance permit will result in minimal sedimentation/turbidity. Several measures such as rock entrances, silt fencing, physical runoff control as well as other best management practices will be in the plan to reduce impacts to water quality. Areas disturbed during construction would be subsequently stabilized upon completion of construction activities and turbidity is expected to return to normal levels.

8.2.4.16.1.2.2 Indirect Impacts (Temporary)

The indirect impacts of the construction and operation and maintenance of inlet SSBs and CBBs on water quality are not considered to be significant. The generation of turbidity during construction will have temporary impacts on fish respiration, filter feeders, sight feeders, and may inhibit photosynthesis of nearby SAV beds, if present. These impacts would be more severe on sessile organisms because they will not be able to avoid the turbidity generated during construction. However, this effect is expected to be localized and of short duration until construction activities cease

8.2.4.16.1.2.3 Indirect Impacts (Long-term)

The shallow lagoonal coastal bays in New Jersey are susceptible to potential changes caused by the placement of structures such as SSBs across the affected inlets and CBBs, which run across the bays in an east-west direction. Both of these types of structures can potentially modify tidal flows by reducing the cross section and free exchange of tidal flows through the inlets and bay systems. Thus, the implementation and operation of barriers and closures have the potential for significant impacts on water quality based on their potential for altering flow and circulation patterns. These impacts are inherently based on the design of the barrier andclosure criteria, such as the number of openings and widths of these openings, which could significantly alter the flow patterns through the inlets and bays by constricting flows and affecting current velocities. A number of design components make up these barriers, including navigable sector gates, auxiliary flow lift gates, impermeable barriers, levees, and seawalls. For the SSBs, the navigable sector gates, auxiliary flow lift gates, and their support piers are the predominant in-water structures. The impermeable barrier structure is a hardened structure that is also an in-water structure that ties the gates into features on the adjacent land such as a levee, seawall, or existing dune. The CBBs have the same components as the SSBs, but the CBBs also have other features such as levees, road closures and miter gates and sluice gates, which are for smaller channels and tidal guts. The navigable sector gate is open under normal conditions to allow for navigation traffic and tidal exchange. The auxiliary lift gates are vertical gates that are “up” during normal conditions to allow for tidal exchange. These gates would be designed to remain open during normal conditions. However, even with the gates in opened positions, there would be a net reduction in channel cross-sectional area that would act as a constriction to flood and ebb tidal flow through the inlets. Table 94. provides a preliminary estimate of cross- sectional areas of the A1 alignments affected by the combinations of the features of the SSBs in the TSP and shows significant changes in conveyance from baseline conditions (100% conveyance) particularly at the larger inlets at Barnegat Inlet and Great Egg Harbor Inlet. The Barnegat Inlet SSB alignment results in the greatest net flow restriction at 46% of the current cross section while the Manasquan Inlet SSB has the least effect on the inlet cross-section.

Table 94: Inlet Cross Sectional Changes from TSP Storm Surge Barriers

SSB Location	Existing Wetted Cross Section Area (SF)	A1 Wetted Area (SF)	A1 Conveyance (%)	A1 Restriction (%)
Manasquan Inlet	8,011	6,134	77%	23%
Barnegat Inlet	45,631	24,854	54%	46%
Great Egg Harbor Inlet	70,618	40,682	58%	42%

Based on these restrictions, changes in tidal flow velocity are likely, which could increase susceptibility to scour and erosion in areas with increased velocity and sediment deposition in areas of lowered velocity. These flow pattern changes could potentially result in changes in circulation and increased residence times, which could have more profound effects in backwater areas that are already poorly flushed. Restrictions in tidal flows and increases in residence times could affect salinity levels, stratification, nutrients, chlorophyll 'a' and dissolved oxygen concentrations. These effects could be exacerbated at times when the gates are closed during a significant storm event when increased freshwater inputs, nutrients, bacteria, and other pollutants discharged from tributaries and point and non-point sources are held in the bays for a longer period. The frequencies and durations of gate closures may vary where closures at a minimum would be over two tide cycles (approximately 24 hours) to approximately 48 hours several times a year. These closures are unpredictable and would depend on the number and severity of the storms in the affected area.

Measuring these physical changes is important for understanding the potential for effects on water quality. Therefore, a two-dimensional (2D) Adaptive Hydraulics (AdH) model was developed and validated for simulation of hydrodynamics and salinity within the affected areas. The model was validated to available field data for all parameters and then utilized to test project alternatives for present and future sea level rise conditions (McAlpin and Ross, 2020). Baseline field measurements and modeling occurred at 30 locations situated throughout the study area. The results of the AdH modeling include changes in salinity, velocity, and water levels throughout the model domain under the various alternative conditions. Additionally, particle tracking was conducted by Lackey et al. (2020) utilizing the Particle Tracking Model (PTM) (McDonald et al 2006, Gailani et al 2016, Lackey et al 2008) to determine any changes in residency times of the affected estuaries from the structures associated with the TSP. At this time, the AdH model and particle tracking model (PTM) was only applied for the open-gate condition, which would be the predominant condition for the with-project TSP. Subsequent analyses of AdH and PTM will be conducted to simulate conditions with the gates closed during storm events and maintenance activities.

8.2.4.16.1.2.4 Open-Gate Scenario

Results of the open-gate AdH modeling indicate significant localized increases in velocity at all three inlets where SSBs are planned. However, the impact of the velocity magnitudes away from the structures would be very little. The tidal prism (volume of water exchange) would be relatively unchanged at Manasquan Inlet, and would be reduced by 2.5% and 4.8% at Barnegat Bay and Great Egg Harbor, respectively. The impacts to tidal amplitudes were found to be unevenly distributed throughout the bays with individual reduction in tidal amplitude ranging from 1.3% to 8.3% through Barnegat Bay and 0.1% to 4.5% in Great Egg Harbor for the TSP.

Changes in salinity were also modeled in the AdH model for the open-gate conditions. Table 95 presents the open-gate baseline salinities and the salinities as impacted by the TSP- SSBs and CBBs in place per location. Little variability in mean salinity was evident between the baseline condition and with-project TSP at individual stations with station JACNEWQ (Lower Mullica River) showing the largest change at +0.34 ppt.

Table 95: AdH Model Comparing Mean Baseline Salinities with TSP (A1 Alignments) for Alternatives 3E(2) and 4G(8) Open-Gate Conditions and with Sea Level Rise (SLR) at Locations Throughout the NJBB CSRM Study Area (McAlpin and Ross, 2020)

Study Region	Waterway	Station	Existing Conditions			With SLR		
			Base (ppt)	TSP (ppt)	Change (ppt)	Base (ppt)	TSP (ppt)	Change (ppt)
NORTHERN REGION	Manasquan River	Watson Creek	23.44	23.5	+0.06	24.87	24.74	-0.13
		Manasquan River	24.03	24.14	+0.11	25.46	25.29	-0.17
	Barnegat Bay- Little Egg Harbor	Brick	5.14	5.2	+0.06	7.96	8.31	0.35
		Barnegat Bay at Mantoloking	20.87	21.0	+0.13	21.79	21.26	-0.53
		Barnegat Bay at Route 37 Bridge	12.48	12.38	-0.1	13.65	12.55	-1.1
		Berkeley	1.91	1.92	+0.01	2.64	2.62	-0.02
		Barnegat Light	25.1	24.86	-0.24	26.74	26.67	-0.07
		Barnegat Bay at Waretown	25.29	25.06	-0.23	26.2	26.27	0.07
		Barnegat Bay at Barnegat Light	27.1	27.27	+0.17	27.69	27.95	0.26
		Barnegat Light (Ocean)	28.38	28.42	+0.04	28.73	28.71	-0.02
		East Thorofare	25.77	25.92	+0.15	26.61	26.52	-0.09
		Westecunk	21.78	21.96	+0.18	24.34	24.41	+0.07
		Beach Haven	27.28	27.37	+0.09	27.9	27.83	-0.07
CENTRAL REGION	Mullica River	JACNEWQ (Mullica River)	4.8	5.14	+0.34	10.01	9.9	-0.11
	Little Egg Inlet/Great Bay	Little Egg Inlet	26.89	27.04	+0.15	27.31	27.29	-0.02

Study Region	Waterway	Station	Existing Conditions			With SLR		
			Base (ppt)	TSP (ppt)	Change (ppt)	Base (ppt)	TSP (ppt)	Change (ppt)
	Absecon Bay	Absecon Creek	27.52	27.6	+0.08	27.77	27.81	+0.04
	Obes Thorofare	Brigantine	27.67	27.71	+0.04	27.93	27.92	-0.01
	Absecon Inlet	Absecon Channel	28.44	28.5	+0.06	28.51	28.52	+0.01
	Atlantic Ocean	Atlantic City (Ocean)	28.65	28.7	+0.05	28.61	28.62	+0.01
	Inside Thorofare	Inside Thorofare (Rt. 40)	27.6	27.25	-0.35	27.89	27.57	-0.32
	Beach Thorofare	Beach Thorofare (Margate Blvd.)	28.25	28.18	-0.07	28.46	28.33	-0.13
	Scull Bay	Scull Bay	27.77	27.75	-0.02	27.81	27.68	-0.13
	Great Egg Harbor River	Great Egg Harbor River	18.99	18.73	-0.26	21.79	20.97	-0.82
	Rainbow Channel	Great Egg Harbor Bay	27.34	27.21	-0.13	27.43	27.06	-0.37
	Crook Horn Creek	Ocean City 39th St	25.75	25.45	-0.3	25.79	25.18	-0.61
SOUTHERN REGION	Middle Thorofare	Corson Sound	28.05	28.17	+0.12	27.97	28.12	+0.15
	Ludlum Thorofare	Ludlum Thorofare (Sea Isle Blvd.)	27.74	27.8	+0.06	27.95	27.97	+0.02
	Ingram Thorofare	Ingram Thorofare (Old Avalon Blvd.)	28.34	28.38	+0.04	28.57	28.58	+0.01
	Cape May Canal	Cape May Ferry	27.33	27.35	+0.02	27.33	27.28	-0.05
	Cape May Harbor	Cape May Harbor	28.64	28.67	+0.03	28.64	28.66	+0.02

McAlpin and Ross (2020) conclude that overall, the TSP SSBs do not significantly impact the salinity in the back-bay region. The mean salinity does not vary by more than 0.34 ppt for the TSP. There is a slightly larger range in the salinity variation among the sea level rise alternatives, but this is still generally less than 2 ppt (SLR TSP showed a 1.1 ppt reduction at Barnegat Bay Rt. 37 Bridge area). The variation at specific times may be larger but overall, the impact is small. Given the well-mixed nature of the inlets, ocean salinity is pushed into the back-bay areas and allowed to move easily throughout the area. The restrictions created by the alternative structures and the reduction in tidal prism are not large enough to significantly impact the salinity at the analysis locations.

Because of the potential for the SSBs and CBBs to increase residency time of the affected estuaries and the potential indirect effects on water quality, Lackey et. al (2020) applied the AdH hydrodynamic model results to the Particle Tracking Model (PTM) to evaluate the impact of the SSBs (open gates conditions) on residence time in the NJBB CSRM Study area. Overall, the PTM results (Table 96) show that the structures result in little discernable changes to residence time, with modeled differences generally within the uncertainty range from innate model randomness caused by diffusion. Model results show that the TSP in general increases in residence time in South and Central Regions by 2 to 5 days and reduces residence time in North region by 1 to 2 days. Additionally, an investigation of sea level rise (SLR) with PTM, showed that flushing increases with SLR for all structural configurations.

Table 96: Baseline and TSP with Project Condition Average Residence Time (Days) for Affected NJBB Estuaries Utilizing Particle Tracking Model (PTM) (Lackey et al. 2020)

Location	Baseline Residency (Days)	TSP w/Project Residency (Days)	Change from Baseline (Days)
Cape May	10.88	9.85	-1.03
Hereford	24.96	26.95	1.99
Townsends	35.97	39.89	3.92
Corson	19.14	23.95	4.81
Great Egg Harbor Bay	19.59	22.09	2.50
Absecon Bay	26.2	27.92	1.72
Great Bay	20.03	19.09	-0.94
Barnegat Bay	30.48	29.55	-0.93
Manasquan River	29.66	27.37	-2.29

Based on these model outputs, it is reasonable to conclude that the small changes in residence times would not contribute to large scale increases in stagnation and/or water quality degradation associated by nutrient loading in areas most affected by SSBs. However, subtle changes are more difficult to model, thus implementation of these structures still present a higher risk for either overestimating or underestimating water quality impacts especially in estuarine systems stressed by nutrient enrichment. In order to mitigate this risk, additional modeling and refinements along with collecting long-term data sets on measured attributes would provide a better baseline to compare changes prior to any SSB implementation. Additionally, incorporating and budgeting for environmental mitigation through either subsequent refinement in design or adaptive management is an important part in assuring that this risk is minimized.

8.2.4.16.1.2.5 Closed Gate Scenario

Inlet SSB gate closures for maintenance/testing or during storm events would temporarily block all tidal flows from entering the estuaries from the ocean inlets. Gate closures for the CBBs would also temporarily inhibit tidal flows and circulation within the bay systems as well. As previously stated, AdH modeling and PTM have not been conducted for TSP closed gate scenarios. This type of modeling is expected to be completed prior to the conclusion of the Feasibility Study and/or for a Tier 2 level assessment during the PED Phase. Nevertheless, the frequency and duration of closure operations are expected to have significant effects on water quality within the affected estuaries, which would be heavily dependent on the timing and duration of these closures. A current closure scenario is that the gates will be closed at a minimum of once per year for testing. The exact details of closure operations for storm events are still being determined and will be refined as the study progresses. At this point, closing of the SSB gates for storm events about once every 5 years (20% AEP) is anticipated. Additionally, it is expected that there will be adjustments to the water level threshold over time in response to RSLR, so that the frequency of closure operations (about once every 5 years) remains constant over the life of the project.

Based on this and taking a conservative estimate of 3 days per closure, this would yield approximately 18 days of closures over a 5-year period (assuming 3 days/year for maintenance and 3 days per 5 years for a storm event). This results in about 1% of the time that closures would be conducted.

These closures are expected to increase retention times during the duration of each closure by closing off any tidal exchange of seawater entering through the inlets which would normally have the effect of flushing out non-point source pollutants such as nutrients (nitrogen and phosphorous), bacteria, and other organic/inorganic contaminants stemming from primarily non-point sources(urban areas, roadways, septic systems, marinas, leaking storage tanks, etc.) which may be exacerbated at a time of heavy rainfall and associated runoff. The seasonality of these closure events would be critical to the effects that these increased residence times would have on estuarine water quality. Closures during the growing season may have greater adverse effects on promoting algal blooms and associated dissolved oxygen depressions, while closures during the winter months may have a lesser effect. Additionally, gate closures would affect the distribution of salinity particularly at a time of a storm event where huge amounts of freshwater from precipitation may be entering the bay systems from the rivers and tributaries that discharge into these bays. A gate closure, though temporary, would prevent the mixing of saline seawater in these areas during the duration of such a closure and salinity levels would likely decrease. To understand these effects, additional AdH modeling is required that first measures the physical changes a gate closure would impose and then second how these physical changes affect water quality in these systems. As discussed in the open-gate discussion, a higher risk for underestimating or overestimating water quality impacts especially in estuarine systems stressed by nutrient enrichment exists. In order to mitigate this risk, additional modeling, and refinements along with collecting long-term data sets on measured attributes would provide a better baseline to compare changes prior to any SSB implementation. Additionally, incorporating and budgeting for environmental mitigation through either subsequent refinement in design, operation or adaptive management is an important part in assuring that this risk is minimized.

8.2.4.16.1.2.6 Cumulative Impacts

The cumulative impacts during the construction of the inlet SSBs and CBBs on water quality are not expected to be significant because the generation of turbidity during construction would be of short duration and limited to within work segments. However, the cumulative effects of turbidity may be increased if there are other similar activities ongoing and nearby that generate turbidity such as dredging, earth disturbance, non-point storm water discharges, etc.

The cumulative impacts of the operation of SSBs and CBBs on water quality are not well known. Since these structures have the potential to affect bay-wide system water quality, there is a potential for cumulative effects on water quality when coupled with existing water quality trends and the effects of climate change/sea level rise. Results of the AdH modeling for the open gate scenario do not indicate significant effects on the tidal prism or residence times, and it can be assumed that the amount of current seawater flushing of these bays would be maintained. However, the closed-gate conditions, although temporary, may result in cumulative effects on water quality. To better understand the effects of the various SSBs and CBBs in the TSP, the next phase of the study will include additional hydrodynamic and water quality modeling that would be applied to better assess the effects that these measures would have on these bay systems.

8.2.4.16.2 Nonstructural Measures (TSP Features for 2A, 3E(2), 4G(8) and 5A)

Nonstructural measures involve a significant construction effort whether it be from building retrofits such as elevation (including raising a structure on fill or foundation elements such as solid perimeter walls, pier, posts, columns, or pilings) or buyout/ relocations that are likely to involve demolition, grading, and soil stabilization/ revegetation. All of these activities would involve earth disturbances similar to some of the effects discussed for temporary construction of the structural measures that would produce turbidity. However, soil disturbances can be readily managed by implementing appropriate BMPs.

Nonstructural measures such as buyout and relocation could result in indirect improvements to water quality by the removal of impervious surfaces (through demolition) and replacement with permeable soils and vegetation. In some cases, it may be possible to implement stormwater facilities in these locations. This action could effectively, if implemented on a large scale, reduce urban runoff and stormwater that would carry sediments and a number of other pollutants into the bays.

8.2.4.16.3 Natural and Nature-Based Features (TSP Features Warranting Further Analysis)

NNBFs, similar to the other structural and nonstructural measures would involve construction impacts during the time of implementation. The degree of the impact is largely dependent on the feature and its method of construction. For instance, some NNBFs like wetland restoration or reef construction may require the aquatic placement of fill materials that would disturb existing substrates (soil or sediments), and likewise generate localized, but temporary, turbidity in the water column. Should any dredging/fill placement be required an evaluation of the Clean Water Act Section 404(b)(1) guidelines will be conducted prior to undertaking any work and the procedures in the “The Management and Regulation of Dredging Activities and Dredged Material in New Jersey's Tidal Water" for Section 401 Water Quality Certification compliance will be implemented. These effects are expected to be temporary. After construction is completed, these areas would become stabilized with vegetation and/or with other biogenic processes. NNBFs are expected to have long-term beneficial impacts on water quality by providing services such as more stable substrates (less turbidity), nutrient uptake, and/or provide habitat that is better suited for filter feeders that can capture phytoplankton and suspended particles.

8.2.4.17 Plankton

8.2.4.17.1 Structural Measures

8.2.4.17.1.1 Perimeter – Floodwalls, Levees and Miter Gates (4D(1), 4D(2) and 5D(2)

8.2.4.17.1.1.1 Direct Impacts

The direct impacts of the implementation of floodwalls and levees on both zooplankton and phytoplankton include temporary increases in turbidity and total suspended solids in the vicinity during construction. Increased turbidity is likely to inhibit photosynthesis and primary production provided by phytoplankton and thus may have some minor effects on the food chain.

8.2.4.17.1.1.2 Indirect Impacts

Indirect impacts could be the resuspension of sediments containing nutrients and a decrease of transitional upland areas (by increasing hardened shoreline) that act as filters for non-point source run-off. An indirect effect of increased run-off and nutrients would contribute to eutrophication and phytoplankton blooms. Additionally, bay nettles (*Chrysaora chesapeakei*) are a stinging jellyfish that have become increasingly prevalent, and a nuisance, in Barnegat Bay and other coastal waterways in New Jersey. They can be planktonic for a brief period but occur as sessile polyps or as free-swimming medusae. Bay nettles can greatly affect recreational activities that involve human contact with the water where people can be stung by their tentacles. It is believed that bay nettle blooms are greatly influenced by a number of factors such as increases in the presence of manmade structures (pilings, floating docks, and bulkheads), which allow for a suitable substrate for the polyps to attach (https://www.barnegatbaypartnership.org/protect/threats-to-barnegat-bay/jellyfish/sea-nettles/ accessed on 1/4/2019) . Therefore, the installation of floodwalls and miter gates would provide hardened substrate that could potentially be used by stinging nettle polyps to attach. In areas with existing hardened shorelines such as bulkheads, the construction of floodwalls will not have a significant effect. However, any increases in hardened substrate where there are no current man-made features, could potentially result in a net-increase of the surface area for polyps to attach, although the degree of this potential effect is not well understood.

8.2.4.17.1.1.3 Cumulative Impacts

The cumulative impacts of floodwalls and levees on plankton are not expected to be significant because the generation of turbidity during construction would be of short duration and limited to in-water work segments. However, the cumulative effects of turbidity, which may affect plankton, may be increased if there are other similar activities ongoing and nearby that generate turbidity such as dredging, earth disturbance, non-point storm water discharges, etc. The widespread construction of floodwalls and levees may have some indirect cumulative effects as discussed previously such as losses of transitional upland areas that could filter nutrients and additional hardened substrates suitable for bay nettle polyp attachment. These effects coupled with climate change and sea level rise are less understood.

8.2.4.17.1.2 Inlet Storm Surge Barriers/Cross-bay barriers (TSP Features in Alternatives 3E(2) and 4G(8)

8.2.4.17.1.2.1 Direct Impacts

The direct impacts of the construction of SSBs and CBBs on both zooplankton and phytoplankton would result from temporary increases in turbidity and total suspended solids in the vicinity during construction. Increased turbidity is likely to inhibit photosynthesis and primary production provided by phytoplankton and thus may have some minor effects on the food chain.

8.2.4.17.1.2.2 Indirect Impacts

The operation of SSBs and CBBs could potentially have significant effects on plankton abundance and distribution in the affected bays by altering water quality, velocities, salinity levels and nutrient levels. Recent AdH hydrodynamic modeling does not indicate significant impacts on water quality from SSBs and CBBs in the open-gate condition. However, during the operation of the gates when they are closed during storm events these changes may be more profound, albeit temporary, and could affect the survival rate of plankton. A salinity reduction due to gate closures (>5 days) could result in a 100% post-hatch zooplankton larvae mortality rate. A majority of larvae will not survive past day three days with reductions in salinity (Richmond & Woodin, 1996). Varying growth rates during a salinity drop is dependent on the duration of the salinity reduction and the age of the embryos and larvae when exposed to the reduced salinity environment. Phytoplankton are vulnerable to large salinity changes, with the exception of picoplankton, which are able to survive in salinities from 5ppt and up. In the upper reaches of the waterbodies protected by surge barriers, closures during storm events can decrease salinity to less than 5ppt. Drastic changes can be expected to cause some mortality of phytoplankton (Lancelot and Muylaert, 2011), as well as zooplankton (Lance, 1963). Any closures are not planned to be for long periods of time so these salinity differences due to closures are minor to moderate and temporary, and mortalities of plankton are expected to be localized.

Predictive alterations in hydrodynamics through changes in bay circulation and flushing would require hydrodynamic modeling to determine changes in residence time with gates open and closed. Significant changes in residence time could affect nutrient levels, salinity, and temperature, which could potentially promote phytoplankton blooms including the more problematic harmful algal blooms (HABs). HABs can adversely affect aquatic life including fish, shellfish and SAV beds along with some human health implications. To better understand the effects of the various SSBs and CBBs under consideration, the next phase of the study will include initial hydrodynamic and water quality modeling that would be applied to better assess the effects that these measures would have on these bay systems.

8.2.4.17.1.2.3 Cumulative Impacts

The combination of SSBs and/or CBBs and existing water quality trends concerning algal blooms and climate change/sea level rise have the potential to result in cumulative disruptions in the planktonic community by affecting the balance and seasonal abundances of the native planktonic species. Potential adverse cumulative effects could result in phytoplankton/zooplankton mortalities and/or the promotion of increased bay-wide systemic algal blooms including HABs. However, the cumulative impacts of the operation of SSBs and CBBs during closed gate conditions on water quality are not well known. Since these structures have the potential to affect bay-wide system water quality, there is a potential for cumulative effects on water quality and plankton when coupled with existing water quality trends and the effects of climate change/sea level rise. Hydrodynamic and water quality modeling of these structures will help inform the degree, if any, of cumulative effects on plankton in the affected bays.

Climate change and sea level rise introduce greater uncertainty when combined with the effects of SSBs where changes in temperature, precipitation and flooding patterns, and chemical changes could impose synergistic effects on the NJBB water quality where the bay's plankton may experience shifts in distribution and abundance.

8.2.4.17.2 Nonstructural Measures (TSP Features for 2A, 3E(2), 4G(8) and 5A)

Nonstructural measures involve a significant construction effort whether it be from building retrofits such as elevation (including raising a structure on fill or foundation elements such as solid perimeter walls, pier, posts, columns, or pilings) or buyout/ relocations that are likely to involve demolition, grading, and soil stabilization/ revegetation. All of these activities would involve temporary earth disturbances, similar to those expected during construction of the structural measures, that would produce turbidity, introduce nutrients, and increase eutrophication that could facilitate the formation of an algal bloom. However, these soil disturbances are temporary and can be readily managed by implementing appropriate BMPs.

Nonstructural measures such as buyout and relocation could result in indirect improvements to water quality by the removal of impervious surfaces (through demolition), and replacement with permeable soils and vegetation. In some cases, it may be possible to implement stormwater facilities in these locations. This action could effectively, if implemented on a large scale, reduce urban runoff and stormwater that would carry sediments and a number of other pollutants into the bays, thus reducing nutrients and their potential for promoting algal blooms.

8.2.4.17.3 Natural and Nature-Based Features (TSP Features Warranting Further Analysis)

NNBFs, similar to the other structural and nonstructural measures, would involve construction impacts during the time of implementation. The degree of the impact is largely dependent on the feature and its method of construction. NNBFs are expected to have long-term beneficial impacts on water quality, and will help to minimize harmful phytoplankton blooms by providing services such as more stable substrates (less turbidity), nutrient uptake, and/or provide habitat that is better suited for filter feeders that can capture phytoplankton and suspended particles.

8.2.4.18 Submerged Aquatic Vegetation and Macroalgae

8.2.4.18.1 Structural Measures

8.2.4.18.1.1 Perimeter – Floodwalls, Levees and Miter Gates (4D(1), 4D(2) and 5D(2)

8.2.4.18.1.1.1 Direct Impacts

The direct impacts of construction of floodwalls and miter gate structures within shallow bay waters would be the direct mortality of SAVs and permanent loss of SAV habitat within the footprint alignment of the structure. These mortalities would result from either removal through excavations, burial from fill placement, or excessive turbidity, which may inhibit photosynthesis. Additionally, temporary losses of SAVs may be experienced through the placement of de-watering structures and either temporary fills or excavation for temporary access points to the work segment. Preliminary estimates of affected SAV beds are based on existing mapping, the current (preliminary) alignments and an assumed width of the disturbance offset from the structure. No SAV surveys have been conducted along any of the preliminary perimeter plan alignments. Additionally, mapping of SAV beds is only available for Barnegat Bay (spatial data adopted from http://crssa.rutgers.edu/projects/coastal/sav/ and Lathrop and Haag, 2010). Therefore, the only alternative in the focused array with a perimeter plan where SAV bed mapping is available is 3E(3), which includes a perimeter along the southern end of Long Beach Island (from Ship Bottom to Holgate). Based on the current alignment and level of design, it was estimated that up to 11 acres of predominantly sparse (10-40%) cover density SAVs would be impacted. A loss of 11 acres of SAVs would be considered significant based on the value of this type of habitat and the acreage involved, and would therefore require compensatory mitigation if avoidance and minimization of the impact cannot reduce this impact. However, it should be noted that this estimate is very preliminary. A more precise estimate of temporary and permanent disturbance will be available upon completion of SAV surveys in all locations/waterways with HFF perimeter structures and with a higher level of design and construction plan of the structures involved.

8.2.4.18.1.1.2 Indirect Impacts

Indirect impacts are not significant due to the duration of impact, but they may contribute to additional stressors on an already biologically stressed community. Indirect impacts could result from the resuspension of sediments containing nutrients and a decrease of transitional upland areas (by increasing hardened shoreline) that act as filters for non-point source run-off. An indirect effect of increased run-off and nutrients could be increased turbidity, eutrophication, and phytoplankton/filamentous algae and macroalgae blooms. Increased phytoplankton blooms contribute to significant declines in SAV beds and their density by interfering with photosynthesis that include shading of the water column and/or promoting the epiphytic growth on the leaves (wasting disease), and the smothering of beds with decaying algae. Reductions in SAV beds have further indirect impacts on the ecological services provided by SAVs to benthic invertebrate communities, shellfish beds, fish nurseries, sediment stabilization and wave attenuation. The level of these effects is difficult to quantify, but the temporary impacts can be managed by implementing best management practices during construction to minimize sedimentation and turbidity.

8.2.4.18.1.1.3 Cumulative Impacts

Despite recent efforts at restoration of SAVs in Barnegat Bay, the direct loss of SAV beds from the implementation of the perimeter plan will contribute to continued degradation and losses of this valuable habitat. A loss of 11 acres of SAVs would be considered significant based on the value of this type of habitat and the acreage involved, and would require compensatory mitigation if avoidance and minimization cannot reduce this impact.

Climate change and sea level rise introduce greater uncertainty when combined with the effects of perimeter measures within the vicinity of SAV beds where changes in temperature, precipitation and flooding patterns, and chemical changes could impose synergistic effects on the NJBB water quality where the bays SAV may experience shifts in distribution and abundance.

8.2.4.18.1.2 Inlet Storm Surge Barriers/Cross-bay barriers (TSP Features for 3E(2) and 4G(8)

8.2.4.18.1.2.1 Direct Impacts

No recent SAV surveys have been conducted along any of the preliminary SSB and CBB (CBB) alignments for the NJBB study. Mapping of SAV beds are available for Barnegat Bay (spatial data adopted from http://crssa.rutgers.edu/projects/coastal/sav/ and Lathrop and Haag, 2010), and for the entire study area using the 1979 NJ Submersed Aquatic Vegetation Distribution maps prepared by Earth Satellite Corporation (Macomber and Allen, 1979), and the National Wetland Inventory (NWI) mapping. The Barnegat Inlet SSB 3E(2) A1 alignment encroaches on two small SAV areas mapped in the NWI map as “E1AB3L” and would directly impact approximately 2.6 acres based on the mapping. Additionally, there are two historic SAV beds (1979 Barnegat Map 032) mapped in the area - one is located about 600 feet northwest of the vertical lift gates crossing the bay and the other is located about 1,000 feet southwest of the navigable sector gates of the Barnegat Inlet SSB A1 alignment. No SAV beds were in the vicinity of the Barnegat Inlet SSB mapped in the more recent CRSSA Rutgers mapping from 2009. No SAVS were historically mapped within the vicinity of the proposed Great Egg Harbor Inlet and Manasquan Inlet A1 alignments. For the CBBs, the 1979 Oceanville Map 043 SAV survey indicates historic SAV beds occurred in the Newfound Thorofare where the Absecon Boulevard CBB crosses this waterway with miter gates. No historical SAV beds occurred within the Southern Ocean City CBB, although two historic beds are mapped about 1,000 feet to the north and about 600 feet to the south of the navigable sector gate crossing Crook Horn Creek (1979 Sea Isle City Map 047). The southern bed occurred within a dredge hole/embayment.

An SAV area is a special aquatic site under the Section 404(b)(1) guidelines. Under NJ Coastal Zone Management rules, SAV areas are considered special areas. In N.J.A.C. 7:7-9.6, submerged vegetation habitat is defined: “(a) A submerged vegetation habitat special area consists of water areas supporting or documented as previously supporting rooted, submerged vascular plants…” A more precise estimate of temporary and permanent disturbance will be available upon completion of SAV surveys in all locations/waterways with SSB and CBB structures and with a higher level of design and construction plan of the structures involved. If SAVs are present, the practice of avoidance, minimization and compensation will be implemented. If SAVs are present within the affected area, compensation will only be done if there are no practicable alignments that can avoid these areas. At this time, compensatory mitigation is being considered for the historic beds along the Barnegat Inlet SSB and for the historic beds mapped along the Absecon Blvd. CBB.

8.2.4.18.1.2.2 Indirect Impacts

The implementation of SSBs and CBBs could potentially have significant effects on SAV abundance and distribution in the affected bays by potentially altering velocities, sediment scour and deposition, water quality, salinity levels and nutrient levels. These changes may be most significant in the Barnegat Bay – Little Egg Harbor Estuary, which have the most extensive beds, and account for nearly 75% of the beds in New Jersey (Kennish et al. 2010). The potential changes associated with constrictions of flow while the gates are open during normal conditions may be negligible to significant depending on the gate design and associated cross-sectional areas. Localized changes in velocity are expected; however, SAV beds are not expected within the immediate vicinity of the SSBs within the inlet areas. Modeled AdH hydrodynamic modeling for the open gate scenario supports that velocity increases would be localized at the location of the gates, with little change in velocity beyond these areas. Additionally, the AdH suggests minor effects on tidal prism, tidal amplitude, and residence time in the affected areas. There are no CBBs identified in the TSP in the Barnegat Bay and Little Egg Harbor estuaries. No recent SAV information is currently available for CBB locations in Absecon Blvd. (Atlantic City) and 52nd St. (Ocean City).

Except for maintenance activities, gate closures would occur at times of storms with increased precipitation, which have the potential to alter salinity (reduce), sedimentation patterns, and circulation. The duration of these closures is uncertain but could generally range from 24 to 48 hours. Although eelgrass can be found in a wide range of salinity (0-30 ppt), eelgrass populations from different areas may have developed genetic adaptations to local salinity regimes and salinity/nutrient interactions (Kukola, undated draft white paper), which could potentially make them susceptible to stress due to increased fluctuations in salinity. These fluctuations in salinity would result from the gates preventing polyhaline marine waters from entering the estuary during a time of heavy freshwater precipitation and freshwater discharge from the rivers and streams entering the estuary.

The potential effects of gate closures may alter sedimentation patterns that could affect eelgrasses. Kukola (undated) reports that coarse-grained sediment substrates with less than 4% organic matter are ideal for eelgrass and that dark anaerobic silty sediments are not suitable. It is not known if significant deposition of fine-grained sediments would occur following a gate closure. However, any changes in sediment deposition patterns could affect eelgrass distribution in the bay.

Gate closures could potentially affect circulation and bay water residence time, which could exacerbate existing eutrophication problems resulting in eelgrass becoming more stressed and more susceptible to wasting disease from these changes.

Predictive alterations in hydrodynamics through changes in bay circulation and flushing would require hydrodynamic modeling to determine changes in residence time with gates closed. Significant changes in residence time could affect nutrient levels, salinity, and temperature, which could potentially promote phytoplankton and certain macroalgae blooms including the more problematic harmful algal blooms (HABs). HABs can adversely affect aquatic life including fish, shellfish and SAV beds along with some human health implications. The degree of measured changes to residence times based on SSB and CBB gate openings and closure scenarios through the use of hydrodynamic and water quality modeling will inform the level of concern for the potential of promoting phytoplankton blooms including HABs. To better understand the effects of the various SSBs and CBBs under consideration, the next phase of the study will include additional hydrodynamic (AdH) and water quality modeling that would be applied to better assess the effects that these measures in a closed condition would have on these bay systems.

8.2.4.18.1.2.3 Cumulative Impacts

Climate change and sea level rise (which are expected to affect future bay temperatures, precipitation events, water quality, and shifts in photic zones due to changes in water depths), along with current negative trends for nutrient enrichment, are all significant stressors on eelgrass beds, particularly in the Barnegat Bay – Little Egg Harbor estuary. The introduction of SSBs, which have the potential to affect hydrodynamics and water quality could impose additional indirect stressors on SAVs (eelgrass in particular), contributing to cumulative adverse impacts on this resource. Although AdH modeling did not indicate significant physical changes beyond the structure in an open-condition, hydrodynamic and water quality modeling for the closed gate condition will help inform the degree of cumulative effects on SAVs and marine macroalgae.

8.2.4.18.2 Nonstructural Measures (TSP Features for 2A, 3E(2), 4G(8) and 5A)

Nonstructural measures involve a significant construction effort whether it be from building retrofits such as elevation (including raising a structure on fill or foundation elements such as solid perimeter walls, pier, posts, columns, or pilings) or buyout/ relocations that are likely to involve demolition, grading, and soil stabilization/ revegetation. All of these activities would involve temporary earth disturbances, similar to those expected to occur during construction of the structural measures, that would produce turbidity, introduce nutrients, and increase eutrophication that could facilitate the formation of algal blooms. Both turbidity and algal blooms are detrimental to SAVs. However, these temporary soil disturbances can be readily managed by implementing appropriate BMPs.

Nonstructural measures such as buyout and relocation could result in indirect improvements to water quality by the removal of impervious surfaces (through demolition), and replacement with permeable soils and vegetation. In some cases, it may be possible to implement stormwater facilities in these locations. This action, if implemented on a large scale, could reduce urban runoff and stormwater carrying sediments and a number of other pollutants into the bays,thus reducing nutrients and their potential for promoting algal blooms, which are detrimental to SAVs.

8.2.4.18.3 Natural and Nature-Based Features (TSP Features Warranting Further Analysis)

NNBFs, similar to the other structural and nonstructural measures, would involve construction impacts during the time of implementation. The degree of the impact is largely dependent on the feature and its method of construction. Avoidance of important SAV habitats would be part of the criteria for choosing NNBF locations. Therefore, no adverse effects on SAVs are expected.

However, as discussed, SAVs can be utilized as an NNBF measure in the form of restoration. The implementation of SAV NNBFs would provide all of the ecological services described in the affected environment section including more stable substrates (less turbidity) and nutrient uptake, as well as provide habitat that is better suited for filter feeders that can capture phytoplankton and suspended particles and meets critical fish and shellfish habitat life requisites. Should NNBF measures be proposed, the use of SAVs will be considered wherever practicable.

8.2.4.19 Wetlands, Tidal Flats and Subtidal Habitats

8.2.4.19.1 Structural Measures

8.2.4.19.1.1 Perimeter – Floodwalls, Levees and Miter Gates (4D(1), 4D(2) and 5D(2)

8.2.4.19.1.1.1 Direct Impacts

The direct impacts of the construction of floodwalls, levees, and miter gate structures/perimeter measures within coastal wetlands and shallow bay waters would be the loss of these habitats within the footprint alignment of the structures. These losses would result from either their removal from excavations or burial from fill placement. Additionally, temporary losses may be experienced through the placement of de-watering structures and either temporary fills or excavations for temporary access points to the work segment. Preliminary estimates of the affected wetland and shallow water habitats are based on existing mapping (NJDEP wetland mapping – 2012 and National Wetlands Inventory - NWI), the current (preliminary) alignments and an assumed width of the disturbance offset from the structure. The footprints of the perimeter measures pass through subtidal, intertidal, and supratidal regimes, which include 14 different aquatic and wetland habitat types. The habitats most affected by the perimeter measures are the subtidal soft bottom areas with hardened (bulkhead, concrete wall) shorelines, intertidal mudflats and sandy beaches, low and high tidal saltmarshes, scrub-shrub habitats, and *Phragmites*-dominated marshes. A high number of these habitats are encountered as small pockets along heavily developed bay shorelines of the barrier islands. However, since the perimeter plan segments tend to be several miles long, the impacts are cumulative and significant. Tables 97 and 98 provide preliminary estimates of direct permanent wetland impacts and impacts to other significant habitat types resulting from the construction of the final array of alternatives which included both perimeter plans and the TSP (3 SSBs and 2 CBBs). These tables do not account for future losses of these habitats due to sea level rise. Additionally, it should be noted that, to date, no jurisdictional wetland delineations have been conducted along any of these alternatives and that a 20% range of impacts is provided to account for a lack of design details, specific alignments, jurisdictional determinations, and the practice/refinement of avoidance/minimization. Ecosystem modeling is not complete that accounts for the affected wetland/intertidal/subtidal habitats. The USACE EcoPCX-approved New England Marsh Model (McKinney et al., 2009) was utilized to determine direct effects on saltmarsh habitats and to provide compensatory mitigation estimates commensurate with the current level of design and planning, but it does not account for isolated intertidal flats or subtidal habitats. The effects on these habitats are being modeled with the New York Bight Ecological Model (NYBEM), which is currently under development, and will be phased in with subsequent study phases to provide a more precise estimate of effects on all affected aquatic habitats in the action areas.

8.2.4.19.1.1.2 Indirect Impacts

The indirect impacts of perimeter structures on aquatic habitats and wetlands are expected to be minimal to moderate and are related to temporary impacts such as sedimentation during construction and long-term impacts where hardened structures could halt landward migration of marshes, particularly with sea level rise. However, this effect is not significant since the majority of the shorelines along the back bays already are hardened with bulkheads, concrete revetments, and riprap.

Significant losses of these habitats will indirectly affect a number of aquatic biota such as shellfish, finfish, and a number of different types of birds including shorebirds, wading birds, waterfowl, raptors, and neo-tropical migrants that utilize these habitats for various life requisite stages such as spawning/nesting, nursery/rearing, feeding, reproduction, etc.

8.2.4.19.1.1.3 Cumulative Impacts

Direct cumulative impacts from the implementation of perimeter measures on wetland and other aquatic habitats are significant based on the linear nature of these structures over long distances. These linear features encounter a number of wetland aquatic habitats that are predominantly subtidal soft bottom, intertidal mudflats, intertidal sandy beaches, low salt marshes, high salt marshes, scrub-shrub wetlands, and *Phragmites*-dominated wetlands. Losses of these habitats particularly on the upper intertidal range (i.e., high salt marshes, scrub-shrub wetlands) may be more significant when coupled with sea level rise, as these types of habitats will not be able to migrate landward where existing heavy development and hardened structures already exist. Cumulative losses of wetland and other aquatic habitats will indirectly affect a number of aquatic biota such as shellfish, finfish, and a number of different types of birds including shorebirds, wading birds, waterfowl, raptors, and neo-tropical migrants where they may be forced to crowd into diminishing suitable habitats affected by sea level rise.

8.2.4.19.1.2 Inlet Storm Surge Barriers/Cross-bay barriers (TSP Features for 3E(2) and 4G(8)

8.2.4.19.1.2.1 Direct Impacts

The direct impacts that the implementation of SSBs in inlets would have on aquatic and wetland habitats would be significant, but due to the smaller footprint of these structures, they would have comparatively less direct impacts than the CBBs and perimeter structures. Because SSBs are located within existing stabilized inlets, the footprint of these structures would mostly affect subtidal soft bottom, intertidal sandy beach, and intertidal rocky shorelines (inlet jetties) resulting in losses of these habitats. These losses would result from either their removal from excavations or burial from fill placement. Additionally, temporary losses may be experienced through the placement of de-watering structures and either temporary fills or excavations for temporary access points to the work segment. The TSP alternative 3E(2) and 4G(8), which includes SSBs at Manasquan Inlet, Barnegat Inlet and Great Egg Harbor Inlet demonstrate the estimated acreages of habitats affected by their footprints with additional space to account for error. The alignments of the TSP SSBs are presented in Figures 103 through 107.

Table 97: Comparative Estimated Wetland Impacts (in acres) among TSP and Perimeter measure Alternatives Considered in the Final Array of Alternatives

		Saline Low Marsh	Saline High Marsh	Scrub Shrub Deciduous	Scrub Shrub Coniferous	Forested Wetlands	Phragmites Dominated Wetland	Herbaceous Wetlands	Disturbed Wetlands	Managed Wetlands (Lawn)
ALTS	**NWI Class:**	E2EM1N, E2EM1Nd, E2EM1P	E2EM1N, E2EM1P	E2SS1P, E2EM5P, PSS1/4B	PEM1R, E2EM1P	PF01	E2EM1N, E2EM5P, E2EM1P	E2EM1N, PEM1A, PEM1E	PEM1R, E2EMP	PEM1R
		Impact Acres	Impact Acres	Impact Acres	Impact Acres		Impact Acres	Impact Acres	Impact Acres	Impact Acres
	Features									
3E-2	**Manasquan + Barnegat SSB**									
	Barnegat Inlet SSB (A1)	-	-	-	-	-	-	-	-	-
	Manasquan Inlet SSB (A1)	-	-	-	-	-	-	-	-	-
	TOTAL	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
	20% Impact Range*:	0	0	0	0	0	0	0	0	0
4D-2	**Central ALL PP**									
	Ocean City PP	37.9	2.9	2.7	3.4	-	18.6		4.8	4.7
	Absecon Island PP	15.7	5.1	4.3	-	-	0.6	0.3	-	-
	Brigantine PP	14.5	3.6	0.1	-	-	-	0.4	-	-
	TOTAL	**68.1**	**11.6**	**7.1**	**3.4**	**0.0**	**19.2**	**0.7**	**4.8**	**4.7**
	20% Impact Range*:	**54-82**	**9-14**	**6-8**	**2.7-4.0**	**0**	**15-23**	**0.6-0.9**	**4-6**	**4-6**
4D-1	**Central ALL PP**									
	Ocean City PP	37.9	2.9	2.7	3.4	-	18.6	-	4.8	4.7
	Absecon Island PP	15.7	5.1	4.3	-	-	0.6	0.3	-	-
	TOTAL	**53.6**	**8.0**	**6.9**	**3.4**	**0.0**	**19.2**	**0.3**	**4.8**	**4.7**
	20% Impact Range*:	**43-64**	**6-10**	**6-8**	**2.7-4.0**	**0**	**15-23**	**0-1**	**4-6**	**4-6**
4G-8	**GEHI SSB+Absecon CBB+SOC CBB**									
	Great Egg Harbor Inlet SSB (A1)	-	-	-	-	-	-	-	-	-
	Absecon Blvd. CBB CBB	38.9	10.8	1.5	-	1.3	2.6	0.3	1.0	-

		Saline Low Marsh	Saline High Marsh	Scrub Shrub Deciduous	Scrub Shrub Coniferous	Forested Wetlands	Phragmites Dominated Wetland	Herbaceous Wetlands	Disturbed Wetlands	Managed Wetlands (Lawn)
ALTS	**NWI Class:**	E2EM1N, E2EM1Nd, E2EM1P	E2EM1N, E2EM1P	E2SS1P, E2EM5P, PSS1/4B	PEM1R, E2EM1P	PF01	E2EM1N, E2EM5P, E2EM1P	E2EM1N, PEM1A, PEM1E	PEM1R, E2EMP	PEM1R
		Impact Acres	Impact Acres	Impact Acres	Impact Acres		Impact Acres	Impact Acres	Impact Acres	Impact Acres
	South Ocean City 52ND ST CBB	20.6	2.9		1.8	-	0.3	-	-	-
	TOTAL	**59.5**	**13.7**	**1.5**	**1.8**	**1.3**	**2.9**	**0.3**	**1.0**	**0.0**
	20% Impact Range*:	**48-71**	**11-16**	**1.2-1.8**	**1.5-2.2**	**1.0-1.6**	**2.3-3.5**	**0-1**	**0.8-1.2**	**-**
5D-2	**All Perimeter**									
	Cape May PP	2.0	3.7	2.4	2.1	3.7	1.1	1.3	-	0.5
	Wildwood PP	22.4	10.7	7.6	-	-	1.4	-	-	-
	Stone Harbor/Avalon PP	16.9	7.3	0.3	4.1	-	0.9	-	-	-
	Sea Isle City PP	22.6	10.3	3.4	-	-	6.4	-	-	-
	TOTAL	**63.9**	**32.0**	**13.7**	**6.2**	**3.0-4.4**	**9.8**	**1.3**	**0.0**	**0.5**
	20% Impact Range*:	**51-77**	**26-38**	**11-16**	**5-7**	**3.7**	**8-12**	**1-2**	**-**	**0-1**

TSP Component (green) **Alternative Requiring Further Evaluation** (yellow) *Due to the uncertainty of impact and mitigation estimates at this level of design and evaluation at a Tier 1 level, a 20% variation of the current alignment is presented as a range of impacts.

Table 98: Comparative Estimated Direct Impacts of Open Water, Shallow Subtidal, and Intertidal Mudflat/Sandy Beach (in acres) among TSP and Perimeter measure (PP) Alternatives Considered in the Final Array of Alternatives

		Open Water Subtidal Soft Bottom	Open Water Subtidal Soft Bottom (shellfish)	SAV Beds (subtidal)	Subtidal Open Water Hardened Shoreline	Subtidal Open Water Hardened Shoreline (shellfish)	Intertidal Rocky SL (lf.)	Intertidal Mudflat	Intertidal Mudflat (shellfish)	Intertidal Sandy Beach	Intertidal Sandy Beach (shellfish)
ALTS	**NWI Class:**	E1UBL, E1UBLx, M1UBL		E1AB3L, E1ABLx, E1ABL	E1UBL, E1UBLx, E1UBL6		E2RS2, M2USN, Riprap	E2USM, E2USP, E2USN		E2USS, E2USM,E2USP,E2US2P,E2USN,M2US2N,M2US2P	
		Impact Acres	Impact Acres	Impact Acres	Impact Acres	Impact Acres	Impact lf.	Impact Acres	Impact Acres	Impact Acres	Impact Acres
	Features										

		Open Water Subtidal Soft Bottom	Open Water Subtidal Soft Bottom (shellfish)	SAV Beds (subtidal)	Subtidal Open Water Hardened Shoreline	Subtidal Open Water Hardened Shoreline (shellfish)	Intertidal Rocky SL (lf.)	Intertidal Mudflat	Intertidal Mudflat (shellfish)	Intertidal Sandy Beach	Intertidal Sandy Beach (shellfish)
ALTS	**NWI Class:**	E1UBL, E1UBLx, M1UBL		E1AB3L, E1ABLx, E1ABL	E1UBL, E1UBLx, E1UBL6		E2RS2, M2USN, Riprap	E2USM, E2USP, E2USN		E2USS, E2USM,E2USP,E2US2P,E2USN,M2US2N,M2US2P	
		Impact Acres	Impact Acres	Impact Acres	Impact Acres	Impact Acres	Impact lf.	Impact Acres	Impact Acres	Impact Acres	Impact Acres
3E-2	**Manasquan + Barnegat SSB**										
SSB.09	Barnegat Inlet SSB (A1)		12.2	2.6							0.8
SSB.10	Manasquan Inlet SSB (A1)	2.1					2279				0.0
	TOTAL	**2.1**	**12.2**	**2.6**	**0.0**	**0.0**	**2279**	**0.0**	**0.0**	**0.0**	**0.8**
	20% Impact Range*	**1.7-2.6**	**9.8-14.6**	**2.1-3.1**	**0**	**0**	**1824-2736**	**0**	**0**	**0**	**0.6-0.9**
4D-2	**Central ALL PP**										
G12	Ocean City PP		1.0		10.3	23.9		2.0	1.6		0.6
G18	Absecon Island PP	0.5	2.2		32.9	12.5	4196	6.2	6.6	9.0	1.7
G23	Brigantine PP		0.8		1.8	13.9		1.8	8.1	0.3	0.6
	TOTAL	**0.5**	**4.0**	**0.0**	**45.1**	**50.2**	**4196**	**10.0**	**16.2**	**9.2**	**2.9**
	20% Impact Range*	**0.4-0.6**	**3.2-4.8**	**0**	**36-54**	**40-60**	**3357-5036**	**8-12**	**13-19**	**7-11**	**2.3-3.5**
4D-1	**Central ALL PP**										
G12	Ocean City PP		1.0		10.3	23.9		2.0	1.6		0.6
G18	Absecon Island PP	0.5	2.2		32.9	12.5	4196	6.2	6.6	9.0	1.7
	TOTAL	**0.5**	**3.2**	**0.0**	**43.2**	**36.3**	**4196**	**8.2**	**8.1**	**9.0**	**2.3**
	20% Impact Range*	**0.4-0.6**	**2.6-3.8**	**0**	**35-52**	**29-44**	**3357-5036**	**7-10**	**6-10**	**7-11**	**1.8-2.8**
4G-8	**GEHI SSB+Absecon CBB+SOC CBB**										
SSB.06	Great Egg Harbor Inlet SSB (A1)	20.0								5.6	
CBB.01	Absecon Blvd. CBB	0.7	2.4		4.5	13.4	1831	2.3	1.0	1.1	1.6
CBB.08	South Ocean City 52ND ST CBB		1.6								

		Open Water Subtidal Soft Bottom	Open Water Subtidal Soft Bottom (shellfish)	SAV Beds (subtidal)	Subtidal Open Water Hardened Shoreline	Subtidal Open Water Hardened Shoreline (shellfish)	Intertidal Rocky SL (lf.)	Intertidal Mudflat	Intertidal Mudflat (shellfish)	Intertidal Sandy Beach	Intertidal Sandy Beach (shellfish)
ALTS	**NWI Class:**	E1UBL, E1UBLx, M1UBL		E1AB3L, E1ABLx, E1ABL	E1UBL, E1UBL$_x$, E1UBL6		E2RS2, M2USN, Riprap	E2USM, E2USP, E2USN		E2USS, E2USM,E2USP,E2US2P,E2USN,M2US2N,M2US2P	
		Impact Acres	Impact Acres	Impact Acres	Impact Acres	Impact Acres	Impact lf.	Impact Acres	Impact Acres	Impact Acres	Impact Acres
	TOTAL	**20.7**	**4.0**	**0.0**	**4.5**	**13.4**	**1831**	**2.3**	**1.0**	**6.6**	**1.6**
	20% Impact Range*	**17-25**	**3-5**	**0**	**4-5**	**11-16**	**1465-2197**	**1.9-2.8**	**0.8-1.2**	**5-8**	**1.3-2.0**
5D-2	**All Perimeter**										
G1	Cape May PP	0.1				6.4	2324		0.5		7.3
G2	Wildwood PP		0.5			19.2			21.5		2.0
G5	Stone Harbor/Avalon PP		0.4		3.5	63.2	79	1.0	8.7	1.0	
G10	Sea Isle City PP		0.4			13.2			0.5		0.1
	TOTAL	**0.1**	**1.3**	**0.0**	**3.5**	**102.0**	**2404**	**1.0**	**31.2**	**1.0**	**9.4**
	20% Impact Range*	**-**	**1.1-1.6**	**0**	**2.8-4.2**	**82-122**	**1923-2885**	**0.8-1.2**	**25-37**	**0.8-1.2**	**7-11**

TSP Component **Alternative Requiring Further Evaluation** *Due to the uncertainty of impact and mitigation estimates at this level of design and evaluation at a Tier 1 level, a 20% variation of the current alignment is presented as a range of impacts.

Like the perimeter measures, CBBs have perimeter components that include floodwalls, levees, and miter gates across selected waterways. They also include navigable sector gates like the SSBs across some of the larger waterways that they span. The CBBs would potentially have greater direct impacts on intertidal wetland habitats (more so than SSBs) mainly due to their locations, which span (generally east-west) across a number of habitats including subtidal soft bottom, intertidal mudflats, and intertidal low and high saltmarshes across the bays. The CBBs that are in the TSP Alternative 4G(8) are both located in the Central Region, and they would occur at Absecon Blvd. (Atlantic City) and Southern Ocean City (along an abandoned railroad embankment off of 52nd St.). The CBBs would have the most direct effects on intertidal saltmarshes, and could collectively result in losses of 65 to 97 acres of low and high marshes. These losses of saltmarshes stem primarily from the levee alignments. However, the location of these alignments was chosen based on existing features such as roadway embankments (Absecon Boulevard) and an old railroad embankment (Southern Ocean City), where wetland impacts would have been much greater if they were not aligned with these existing structures.

It should be noted that, to date, no jurisdictional wetland delineations have been conducted along any of the preliminary perimeter measure, SSB and CBB alignments at this point. Therefore, these impact estimates may be modified and refined based on a higher level of design detail that include surveyed wetland jurisdictional lines, and mitigation measures that first employ avoidance and minimization.

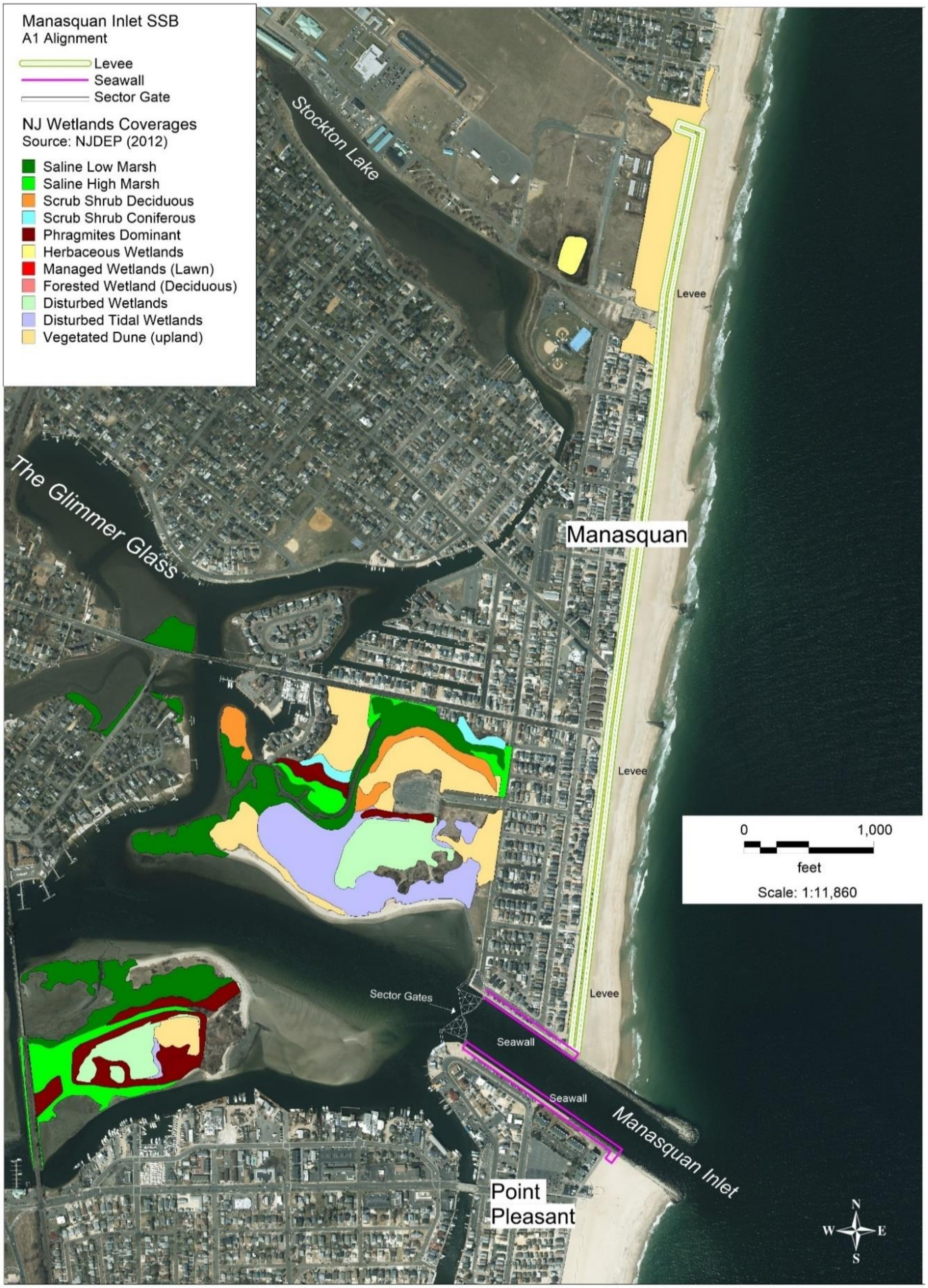


Figure 103: Alignment of Manasquan Inlet Storm Surge Barrier (SSB) and Features with Wetland Habitats

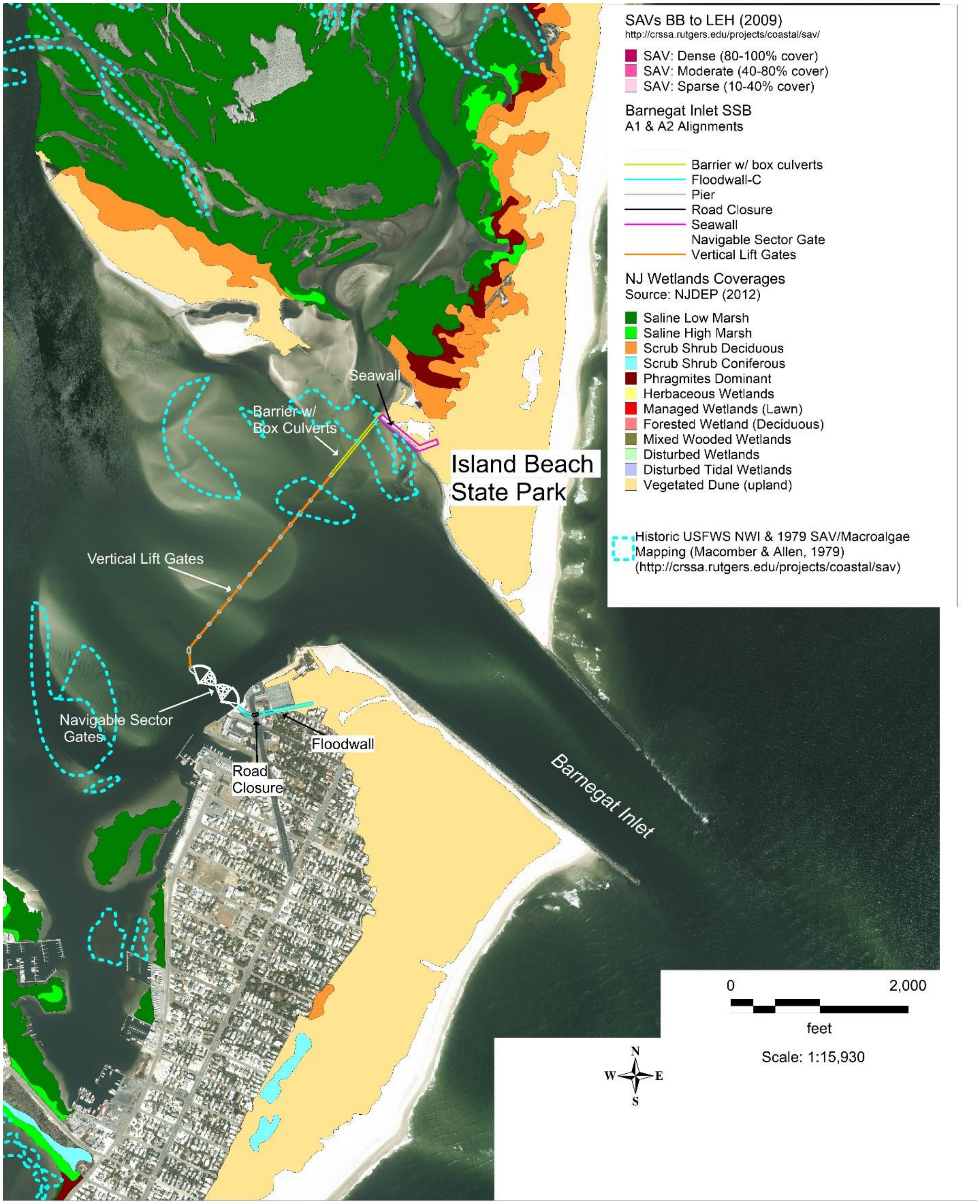


Figure 104: Alignment of Barnegat Inlet Storm Surge Barrier (SSB) and Features with Wetland Habitats

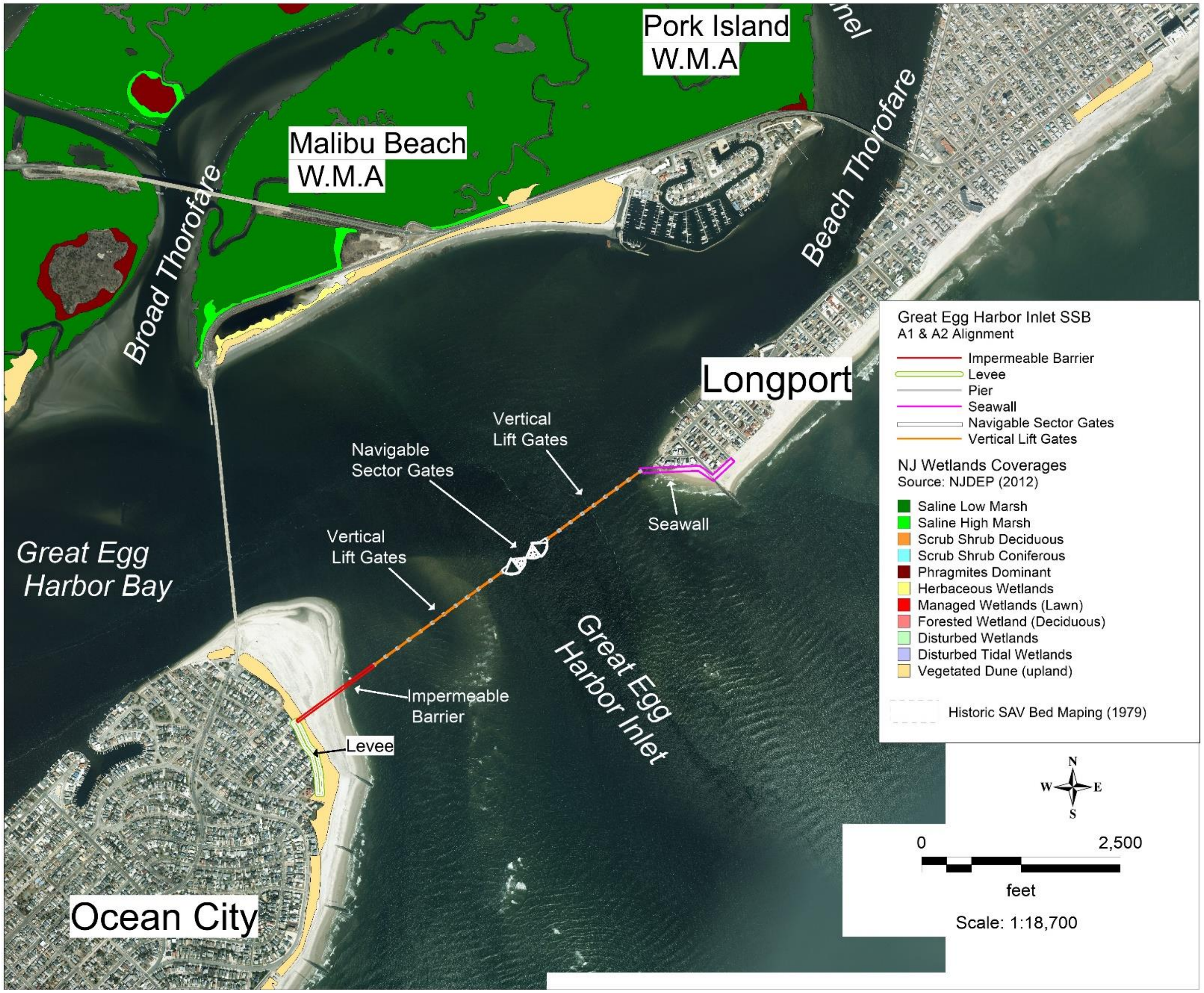


Figure 105: Alignment of Great Egg Harbor Inlet Storm Surge Barrier (SSB) and Features with Wetland Habitats

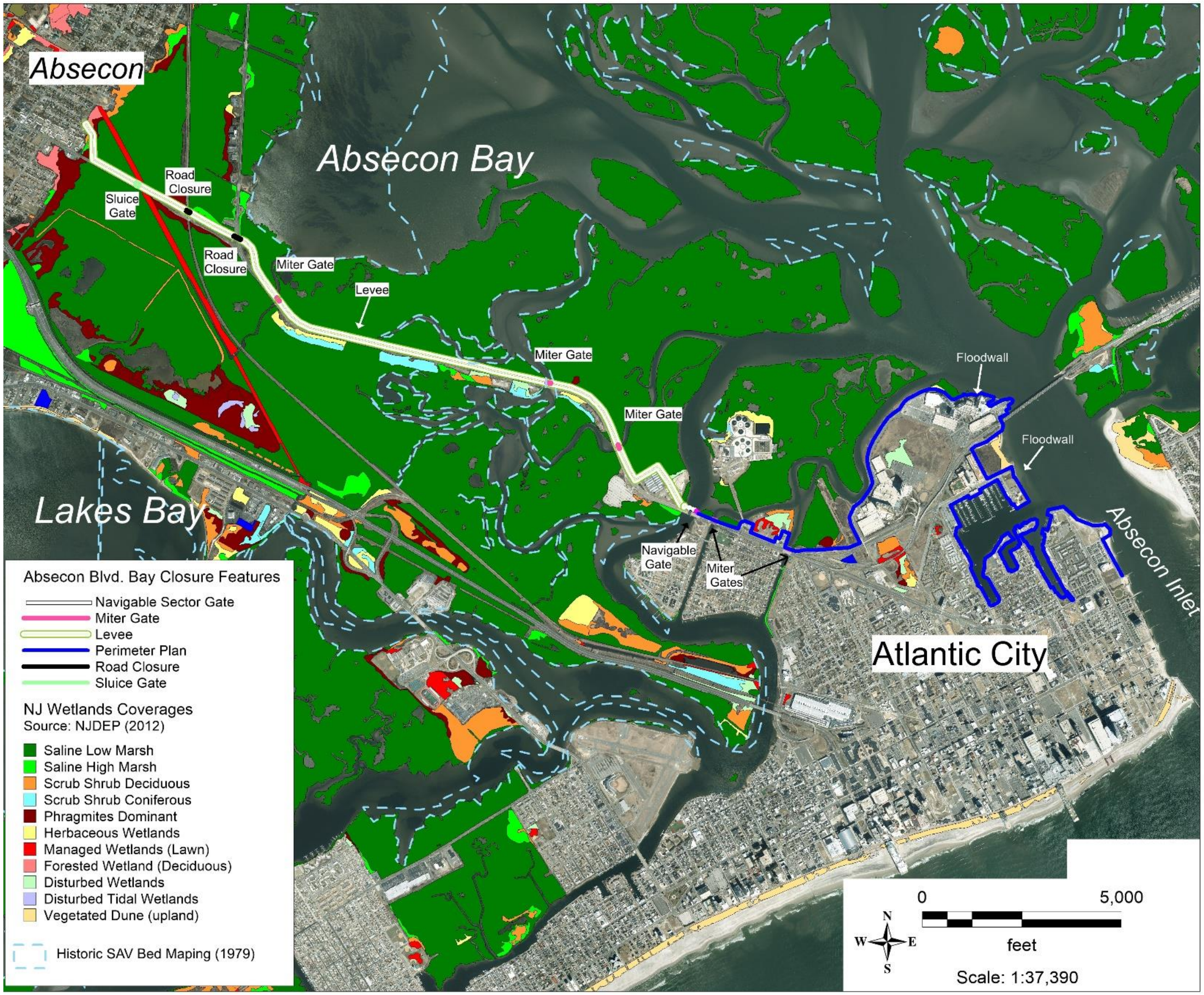


Figure 106: Alignment of Absecon Boulevard Cross-bay barrier (CBB) and Features with Wetland Habitats

Figure 107: Alignment of the Southern Ocean City Cross-bay barrier (CBB) and Features with Wetland Habitats

8.2.4.19.1.2.1.1 Compensatory Mitigation

It is assumed that for unavoidable wetland and aquatic habitats, compensatory mitigation will be required based on habitat modeling. The USACE EcoPCX-approved New England Marsh Model (NESMM) (McKinney et al., 2009) was utilized to determine the direct effects on saltmarsh habitats and to provide compensatory mitigation estimates commensurate with the current level of design and planning. A 20% variance is provided to account for inaccuracies in designs and wetland mapping to provide a range of impacts and compensatory mitigation. Additionally, effects on these habitats are being modeled with the New York Bight Ecological Model (NYBEM), which is currently under development, and will be phased in with subsequent study phases to provide a more precise estimate of effects on all affected aquatic habitats in the action areas. Table 99 provides mitigation estimates utilizing the NESMM, which is provided in greater detail in Appendix F.4. Additionally, mitigation estimates are provided for other aquatic habitats in Table 100., but these may be refined after application of the NYBEM, which is currently under development.

8.2.4.19.1.2.2 Indirect Impacts

The short-term indirect impacts of SSB and CBB structures on aquatic habitats and wetlands are expected to be minimal to significant and are related to temporary impacts such as sedimentation during construction and temporary access/staging in these areas. However, SSBs and CBBs may pose long-term significant indirect effects on wetlands and other aquatic habitats. Depending on the design of an SSB or CBB, the available openings to pass tidal flows when open during normal conditions would be more constricted than existing inlets and other waterways. A constriction would change the tidal prism by limiting incoming (flood) tides that could result in tidal amplitudes where a lowered high tide elevation and the outgoing (ebb) tides could result in higher low tides, thereby affecting wetland and aquatic habitats at each end of the tidal range on a bay-wide scale. In Orton et al. 2020, it was found that SSBs have the potential to change geomorphic processes that shape and maintain saltmarsh habitats and was recommended that effects for SSBs should be evaluated for these possibilities: 1.) whether reductions in tidal amplitude will decrease sediment accretion through reduced biomass production and sediment deposition, 2.) whether reduction in high water levels will decrease inundation time and sediment deposition, and 3.) whether reduction in water levels in severe storms will modify edge erosion process, and changes to estuary salinity or its extremes could cause an evolution of marsh species (e.g. conversions of salt marsh species to *Phragmites*).

Modeling was conducted on the affected NJBB estuaries utilizing the AdH model open-gate scenario, which measured changes in tidal prisms, tidal amplitudes, and salinity. The effects of SSBs and CBBs on tidal amplitudes are not evenly distributed throughout the bays, with individual reductions in tidal amplitude ranging from 1.3% to 8.3% through Barnegat Bay and 0.1% to 4.5% in Great Egg Harbor for the TSP. Table 101. shows that with the exception of Watson Creek, a tributary to the Manasquan River, all locations showed slight reductions in amplitude. Table 101 presents the mean reductions per station. From a with-project condition at time of implementation, within the Manasquan River system tidal amplitudes ranged from an increase of 1.4 cm at Watson Creek to a decrease of 1.1 cm along the Manasquan River. Within the northern region (Barnegat Bay to Little Egg Harbor) all stations showed reductions in tidal amplitudes ranging from 0.4 cm to 1.6 cm. An outlier in this zone was the Barnegat Light station that showed a reduction of 25 cm, which will require additional modeling. The Central Region AdH model results showed reductions in amplitude ranging from 0.4 to 2.4 cm and the Southern Region had amplitude reductions that showed the least in reductions, from 0.3 to 1.2 cm. The AdH model also considered these TSP

Table 99. Compensatory Wetland Mitigation Estimates from New England Salt Marsh Modell (NESMM)

Alternative		Marsh Impact Acres	Proposed Mitigation Acres
Alternative 4G(8) – Bay Closures			
Absecon Boulevard Bay Closure	SUBTOTAL	55 (44-66)*	90 (72-108)*
South Ocean City (52nd St.) Bay Closure	SUBTOTAL	26 (21-31)*	48 (38-58)*
	TOTAL Estimated	81	138
	Total Range* (20% Difference)	65-97	110-166
4D(1) CENTRAL PERIMETER MEASURES			
Ocean City Perimeter Measures	SUBTOTAL	75 (60-90)*	121 (97-145)*
Absecon Island Perimeter Measures	SUBTOTAL	27 (21-32)*	38 (30-45)*
	TOTAL Estimated	102	159
	Total Range* (20% Difference)	81-122	110-190
4D(2) CENTRAL PERIMETER MEASURES			
Ocean City Perimeter Measures	SUBTOTAL	75 (60-90)*	121 (97-145)*
Absecon Island Perimeter Measures	SUBTOTAL	27 (21-32)*	38 (30-45)*
Brigantine Perimeter Measures	SUBTOTAL	18 (15-22)*	28 (22-33)*
	TOTAL Estimated	120	187
	Total Range* (20% Difference)	96-144	132-223
5D(2) SOUTHERN PERIMETER MEASURES			
Cape May Perimeter Measures	SUBTOTAL	15 (12-17)*	25 (20-30)*
Wildwood Perimeter Measures	SUBTOTAL	44 (35-53)*	73 (58-87)*
Stone Harbor/Avalon Perimeter Measures	SUBTOTAL	38 (30-45)*	52 (42-63)*

Alternative		Marsh Impact Acres	Proposed Mitigation Acres
Sea Isle City Perimeter Measures	SUBTOTAL	45 (36-54)*	63 (50-76)*
	TOTAL Estimated	142	213
	Total Range* (20% Difference)	113-169	170-256

TSP Component **Alternative Requiring Further Evaluation**

*Due to the uncertainty of impact and mitigation estimates at this level of design and evaluation at a Tier 1 level, a 20% variation of the current alignment is presented as a range of impacts and compensatory mitigation.

Table 100: Compensatory Aquatic Habitat Mitigation Estimates

		Open Water Subtidal Soft Bottom		Open Water Subtidal Soft Bottom (shellfish)		SAV Beds (subtidal)		Subtidal Open Water Hardened Shoreline		Subtidal Open Water Hardened Shoreline (shellfish)		Intertidal Rocky SL (l.f.)		Intertidal Mudflat		Intertidal Mudflat (shellfish)		Intertidal Sandy Beach		Intertidal Sandy Beach (shellfish)	
	NWI Class:	E1UBL, E1UBLx, M1UBL		E1UBL, E1UBLx, M1UBL		E1AB3L, E1ABLx, E1ABL		E1UBL, E1UBLx, E1UBL6		E1UBL, E1UBLx, E1UBL6		E2RS2, M2USN, RipRap		E2USM, E2USP, E2USN		E2USM, E2USP, E2USN		E2USS, E2USM,E2USP,E2US2P, E2USN,M2US2N,M2US2P		E2USS, E2USM,E2USP,E2US2P, E2USN,M2US2N,M2US2P	
	Features	Impact Acres	Mit. Acres	Impact Acres	Mit. Acres	Impact Acres	Mit. Acres	Impact Acres	Mit. Acres	Impact Acres	Mit. Acres	Impact l.f.	Mit. l.f.	Impact Acres	Mit. Acres	Impact Acres	Mit. Acres	Impact Acres	Mit. Acres	Impact Acres	Mit. Acres
3E-2	**Manasquan + Barnegat SSB**																				
SSB. 09	Barnegat Inlet SSB (A1)		0.0	12.2	16.3	2.6	5.2		0.0		0.0		0.0		0.0		0.0		0.0	0.8	1.1
SSB. 10	Manasquan Inlet SSB (A1)	2.1	1.7		0.0		0.0		0.0		0.0	2280	1140		0.0		0.0		0.0	0.0	0.0
	TOTAL	**2.1**	**1.7**	**12.2**	**16.3**	**2.6**	**5.2**	**0.0**	**0.0**	**0.0**	**0.0**	**2280**	**1140**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.8**	**1.1**
	Total Range* (20% Difference)	**1.7-2.6**	**1.4-2.0**	**9.8-14.6**	**13.0-19.5**	**2.1-3.1**	**4.2-6.3**					**1824-2736**	**912-1368**							**0.6-0.9**	**0.8-1.3**
4D-2	**Central ALL PP**																				
12	Ocean City PP		0.0	1.0	1.3		0.0	10.3	8.2	23.9	31.8		0.0	2.0	1.6	1.6	2.1		0.0	0.6	0.8
18	Absecon Island PP	0.5	0.4	2.2	2.9		0.0	32.9	26.3	12.5	16.6	4196	2098	6.2	5.0	6.6	8.7	9.0	7.2	1.7	2.2
23	Brigantine PP		0.0	0.8	1.1		0.0	1.8	1.5	13.9	18.5		0.0	1.8	1.4	8.1	10.8	0.3	0.2	0.6	0.8
	TOTAL	**0.5**	**0.4**	**4.0**	**5.3**	**0.0**	**0.0**	**45.1**	**36.1**	**50.2**	**67.0**	**4196**	**2098**	**10.0**	**8.0**	**16.2**	**21.6**	**9.2**	**7.4**	**2.9**	**3.9**
	Total Range* (20% Difference)	**0.4-0.6**	**0.3-0.5**	**3.2-4.8**	**4.3-6.4**			**36.1-54.1**	**28.9-43.3**	**40.2-60.3**	**53.6-80.4**	**3357-5036**	**1679-2518**	**8.0-12.0**	**6.4-9.6**	**13.0-19.5**	**17.3-26.0**	**7.4-11.1**	**5.9-8.8**	**2.3-3.5**	**3.1-4.7**
4D-1	**Central ALL PP**																				
12	Ocean City PP		0.0	1.0	1.3		0.0	10.3	8.2	23.9	31.8		0.0	2.0	1.6	1.6	2.1		0.0	0.6	0.8
18	Absecon Island PP	0.5	0.4	2.2	2.9		0.0	32.9	26.3	12.5	16.6	4196	2098	6.2	5.0	6.6	8.7	9.0	7.2	1.7	2.2
	TOTAL	**0.5**	**0.4**	**3.2**	**4.3**	**0.0**	**0.0**	**43.2**	**34.6**	**36.3**	**48.4**	**4196**	**2098**	**8.2**	**6.6**	**8.1**	**10.8**	**9.0**	**7.2**	**2.3**	**3.1**
	Total Range* (20% Difference)	**0.4-0.6**	**0.3-0.5**	**2.6-3.8**	**3.4-5.1**			**34.6-52.0**	**28.0-42.0**	**29.1-43.6**	**39-58**	**3357-5036**	**1679-2518**	**6.6-9.8**	**5.2-7.9**	**6.5-9.7**	**8.7-13.0**	**7.2-10.8**	**5.7-8.6**	**1.8-2.8**	**2.5-3.7**
4G-8	**GEHI SSB+Absecon BC+SOC BC**																				

		Open Water Subtidal Soft Bottom		Open Water Subtidal Soft Bottom (shellfish)		SAV Beds (subtidal)		Subtidal Open Water Hardened Shoreline		Subtidal Open Water Hardened Shoreline (shellfish)		Intertidal Rocky SL (l.f.)		Intertidal Mudflat		Intertidal Mudflat (shellfish)		Intertidal Sandy Beach		Intertidal Sandy Beach (shellfish)	
	NWI Class:	E1UBL, E1UBLx, M1UBL		E1UBL, E1UBLx, M1UBL		E1AB3L, E1ABLx, E1ABL		E1UBL, E1UBLx, E1UBL6		E1UBL, E1UBLx, E1UBL6		E2RS2, M2USN, RipRap		E2USM, E2USP, E2USN		E2USM, E2USP, E2USN		E2USS, E2USM,E2USP,E2US2P, E2USN,M2US2N,M2US2P		E2USS, E2USM,E2USP,E2US2P, E2USN,M2US2N,M2US2P	
	Features	Impact Acres	Mit. Acres	Impact Acres	Mit. Acres	Impact Acres	Mit. Acres	Impact Acres	Mit. Acres	Impact Acres	Mit. Acres	Impact l.f.	Mit. l.f.	Impact Acres	Mit. Acres	Impact Acres	Mit. Acres	Impact Acres	Mit. Acres	Impact Acres	Mit. Acres
SSB.06	Great Egg Harbor Inlet SSB (A1)	20.0	16.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0	5.6	4.4		0.0
BC.01	Absecon Blvd. Bay Closure BC	0.7	0.5	2.4	3.2		0.0	4.5	3.6	13.4	17.9	1831	916	2.3	1.9	1.0	1.4	1.1	0.9	1.6	2.2
BC.08	South Ocean City 52ND ST BC		0.0	1.6	2.1		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
	TOTAL	**20.7**	**16.6**	**4.0**	**5.3**	**0.0**	**0.0**	**4.5**	**3.6**	**13.4**	**17.9**	**1831**	**916**	**2.3**	**1.9**	**1.0**	**1.4**	**6.6**	**5.3**	**1.6**	**2.2**
	Total Range* (20% Difference)	**16.6-25.0**	**13.3-20.0**	**3.2-4.8**	**4.2-6.4**			**3.6-5.3**	**2.8-4.3**	**10.7-16.1**	**14.3-21.5**	**1465-2197**	**732-1098**	**1.9-2.8**	**1.5-2.2**	**0.8-1.2**	**1.1-1.6**	**5.3-8.0**	**4.3-6.4**	**1.3-2.0**	**1.7-2.6**
5D-2	**All Perimeter**																				
1	Cape May PP	0.1	0.1		0.0		0.0		0.0	6.4	8.5	2324	1162		0.0	0.5	0.6		0.0	7.3	9.7
2	Wildwood PP		0.0	0.5	0.7		0.0		0.0	19.2	25.7		0.0		0.0	21.5	28.7		0.0	2.0	2.7
5	Stone Harbor/Avalon PP		0.0	0.4	0.6		0.0	3.5	2.8	63.2	84.3	80	40	1.0	0.8	8.7	11.6	1.0	0.8		0.0
10	Sea Isle City PP			0.4	0.6					13.2	17.6					0.5	0.7			0.1	0.1
	TOTAL	**0.1**	**0.1**	**1.3**	**1.8**	**0.0**	**0.0**	**3.5**	**2.8**	**102.0**	**136.0**	**2404**	**1202**	**1.0**	**0.8**	**31.2**	**41.6**	**1.0**	**0.8**	**9.4**	**12.5**
	Total Range* (20% Difference)	**0.1-0.1**	**0.1-0.1**	**1.1-1.6**	**1.4-2.1**			**2.8-4.2**	**2.2-3.4**	**81.6-122.4**	**109-163**	**1923-2885**	**962-1443**	**0.8-1.2**	**0.6-0.9**	**25.0-37.5**	**33.3-50.0**	**0.8-1.2**	**0.7-1.0**	**7.5-11.2**	**10.0-15.0**

TSP Component **Alternative Requiring Further Evaluation**

*Due to the uncertainty of impact and mitigation estimates at this level of design and evaluation at a Tier 1 level, a 20% variation of the current alignment is presented as a range of impacts and compensatory mitigation.

amplitude changes with sea level rise, which showed greater reductions in amplitude when compared to the baseline SLR condition. However, the effects of SLR appear to offset the reductions in amplitude caused by the TSP when compared to the current baseline condition where many of the stations showed net increases in amplitude with SLR.

Based on the results of the AdH modeling, it can be assumed that even small reductions in tidal amplitude caused by the TSP could result in initial significant conversions of transitional intertidal habitats such as high marshes to upland and some of the intertidal mudflats to open water. Over time with sea level rise, some of these transitional conversions may revert back to their original regime with higher amplitudes introduced by SLR but become somewhat offset by the SSBs and CBBs. Figure 108 is an example of the with-project tidal range changes at Berkeley, NJ (Barnegat Bay) where sea level rise effects will completely overtake the tidal amplitude/range changes over a 50-year period from 2030-2050 (using USACE intermediate curve). At some point in the future, it is assumed that marsh sediment accretion rates will not keep pace with SLR, and areas where marshes cannot migrate, significant losses may result as evidenced in the SLAMM modeling (Warren Pinnacle Consulting, 2012) discussed in the FWOP/No action section. To accurately measure this effect, these changes will require additional modeling that would account for sensitivities associated with tidal changes of a few centimeters over the existing and future spatial land/water interfaces. This will further be assessed by the NYBEM model.

Table 101: Model Comparing Mean Baseline Tidal Amplitudes with TSP (A1 Alignments) for Alternatives 3E(2) and 4G(8) Open-Gate Conditions and with Sea Level Rise (SLR) at Locations Throughout the NJBB CSRM Study Area (McAlpin and Ross, 2020)

Study Region	Waterway	Station	Existing Conditions				With SLR			
			Base (m)	TSP (m)	Change (m)	Change (cm)	Base (m)	TSP (m)	Change (m)	Change (cm)
NORTHERN REGION	Manasquan River	Watson Creek	0.941	0.955	+0.014	1.4	0.88	0.87	-0.01	-1.0
		Manasquan River	0.604	0.593	-0.011	-1.1	0.74	0.67	-0.07	-7.0
	Barnegat Bay- Little Egg Harbor	Brick	0.103	0.098	-0.005	-0.5	0.22	0.21	-0.01	-1.0
		Barnegat Bay at Mantoloking	0.162	0.154	-0.008	-0.8	0.23	0.22	-0.01	-1.0
		Barnegat Bay at Route 37 Bridge	0.17	0.16	-0.01	-1	0.25	0.23	-0.02	-2.0
		Berkeley	0.164	0.154	-0.01	-1	0.24	0.23	-0.01	-1.0
		Barnegat Light	0.168	0.157	-0.011	-1.1	0.20	0.19	-0.01	-1.0
		Barnegat Bay at Waretown	0.172	0.162	-0.01	-1	0.20	0.19	-0.01	-1.0
		Barnegat Bay at Barnegat Light	0.404	0.370	-0.034	-3.4	0.46	0.40	-0.06	-6.0
		Barnegat Light (Ocean)	0.708	0.692	-0.016	-1.6	1.02	1.02	0.00	0.0

Study Region	Waterway	Station	Existing Conditions				With SLR			
			Base (m)	TSP (m)	Change (m)	Change (cm)	Base (m)	TSP (m)	Change (m)	Change (cm)
		East Thorofare	0.472	0.463	-0.009	-0.9	0.38	0.37	-0.01	-1.0
		Westecunk	0.336	0.332	-0.004	-0.4	0.32	0.31	-0.01	-1.0
		Beach Haven	0.505	0.492	-0.013	-1.3	0.53	0.48	-0.05	-5.0
CENTRAL REGION	Mullica River	JACNEWQ (Mullica River)	0.428	0.414	-0.014	-1.4	0.39	0.38	-0.01	-1.0
	Little Egg Inlet/Great Bay	Little Egg Inlet	0.57	0.558	-0.012	-1.2	0.75	0.68	-0.07	-7.0
	Absecon Bay	Absecon Creek	0.586	0.567	-0.019	-1.9	0.63	0.62	-0.01	-1.0
	Obes Thorofare	Brigantine	0.53	0.514	-0.016	-1.6	0.65	0.61	-0.04	-4.0
	Absecon Inlet	Absecon Channel	0.681	0.677	-0.004	-0.4	0.91	0.82	-0.09	-9.0
	Atlantic Ocean	Atlantic City (Ocean)	0.739	0.738	-0.001	-0.1	1.04	1.04	0.00	0.0
	Inside Thorofare	Inside Thorofare (Rt. 40)	0.686	0.67	-0.016	-1.6	0.70	0.66	-0.04	-4.0
	Beach Thorofare	Beach Thorofare (Margate Blvd.)	0.71	0.682	-0.028	-2.8	0.75	0.70	-0.05	-5.0
	Scull Bay	Scull Bay	0.56	0.543	-0.017	-1.7	0.75	0.60	-0.15	-15.0
	Great Egg Harbor River	Great Egg Harbor River	0.6	0.586	-0.014	-1.4	0.50	0.47	-0.03	-3.0
	Rainbow Channel	Great Egg Harbor Bay	0.713	0.689	-0.024	-2.4	0.95	0.78	-0.17	-17.0
	Crook Horn Creek	Ocean City 39th St	0.622	0.608	-0.014	-1.4	0.72	0.57	-0.15	-15.0
SOUTHERN REGION	Middle Thorofare	Corson Sound	0.566	0.554	-0.012	-1.2	0.49	0.48	-0.01	-1.0
	Ludlum Thorofare	Ludlum Thorofare (Sea Isle Blvd.)	0.573	0.563	-0.01	-1.0	0.47	0.47	0.00	0.0
	Ingram Thorofare	Ingram Thorofare (Old Avalon Blvd.)	0.641	0.635	-0.006	-0.6	0.74	0.68	-0.06	-6.0
	Cape May Canal	Cape May Ferry	1.022	1.018	-0.004	-0.4	1.28	1.28	0.00	0.0

Study Region	Waterway	Station	Existing Conditions				With SLR			
			Base (m)	TSP (m)	Change (m)	Change (cm)	Base (m)	TSP (m)	Change (m)	Change (cm)
	Cape May Harbor	Cape May Harbor	0.909	0.906	-0.003	-0.3	1.10	1.10	0.00	0.0

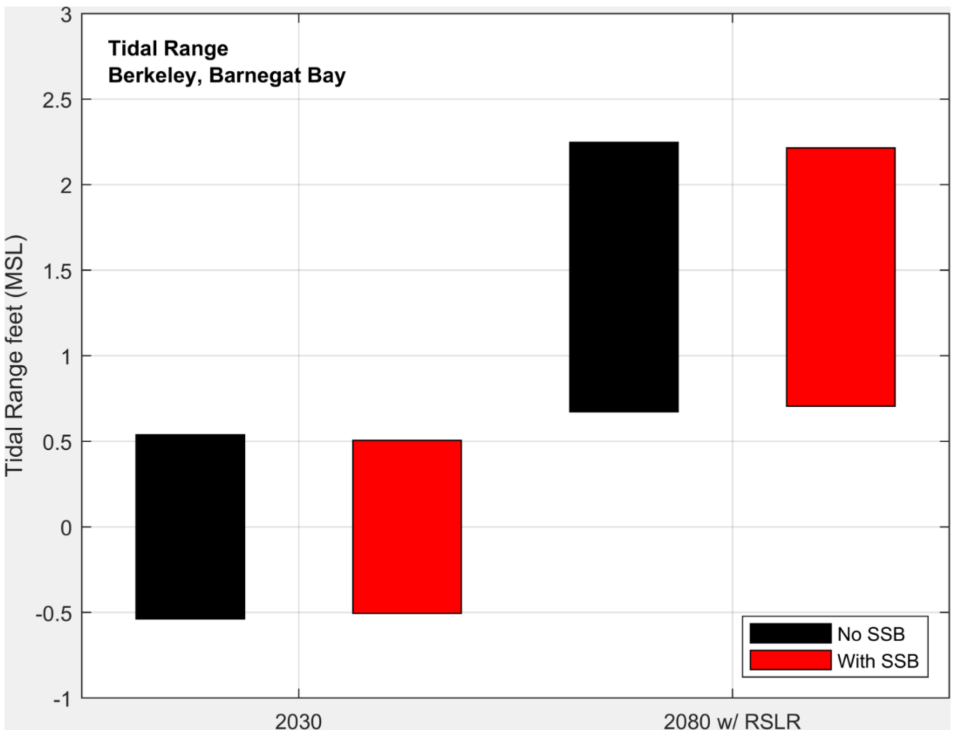


Figure 108. Changes in With-Project Tide Ranges with Relative Sea Level Rise

Additional indirect impacts on these habitats relate to potential changes in salinity from gate closures and influxes of freshwater from precipitation, which could result in floral and faunal community shifts within these habitats. Changes in salinity were also modeled in the AdH model for the open-gate conditions. Table 101 presents the open-gate baseline salinities and the salinities of the with-project TSP- SSBs and CBBs in place per location. There was little variability in mean salinity between the baseline condition and with-project TSP condition at individual stations, with station JACNEWQ (Lower Mullica River) showing the largest change at +0.34 ppt (rising from a mean of 4.80 ppt to a mean of 5.14 ppt). This suggests that freshwater or oligohaline marsh habitats could be susceptible to increased salinity from the TSP SSBs and CBBs. However, the modeling with TSP and SLR suggests a small moderating effect at this location with a baseline without project salinity at JACNEWQ (Mullica River) predicted to be 10.01 ppt and the with-project TSP at 9.90 ppt. As is the case with the tidal amplitudes and changes from SLR and the with-project TSP conditions, additional modeling in the next phase will need to be conducted to interpret these complex changes and effects on freshwater and saltwater tidal habitats.

The AdH modeling which measured localized velocity changes within the SSB gate areas suggests that significant velocity increases are expected to adjust for the constrictions imposed by these structures. Of concern are potential geomorphic changes that may change the established shoaling patterns and create scour zones in the vicinity of these structures. The Barnegat Inlet SSB is nearest to intertidal wetlands and mudflats potentially affected by increases in tidal velocities. The jetties and rock revetments on the north and south sides of Barnegat Inlet offer more shoreline stability eastward of the structure, however, the velocity effects on intertidal areas and shorelines west of the gates such as at Sedge Islands on the north side could result in losses in intertidal habitats.

8.2.4.19.1.2.3 Gates Closed Scenario

The natural inputs of freshwater from tributaries and salinity inputs from the ocean make estuaries subject to great fluxes in salinity and turbidity depending on the seasonality, bathymetry and position and location within an estuary. Despite these fluxes brought on by tidal or other meteorological events, wetland habitats have become established over time where long-term biotic and abiotic factors such as sediment supply, nutrients and salinity contribute to the form and type of wetland present. Freshwater tidal marshes generally have little tolerance to any salinity, while brackish wetlands have the ability to persist in a range of saline conditions. Saltmarshes are composed of specialized vegetation that are physiologically adapted to thrive in saline conditions. The gates-closed scenario would fundamentally cut off all tidal inundation coming in from the ocean during the duration of a closure event, with a frequency expected to occur annually for maintenance/testing and predicted every 5 years (20% AEP) for significant storm events. The closure durations could last from several hours to several days depending on the activity or storm event duration. Therefore, it is likely that closure could occur during more than one tidal cycle. Depending on the state of tide at the time of closure, salinity changes are expected where heavy precipitation, such as during a major storm, would increase freshwater discharges into brackish or saline wetlands. Although this exposure is short-term, the effects under such an extreme condition are not well understood. Some plants such as smooth cordgrass may be fairly resilient to short-term exposure to freshwater (Hanson et al. 2011) while other wetland plants and fauna may become stressed during these events. Additionally, interruptions in sediment supplies resulting from gate closures may have geomorphic effects on saltmarshes. As noted in Orton et al. 2020, saltmarshes may become affected by the modification of edge erosion processes and/or sediment inputs from moderate or severe storms, respectively, which shape and form the horizontal and vertical dimensions of saltmarshes.

Because of the high potential risk for wetland and other aquatic habitat impacts and the uncertainty of identifying these impacts. It is assumed that compensatory mitigation will be required for the potential direct and indirect impacts on tidal wetlands. The Environmental Appendix F.4 provides compensatory mitigation estimates for direct impacts, but indirect impacts will require additional evaluation using models such as the NYBEM (in development) and developing additional avoidance and minimization measures as design details become better refined. It is expected that this information will be fully evaluated at the Tier 2 level.

8.2.4.19.1.2.4 Cumulative Impacts

Indirect cumulative impacts from the implementation of SSBs and CBBs on wetland and other aquatic habitats are potentially significant based on the potential system-wide effects on hydrodynamics including tidal range and salinity. Small, induced changes over a widespread area such as an entire bay system have the potential to result in significant impacts including losses of high marshes/transitional wetlands on the upper end and losses of mudflats on the lower end of the tidal range. These effects coupled with sea level rise and potential habitat shifts as evidenced by SLAMM model runs are uncertain and will require additional hydrodynamic modeling to inform the degree of this effect. Additionally, cumulative losses of wetland and other aquatic habitats will indirectly affect a number of aquatic biotas such as shellfish, finfish, and a number of different types of birds including shorebirds, wading birds, waterfowl, raptors, and neo-tropical migrants.

8.2.4.19.2 Nonstructural Measures (TSP Features for 2A, 3E(2), 4G(8) and 5A)

Nonstructural measures involve a significant construction effort whether it be from building retrofits such as elevation (including raising a structure on fill or foundation elements such as solid perimeter walls, pier, posts, columns, or pilings) or buyout/ relocations that are likely to involve demolition, grading, and soil stabilization/ revegetation. However, existing structures would most likely be in upland urbanized settings where construction activities would not result in any direct wetland and aquatic habitat impacts. All of these activities would involve temporary earth disturbances similar to those expected for construction of the structural measures that would produce turbidity, introduce nutrients, and increase eutrophication that could degrade wetlands and aquatic habitats from stormwater. However, these temporary soil disturbances can be readily managed by implementing appropriate BMPs.

Nonstructural measures such as buyout and relocation could result in indirect improvements to water quality and wetland habitats by the removal of impervious surfaces (through demolition), and replacement with permeable soils and vegetation. In some cases, it may be possible to implement stormwater facilities or as freshwater wetlands in these locations. This action, if implemented on a large scale, could reduce urban runoff and stormwater carrying sediments and a number of other pollutants into the bays, as well as potentially providing additional wetland habitat.

8.2.4.19.3 Natural and Nature-Based Features (TSP Features Warranting Further Analysis)

NNBFs, similar to the structural and nonstructural measures, would involve construction impacts during the time of implementation. The degree of the impact is largely dependent on the feature and its method of construction. For instance, some NNBFs like wetland restoration or reef construction may require the aquatic placement of fill materials that would disturb existing substrates of subtidal soft bottoms or intertidal mud or sand flats and generate localized, but temporary, turbidity in the water column. These effects are expected to be temporary and will end after construction is completed and the areas become stabilized with vegetation and/or other biogenic processes. The installation of NNBFs would also result in conversions of habitat. For instance, a subtidal soft-bottomed subtidal habitat may be changed to an intertidal saltmarsh, mudflat, beach, or reef. However, the installation of NNBFs would have beneficial impacts, such as providing overall ecological uplifts of wetland and aquatic habitats in the NJBB CSRM Study area.

8.2.4.20 Terrestrial Habitats

8.2.4.20.1 Structural Measures

8.2.4.20.1.1 Perimeter – Floodwalls, Levees and Miter Gates (4D(1), 4D(2) and 5D(2)

8.2.4.20.1.1.1 Direct Impacts

In general, the perimeter measures include floodwalls and levees that would be constructed on the western side of the barrier islands along residential bay fronts and would tie into existing dunes at the northern and southern ends of the barrier islands. An exception to this would be for Manasquan Beach (north of Manasquan Inlet), where a levee/dune structure would be constructed along the upper beach extending north for over one mile of Atlantic Coast beach (alternative 3D). The majority of the terrestrial habitats affected by the various perimeter measure configurations are urbanized residential areas, where there are predominantly bulkhead structures that line the back bays and lagoons. The impacts of floodwall construction on terrestrial habitats in these areas would be temporary and minimal since they do not provide high habitat value for terrestrial fauna, and disturbance to ground and vegetation would be temporary until construction activities cease and the areas are stabilized, and vegetation is restored.

Table 102 provides estimates of terrestrial vegetated dune and upper beach habitats affected by the various focused array of alternatives. Alternatives that have been screened out are exhibited with a strike-through. Upper beach habitats are along the Atlantic Ocean coast beaches and are above mean high water. These areas receive frequent salt spray and possess sparse vegetation. In the case of Manasquan Beach, there is little or no existing vegetated dune along the upper beach. Alternative 3(D) includes a levee type of structure for a distance of about 6,000 linear feet from Manasquan Inlet and north. Although design details are limited at this time, this levee would likely include an impermeable core with an outer dune-like sandy layer that would be stabilized with American beachgrass and other suitable vegetation. Other alternatives with perimeter measures (as presented in Table 102) that affect vegetated dunes include levee/floodwall structures on the northern and/or southern ends of barrier islands where they tie into existing dunes. These areas would be stabilized and restored with coastal dune vegetation once construction is completed, and impacts on terrestrial habitat would therefore be temporary and minor. Pump stations for interior drainage will be required for perimeter measures and would likely be located in a terrestrial location behind the perimeter structures. At this time, it is not known where the location of pump stations would be constructed. However, urbanized locations for these features would have the least impacts on terrestrial habitats.

Table 102: Estimate of Vegetated Dune/Upper Beach Habitats Affected by Alternatives with Structural Measures

Alternative	Vegetated Dune/Upper Beach Impacted (Acres)**	Maritime Forest Impacts (Acres)	Notes:
2A[N] (Shark River & Coastal Lakes Region)	-		All nonstructural
3E(2) *[N]	21.6	0.4	Levee structure for SSB along approx. 6,000 lf. of upper beach area along Atlantic Ocean north of Manasquan Inlet and SSB tie-ins into existing dunes N. and S. of Barnegat Inlet.
4D(1)[†N]	8		PP in vegetated dunes in N. Ocean City (Great Egg Harbor Inlet)
4D(2)[†N]	10.6		PP in vegetated dunes in S. Brigantine and N. Ocean City (Great Egg Harbor Inlet)
4G(8) *[~N]	1.9		SSB seawall tie-ins to dunes at Great Egg Harbor Inlet and CBB levee at S. O.C.
5A[N]	-		All nonstructural
5D(2)[†N]	9.3		PP levee on vegetated dunes in S. Sea Isle City and S. Stone Harbor.

KEY: [†] Alternative includes one or more perimeter (floodwalls/levees) protection (PP) segments.

[N] Alternative includes nonstructural (building raising) measures at one or more location(s).

* Alternative includes one or more inlet SSB(s).

[~] Alternative includes one or more CBB(s).

** Acreages only estimate areas affected by construction, and do not represent permanent losses of habitat since some of the alignments include levees that would be planted with coastal vegetation that would function as a vegetated dune habitat.

Northern Region | Central Region | Southern Region

Note: Estimates (in acres) are very preliminary based on a low-level of design, and have not undergone avoidance and minimization analyses, which may result in later changes in estimates.

8.2.4.20.1.1.2 Indirect Impacts

Indirect impacts are not significant. Construction activities would temporarily remove vegetation and displace terrestrial wildlife during construction. These habitats will become available to nesting species such as neo-tropical migrant birds and diamondback terrapins (dunes) once construction is completed and restored with dune vegetation.

8.2.4.20.1.1.3 Cumulative Impacts

Cumulative impacts on terrestrial habitats are not expected to be significant because the perimeter measures will not result in cumulative losses of terrestrial habitats since the levee structures would be designed to mimic existing dunes.

8.2.4.20.1.2 Inlet Storm Surge Barriers/Cross-bay barriers (TSP Features for 3E(2) and 4G(8)

8.2.4.20.1.2.1 Direct Impacts

In general, the SSBs would be constructed at the selected inlets and would tie into existing dunes at the northern and southern ends of the barrier islands. An exception to this would be for Manasquan Beach (north of Manasquan Inlet), where a levee/dune structure would be constructed along the upper beach for over one mile of Atlantic Coast beach (TSP alternatives 3E(2)). All SSBs require seawall tie-ins to existing dunes at each of the inlets identified in the TSP. The impacts of seawall construction on terrestrial habitats in these areas are variable based on the local habitat conditions. For example, a seawall that ties into an existing natural dune on the north side of Barnegat Inlet represents a permanent loss and disturbance to a sensitive habitat whereas a seawall along the Manasquan Inlet would have less of an impact by tying into a more developed shoreline.

Table 102 provides estimates of terrestrial vegetated dune and upper beach habitats affected by the various focused array of alternatives (some of which include SSBs and CBBs) and Figures 103 through 107 provide the alignments of these structural features through these habitats. Upper beach habitats are along the Atlantic Ocean coast beaches above mean high water. These areas receive frequent salt spray and possess sparse vegetation. In the case of Manasquan Beach, there is little or no existing vegetated dune along the upper beach. Alternative 3E(2) includes a levee type of structure for a distance of about 6,000 linear feet from Manasquan Inlet and north. Although design details are limited at this time, this levee would likely include an impermeable core with an outer dune-like sandy layer that would be stabilized with American beachgrass and other suitable vegetation.

Other perimeter measures that affect vegetated dunes would be the construction of the levee structures for CBBs through existing vegetated dune habitats, particularly on the southern end of Ocean City where the CBB ties into existing dunes. These areas would be stabilized and restored with coastal dune vegetation once construction is completed, and impacts on terrestrial habitat would therefore be temporary and minor. Other terrestrial habitats affected by CBBs involve levee structures along urbanized roadways and abandoned railroad embankments (S. Ocean City), which are more terrestrial in nature. Support facilities for SSBs will be required and would likely be sited in a terrestrial location adjacent to the barriers. At this level of design, it is not known where these features would be constructed.

8.2.4.20.1.2.2 Indirect Impacts

Indirect impacts are not significant. Construction activities will temporarily remove vegetation and displace terrestrial wildlife during construction. These habitats will be available to nesting species such as neo-tropical migrant birds and diamondback terrapins (dunes) once construction is completed and these areas are restored with dune vegetation. The permanent seawalls required to tie SSBs into existing dunes will result in a permanent loss of habitat for these species. However, the actual footprint of these structures is small.

8.2.4.20.1.2.3 Cumulative Impacts

Cumulative impacts on terrestrial habitats are not expected to be significant because the SSBs and CBBs will not result in cumulative losses of terrestrial habitats such as vegetated dunes since the levee structures associated with SSBs and CBBs would be designed to mimic existing dunes. The footprint impacts of seawalls at dune tie-in locations on vegetated dune habitats would be minimal.

8.2.4.20.2 Nonstructural Measures (TSP Features for 2A, 3E(2), 4G(8) and 5A)

Nonstructural measures involve a significant construction effort whether it be from building retrofits such as elevation (including raising a structure on fill or foundation elements such as solid perimeter walls, pier, posts, columns, or pilings) or buyout/ relocations that are likely to involve demolition, grading, and soil stabilization/ revegetation. Existing structures would most likely be in upland urbanized settings where construction activities would result in direct terrestrial habitat impacts. However, these effects would be temporary, and would be most likely in urban areas that do not possess high terrestrial habitat values.

Nonstructural measures such as buyout and relocation could result in direct improvements to terrestrial habitats by the removal of impervious surfaces (through demolition), and replacement with permeable soils and vegetation.

8.2.4.20.3 Natural and Nature-Based Features (TSP Features Warranting Further Analysis)

NNBFs, similar to the other structural and nonstructural measures, would involve construction impacts during the time of implementation. The degree of the impact is largely dependent on the feature and its method of construction. At this time, the degree and extent of impacts an NNBF measure would have on terrestrial habitats is not known. NNBFs, for the most part, involve aquatic habitats. It is assumed that access through terrestrial areas and the need for staging may be required that could result in temporary land disturbance. Avoidance of sensitive terrestrial habitats would be managed to the maximum extent practicable. Depending on the NNBF measure proposed, terrestrial habitat could be incorporated into it, if appropriate. An example would be the creation of a supratidal open sandy area for colonial nesting birds on a predominantly saltmarsh island.

8.2.4.21 Wildlife

8.2.4.21.1 Structural Measures

8.2.4.21.1.1 Perimeter – Floodwalls, Levees and Miter Gates (4D(1), 4D(2) and 5D(2)

8.2.4.21.1.1.1 Direct Impacts

Disturbance and noise during construction would result in habitat losseswhich will temporarily displace most of the wildlife as described in the Affected Environment section. Most of the wildlife are expected to return to the vicinity of the work areas once construction activities cease and the areas are stabilized. However, permanent displacement of aquatic and terrestrial wildlife through permanent loss of habitat will result in significant adverse impacts on wildlife. Wildlife species such as shorebirds and wading birds that feed in intertidal mudflats, sandy beaches and saltmarshes would lose this habitat. Additionally, affected areas would require an evaluation of the potential impact on nesting migratory birds and the implementation of appropriate measures to be comply with the Migratory Bird Treaty Act. Vertical barriers such as floodwalls may cut off access between aquatic and terrestrial habitats, which could affect diamondback terrapins migrating from the bays and saltmarshes to nest in sand dunes. However,Although, this effect may be minimal since the majority of floodwall areas are located at existing bulkheads/hardened shorelines, and the terrestrial land behind them is urbanized. In some locations, a floodwall may act as a barrier that prevents diamondback terrapins from crossing roads thereby preventing mortalities resulting from vehicle strikes.

8.2.4.21.1.1.2 Indirect Impacts

The indirect impacts that habitat loss would have on wildlife may result in displacement of birds into more crowded areas that have fewer food resources available. This situation would be particularly critical for resting and feeding shorebirds in their stopovers during migratory flights.

8.2.4.21.1.1.3 Cumulative Impacts

Cumulative impacts from the implementation of perimeter measures on wetland and other aquatic habitats necessary for a number of wildlife species, particularly birds, are potentially significant based on the linear nature of these structures over long distances. These linear features encounter a number of wetland aquatic habitats that are predominantly subtidal soft bottom, intertidal mudflats, intertidal sandy beaches, low salt marshes, high salt marshes, scrub-shrub wetlands, and *Phragmites*-dominated wetlands. Losses of these habitats, particularly on the upper intertidal range (i.e., high salt marshes, scrub-shrub wetlands), may be more significant when coupled with sea level rise, as these types of habitats will not be able to migrate landward where existing heavy development and hardened structures already exist. Cumulative losses of wetland and other aquatic habitats will indirectly affect a number of aquatic biotas such as shellfish, finfish, and a number of different types of birds including shorebirds, wading birds, waterfowl, raptors, and neo-tropical migrants.

8.2.4.21.1.2 Inlet Storm Surge Barriers/Cross-bay barriers (TSP Features for 3E(2) and 4G(8)

8.2.4.21.1.2.1 Direct Impacts

The construction of SSBs and CBBs will temporarily displace wildlife within the active areas as described in the Affected Environment section. However, most of the displaced wildlife are expected to return to the vicinity of the work areas once construction activities cease and the areas are stabilized. Permanent direct losses of wildlife habitats at inlet SSBs are minimal as the majority of the direct impacts are in marine subtidal habitats. Some terrestrial upper beach/vegetated dune habitat would be lost to seawalls that tie into existing dunes on both sides of the inlets where SSBs are located. Marine mammals such as harbor seals and gray seals may be directly impacted by construction activities (Barnegat Inlet is a major “haul out” location). Construction activities such as loud equipment, pile driving, vehicles or human disturbance could physiologically stress seals by causing them to frequently return to the water. Additionally, the operation and closure of the SSB gates could potentially impinge marine mammals if present.

The CBBs, based on their cross-bay orientation, would result in greater intertidal aquatic and wetland habitat losses that could affect a number of shorebirds and wading birds. Additionally, affected areas would require an evaluation to determine the potential impacts on nesting migratory birds, and the implementation of appropriate measures to be in compliance with the Migratory Bird Treaty Act. CBBs would not be expected to adversely impact the movement/migration and nesting of diamondback terrapins as these structures (floodwalls/levees) would mostly be located along existing roadways or railway embankments. These structures could offer some benefit to diamondback terrapins by inhibiting their access to existing roadways preventing them from vehicle strikes. Consideration will be given to providing sandy habitat on the water/marsh facing side of these structures to promote nesting habitat.

8.2.4.21.1.2.2 Indirect Impacts

The indirect effects of SSBs and CBBs with respect to the impact of changes in hydrodynamics and water quality on wildlife are relatively unknown. However, it is assumed that any adverse effects caused by SSBs and CBBs on organisms lower in the food chain such as phytoplankton, zooplankton, benthic invertebrates, and fish would result in indirect trophic impacts on wildlife that depend on these food resources. Additionally, velocity changes in the vicinity of an opened SSB gate could potentially impede migration of sea turtles and marine mammals through coastal inlets. In Orton et al. 2020, case studies in the Netherlands (Eastern Scheldt SSB) show evidence that seal populations are permanently remaining within the estuary and not mixing with the population outside of the estuary. Increased human activity associated with gate operations and maintenance activities may also result in intermittent or long-term adverse effects to wildlife within the vicinity of the activities.

8.2.4.21.1.2.3 Cumulative Impacts

The cumulative impacts of SSBs and CBBs on wildlife are generally unknown and could result indirectly from potential cumulative impacts on organisms lower in the food chain over entire bay-wide systems.

8.2.4.21.2 Nonstructural Measures (TSP Features for 2A, 3E(2), 4G(8) and 5A)

Nonstructural measures involve a significant construction effort whether it be from building retrofits such as elevation (including raising a structure on fill or foundation elements such as solid perimeter walls, pier, posts, columns, or pilings) or buyout/ relocations that are likely to involve demolition, grading, and soil stabilization/ revegetation. Existing structures would most likely be in upland urbanized settings where construction activities would result in direct terrestrial wildlife habitat impacts and noise and disturbance may result in wildlife temporarily relocating. However, these effects would be temporary, and would be most likely in urban areas that do not possess high terrestrial habitat values.

Similarly, nonstructural measures such as buyout and relocation could result in temporary impacts to wildlife species that inhabit urbanized settings. However, direct improvements to terrestrial habitats by the removal of impervious surfaces (through demolition), and replacement with permeable soils and vegetation would offer more opportunities for birds, mammals, and reptiles to inhabit these areas.

Individual properties would require an evaluation to determine potential impacts to nesting migratory birds and the implementation of appropriate measures to be in compliance with the Migratory Bird Treaty Act.

8.2.4.21.3 Natural and Nature-Based Features (TSP Features Warranting Further Analysis)

NNBFs, for the most part, involve implementing features in aquatic habitats. Implementation of NNBFs during construction are expected to have short-term adverse impacts on wildlife species, particularly for migratory shorebirds, water birds and waterfowl. However, NNBFs have the potential for having substantial beneficial impacts on these wildlife species by providing suitable foraging, resting, and breeding habitats such as saltmarshes, SAV beds, and living shorelines. This benefit would depend on the scale of implementation and the quality of habitat to meet the life requisites of target species.

8.2.4.22 Fisheries Resources

8.2.4.22.1 Structural Measures

8.2.4.22.1.1 Perimeter – Floodwalls, Levees and Miter Gates (4D(1), 4D(2) and 5D(2)

8.2.4.22.1.1.1 Direct Impacts

The construction of perimeters including floodwalls, levees, and miter gates will have temporary and permanent adverse significant impacts on fisheries and Essential Fish Habitat (EFH). The temporary effects on fisheries would be based on disturbances during construction such as noise, water quality (turbidity, DO), and physical displacement. Noise impacts such as pile-driving could result in direct lethal and/ or sub-lethal effects to some finfish during construction. The generation of turbidity can adversely affect fish respiration, sight feeding, and could smother eggs/larvae. The generation of turbidity can also affect dissolved oxygen levels that can result in either mortalities or heavily stressed fish. With the exception of some smaller species and larval stages, most mobile fish would be able to move out of the active construction areas. The construction of floodwalls along intertidal and subtidal areas would also require temporary de-watering structures, which would temporarily displace access to these aquatic habitats for feeding or spawning activities.

Temporary effects on shellfish such as hard clams in construction areas would be adverse related to their sessile nature and for blue crabs that may become trapped in a construction segment. The generation of turbidity and low DO could result in lethal or sub-lethal effects on shellfish.

Permanent impacts to fish and fisheries are significant and are associated with permanent habitat losses within the footprints of the perimeter structures. Table 103 provides preliminary estimated habitat losses for the focused array of alternatives (including the TSP), with several plans including perimeter measures (Since the perimeter measures are not part of the TSP, they were crossed out but presented here for comparative purposes). The highest direct losses of fisheries habitat (and EFH) are within shallow subtidal soft bottom habitats along an existing hardened shoreline, which is usually a bulkhead structure. The habitat loss is based on the width of a proposed floodwall in these areas that would be wider than the existing structure. Estimates of this impact range from 1.1 acres to nearly 108 acres of subtidal soft bottom. Alternatives with the highest impact on the bottom also have the longest perimeter measures along the bayfronts.

Some other habitats directly affected by perimeters are intertidal mudflats that range from 0.3 acres to 33 acres and lower salt marshes that range from 1.0 acres to 84 acres (includes perimeter and CBB). Additionally, alternative 3E(3), which was screened out, was estimated to impact approximately 11.2 acres of seagrass (SAV) beds within the Barnegat Bay/Little Egg Harbor Estuaries. These habitats are all EFH for a number of managed species including summer flounder, winter flounder (north of Absecon Inlet), and bluefish. Additionally, SAV beds are a "Habitat Area of Particular Concern" (HAPC) for summer flounder.

Estimates of shellfish habitat impacts are based on historical mapping obtained from NJDEP (Source: https://www.nj.gov/dep/landuse/shellfish.html) that include coast-wide mapping from 1963, and mapping in the Barnegat-Little Egg estuary from the mid-1980's, and 2011-2012. These estimates include affected habitats such as soft-bottom subtidal habitats, intertidal sand, and mudflats, and SAV beds. The focused array did not encounter soft clam, oyster seed production, scallop production, and leased beds. However, mapped hardclam beds were encountered resulting in potential significant impacts. Table 103 provides estimates of these impacts for the focused array of alternatives, which includes perimeter measures and/or SSBs and CBBs.

Table 103: NJBB Focused Array of Alternatives Comparative Preliminary Estimates of Direct Impacts (Acres) on Shellfish Beds Based on Historic Shellfish Resource Maps (Alternatives crossed out were screened out and are not part of the TSP)

Region	Year of Mapping:	1963			1980's (Northern Region Only)			2011-2012 (Northern Region Only)			
	Alternative	Hard clam High Com. Value	Hard clam Moderate Com. Value	Hard clam Rec. Value	Hardclam High Density	Hardclam Moderate Density	Hardclam Occurrence	Hardclam High Density	Hardclam Moderate Density	Hardclam Low Density	Hardclam Occurrence
Shark River & Coastal Lakes	**2A N**	0	0	0	0	0	0	0	0	0	0
	3E(2)* N	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	4D(1) †N	70	0	0	-	-	-	-	-	-	-
	4D(2) †N	96	0	0	-	-	-	-	-	-	-
	4G(8)* ≈N	**2**	**8**	**0**	-	-	-	-	-	-	-
South	**5A N**	**0**	**0**	**0**	-	-	-	-	-	-	-
	5D(2) †N	140	0	0	-	-	-	-	-	-	-

KEY: † Alternative includes one or more perimeter (floodwalls/levees) protection segments.

N Alternative includes nonstructural (building raising) measures at one or more location(s).

* Alternative includes one or more inlet SSB(s).

≈ Alternative includes one or more CBB(s).

"0" Indicates that the alternative either avoids impacting that resource category or resource category is not present

"–"Indicates that no surveys or data are available.

Alternatives in bold are the TSP

Note: Estimates (in acres) are very preliminary based on a low-level of design, and have not undergone avoidance and minimization analyses, which may result in later changes in estimates.

The alternatives with the longest perimeter measures and/or CBBs had the highest impact acreages of historic shellfish (hard clam) habitat. In the north, alternative 3E(3) had the highest impacts of a combined 89 acres for hard clam - moderate commercial value and recreational value from the 1963 mapping and a total of 32 acres from the 2011-2012 mapping. This impact is attributed to the perimeter measures for southern Long Beach Island. Based on the 1963 mapping for hard clam high commercial values, the Central Region had the highest impacts from the perimeter measures in 4D(1) (70 acres) and 4D(2) (96 acres), and the southern region had high impacts from both plans that had perimeter measures 5D(1) (68 acres) and 5D(2) (140 acres).

8.2.4.22.1.1.2 Indirect Impacts

Indirect impacts of perimeters on fisheries are not significant and are related to temporary impacts on noise, water quality such as turbidity and sedimentation during construction. The displacement and/or mortality of smaller forage fish could have some indirect trophic effects within the food chain for commercial and recreational species including species with EFH within the affected areas.

8.2.4.22.1.1.3 Cumulative Impacts

The direct cumulative losses of aquatic habitats for finfish, shellfish, and EFH over long distances of perimeters are significant based on the current estimated impacts. These losses coupled with the effects of climate change and sea level rise are likely to contribute to stressors on finfish and shellfish habitats, population abundances, and distributions.

8.2.4.22.1.2 Inlet Storm Surge Barriers/Cross-bay barriers (TSP Features for 3E(2) and 4G(8)

8.2.4.22.1.2.1 Direct Impacts

The direct impacts of the construction of SSBs and CBBs on fisheries including finfish, shellfish and EFH are similar to perimeters. The temporary effects on fisheries would be based on disturbances during construction such as noise, water quality (turbidity, DO), and physical displacement. Noise impacts such as pile-driving could result in direct lethal and/ or sub-lethal effects to some finfish during construction. The generation of turbidity can adversely affect fish respiration, sight feeding, and could smother eggs/larvae. The generation of turbidity can also affect dissolved oxygen levels that can result in either mortalities or heavily stressed fish. In addition, these disturbances could disrupt or inhibit seasonal fish migrations especially in the vicinity of important migratory corridors in the affected inlets. With the exception of some smaller species and larval stages, most mobile fish would be able to move out of the active construction areas. The construction of floodwalls for CBBs along intertidal and subtidal areas would also require temporary de-watering structures, which would temporarily displace access to these aquatic habitats for feeding or spawning activities.

Gate closures of SSBs and CBBs are likely to entrain smaller and slow-moving fish or larvae resulting in their mortalities. Impediment of movement and/or migration of fishes trapped behind closed tide gates and/or surge barrier is also possible (USACE, 2017). These effects could impact migrations of anadromous fish species such as river herrings (alewife and blueback herring and striped bass that transit through inlet areas to spawn in freshwater upstream) and the catadromous fish (American eel that transit through inlets to spawn in the Sargasso Sea). To minimize these effects, planned closures for maintenance and testing (about once a year) would need to be timed during off-peak migration times. However, storm closures are difficult to predict and a closure during the spring migration would have a greater adverse effect on migratory fish. Current storm closure triggering events are predicted water levels for a 5-year storm event (20% AEP) that are adjusted to sea level rise conditions over time to minimize increases in gate closures.

Based on preliminary estimates, SSBs are likely to have less direct fish and shellfish habitat losses than perimeter measures due to the overall smaller footprints affected. SSBs would primarily affect subtidal soft bottom habitats within the coastal inlets. CBBs, because of their lengths and locations, resulting in higher impacts on fish habitats compared to SSBs. Alternative 3E(2) utilizes SSBs at Manasquan Inlet and Barnegat Inlet and only directly impact about 7.5 acres of subtidal soft bottom. However, alternatives with both SSBs and CBBs such as 4E(4) demonstrate higher impacts to fish habitat, and those combinations with SSBs, CBBs and perimeters have comparatively much higher impacts to fish habitats.

Historic shellfish bed mapping did not demonstrate SSB impacts on hardclam beds. However, the plans with CBBs did impact historic (1963) hardclam areas, but to a much lesser extent than the perimeter measures. These CBB areas would directly affect approximately 10 acres of shellfish habitat, which is defined by N.J.AC. 7:7-9.2 as follws: “The area has a history of natural shellfish production according to data available to the New Jersey Bureau of Shellfisheries, or is depicted as having high or moderate commercial value in the Distribution of Shellfish Resources in Relation to the New Jersey Intracoastal Waterway (U.S. Department of the Interior, 1963) and/or "Inventory of New Jersey's Estuarine Shellfish Resources" (Division of Fish, Game and Wildlife, Bureau of Shellfisheries, 1983-present)”. It is assumed that current shellfish surveys would be conducted in the next phase to determine if there are beds meeting current shellfish designation densities of 0.20 shellfish per square foot.

8.2.4.23 Essential Fish Habitat

8.2.4.23.1 Structural Measures TSP

8.2.4.23.1.1 Direct Impacts

The direct effects on Essential Fish Habitat (EFH) are evaluated in Appendix F.2. The TSP components would directly affect over 153 acres of EFH, which includes about 59 acres of subtidal soft-bottom habitats, about two acres of intertidal mud/sand flats, about nine acres of intertidal sandy beach, and 73 acres of low and high marshes. The remaining acres are adjacent scrub-shrub and supratidal wetlands. EFH species and life stages are presented in the Environmental Appendix. The EFH assessment projects moderate to high impacts on habitats for Atlantic surfclam, windowpane flounder, black seabass, inshore long-finned squid, scup, spiny dogfish, red hake, sandbar shark, summer flounder, winter flounder, little skate, winter skate and clear nose skate. Additionally, two HAPCs would be affected for sandbar sharks (Absecon Blvd. CBB) and summer flounder (potential SAV beds near Barnegat Inlet).

8.2.4.23.1.2 Indirect Impacts

The indirect impacts of SSBs and CBBs on finfish, shellfish and EFH are potentially significant. Under normal conditions, the gates of SSBs and CBBs would remain open and fish and other aquatic organisms should be able to transit through these structures. However, because SSBs require large in-water structural components such as the gate housing and abutments/piers, preliminary estimates indicate significant cross-sectional restrictions where 23% of the Manasquan Inlet, 46% of the Barnegat Inlet and 42% of the Great Egg Harbor Inlet would be blocked by these SSB structures in an open-gate scenario. These constrictions would produce changes in velocity as tidal flows have less area to push into and out of the inlets, thus flow velocities will increase significantly at the gate locations to compensate for tidal forcing. It is not well understood if these velocities would change migratory fish patterns for fish traversing through the inlet areas. Migratory fish potentially affected include obligate migrators (diadromous fishes such as eels, alosines, and Atlantic sturgeon) and marine fishes and other facultative migrators (e.g., bluefish, flounders, and weakfish) and forage fishes (e.g., menhaden, bay anchovy, Atlantic silversides) (Orton et al. 2020). Anadromous fish such as river herrings seek higher velocities to ascend into their natal rivers, but there is little known on what the effects of these velocity changes would have on fish at the inlet areas, and if the fish would adapt to these changes. Observations in the UK noted that adult and juvenile salmon upstream and downstream migrations were delayed after a barrier was implemented (Orton et al. 2020). Additionally, fish larval transport is also likely to be affected by the changes where the gate structures may block or inhibit larvae from entering or exiting the inlet or the increased velocities may have a “jettison” effect on them. Because these effects of SSBs are relatively unknown, there is a high risk for significant effects on fisheries. Additional modeling and fish census studies would need to be conducted to better understand these effects before proceeding with implementation. These actions can be implemented prior to the completion of the Final Tier 1 EIS and/or during the Tier 2 – Engineering and Design phase.

With the gates open, the small salinity changes could potentially result in minor to significant effects on the abundance and distribution of fisheries. For instance, adult hard clams cannot tolerate lowered salinities where they do not grow at ≤ 12 ppt salinity, and are intolerant of protracted salinities < 15 ppt, and interactions between temperature and salinity on hard clam larval development are stressed at lower salinities (Bricelj *et al*. 2012). The AdH modeling did not demonstrate large changes in the mean salinity (the highest mean salinity change was slightly above 1 ppt) with the TSP SSB/CBBs, but even small changes on the margins may be enough to stress these organisms. Because of normal fluctuations of salinities within the estuarine mixing zones, the effects on EFH may not be severe. However, additional evaluations are required in subsequent phases to evaluate changes from the TSP structures on the extremes and salinity tolerances for the most affected EFH species.

Gate closures may have even more of an effect on fisheries/EFH, although temporary. Extreme storm and high tide events would trigger the closure of SSBs and CBBs, causing shifts in water quality and flow rates. During these closures, tidal fluxes in water would cease for a period of time, potentially reducing water quality and dissolved oxygen (DO), while increasing the number of harmful nutrients in the water. The changes in water quality, DO, and nutrients could have compound and/or cumulative interactions, causing increased stress levels to fish populations, which may lead to increased susceptibility to disease or even a mortality event (Tietze 2016; Bachman and Rand 2008). Additionally, periodic maintenance of the structures proposed would be necessary over time; the maintenance would likely result in localized disturbances caused by increased underwater noise and turbidity. The operation and maintenance of SSBs and CBBs could potentially result in temporary to permanent significant adverse impacts to fish and fisheries resources (USACE, 2017).

8.2.4.23.1.3 Cumulative Impacts

The direct cumulative losses of aquatic habitats for finfish, shellfish, and EFH over long distances of SSBs, CBBs and perimeters are significant based on the current estimated impacts. Operation of SSBs and CBBs could potentially affect bay-wide fisheries by affecting hydrodynamics and water quality. These effects coupled with the effects of climate change and sea level rise are likely to contribute to stressors on finfish and shellfish habitats, population abundances, and distributions. To compensate for the effects of the structural components in the TSP, compensatory mitigation is estimated in the Environmental Appendix.

8.2.4.23.2 Nonstructural Measures (TSP Features for 2A, 3E(2), 4G(8) and 5A)

Nonstructural measures involve a significant construction effort whether it be from building retrofits such as elevation (including raising a structure on fill or foundation elements such as solid perimeter walls, pier, posts, columns, or pilings) or buyout/ relocations that are likely to involve demolition, grading, and soil stabilization/ revegetation. However, existing structures would most likely be in upland urbanized settings where construction activities would not result in any direct wetland and aquatic habitat impacts. All of these activities would involve earth disturbances similar to some of the effects discussed for temporary construction of the structural measures that could potentially produce turbidity, introduce nutrients, and increase eutrophication that could degrade wetlands and aquatic habitats from stormwater. However, soil disturbances can be readily managed by implementing appropriate BMPs. Therefore, direct, and indirect impacts to fisheries resources and EFH are expected to be minimal.

Nonstructural measures such as buyout and relocation could result in indirect improvements to water quality and wetland habitats by the removal of impervious surfaces (through demolition), and replacement with permeable soils and vegetation. In some cases, it may be possible to implement stormwater facilities or as freshwater wetlands in these locations. If implemented on a large scale, this action could reduce urban runoff and stormwater carryingsediments and a number of other pollutants into the bays and potentially provide additional wetland habitat. Depending on the scale of implementation, this alternative may have an indirect minor to moderate beneficial impact on fisheries resources and EFH through water quality improvements.

8.2.4.23.3 Natural and Nature-Based Features (TSP Features Warranting Further Analysis)

NNBFs, similar to the other structural and nonstructural measures, would involve construction impacts during the time of implementation. The degree of the impact is largely dependent on the feature and its method of construction. At this time, it is not known the degree and extent of impacts an NNBF measure would have on fisheries and essential fish habitats. NNBFs, for the most part, involve implementing features in aquatic habitats. Implementation of NNBFs during construction are expected to have short-term adverse impacts on fish, EFH, and shellfish species, as these activities may significantly disturb the aquatic habitat and generate turbidity during construction. Most finfish would be expected to be able to move out of the active areas. However, shellfish and other less mobile organisms would be impacted within the footprint of the disturbance and through the effects of turbidity. The long-term effects of NNBFs on fish and shellfish are either beneficial for some or detrimental to others depending on the NNBF measure and the existing habitat. For instance, an existing intertidal mudflat may have suitable hard clam habitat that is converted to a low saltmarsh by raising the substrate elevation, thus eliminating the hard clam habitat, while saltmarshes are important nursery areas for fish species such as spot and flounder. However, the restoration of an SAV bed NNBF may have substantial benefits for both fish and shellfish. These effects would have to be weighed based on the location of existing sensitive habitats and the ecological services and uplift that an NNBF measure provides.

8.2.4.24 Invertebrates

8.2.4.24.1 Impacts Common to All Structural Alternatives

8.2.4.24.1.1 Perimeter – Floodwalls, Levees and Miter Gates (4D(1), 4D(2) and 5D(2)

8.2.4.24.1.2 Storm Surge Barriers/Cross-bay barriers (TSP Features for 3E(2) and 4G(8)

8.2.4.24.1.2.1 Direct Impacts

The direct impacts of structural measures such as perimeters (floodwalls, levees, miter gates), SSBs, and CBBs will result in direct mortalities of benthic fauna and permanent loss of their habitat located within the footprint of the construction. As discussed previously, a variety of wetland and other aquatic habitats are directly impacted, and their estimated acres of impact are provided for each alternative where benthic fauna live as infauna (burrowers) or epifauna (on bottom surface). These losses are associated with construction activities that involve excavation/dredging and fill placement over benthic habitats, which result in the complete removal or burial of these organisms. Subtidal (including SAV beds) and intertidal soft bottom habitats are likely to include polychaetes (worms), bivalves (clams), gastropods (snails), amphipods, and various decapods (crabs). Important commercial and recreational species affected include hard clams and blue crabs. Species composition may vary based on sediment substrate types, depth, water quality, and predation. Rocky intertidal habitats may include more encrusting organisms such as barnacles, blue mussels, and bryozoans as well as crabs, polychaetes and amphipods. Tidal marsh habitats are likely to have polychaetes, snails, ribbed mussels, fiddler crabs and various insect larvae. Hardened structures with subtidal and intertidal portions are likely to become colonized by encrusting organisms; however, the degree of recruitment on these structures will depend on the suitability of the substrate. Smooth vertical walls may not be very attractive to benthic organisms, but rough and rocky substrates may have more value.

8.2.4.24.1.2.2 Indirect Impacts

The loss of benthic fauna would indirectly affect fisheries by eliminating an important food source within the footprint of these structures. Loss of benthic food sources in subtidal SAV beds, intertidal mudflats, sandy beaches, and tidal marshes would also affect shorebirds and other various wading birds and waterfowl. The effects of the implementation and operation of SSBs and CBBs could result in changes to hydrodynamics and water quality, thereby potentially affecting benthic community composition due to changes in substrate and salinity.

8.2.4.24.1.2.3 Cumulative Impacts

The direct cumulative losses of benthic habitats over long distances of SSBs, CBBs and perimeters are significant based on the current estimated impacts. Operation of SSBs and CBBs could potentially affect bay-wide benthic communities by affecting hydrodynamics and water quality. These effects coupled with the effects of climate change and sea level rise are likely to contribute to stressors on benthic habitats, population abundances, and distributions.

8.2.4.24.2 Nonstructural Measures (TSP Features for 2A, 3E(2), 4G(8) and 5A)

Nonstructural measures involve a significant construction effort whether it be from building retrofits such as elevation (including raising a structure on fill or foundation elements such as solid perimeter walls, pier, posts, columns, or pilings) or buyout/ relocations that are likely to involve demolition, grading, and soil stabilization/ revegetation. However, existing structures would most likely be in upland urbanized settings where construction activities would not result in any direct wetland and aquatic habitat impacts. All of these activities would involve temporary earth disturbances (similar to those expected during construction of the structural measures) that could potentially produce turbidity, introduce nutrients, and increase eutrophication that could degrade wetlands and aquatic habitats from stormwater. However, these temporary soil disturbances can be readily managed by implementing appropriate BMPs. Therefore, direct, and indirect impacts to benthic invertebrate resources are expected to be minimal.

Nonstructural measures such as buyout and relocation could result in indirect improvements to water quality and wetland habitats by the removal of impervious surfaces (through demolition), and replacement with permeable soils and vegetation. In some cases, it may be possible to implement stormwater facilities or as freshwater wetlands in these locations. If implemented on a large scale, this action could reduce urban runoff and stormwater carrying sediments and a number of other pollutants into the bays and potentially provide additional wetland habitat. Depending on the scale of implementation, this alternative may have an indirect minor to moderate beneficial impact on benthic invertebrate resources through water quality improvements.

8.2.4.24.3 Natural and Nature-Based Features (TSP Features Warranting Further Analysis)

NNBFs, similar to the other structural and nonstructural measures, would involve construction impacts during the time of implementation. The degree of the impact is largely dependent on the feature and its method of construction. At this time, the degree and extent of impacts an NNBF measure would have on the benthic habitats is not known. NNBFs, for the most part, involve implementing features in aquatic habitats. Implementation of NNBFs during construction are expected to have short-term adverse impacts on benthic species (infauna and less mobile epifauna), as these activities may significantly disturb the aquatic habitat and generate turbidity during construction. Most benthic organisms are sessile in nature and would not be able to move out of an area being disturbed, where they could either be removed through excavation/dredging or buried. The long-term effects of NNBFs on benthos may have variable results where habitat conversions may suit one species or community over another. For instance, an existing subtidal soft bottom that contain burrowing deposit feeders could be converted to either a hard reef or a living shoreline composed of shell material, which may be more favorable for encrusting organisms. These effects would have to be weighed based on the location of existing sensitive habitats and the ecological services and uplift that an NNBF measure provides.

8.2.4.25 Special Status Species

8.2.4.25.1 Impacts Common to All Structural Alternatives

8.2.4.25.1.1 Perimeter – Floodwalls, Levees and Miter Gates (4D(1), 4D(2) and 5D(2)

8.2.4.25.1.2 Storm Surge Barriers/Cross-bay barriers (TSP Features for 3E(2) and 4G(8)

8.2.4.25.1.2.1 Direct and Indirect Impacts

A large number of special status species occur within the NJBB CSRM Study area that could potentially be affected by construction activities (temporary) and/or habitat losses from the implementation of structural measures that include perimeter measures, SSBs and CBBs. Table 104 provides a brief summary of the structural measures identified in the TSP, as well as the PPs being carried forward, and their impacts on the special status species. For Federally listed species, coordination is ongoing with the U.S. Fish and Wildlife Service and NOAA Fisheries to determine if the alternatives in the focused array require informal or formal consultation pursuant to Section 7 of the Endangered Species Act. A consolidated Biological Assessment for species under the jurisdictions of both USFWS and NOAA Fisheries is provided in the Environmental Appendix to initiate consultation. Table 105 provides specific habitats of Federally listed species evaluated in the BA within the footprint of the alternative structures including the TSP SSBs and CBBs. A number of species have the potential to be affected by the proposed TSP directly (temporary – construction disturbance/displacement; permanent – displacement), indirectly (water quality changes, habitat changes, trophic changes) or cumulatively (other small or large actions that affect these species directly or indirectly).

Federally listed species within the action area include:

- Piping plover
- Eastern black rail
- Seabeach amaranth
- Atlantic loggerhead sea turtle
- Kemp's ridley sea turtle
- Atlantic green sea turtle

- Leatherback sea turtle
- Roseate tern
- Red knot
- North Atlantic right whale
- Fin whale
- Atlantic sturgeon

Table 104: Potential Impacts of Structural Features of Alternatives on Special Status Species in the NJBB CSRM Study Area

Species	Status	Habitat in NJBB	Perimeter Impacts (see note #1)	SSB Impacts (TSP Features)	CBB Impacts (TSP Features)
American Bittern (*Botaurus lentiginosos*) BR	SE	Freshwater and brackish marshes for breeding season. Salt marshes rest of year.	Direct habitat impacts are likely on non-breeding saltmarsh losses. Indirect impacts through disruptions in food chain.	No direct impacts anticipated. Indirect impacts through disruptions in food chain.	Direct habitat impacts are likely on non-breeding saltmarsh losses. Indirect impacts through disruptions in food chain.
Bald Eagle (*Haliaeetus leucocephalus*) BR/NB	SE/ ST	Forest edges, open water	Indirect impacts through disruptions in food chain.	No direct impacts anticipated. Indirect impacts through disruptions in food chain.	Indirect impacts through disruptions in food chain.
Northern Harrier (*Circus cyaneus*) BR	SE	Tidal marshes	Direct habitat impacts/losses are likely on breeding in higher saltmarshes. Indirect impacts through disruptions in food chain.	No direct impacts anticipated. Indirect impacts through disruptions in food chain.	Direct habitat impacts/losses are likely on breeding in higher saltmarshes. Indirect impacts through disruptions in food chain.
Red knot* (*Calidris canutus rufa*) NB	**FT***, SE	Sandy beaches, spits, marsh islands, tidal flats	Direct habitat impacts are likely on non-breeding saltmarsh and tidal flats losses. Indirect impacts through disruptions in food chain.	No direct impacts anticipated. Indirect impacts through disruptions in food chain.	Direct habitat impacts are likely on non-breeding saltmarsh and tidal flats losses. Indirect impacts through disruptions in food chain.
Short-Eared Owl (*Asio flammeus*) BR	SE	Coastal marshes	Direct habitat impacts/losses are likely on breeding in higher saltmarshes. Indirect impacts through disruptions in food chain.	No direct impacts anticipated. Indirect impacts through disruptions in food chain.	Direct habitat impacts/losses are likely on breeding in higher saltmarshes. Indirect impacts through disruptions in food chain.
Black-Crowned Night-Heron (*Nycticorax nycticorax*) BR	ST	Maritime forests, scrub-shrub, mixed *Phragmites* marshes	Direct habitat impacts/losses are likely on breeding in higher saltmarshes/transitional wetlands. Indirect impacts through disruptions in food chain.	Approximately 0.4 acres of maritime forest would be affected by a floodwall associated with the Barnegat Inlet SSB at Barnegat Inlet State Park. The Tier 2 EIS during Engineering and Design Phase will consider any alternative alignments to avoid/minimize this impact.	Direct habitat impacts/losses are likely on breeding in higher saltmarshes/transitional wetlands. Indirect impacts through disruptions in food chain.
Yellow-Crowned Night-Heron (Nyctanassa violacea)	ST	Maritime forests, scrub-shrub on barrier and bay islands	Direct habitat impacts/losses are likely on breeding in higher saltmarshes/transitional wetlands. Indirect impacts through disruptions in food chain.	Approximately 0.4 acres of maritime forest would be affected by a floodwall associated with the Barnegat Inlet SSB at Barnegat Inlet State Park. The Tier 2 EIS during Engineering and Design Phase will consider any alternative alignments to avoid/minimize this impact.	Direct habitat impacts/losses are likely on breeding in higher saltmarshes/transitional wetlands. Indirect impacts through disruptions in food chain.
Osprey (*Pandion haliaetus*) BR	ST	Coastal rivers, marshes, bays & inlets. Nest on dead trees, platforms, poles	Potential disturbance to nests/nesting platforms throughout bay areas. Indirect impacts through disruptions in food chain.	No direct impacts anticipated. Indirect impacts through disruptions in food chain.	Potential disturbance to nests/nesting platforms throughout bay areas. Indirect impacts through disruptions in food chain.
Piping plover* (*Charadrius melodus*)	**FT*** SE	Ocean beaches, inlets, washover areas, tidal flats	Potential disturbance to nests/foraging areas on beaches and inlet dune tie-ins. Indirect impacts through disruptions in food chain.	Potential disturbance to nests/foraging areas on beaches and inlet dune tie-ins. Indirect impacts through disruptions in food chain.	Potential disturbance to nests/foraging areas on beaches and inlet dune tie-ins. Indirect impacts through disruptions in food chain.
Black Rail* (*Laterallus jamaicensis*) BR/NB	FT/SE/S T	High marshes	Direct habitat impacts/losses are likely on breeding in higher saltmarshes. Indirect impacts through disruptions in food chain.	No direct impacts anticipated. Indirect impacts through disruptions in food chain.	Direct habitat impacts/losses are likely on breeding in higher saltmarshes. Indirect impacts through disruptions in food chain.
Black Skimmer (*Rynchops niger*)	SE	Sandy beaches, inlets, sandbars, offshore islands	Potential disturbance to nests on beaches and inlet dune tie-ins. Indirect impacts through disruptions in food chain.	Potential disturbance to nests on beaches and inlet dune tie-ins. Indirect impacts through disruptions in food chain.	Potential disturbance to nests on beaches and inlet dune tie-ins. Indirect impacts through disruptions in food chain.
Least Tern (*Sternula antillarum*)	SE	Sandy beaches, bay islands	Potential disturbance to nests on beaches and inlet dune tie-ins. Indirect impacts through disruptions in food chain.	Potential disturbance to nests on beaches and inlet dune tie-ins. Indirect impacts through disruptions in food chain.	Potential disturbance to nests on beaches and inlet dune tie-ins. Indirect impacts through disruptions in food chain.

Species	Status	Habitat in NJBB	Perimeter Impacts (see note #1)	SSB Impacts (TSP Features)	CBB Impacts (TSP Features)
Roseate Tern (*Sterna dougallii*)	**FE**/SE	Beaches w/ vegetated dunes	No breeding population currently in NJ. Potential disturbance to foraging areas. Indirect impacts through disruptions in food chain.	No breeding population currently in NJ. Potential disturbance to foraging areas. Indirect impacts through disruptions in food chain.	No breeding population currently in NJ. Potential disturbance to foraging areas. Indirect impacts through disruptions in food chain.
Sedge Wren (*Cistothorus platensis*)	SE	High marshes	Direct habitat impacts/losses are likely on breeding in higher saltmarshes/transitional wetlands. Indirect impacts through disruptions in food chain.	No direct impacts anticipated. Indirect impacts through disruptions in food chain.	Direct habitat impacts/losses are likely on breeding in higher saltmarshes/transitional wetlands. Indirect impacts through disruptions in food chain.
American oystercatcher (*Haematopus palliates*)	SOC	Breed in coastal beaches, inlet spits, and back bay marshes.	Potential disturbance to nests/foraging areas on beaches, inlet dune tie-ins, and saltmarsh losses. Indirect impacts through disruptions in food chain.	Potential disturbance to nests/foraging areas on beaches and inlet dune tie-ins. Indirect impacts through disruptions in food chain.	Potential disturbance to nests/foraging areas on beaches, inlet dune tie-ins, and saltmarsh losses. Indirect impacts through disruptions in food chain.
Common Tern (*Sterna hirundo*)	SOC	Nest on islands, barrier beaches, coastal promontories, dredged material islands, and some other artificial structures.	Potential disturbance to nests/foraging areas on beaches, inlet dune tie-ins, and saltmarsh losses. Indirect impacts through disruptions in food chain.	Potential disturbance to nests/foraging areas on beaches and inlet dune tie-ins. Indirect impacts through disruptions in food chain.	Potential disturbance to nests/foraging areas on beaches, inlet dune tie-ins, and saltmarsh losses. Indirect impacts through disruptions in food chain.
Atlantic Loggerhead* (*Caretta caretta*)	**FT***/SE	Marine/Estuarine Pelagic/demersal	No direct impacts anticipated. Indirect impacts through disruptions in food chain.	May enter through inlets to forage in NJBB. Potential impingement on SSB gates when closed. Indirect impacts through disruptions in food chain.	May enter through inlets to forage in NJBB. Potential impingement on CBB gates when closed. Indirect impacts through disruptions in food chain.
Kemp's Ridley* (*Lepidochelys kempii*)	**FE***/SE	Marine/Estuarine Pelagic/demersal	No direct impacts anticipated. Indirect impacts through disruptions in food chain.	May enter through inlets to forage in NJBB. Potential impingement on SSB gates when closed. Indirect impacts through disruptions in food chain.	May enter through inlets to forage in NJBB. Potential impingement on CBB gates when closed. Indirect impacts through disruptions in food chain.
Atlantic Green Sea Turtle* (*Chelonia mydas*)	**FT***/ST	Marine/Estuarine Pelagic/demersal	No direct impacts anticipated. Indirect impacts through disruptions in food chain.	May enter through inlets to forage in NJBB. Potential impingement on SSB gates when closed. Indirect impacts through disruptions in food chain.	May enter through inlets to forage in NJBB. Potential impingement on CBB gates when closed. Indirect impacts through disruptions in food chain.
North Atlantic Right Whale (*Eubalaena glacialis*)	**FE**/SE	Marine pelagic	No direct or indirect impacts anticipated.	No direct or indirect impacts anticipated.	No direct or indirect impacts anticipated.
Blue Whale (*Balaenoptera musculus*)	**FE**/SE	Marine pelagic	No direct or indirect impacts anticipated.	No direct or indirect impacts anticipated.	No direct or indirect impacts anticipated.
Fin Whale (*Balaenoptera physalus*)	**FE**/SE	Marine pelagic	No direct or indirect impacts anticipated.	No direct or indirect impacts anticipated.	No direct or indirect impacts anticipated.
Humpback Whale (*Megaptera novaeangliae*)	**FE**/SE	Marine pelagic	No direct or indirect impacts anticipated.	No direct or indirect impacts anticipated.	No direct or indirect impacts anticipated.
Sei Whale (*Balaenoptera borealis*)	**FE**/SE	Marine pelagic	No direct or indirect impacts anticipated.	No direct or indirect impacts anticipated.	No direct or indirect impacts anticipated.
Sperm Whale	**FE**/SE	Marine pelagic	No direct or indirect impacts anticipated.	No direct or indirect impacts anticipated.	No direct or indirect impacts anticipated.

Species	Status	Habitat in NJBB	Perimeter Impacts (see note #1)	SSB Impacts (TSP Features)	CBB Impacts (TSP Features)
(*Physeter microcephalus*)					
Northern Long-Eared Bat (*Myotis septentrionalis*)	FT	Summertime roosts beneath the bark of live and dead trees.	Perimeter measures for Cape May was screened out that would have impacts on forested wetland	Approximately 0.4 acres of maritime forest would be affected by a floodwall associated with the Barnegat Inlet SSB at Barnegat Inlet State Park. The Tier 2 EIS during Engineering and Design Phase will consider any alternative alignments to avoid/minimize this impact.	A deciduous forested wetland is mapped at the western end of the Absecon Boulevard CBB. Approximately 1.3 acres would be impacted by the levee structure that ties into higher ground. Additional investigation would be required to determine if suitable swamp pink habitat exists and to consider alternative alignments that avoid this wetland altogether.
Atlantic Sturgeon* (*Acipenser oxyrinchus oxyrinchus*)	**FE***/SE	Marine/estuarine Demersal/pelagic	Construction/noise vibrations could impact migrations/feeding habits of adults and subadults. Indirect impacts through disruptions in food chain.	Construction/noise vibrations could impact migrations/feeding habits of adults and subadults. Hydrodynamic/velocity changes could affect migrations through inlets. Indirect impacts through disruptions in food chain.	Construction/noise vibrations could impact migrations/feeding habits of adults and subadults. Hydrodynamic/velocity changes could affect migrations through CBB gates. Indirect impacts through disruptions in food chain.
Northeastern Beach Tiger Beetle (*Cincindela d. dorsalis*)	SE	Atlantic coast sandy beaches	Potential disturbance to habitat on beaches and inlet dune tie-ins.	Potential disturbance to habitat on beaches and inlet dune tie-ins.	Potential disturbance to habitat on beaches and inlet dune tie-ins.
Bronze Copper (butterfly) (*Lycaena hyllus*)	SE	Brackish marshes	Potential disturbance to habitat: brackish marshes.	No direct or indirect impacts anticipated.	Potential disturbance to habitat: brackish marshes.
Seabeach amaranth* (*Amaranthus pumilus*)	**FT***/SE	Upper sandy beaches, accreting ends of inlets	Potential disturbance to habitat on beaches and inlet dune tie-ins.	Potential disturbance to habitat on beaches and inlet dune tie-ins.	Potential disturbance to habitat on beaches and inlet dune tie-ins.
Swamp Pink (*Helonias bullata*)	**FT/SE**	Forested wetlands, primarily in Atlantic white cedar forests	Perimeter measures for Cape May extends into a forested wetland area. If this plan goes forward, then T&E surveys will be done to establish if swamp pink habitat is present and/or for the presence of swamp pink.	No direct or indirect impacts anticipated.	A deciduous forested wetland is mapped at the western end of the Absecon Boulevard CBB. Approximately 1.3 acres would be impacted by the levee structure that ties into higher ground. Additional investigation would be required to determine if suitable swamp pink habitat exists and to consider alternative alignments that avoid this wetland altogether.

FT= Federally Threatened

Note: 1. Perimeter measures were screened out but may be considered for High Frequency Flooding for smaller, localized CSRM measures after additional evaluation.

2. There are over 800 species of Special Status Plants in NJ. Due to the large study area, site specific species data searches will be conducted for the TSP

FE= Federally Endangered

ST=State Threatened

*Informal or formal Section 7 Endangered Species Act consultation anticipated

SE= State Endangered

SOC=Species of Concern

BR= Breeding Population Only

NB= Non-Breeding Population Only

Table 105: Presence of Threatened and Endangered Species Habitat within the Footprint of Measures (Nonstructural, Storm Surge Barriers, Cross-bay barriers, and Perimeter Measures) in Each Region

Threatened and Endangered Species Habitat	TE Species Associated w/ Habitat	Habitat Present within the Footprint of Measures[1] Proposed in Each Region			
		Shark River & Coastal Lakes	North Region	Central Region	South Region
Woodlands: Live and dead trees and/or snags (typically: >:3 inches dbh)	1. N. Long-eared bat 2. Swamp pink (forested wetland)	NS: Yes	MI SSB: No BI SSB[2]: No NS: Yes	GE SSB[2]: No AB CBB: Yes SOC CBB: No PP: No NS: Yes	NS: Yes PP: Yes
Vegetated Dunes and Upper Beaches: Beach above the high tide line, gently sloping foredunes, blowout areas, overwash fans and sand flats	1. Piping plover (nesting) 2. Seabeach amaranth	NS: No	MI SSB: Yes BI SSB[2]: Yes NS: No	GE SSB[2]: Yes AB CBB: Yes SOC CBB: No PP: Yes NS: No	NS: No PP: Yes
Intertidal Habitats: Tidal inlets, sand spits, islets, shoals, sandbars, intertidal sand, or mudflats	1. Red knot (resting/foraging) 2. Piping plover (foraging) 3. Roseate tern (resting/foraging)	NS: No	MI SSB: Yes BI SSB[2]: Yes NS: No	GE SSB[2]: Yes AB CBB: Yes SOC CBB: No PP: Yes NS: No	NS: No PP: Yes
Wetlands: Salt and brackish marshes and associated uplands	1. Black rail	NS: No	MI SSB: No, but could be indirectly affected. BI SSB[3]: Yes NS: No	GE SSB[4]: Yes AB CBB: Yes SOC CBB: Yes PP: Yes NS: No	NS: No PP: Yes
Estuarine open waters	1. Atlantic sturgeon 2. Sea turtles	NS: No	MI SSB: Yes BI SSB[2]: Yes NS: No	GE SSB[2]: Yes AB CBB: Yes SOC CBB: Yes PP: Yes NS: No	NS: No PP: Yes
SAV	1. Sea turtles	NS: No	MI SSB: No, but could be indirectly affected.	GE SSB[2]: No, but could be indirectly affected.	NS: No

Threatened and Endangered Species Habitat	TE Species Associated w/ Habitat	Habitat Present within the Footprint of Measures[1] Proposed in Each Region			
		Shark River & Coastal Lakes	North Region	Central Region	South Region
			BI SSB[2]: No, but could be indirectly affected. NS: No	AB CBB: No SOC CBB: No PP: No NS: No	PP: Yes
Subtidal: Benthic and demersal habitat such as shellfish beds or structure	1. Atlantic sturgeon 2. Sea turtles	NS: No	MI SSB: Yes BI SSB[2]: NS: No	GE SSB[2]: Yes AB CBB: Yes SOC CBB: Yes PP: Yes NS: No	NS: No PP: Yes
Pelagic open ocean waters	1. Northern right whale 2. Fin whale 3. Atlantic sturgeon 4. Sea turtles	Outside of study area but could be indirectly affected.	Outside of study area but could be indirectly affected.	Outside of study area but could be indirectly affected.	Outside of study area but could be indirectly affected.

Notes: [1]Measures include nonstructural, SSBs, CBBs, and perimeter measures.
[2] All alignments (includes A1 – the TSP alignment).
[3] C1 Alignment only (not a current TSP alignment)
[4] B1 and C1 Alignments only (not a current TSP alignment).

Abbreviations: NS=Nonstructural; MI SSB=Manasquan Inlet SSB; BI SSB=Barnegat Inlet SSB; GE SSB = Great Egg Harbor SSB; AB CBB=Absecon Boulevard CBB; SOC CBB=South Ocean City CBB; PP=Perimeter Measures (previously screened out).

Piping Plover

Piping plovers have the potential to nest, forage, rest, and migrate through the Action Area. Noise associated with construction and maintenance of structural and nonstructural measures in the TSP, including flushing from these activities, have the potential to result in minor direct and indirect impacts on piping plover flight, foraging, and nesting behaviors. These disturbances could occur from upland or aquatic construction or maintenance activities. These impacts are expected to be temporary and localized and would be avoided by avoiding construction and maintenance activities during piping plover breeding season, to the maximum extent practicable.

Construction of SSBs, CBBs, and nonstructural measures have the potential to affect piping plover nesting habitat in the upper beach and dunes. Beach slope is a critical factor for piping plover habitat selection and use. It is important not to design a slope greater than the piping plover can utilize. In order to maintain existing habitat conditions, the slope of the placement material shall be consistent with adjacent existing beaches that contain successful brooding areas. It is the practice of the USACE Philadelphia District to create stable beaches which mimic natural, pre-erosion conditions; therefore, the beach slope suitable for use by plovers for nesting or foraging will be maintained or created to the maximum extent practicable.

Noise and sediment disturbances caused by aquatic construction activities have the potential to indirectly affect the foraging success of the piping plover by disturbing benthic invertebrates in intertidal habitat. Studies have shown that most species within the benthic invertebrate community along the shoreline will repopulate the area of impact within a few months (National Research Council, 1995; USACE, 1999; Versar 2001). Closure of the SSBs and tide gates could also result in upstream shifts in salinity, dissolved oxygen, and nutrients which could also temporarily limit prey species availability.

If construction and maintenance activities of SSBs and CBBs occur outside of the plover nesting season (April 1 - August 15), these activities would not have any direct impacts on the piping plover nests, chicks, or the population itself. Similarly, if construction activities would not have direct effects on piping plovers if they are conducted during the plover nesting season in areas that do not provide piping plover habitat. If construction activities taking e place during the plover season when plovers are present could have both direct and indirect impacts on nesting plovers and chicks, as well as their habitat. Trucks or bulldozers, for example, could trample plover chicks, or noise from their operation could impact mate selection, courtship displays, and territorial defense.

In order to avoid direct and indirect impacts, the USACE Philadelphia District will try to avoid construction activities during the plover nesting where plover is present to the maximum extent practicable. If construction activities during the nesting season cannot be avoided (due to monetary issues, quantity of sand required, weather constraints, etc.) the USACE Philadelphia District would attempt to survey for nests and mark avoidance buffers around them and schedule activities in such a way as to avoid areas within the action area with active nests until nesting is complete.

In summary, potential direct impacts to piping plovers, if construction takes place during nesting and breeding season in areas where plovers are present, include: ·

- Temporary unavailability of suitable resting, foraging, and nesting habitat during construction.

- Decrease in available nesting and foraging habitat.
- Loss of productivity due to construction disturbance and harassment.
- Temporary unavailability or reduction of benthic prey resources.
- Injury to or loss of piping plover nests and/or chicks

The Corps would adopt measures to avoid impacts on piping plovers, to the maximum extent practicable.

Cumulative impacts to the piping plover include the reduction of beach nesting, breeding, and foraging habitat. Increased sea levels and continued development also have the potential to impact this species, although the level of impact is relatively uncertain. The impact of the TSP is expected to be negligible relative to the impacts from past, present, and future development and sea level rise. The TSP is not predicted to cumulatively or synergistically interact with other past, present, or future projects in such a way that would significantly adversely the piping plover.

Eastern Black Rail

Direct and indirect impacts/habitat losses on saltmarshes would affect important habitats for the Eastern black rail through either direct displacement of habitat or indirect hydrodynamic changes influenced by the SSBs and CBBs. Eastern black rails have the potential to nest, forage, rest, and migrate through the Action Area. Noise associated with construction and maintenance of structural or nonstructural measures in the TSP, including flushing from these activities, have the potential to result in minor direct and indirect impacts on eastern black rail flight, foraging, and nesting behaviors. These disturbances could occur from upland or aquatic construction or maintenance activities. These impacts are expected to be temporary and localized and would be avoided by avoiding construction during breeding season, to the maximum extent practicable.

Construction of SSBs and CBBs in the TSP have the potential to cause permanent and temporary impacts on wetland habitats that provide nesting habitat for Eastern black rails. It is assumed that for unavoidable wetland and aquatic habitats, compensatory mitigation will be required based on habitat modeling.

Sediment disturbances caused by aquatic construction activities have the potential to indirectly affect the foraging success of the Eastern black rail by disturbing benthic invertebrates in intertidal habitat. However, studies have shown that most species within the benthic invertebrate community along the shoreline will repopulate the area of impact within a few months (National Research Council, 1995; USACE, 1999; Versar 2001). Closure of the SSBs and tide gates could also result in upstream shifts in salinity, dissolved oxygen, and nutrients which could also temporarily limit prey species availability.

Construction of SSBs and CBBs have the potential to affect vegetated dunes and upper beaches that provide habitat for seabeach amaranth. Direct sand placement onto the plant species during the growing season will result in mortality with no chance of seed production. Also, if seeds are buried, the population could suffer adverse impacts that could significantly impact the local population. The construction of impermeable barriers and levee/dune structures along the upper beach have the potential to displace seabeach amaranth habitat along the upper beach/lower dune areas along inlets and ocean beaches.

In summary, potential direct impacts to eastern black rail, if construction takes place during nesting and breeding season in areas where rails are present include: ·

- Temporary unavailability of suitable resting, foraging, and nesting habitat during construction.
- Decrease in available nesting and foraging habitat.
- Temporary unavailability or reduction of benthic prey resources.

Cumulative impacts to Eastern black rail include the loss of nesting, breeding, and foraging habitat. Increased sea levels and continued development also have the potential to impact these species, although the level of impact is relatively uncertain. The impact of the TSP is expected to be negligible relative to past, present, and future development and sea level rise. The TSP is not predicted to cumulatively or synergistically interact with other past, present, or future projects in such a way that would significantly adversely the Eastern black rail.

Red Knot

Red knots have the potential to forage, rest, and migrate through the Action Area. Noise associated with construction and maintenance structural or nonstructural measures in the TSP, including flushing from these activities, have the potential to result in minor impacts on red knot flight and foraging behaviors. These disturbances could occur from upland or aquatic construction or maintenance activities. These impacts are expected to be temporary and localized and would be avoided to the maximum extent practicable.

Noise and sediment disturbances caused by aquatic construction activities have the potential to indirectly affect red knot by disturbing benthic invertebrates in intertidal habitat. Closure of the SSBs and tide gates can result in upstream shifts in salinity, dissolved oxygen, and nutrients which could also temporarily limit prey species availability.

In summary, potential direct impacts to red knots if construction takes place during when they are present include:

- Temporary unavailability of suitable resting and foraging habitat during construction.
- Temporary unavailability or reduction of prey resources.

Cumulative impacts to the red knot could include a change in distribution of species related indirect impacts from SSBs and from sea level rise, although the level of impact is relatively uncertain. The impact of the TSP is expected to be negligible relative to the impacts from sea level rise. The TSP is not predicted to cumulatively or synergistically interact with other past, present, or future projects in such a way that would significantly adversely the red knot.

Roseate Tern

Roseate terns have the potential to forage, rest, and migrate through the Action Area. Noise associated with construction and maintenance structural or nonstructural measures in the TSP, including flushing from these activities, have the potential to result in minor impacts on roseate flight and foraging behaviors. These disturbances could occur from upland or aquatic construction or maintenance activities. These impacts are expected to be temporary and localized and would be avoided to the maximum extent practicable.

Noise and sediment disturbances caused by aquatic construction activities have the potential to indirectly affect the nesting foraging success of the roseate by disturbing fish in estuarine waters. Closure of the SSBs and tide gates can result in upstream shifts in salinity, dissolved oxygen, and nutrients which could also temporarily limit prey species availability.

In summary, potential direct impacts to roseate terns if construction takes place during when they are present include:

- Temporary unavailability of suitable resting and foraging habitat during construction.
- Temporary unavailability or reduction of prey resources.

Cumulative impacts to the roseate tern could include a change in distribution of species related to indirect impacts from SSBs and from sea level rise, although the level of impact is relatively uncertain. The impact of the TSP is expected to be negligible relative to the impacts from sea level rise. The TSP is not predicted to cumulatively or synergistically interact with other past, present, or future projects in such a way that would significantly adversely the roseate tern.

Seabeach Amaranth

Construction of SSBs and CBBs have the potential to affect vegetated dunes and upper beaches that provide habitat for seabeach amaranth. Direct sand placement onto the plant species during the growing season will result in mortality with no chance of seed production. Also, if seeds are buried, the population could suffer adverse impacts that could significantly impact the local population.

Beach slope is also a critical factor for seabeach amaranth habitat selection and use. It is important not to engineer a slope greater than what is exhibited at existing seabeach amaranth locations. In order to maintain existing habitat, the slope of the placement material must be consistent with the current habitat.

If construction activities occur during the seabeach amaranth growing season, potential trampling of the plants by workers, vehicles, or construction equipment could also destroy the plants directly.

Construction impacts on seabeach amaranth would be avoided to the maximum extent practicable. Surveys in the appropriate habitat for seabeach amaranth would be conducted prior to construction during the growing season. USFWS would be consulted if seabeach amaranth is identified. Seabeach amaranth dies back in September and is no longer in a form that is easily impacted.

North Atlantic Right Whale and Fin Whale

North Atlantic right whales use the waters off New Jersey as a migratory pathway, but typically occur further offshore than the action area. Fin whales also use the waters off New Jersey for migration, but also potentially calve there. It is unknown where calving, mating, and wintering occur for the majority of the fin whale population. Fin whale also typically occur outside the action area in New Jersey.

These species have the potential to be affected by noise and vessel operations associated with construction, operation, and maintenance of the SSB; however, they are generally expected occur further offshore than the extent of these impacts making the potential for these impacts discountable.

Atlantic Loggerhead, Kemp's Ridley, Atlantic Green, and Leatherback Sea Turtle

Construction, operation, and maintenance of the SSBs in the TSP have the potential to result in direct and indirect effects on sea turtles. Atlantic Loggerhead, Kemp's Ridley, Atlantic Green, and leatherback sea turtles have the potential to occur in the action area, typically from May through November. Leatherback sea turtles generally occur further offshore than the other sea turtles.

Construction of the SSBs have would temporary direct impacts on estuarine open waters, intertidal and subtidal benthic habitat, including SAV, which serve as sea turtle forging habitat. Minor and temporary increases in turbidity are expected during construction from activities such as the installation and removal of temporary cofferdams, temporary excavations, fill and rock placement, concrete work, and noise and vibrations during pile driving. Temporary disturbances of intertidal and subtidal habitats, including SAV, may be experienced through the placement of de-watering structures and either temporary fills or excavations for temporary access points to the work segment. Temporary habitat impacts could also result from sedimentation caused by sediment disturbance. Benthic habitats are expected to recover quickly. Because these impacts are temporary and localized, impacts are expected to be insignificant.

Storm surge barriers and CBBs have the potential to result in the loss of 12 acres of intertidal habitat, 56 acres of subtidal habitat, and three acres of historical SAV beds. The presence of the SSBs could result in additional long-term impacts from increased velocities and scouring.

Turbidity and noise associated with construction, maintenance, and operation of the structures could disturb sea turtles foraging in New Jersey back bays, causing them to move away from these activities. This could result in an adverse effect in their daily movement patterns or foraging in the Action Area. Depending on the noise source, noise could result in injuries to sea turtles. Interactions with mechanical equipment could also result in injury to sea turtles. If possible, construction would be scheduled to avoid times when sea turtles are present in the action area. If construction cannot be avoided when sea turtles are present in the action area, BMPs such as the following would be implemented to avoid and minimize impacts on sea turtles:

- Develop a protected marine species monitoring and shut down plan.
- Use a mechanical dredge rather than a pipeline or hopper dredge.
- For pile driving, use a vibratory hammer instead of an impact hammer, to the maximum extent practicable.
- Use cushion blocks or other noise attenuation devices when using an impact hammer for pile driving.
- Limit pile driving activities to no more than 12 hours per day.
- Use a "soft start" for a pile driving activities where driving does not occur at full power at first.

- Pile driving should be carried out in a way that avoids exceeding noise thresholds identified for the protected marine species that occur in the action area.

Construction and maintenance of the SSBs and CBBs could result in a slight increased risk of a sea turtle-vessel interaction or collision. A risk of a vessel strike would be low because of the very limited amount of time construction or maintenance barges or vessels would be in the water and the limited speed of the vessels. Additionally, NMFS vessel operation BMPs would be implemented to the maximum extent practicable to avoid and minimize impacts; these include:

- Shallow draft vessels that maximize the navigational clearance between the vessel and the river bottom should be used where possible.
- Vessels should operate at speeds of less than 10 knots. Whenever operating in areas where whales or sea turtles are present, a look out should be posted and measures taken to slow down and avoid any whales or sea turtles spotted.

Indirect impacts on sea turtle foraging habitat could result from potential changes in salinity from gate closures and influxes of freshwater from precipitation, which could result in changes in floral and faunal community. Indirect effect on sea turtle foraging habitat and prey species could result from the operation of SSBs by altering velocities, sediment scour and deposition, water quality, salinity levels, and nutrient levels. The changes could occur from both from the presence of the SSBs and CBBs, as well as the closing of the barriers. Gate closures would occur with influxes of freshwater from precipitation. These changes could result in the effects on the abundance and distribution of SAV, as well as benthic and floating invertebrates that serve as foraging habitat and prey for sea turtles.

Understanding of potential direct and indirect effects of SAV are speculative. While no direct effects on existing SAV beds are expected, SAV mapping does not exist for the entire f ootprint. However, historic mapping indicates SAV occurrences within 2.6 acres of the Barnegat Inlet SSB alignment. Additionally, SAV distributions are seasonal and can change from year to year. A more precise estimate of temporary and permanent disturbance will be available upon completion of SAV surveys in all locations/waterways with SSB and CBB structures and with a higher level of design and construction plan of the structures involved

Closure of the SSBs and tide gates could result trap sea turtles or impede their passage into the Action Area. This could potentially affect their daily movement patterns, migrations in and out of the Action area, and potentially could also impact their foraging in the Action Area. Storm surge barriers could also result in indirect effects in the Action Area, which could, in turn, foraging opportunities for sea turtles in the Action Area while turtles are trapped behind the SSBs. This would only occur SSBs and CBBs are closed during storm conditions. This would be a temporary effect as the SSBs and CBBs would not likely be closed for a period of more than a week at a time and mortalities are not expected.

In summary, construction, operation, and maintenance of the SSBs associated with the TSP have the potential for direct and indirect effects on sea turtles. These include

- Loss of habitat;
- Changes in distribution of SAV and prey species;
- Noise impacts including changes in behavior or injury;
- Potential for injury from mechanical equipment associated with construction;

- Vessel interactions; and
- Entrapment within SSBs.

The impacts from the TSP could result in potential cumulative on sea turtles from the following past, present, and future impacts which occur throughout the sea turtles' range:

- Ship strikes from commercial and recreational vessel traffic;
- Noise impacts from other waterfront construction and development;
- Exposure to contaminants such as oil spills;
- Loss of habitat from development and sea level rise;
- Changes in the abundance and distribution of foraging habitat and prey species associated with climate change.
- Fishery bycatch and entanglement in derelict fishing gear.

The impact of the TSP is expected result be negligible relative to the effects, injuries, and mortalities resulting from these stressors.

Atlantic Sturgeon

Atlantic sturgeon might use the New Jersey Back Bay and the nearshore coastal waters off New Jersey during their adult marine life stage, but typically occur further offshore than the action area. While this species has the potential to be affected by noise and vessel operations associated with construction, operation, and maintenance of the SSB, because it is expected occur further offshore than the extent of these impacts, the potential for these impacts is discountable.

Based on a review of existing information, the USACE draft Biological Assessment (BA) has concluded that the TSP is likely to adversely affect the following species:

- Piping plover
- Eastern black rail
- Seabeach amaranth
- Atlantic loggerhead sea turtle
- Kemp's ridley sea turtle
- Atlantic green sea turtle
- Leatherback sea turtle

The USACE BA has concluded that the TSP is not likely to adversely affect the following species:

- Roseate tern
- Red knot
- North Atlantic right whale
- Fin whale

- Atlantic sturgeon

8.2.4.25.2 Nonstructural Measures (TSP Features for 2A, 3E(2), 4G(8) and 5A)

Nonstructural measures involve a significant construction effort whether it be from building retrofits such as elevation (including raising a structure on fill or foundation elements such as solid perimeter walls, pier, posts, columns, or pilings) or buyout/ relocations that are likely to involve demolition, grading, and soil stabilization/ revegetation. However, existing structures would most likely be in upland urbanized settings where construction activities are not expected to result in any direct takes or loss of critical habitats for special status species. However, for Federal status species, a "no effect" determination cannot be made until site specific details on locations and methods are available.

8.2.4.25.3 Natural and Nature-Based Features (TSP Features Warranting Further Analysis)

NNBFs, similar to the other structural and nonstructural measures would involve construction impacts during the time of implementation. The degree of the impact is largely dependent on the feature and its method of construction. At this time, the degree and extent of impacts an NNBF measure would have on special status species it is not known. NNBFs, for the most part, involve implementing features in aquatic habitats. Implementation of NNBFs during construction is expected to have short-term adverse impacts on both aquatic and terrestrial habitats, as these activities may significantly disturb these habitats and generate turbidity during construction. NNBFs such as saltmarsh restoration have the potential to have long-term direct or indirect benefits for a number of Federal and state special status species that require an NNBF habitat for one of its life requisite needs. These effects would have to be weighed based on the location of existing sensitive habitats and the ecological services and uplift that an NNBF measure provides.

8.2.4.26 Coastal Lakes

8.2.4.26.1 Impacts Common to All Structural Alternatives

8.2.4.26.1.1 Perimeter – Floodwalls, Levees and Miter Gates (Screened Out Measure)

8.2.4.26.1.2 Storm Surge Barriers/Cross-bay barriers (TSP Features for 3E(2) and 4G(8)

8.2.4.26.1.2.1 Direct and Indirect Impacts

Several Coastal Lakes occur within the lower Manasquan River estuary, which are tidally connected to the Manasquan River and Manasquan Inlet. These lakes include Stockton Lake, Glimmer Glass, and Lake Louise. The Manasquan perimeter measures (Alternative 3D) would provide miter gates at the bridges on Brielle Road and Green Road. These gates would remain open during normal conditions and would maintain tidal exchange with Glimmer Glass and

Stockton Lake. However, closure of the miter gates during extreme storm events could result in upstream shifts in salinity, dissolved oxygen, and nutrients which could temporarily limit prey species availability.

SSBs are features located in Manasquan Inlet and Barnegat Inlet as TSP alternative 3E(2). The Manasquan Inlet SSB would indirectly affect Stockton Lake, Glimmer Glass, and Lake Louise, and the Barnegat Inlet SSB would have indirect effects on Twilight Lake (Bay Head), which is in the upper Barnegat Bay. Similar to the perimeter measure miter gates, the SSB closures during extreme storm events could result in upstream shifts in salinity, dissolved oxygen, and nutrients which could also temporarily limit prey species availability.

8.2.4.26.2 Nonstructural Measures (TSP Features for 2A, 3E(2), 4G(8) and 5A)

Nonstructural measures were identified in the focused array of alternatives in several coastal lake areas that are within the Shark River, Coastal Lakes, and Northern Regions. The Shark River area includes nonstructural measures around the freshwater and slightly brackish lakes that do not have direct tidal influence. Those lakes are Sylvan Lake, Silver Lake, and Lake Como, which are all considered to be impaired due to pathogen contamination, algal blooms, aquatic weed overgrowth and eutrophication primarily related to inputs of stormwater and runoff from their surrounding watersheds (Tiedeman et al. 2009). In the Northern Region, tidally influenced lakes occur in the Manasquan Estuary, including Stockton Lake, Glimmer Glass, and Lake Louise. Twilight Lake receives tidal influence from the northern Barnegat Bay. Other lakes included in this region that do not have direct tidal connections are Little Silver Lake and Lake of the Lilies, which are both in Point Pleasant Beach.

Nonstructural measures involve a significant construction effort whether it be from building retrofits such as elevation (including raising a structure on fill or foundation elements such as solid perimeter walls, pier, posts, columns, or pilings) or buyout/ relocations that are likely to involve demolition, grading, and soil stabilization/ revegetation. All of these activities would involve temporary earth disturbances, similar to some of the effects expected during construction of the structural measures, that could potentially produce turbidity in the coastal lakes causing further degradation of these impaired waterbodies. However, these temporary soil disturbances can be readily managed by implementing appropriate BMPs to minimize turbidity generated from stormwater runoff into these waterbodies.

Nonstructural measures such as buyout and relocation could result in indirect improvements to water quality by the removal of impervious surfaces (through demolition) and replacement with permeable soils and vegetation. In some cases, it may be possible to implement stormwater facilities in these locations. If implemented on a large scale, this action could effectively reduce urban runoff and stormwater carrying sediments and a number of other pollutants into the coastal lakes.

8.2.4.26.3 Natural and Nature-Based Features (TSP Features Warranting Further Analysis)

Due to the highly variable conditions of the various lakes, very few generalizable NNBF measures are possible within this region. The reduction of flood risk is something that must be considered on a lake-by-lake basis. However, terracing or lining lakes with vegetation that could serve as stormwater filters, habitat, and increased recreational amenities is one overall NNBF strategy. Other NNBF considerations for this region include tide gate improvements and dune enhancements along the Atlantic Coast shoreline. Any NNBF strategies implemented would likely involve invasive earth-disturbance, de-watering, and many activities that would temporarily introduce turbidity, vegetation removal and disrupt fish and wildlife habitats and the communities that surround these lakes. Ultimately, NNBFs would enhance these lakes. Additional evaluations on NNBFs in the Coastal Lakes Region will be considered in subsequent phases.

8.2.4.27 Cultural Resources

No Action/Future Without Project Alternative

The No Action/Future Without Project Alternative involves no additional action by USACE to mitigate against coastal storm risk. Climate change-driven sea level change and the potential for more frequent coastal storms are expected to continue over the next 50 years and into the future. Predicted climate change impacts, such as erosion of beaches and extended storm surge inundation may likely continue and worsen over time. Climate change and associated sea level change may likely increase the depth and extent of storm surge inundation, as well as increase potential for more frequent nuisance flooding and increase the depth of water during nuisance flood events.

It is expected that sea level change and coastal storms would continue to increase along with population growth in the APE, potentially impacting historic properties. Effects upon historic properties would be cumulative and are expected to continue over time without further action or project implementation. Additional historic properties and archaeological sites would potentially be added to the county database with new investigations associated with future development and with buildings and structures reaching 50 years of age.

TSP Alternative

Each of the three SSBs will require a marine remote-sensing investigation to assess for submerged historic resources, and a terrestrial archaeological investigation at each anchor point, as well as areas of access and staging.

The Absecon Boulevard bay closure has the potential to impact, either directly or indirectly, the following recorded historic properties: The US Coast Guard Station, Atlantic City; the Atlantic City Armory; the Absecon Boulevard Bridge; the Venice Park School; the Atlantic City Beautiful Historic District; the South Main Avenue Streetscape; and numerous individual historic properties that have not yet been assessed for their eligibility for listing on the NRHP. Further assessments of direct, indirect, or visual impacts will be needed.

The South Ocean City Bay Closure has the potential to impact, either directly or indirectly, the Atlantic City Railroad OCB Trestle over Edwards Creek, and numerous individual historic properties that have not yet been assessed for their eligibility for listing on the NRHP. Further assessments of direct, indirect, or visual impacts will be needed.

The Nonstructural solutions for 18,800 structures will have an effect on both recorded and unassessed historic properties. This solution has the potential to cause greater adverse effects to historic properties than any of the other structural solutions, and thus carries the most risk and the potential for expensive mitigation. Recorded Historic Districts (HD) within these areas include: the Camp Evans National Historic Landmark (NHL), North Shore Road, the Oceanville/Leeds Point/ Moss Mill, Beach Haven, Tuckerton, Shipbottom, Barnegat, Viking Village, Midway Camps, Seaside Park Yacht Club, Ocean Beach, Mantoloking, Bayhead, Manasquan Main Street, Ocean City Residential, Somers Point Bay Front, Morris Beach, Linwood, Ventnor Parkway, Marven Gardens, Ventnor Avenue Residential, Northside Institutional, Atlantic City Beautiful, Stone Harbor Downtown, Wildwood Shore Resort, Cape May Point, and the City of Cape May NHL. Each of these Historic Districts include numerous individually eligible historic properties, as well as contributing structures. Further investigations, analyses, and determinations of eligibility will be needed.

A Phase IA scope of work and independent government estimate has been prepared for the TSP which will include: 1) an temporal overview of the southern coast of New Jersey, with a more defined historic context within each study reach; 2) tables of eligible and listed aboveground historic structures and districts; 3) tables of below-ground historic and prehistoric archaeological sites; 4) recorded shipwrecks and sensitive anomalies/targets; and, 5) defined areas of cultural resource sensitivity within the TSP APE and recommendations for further research and investigation.

As we are anticipating the need for additional analyses to determine the project's impact on historic properties, the USACE will be negotiating a Programmatic Agreement to continue Section 106 investigations in consultation with the NJSHPO, the Tribes, and other consulting parties within the TSP.

8.2.4.28 Recreation

8.2.4.28.1 Impacts Common to All Structural Alternatives

8.2.4.28.1.1 Perimeter – Floodwalls, Levees and Miter Gates (4D(1), 4D(2) and 5D(2)

8.2.4.28.1.2 Storm Surge Barriers/Cross-bay barriers (TSP Features for 3E(2) and 4G(8)

"Leisure and Recreation" is a category in the "Other Social Effects" system of accounts in USACE plan formulation. Leisure and Recreation is defined as having access to healthy and safe outdoor recreation. For the perimeter protection plans, the implementation of floodwalls and levees could have potential significant adverse effects on recreation by limiting easy access to the bays and other waterways for water- oriented activities as described in the Affected Environment Section. In many locales within the focused array of alternatives, the floodwalls would form a barrier that would be approximately 5 to 10 feet higher than the ground surface elevation, which would make it difficult for persons to access docks, boats, or the bay shoreline. This potential effect would require further evaluation to determine the extent of this impact, and to identify acceptable means to avoid or minimize this impact. In some locales, levees are also a perimeter feature that could also limit access to recreational activities.

Storm surge barriers and CBBs would maintain navigable access under normal conditions through opened sector gates or miter gates (in smaller waterways). However, navigation in these locations would be restricted to only locations where there are navigable sector gates. Miter gates are also a component of the perimeter measures but also exist in the CBB plans. Recreational access will be cut off when the gates of these structures are closed during extreme flood events. However, this effect would not have significant impacts on recreation because recreational activities are not likely during a storm event. Additionally, gate openings (when open) may permanently constrict flows causing higher velocity changes around these structures and could have significant adverse effects on recreational boaters. Therefore, further evaluation of potential effects on velocity changes would be required to determine if there are any indirect effects such as changes to navigation channel velocities and effects on recreational water uses.

8.2.4.28.2 Nonstructural Measures (TSP Features for 2A, 3E(2), 4G(8) and 5A)

Nonstructural measures involve a significant construction effort, whether from building retrofits such as elevation (including raising a structure on fill or foundation elements such as solid perimeter walls, pier, posts, columns, or pilings) or buyout/ relocations that are likely to involve demolition, grading, and soil stabilization/ revegetation. The implementation of nonstructural measures such as building retrofits or buyout/relocations will result in temporary disruptions in the communities surrounding these activities due to noise, vehicles, and temporary road closures. All of these disruptions could temporarily affect recreation depending on the type of construction activity, season, and the type of recreation activities within the vicinity. However, recreation activities would be expected to resume once the construction/demolition ceases. Programs such as buyouts could result in more recreational opportunities as these areas would likely become public lands intended for recreation and conservation.

8.2.4.28.3 Natural and Nature-Based Features (TSP Features Warranting Further Analysis)

NNBFs during their implementation phases, may result in reduced recreational access and opportunities. However, long-term recreational opportunities may be increased in some NNBFs that offer greater fishing, clamming, birdwatching, and hunting opportunities. Therefore, NNBFs are expected to have beneficial impacts on recreation.

8.2.4.29 Visual Resources and Aesthetics

8.2.4.29.1 Impacts Common to All Structural Alternatives

8.2.4.29.1.1 Perimeter – Floodwalls, Levees and Miter Gates (4D(1), 4D(2) and 5D(2)

Perimeter protection plan structures such as floodwalls, levees, miter gates, and pump stations, have the potential to produce significant adverse impacts on aesthetics, particularly for visual resources, which may affect several key human needs dimensions under the “Other Social Effects” category in the system of accounts. Floodwalls with heights ranging from approximately 5 to 10 feet along the back bay communities would obstruct first-floor and patio views of the bays, marshes, and other waterways. Therefore, many residents, restaurants, hotels, and other businesses that include attractive bay views may lose this amenity. Levees with vegetation would be more aesthetically pleasing than floodwalls but would still obstruct bay and marsh views. Also, views would be obstructed along roadways and walking paths. It is anticipated that these effects would be of great interest to adjacent landowners and the communities in general. As such, further evaluation of these potential impacts would be required to determine their social acceptability.

Pump stations, depending on their locations, are expected to have localized minor effects on the aesthetics and visual resources.

8.2.4.29.1.2 Storm Surge Barriers/Cross-bay barriers (TSP Features for 3E(2) and 4G(8)

Similar to the perimeter protection plans, SSBs and CBBs are likely to have significant visual impacts, and given their sizes, would be visible from far distances. The SSBs would be constructed with concrete and steel and would more or less resemble bridge-like structures across the inlets. Based on their locations, the SSBs would have variable adverse effects on visual resources.

<u>Manasquan Inlet SSB</u>: The SSB at the Manasquan Inlet is the smallest of the three structures and has the least effect on visual resources since most of the structure would be built into the existing banks of the inlets with little visual encroachment into the inlet in a “gates open” condition. Though the location of the gates is in an existing developed location, a concrete and steel structure composed of navigable sector gates and their housing would be visible from both banks of the inlet, within the inlet and west of the inlet.

<u>Barnegat Inlet SSB</u>: An SSB at Barnegat Inlet would be situated west of the inlet but would impose significant adverse effects on visual resources in the general area. A concrete and steel structure would permanently span across the bay for approximately 4,300 ft., which would include navigable sector gates, vertical lift gates and abutments, box culverts, and a seawall tying into Island Beach State Park would span Barnegat Bay in the inlet region, and be visible from the west side of Barnegat Light, Barnegat Lighthouse/Barnegat Inlet State Park, recreational boaters in Barnegat Bay, and Island Beach State Park. There are no existing similar structures of this type within the Barnegat Inlet area.

<u>Great Egg Harbor Inlet (GEHI) SSB</u>: The SSB at GEHI is the largest of the three SSBs in the TSP and would permanently span a little over a mile across the inlet. Like the Barnegat Inlet SSB, the GEHI would have similar structures such as navigable sector gates, vertical liftgates and their abutments, and impermeable barriers composed of concrete and steel. The GEHI SSB would impose a significant visual impact from the beaches and residences of northern Ocean City and Southern Longport, visitors to Malibu Beach W.M.A., and from recreational boaters transiting GEHI. Although the GEHI SSB would be a massive structure, there are several existing large bridges in the general area that visually characterize the area including the Ocean Drive Bridge, Somers Point Blvd. Bridge, JFK Memorial Bridge, and the Stanton Memorial Causeway. Therefore, the visual effects would be significant, but not overall out of character for the area.

Cross-bay barriers: Portions of the CBBs contain perimeter (floodwall or levee) features that abut existing residential and commercial areas in Atlantic City and Southern Ocean City where first floor views may become obstructed by these structures. For Atlantic City, these areas would mostly be along the waterfronts of Gardner's Basin, Snug Harbor, Delta Basin, State Marina, and along the Clam Thorofare waterfront walkway. In Southern Ocean City, first floor view obstructions would likely be experienced from 59th Street to 52nd Street where a perimeter floodwall or levee would be required. Here, extensive saltmarshes currently offer a scenic visual amenity to the local community and a perimeter feature would significantly affect the viewshed. Figure 109 provides a representative view along this location and the blue line represents an approximate location of the perimeter feature. Because of the visual obstruction that a floodwall or traditional levee structure would impose on visual resources, this location would benefit by implementing the NNBF horizontal levee concept with a recreational trail incorporated as a means to minimize the adverse effect on visual resources. This type of feature will be considered in greater detail in subsequent study/design phases.

Figure 109: View Looking South Along Ensign Road in Southern Ocean City. An extensive saltmarsh landscape occurs to the west where a partially obstructed view would be impacted by a perimeter structure as part of the Southern Ocean City CBB. The blue line represents the approximate location of the perimeter feature.

8.2.4.29.2 Nonstructural Measures (TSP Features for 2A, 3E(2), 4G(8) and 5A)

Nonstructural measures involve a significant construction effort whether it be from building retrofits such as elevation (including raising a structure on fill or foundation elements such as solid perimeter walls, pier, posts, columns, or pilings) or buyout/ relocations that are likely to involve demolition, grading, and soil stabilization/ revegetation. The implementation of nonstructural measures such as building retrofits or buyout/relocations will result in temporary disruptions in the communities surrounding these activities due to earth disturbance, noise, vehicles, and temporary road closures. Earth disturbances would be a temporary impact on aesthetics and would improve after the disturbed areas are stabilized with vegetation. Building retrofits such as elevation may have minor permanent adverse impacts on visual resources in some locations where views could potentially be blocked for some people by raised structures; alternatively, some structures may have improved views due to being elevated. Buyouts would likely result in permanent beneficial impacts by improving aesthetics with more natural scenery through increased green spaces and the removal of visual obstructions caused by buildings.

8.2.4.29.3 Natural and Nature-Based Features (TSP Features Warranting Further Analysis)

NNBFs, similar to the other structural and nonstructural measures, would involve construction impacts during the time of implementation. The degree of the impact is largely dependent on the feature and its method of construction. NNBFs, for the most part, involve implementing features in aquatic habitats. Implementation of NNBFs during construction are expected to have short-term adverse impacts on aesthetics by earth and sediment disturbances, noise, and odors. Most of the NNBFs would be constructed in aquatic ecosystems and would be low-profile. Therefore, they are not expected to have adverse effects on viewsheds. Additionally, in most cases NNBFs may improve aesthetics by providing natural features that are consistent with the surrounding landscapes and bay features.

8.2.4.30 Air Quality

8.2.4.30.1 Impacts Common to All Structural Alternatives

8.2.4.30.1.1 Perimeter – Floodwalls, Levees and Miter Gates (4D(1), 4D(2) and 5D(2)

8.2.4.30.1.2 Storm Surge Barriers/Cross-bay barriers (TSP Features for 3E(2) and 4G(8)

The structural alternatives will temporarily produce emissions associated with diesel-fueled equipment used for either water-based or landside construction activities. Construction schedules and durations for any of the structural alternatives are unknown at this time, although it is likely that construction would be in phases over several years. The localized emission increases from the diesel-fueled construction equipment will last only during the project's construction period and primarily occur only locally where work is taking place at any point in time. Therefore, any potential construction impacts will be temporary in nature. However, longer term effects are possible with the operation and maintenance of pump stations for the perimeter protection plans and gate mechanisms for the SSBs and CBBs. These pumps and gate mechanisms could be operated by diesel-powered electrical generators that would produce emissions or they could be powered by the electric grid. Estimates of air contaminant emission rates for the TSP alternatives require more detailed construction schedules and phasing details that are not available during this feasibility study. Therefore, because the study area is in marginal and moderate non-attainment status for ground level ozone, a detailed emissions estimate will be required as part of the Tier 2 EIS prepared during the Engineering and Design Phase. Based on these air quality estimates, a statement of conformity could be required.

8.2.4.30.2 Nonstructural Measures

Nonstructural measures involve a significant construction effort whether it be from building retrofits such as elevation (including raising a structure on fill or foundation elements such as solid perimeter walls, pier, posts, columns, or pilings) or buyout/ relocations that are likely to involve demolition, grading, and soil stabilization/ revegetation. The implementation of nonstructural measures such as building retrofits or buyout/relocations will result in temporary disruptions in the communities surrounding these activities due to earth disturbance, noise, vehicles, and temporary road closures.

Similar to the structural alternatives, the nonstructural alternatives will temporarily produce emissions associated with diesel-fueled equipment used for landside construction activities. Construction schedules and durations for any of the focused array of alternatives are unknown at this time,although it is likely that construction/demolition would take place in phases over several years. The localized emission increases from the diesel-fueled equipment will last only during the construction period and occur primarily where work is taking place at any point in time. Therefore, any potential construction impacts on air quality will be temporary in nature. Implementation of buyouts or relocations may have localized permanent beneficial impacts on air quality by removing emissions sources in residential and commercial areas. However, the effect of the relocation of residents and business on air quality to other locations is unknown.

8.2.4.30.3 Natural and Nature-Based Features (TSP Features Warranting Further Analysis)

NNBF’s in the form of standalone features or as a complementary feature to a structural feature could include living shorelines, reefs, wetland restoration, submerged aquatic vegetation (SAV), and modifications to structural measures including habitat benches to restore more natural slope along shorelines and textured concrete to support colonization of algae and invertebrates.

Similar to the structural and nonstructural alternatives, construction of NNBFs will temporarily produce emissions associated with diesel-fueled equipment used for water and landside construction activities. Construction schedules and durations for any NNBFs are unknown at this time, although it is likely that construction would take place in phases over several years. The localized emission increases from the diesel-fueled construction equipment will last only during the construction period and occur primarily locally to where work is taking place at any point in time. Therefore, any potential construction impacts on air quality will be temporary in nature.

8.2.4.31 Greenhouse Gas (GHG) Emissions

8.2.4.31.1 Impacts Common to All Structural Alternatives

8.2.4.31.1.1 Perimeter – Floodwalls, Levees and Miter Gates (4D(1), 4D(2) and 5D(2)

8.2.4.31.1.2 Storm Surge Barriers/Cross-bay barriers (TSP Features for 3E(2) and 4G(8)

The structural alternatives will temporarily produce GHG emissions (carbon dioxide, methane, nitrous oxide, et. al) associated with diesel-fueled equipment used for either water-based or landside construction activities. Construction schedules and durations for any of the focused array of alternatives are unknown at this time, although it is likely that construction would take place in phases over several years. The localized emission increases from the diesel-fueled construction equipment will last only during the construction period and occur primarily locally to where work is taking place at any point in time. Therefore, any potential construction impacts will be temporary in nature. However, longer term effects are possible with the operation and maintenance of pump stations for the perimeter protection plans and pump and gate mechanisms for SSBs and CBBs. These pumps and gate mechanisms would likely be operated by diesel-powered electrical generators that would produce GHG emissions. The CEQ 2014 GHG guidance focuses the consideration of GHGs on 1) the potential effects of the proposed action on climate change as indicated by its GHG emissions, and 2) the implications of climate change for the environmental effects of the proposed action. At this time, the quantity of GHG emissions is not known. However, a detailed emissions estimate will be required as part of the Tier 2 EIS prepared during the Engineering and Design Phase. These estimates require a more detailed in accordance with current CEQ guidance.

8.2.4.31.2 Nonstructural Measures

Nonstructural measures involve a significant construction effort whether it be from building retrofits such as elevation (including raising a structure on fill or foundation elements such as solid perimeter walls, pier, posts, columns, or pilings) or buyout/ relocations that are likely to involve demolition, grading, and soil stabilization/ revegetation. The implementation of nonstructural measures such as building retrofits or buyout/relocations will result in temporary disruptions in the communities surrounding these activities due to earth disturbance, noise, vehicles, and temporary road closures.

Similar to the structural alternatives, the nonstructural alternatives will temporarily produce GHG emissions associated with diesel-fueled construction equipment used for landside construction activities. Construction schedules and durations for any of the focused array of alternatives are unknown at this time, although it is likely that construction/demolition would take place in phases over several years. The GHG emission increases from the diesel-fueled construction equipment will last only during the construction period and occur primarily locally to where work is taking place at any point in time. Therefore, any potential construction impacts on GHGs will be temporary in nature. Implementation of buyouts or relocations may have localized permanent beneficial impacts on GHGs by removing emissions sources in residential and commercial areas, and by replacing these structures with vegetation such as trees that can consume carbon dioxide.

However, the effect of the relocation of residents and business on GHGs to other locations is unknown.

8.2.4.31.3 Natural and Nature-Based Features (TSP Features Warranting Further Analysis)

Similar to the structural and nonstructural alternatives, the construction of NNBFs will temporarily produce GHG emissions associated with diesel-fueled construction equipment used for water and landside construction activities. Construction schedules and durations for any NNBFs are unknown at this time, although it is likely that construction would take place in phases over several years. The localized GHG emission increases from the diesel-fueled construction equipment will last only during the construction period and occur primarily locally to where work is taking place at any point in time. Therefore, any potential construction impacts on GHGs will be temporary in nature.

8.2.4.32 Climate and Climate Change

8.2.4.32.1 Impacts Common to All Structural Alternatives

8.2.4.32.1.1 Perimeter – Floodwalls, Levees and Miter Gates (4D(1), 4D(2) and 5D(2)

8.2.4.32.1.2 Storm Surge Barriers/Cross-bay barriers (TSP Features for 3E(2) and 4G(8)

As discussed previously, construction and operation and maintenance of the structural alternatives would result in emissions of GHGs. The extent of these emissions is unknown at this time. However, a detailed emission estimate and analysis will be completed upon selection of the Recommended Plan in accordance with current CEQ guidance on GHGs and Climate Change.

The implementation of the structural measures would have beneficial permanent impacts on the affected communities and the region by making them more resilient to future storms and sea level rise.

8.2.4.32.2 Nonstructural Measures

Nonstructural measures involve a significant construction effort whether it be from building retrofits such as elevation (including raising a structure on fill or foundation elements such as solid perimeter walls, pier, posts, columns, or pilings) or buyout/ relocations that are likely to involve demolition, grading, and soil stabilization/ revegetation. The implementation of nonstructural measures such as building retrofits or buy/out relocations will result in temporary disruptions in the communities surrounding these activities due to earth disturbance, noise, vehicles, and temporary road closures.

Similar to the structural alternatives, the nonstructural alternatives will temporarily produce GHG emissions associated with diesel-fueled construction equipment used for landside construction activities but are expected to have a negligible effect on climate change and sea level rise. Implementation of buyouts or relocations may have localized permanent beneficial impacts on

GHGs by removing emissions sources in residential and commercial areas, and by replacing these structures with vegetation such as trees that can consume carbon dioxide. However, the effect of the relocation of residents and business on GHGs to other locations is unknown. Therefore, the effect on climate change is either negligible or unknown.

The implementation of nonstructural measures would have beneficial permanent impacts on the affected communities and the region by making them more resilient to future storms and sea level rise.

8.2.4.32.3 Natural and Nature-Based Features (TSP Features Warranting Further Analysis)

Similar to the structural and nonstructural alternatives, NNBFs will temporarily produce GHG emissions associated with diesel-fueled construction equipment used for water-based and landside construction activities but are expected to have a negligible effect on climate change and sea level rise. Implementation of NNBFs, such as saltmarsh restoration, may have complex associations with GHGs. Under normal conditions, saltmarshes can act as sinks for carbon dioxide where they may store more carbon than a forest, thus giving CO2 the term, “blue carbon”. However, GHG fluxes of carbon dioxide, methane and nitrous oxide may vary based on the degree of cultural eutrophication from high nutrient loads (inputs of N and P), and other factors such as temperature and salinity that affect soil microbe activity. This could result in greater fluxes of the more potent GHG gases, such as methane and nitrous oxide, where marshes could be converted from a GHG sink to a GHG source (Chmura et al. 2016). Since cultural eutrophication is well documented in the NJBB estuary systems, the degree of this effect is unknown when applied to the implementation of saltmarsh NNBFs. Therefore, the effect on climate change is either negligible or unknown.

8.2.4.33 Noise

8.2.4.33.1 Impacts Common to All Structural Alternatives

8.2.4.33.1.1 Perimeter – Floodwalls, Levees and Miter Gates (4D(1), 4D(2) and 5D(2)

8.2.4.33.1.2 Storm Surge Barriers/Cross-bay barriers (TSP Features for 3E(2) and 4G(8)

Humans and fish and wildlife are likely to be adversely impacted by noise generated from construction of the structural measures. During construction of these various features, there will be associated noise from the operation of equipment to construct the floodwalls, levees, and associated miter gates, SSBs, CBBs and pump stations. These activities will produce noise emissions exceeding ambient noise conditions in the general vicinity. The use of heavy construction equipment including graders, dozers, front end loaders, backhoes, cranes, air compressors, and pile hammers will produce the majority of noise during construction, where much of the work will be done in close proximity to residential and commercial areas.

Noise can impact humans and animals in a number of ways. Depending on the magnitude and duration, loud noises can result in hearing loss. On construction sites, hearing loss is typically not associated with residents, but is addressed by OSHA regulations. Other effects noise has on humans can include speech interference, activity interference (sleeping, watching TV, reading, schools, church, etc.) and general annoyance. Water-borne sound and vibration waves caused by construction activities such as blasting, and pile-driving can physically harm aquatic mammals and fish. Knowledge of physical effects of noise on land-based animals is limited.

HUD (1985) provides a range of sounds in decibels (dB) that are comparable to common sounds. On the very faint end of the spectrum, an average whisper measures about 20 dB. Average office sounds and auto traffic near a freeway describe moderate noises in the 42-62 dB range. A loud car horn at 10 feet away is considered very loud at 100 dB, and the noise produced near a jet engine at 140 dB is at the extreme end of the spectrum, which is described as deafening. The U.S. EPA (1972) has adopted the "A" weighting system which adjusts noises frequencies to approximate the sensitivity of a human ear (FAA, 2008). Using this system, construction equipment likely to be used may include common earth moving equipment (72-96 dBA at 50 feet), concrete mixers/pumps (75-88 dBA at 50 ft.), and impact pile drivers (peaks at 95-105 dBA at 50ft.)(Canter, 1993 and U.S. EPA, 1972). Table 106 provides maximum noise ranges of construction equipment over variable distance. Both the FAA and Department of Housing and Urban Development (HUD) define the DNL (average day/night sound level) 65 dB as the threshold of noise incompatibility with residential land uses. Also, the DNL 65 dB provides the basis that FAA uses to determine sound insulating eligibility. Impact pile drivers would likely generate the loudest noises while driving piles. At 50 ft. from the source of pile driving, this would produce noise levels approximately 40 dB higher than the DNL 65 dB level estimated by the FAA (106 dB). Vibratory pile hammers would be less at 95 dBA at 50 feet. Table 107 provides an example of lot-line construction noise criteria limits that were set-up for a project.

Table 106: Maximum Noise Ranges at Various Distances Over Open Air for Some Common Construction Equipment

Equipment	Max. Noise Level at 50 feet. dBA*	Max. Noise Level at 100 ft. dBA**	Max. Noise Level at 200 ft. dBA**	Max. Noise Level at 500 ft. dBA**	Max. Noise Level at 1000 ft. dBA**	Max. Noise Level at 2000 ft. dBA**	Max. Noise Level at 1 mile (5,280 ft.) dBA**
Backhoes	93	87	81	73	67	61	52.5
Tractors	95	89	83	75	69	63	54.5
Cranes, movable	87	81	75	67	61	55	46.5
Generators	82	76	70	62	56	50	41.5
Jackhammers and Rock drills	98	92	86	78	72	66	57.5
Impact pile drivers, peaks	106	100	94	86	80	74	65.5
Vibrator	81	75	69	61	55	49	40.5
Vibratory Pile driver w/ noise	95†	89	83	75	69	63	54.5

Equipment	Max. Noise Level at 50 feet. dBA*	Max. Noise Level at 100 ft. dBA**	Max. Noise Level at 200 ft. dBA**	Max. Noise Level at 500 ft. dBA**	Max. Noise Level at 1000 ft. dBA**	Max. Noise Level at 2000 ft. dBA**	Max. Noise Level at 1 mile (5,280 ft.) dBA**
emission controls							

*from U.S. EPA (1972)

** calculated using inverse square equation: Sound $level_1$-Sound $level_2$=20 log_{10} r_1/r_2

†U.S. Department of Transportation (FHWA, 2006)

Table 107: Example of Lot-Line Construction Noise Criteria Limits A-weighted in dB, RMS slow (FHWA, 2006)

Noise Receptor Locations and Land-Uses	Daytime (7 AM to 6 PM)		Evening (6 PM to 10 PM)		Nighttime (10 PM - 7 AM)	
	L_{10}	L_{max}	L_{10}	L_{max}	L_{10}	L_{max}
Noise-Sensitive Locations: (Residences, Institutions, Hotels, etc.)	75 or Baseline + 5 (whichever is louder)	85-90 (impact)	Baseline + 5	85	Baseline + 5 > (if Baseline <70) >Baseline + 3 (if Baseline 70)	80
Commercial Areas: (Businesses, Offices, Stores, etc.)	80 or Baseline + 5	None	None	None	None	None
Industrial Areas: (Factories, Plants, etc.)	85 or Baseline + 5	None	None	None	None	None

Notes: L_{10} noise compliance readings are averaged over 20 minute intervals. L_{max} noise compliance readings can occur instantaneously. Baseline noise conditions must be measured and established prior to construction work, commencing in accordance with the noise specification, which requires baseline noise readings over three 24-hour periods at each receptor lot-line location.

Based on information provided in Tables 106 and 107, it is likely that maximum noise emissions during construction will exceed the L_{10} of 75 dB or the DNL of 65 dB in any residential or noise-sensitive land uses unless measures are implemented to reduce these levels for the receptors. Construction will be limited to daytime (7 AM to 6 PM) hours during the workweek (Monday – Friday). However, many of these locales are immediately adjacent to residential and rental homes, and this impact would be greatest during peak tourism season.

Effects of noise on fish are complex, and less understood. Studies have indicated that fish are sensitive to sounds where they can detect and respond to sound utilizing cues to hunt for prey, avoid predators, and for social interaction (LFR, 2004). It is documented that intense pressure waves generated from blasting or pile driving can harm or kill most fish in close proximity to the source. High intensity sounds can also permanently damage fish hearing (Nightingale and Simenstad, 2001). Depending upon the duration, location, distance to the fish, and type of sound (i.e., explosions vs. vessel sounds), man-made noise in the marine environment has the potential to impact fish. Studies have found that there are a wide range of potential impacts in response to sounds by fish, ranging from death to behavioral responses. According to ERC, 2012, little research has been done on the effects of sound from dredging on aquatic life, and therefore, little data is available. Behavioral reactions to construction noises (particularly pile driving) are to be expected, however, with possible negative consequences. Behavioral changes could consist of a mild "awareness" of the sound, a startle response (but otherwise no change in behavior) (Wardle et al., 2001), small temporary movements for the duration of the sound, or larger movements that might displace fish from their normal locations for short or long periods of time. Depending upon the level of behavioral change, there may be no significant impact on individual fish or fish populations or there may be a substantial change (e.g., movement from a feeding or breeding site) which could negatively impact the survival of a population (Popper and Hastings, 2009). The noise associated with construction activities will be fairly continuous or at times sporadic. Although there remains some uncertainty until more details about construction activities are known, short-term negative consequences to fish are anticipated, but they are not expected to have a significant long-term impact on fishery resources in the study are. It is expected that fish will generally avoid the active areas during construction but will return once work is complete.

Likewise, construction generated noise can potentially impact wildlife species by impacting breeding, foraging, and resting activities. Buffer zones around sensitive nesting areas would likely minimize this impact. Recent monitoring for piping plovers demonstrates that buffers of 100 meters are appropriate for construction activities from a nest location. A 100-meter buffer zone was established previously in the Longport Bridge Replacement Biological Opinion (USFWS, 2001), where a no jeopardy opinion was rendered provided that a number of protective measures and construction limitations including a 100-meter buffer from pile driving or demolition activities from active nests was implemented. Also, informal consultation for the Route 36 Bridge Replacement over the Shrewsbury River required a noise threshold of +6.0 dBA over ambient sounds on adjacent beaches (Amy S. Greene Environmental Consultants, Inc., 2009). The results of this monitoring concluded that the highest recorded noise level from all construction activities was at +6.1 dBA (from a vibratory pile hammer). However, no behavioral responses by piping plovers to the vibratory pile hammer or other activities were observed. Based on these monitoring studies, it appears that a 100-meter buffer area may be sufficient to minimize and/or prevent impacts to nesting piping plovers from the noise associated with waterborne activities.

8.2.4.33.2 Nonstructural Measures

Nonstructural measures involve a significant construction effort whether it be from building retrofits such as elevation (including raising a structure on fill or foundation elements such as solid perimeter walls, pier, posts, columns, or pilings) or buyout/ relocations that are likely to involve demolition, grading, and soil stabilization/ revegetation. The implementation of nonstructural measures such as building retrofits or buyout/relocations will result in temporary disruptions in the communities surrounding these activities due to earth disturbance, noise, vehicles, and temporary road closures.

Similar to the structural alternatives, the nonstructural alternatives will temporarily produce noise emissions associated with diesel-fueled construction equipment used for landside construction/demolition activities. The effects of the noises generated would be similar to the effects described in the structural impacts section, as these activities would be conducted in urbanized settings composed of residents and commercial activities. However, no long-term adverse noise impacts are expected once construction activities cease. The buyout/relocation alternative may actually improve noise conditions in the surrounding community by the localized removal of noise sources typical of urbanized settings.

8.2.4.33.3 Natural and Nature-Based Features (TSP Features Warranting Further Analysis)

Similar to the structural and nonstructural alternatives, NNBFs will temporarily produce noise emissions associated with diesel-fueled construction equipment used for water-based and landside construction activities. The effects of the noises generated would be similar to the effects described in the structural and nonstructural impacts section, as these activities would be conducted in either urbanized settings composed of residents and commercial activities or in remote bay locations. However, no long-term adverse noise impacts are expected once construction activities cease.

8.2.4.34 Any Adverse Environmental Impacts That Cannot Be Avoided Should the TSP Be Implemented

The TSP will result in minor adverse impacts to benthic organisms during construction , however these impacts would be temporary. Estuarine faunal productivity could be reduced with the TSP. Potential long-term impacts to fish and shellfish with larval and juvenile life stages that depend largely on passive transport through the inlets could result in cumulative impacts. However, particle tracking models indicate that this effect may not be significant as with project residence times in the affected estuaries are very similar to existing conditions.

The ecological effects that the SSBs and CBBs gate structures will have on the affected estuaries were based on modeled constrictions of xx% to 46%. This results in volumetric changes to flow being exchanged through the inlets, known as the tidal prism. However, AdH modeling indicates very little effect on tidal prism in the Manasquan River system, and mean reductions of the tidal prism in Barnegat Bay and Great Egg Harbor by 2.5% and 4.8%, respectively. The impacts of the TSP extend beyond the immediate bays at which the closures are located with reductions in tidal prism less than 1.6%. The modeling results proved to be sensitive to the design configurations with tidal prism reductions two to three times greater in design variations with less gates or shallower sills. Additionally, tidal amplitude changes were modeled with the TSP with reductions by 1.3% to 8.3% throughout Barnegat Bay and 0.1% to 4.5% in Great Egg Harbor estuaries. These impacts may be further reduced as barrier designs are refined.

Direct unavoidable habitat impacts were estimated at the current Tier 1 design level. The TSP components would directly affect over 153 acres of aquatic habitats, which includes about 59 acres of subtidal soft-bottom habitats, about two acres of intertidal mud/sand flats, about nine acres of intertidal sandy beach, and 73 acres of low and high intertidal saltmarshes. These impacts would have unavoidable direct effects on flora and fauna including EFH species. Compensatory mitigation will be required, and preliminary mitigation amounts are provided in the Environmental Appendix. Because that small, expected changes in tidal amplitude are expected over large areas, potential indirect tidal marsh acre losses could be significant. Based on a review of the affected areas, there are thousands of acres of potential compensatory mitigation opportunities with either degraded marsh and aquatic habitats or transitional filled areas that can be restored to full intertidal functions. Subsequent study and project phases will continually refine the designs of the SSBs and CBBs along with additional detailed modeling to predict the hydrodynamic effects on aquatic habitats along with a detailed compensatory mitigation site screening process. These analyses, as part of the Tier 2 EIS, will provide a greater degree of confidence and risk management for establishing appropriate compensatory habitat mitigation needs for indirect effects.

8.2.4.35 Any Irreversible or Irretrievable Commitments of Resources Involved In The Implementation of the TSP

The labor, capital, and material resources expended in the construction of this project are irreversible and irretrievable commitments of human, economic, and natural resources. The loss of over 153 acres of wetlands and aquatic habitats during construction is irreversible; however, mitigation activities would create/restore wetlands on a landscape scale.

8.2.4.36 Relationship Between Local Short-Term Uses of Man's Environment and the Maintenance and Enhancement of Long-Term Productivity

Pursuant to NEPA regulation (40 CFR 1502.16) an EIS must consider the relationship between the short-term uses of the environment and the maintenance and enhancement of long-term productivity. The primary goal of the New Jersey Back Bays Study is to evaluate the feasibility of implementing projects for the purpose of coastal storm risk management along the New Jersey coast.

The construction of the TSP would result in the direct loss of approximately 153 acres of wetlands and associated aquatic habitats. These impacts would be fully mitigated in the same general area resulting in on let loss and preservation of the area's long-term productivity. Indirect effects on these habitats also could stem from slight reductions in tidal amplitudes which may have a greater effect over a large area. Based on a review of the affected areas, there are thousands of acres of potential compensatory mitigation opportunities with either degraded marsh and aquatic habitats or transitional filled areas that can be restored to full intertidal functions. Subsequent study and project phases will continually refine the designs of the SSBs and CBBs along with additional detailed modeling to predict the hydrodynamic effects on aquatic habitats along with a detailed compensatory mitigation site screening process. These analyses, as part of the Tier 2 NEPA phase, will provide a greater degree of confidence and risk management for establishing appropriate compensatory habitat mitigation needs for indirect effects which would account for any losses of long-term productivity of these habitats.

8.2.4.37 Energy and Natural or Depletable Resource Requirements and Conservation Potential of Various Alternatives and Mitigation Measures

NEPA regulations in 40 CFR 1502.16(e) and (f) require a discussion of project energy requirements and natural or depletable resource requirements, along with conservation potential of alternatives and mitigation measures in an EIS. Energy (fuel) will be required to construct the

TSP measures but would only have a short-term impact and would not result in major depletion of depletable energy or natural resources.

8.3 TSP Assumptions including Risk and Uncertainty Analyses Associated with the TSP

In accordance with the Principles and Guidelines (1983) where "planners should identify areas of risk and uncertainty in their analyses and describe them clearly", the NJBB CSRM Study has included risk informed decision making in all aspects of the study. This includes: 1) SMART Planning imperatives such as balancing the level of uncertainty and risk with the level of detail of analysis of the study; 2) ensuring transparent and early vertical team engagement of decision makers as the study process progresses; identifying the Federal role in resolving a problem up front; 3) recognizing there is no single best plan and that there are quantitative and qualitative methods of alternative comparison and analysis; and 4) iterative incorporation of the six-step planning process. In addition, the consideration of risk and uncertainty is built into technical analyses including economic Monte Carlo simulation analyses; inclusion of a number of storm events and scenarios in hydrodynamic modeling to determine with project water levels with statistical confidence levels; and consideration of water level crest height analyses in floodwall design height analyses. Lastly, stakeholder, public and agency involvement has been a critical component of the NJBB CSRM Study and the development of a back bay region-wide vision for managing coastal storm risk throughout the area.

The TSP has made certain assumptions regarding risk and uncertainty elements (which will ultimately be addressed in the Agency Decision Milestone Phase) including:

- TSP reasonably-maximizing NED plan
- System of account, performance, reliability, life safety and adaptability decision metrics
- Overall level of design
- Cost uncertainty/contingency
- Nonstructural analysis expansion
- Environmental indirect impacts/acceptability of features/mitigation costs
- Cultural resources (Phase 1A Contract under development)
- NNBF CSRM benefits
- Real estate analyses (Value estimate under development)

8.4 Future Analyses

A greater level of detail of analysis will be applied to subsequent plan formulation efforts following this Draft Feasibility Report and Tiered EIS. Additional detailed planning analyses will be conducted towards developing a Final Feasibility Report and Environmental Impact Statement with a recommended plan in 2022.

There exist potential refinements to be made before release of the Final Report to ensure proper identification of the NED Plan. The TSP is expected to continue to definitively represent the NED Plan after future evaluation of the key inputs and decision criteria. Using FY21 price levels, the TSP is expected to provide mean AANB of $612,131,000 with a Benefit-to-Cost ratio of 1.8 and 22% in Residual Damages. The TSP is identified to reasonably maximize net NED benefits while accounting for project performance, SLC adaptability, and risk to life safety.

In accordance with ER 1105-2-100, the current NED Plan must also be identified. It provides estimated mean AANB of $632,478,000 with a Benefit-to-Cost Ratio of 1.8 and 23% in Residual Damages.

In addition to the future consideration of the identified TSP and NED plans, continued assessment of nonstructural and perimeter measures in the Central Region are required to conclusively show they are not aspects of the eventual NED Plan and to provide better decision criteria to the non-Federal sponsor in the scenario of a Locally Preferred Plan (LPP).

Future analysis will continue to evaluate the current TSP and the other potential plans under the low and the high curves for sea level change in accordance with ER 1110-2-8162 *Incorporating Sea Level Change in Civil Works Programs.* The quantitative results of this SLC analysis, in conjunction with the results for intermediate SLC, is expected to have a large impact on final plan selection. A detailed discussion of additional future economic analyses is provided in the Economics Appendix.

For nonstructural, future analyses will likely address four methodological refinements. The first is to move away from using focusing on the 5% AEP event floodplain and instead identify structures on the basis of whether the benefits of treating them are larger than the costs. Preliminary analysis suggests that the number of structures selected in this method is similar to that of the 5% AEP event floodplain, but the makeup of the structures, their locations, and the overall net benefits may vary. This work will also make it easier to move towards a neighborhood-based approach, which is likely a more realistic model for how a nonstructural plan would be rolled out to maintain community cohesion.

The second nonstructural refinement is to select structures based on a probabilistic first floor elevation. Currently, structures are selected based on a ground elevation and a foundation height. The ground elevation is highly accurate and is gathered on a structure-by-structure basis, but the foundation height is calculated at a structure occupancy type level. When the FFE is calculated, it sums the structure ground elevation and the mean structure type foundation height. This ignores the wide variation in foundation heights and may systematically under- or over-estimate the number of structures that call for nonstructural. Shifting to a Monte Carlo probabilistic approach, instead of a deterministic approach, will mitigate these risks.

The third nonstructural refinement is to base all nonstructural costs on the square footage of the structure being evaluated. Adding in square footage data would facilitate determining if non-residential structures should be elevated, wet floodproofed, or dry floodproofed as well as provide more realistic costs per structure across all occupancy types.

The fourth nonstructural refinement would address that while buyouts are not part of the TSP at this phase of the study, future analyses would consider that buyouts would have to be 100% non-voluntary and that every house would have to purchase at 100% participation rate for that plan to work and build the perimeter.

The fifth nonstructural analyses to consider in future phases include alternative derivations of clustering. Some of the clustering or aggregation methods that will be considered are areas where a large number of nonstructural methods is recommended for a small area. Designations such as repetitive loss can be used to inform some of the most at risk structures from a historical damage's perspective. Implementing nonstructural in clusters can help reduce the mobilization cost for equipment needed attempting to lower project cost. Structures within political boundaries will also be considered as well as geographic boundaries. Considerations for historical structures can help inform the future aggregations.

The sixth nonstructural analysis will include additional building retrofits such as flood proofing and ring levees for commercial, public, and industrial structures, as well as managed coastal retreat including acquisition / relocation. Future recommendations will also be made regarding land use management and early flood warning elements.

Future analyses will also be performed to assess CSRM opportunities for critical infrastructure. While the type of SSB, gates, and shoreline-based measures (floodwall vs levee, nonstructural, or natural and nature-based features) have tentatively been identified in this report, a detailed critical infrastructure plan will be developed in a near-future study phase towards the development of a comprehensive CSRM assessment for the entire NJBB Region towards managing the risk of coastal flooding and sea level rise to critical infrastructure, property and economic assets as well as maintaining sustainable cohesive resilient neighborhoods.

The development of a more detailed CIP will include detailed ranking and identification of individual focus areas will be evaluated as the recommended plan is further developed. Ranked focus areas can then be developed and subsequently refined based upon social and environmental justice criteria in associated indexes.

Additional potential analyses to be performed during the NJBB CSRM Study phase include:

- Continued assessment of the ability of CSRM measures to meet NJBB CSRM objectives and avoid constraints;
- Continued analyses across the system of accounts inclusive of economic NED, RED, OSE and EQ accounts of alternatives towards the ultimate selected plan;
- Continued analyses to compare alternatives based on completeness, effectiveness, efficiency, and acceptability;
- More detailed Draft Tier 1 EIS inclusive of broad-in-scope (less detail) risk-informed environmental analyses to assist in alternative evaluation to help identify and evaluate broad impact and mitigation concerns. This draft Tier 1 EIS establishes standards, constraints, and processes to be followed in future phases;
- Continued environmental analyses to quantify indirect environmental impacts during closed SSB conditions to consider factors such as impacts to habitat, salinity, circulation, endangered species, cultural resources, or communities as well as assessment of mitigation opportunities and costs;
- Continued cultural resources analyses including development of a Phase 1A archaeological investigation to determine the presence or absence of archaeological resources within a project area and a Phase 2 evaluation to define the spatial boundaries of an archaeological site which provides the information necessary to

design around National Register-eligible sites because parameters have been determined;

- Continued incorporation and integration of Federal and state agency, stakeholder and public comments and efforts into subsequent planning analyses and feasibility report drafts;
- Completion of 30% Design Real Estate Plan (REP), to include complete review of project area real estate as shown on 30% plans. REP will consider real estate interests required, numbers of parcels and landowners in the acquisition area, utilities and other relocations that may be required, the possibility of additional compensable interests, and the inclusion of outstanding probable/possible real estate risks that may impact the project through 100% design, as well as provide a gross estimate of land and ancillary costs;
- A locally preferred plan is a fourth plan type which can be identified in the future if non-benefit maximizing plan is proposed by a non-Federal entity;
- The TSP measures identified in this Draft Integrated Report will undergo a rigorous evaluation of compliance with environmental protection statutes and Executive Orders at subsequent phases of the feasibility study and beyond. A detailed examination of impact avoidance and minimization to better quantify both direct and indirect environmental impacts will also be performed in the future;
- Fragility curves for floodwalls as analyzed in HEC-FDA allows the introduction to properly assess the economic project performance of the proposed plans. While this will not provide insight on life safety concerns nor fully identify the economic risk for perimeter measures, it can partially quantify the risk to adjust estimated NED AANBs. The implementation of these fragility curves is planned for future work before release of the final report;
- Presentation of the TSP as the non-maximizing NED Plan is made with the understanding that significant risk and uncertainty is present in the economic analysis of the TSP and the alternative NED and nonstructural plans due to the level of detail and that these uncertainties will be addressed in future post-TSP analyses to inform the ADM;
- Storm surge barrier gate types and alignments are considered tentative and may change in future phases of the study with more detailed engineer analyses and designs;
- Quantitative life safety risk assessment considering both structural and nonstructural alternatives;
- Consideration of NNBFs as compensatory mitigation for structural features;
- Assessment of the role of the USACE CSRM beach and dune program including obtaining a better understanding of the sensitivity of back-bay water levels to the dune conditions and the performance of the NJBB alternatives both with and without any modifications to existing individual USACE CSRM beach and dune projects;
- Identification of HTRW for FWOP condition and environmental consequences associated with the TSP, and:

- Assessment of socially vulnerable population estimates on an individual county basis.

Following the incorporation of public, stakeholder and agency comments on this Draft Feasibility Report and Tiered EIS in 2021, and subsequent approval by HQUSACE, the TSP will be optimized including the maximization of net benefits towards the Agency Decision Milestone and the Final Feasibility Report and Tiered EIS both of which are scheduled for 2022. During the optimization process, while the footprint of the alternative is not expected to change, other design criteria including the height and design quantities may change and more cost-effective ways to achieve the target level of risk management will be considered.

9 Environmental Laws and Compliance*

The Tentatively Selected Plan and other measures still in consideration require a rigorous examination of compliance with the applicable Environmental Protection Statutes and Executive Orders. Due to the size, scope, and complexity of the problems in the study area, the structural and nonstructural measures being considered, potential impacts and gaps in information on the potential impacts of the structural measures being considered, a Tiered approach is being undertaken in accordance with of the National Environmental Policy Act. The DEIS is considered a Tier 1 document where broad information is being presented for decision-makers, and to establish the appropriate level of compliance with the applicable environmental laws and Executive Orders. For measures that are considered actionable, full compliance must be achieved prior to the issuance of the Chief's Report and Record of Decision at the end of the Feasibility Study. At this time, there are no measures that are considered actionable. However, some items that may not require complex environmental regulatory reviews such as nonstructural measures may be considered actionable at the time of the Agency Decision Milestone (ADM), and will be identified as such. Table 108 provides a rationale for the consideration of TSP measures and other measures still being considered as being actionable at this stage for the applicable environmental laws and executive orders. Therefore, full environmental compliance has not been met. However, with circulation of this document, and earlier scoping activities that involved public notices, letters, public, stakeholder and interagency scoping meetings, and the publication of a Notice of Intent (to prepare an EIS), partial compliance is achieved for the current study phase in accordance with NEPA. Table 108 provides a representation of key environmental compliance statutes and Executive Orders.

9.1 National Environmental Policy Act (NEPA) of 1970, As Amended, 42 U.S.C. 4321, *et seq.*

NEPA requires that all federal agencies use a systematic, interdisciplinary approach to protect the human environment. This approach promotes the integrated use of natural and social sciences in planning and decision-making that could have an impact on the environment. NEPA requires the preparation of an Environmental Impact Statement (EIS) for any major federal action that could have a significant impact on quality of the human environment and the preparation of an Environmental Assessment (EA) for those federal actions that do not cause a significant impact but do not qualify for a categorical exclusion. The NEPA regulations issued by Council on Environmental Quality (CEQ) (40 CFR Part 1500–1508) and the USACE's regulation ER 200-2-2 -Environmental Quality: Policy and Procedures for Implementing NEPA, 33 CFR 230 provide for a scoping process to identify and the scope and significance of environmental issues associated with a project. The process identifies and eliminates from further detailed study issues that are not significant. USACE will use this process to comply with NEPA and focus this General Investigation (GI) study on the issues most relevant to the environment and the decision-making process.

Because of the large scope, scale and complexity of the affected environment and TSP measures, the EIS will be conducted in two stages or tiers. Tiering, which is defined in 40 CFR 1508.28, is a means of making the environmental review process more efficient by allowing parties to "eliminate repetitive discussions of the same issues and to focus on the actual issues suitable for decision at each level of environmental review" (40 CFR 1502.20).

Tier 1 is a broad-level review, and Tier 2 consists of subsequent specific detailed reviews. The broad-level review identifies and evaluates the issues that can be fully addressed and resolved, notwithstanding possible limited knowledge of the project. In addition, it establishes the standards, constraints, and processes to be followed in the specific detailed reviews. As proposed alternatives are developed and refined, incorporating a higher level of detail, the specific detailed reviews evaluate the remaining issues based on the policies established in the broad-level review. Together, the broad-level review and all specific detailed reviews will collectively comprise a complete environmental review addressing all required elements. Tiering the EIS resolves the "big-picture" issues so that subsequent studies can focus on project-specific impacts and issues.

9.2 Clean Air Act, As Amended, 42 U.S.C. 7401, et seq.

Section 118 of the Clean Air Act states that any Federal action that may result in discharge of air pollutants must comply with Federal, State, interstate and local requirements respecting control and abatement of air pollution. Section 176(c) of the Act requires that Federal actions conform to an implementation plan after it has been approved or promulgated under Section 110 of the Act. Because all of the counties within the NJBB CSRM Study area are in non-attainment for ozone, an accounting of emissions for any action contemplated will be required in order to determine if any threshold levels are exceeded that would trigger General Conformity Review. At this stage, no accounting for emissions estimates for temporary construction or long-term operations and maintenance activities has been performed. Emissions estimates will become available in subsequent phases as design and construction details become more refined. Appendix F.8 provides more information.

9.3 Clean Water Act (CWA), 33 U.S.C. 1251, et seq.

Section 401 of the CWA requires every applicant for a Federal license or permit for any activity that may result in a discharge into navigable waters to obtain a State Water Quality Certification (Certification) or waiver that the proposed activity will comply with state water quality standards (*i.e.*, beneficial uses, water quality objectives, and anti-degradation policy). The NJDEP issues section 401 Water Quality Certifications for activities within NJ via the Waterfront Development Permits and CAFRA Permits processes.

Section 402 prohibits the discharge of pollutants to "waters of the United States" from any point source unless the discharge follows a National Pollutant Discharge Elimination System (NPDES) Permit (NJPDES in NJ). Additionally, storm water discharges associated with activities that involve earth disturbances that exceed one acre require an NPDES permit. Given the size and scope of the preliminary focused array of alternative plans, and NPDES storm water permit will likely be required.

Section 404 regulates the discharge of dredged or fill materials into the waters of the United States, including wetlands, at specified disposal sites. The selection and use of disposal sites must be in accordance with guidelines developed by the Administrator of EPA in conjunction with the Secretary of the Army and published in 40 CFR Part 230 (known as the 404(b)(1) guidelines). Under the Section 404(b)(1) guidelines, the USACE shall examine practicable alternatives to the proposed discharge and permit only the Least Environmentally Damaging Practicable Alternative (LEDPA). Section 404 of the CWA and 33 C.F.R. 336(c)(4) and 33 C.F.R. 320.4(b) require the USACE to avoid, minimize, and mitigate impacts to wetlands. The structural alternatives and

NNBF alternatives would likely involve discharges of dredged or fill materials into waters of the United States including wetlands. An evaluation of the Section 404(b)(1) guidelines would be performed as detailed information such as fill quantities; discharge rates and locations are specified in subsequent phases. Jurisdictional wetland determinations would be conducted at the Tier 2 Level. Appendix F.6 provides more information.

9.4 Rivers and Harbors Act, 33 U.S.C. 401, et seq.

This law and its implementing regulations prohibit the construction of any bridge, dam, dike, or causeway over or in navigable waters of the U.S. without Congressional approval. The U.S. Coast Guard administers Section 9 and issues bridge crossing permits over navigable waters. This law and its implementing regulations also allows the U.S. Coast Guard to require necessary lighting and aids to navigation, and to approve any temporary or permanent closures or restrictions of navigation channels. The SSBs and CBBs would constitute bridge crossings by definition; therefore, a permit must be obtained from the USCG once these structures are designed.

9.5 Endangered Species Act (ESA), As Amended 16 U.S.C. 1531, et seq.

The ESA protects threatened and endangered species, and their designated critical habitat, from unauthorized take. Section 9 of the Act prohibits such take, and defines take as to harm, harass, pursue, hunt, shoot, wound, kill, trap, capture, or collect or to attempt to engage in any such conduct. Section 7 of the ESA requires Federal agencies to ensure that any action authorized, funded, or carried out by them is not likely to jeopardize the continued existence of listed species or modify their critical habitat. Consultation with the USFWS or NOAA Fisheries is required if the Federal action may affect a Federally-listed species or designated critical habitat. Given the potential for impacts to Federally-listed species within the NJBB CSRM Study area with any of the preliminary focused array of alternative plans that utilize structural measures informal and/or formal Section 7 consultation is likely to be required. Initiation of consultation will be undertaken with distribution of this document. Appendix F.3 provides a Tier 1 Level Biological Assessment.

9.6 Magnuson-Stevens Fishery Conservation and Management Act (MSA), 16 U.S.C. 1801, et seq.

The Magnuson-Stevens Fishery Conservation and Management Act (PL 94-265), as amended, establishes procedures for the identification of EFH and required interagency coordination to further the conservation of Federally-managed fisheries. Its implementing regulations specify that any Federal agency that authorizes, funds, or undertakes, or proposes to authorize, fund, or undertake, an activity that could adversely affect EFH is subject to the consultation provisions of the Act and identifies consultation requirements. EFH consists of those habitats necessary for spawning, breeding, feeding, or growth to maturity of species managed by Regional Fishery Management Councils in a series of Fishery Management Plans. Based on the locations of the preliminary focused array of alternative plans, all of the structural measures will have direct, indirect, and cumulative effects on EFH, therefore, an EFH assessment was prepared for the TSP and is provided in Appendix F.2.

9.7 Federal Coastal Zone Management Act (CZMA), 16 U.S.C. 1451, et seq.

The CZMA requires each federal agency activity performed within or outside the coastal zone (including development projects) that affects land or water use, or natural resources of the coastal zone to be carried out in a manner which is consistent to the maximum extent practicable, i.e., fully consistent, with the enforceable policies of approved state management programs unless full consistency is prohibited by existing law applicable to the federal agency.

To implement the CZMA and to establish procedures for compliance with its federal consistency provisions, the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), promulgated regulations which are contained in 15 C.F.R. Part 930. As per 15 CFR 930.37, a federal agency may use its NEPA documents as a vehicle for its consistency determination.

In New Jersey, the CZMA Federal Consistency program is administered by the New Jersey Department of Environmental Protection – Division of Land Use Regulation (NJDEP-DLUR). The preliminary focused array of alternative plans includes a number of structural and nonstructural measures that would have significant effects in New Jersey's coastal zone. Appendix F.7 provides a review of applicability of the TSP and other measures of New Jersey's policies pursuant to NJAC 7:7.

9.8 Fish and Wildlife Coordination Act (FWCA), 16 U.S.C. 661, et seq.

The FWCA requires Federal agencies to consult with the U.S. Fish and Wildlife Service (USFWS), NOAA Fisheries, and the fish and wildlife agencies of States where the "waters of any stream or other body of water are proposed or authorized, permitted or licensed to be impounded, diverted or otherwise controlled or modified" by any agency under a Federal permit or license. Consultation is to be undertaken for the purpose of "preventing loss of and damage to wildlife resources." The intent is to give fish and wildlife conservation equal consideration with other purposes of water resources development projects.

Early coordination with the USFWS has been initiated for the NJBB CSRM Feasibility Study. Submittal of the DEIS to USFWS, NOAA Fisheries, and NJDEP initiates coordination pursuant to the FWCA. USFWS will provide a draft FWCA 2(b) Report as part of the formal review. A final FWCA 2(b) Report will be prepared after agency review of the Draft EIS and USACE responses to comments are reviewed. Appendix F.10 provides correspondence from USFWS.

9.9 Migratory Bird Treaty Act (MBTA), 16 U.S.C. 715-715s, and Executive Order 13186 Responsibilities of Federal Agencies to Protect Migratory Birds

The MBTA prohibits the taking or harming of any migratory bird, its eggs, nests, or young without an appropriate Federal permit. Almost all native birds are covered by this Act and any bird listed in wildlife treaties between the United States and several other countries. A "migratory bird" includes the living bird, any parts of the bird, its nest, or eggs. The take of all migratory birds is governed by the MBTA's regulation of taking migratory birds for educational, scientific, and recreation purposes and requiring harvest to be limited to levels that prevent over-utilization. Section 704 of the MBTA states that the Secretary of the Interior is authorized and directed to determine if, and by what means, the take of migratory birds should be allowed and to adopt suitable regulations permitting and governing take. Disturbance of the nest of a migratory bird requires a permit issued by the USFWS pursuant to Title 50 of the Code of Federal Regulations (CFR).

Construction of the measures identified in the TSP and other alternative plans have the potential to “take” migratory birds, eggs, nests, or young during construction that may involve mechanized land clearing particularly during nesting seasons. In order to comply with MBTA, USACE will coordinate with USFWS and NJDEP to determine appropriate construction windows that avoid such takes, and implement protection measures as part of construction and O&M activities.

9.10 Marine Mammal Protection Act (MMPA) of 1972, 16 U.S.C. 1631, et seq.

The MMPA was passed in 1972 and amended through 1997. It is intended to conserve and protect marine mammals and establish the Marine Mammal Commission, the International Dolphin Conservation Program, and a Marine Mammal Health and Stranding Response Program. The MMPA prohibits the take of marine mammals, and all cetaceans found within the affected areas. The TSP and other measures are being coordinated with USFWS and NOAA Fisheries. Because some of the structures within the TSP include SSBs and CBBs, there is a potential for restriction of aquatic life passage to some marine mammals. USACE will continue to coordinate with these agencies to determine the level of effect, and whether a permit that authorizes incidental take is anticipated to be required for this project.

9.11 National Historic Preservation Act (NHPA) of 1966, 16 U.S.C. 6901, et seq.

The adverse impacts to historic properties that are potentially significant will be addressed by a Programmatic Agreement that specifies the appropriate historic, architectural, and archaeological assessments and investigations required, the process for coordination of these studies with project stakeholders and interested parties, and appropriate mitigation measures agreed to by all. A Draft Programmatic Agreement is being prepared and will be provided in the Cultural Resources Appendix F.5. Although the work specified in the Programmatic Agreement would not begin until the PED Phase of the project, the Programmatic Agreement would be executed prior to signing of the Record of Decision for the EIS. A Programmatic Agreement may be implemented when the effects on historic properties cannot be fully determined prior to the approval of an undertaking (Engineering Regulation 1105-2-100 Appendix C6 4 C(e)).

Under NEPA guidance for Effects upon Cultural Resources (40 CFR 1508.8), Cultural resources would likely be affected by the proposed undertaking although the extent is unknown at this time. However, a Programmatic Agreement, as referenced above, would be implemented during the PED Phase of the study that would include historic and archaeological studies and investigations to complete the identification of historic properties within the project area or Area of Potential Effect (APE). Procedures for the avoidance, minimization and/or mitigation of cultural resources, if identified, would be included along with appropriate coordination with the SHPO, Tribes and other interested parties. Therefore, the overall effects upon cultural resources would be expected to be minimized and mitigated. The draft Programmatic Agreement is provided in Appendix F.5.

9.12 Coastal Barrier Improvement Act (CBIA) of 1990

The CBIA is a reauthorization of the Coastal Barrier Resources Act (CBRA) of 1982. This act is intended to protect fish and wildlife resources and habitat, prevent loss of human life, and preclude the expenditure of Federal funds that may induce development on coastal barrier islands and adjacent nearshore areas. The CBRA established the Coastal Barrier Resources System (CBRS), which consists of mapping of those undeveloped coastal barriers and other areas located on the coasts of the U.S. that were made ineligible for most Federal expenditures and financial assistance. The CBIA of 1990 expanded the CBRS and created a new category of lands known as otherwise protected areas (OPAs). The only Federal funding prohibition within OPAs is Federal flood insurance. Other restrictions to Federal funding that apply to CBRS units do not apply to OPA's. Within the NJBB CSRM Study area, there are 2 existing CBRS units in Barnegat Bay, 1 CBRS unit located at Hereford Inlet and 7 OPA's located throughout the study area. Additionally, the US Fish and Wildlife Service prepared "Draft Revised" CBRA maps, which include a number of proposed changes to existing CBRS units and OPAs within the NJBB CSRM Study area; however, these changes require Congressional authorization. Maps of the existing CBRA areas and "Draft Revised" areas are presented in Appendix F.1.

9.13 Wild and Scenic Rivers Act of 1968 (Public Law 90-542; 16 U.S.C. 1271, et seq.

The National Wild and Scenic Rivers System was created by Congress in 1968 to preserve certain rivers with outstanding natural, cultural, and recreational values in a free-flowing condition for the enjoyment of present and future generations. The Act is notable for safeguarding the special character of these rivers, while also recognizing the potential for their appropriate use and development. It encourages river management that crosses political boundaries and promotes public participation in developing goals for river protection.

The Great Egg Harbor River is located within the NJBB CSRM Study area, and was designated on October 27, 1992. In the NJBB CSRM Study area, Wild and Scenic River status of the Great Egg Harbor River and tributaries are generally west of the Garden State Parkway. Key drainages that are part of the system include Patcong Creek and the Tuckahoe River at near the confluence west of the Garden State Parkway. The TSP includes structural alternatives such as the SSB at Great Egg Harbor Inlet have potential indirect impacts on the Great Egg Harbor River, therefore, USACE will undertake coordination with the National Park Service and the Great Egg Harbor River Council for review under Section 7(a) of the Wild and Scenic Rivers Act. An evaluation of the TSP on the Great Egg Harbor Wild and Scenic River is provided in Appendix F.11.

9.14 Marine Protection Research and Sanctuaries Act (MPRSA)

The Act has two essential aims: to regulate intentional ocean disposal of materials, and to authorize any related research. While the MPRSA regulates the ocean dumping of waste and provides for a research program on ocean dumping, it also provides for the designation and regulation of marine sanctuaries.

The TSP and other measures have not identified any needs, to date, that would involve ocean dumping of waste. A full compliance review of MPRSA will be conducted as engineering details are refined in subsequent phases.

9.15 Resource Conservation and Recovery Act, As Amended, 42 U.S.C. 6901, et seq.

The Resource Conservation and Recovery Act (RCRA) RCRA controls the management and disposal of hazardous waste. “Hazardous and/or toxic wastes”, classified by the Resource Conservation and Recovery Act (RCRA), are materials that may pose a potential hazard to human health or the environment due to quantity, concentration, chemical characteristics, or physical characteristics. This applies to discarded or spent materials that are listed in 40 CFR 261.31-.34 and/or that exhibit one of the following characteristics: ignitable, corrosive, reactive, or toxic. Radioactive wastes are materials contaminated with radioactive isotopes from anthropogenic sources (e.g., generated by fission reactions) or naturally occurring radioactive materials (e.g., radon gas, uranium ore).

As part of the feasibility study, evaluations will be conducted in accordance with ER 1165-2-132, entitled *Hazardous, Toxic and Radioactive Wastes (HTRW) Guidance for Civil Works Projects,* dated June 26, 1992, where investigations must be conducted to assess the existence, nature, and extent of HTRW within a project impact area.

9.16 Comprehensive Environmental Response, Compensation and Liability Act, 42 U.S.C. 9601, et seq.

The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA or Superfund) governs the liability, compensation, cleanup, and emergency response for hazardous substances released into the environment and the cleanup of inactive hazardous substance disposal sites.

As part of the feasibility study, evaluations will be conducted in accordance with ER 1165-2-132, entitled *Hazardous, Toxic and Radioactive Wastes (HTRW) Guidance for Civil Works Projects,* dated June 26, 1992, where investigations must be conducted to assess the existence, nature, and extent of HTRW within a project impact area.

9.17 Farmland Protection Policy Act of 1981 and the CEQ Memorandum Prime and Unique Farmlands

In 1980, the CEQ issued an Environmental Statement Memorandum “Prime and Unique Agricultural Lands” as a supplement to the NEPA procedures. Additionally, the Farmland Protection Policy Act, passed in 1981, requires Federal agencies to evaluate the impacts of Federally funded projects that may convert farmlands to nonagricultural uses and to consider alternative actions that would reduce adverse effects of the conversion. The preliminary focused array of alternatives does not appear to have any effects on farmlands within the study area. An evaluation of the effects of the TSP on farmlands has not identified any adverse effects on prime and unique agricultural lands.

9.18 Executive Order 11990, Protection of Wetlands

This EO directs Federal agencies to avoid undertaking or assisting in new construction located in wetlands unless no practicable alternative is available. A preliminary review of wetland impacts for the TSP and other measures demonstrates a potential significant direct and indirect impacts on wetland resources for the SSBs, CBBs perimeter measures and NNBFs with coastal wetlands. However, to date, these alternatives have not undergone detailed designs, wetland delineations, and avoidance and minimization reviews, which will be done in subsequent design phases. Despite these measures, compensatory mitigation will likely be required for unavoidable impacts as presented in Appendix F.4.

9.19 Executive Order 11988, Floodplain Management

This EO directs Federal agencies to evaluate the potential effects of proposed actions on floodplains. Such actions should not be undertaken that directly or indirectly induce growth in the floodplain unless there is no practicable alternative. The Water Resources Council Floodplain Management Guidelines for implementation of EO 11988, as referenced in USACE ER 1165-2-26, require an eight-step process that agencies should carry out as part of their decision making on projects that have potential impacts on or within the floodplain. A full evaluation pursuant to EO 11900 will be completed as part of the draft and final feasibility study phases.

9.20 Executive Order 12898, Environmental Justice

This EO directs Federal agencies to determine whether the Preferred Alternative would have a disproportionate adverse impact on minority or low-income population groups within the project area. A review of EO 12898 has determined that EJ populations occur within the affected areas of the TSP and other measures, but they are not likely to have disproportionate adverse impacts on minority or low-income population groups.

9.21 Executive Order 13045, Protection of Children from Environmental and Safety Risks

This EO requires Federal agencies to make it a high priority to identify and assess environmental health and safety risks that may disproportionately affect children and to ensure that policies, programs, activities, and standards address these risks. Based on a preliminary review of all structural, nonstructural and NNBFS, it is concluded that the TSP and other measures are not likely to increase risks environmental and safety risks to children Full compliance would likely be achieved upon review of more detailed plans and locations of selected structural and nonstructural measures.

Table 108. Environmental Compliance Status of TSP and Other Measures

	Manasquan Inlet SSB	Barnegat Inlet SSB	Great Egg Harbor Inlet SSB	Absecon Boulevard CBB	Southern Ocean City CBB	Perimeter Measures	Nonstructural Plans	Natural and Nature Based Features	Critical Infrastructure CSRM Measures
	3E(2)*	**3E(2)***	**4G(8)***	**4G(8)***	**4G(8)***	**4D(1), 4D(2) and 5D(2)**	**2A*, 3E(2)*, 4G(8)*, 5A*, 4D(1), 4D(2), and 5D(2)**	**Preliminary Conceptual Designs Being Considered in Each Region**	**No specific CI CSRM Measures proposed at this time, but will continue to be evaluated**
National Environmental Policy Act (NEPA), As Amended, 42 U.S.C. 4321, *et seq.*	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Insufficient information for compliance
	SSB requires additional modeling and design to inform direct and indirect impacts for Tier 1 level FEIS. Full compliance is expected for Tier 1 when ROD is signed. Additional Tier 2 Level NEPA would be conducted during PED phase.			CBB requires additional modeling and design to inform direct and indirect impacts for Tier 1 level FEIS. Full compliance is expected for Tier 1 when ROD is signed. Additional Tier 2 Level NEPA would be conducted during PED phase.		Perimeter Measures would have less complex environmental impacts, and compensatory mitigation estimates could be achieved by Tier 1 FEIS.	No specific NS measures have been proposed at specific locations at this time, but this status could change prior to development of Tier 1 FEIS	No specific NNBF measures have been proposed at specific locations at this time. Further investigations are required to determine NNBF applicability to be complementary to structural and NS measures.	No specific CI measures have been proposed at specific locations at this time. Further investigations are required to determine CI recommendations.
Clean Air Act, As Amended, 42 U.S.C. 7401, et seq.	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Insufficient information for compliance
	Construction details and Operations and Management detail are insufficient at this time to determine emissions estimates and/or need for General Conformity. This would likely be achieved at the Tier 2 EIS Level during PED.								
Clean Water Act (CWA), 33 U.S.C. 1251, et seq.	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance or NA	Partial Compliance	Insufficient information for compliance
	Construction details and Operations and Management detail are insufficient at this time to determine discharge estimates and other effects on water quality. This would likely be achieved at the Tier 2 EIS Level during PED.						NS may not be applicable if they do not result in any type of discharges into waters of the United States.	NNBFS are likely to result in discharges requiring CWA reviews. Insufficient details on quantities and nature of discharges known.	Currently, it is unknown if any potential CI CSRM measures would result in discharges affecting water quality.
Rivers and Harbors Act, 33 U.S.C. 401, et seq.	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance or NA	Partial Compliance	Insufficient information for compliance

	Manasquan Inlet SSB	Barnegat Inlet SSB	Great Egg Harbor Inlet SSB	Absecon Boulevard CBB	Southern Ocean City CBB	Perimeter Measures	Nonstructural Plans	Natural and Nature Based Features	Critical Infrastructure CSRM Measures
	3E(2)*	**3E(2)***	**4G(8)***	**4G(8)***	**4G(8)***	**4D(1), 4D(2) and 5D(2)**	**2A*, 3E(2)*, 4G(8)*, 5A*, 4D(1), 4D(2), and 5D(2)**	**Preliminary Conceptual Designs Being Considered in Each Region**	**No specific CI CSRM Measures proposed at this time, but will continue to be evaluated**
	The structural alternatives would involve in-water construction and the permanent placement of structures and other materials in navigable waters where navigation patterns may be either temporarily disrupted or permanently changed. These alternatives are being coordinated with the U.S. Coast Guard and other interested parties. Because designs are preliminary at this time, compliance is not likely to be achieved until the Tier 2 EIS Level during PED.						NS measures are not likely to involve navigable waters.	NNBFS would involve in-water construction and the permanent placement of structures and other materials in navigable waters where navigation patterns may be either temporarily disrupted or permanently changed. These alternatives are being coordinated with the U.S. Coast Guard and other interested parties. Because designs are preliminary at this time, compliance is not likely to be achieved until the Tier 2 EIS Level during PED.	TBD
Endangered Species Act (ESA), As Amended 16 U.S.C. 1531, et seq.	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance or NA	Partial Compliance	Insufficient information for compliance
	All structural alternatives have the potential to directly or indirectly affect one or more Federally listed species, candidate species or species under review. Partial compliance is achieved by initiating consultation with the USFWS and NOAA Fisheries. Full compliance would require the issuance of a Biological Opinion (BO) and adherence to the reasonable and prudent measures. Agencies have indicated there may not be sufficient information to undertake formal consultation at this level (Tier 1). Because designs are preliminary at this time, compliance is not likely to be achieved until the Tier 2 EIS Level during PED.						NS are not likely to have effects on T&E species, but this is not known until specific measures at	NNBFS are likely to affect T&E species and their habitats, but these effects are unknown until specific NNBF measures/locations are proposed.	TBD

	Manasquan Inlet SSB	Barnegat Inlet SSB	Great Egg Harbor Inlet SSB	Absecon Boulevard CBB	Southern Ocean City CBB	Perimeter Measures	Nonstructural Plans	Natural and Nature Based Features	Critical Infrastructure CSRM Measures
	3E(2)*	**3E(2)***	**4G(8)***	**4G(8)***	**4G(8)***	**4D(1), 4D(2) and 5D(2)**	**2A*, 3E(2)*, 4G(8)*, 5A*, 4D(1), 4D(2), and 5D(2)**	**Preliminary Conceptual Designs Being Considered in Each Region**	**No specific CI CSRM Measures proposed at this time, but will continue to be evaluated**
							specific locations are identified.		
Magnuson-Stevens Fishery Conservation and Management Act (MSA), 16 U.S.C. 1801, et seq.	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance or NA	Partial Compliance	Insufficient information for compliance
	All structural alternatives have the potential to directly or indirectly affect one or more species with EFH. Partial compliance is achieved by initiating consultation with NOAA Fisheries. Full compliance would require the issuance of a Conservation Recommendations (CRs) and a satisfactory response under Section 305(b) of the MSA. NOAA Fisheries has indicated there may not be sufficient information to undertake formal consultation at this level (Tier 1). Because designs are preliminary and information on indirect effects is not available at this time, compliance is not likely to be achieved until the Tier 2 EIS Level during PED.						NS are not likely to have effects on EFH, but this is not known until specific measures at specific locations are identified.	NNBFS are likely to affect EFH, but these effects are unknown until specific NNBF measures/locations are proposed.	TBD
Federal Coastal Zone Management Act (CZMA), 16 U.S.C. 1451, et seq.	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Insufficient information for compliance
	All structural, nonstructural and NNBFS would have effects in New Jersey's Coastal Zone. Federal consistency with the policies in N.J.A.C. 7:7 would be required for all applicable measures to achieve full compliance. USACE will continue to work with NJDEP to determine if any measures or components of measures are consistent with N.J.A.C 7:7 and to identify information for measures that do not contain enough information to make any determination. Because designs are preliminary and information on indirect effects is not available at this time, compliance is not likely to be achieved until the Tier 2 EIS Level during PED.								TBD
Fish and Wildlife Coordination Act (FWCA), 16 U.S.C. 661, et seq.	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Insufficient information for compliance
	All structural, nonstructural and NNBFS would be reviewed in accordance with the FWCA. Because the FWCA review is part of a review of the Tier 1 EIS, additional FWCA reviews may be required during subsequent phases as designs, impact assessment information and mitigation are further refined/developed. Because designs are preliminary and information on indirect effects is not available at this time, full compliance is not likely to be achieved until the Tier 2 EIS Level during PED. However, it is possible that full compliance with FWCA could be achieved during the Tier 1 EIS for some of the NS measures.								TBD
Migratory Bird Treaty Act (MBTA), 16 U.S.C. 715-715s, and Executive Order 13186 Responsibilities of Federal	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Insufficient information for compliance
	All structural, nonstructural and NNBFS would be reviewed in accordance with the MBTA. For full compliance, construction and O&M Activities would require avoidance of harming species on the MBTA list, which would include seasonal restrictions where nesting occurs or surveys to avoid harm. If avoidance is not practicable, MBTA permits would be required.								TBD

	Manasquan Inlet SSB	Barnegat Inlet SSB	Great Egg Harbor Inlet SSB	Absecon Boulevard CBB	Southern Ocean City CBB	Perimeter Measures	Nonstructural Plans	Natural and Nature Based Features	Critical Infrastructure CSRM Measures
	3E(2)*	**3E(2)***	**4G(8)***	**4G(8)***	**4G(8)***	**4D(1), 4D(2) and 5D(2)**	**2A*, 3E(2)*, 4G(8)*, 5A*, 4D(1), 4D(2), and 5D(2)**	**Preliminary Conceptual Designs Being Considered in Each Region**	**No specific CI CSRM Measures proposed at this time, but will continue to be evaluated**
Agencies to Protect Migratory Birds									
Marine Mammal Protection Act (MMPA) of 1972, 16 U.S.C. 1631, et seq.	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance or NA	Partial Compliance	Insufficient information for compliance
	As discussed in the environmental consequences sections for wildlife and special status species, all structural and NNBFS have the potential for impacting marine mammals protected under the MMPA. These actions would be reviewed in accordance with the MMPA by NOAA Fisheries and USACE will continue to consult and coordinate with NOAA Fisheries to ensure full compliance for during construction, and O&M activities.						NS are not likely to have effects on marine mammals, but this is not known until specific measures at specific locations are identified.	See structural rationale.	TBD
National Historic Preservation Act (NHPA) of 1966, 16 U.S.C. 6901, et seq.	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Insufficient information for compliance
	All structural, nonstructural and NNBFS would be reviewed in accordance with Section 106 of the NHPA. USACE is currently developing a Programmatic Agreement (PA) with the NJ State Historic Preservation Office. This PA (see Appendix F.5) will ensure that compliance is achieved through the various stages of review.								TBD
Coastal Barrier Resources Act (CBRA) or Coastal Barrier Improvement Act (CBIA) of 1990	NA	Partial Compliance	NA	NA	Partial Compliance	Partial Compliance	NA or Partial Compliance	Partial Compliance	Insufficient information for compliance
		NJ-05P is an OPA in the affected area.			NJ-08 is a proposed modified area adjacent to barrier, NJ-08P is an OPA in affected area.	NJ-19P, NJ-08P, NJ-09	NJ-06, NJ-07P, NJ-19P, NJ-07P, -NJ-09, NJ-09P, NJ-10P, NJ-11P, NJ-20P	TBD. Coordination with USFWS would be required for NNBF features (for CSRM purposes) comply with CBRA in a CBRA unit.	TBD
Wild and Scenic Rivers Act (WSRA) of 1968	NA	NA	Partial Compliance	Partial Compliance	Partial Compliance	NA	NA or Partial Compliance	NA or Partial Compliance	Insufficient information for compliance

	Manasquan Inlet SSB	Barnegat Inlet SSB	Great Egg Harbor Inlet SSB	Absecon Boulevard CBB	Southern Ocean City CBB	Perimeter Measures	Nonstructural Plans	Natural and Nature Based Features	Critical Infrastructure CSRM Measures
	3E(2)*	**3E(2)***	**4G(8)***	**4G(8)***	**4G(8)***	**4D(1), 4D(2) and 5D(2)**	**2A*, 3E(2)*, 4G(8)*, 5A*, 4D(1), 4D(2), and 5D(2)**	**Preliminary Conceptual Designs Being Considered in Each Region**	**No specific CI CSRM Measures proposed at this time, but will continue to be evaluated**
(Public Law 90-542; 16 U.S.C. 1271, et seq.			The proposed SSB is downstream of Great Egg Harbor River WSRA area but may have indirect effects that would trigger a Section 7a Review.	The proposed CBB may have indirect effects that would trigger a Section 7a Review for Great Egg Harbor River WSRA area.	The proposed CBB may have indirect effects that would trigger a Section 7a Review for Great Egg Harbor River WSRA area.		Some NS actions may occur in the vicinity of WSRA area of Great Egg Harbor River that could trigger a Section 7a review.	Some NNBF measures may have direct or indirect effects (adverse or beneficial) on Great Egg Harbor River WSRA areas that could trigger a Section 7a review.	TBD
Marine Protection Research and Sanctuaries Act (MPRSA)	NA	NA	NA	NA	NA	NA	NA	NA	Insufficient information for compliance
	All structural, nonstructural and NNBFS would not require ocean dumping of materials regulated under the MPRSA. No national marine sanctuaries occur within the affected areas.								TBD
Resource Conservation and Recovery Act (RCRA), As Amended, 42 U.S.C. 6901, et seq.	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Insufficient information for compliance
	All structural, nonstructural and NNBFS would undergo detailed HTRW investigations in subsequent phases to characterize or identify the potential for generating HTRW regulated under RCRA.								TBD
Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), 42 U.S.C. 9601, et seq.	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Insufficient information for compliance
	All structural, nonstructural and NNBFS would undergo detailed HTRW investigations in subsequent phases to characterize or identify the potential for generating HTRW regulated under CERCLA.								TBD
Farmland Protection Policy Act of 1981 and the CEQ Memorandum Prime and Unique Farmlands	NA	NA	NA	NA	NA	NA	NA	NA	Insufficient information for compliance
	All structural, nonstructural and NNBFS are not expected to affect lands under the Farmland Protection Policy Act.								TBD
Executive Order 11990, Protection of Wetlands	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Insufficient information for compliance
	All structural, nonstructural and NNBFS would have potential direct and indirect effects on Wetlands protected under E.O. 11990. Compensatory mitigation would be provided for unavoidable effects.								TBD

	Manasquan Inlet SSB	Barnegat Inlet SSB	Great Egg Harbor Inlet SSB	Absecon Boulevard CBB	Southern Ocean City CBB	Perimeter Measures	Nonstructural Plans	Natural and Nature Based Features	Critical Infrastructure CSRM Measures
	3E(2)*	**3E(2)***	**4G(8)***	**4G(8)***	**4G(8)***	**4D(1), 4D(2) and 5D(2)**	**2A*, 3E(2)*, 4G(8)*, 5A*, 4D(1), 4D(2), and 5D(2)**	**Preliminary Conceptual Designs Being Considered in Each Region**	**No specific CI CSRM Measures proposed at this time, but will continue to be evaluated**
Executive Order 11988, Floodplain Management	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Insufficient information for compliance
	All structural, nonstructural and NNBFS would have potential direct and indirect effects on floodplains managed under E.O. 11988. As a CSRM project, these measures are likely to have beneficial effects on floodplains. The USACE Feasibility Study Planning and NEPA process would follow the 8-step process for decision-making when full compliance would be achieved prior to implementation of any of the measures.								TBD
Executive Order 12898, Environmental Justice	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Insufficient information for compliance
	Based on a preliminary review of all structural, nonstructural and NNBFS, it is concluded that the TSP and other measures would not have a disproportionate adverse impact on minority or low-income population groups within the affected areas. CSRM measures are likely to provide benefits to these groups. Full compliance would likely be achieved upon review of more detailed plans and locations of selected structural and nonstructural measures.								TBD
Executive Order 13045, Protection of Children from Environmental and Safety Risks	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Partial Compliance	Insufficient information for compliance
	Based on a preliminary review of all structural, nonstructural and NNBFS, it is concluded that the TSP and other measures are not likely to increase risks environmental and safety risks to children Full compliance would likely be achieved upon review of more detailed plans and locations of selected structural and nonstructural measures.								
NA=Measure is not applicable to specific statute and does not require review. Partial Compliance = Statutory review of measure is in progress but either no or some compliance is achieved at this stage. Full Compliance= Measure has undergone full statutory reviews and has achieved approvals or met review requirements prior to implementing action.									

10 Agency Coordination and Public Involvement*

Additional information pertaining to the below discussed meetings, workshops and interagency coordination is provided in the Pertinent Correspondence and NEPA Scoping Appendix F.12.

10.1 Agency Coordination

On June 17, 2016 and June 21, 2016 USACE and NJDEP conducted Stakeholder Planning Workshops for Study. The purpose of these workshops was to obtain feedback from stakeholders including agency partners to assist NAP in developing problems, objectives, and potential measures throughout the NJBB CSRM Study area. In recognition of the diversity of the existing conditions and CSRM issues throughout the study area, NAP sent out invitations to a wide range of stakeholders including representatives from Federal agencies, state agencies, counties, municipalities, NGOs, elected officials, and academia. A total of 39 and 52 stakeholders attended the June 17 and June 21 workshops, respectively. Feedback was gathered from discussion at the meetings as well as written responses submitted during and after the meetings. Analysis of stakeholder feedback on coastal flooding issues identified problems, opportunities, considerations, and constraints in the NJBB CSRM Study.

A total of eight NEPA scoping comment emails/letters were received, including: four from Federal agencies, three from State agencies, and one from a Native American Tribe. Each comment email/letter included several individual comments typically regarding alternatives, environmental consequences, and coordination and compliance. The majority of comments addressed the effect of CSRM measures on the environmental integrity of the back bays. The USFWS had the most comments which included 24 comments. In addition, the following were invited to be cooperating agencies: U.S. Environmental Protection Agency (USEPA), U.S. Coast Guard, FEMA, National Oceanic and Atmospheric Administration Fisheries (NOAA Fisheries), and the U.S. Fish and Wildlife Service (USFWS). The EPA, USFWS and NOAA NMFS accepted the invitation, although coordination with the remaining agencies is ongoing. Although the Coast Guard verbally expressed interest, it has not officially accepted, but has attended several meetings. No agency declined. FEMA did not respond, although they have participated in meetings.

USACE has held two interagency regulatory resource meetings on 6 June 2018 and 29 November 2018. All of the above agencies participated except for the Coast Guard. The agencies were briefed on the status of the study at that time. Few initial comments were received. Further cooperating agency meetings will be held in the future.

USACE has held six Cooperating Agency Resource Meetings in 2019.

USACE has held two NNBF Workgroup Meetings on April 21, 2019 and September 9, 2019.

USACE has held four strategic engagement virtual meetings with NGOs, Federal and State agencies, and with elected officials in May 2021.

Coordination under the U.S. Fish and Wildlife Coordination Act (FWCA) with the U.S. Fish and Wildlife Service (USFWS) is ongoing. Coordination under Section 7 of the Endangered Species Act is also ongoing.

Coordination with the NMFS under the Magnuson-Stevens Fishery Conservation and Management Act is ongoing, and an Essential Fish Habitat (EFH) Assessment is under development. Coordination as required per Section 106 the National Historic Preservation Act is ongoing. Further coordination will occur between the release of this Draft Integrated Report and subsequent reports.

10.2 Public Involvement

On December 01, 2016, and on September 12 and 13, 2018, USACE conducted Public Meetings for the Study. The purpose of these meetings was to provide an introduction of the study and to obtain feedback from the general public to assist USACE in identifying problems, opportunities, objectives, constraints and potential CSRM measures throughout the NJBB CSRM Study area.

Common themes garnered from verbal and written comments both during and after the 2016 and 2018 Public Meetings include:

- Understanding how ongoing state, local, and Federal activities fit with the NJBB CSRM Study towards the development of a comprehensive, systems-based CSRM approach should be considered.
- Meeting participants expressed a need for USACE to coordinate with other Federal agencies NGO's, the Governor's office, state agencies, and municipalities to ensure that the NJBB CSRM Study is in alignment with existing efforts and to best leverage study resources. After Hurricane Sandy, some meeting participants stated there was a need that went unmet for state and Federal agencies to distribute best management practices for storm recovery and future flood risk management.
- There was interest at the meeting for wider policy centered solutions in addition to the largely engineering based solutions discussed at the meeting. Specifically, meeting participants expressed the difficulty in implementing system wide changes when different municipalities have different levels of engagement and participation in CSRM policies and activities.
- Both the agencies and the public offer support and opposition to structural solutions. Comprehensive solutions considering structural, nonstructural and NNBF measures should be considered. Proper evaluation of SSB benefits and costs and their potential impacts to people, property, the local economy, and the environment should be strongly considered. Apprehension was expressed regarding tidal velocities and exchange between the bay and the ocean, the accuracy of methodology of inlet hydrodynamic modeling, impacts to navigation and factoring of future breaches in barrier islands.
- Commentary regarding floodwall aesthetics, limitations in access, interior drainage and wall heights was transcribed.
- Interest was expressed in land use changes to facilitate movement out of high-risk areas and to decrease development in floodplains, acquisition/relocation as well as elevation strategies was expressed.
- Support was offered for using dredged materials to build berms and dunes and thin layer placement at back bay areas, and both support and opposition to NNBFs due to perceived lack of risk management.
- Concerns about the length of the study given uncertainty in funding, legislation, and bureaucracy. Specific emphasis was given to the desire for the study to be constructed in a timely fashion and in a scaled fashion rather than at one time to facilitate timeliness.

- A greater understanding on how climate change and sea level rise and associated adaptation is considered in the study process was expressed as a concern by stakeholders.
- Flooding of roads and properties from high-frequency flooding including through the overtopping of bulkheads and inundation of salt marsh areas were highlighted as an issue in several parts of the study area. Backflow of water through storm water management systems was also discussed as an issue. Structural solutions to coastal flooding that were discussed by the public included bulkheads along shorelines, check valves at storm water outfalls, storm water improvements, movable flood gates, and SSBs.
- The health of salt marshes within the study area as a result of some of the CSRM measures was a topic of discussion. Structural measures that may cause negative impacts to the environment area major concern.
- Flood risk assessment procedures particularly with respect to prioritization of risk management along the ocean coast compared to the Back Bay Region was discussed amongst stakeholders.

In May and June of 2018, and in May of 2021, USACE and NJDEP conducted Mayor Association Meetings/Elected Official Meetings for each of the five counties in the study area including Monmouth, Ocean, Burlington, Atlantic and Cape May Counties. The purpose of these meetings was to provide the Mayors with a more detailed summary of the study and to obtain feedback on the different structural, nonstructural, perimeter and NNBF measures throughout the NJBB CSRM Study area.

The NJBB CSRM Interim Feasibility Report and Environmental Scoping Document was distributed in March of 2019. The public, stakeholders and environmental resource agencies generated 147 review comments. These comments addressed the environmental impacts of structural features, namely SSBs (Figure 110). Specifically, these comments addressed the need for a detailed EIS ultimately, impacts to tidal flow and circulation, impacts to natural and cultural/historical resources, sediment transport and distribution, recreational opportunities, and impacts to Federal agency resources and managed lands. Continued, ongoing environmental modeling will assist in addressing these study facets and the finding will be communicated to interested parties during future study milestones. Interest was also expressed regarding historical rates and future habitat loss estimates, as well as ecological services consideration in benefit calculations.

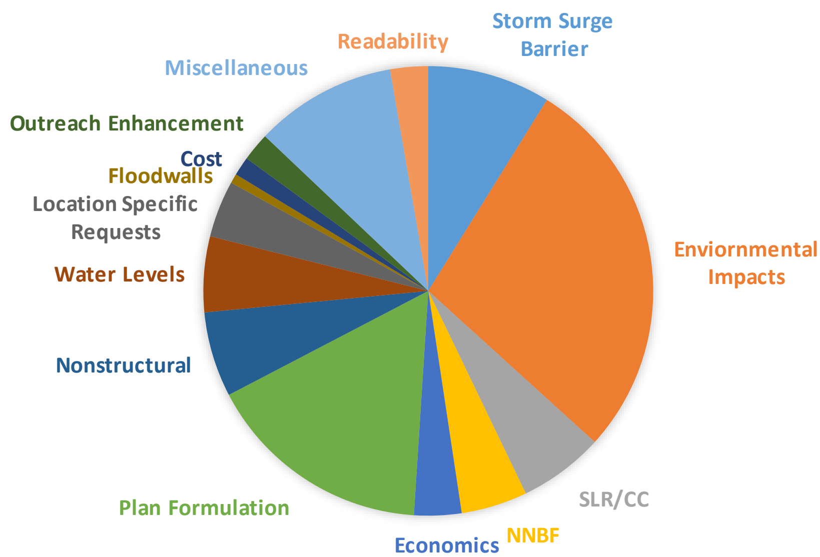


Figure 110: NJBB Interim Report Comment Classification

A number of comments were also made on the plan formulation aspects of the study and address measure screening and ranking methodology including consideration of data gaps/uncertainty as well as risk and uncertainty in structural measure formulation and associated assumptions. Additional plan formulation topics addressed the inclusion of regional management plan perspectives, and enhanced outreach. Further comments reflected the need to consider sea level rise projections more comprehensively (including land subsidence) and clearer identification of strategies to manage the risk from future sea level rise. Commenters suggested clarification or enhanced/continued analyses of nonstructural measures, benefit and cost analyses, design and associated assumptions, and induced flooding and high frequency flooding analyses and associated stormwater management. Interest was also expressed regarding coastal lake analysis refinement, innovative technologies including flumes/culverts and glass floodwalls, location specific requests, Green Acres Program consideration refined definition of resilience, and report readability improvements including resilience plan components.

A virtual meeting for the public was held via webinar on March 14, 2019 to summarize the results of the NJBB CSRM Interim Feasibility Report and Environmental Scoping Document. The presentation highlighted some of the take home messages of the Report and provided specific locations where that information could be located in the text. Approximately thirty attendees participated in the webinar.

10.3 List of Recipients*

This document and appendices were uploaded to the e-NEPA website on August 20, 2021 with a subsequent Notice of Availability (NOA) of this document published in the Federal Register on August 27, 2021 announcing the commencement of public review in accordance with NEPA. This document and appendices are being made available on the USACE Philadelphia District's Internet Website and can be retrieved at https://www.nap.usace.army.mil/Missions/Civil-Works/New-Jersey-Back-Bays-Study/. Additionally, the availability of this document was announced in a public notice and press release on August 19, 2021. The following list in Table 109 includes, but is not limited to, a number of Federal, State, and local agencies, organizations and stakeholders that were invited to review and comment on these documents via e-mail notification.

Table 109: Recipients Invited to Review and Comment on the NJBB CSRM DIFR-EIS

Category	Agency/Organization
Congressional Delegation	U.S. Senator Robert Menendez
	U.S. Senator Cory Booker
	U.S. Representative Jefferson Van Drew (2nd District)
	U.S. Representative Andy Kim (3rd District)
	U.S. Representative Chris Smith (4th District)
	U.S. Representative Frank Pallone, JR. (6th District)
Federal	United States Environmental Protection Agency (USEPA)
	NOAA Fisheries (NOAA Fisheries)
	U.S. Fish and Wildlife Service (USFWS)
	National Park Service (NPS)
	U.S. Geological Survey
	U.S. Coast Guard (USCG)
	Federal Emergency Management Agency (FEMA)
	Natural Resources Conservation Service
State	New Jersey Department of Environmental Protection (NJDEP)
	NJDEP – Division of Coastal Engineering
	NJDEP – Division of Land Resource Protection
	NJDEP – Office of Permitting and Project Coordination
	NJDEP – Historic Preservation Office
	New Jersey Pinelands Commission
	New Jersey Department of Transportation
	New Jersey Department of Agriculture
	New Jersey Department of Health
Local	New Jersey Coastal Coalition
	NJBB Municipal List
	Freehold Soil Conservation District
	Ocean County Soil Conservation District
Organizations	Barnegat Bay Partnership
	Jacques Cousteau National Estuarine Research Reserve
	The Nature Conservancy
	The Wetlands Institute
	Great Egg Harbor River Council
	New Jersey Sierra Club
	American Littoral Society
	New Jersey Environmental Federation
	Save Barnegat Bay
Academia	Stockton University
	Rutgers University
	College of New Jersey
	Monmouth University
	Ocean County Community College
Tribes	Delaware Tribe Historic Preservation Representatives

Category	Agency/Organization
	Delaware Nation
	Eastern Shawnee Tribe of Oklahoma
	Oneida Indian Nation
	Stockbridge-Munsee Mohican Tribal Historic Preservation
	St. Regis Mohawk Tribe

11 Implementation Requirements

11.1 Institutional Requirements

The completion of the feasibility study and recommendation by the District Engineer are the first steps toward implementing the design and construction of the CSRM project in the New Jersey Back Bays region. Upon approval by the ASA (CW), the project will be considered for design and construction with funding made available through P.L. 113-2 and/or a Water Resources Development Act (WRDA).

While the NJDEP has served as the non-Federal sponsor for the feasibility study phase, due to the scale of the project, a modified arrangement is necessary for the subsequent phases of the project, including PED, Construction, and Operations and Maintenance. Additionally, local entities such as counties, municipalities, or other special taxing entities may elect to, or be created to, support potential sponsorship by the State of New Jersey in partnership with the USACE in the implementation of this project. An initial step towards the implementation of the NJBB project would be a Letter-of-Intent prior to PPA execution stating intent to serve as the non-Federal sponsor.

Upon receipt of Federal construction funds, USACE and the non-Federal sponsor would enter into a single or several PPAs. This PPA would define the Federal and non-Federal responsibilities for implementing, operating, and maintaining the project.

The CSRM project will be cost-shared 65% by the Federal government and 35% by the non-Federal sponsor, as summarized in Table 110:

Table 110: New Jersey Back Bays Cost Sharing Table for the TSP

Item	Federal Cost (65%)	Non-Federal Cost (35%)	Total Cost
PED	$497,480,199	$267,873,954	$765,354,153
LERRD	$588,672,244	$316,977,363	$905,649,607
Construction	$7,940,303,787	$4,275,548,193	$12,215,851,980
Construction Management	$159,186,555	$85,715,837	$244,902,392
Interest During Construction			$1,935,777,868
Total Project	$10,443,898,400	$5,623,637,600	$16,067,536,000

Note: FY2021 Price Level

OMRR&R for CSRM projects nationwide are typically a 100-percent non-Federal sponsor responsibility. There is expected to be significant OMRR&R costs associated with the NJBB project. The possibility exists that the sponsor will likely request federal assistance on OMRR&R through WRDA or other means. Alternative funding avenues will be researched closer towards the commencement of the PED, Construction, and Operations and Maintenance Phases.

The non-Federal sponsor would be required to comply with all applicable Federal laws and policies and other requirements, including but not limited to:

- Provide a minimum of 35% of initial project costs assigned to coastal and storm damage reduction, plus 100% of initial project costs assigned to protecting undeveloped private lands and other private shores which do not provide public benefits, and 50% of periodic renourishment costs assigned to coastal and storm damage reduction, plus 100% of periodic renourishment costs assigned to protecting undeveloped private lands and other private shores which do provide public benefits, and as further described below:
    - Provide, during design, 35% of design costs allocated to coastal and storm damage reduction in accordance with the terms of the PPA entered into prior to commencement of design work for the project;
    - Provide all lands, easements, rights-of-way, including suitable borrow areas, and perform or assure performance of all relocations, including utility relocations, as determined by the Federal government to be necessary for the initial construction, periodic renourishment or operation and maintenance of the project;
    - Provide, during construction, any additional amounts necessary to make its total contribution equal to 35% of initial project costs assigned to coastal and storm damage reduction plus 100% of initial project costs assigned to protecting undeveloped private lands and other private shores which do not provide public benefits;
- Perform, or cause to be performed, any investigations for hazardous substances as are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Public Law (PL) 96-510, as amended, 42 U.S.C. 9601-9675, that may exist in, on, or under lands, easements, or rights-of-way that the Federal government determines to be required for the construction, operation, and maintenance of the project.
- Coordinate all necessary cleanup and response costs of any CERCLA-regulated materials located in, on, or under lands, easements, or rights-of-way that the Federal government determines to be necessary for the construction, operation, or maintenance of the project.
- Coordinate mitigation and data recovery activities associated with historic preservation, that are in excess of one percent of the total amount authorized to be appropriated for the project.
- Operate, maintain, repair, replace, and rehabilitate the completed project, or functional portion of the project, including mitigation features, at no cost to the government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and state laws and any specific directions prescribed by the government in the Operations, Maintenance, Replacement, Repair and Rehabilitation (OMRR&R) manual and any subsequent amendments thereto.
- Provide the Federal government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal project partner, now or hereafter, owns or controls for access to the project for the purpose of inspection, and, if necessary, after failure to perform by the non-Federal project partner, for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating the project. No completion, operation, maintenance, repair, replacement, or rehabilitation by the Federal government shall operate to relieve the non-Federal project partner of the responsibility to meet the

non-Federal project partner's obligations, or to preclude the Federal government from pursuing any other remedy at law or equity to ensure faithful performance.

- Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, replacement, and rehabilitation of the project and any project-related betterments, except for damages due to the fault or negligence of the United States or its contractors.
- Keep, and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local governments at 32 codes of Federal regulations (CFR) Section 33.20.
- As between the Federal government and the non-Federal project partners, the non-Federal project partner shall be considered the operator of the project for the purpose of CERCLA liability. To the maximum extent practicable, operate, maintain, repair, replace and rehabilitate the project in a manner that will not cause liability to arise under CERCLA.
- Comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1790, Public Law 91-646, as amended by Title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987 (Public Law 100-17), and the uniform regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way, required for construction, operation, and maintenance of the project, including those necessary for relocations, borrow materials, and dredged or excavated material disposal, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act.
- Comply with all applicable Federal and state laws and regulations, including, but not limited to, Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d), and Department of Defense directive 5500.11 issue pursuant thereto, as well as Army regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted of Conducted by the Department of the Army.
- Participate in and comply with applicable Federal floodplain management and flood insurance programs and comply with requirements in Section 402 of the Water Resources Development Act of 1986, as amended.
- Not less than once each year inform affected interests of the extent of protection afforded by the project.
- Publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in preventing unwise future development in the floodplain and in adopting such regulations as may be necessary to prevent unwise future development and to ensure compatibility with the protection provided by the project.
- Prevent obstructions of or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) which might hinder its operation and maintenance, or interfere with its proper function, such as any new development on the project lands or the addition of facilities which would degrade the benefits of the project.

- Provide and maintain necessary access roads, parking areas, and other public use facilities, open and available to all on equal terms.
- Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, and Section 103 of the Water Resources Development Act of 1986, Public Law 99-662, as amended, which provides the Secretary of the Army shall not commence the construction any water resources project or separable element thereof, until the non-Federal project partner has entered into a written agreement to furnish its required cooperation for the project or separable element.
- At least twice annually and after storm events, perform surveillance of the Line of Protection and determine any physical variances from the project design section and provide the results of such surveillance to the Federal government.
- Inform affected interests, at least annually, of the extent of protection afforded by the structural flood damage reduction features.
- Assume, as between the Federal government and the non-Federal sponsor, complete financial responsibility for all necessary cleanup and response costs of any hazardous substances regulated under CERCLA that are located in, on, or under lands, easements, or rights-of-way required for construction, operation, maintenance, repair, rehabilitation, or replacement of the project.
- Not use funds from other Federal programs, including any non-Federal contribution required as a matching share therefore, to meet any of the non-Federal sponsor's obligations for the project unless the Federal agency providing the funds verifies in writing that such funds are authorized to be used to carry out the project.

11.2 Implementation Schedule

Before design and construction may be initiated, the report must be approved and submitted to the Office of Management & Budget. Further, the PPA must be executed by USACE and the non-Federal sponsor. Table 111 provides the current schedule for study approval and PPA execution. Note that dates in this implementation schedule are subject to change. Of particular note are the dates after project authorization as these dates are dependent on funding capabilities at both the Federal and non-Federal levels.

Table 111: Implementation Schedule

Final Feasibility Report & Integrated EIS to USACE Higher Authority for Approval	March 2023
Chief's Report submitted to ASA (CW)	April 2023
ASA (CW) Final Feasibility Report & Integrated EIS Approval	June 2023
ASA (CW) submits report to OMB	July 2023

Final Report to Congress	August 2023
Project Authorization by Congress	January 2024
Project appropriation in Federal budget	March 2024
Execute Initial PPA with non-Federal Sponsor	April 2024
Start Plans and Specifications (Design Phase)	May 2024
Finalize Plans and Specifications for Contract	January 2027
Real Estate Certification for Contract	January 2028
Ready to Advertise Contract	January 2029
Award Construction Contract with Notice to Proceed	January 2030

11.3 Cost Summary

The estimated cost for the recommended plan is $16,067,536,000 (FY2021 Price Level and a 240-month construction duration) which includes real estate acquisition costs (including administration costs); planning, engineering, and design (PE&D); construction management (S&A); Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R); and associated contingencies. A summary of estimated project costs is provided on Table 112.

Table 112: New Jersey Back Bays Study Project Total First Cost Summary for the TSP

Construction Item	Cost
Lands & Damages	$905,649,607
Relocations	$5,257,276
Fish & Wildlife Mitigation	$393,189,103
Breakwaters & Seawalls	$5,413,772,034
Levees & Floodwalls	$1,022,257,273
Pumping Plant	$20,828,848
Floodway Control and Division Structures	$252,049,963
Cultural Resources Preservation	$97,662,046
Buildings, Grounds, & Utilities	$5,010,835,348
Preconstruction Engineering & Design (PED)	$765,354,153

Construction Management (E&D, S&A)	$244,902,480
Total First Cost	**$14,131,758,131**

Note: FY2021 Price Level

Note that the Total First Cost Summary Table above presents the Total First Cost, or the actual, budgetary construction cost of building the project. This is different than the Total Initial Construction Cost which is used to determine the economic viability of a proposed measure and is presented in previous tables. The key difference between the two estimates is the inclusion of Interest During Construction (IDC) and variable nonstructural costs in the Total Initial Construction Cost.

In accordance with the Water Resources Development Act of 1986, as amended, the cost sharing for initial construction is 65% Federal and 35% non-Federal, which includes cash and credits associated with obtaining the required lands, easements, rights-of-way, relocations, and disposal areas (LERRD). Periodic renourishment is cost-shared 50% Federal and 50% non-Federal. OMRR&R is a 100% non-Federal responsibility and is included in the calculation of annualized project costs for economic purposes. The Federal government will design the project, prepare detailed plans/specifications, and construct the project, exclusive of those items specifically required of the non-Federal partner.

11.4 Views of the Non-Federal Sponsor

The non-Federal sponsor (NJDEP) supports the continued investigation of alternatives to ultimately arrive at a recommended plan for construction authorization that is supported by the federal government.

12 Conclusions and Recommendations

12.1 Summary

The recommended plan consists of the following elements:

- Three SSBs at Manasquan Inlet, Barnegat Inlet, and Great Egg Harbor Inlet;
- Two CBBs at Absecon Boulevard, and southern Ocean City and;
- Nonstructural solutions for 18,800 structures including elevation and floodproofing. Nonstructural solutions are considered for 11% of the study area and are concentrated in the Shark River & Coastal Lakes region, and in Ocean and Atlantic Counties specifically on Long Beach Island and Brigantine as well as mainland shorelines between Beach Haven West and Absecon. Nonstructural solutions are also concentrated in Cape May County.

In making the above-reference recommendation, USACE has considered all significant aspects in the overall public interest, including environmental quality, social effects, economic effects, engineering feasibility, and compatibility of the recommended plan with policies, desires, and capabilities of the State of New Jersey and other non-Federal interests. USACE has evaluated several alternative plans for the purpose of coastal storm risk management. A recommended plan has been identified that is technically sound, economically cost-effective over the 50-year period of analysis, socially and environmentally acceptable, and has support from the non-Federal sponsor.

The selected plan has primary benefits based on coastal storm risk management and provides average annual total net benefits in accordance with Table 113:

Table 113: Summary of Costs & Benefits

Site	AAC	AAB	AANB	BCR
Shark River and Coastal Lakes (2A)	$1,538,000	$3,157,000	$1,619,000	2.1
North Region (3E(2))	$310,793,000	$579,674,000	$268,881,000	1.9
Central Region (4G(8))	$376,684,000	$589,605,000	$212,921,000	1.6
South Region (5A)	$115,769,000	$213,527,000	$97,758,000	1.8
Total Project	**$7,687,000**	**$12,231,000**	**$4,545,000**	**1.8**

Note: The cost and benefit values in Table 112 cover a 50-year period of analysis with a base year of 2030.

The recommended plan reflects information available at the time and current USACE policies governing formulation of coastal storm risk management projects. These recommendations may be modified before they are transmitted to Congress as proposals for authorization and implementation funding. However, prior to transmittal to Congress, the Sponsor, the States, interested Federal agencies, and other parties will be advised of any modifications and will be afforded the opportunity to comment further.

To Be Signed at Final Feasibility Report

Ramon Brigantti

Lieutenant Colonel, Corps of Engineers

District Commander

12.2 Path Forward

12.2.1 Feasibility Phase

This NJBB CSRM Draft Feasibility Report and Tiered Environmental Impact Statement has identified the TSP and subsequent feasibility study analyses towards developing a Final Feasibility Report and Environmental Impact Statement in 2022. These analyses are inclusive of continued system of accounts analyses (NED, RED, OSE and EQ), planning criteria analyses, and other engineering, planning, and environmental analyses. These continued analyses will result in the selection of a recommended plan for construction authorization that reduces coastal storm risk in the NJBB Region consistent with planning objectives in addition to minimizing environmental, social, and economic impacts. Each measure type and alternative plan has pros and cons, and further investigation is necessary to determine the optimal measure combination for each Region and for the study area as a whole.

This Draft Feasibility Report has been prepared in accordance with relevant laws and USACE policy. Analyses have been conducted to address the specific requirements necessary to demonstrate that the preliminary focused array of alternative plans will form a recommended plan for construction authorization that is technically feasible, economically justified, and environmentally compliant and ultimately develop costs and cost-sharing to support a Project Partnership Agreement (PPA).

The information contained within this Draft Feasibility Report is preliminary and will be undergoing modifications and additions until approval of the recommended plan for construction authorization scheduled for 2023. The deliverable for this study will be a feasibility report with integrated NEPA compliance documentation (EIS) culminating in a Chief's Report in 2023. This Document will undergo review by USACE technical teams, while this Draft and the Final Feasibility Reports and EISs will also undergo an independent external technical peer review by an organization external to the USACE. Prior to submission of the final version of this report to Congress, the report will also undergo review by national policy reviewers, other local, state, and federal agencies, NGOs, and the public. All comments submitted by the aforementioned parties will be addressed. Review comments and responses to those comments will be documented in the future reports discussed above. Upon approval by USACE's Assistant Secretary of the Army, Civil Works (ASA [CW]), the project will be considered for design and construction.

Using the information in subsequent Reports, the USACE will continue to coordinate with the NJDEP to implement the recommended project in accordance with current policy and in the most expeditious manner available by maximizing the use of available construction and study authorities (i.e., modifications of on-going projects/studies, post-authorization change reports, or new authorizations).

12.2.2 Plan Implementation

Following the feasibility phase of a project, the pre-construction engineering and design (PED) phase of a project initiates the implementation process of the recommended plan for construction authorization including the development of plans and specifications. Funding by the Federal Government to support these activities would have to meet traditional civil works budgeting criteria. In order for the PED Phase to be initiated, USACE must sign a single or multiple Project Partnering Agreement (PPA) with a non-Federal sponsor to cost share the PED phase. Additional PPAs may be required for the construction phase given the financial commitments of each partner. This project would require congressional authorization for PED and construction. PED and construction are cost shared 65% Federal and 35% non-Federal. Implementation would then occur provided that sufficient funds are appropriated to design and construct the project.

A phased, incremental implementation schedule will be developed for the recommended plan. This approach identifies eligibility threshold stages over time to accommodate as sea level change causes more structures in the study area to become vulnerable and fall below the eligibility threshold stage. This approach also indexes the SSB closure criteria to certain flood recurrence intervals to identify complementary nonstructural measures particularly in the Central Region. This managed adaptive approach ensures a constant project performance level with clear closure criteria guidelines and minimizes coastal storm impacts for both high-frequency and low-frequency events.

The construction of scaled, incrementally implementable integrated USACE construction opportunities associated with the ultimate recommended plan for construction authorization to reduce risk along the NJBB coast is massive in scale and thus necessitates phasing of the actions with respect to realizing the life cycle of the plan. A strategy for implementation and sequencing of the recommended plan for construction authorization would consider a tiered sequence and would be based on ranking of certain locations or features, level of design detail and uncertainty regarding conditions for CSRM benefits, long term sustainability including low, medium, and high projections for future sea level rise, and construction costs. A three-tiered implementation strategy would consider:

- Tier 1 – Critical infrastructure assets risk management;
- Tier 2 – Nonstructural including major evacuation routes, elevation of structures or low elevation floodwall in a high-recurrence floodplain (i.e., 5-year); and
- Tier 3 – SSB construction at individual inlets.

Such a strategy will ultimately need to be prepared amongst team partners in order to identify and make available construction funds and to communicate the construction priority to stakeholders. This sequenced approach will also facilitate sponsor readiness and will accommodate the possible intermittent Federal and non-Federal budget cycles. This phased approach will also offer cost saving opportunities through combining efforts on varying scales and accelerating benefit flows by prioritizing actions. The completion of the Chief's Report is the first step toward implementing the design and construction of the NJBB CSRM Study.

The implementation of the nonstructural plan in included in the Nonstructural Appendix.

12.2.3 Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R)

The purpose of OMRR&R is to sustain the constructed project. The most significant OMRR&R is associated with the SSBs. At this point of the study, it is estimated that barriers would be closed for a 5-yr and higher storm surge event, with an average of one closure operation every five years. In the next phase of the study the SSB operations plan, and closure criteria will be revaluated. OMRR&R for SSBs typically include monthly startup of backup generators/systems, annual closure of surge barrier gates pre-hurricane season, dive inspections, gate adjustments/greasing, gate rehab and gate replacement. Annual OMRR&R costs of 1.96% of the construction cost were included for the SSB features and 1.0% of the project cost for the perimeter measure features for each year of the 50-year project life. OMRR&R costs for the SSBs are based on the work performed in the NYNJHAT CSRM Feasibility Study. There is no OMRR&R associated with nonstructural solutions.

12.3 Interagency Alignment

A variety of stakeholders have been identified that will be interested in the conduct of the NJBB CSRM Study. These groups include:

- Federal and State Agencies
- Regional entities and NGOs
- Tribes
- Academia
- Communities affected by Hurricane Sandy (including local governments and community groups)
- Congressional and Political Leaders
- Media

Federal agency stakeholders include USACE (Institute of Water Resources, USACE ERDC, Silver Jackets), FEMA, USGS, NOAA (NWS and NMFS), USDOI, USDA/NRCS, HUD, BOEM, NASA, SBA, USFWS, USEPA, NPS and NFWF. State agency stakeholders include NJDEP, NJDOT, NJOEM, NJ Department of Community Affairs (CDBG), NJSHPO and NJFWS. NGOs include The Nature Conservancy, Barnegat Bay Partnership, Rockefeller Foundation, Jacques Cousteau National Estuarine Research Reserve, NJ Adapt, American Littoral Society, Sustainable Jersey, and the Trust for Public Lands. Native American Tribes include the Lenni-Lanape.

12.4 Systems / Watershed Context

The TSP and alternative plans were formulated to ultimately develop a recommended plan for construction authorization which provides a comprehensive CSRM plan within the study area and supports the national and regional economy as well as the social vulnerability of the watershed. Throughout the study, coordination was maintained with the State of New Jersey as well as counties and municipalities throughout the study area as well as academic institutions, environmental/resource agencies, and other key stakeholders. Continued NJBB analyses will incorporate Federal, State, local, NGOs and academic datasets and tools as applicable and will consider ways to coordinate with and leverage other federal and state resilience projects. The development of relationships with Cooperating Agencies was and will continue to be critical in conducting future analyses.

12.5 Sustainability / Adaptability

The TSP and overall formulation of alternative plans positively affects the sustainability of environmental conditions in the affected area. The TSP meets the economic, environmental, and community sustainability goals for the fifty-year length of the project. Economic principals are used in benefit calculations, plan formulation ranking, and project justification by their contributions to the both the National Economic Development account and community resiliency goals. Environmental concerns are evaluated in the EIS and through coordination and review by the resource agencies including the Environmental Protection Agency, the USFWS and NOAA-NMFS as part of the feasibility process. Social accounts are intrinsic in CSRM projects since USACE guidance requires risk management of social vulnerability. The combination of these pillars indicates that this project is sustainable.

12.6 Environmental Operating Principles

In 2002, USACE reaffirmed its long-standing commitment to environmental conservation by formalizing a set of environmental operating principles applicable to all decision making in all programs. The principles are consistent with NEPA; the Department of the Army's Environmental Strategy with its four pillars of prevention, compliance, restoration, and conservation; other environmental statutes and WRDA that govern USACE activities. The Environmental Operating Principles informed the plan formulation process and are integrated into all proposed program and project management processes.

The Environmental Operating Principles are:

- Foster sustainability as a way of like throughout the organization.
- Proactively consider environmental consequences of all USACE activities and act accordingly.
- Create mutually supporting economic and environmentally sustainable solutions.
- Continue to meet our corporate responsibility and accountability under the law for activities undertaken by USACE which may impact human and natural environments.
- Consider the environment in employing a risk management and systems approach throughout the life cycles of projects and programs.
- Leverage scientific, economic, and social knowledge to understand the environmental context and effects of USACE actions in a collaborative manner.
- Employ an open transparent process that respects views of individuals and groups interested in USACE activities.

Plan selection took these principles into account to ensure the sustainability and resiliency of the NED plan while considering the environmental consequences of implementation. USACE considered the environmental and cultural resources in the study area.

12.7 Point of Contact

Interested parties can access further information at the USACE's NJBB Web Portal which is situated at the following link:

https://www.nap.usace.army.mil/Missions/Civil-Works/New-Jersey-Back-Bays-Coastal-Storm-Risk-Management/

Alternatively, interested parties can email all questions and comments to (reference "NJBB" in the subject headings):

PDPA-NAP@usace.army.mil,

A third avenue for contacting the USACE includes providing written correspondence to:

U.S. Army Corps of Engineers, Planning Division

100 Penn Square East (7th floor South)

Wanamaker Building

Philadelphia, PA 19107

13 List of Preparers*

The project delivery team (PDT) prepared the report and consisted of the following people (Table 114):

Table 114: Project Delivery Team

Name	Discipline
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Steve Allen	USACE – Environmental Coordinator
Preston Oakley	USACE – Economics
Brian Bogle	USACE – Plan Formulation
Rob Hampson	USACE – Hydrology & Hydraulics
Nicole Minnichbach	USACE – Cultural Resources
Mary Pakan	USACE – Civil Design
Sam Weintraub	USACE – Civil Design
Jeff Yates	USACE – Geotechnical Engineering
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15 Glossary of Terms

Active profile zone - The nearshore zone across which the dominant sediment motion occurs.

Barrier island - A sand body that is essentially parallel to the shore, the crest of which is above normal high water level.

Beach - The zone of unconsolidated material that extends landward from the low water line to the place where there is marked change in material or physiographic form, or to the line of permanent vegetation (usually the effective limit of storm waves). The seaward limit of a beach unless otherwise specified is the mean low water line.

Beach profile - The intersection of the ground surface with a vertical plane; may extend from behind the dune line or the top of a bluff to seaward of the breaker zone.

Beach renourishment - Pumping sand onto the beach and building up former dunes and upper beach after construction of an initial nourishment.

Benthic community - Organisms that live on the sub-aquatic bottom.

Biogenically derived sediments - Biogenous sediments consist of the remains of either marine plant or animal skeletons, either coarse grained as found in shallow coastal waters, or fine grained as found in deeper waters.

Borrow site - A term used to describe the site identified for, or remaining after, borrow material has been removed for placement onto a beach. In upland areas, the site frequently becomes a body of water. In marine areas, the site becomes a hole in a bay or nearshore area.

Carbonate platform - A large and thick accumulation of carbonate strata that it typically isolated from other land masses.

Carbonate sediments - Sediment formed by the organic or inorganic precipitation from aqueous solution of carbonates of calcium, magnesium, or iron.

Closure depth - The depth of water beyond which sediments are not normally affected by waves.

Coastal geology - Origin, structure, and characteristics of the sediments that make up the coastal region, from the uplands to the nearshore region. Sediments can vary from small particles of silt or sand to larger particles of gravel and cobble, to formations of consolidated sediments and rock.

Coastal plain - A broad, low relief region composed of horizontal or gently sloping strata of clastic materials fronting the coast, and generally representing a strip of sea bottom that has emerged from the sea in recent geologic time.

Coastal sediment budget - The identification of sediment sources and sinks, and the quantification of the amounts and rates of sediment transport, erosion, and deposition within a defined region.

Compatibility analysis - Methods used to evaluate the suitability of the sediments in a borrow area for beach nourishment purposes based on the characteristics of the native beach material and / or the profile shape of the constructed beach.

Continental shelf - The region of the oceanic bottom that extends outward from the shoreline with an average slope of less than 1:100, to a line where the gradient begins to exceed 1:40.

Cross-shore direction - Perpendicular to the shoreline.

Cross-shore transport - A wave and / or tide-generated movement of shallow-water coastal sediments toward or away from the shoreline.

Drowned barrier island - A long, narrow coastal sandy body, representing a broadened barrier beach that was above high tide and parallel to the shore in prior sea level conditions and is now underwater.

Dune - A ridge or mound of loose, wind-blown material, usually sand.

Ebb tidal delta - The bulge of sand formed at the seaward mouth of tidal inlets as a result of interaction between tidal currents and waves.

Equilibrium beach profile - The slightly concave slope of the floor of a sea or lake, taken in a vertical plane and extending away from and transverse to the shoreline, being steepest near the shore, and having a gradient such that the amount of sediment deposited by waves and currents is balanced by the amount removed by them, the transverse slope of a graded shoreline. The profile is easily disturbed by strong winds, large waves, and exceptional high tides.

Estuary - (1) A coastal embayment where there is freshwater input that is influenced by tides. (2) The part of a river that is affected by tides. (3) The region near a river mouth in which the fresh water of the river mixes with the salt water of the sea.

Flood tidal-delta - The bulge of sand formed at the landward mouth of tidal inlets as a result of flow expansion.

Gross sediment transport - The sum of the sediment transport magnitudes in the dominant and secondary directions. The gross sediment transport does not have a direction or sign.

Hot spot - Shoreline segment characterized by erosion rates that are significantly greater than adjacent shoreline segments.

Hydraulic sand placement - Sediment (sand) moved using water and centrifugal pumps mounted on a barge or large seagoing vessel (hydraulic dredging), usually moving sediment originating from an offshore site.

Hydrographic surveys - 1) The description and study of seas, lakes, rivers, and other waters. (2) The science of locating aids and dangers to navigation. (3) The description of physical properties of the waters of a region.

Inlet improvement - Modifications to an existing inlet, usually for purposes of navigation, which may include channel deepening and/or jetty construction. Other reasons for inlet improvement may include positional stabilization and improved flushing of the bay served by the inlet.

Inlet positional stability - A type of stability related to the orientation of the inlet's tidal jet.

Intertidal Zone - The zone between spring high tide and spring low tide.

Jet-probe - A long pipe into which water under high pressure is pumped in order to penetrate into unconsolidated sediment.

Littoral cell - A reach of the coast that is isolated sedimentologically from adjacent coastal reaches and that features its own sources and sinks. Isolation is typically caused by protruding headlands, submarine canyons, inlets, and some river mouths that prevent littoral sediment from one cell from passing into the next.

Littoral zone - In beach terminology, an indefinite zone extending seaward from the shoreline to just beyond the breaker zone.

Longshore bar - A sand bar that extends roughly parallel to the shoreline.

Longshore direction - Parallel to and near the shoreline, alongshore.

Longshore sand bars - A sand ridge or ridges, running roughly parallel to the shoreline and extending along the shore outside the trough, that may be exposed at low tide or may occur below the water level in the offshore.

Longshore transport - A wave- and/or tide-generated movement of shallow-water coastal sediments parallel to the shoreline.

Low energy environments - Coastlines where wave and tidal forces are typically relatively small due to the climate, the location of the site and / or due to nearshore submerged features that function to reduce incoming wave energy.

Magnetometer survey - A geophysical test to determine the ferrous returns for subsurface materials such as shipwrecks, debris and other anomalies located within a borrow site. Such materials must be located to avoid damage to dredge equipment or to determine the precise location of historic relics, shipwrecks, or other artifacts.

Marsh - An area of soft, wet, or periodically inundated land, generally treeless and characterized by grasses.

Miocene Epoch - The period of geologic time that extends from 24 million years to 5 million years before the present.

Moraine - An accumulation of earth, stones, etc. deposited by a glacier, usually in the form of a mound, ridge, or other prominence on the terrain.

Nearshore - In beach terminology, an indefinite zone extending seaward from the shoreline well beyond the breaker zone.

Nearshore zone - In beach terminology, the zone that extends seaward from the low tide line including the bar and trough topography that commonly extends well beyond the breaker zone.

Net sediment transport - The difference between the sediment transport magnitude in the dominant direction and the transport magnitude in the secondary direction. Sediment transport is usually considered to be positive to the right as an observer looks seaward. The net sediment transport can be positive, negative, or zero.

Oblique sand ridge - A generic name for any low ridge of sand formed at some distance from the shore, either submerged or emergent at an angle to the shoreline.

Planform - The outline or shape of a body of water as determined by the still-water line, that is, a map.

Planform evolution - The morphodynamical changes that take place over time on a particular geographic entity.

Profile equilibration - The process of adjustment of a beach profile from one shape to one which is in more of an equilibrium condition with the waves and tides. Occurs after placement of nourishment materials at a slope steeper than equilibrium.

Quartz sediment - Sediment formed by solid fragmental material that originates from the weathering of quartz rocks and comprises most sediment along the Atlantic Coast.

Reconnaissance level sand source investigations - Broad scale field investigation to provide sediment stratigraphy and particle size information to identify prospective candidate sand source and to provide information for the preparation of preliminary project design and cost estimates.

Regional sand management - Management of sediment resources based on broad geographic considerations.

Relict - Remnant left after decay, disintegration, or disappearance.

Sediment budget - The mass balance between inputs and outputs of sediment within a defined coastal environment.

Sediment characteristics - Physical attributes of a sediment sample measured by the statistical variations in particle size, chemical composition, density, moisture content, and color. Sediment is a solid fragmental material that originates from weathering of rocks and is transported or deposited by air, water, or ice, or that accumulates by other natural agents, such as chemical precipitation from solution or secretion by organisms (biological origin), and that forms in layers on the Earth's crust or surface at ordinary temperatures in a loose, unconsolidated form (for example, sand, gravel, silt, mud).

Sediment composites - A particle size distribution that represents the overall average of all sediment strata within a borrow site, usually based on multiple sediment grain size distributions weighted accordingly.

Sediment pathways - The routes along which sediment movement occurs.

Shore-parallel structures - Structures that are constructed onshore and parallel to the beach, including seawalls and revetments designed to protect the land and buildings located immediately landward. Shore-parallel structures also include breakwaters and submerged sills located in nearshore waters which act to intercept and reduce the energy of approaching waves.

Shore-perpendicular structures - Structures such as groins and jetties that are constructed perpendicular to the beach and extend out into the water. These types of structures are designed to retard or interrupt the longshore movement of sand and accumulate sand on the beach updrift of the structure.

Shoreline stabilization - Measures to retard erosion to protect upland property. Recognized erosion control measures include seawalls, revetments, jetties, groins, breakwaters, and beach nourishment.

Siliciclastic sediment - Sediment that is composed primarily of fragments of silicate minerals or rock fragments, most commonly quartz.

Storm tide - A rise above normal water level on the open coast due to the action of wind stress on the water surface. Storm surge resulting from a hurricane also includes that rise in level due to atmospheric pressure reduction as well as that due to wind stress.

Tidal delta - An alluvial deposit, usually triangular or semi-circular, at the mouth of a tidal inlet that accumulates as the result of the combination of wave processes and tidal currents.

Tidal flat - Unvegetated sandy or muddy land area that is covered and uncovered by the rise and fall of the tide.

Tombolo - A bar or spit of sand that connects or "ties" an island to the mainland or to another island.

Trough sand accumulation - Where sand accumulates in a long and broad bathymetric low between adjacent sand bars or reefs.

Washover fan - Sediment deposited inland of a beach by overwash processes associated with storms where elevated water level and large waves transport sediment across the beach.

Wetland - Land whose saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities that live in the soil and on its surface.

16 Index*

non-structural, 258

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