Fire Island Inlet to Montauk Point

New York

FIRE ISLAND INLET
to
MONTAUK POINT
Reformulation Study

Draft General Reevaluation Report

U.S. Army Corps of Engineers

New York District

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EXECUTIVE SUMMARY

Introduction

The Fire Island Inlet to Montauk Point, New York Combined Beach Erosion Control and Hurricane Protection Project (FIMP) was authorized by the River and Harbor Act of 1960. The project is being reformulated to identify a long-term solution to manage the risk of coastal storm damages along the densely populated and economically valuable south shore of Long Island, New York in a manner which balances the risks to human life and property, while maintaining, enhancing, and restoring ecosystem integrity and coastal biodiversity.

There is a long history of damaging storms along the south shore of Long Island, as well as many efforts to mitigate the damages, including construction of several features of the authorized FIMP project that are described later in the report. The study area also includes critical coastal habitat and environmentally sensitive areas, such as the Fire Island National Seashore (FIIS).

This current study is called a Reformulation, because it seeks to reexamine the project that was originally formulated in the 1950's. This Reformulation came about in part due to a referral to the Council on Environmental Quality in response to the 1978 Environmental Impact Statement (EIS) that was prepared for the project subsequent to passage of the National Environmental Policy Act of 1969. As a result of the referral the Corps of Engineers agreed to reformulate the project with particular emphasis on identifying and evaluating alternatives that considers cumulative impacts on the overall coastal system. The goal of the Reformulation study is to identify an economically viable, environmentally acceptable plan that addresses the coastal storm risk management needs of the study area and is acceptable to the key Federal, State, and local stakeholders. Included within the study area is the Fire Island National Seashore (FIIS). The authorizing law for FIIS specified that any plan for coastal storm risk management within the boundary of the National Seashore be mutually acceptable with the Secretary of the Interior and the Secretary of the Army. A Memorandum of Understanding (MOU) between the U.S. Army and the Department of Interior was signed in July 2014 that provides the foundation for "…developing a plan that is mutually acceptable for hurricane and storm damage reduction, including identifying and evaluating natural and nature-based measures that contribute to coastal storm damage risk reduction, in the Reformulation Study for the FIMP project." (MOU, 2014 – See Pertinent Correspondence – Appendix L)

Given the complex system and the large number of stakeholders, an Interagency Reformulation Group (IRG) was established to provide executive level leadership for the study from the key Federal and State agencies. The IRG developed the vision statement that identified the broad objectives for the study.

In May 2009, a Formulation Report (USACE, 2009) was provided to the key government partners and stakeholders that identified the problems, opportunities, objectives and constraints, analyzed alternatives, and proposed several alternative plans for consideration. Based on the comments received and subsequent discussions among the stakeholders and the public, a Tentative Federally Supported Plan (TFSP) was jointly identified by the Corps of Engineers and the Department of Interior and submitted to the New York State Department of Environmental Conservation (NYSDEC), the non-Federal sponsor, in March 2011. The TFSP identified a plan that met the study objectives and the requirements of both the Corps' and DOI.

On October 29, 2012, Hurricane Sandy made landfall near Atlantic City, NJ, where it collided with a blast of arctic air from the north, creating conditions for an extraordinary historic ‘super storm’ along the East Coast with the worst coastal impacts centered on the northern New Jersey, New York City, and the Long Island coastlines. Storm damages within the FIMP study area, including flooding, erosion, and wave damages, as a result of Hurricane Sandy were severe and substantial. There were three breaches of the barrier island (Figure 1), multiple overwashes, extensive shorefront damages, and extensive back bay flooding. Post-Sandy measurements of beach and dune volume loss on Fire Island indicated that the subaerial beach lost 55 percent of its pre-storm volume equating to a loss of 4.5 million cubic yards. A majority of the dunes either were flattened or experienced severe erosion and scarping (Hapke et al, 2013).

Figure 1. Post Sandy Photo of the Breach in the Otis Pike Wilderness Area

Due to the significant changes brought about by Hurricane Sandy, a reanalysis of the TFSP was undertaken to take into account these changes to the landform, development patterns, and risk.

The post-Sandy TFSP plan was provided to New York State in May 2013, who agreed in concept with the plan. With sponsor support, the TFSP has been identified as the Tentatively Selected Plan (TSP), subject to refinement, based upon public and agency comment. The public and agency review process will also be the basis for finalizing a TSP that meets the requirement of being mutually acceptable to the Secretary of the Army and Secretary of the Interior. The Federal and non-Federal partners have agreed that there are plan details that still need to be finalized. This GRR identifies several plan elements that will continue to be refined during the public and agency review process.

This GRR will serve as the decision document for implementation of the reformulated FIMP project. As an “authorized, but unconstructed” project, the FIMP Reformulation study is being completed with funds authorized by P.L. 113-2 at full federal expense. Per P.L. 113-2, the initial project construction is eligible for 100% federal funding, subject to approval of the Report and execution of a Project Partnership Agreement.

Study Authorization and Construction History

The Fire Island Inlet to Montauk Point, NY, Combined Beach Erosion Control and Hurricane Protection Project (FIMP) was authorized by the River and Harbor Act of 14 July 1960. The authorization provides for beach erosion control and hurricane protection along five reaches of the Atlantic Coast of New York from Fire Island Inlet to Montauk Point, a distance of about 83 miles, by widening the beaches along the developed areas to a minimum width of 100 feet, with berm elevation of 14 feet above mean sea level, and by raising dunes to an elevation of 20 feet above mean sea level, from Fire Island Inlet to Hither Hills State Park, at Montauk and opposite Lake Montauk Harbor.

The original authorization also provides for the construction of up to 50 groins, grass planting on the dunes, interior drainage structures at Mecox Bay, Sagaponack Lake and Georgica Pond, and beach renourishment for a period of ten years after initial construction.

This authorization has been modified by Section 31 of the Water Resources Development Act (WRDA) of 1974, and Sections 103, 502, and 934 of the WRDA of 1986 (P.L. 99-662), which modified the cost-sharing percentages and the period of renourishment. As mentioned previously the reformulated FIMP project is also eligible for funding under P.L. 113-2, which would be at “full federal expense” for initial construction.

Construction of two (2) groins in East Hampton in the vicinity of Georgica pond (Reach 4) were completed in September 1965. Eleven groins in Westhampton Beach (Reach 2) were completed in 1966, with an additional four (4) groins completed in 1970.

Due to severe erosion in the community of Westhampton Dunes located west of the Westhampton groins, an interim project was approved in 1995 that provided for a beach berm and dune, tapering of the western two existing groins, construction of an intermediate groin between the two, and periodic renourishment for up to 30 years. Initial construction was completed in 1997 and renourishment took place in 2001, 2004, 2008, and also in 2014, following Hurricane Sandy, utilizing funding per P.L. 113-2.

An Interim Breach Contingency Plan (BCP) was approved in 1996 that authorized the Corps to respond quickly to close breaches within three (3) months. The BCP was used following Hurricane Sandy to close two breaches of the barrier islands at Smith Point County Park, and at Cupsogue County Park.

An interim project was also approved in 2002 for beach nourishment along 4000 ft. of the vulnerable shoreline immediately west of Shinnecock Inlet, which was constructed in 2006. Following Hurricane Sandy, this area was renourished in 2013, utilizing funds appropriated through P.L. 113-2.

Utilizing funding from the Disaster Relief Appropriations Act of 2013 (P.L. 113-2), the Corps in partnership with New York State has undertaken stabilization efforts on Fire Island and in Downtown Montauk, in order to reestablish a protective beach and dune in vulnerable areas. These projects were approved in 2014, and construction initiated in 2014. Construction of the Downtown Montauk Stabilization Project was completed in 2016, construction of the Fire Island Inlet to Moriches Inlet (FIMI) Stabilization Project is scheduled to be completed in 2018.

Problems and Opportunities

Problems: Intensive development has occurred in the study area, which has resulted in structures, infrastructure and people at risk due to coastal storms. In addition, the natural coastal processes that include longshore, cross-island and bay shoreline sediment transport and estuarine circulation have been altered, which has impacted the natural dune and berm features, their resiliency, and ecological functioning of the coastal ecosystem.

Consequences: With continued sea level change, there is the potential for increased damages along the ocean shorefront and also the likelihood of increased coastal flooding along the bay shoreline.

Opportunities: Opportunities exist to manage coastal storm risk to residents, property, and infrastructure from inundation, wave attack and erosion and also to reestablish the natural coastal processes which will increase resiliency within the coastal study area.

Constraints: Any plan within the jurisdictional boundaries of the National Park Service, Fire Island National Seashore must be mutually acceptable to the Secretary of the Army and the Secretary of the Interior.

Without Project Future Condition: The without project future condition (WOPFC) is the projection of the likely future conditions in the Study Area in the absence of any action resulting from the current study. The WOPFC is the baseline for the analysis and comparison of alternatives for this study. The WOPFC for this study includes the following assumptions.

1. Maintenance of the navigation channels through the existing inlets (Fire Island, Moriches, and Shinnecock Inlets) will continue as authorized.
2. The breach within the Wilderness Area of FIIS that opened during Hurricane Sandy will remain open indefinitely.
3. Periodic renourishment of the Westhampton Interim Project will continue until 2027.
4. The one-time, post-Sandy FIMI Project is constructed, and in place.
5. The one-time, post-Sandy Downtown Montauk Stabilization Project is constructed and in place.
6. The interim Breach Contingency Plan (BCP) will not continue. Breaches of the barrier island will continue to be closed (with the exception of the Wilderness Area of FIIS) but will take a year to close in the absence of a streamlined process for Federal participation.
7. Local interests will continue to maintain some level of beach and dune through beach scraping or intermittent beach fills where that has been past practice.

Quantification of Problem:

Table 1 summarizes the expected average annual damages that are likely in the Without Project Future Condition. This analysis is based upon the assumptions presented above, and the continuation of the historic rate of relative sea level rise (approximately 0.7 ft. in 50 years). This table illustrates that the majority of the damages that are experienced are due to flooding to the mainland communities that occurs during storm events. This flooding is due to the combined effects of tidal surge through the inlets and wind and wave setup within the bays. During some large events additional storm surge enters the bay from barrier island overwash or the formation of breaches. The "total inundation" summary in the table below includes flooding from water that enters through the inlets, as well as flooding as a result of breaching and overwash. The summary of "breach open damages" are those damages that continue to occur in future storms, due to a breach remaining open. "Shorefront damages" are those that occur along the Atlantic Ocean shorefront.

Table 1. Expected Average Annual Damages in Without Project Future Condition (Oct 2015 PL)

Damage Category	Without Project Damage
Total Project	
Tidal Inundation occurring due to inlet conditions, wave setup, storm-related breaching and overwash in back bay	
Total Mainland Inundation	*$98,382,500*
Total Barrier Inundation	*$17,016,300*
Total Inundation	*$115,398,800*
Damages (Inundation and Structure Failure) due to a breach remaining open	
Inundation (Open Wilderness Breach)	$4,732,600
Inundation (Future Breaches)	$3,578,400
Total Breach Open Damages	*$8,311,000*
Shorefront Damages*	$12,848,300
Emergency Costs/Breach Closure	$1,816,000
Total Damage	***$138,374,100***

*Breach Related Structure Failures are not included in the total breach failure due to the potential for double counting these damages with other barrier island damage categories.
Discount Rate 3.125%, Period of Analysis 50 years
Damages include the effects of the historic rate of Sea Level Rise projected over the Analysis Period

Plan Formulation

The goal of the Reformulation Study is to manage coastal storm risks and attendant loss of life from tidal flooding, waves and erosion, in part by reestablishing the natural coastal processes while minimizing environmental impacts.

A "Vision Statement for the Reformulation Study" that integrates the policies of the Corps of Engineers, the State of New York and the National Park Service was developed in 2004 and commits the partner agencies to recognize the following during the plan formulation process:

- Decisions must be based upon sound science, and current understanding of the system,
- Flooding will be addressed with site specific measures that address the various causes of flooding,
- Priority will be given to measures which both provide storm risk management and restore and enhance coastal processes and ecosystem integrity,
- Preference will be given to nonstructural measures that minimize impacts to coastal landforms and natural habitats,
- Project features should avoid or minimize adverse environmental impacts and address long-term demands for public resources,
- Balances dune and beach replenishment considering storm damage reduction and environmental considerations,
- Consideration will be given to alteration of existing shore stabilization structures, inlet stabilization measures, and dredging practices.

In support of the goal of the Reformulation study, the planning objectives are:

1. Reduce tidal flooding on the mainland and barrier islands and attendant loss of life, property and economic activity.
2. Reduce damages to structures due to beach and bluff erosion in critical areas.
3. Reestablish coastal processes and utilize coastal process measures to reduce storm damages and provide resiliency to the system.
4. Ensure that any plan within the jurisdictional boundaries of the National Park Service is compatible with the goals and objectives of the Fire Island National Seashore, and is mutually acceptable to the Secretary of the Army and Secretary of the Interior.

The formulation efforts to arrive at the TFSP included an initial Screening of Measures, preliminary design of alternatives, and design optimization. These formulation efforts were contained in a draft Formulation Report (USACE, 2009) which was provided to the partner agencies, the Department of Interior and the State of New York Department of Environmental Conservation, for review and comment. The information contained in the Formulation Report was also presented at public meetings in summer 2010 to obtain public input on the plans. The Formulation Report presented a series of plans that were developed in a system-wide framework that considered the interaction between the barrier island, shorefront system and the back bay environment. These plans include several alternative plans, and were developed considering the effectiveness of project features in addressing the problems, with each successive plan building on the prior plan to increasingly satisfy the project objectives and Interagency Vision Plan.

Plan 1

Plan 1 includes measures to improve the sediment management of the existing system, which contains features to respond to breaches and also maintenance of the Federal navigation channels at Fire Island, Moriches and Shinnecock Inlets. The existence and current maintenance of the navigation channels results in insufficient sand bypassing to the downdrift beaches and instability of the downdrift shoreline due to the sediment deficit. Restoring the natural coastal processes by providing sufficient sand bypassing across the three inlets is an essential component of any mutually acceptable plan with DOI. It addresses the 3rd component of the “Vision Statement” by “provide(ing) storm risk management, and restoring and enhance(ing) coastal processes and ecosystem integrity”. While sand bypassing by itself does not increase the level of risk reduction that is afforded, it reduces the potential for future shoreline change, and also provides a cost effective source of sand for renourishment. The optimum inlet management alternative includes continuation of maintenance dredging (with beneficial reuse of the sediment to downdrift beaches) at the three inlets, plus additional bypassing of sand from the ebb shoals to offset the erosion deficit. Plan 1a is based on the economically optimum inlet management alternative with a +13 ft. NGVD breach response plan (BRP) alternative, while Plan 1b includes the economically optimum inlet management alternative with a 9.5 ft. NGVD BRP. Both plans performed similarly, and were marginal in justification. These plans were not considered to be a complete solution, since the plans only addressed damages that could be attributed to breaching of the barrier island, which is approximately 10% of the damages.

Plan 2

The second series of plans (Plan 2a through Plan 2h) reflect the addition of nonstructural features, such as building retrofits and road raisings to Plans 1a and 1b. These features when combined provide a managed barrier island, with improved inlet management, and nonstructural features to directly address flooding risk within the bays. The nonstructural storm risk management addresses flooding on the mainland from storm surge propagating through inlets into the bays and wind and wave setup within the bays. The nonstructural alternatives that provided the greatest net benefits was nonstructural alternative 2R, which provides storm risk management for 4,450 structures. The plan provides for retrofits for 3,400 structures that are located within the six year floodplain, and also raising the elevation of a total of about six miles of roads in the communities of Amityville, Lindenhurst, and Mastic that would provide storm risk management for an additional 1,050 homes. Also economically justified, but providing slightly less net benefits than nonstructural alternative 2R, is nonstructural alternative 3R, which provides for 4,400 building retrofits within the 10 year flood plain, along with the 6 miles of road raising that provides coastal storm risk management for an additional 1,050 homes. When combined with Plan 1a and 1b, which provides inlet modifications and breach response, each of the Plan 2 combinations are cost-effective, with BCR’s greater than 1, both for each of the individual reaches and also for the combined reaches. Plan 2f, (13.0 ft. NGVD Breach Closure, Inlet Management, and nonstructural plan 2R) provided slightly greater net benefits than Plan 2e (9 ft. NGVD Breach Closure, Inlet Management, and nonstructural plan 2R).

Plan 2 was also not a complete solution since it does not address the coastal damages along the ocean shorefront and does not address restoring the natural coastal processes, beyond the sand bypassing, which restores the alongshore transport coastal processes.

Plan 3

The third series of plans (Plan 3a through Plan 3g) reflects the addition of the optimum beach nourishment alternative identified in Phase 2 to Plans 2e through Plan 2h. The optimum beach nourishment alternative included a +15 ft. NGVD dune and a 90 ft. berm width design for the Great South

Bay and Moriches Bay Reaches. Beach nourishment alternatives were not cost effective in reducing storm damage in the Shinnecock Bay, Ponds, and Montauk Reaches. For the Shinnecock Bay reach the BRP with the +13 ft. NGVD design section is provided.

Within the Great South Bay and Moriches Bay Reaches there are several environmentally sensitive areas along Fire Island that are vulnerable to future breaches. These locations include the Otis Pike Wilderness Area (OPWA), areas designated as Major Federal Tracts (MFT) by FIIS, and the Smith Point County Park (SPCP). Alternative Plans were developed to evaluate the impact of not providing the optimized beach design at these locations, and instead providing a BRP with a +9.5 ft. closure design. Each of the plans provide for Inlet Management, Breach Response in the Shinnecock Bay Reach, and road raising on the mainland, but differ with regard to the nonstructural plan (NS2R or NS3R), the BRP (BRP 13 or BRP 9.5), and the specific locations where beach nourishment would be excluded.

Each of the above plans provide positive net benefits, with the continuous beachfill plan (Plan 3a) providing the greatest storm damage reduction benefits. However, since NPS policies do not permit placing fill within undeveloped tracts of land within FIIS, only Plans 3d and 3g were acceptable to the NPS. Both Plans 3d and 3g include beachfill in the developed areas, along with periodic renourishment for up to 50 years after completion of initial construction. Plan 3g provides nonstructural storm risk management to structures within the 10 year flood plain (NS 3R), while Plan 3d provides nonstructural storm risk management to structures within the 6 year flood plain (NS 3R).

Plan 3g was the identified as the plan that best balances the objectives of coastal storm damage reduction, consistent with the Vision Criteria Objectives. To further address the storm damage reduction needs and achieve the Vision Criteria objectives, this plan also integrated the following:

- Groin modifications
    - Shortening the groins in the Westhampton groin field to reduce renourishment needs to the west
    - Modifying groins at Ocean Beach upon relocation of the water supply.
    - Monitoring groins in the area of Georgica Pond to determine if any structure modification is warranted.
- Restoration of Coastal Processes
    - Sand bypassing, as described above
    - Integration of Sediment Management Features
    - Integration of natural features to reestablish coastal processes
- Integration of Appropriate Land Use and Development Management Measures
- Integration of Considerations of Climate Change and Adaptive Management

Tentative Federally Supported Plan

Based upon the May 2009 Report, and subsequent public and stakeholder meetings, and coordination between the Army and DOI, in March 2011, USACE and DOI reached agreement on a Tentative Federally Supported Plan (TFSP). The TFSP was based on the Plan 3g described above, including refinements made to ensure the plan was mutually acceptable to USACE and DOI. The TFSP was identified as the National Economic Development (NED) Plan, since this is the plan that maximized net benefits, and satisfied the requirement (constraint) to be mutually acceptable with the Secretary of the Army and Secretary of Interior.

In March 2011, the USACE and DOI transmitted a summary of the TFSP to the State of New York to request their concurrence. By letter dated December 29, 2011, the State provided comments on the TFSP and requested clarification and further detail of the proposed project features and implementation steps.

Coordination was ongoing when Hurricane Sandy struck on October 29, 2012, and caused extensive damage to the Project Area, and created three breaches of the barrier island. Two of the breaches were closed. The breach within the OP Wilderness Area remains open. (DOI is currently monitoring the breach and is preparing an Environmental Impact Statement to determine how to best manage the breach).

Following Hurricane Sandy, the Corps took several actions to update the TFSP. The effort included the following updates:

- The Corps updated the structure inventory and shoreline conditions, based upon post-Sandy changes.
- The Corps updated the hydrodynamic modelling that was done previously, to account for the breach that occurred in the Wilderness Area.
- The Corps updated the economics life-cycle model to account for the existing breach in the Otis Pike Wilderness Area, and also to reflect the new information available about expected breach growth rates.
- The Corps accounted for post-Sandy efforts undertaken by the Corps, and by others. This includes repair of the existing projects, the construction of the Fire Island and Downtown Montauk Stabilization Projects, and nonstructural plans that have been implemented in the Project Area.

The Corps updated the TFSP in response to these changed conditions, and the risk and vulnerability within the study area demonstrated by the hurricane. The changes made to the TFSP include:

- A dune alignment on Fire Island located further landward that reflects the post-Sandy beach and dune condition and is consistent with the post-Sandy Fire Island Inlet to Moriches Inlet (FIMI) Stabilization Project.
- A Proactive Breach Response Plan within Smith Point County Park and the FIIS Lighthouse Tract to provide a greater level of risk-reduction to these two heavily impacted areas.
- A 30-yr commitment for periodic renourishment and a Breach Response Plan for years 31-50.
- A Conditional Breach Response Plan on NPS owned lands that provides for a decision-making process to consider if breaches will close naturally, prior to implementing mechanical closure.
- Refinement of the coastal process features, with an emphasis on features that contribute to coastal storm risk management.
- Recognition that changes in land management regulations by non-USACE entities that complement the features recommended for FIMP.

This updated plan was provided to New York State in May 2013. New York State agreed in concept with this plan in June 2013, recognizing that further refinements to the plan would be taking place. In August

2015, the Corps advised New York State and DOI of their intent to proceed with this updated plan as the Tentatively Selected Plan (TSP).

Consistent with the Corps' planning process, the TSP is still subject to refinement, based upon public and agency review. The updates to the plan to arrive at the TSP have not been fully vetted within the Corps and DOI; however, the Corps and DOI have entered into an MOU in July 2014 in which both parties committed to finalizing the FIMP report, consistent with the Vision Statement. The Corps, NYS and DOI agreed to use the public and agency review process to finalize a plan that is mutually acceptable to the Secretary of the Army and Secretary of the Interior, and supported by the non-Federal sponsor.

There are several elements of the TSP that the Corps, DOI, and New York State have agreed to continue to develop concurrent with the public and agency review process that may affect the final plan. These include 1) the scope and extent of the natural features that reestablish coastal processes, 2) refinement of breach response protocols, 3) refinement of adaptive management, and 4) refinement of land management. The Corps and DOI recognize that there are additional needs and opportunities to provide for coastal process features which replicate the cross-island transport of sediment, provide barrier island resiliency, and long-term sustainability. With respect to the breach response protocols, the involved agencies have agreed that refinement of the decision-making protocols to better specify how the decisions related to breach closure would be made, with further work continuing to occur in the design phase of the project. Adaptive management is recognized as an important element of the selected plan, but the framework for adaptive management has not been defined. It is the intent of the agencies to identify the conditions under which changes in the plan could be made, and the framework for decision-making that would constitute an adaptive management plan. Land management is recognized as an important tool to manage future risks. The Federal and State agencies have agreed to continue to identify the land management measures that are available to manage these risks, and how these measures will work in conjunction with the TSP.

The specific features of the TSP are described below.

Inlet Modifications

- Provide for sufficient sand bypassing across the three inlets to ensure the natural longshore transport along the barrier islands.
- Continue the scheduled O&M dredging of the navigation channels at Fire Island, Moriches and Shinnecock Inlets, along with additional dredging of 73,000 to 379,000 cy from the ebb shoals of each inlet, outside of navigation channel, to obtain the required volume of sand needed for the bypassing.
- Bypassed sand is used to construct and maintain a +13 ft. NGVD dune and 90 ft. berm width in identified placement areas.
- Provide for monitoring to facilitate adaptive management changes in the future.

Mainland and Nonstructural

- Addresses approximately 4,400 structures within 10 year flood plain using nonstructural measures, primarily through building retrofits, with limited relocations and buy-outs, based upon structure type and condition.
- Includes road raising in four locations, totaling 5.91 miles in length, which reduce flooding to 1,020 houses.

Barrier Islands

- Breach Response
  - Proactive Breach Response is a plan where action is triggered when the breach and dune are lowered below a 25 year design level of risk reduction, and provides for restoration to the design condition (+13 ft. dune and 90 ft. berm). This plan is included on Fire Island in vicinity of the FIIS Lighthouse Tract, Smith Point County Park East (to supplement when needed the sand from inlet bypassing), in Smith Point County Park West and also along the barrier island fronting Shinnecock Bay.
  - Reactive Breach Response - is a plan where action is triggered when a breach has occurred, e.g. the condition where there is an exchange of ocean and bay water during normal tidal conditions. It will be utilized as needed when a breach occurs.
  - Conditional Breach Response – is a plan that applies to the large, Federally-owned tracts within FIIS (except the Lighthouse Tract), where the breach response team determines if a breach is closing naturally or if mechanical closure is needed. Conditional Breach closure provides for a 90 ft. wide berm at elevation + 9.5 ft.
  - Beach and Dune Fill
    - Provides for a continuous 90 ft. width berm and +15 ft. dune along the developed shorefront areas fronting Great South Bay and Moriches Bay on Fire Island and Westhampton barrier islands.
    - On Fire Island the alignment follows the post-Sandy optimized alignment (consistent with the FIMI alignment) that includes overfill in the developed locations and minimizes tapers into Federal tracts.
    - Periodic Renourishment would take place about every 4 years for a 30 year period after initial construction. For years 31 through 50, there would be Proactive Breach Response in those reaches, which continues to provide some coastal storm risk management, albeit less than what was provided by the periodic renourishment.

Sediment Management at Downtown Montauk (Montauk Beach) and Potato Road

- Provides for placing about 120,000 CY on front face of existing berm at each location approximately every 4 years as advance fill to offset erosion.
- The Potato Road feeder beach is contingent upon implementation of a local pond opening management plan for Georgica Pond.

Groin Modifications

- Shorten existing Westhampton groins (1-13) between 70 — 100 ft. to reestablish coastal processes
- Modify the existing Ocean Beach groins (shorten and lower) after relocation of Ocean Beach water supply wells. Final modifications will be determined during PED.

Coastal Process Features

- Project Features that contribute to coastal storm risk management by enhancing the resiliency of the natural system and its ability to recover after storm events include the following:
  - Sunken Forest – Reestablishes the natural storm risk management conditions of the dune, upper beach and bay shoreline by removing bulkhead adjacent to marina and existing boardwalk, regrading and stabilizing disturbed areas using bioengineering and shoreline,
  - Reagan Property – Reestablishes the natural storm risk management condition of dune, upper beach and shoreline by placing sand fronting the bulkhead, regrading and stabilizing disturbed areas using bioengineering, and creating intertidal areas.
  - Great Gunn – Reestablishes salt marsh features by reestablishing hydrologic connections and disturbances.
  - Tiana – Reestablishes the bay shoreline natural storm risk management features by reestablishing the dune, salt marsh, and enhancing the SAV beds.
  - WOSI – Reestablishes the bay shoreline natural storm risk management features by reestablishing the existing salt marsh.
  - Corneille Estates – Reestablishes bay shoreline natural storm risk management features by reestablishing bayside beach habitat.

Adaptive Management

- Will provide for monitoring for project success, relative to the original objectives and the ability to adjust specific project features to improve effectiveness.
- Climate change will be accounted for with the monitoring of climate change parameters, identification of the effect of climate change on the project design, and identification of adaptation measures that are necessary to accommodate climate changes as it relates to all the project elements.

Integration of Local and Land Use Regulations and Management

- Local land management regulations to include enforcement of federal and state zoning requirements, as a necessary complementary feature for long-term risk reduction.

TSP Costs and Benefits

The TSP has been evaluated to compare the annualized With-Project damages to the Without-Project Damages in order to demonstrate the cost-effectiveness of the TSP. This comparison uses the FY16 discount rate of 3.125%, a project base year of 2021, and a period of analysis of 50 years.[1]

Table 2 summarizes the Initial Project First Costs, Annualized Costs and Benefits and BCR for the overall TSP. The Initial Project First cost is $1.16 billion for the TSP. The TSP has positive net benefits, with a BCR of 1.49.

Table 2. Summary of Initial Project First Costs, Annualized Costs, and BCR*

Formulation Summary	TSP
Initial Project First Cost	$1,107,099,500
IDC	$111,733,000
Investment Cost	$1,218,832,500
Annualized Cost	$67,168,700
Total Storm Damage Reduction Benefits	$72,713,000
Costs Avoided – Breach Closure	$1,816,000
Recreation Benefits	$22,695,000
Total Benefits*	$97,224,000
Net Benefits	$30,055,300
BCR	**1.4**

* Oct 2015 PL, Annualized over the 50 year period of analysis using the Federal Discount rate of 3.125%

Project Performance & Residual Damages

Table 3 provides a comparison of the damages expected to occur in the without project condition to the damages expected to occur in the with-project condition. This shows the reduction in damages that can be achieved by the project features, and the areas of remaining risk. This illustrates that without the project, the largest source of damages is flooding into the back bays. The plan is effective in reducing over 50% of the damages in the back bay, but significant residual risks remain. The plan is also effective in reducing damages associated with breaches remaining open, and acknowledges the continued flooding that is likely to occur with the existing breach in the wilderness area. Shorefront damages are reduced by 50%, but there is a remaining risk to development along the shorefront.

[1] Base year has been revised to 2025. Damages and Benefits will be updated for final report, and are expected to increase slightly.

Table 3. Summary of Without and With Project Damages (Oct 2015 PL)

Damage Category	Without Project Damage	With Project Damage TSP
Back Bay Inundation Damages (Tidal flooding due to inlet conditions, wave setup, storm-related breaching and overwash into back bay)	**$115,398,800**	**$52,316,000**
Mainland Inundation	$98,382,500	$36,407,000
Barrier Island Inundation	$17,016,300	$15,909,000
Total Breach Open Damages (Inundation due to breaches remaining open)	**$8,311,000**	**$4,848,000**
Inundation (Open Wilderness Area Breach)	$4,733,300	$4,733,000
Inundation (Future Breaches)	$3,578,400	$116,000
Shorefront Damages	**$12,848,300**	**$6,681,000**
Total Damages	**$138,374,100**	**$63,845,000**

Discount Rate 3.125%, Period of Analysis 50 years, Low Sea Level Rise Scenario

Sea Level Rise Sensitivity

The estimates of project performance shown in Table 3 are based upon a low (historic) rate of Relative Sea Level Change. Table 4 shows the effectiveness of the TSP under the intermediate and high rate of RSLC. Under the Intermediate and High RSLC, the With Project TSP reduces the Without Project damages by approximately 50 % with BCR's of 1.7 and 4.0, respectively.

Table 4. Summary of Without and With Project Damages for Intermediate and High Sea Level Rise Scenarios (Oct 2015 PL)

Damage Category	Without Project Damages	With Project (TSP) Damages	TSP Benefits	BCR
Intermediate SLR				
Back Bay Inundation	$148,092,400	$71,168,000	$76,924,400	
Breach Open Inundation	$25,306,600	$13,103,000	$12,203,600	
Shorefront	$13,756,500	$7,654,000	$6,102,500	
Total Storm Damages (Intermediate SLR)	**$187,155,500**	**$91,925,000**	**$95,230,500**	**1.7**
High SLR				
Back Bay Inundation	$307,970,000	$173,247,000	$134,723,000	
Breach Open Inundation	$303,307,000	$129,443,000	$173,864,000	
Shorefront	$18,623,000	$12,940,000	$5,683,000	
Total Storm Damages (High SLR)	**$629,900,000**	**$315,630,000**	**$314,270,000**	**4.0**

PERTINENT DATA

DESCRIPTION

The Tentative Selected Plan (TSP) provides for coastal storm risk management along the South of Long Island from Fire Island Inlet to Montauk Point that includes reestablishing coastal processes that enhances resiliency and sustainability.

GENERAL DATA

FIMP study area: 126 sq. miles within Suffolk, NY. Includes portions of Towns of Babylon, Islip, Brookhaven, Southampton, and East Hampton, as well as 12 incorporated villages, the entirety of Fire Island National Seashore (FIIS), the Poospatuck Indian Reservation, and the Shinnecock Indian Reservation.

Shoreline: 83 miles along Atlantic Coast shoreline and over 200 miles of back bay shoreline along Great South, Moriches and Shinnecock Bays.

Structures Impacted by a 100-year Flood Event: approximately 9,000

Population residing within 100 year floodplain: approximately 150,000

DATUMS

This Reformulation Study has been prepared with references to the National Geodetic Vertical Datum of 1929 (NGVD). The project datum will be updated to the North American Vertical Datum of 1988 in the design phase. The conversion from NGVD 1929 to NAVD 1988 in the Study Area is accomplished by subtracting 1.1 feet from the original NGVD 1929 elevation value, or in other words NGVD 1929 - 1.1 ft. = NAVD 1988.

TENTATIVELY SELECTED PLAN

The plan includes the following components, as shown in Figure 2.

Inlet Management

- Fire Island Inlet
  - O&M on 2 year interval (Authorized);
  - 819,000 cy (per O&M event) dredged from channel and deposition basin and placed downdrift at Gilgo Beach;
  - 214,000 cy (per O&M event) dredged from channel and expanded deposition basin and placed updrift at Robert Moses State Park;
  - 327,000 cy (per O&M event) dredged from ebb shoal and placed downdrift at Gilgo Beach to offset deficit.

- Moriches Inlet
  - O&M on 1 year interval (Authorized);

- 98,000 cy (per O&M event) dredged from channel and deposition basin and placed downdrift at Smith Point County Park (SPCP);
- 73,000 cy (per O&M event) dredged from ebb shoal and placed downdrift at SPCP to offset deficit.

- Shinnecock Inlet
  - O&M on 2 year interval (Authorized);
  - 170,000 cy (per O&M event) dredged from channel and deposition basin and placed downdrift at Sedge Island, Tiana Beach, and West of Shinnecock (WOSI);
  - 105,000 cy (per O&M event) dredged from ebb shoal and placed downdrift to offset sediment deficit.

Mainland Nonstructural

- Consists of building retrofits, flood proofing, relocation and acquisition of 4,400 structures that are located within 10 year floodplain (treatment to provide 100 year level of storm risk management);
- Also includes 5.9 miles of road raising that provides storm risk management for 1054 homes.

Barrier Islands – Include the following components:

- Beach, dune and Periodic Renourishment – Provides for +15 foot NGVD dune with 90 ft. berm (+9.5 ft. NGVD), with post-Sandy optimized alignment for 11 project reaches, totaling approximately 81,000 feet of shoreline. Approximately 3 million cy of sand would be placed during initial construction. Periodic renourishment would take place about every 4 years for a 30 year period after initial construction. For years 31 through 50, there would be proactive breach response in those reaches, which continues to provide some storm risk management, albeit less than what was provided by the periodic renourishment.
- Proactive Breach response – Provides for +13 foot NGVD dune with 90 ft. berm (+9.5 ft. NGVD), for 12 project reaches, totaling about 89,000 feet of shoreline. Approximately 1.9 million cy of sand would be placed during initial construction.
- Conditional Breach response (within Federally-owned tracts within FIIS) – Includes 8 project reaches, totaling about 63,600 feet of shoreline. Provides for breach closure as needed, if a decision is made the breach is not closing naturally, and provision for a 90 ft. berm (+9.5 ft. NGVD).
- Reactive Breach Response – Includes 11 project reaches, totaling approximately 81,000 feet of shoreline. Provides for breach closure and provision for a 90 ft. berm (+9.5 ft. NGVD).
- Sediment Management – Feeder beach with 120,000 cy of sand place once every 4 years at each of the 2 project reaches, totaling about 9,000 feet of shoreline.
- Groin Modifications
  - Westhampton – Shorten groins 1 thru 8 to 380 ft.; shorten groins 9thru 13 to 386, 392, 398, 401 and 410 feet, respectively.
  - Ocean Beach – modify the existing groins (shorten and lower) after relocation of the water supply.

Coastal Process Features (Six locations, see Figure 28**)**

- Includes Inlet Management component of TSP that provides for sand bypassing across the three Inlets and also enhances upper beach/dune width/slope/height;
- Includes the sediment management and groin modification components of the TSP that provides improved alongshore sediment transport;
- Reestablishes the natural coastal processes along the Great South Bay shoreline at Sites T-2 (Sunken Forest), and T-3 (Reagan Property) by removing/burying bulkheads, regrading eroding shorelines, and stabilizing shoreline using vergetated gabions;
- Reestablishes the natural coastal processes along the Shinnecock Bay shorelines at Site T-7 (Tiana) by removing fill material and planting native vegetation;
- Reestablishes upper beach, dunes and interior dune areas at Sites T-2 (Sunken Forest) and T-3 (Reagan Property) by restoring dune to its natural height and width, removing hard structures and restoring dunes at cuts;
- Reestblishes upper beach, dunes and interior dune areas at Site T-7 (Tiana) by removing parking lot, regrading to its natural height and width, removing hard structures and restoring dunes at cuts, and planting native vegetation;
- Reestablishes natural hydrologic connection at Site T-5 (Great Gunn) to existing salt marsh via culvert beneath road.
- Reestablishes existing submergent vegetation at Site T-7 (Tiana).

ECONOMICS

Project First Cost (Oct 2015 PL)..$1,107.1 million

Total Project Cost (fully funded to mid-point of construction)………… ......….. .$ 1,248.4 million

Periodic renourishment* (Oct 2015 PL-(7 cycles over 30 year period)…… ....…$ **525.5** million

Periodic renourishment (fully funded to mid-point of construction)……… ..……. .$ 849.9 million

Total Annual Cost *, ...$67.2 million

Total Annual Benefits* ....$97.2 million

Net Benefits ....$28.0 million

Benefit to Cost Ratio... 1.4

Base Year** 2025

Damage Model Used... HEC-FDA 1.2.5a***

* Oct 2015 PL, Annualized over the 50 year period of analysis using the Federal Discount rate of 3.125%

** Benefits assumed 2021 base year, which has been changed to 2025. Benefits are expected to increase slightly once the analytical models are rerun with 2025 base year, which is not expected to change conclusions and recommendations.

***A suite of models using SAS v9 and @RISK v6 were developed specifically for this study and were subject to certification procedures in accordance with EC 1105-2-412. Data generated using HEC-FDA v1.2.5a was also used to develop key inputs for the SAS and @RISK models.

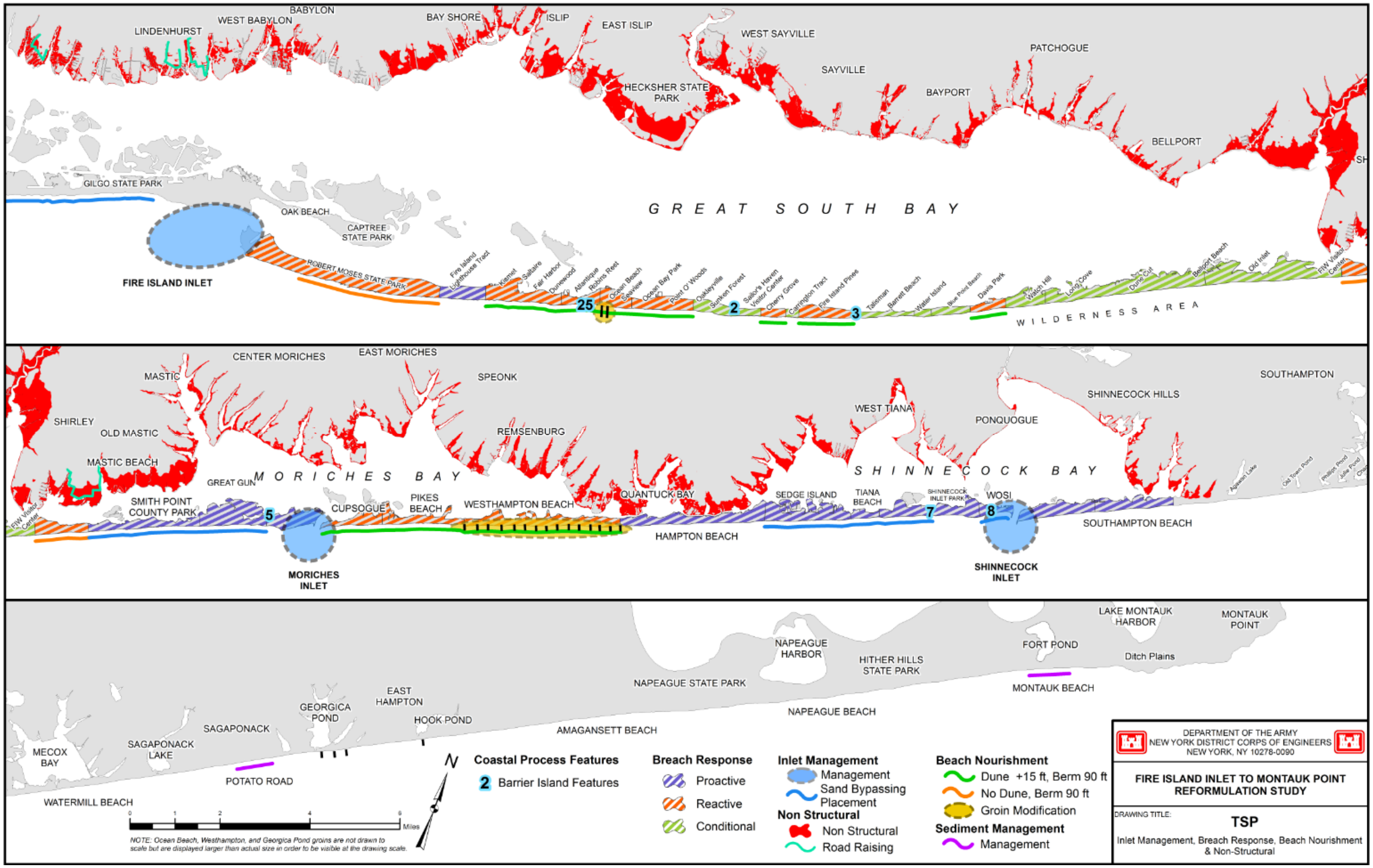

Figure 2. Tentatively Selected Plan

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TABLE OF CONTENTS

APPENDICES

LIST OF TABLES

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

BCP Breach Contingency Plan
BFE Base Flood Elevation
BRP Breach Response Plan
C Celsius
CBRA Coastal Barrier Resources Act of 199
CDP Census Designated Place
CEHA Coastal Erosion Hazard Area
CENAN U.S. Army Corps of Engineers, New York District
CMP Coastal Management Program
CWA Clean Water Act
CZM Coastal Zone Management
DOI United States Department of the Interior
EFH Essential Fish Habitat
EIS Environmental Impact Statement
ESA Endangered Species Act
F Fahrenheit
FEMA Federal Emergency Management Agency
FIIP Fire Island Interim Project
FIIS Fire Island National Seashore
FIMP Fire Island Montauk Point
FIRM Flood Insurance Rate Map
FVC future vulnerable condition
FWOP Future Without Project Condition
GIS geographic information system
GMP General Management Plan
HMP hazard mitigation plan
IRG Interagency Reformulation Group
JMA John Milner Associates
LIPA Long Island Power Authority
LIRR Long Island Railroad
LWRP Local Waterfront Revitalization Plan
LWRPs Local Waterfront Revitalization Programs
MFCMA Magnuson-Stevens Fishery Conservation and Management Act

mg/l milligrams per liter
MHW mean high water
MLW mean low water
MOU Memorandum of Understanding
MREI minimum real estate impact
MSL mean sea level
MTA Metropolitan Transportation Authority
NEPA National Environmental Policy Act of 1969
NFIP National Flood Insurance Program
NGVD National Geodetic Vertical Datum
NMFS National Marine Fisheries Service
NPS National Park Service
NRC National Research Council
NRHP National Register of Historic Places
NYCRR New York Code of Rules and Regulations
NYSDEC New York State Department of Environmental Conservation
NYSDOS New York State Department of State
NYSECL New York State Environmental Conservation Law
NYSEMO New York State Emergency Management Office
NYSOPRHP New York State Office of Parks, Recreation and Historic Preservation
OFD Oceanfront Dune District
SAV submerged aquatic vegetation
SCDPW Suffolk County Department of Public Works
SEQR State Environmental Quality Review
SHPO State Historic Preservation Office
TFSP Tentative Federally Supported Plan
TSP Tentative Selected Plan

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1 INTRODUCTION

The Fire Island Inlet to Montauk Point, New York Combined Beach Erosion Control and Hurricane Protection Project (FIMP) was authorized by the River and Harbor Act of 1960. As described in Section 1.3, the project has been partially constructed, but is being reformulated to identify a long-term solution to manage the risk of coastal storm damages along the densely populated and economically valuable south shore of Long Island, New York in a manner which balances the risks to human life and property, while maintaining, enhancing, and restoring the natural coastal processes and ecosystem integrity.

There is a long history of damaging storms along the south shore of Long Island, as described in detail in Appendix E- Plan Formulation. There have also been efforts to mitigate the damages, including construction of several features of the authorized FIMP project, which are described later in this chapter. The study area also includes critical coastal habitat and environmentally sensitive areas, such as the Fire Island National Seashore.

This current study is called a Reformulation, because it seeks to reexamine the project that was originally formulated in the 1950's. This Reformulation came about in part due to a referral to the Council on Environmental Quality in response to the 1978 Environmental Impact Statement (EIS) that was prepared for the project subsequent to passage of the National Environmental Policy Act of 1969. As a result of the referral the Corps of Engineers agreed to reformulate the project with particular emphasis on identifying and evaluating a broad array of alternatives in the context of cumulative impacts on the overall coastal system. The goal of the Reformulation study is to identify an economically viable, environmentally acceptable plan that addresses the storm risk management needs of the project area and is acceptable to the key Federal, State, and local stakeholders. Included within the study area is the Fire Island National Seashore (FIIS). The authorizing law for FIIS specifies that any plan for coastal storm risk management with the boundary of FIIS be mutually acceptable with the Secretary of the Interior and Secretary of the Army.

Given the complex system and the large number of stakeholders, a collaborative planning approach has been utilized to involve the key stakeholders and the public. An Interagency Reformulation Group (IRG) was established that provided executive level leadership for the reformulation from the key Federal and State agencies. The IRG developed a vision statement that identified the broad objectives for the study. The IRG also established various Technical Management Groups that included agency members, as well as non-governmental organizations and academia.

In May 2009, a draft report (USACE, 2009) was provided to the key government partners and stakeholders, which identified problems, opportunities, objectives and constraints, provided a detailed analysis of the alternatives, and identified several alternative plans for consideration. Based on the comments received and subsequent discussions among the stakeholders and public, a Tentative Federally Supported Plan (TFSP) was developed and provided to the sponsor in March 2011. The Plan Formulation Appendix (Appendix E) describes the detailed formulation process that led to the 2009 draft report and the subsequent coordination and modifications that led to the TFSP.

On October 29, 2012, Hurricane Sandy made landfall near Atlantic City, NJ, where it collided with a blast of arctic air from the north, creating conditions for an extraordinary historic 'super storm' along the East Coast, with the worst coastal impacts centered on northern New Jersey, New York City, and the Long Island coastlines. Hurricane Sandy's unusual track and extraordinary size generated record storms surges and offshore wave heights in the New York Bight. The maximum water level at The Battery, NY peaked at +12.4 feet NGVD, exceeding the previous record by over 4 feet. Coastal erosion and damages within the FIMP study area as a result of Hurricane Sandy were severe and substantial. For example, post-Sandy measurements of volume loss of the beach and dunes on Fire Island indicated that the subaerial beach lost 55 percent of its pre-storm volume equating to a loss of 4.5 million cubic yards. A majority of the dunes either were flattened or experienced severe erosion and scarping (Hapke et al, 2013).

As a result of Sandy, further refinements were made to the TFSP, in order to arrive at the Tentatively Selected Plan (TSP). These refinements are described in Chapter 5, Plan Formulation.

This report will serve as a decision document for implementation of the reformulated FIMP project, in accordance with the Disaster Relief Appropriations Act of 2013 (P.L. 113-2). As an "authorized, but unconstructed" project, the reformulated FIMP project is eligible for funding under P.L. 113-2 for initial construction at full federal expense.

1.1 Study Area

The Study Area (Figure 3) extends from Fire Island Inlet east to Montauk Point along the Atlantic Coast of Suffolk County, Long Island, New York, a distance of about 83 miles. It includes the barrier island chains from Fire Island Inlet to Shinnecock Inlet, and a shorefront area east of Shinnecock Bay to Montauk Point. Behind the barrier islands, the back-bay and lands adjacent to Great South, Moriches, and Shinnecock Bays cover over 200 miles of shoreline that comprises the back bay and estuary system. The study area includes about 126 square miles on the mainland that are vulnerable to flooding.

Within the study area, sediment on the ocean shoreline has a net east to west alongshore movement, in response to waves and currents during normal conditions and during storms. This alongshore movement of sand shapes the prevailing shoreline conditions. In addition to alongshore movement, sediment is also exchanged in the cross-shore direction, through erosion and accretion of the beach and dune, exchange of sand through tidal inlets, and during large storm events (storms generally greater than a 2% annual chance of occurrence) through the episodic transport of sand over the island through overwash or breaching.

There has been extensive development on both the barrier islands and the mainland floodplains and significant modifications to the natural systems and coastal processes. These include constructing jetties and providing navigation channels through Fire Island, Moriches, and Shinnecock Inlets and within the bays; constructing of groins, seawalls, revetment, bulkheads and other structures along the ocean and bays; placing fill and sand along the beaches; ditching of wetlands for mosquito control; and periodic openings of temporary inlets at coastal ponds.

The Study Area includes portions of the Towns of Babylon, Islip, Brookhaven, Southampton and Easthampton and 12 incorporated Villages. The Fire Island National Seashore (FIIS), the Poospatuck Indian Reservation and the Shinnecock Indian Reservation are all within the study area. The study area contains over 46,000 buildings, including 42,600 homes and more than 3,000 businesses. There are 60 schools, 2 hospitals, and 21 firehouses and police stations in the study area. Of the buildings within the study area, more than 9,000 fall within the modeled 100-yr floodplain (storm with a 1% probability of occurring in any given year, based upon current modeling).

Approximately 150,000 people reside within the coastal 100-year floodplain of the South Shore of Suffolk County (2010 U.S. Census). The study area is also a popular summer recreation area with a large seasonal influx of beachgoers and visitors, as well as businesses which support the year round and seasonal population of the area.

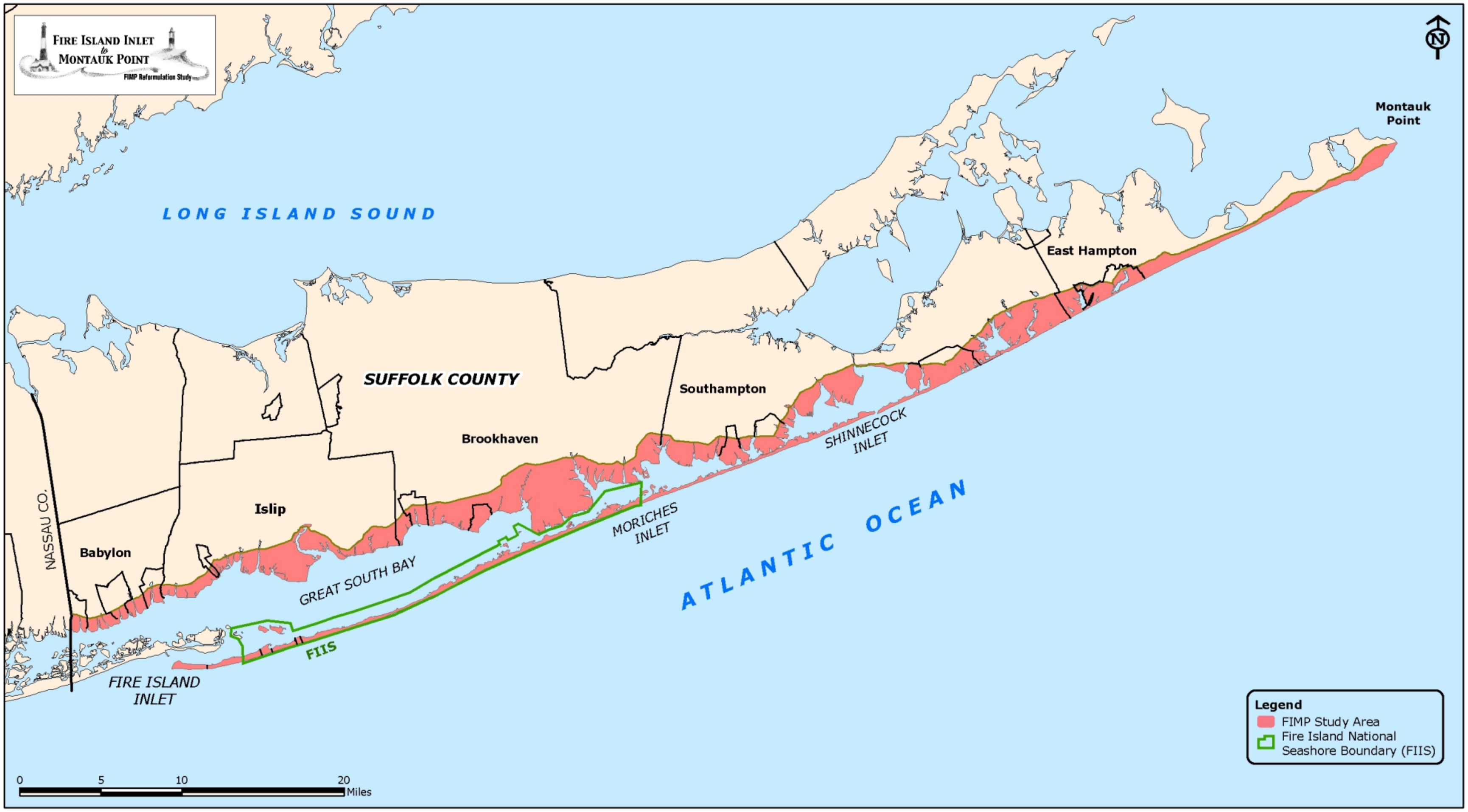


Figure 3. Study Area

1.2 Project Authority

The Fire Island Inlet to Montauk Point, NY, Combined Beach Erosion Control and Hurricane Protection Project (FIMP) was authorized by the River and Harbor Act of 14 July 1960. The authorization provides for beach erosion control and hurricane protection along five reaches of the Atlantic Coast of New York from Fire Island Inlet to Montauk Point, a distance of about 83 miles, by widening the beaches along the developed areas to a minimum width of 100 feet, with an elevation of 14 feet above mean sea level, and by raising dunes to an elevation of 20 feet above mean sea level, from Fire Island Inlet to Hither Hills State Park, at Montauk and opposite Lake Montauk Harbor.

The original authorization also provides for the construction of up to 50 groins, grass planting on the dunes, interior drainage structures at Mecox Bay, Sagaponack Lake and Georgica Pond, and beach renourishment for a period of ten years after initial construction. The authorized plan is shown Figure 4, which shows the five reaches that were to be developed and implemented.

This authorization has been modified by Section 31 of the Water Resources Development Act (WRDA) of 1974, and Sections 103, 502, and 934 of the WRDA of 1986 (P.L. 99-662), which modified the cost-sharing percentages and the period of renourishment. As mentioned previously the reformulated FIMP project is also eligible for funding under P.L. 113-2, which would be at “full federal expense.”

1.3 Project History

The study area has a long history of storm damage. Prior to the 1930s the recorded history is largely anecdotal, but records describe the great storm of 1690 which opened Fire Island Inlet; the major hurricane of 1821, which resulted in flooding 9.3 feet above average in NYC, and the hurricane of 1890 which was labeled as “Long Island’s Most Destructive Storm.” The 1930’s had a number of significant storms, including the March 1931 nor’easter, which created Moriches Inlet and caused widespread erosion. The 1938 hurricane, named the Long Island Express had wind gusts of up to 135 MPH and caused widespread destruction with 50 people killed and over 1,000 homes destroyed. The storm resulted in 11 new openings in the barrier islands, 10 of which were closed using trucks and bulldozers. The 11th breach was at Shinnecock Inlet, which Suffolk County stabilized with a timber crib structure on the western side to create a permanent inlet.

There was a series of storms beginning with the November 1950 and November 1953 Nor’easters, Hurricane Carol in 1954, Hurricane Donna in 1960, and the Ash Wednesday Nor’easter of 1962, also known as the “5 High-Tide Storm”, since the storm resulted in flooding over a period of five high tides. These storms had significant impacts on the project area and resulted in the original FIMP study. The study concluded with a 1958 Survey report that was the basis of the 1960 project authorization.

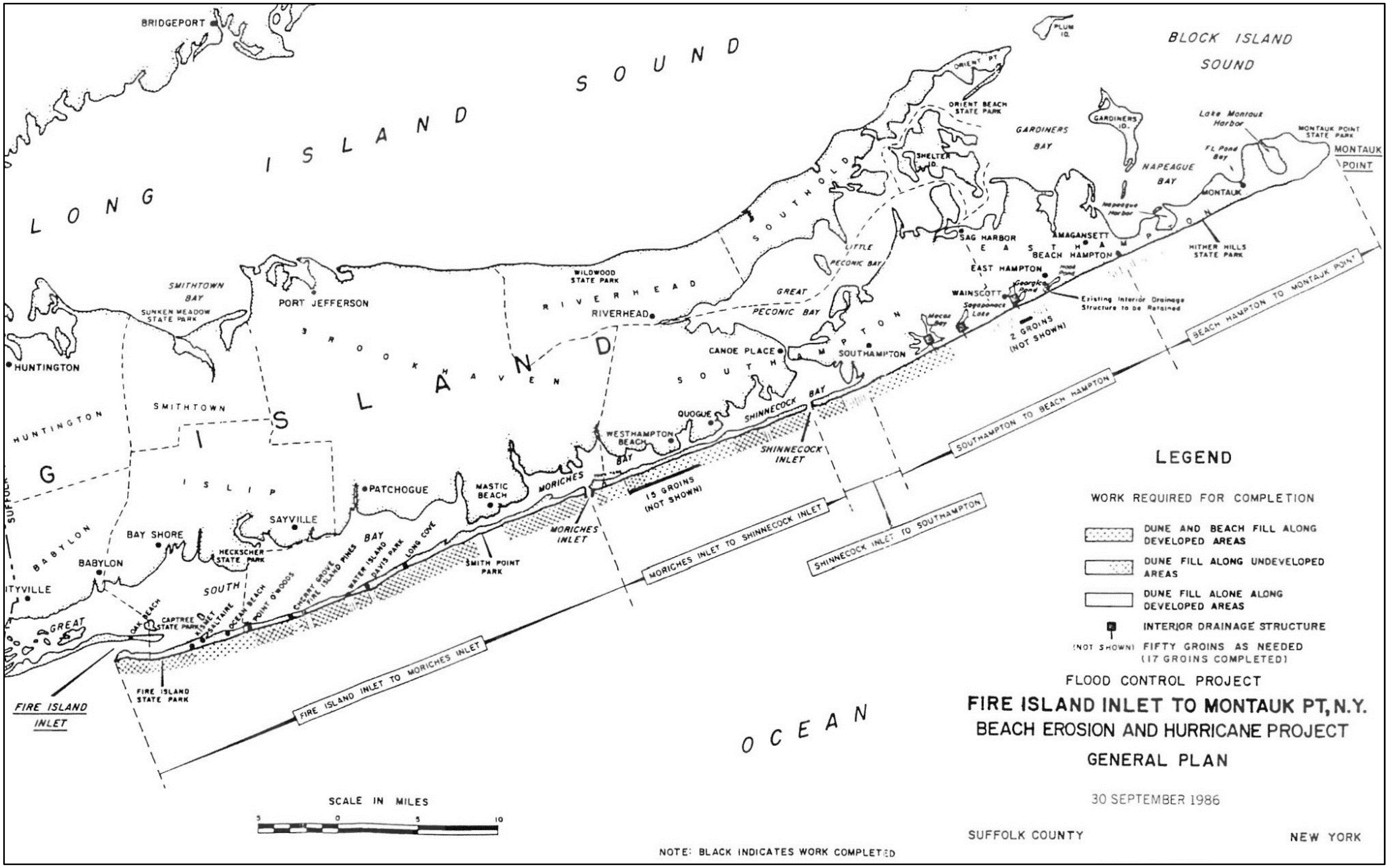


Figure 4. Original Authorized Project

1.3.1 Project Implementation in the 1960's

Following the original project authorization in 1960, several design memoranda (reports) covering portions of the project were prepared. General Design Memorandum (GDM) No. 1 that was approved in January 1964 recommended the construction of 13 groins in the portion of the project between Moriches and Shinnecock Inlet (Reach 2) along with beachfill and dune construction concurrent with the groin construction. Due to objections from local interests, the plan was modified to include construction of 11 groins in Reach 2 with beach fill to be added as necessary but not sooner than three years after groin completion. In a special report of design memorandum scope dated July 1964, the construction of two groins in East Hampton, in the vicinity of Georgica Pond (Reach 4), was recommended and approved. Construction of the 11 groins within Reach 2 was completed in September 1966, while construction of the two groins in Reach 4 was completed in September 1965.

In the years following construction of the eleven groins in Reach 2, erosion was evident in the area west of the eleven groins. In February 1969, Supplement No.1 to GDM No. 1 (Moriches to Shinnecock Reach) recommended the construction of four more groins and placement of beach fill backed by a dune at an elevation of 16 ft. above mean sea level (M.S.L.) in the 6,000 ft. section of beach west of the 11 groin field. The four new groins were filled with 1.95 million cubic yards of sand to construct a beach and dune. This groin construction was completed in July 1970, bringing the total number of groins in Reach 2 to fifteen. Dune and beach fill was placed between October 1969 and October 1970.

1.3.2 1970's Design and NEPA Analysis

Recognizing the need to complete construction within the Moriches to Shinnecock Reach, the New York District prepared plans for six additional groins to the west of the constructed groin field at Westhampton (Section 1B). However, in November 1971, New York State withdrew its support due to a moratorium it imposed on capital projects funding. In April 1973, the State requested that the New York District resume planning for the construction of Section 1B. In November 1974, the Suffolk County Executive opposed the use of Moriches Bay and Moriches Inlet as the sand borrow source for Section 1B. Subsequently, offshore borrow sources were investigated and identified. In 1978 the Suffolk County Legislature and the New York State Department of Environmental Conservation approved participation in the Westhampton project, including beach fill and dune construction obtained from an offshore borrow area.

In conjunction with the design of Section 1B, the Corps was required to comply with the National Environmental Policy Act (NEPA), because the originally authorized project was developed prior to the enactment of the NEPA in 1969. An Environmental Impact Statement (EIS) for the entire project area was prepared and filed with USEPA on 28 January 1978. On 7 March 1978, the Department of the Interior (DOI), supported by other agencies, referred the EIS to the Council on Environmental Quality (CEQ) as unacceptable. The CEQ concluded that the EIS did not sufficiently consider alternatives, did not adequately address project impacts, and did not consider cumulative impacts to the entire system. Following public meetings and public and government agency input, a Plan of Study was approved in July 1980 for a Reformulation Study and an updated EIS.

1.3.3 1980's Project Reformulation, Litigation and Westhampton Interim Project

At the time the Reformulation Study was being scoped, the involved federal agencies agreed on an approach to address the critical erosion in the area west of the existing groin field at Westhampton Beach independent of the overall Fire Island Inlet to Montauk Point reformulation effort. In 1980 HQUSACE approved a plan for beachfill and dunes in this area. However, in 1981, the State objected to the cost-sharing of 6% Federal and 94% non-Federal for the required periodic renourishment at Westhampton. With the State withdrawing their support, all work on both Westhampton and the Reformulation was suspended due to lack of local support.

The State of New York's concern about the cost sharing were resolved with enactment Section 502 of the Water Resources Development Act of 1986 which provides for 70 percent federal funding to be applied to periodic renourishment of continuing construction at Westhampton Beach, for a period of 20 years following the Act. With this resolution, coordination between the State and the New York District resumed on both Westhampton Beach and the Reformulation Study.

In 1984 several lawsuits were brought by various homeowners against the federal government, New York State, and Suffolk County claiming that the failure to complete the project had resulted in the loss of their property. In 1989 the litigation was wrapped into a single suit borne by the Barrier Beach Association (BBA). In November 1993, homeowners, and representatives of the BBA established the area west of the existing groin field into the Village of Westhampton Dunes. Court proceedings took place in 1993 and 1994. The outcome of the litigation was a settlement agreement in November 1994 that provided for a mutually agreeable Westhampton Interim project in the Westhampton Dunes area.

1.3.4 1990's Reformulation and Interim Projects

In 1992 concurrent efforts resumed on the overall reformulation and also on the study for an interim project for the Westhampton Beach potion of the Moriches Inlet to Shinnecock Inlet reach. The Initial Project Management Plan (IPMP) dated June 1993 provided for a comprehensive study of the entire project area as an interrelated system and for consideration of a wide range of possible plan alternatives. During this time there were a series of damaging storms that resulted in breaches to the barrier islands. During the December 1992 Nor'easter, two breaches occurred in the vicinity of Pikes Beach, spanning approximately 4000 feet, westward of the westernmost groin. The western most breach (dubbed Pikes Inlet) was closed by placing 60,000 CY of sand taken from the Intracoastal Waterway. The eastern breach was originally the smaller of the two and was dubbed Little Pikes Inlet. Additional winter storms plus tidal and littoral forces resulted in a growth of this breach to 3,000 feet wide and 12 to 20 feet deep. During the time the breach was open, the consequences of the hydrodynamic changes in the bay were observed. During a relatively small nor'easter in March 1993, there were record levels of flooding along the back-bay communities of East Moriches, Remsenburg, and Mastic Beach. Because of the lengthy process to obtain approvals and funding, closure of the breach required the placement of 1.5 million CY of sand, and also 1,800 ft. of double row steel sheet pile, to aid in the closure, at a cost of $7,000,000.

Following these storms, the Corps was requested by New York State, Congress and the Acting Assistant Secretary of the Army (Civil Works) to evaluate the feasibility of developing other interim projects under the reformulation effort, recognizing that the Reformulation Study was a long-term effort that would leave areas vulnerable to storm damages in the intervening years. The interim projects were intended to be "soft" solutions that would not limit or constrain alternatives for consideration under the Reformulation study. Below is a summary of the interim projects undertaken:

Breach Contingency Plan (BCP). As a result of the experience in the closure of the Little Pikes Inlet, a BCP was prepared and approved in 1996 by Corps Headquarters (HQUSACE) that provides for a rapid response to close breaches along the barrier islands within the authorized project area. This plan provides for a limited response action to restore the barrier island to an elevation of +9 feet NGVD and provides limited risk management (a 20% Annual Chance of Exceedance (ACE)) for low-lying areas likely to be overwashed and subsequently breached again during relatively minor events.

Westhampton Interim Project. A plan to provide interim storm risk management to the Westhampton Beach area west of Groin 15 and the affected mainland communities north of Moriches Bay was completed in July 1995. The plan provides for a beach berm 90 feet wide and a dune of +15 ft. NGVD,[2] tapering of the western two existing groins (groins 14 and 15) and construction of an intermediate groin (groin 14A) between these two. The project also includes periodic renourishment, as necessary to ensure the integrity of the project design, for up to 30 years (2027). Beachfill for this interim project also includes placement within the existing groin field to fill the groin compartments and encourage sand transport to the areas west of groin 15. The interim plan was determined to be in the Federal interest to provide storm risk management until the findings of the reformulation effort are available. Initial construction of the project was completed in December 1997. The interim project was subsequently renourished in 2001, 2004 and 2008, requiring less sand at longer intervals than was estimated when designed. Due to severe erosion experienced due to Hurricane Sandy in 2012, approval was received from HQUSACE to repair the project to the pre-storm conditions, and repair the project to its design condition. A contract was awarded in Sept 2014 with about 750,000 cubic yards of sand placed.

Fire Island Interim Project. The Fire Island Interim Study was initiated in 1995 with a Technical Support Document and Environmental Assessment completed in 1997. Based upon the findings of the Environmental Assessment, it was determined that an Environmental Impact Statement was required, which was released for public review in December 1999. Due to lack of commitment for the project by the non-federal sponsor, the State of New York Department of Environmental Conservation, the report for the Fire Island Interim Project was never finalized. However, the extensive agency and public input received on the Fire Island interim project has been utilized in the development of the Reformulation Study.

West of Shinnecock Inlet Interim Project (WOSI). The West of Shinnecock Interim Project study was initiated in 1995 and was approved in May 2002. The recommendations include beach nourishment along the 4000 ft. long shoreline immediately west of the inlet, and renourishment every 2 years for a period of 6 years, to provide storm risk management for the area until the completion of the Reformulation Study. The project was constructed in March 2005, and received limited placement of sand as part of the maintenance dredging of Shinnecock Inlet, but no renourishment during the authorized period of

[2]National Geodetic Vertical Datum of 1929 (NGVD29 or NGVD) is approximately 1.06 feet lower than North American Vertical Datum of 1988 (NAVD88 or NAVD) within the FIMP study area. Therefore, the crest elevation the dune is +13.94 feet NAVD88.

renourishment between 2005 and 2011. Due to severe erosion experienced due to Hurricane Irene in 2011 and Hurricane Sandy in 2012, approval was received from HQUSACE to repair and restore the beach and dune to the design conditions. Two contracts were awarded with a total of about 500,000 CY of sand placed.

1.3.5 Hurricane Sandy

According to the National Hurricane Center, Hurricane Sandy, at nearly 2,000 kilometers (km) in diameter, is the largest storm on historical record in the Atlantic basin. The storm, which made landfall coincident with astronomical high tides in the New York Bight, affected an extensive area of the east coast of the United States. The highest waves and storm surge were focused along the heavily populated New York and New Jersey coasts. The storm made landfall near Atlantic City, New Jersey, the evening of October 29, 2012. At the height of the storm, a record significant wave height of 31.5 feet was recorded at the wave buoy offshore of Fire Island, New York. During the storm, beaches were severely eroded and dunes extensively overwashed. The study area's barrier islands were breached in three locations, and the coastal infrastructure, including many private residences, were heavily damaged. Two of the three breaches were closed by the Corps in partnership with NYS using the provisions contained in the BCP, the breach within the Wilderness Area of FIIS has remained open and is being monitored by the DOI, and is under evaluation in an EIS to determine future management actions for the breach.

1.3.6 Post-Hurricane Sandy Emergency Stabilization.

<u>Fire Island to Moriches Inlet Stabilization Project:</u> Following Hurricane Sandy, the beach and dune condition along Fire Island were heavily impacted, and there was the need to take action quickly since homes and businesses were vulnerable to subsequent storms. In response to this need, the Corps in partnerships with New York State initiated a stabilization project, under P.L. 113-2 to reestablish the beach and dune condition, as a one-time action. The Corps developed a plan that was supported by NYS and DOI that included a 90 ft. berm and dune at elevation +15 ft. NGVD. The dune is located to consider the post-Sandy dune alignment, and as such, included the acquisition or relocation of approximately 40 homes. The report and NEPA documents (USACE, 2014a) for this project were approved in July 2014, and a Project Partnership Agreement was executed in August 2014. Construction was initiated in September 2014, and is currently underway. The plan features contained in the TSP are similar to those included in the Fire Island stabilization effort.

<u>Downtown Montauk Stabilization Project</u>: The area of downtown Montauk was heavily impacted by Hurricane Sandy. Based upon this need, the Corps in partnership with New York State initiated a stabilization project under the authority of Public Law 113-2. A study was completed and approved in November 2014 (USACE, 2014b) that recommended a geotextile reinforced dune as a one-time project to stabilize the area until a long-term solution could be implemented. A Project Partnership Agreement was entered into in February 2015. Construction was initiated in October 2015, and was completed in April 2016.

1.4 Other Federal, State and Local Constructed Projects within Project area

In addition to the constructed portions of the Fire Island Inlet to Montauk Point Project described in the previous section, there have been several other major coastal engineering actions within the project area that have affected the functioning of the coastal system that include:

- Inlet Stabilization and Navigation Channels. These include the construction of jetties and construction and maintenance of navigation channels in the three inlets within the study area: Fire Island Inlet, Moriches Inlet, and Shinnecock Inlet.
- Major Structural Measures. This includes groins at Ocean Beach, a bulkhead at Smith Point County Park, state groins at Georgica Pond and Hook Pond, a groin at Ditch Plains, and the Montauk Point Revetment.

There are also structures built by individual property owners or community groups to protect their residences. These include small groins, bulkheads, revetments, geotextile-type structures, tetrapod structures, and other measures (cars buried in dunes). There also have been localized beach fill projects that have taken place within the study area following major storms

1.5 Non-Federal Partners and Stakeholders

The non-Federal partner for the overall FIMP project is the New York State Department of Environmental Conservation (NYSDEC). In addition to the non-Federal partner, there has been extensive coordination with study stakeholders including:

- U.S. Department of the Interior: National Parks Service; Fish and Wildlife Service, U.S. Geological Survey
- U.S. Environmental Protection Agency
- U.S. Department of Commerce: NOAA/National Marine Fisheries Service
- US Department of Homeland Security - Federal Emergency Management Agency
- New York State: Department of State and the Office of Emergency Management
- Suffolk County: County Executive, County Parks and Department of Public Works
- Towns of Babylon, Islip, Brookhaven, Southampton, and East Hampton, and also the incorporated villages and unincorporated hamlets within the study area portion of those Towns.

1.6 Problems and Opportunities

Problem Statement: Nor'easters and hurricanes periodically impact the both the barrier islands and mainland of the south shore of Long Island. These storms produce waves and tidal surges that cause extensive flooding and erosion, as was recently seen during Hurricane Sandy.

The natural coastal processes within the study area are also stressed due to human impacts on the different components of the natural system.

Opportunities to provide resilient storm damage reduction while also improving the natural coastal processes will be identified and evaluated for the three primary problem areas within the study area:

- Barrier Island Segments. These include Fire Island and the barrier island between Moriches Inlet and Shinnecock Inlet where many of the structures and buildings are vulnerable to storm damages due to wave attack, erosion of the natural beach and dunes, and tidal flooding. The barrier islands can overwash and breach during significant storm events, which is an important coastal process that contributes to the long-term sustainability of the system, but also impacts development both on the barrier and the back bay,
- Mainland Areas. The back bay segments of the project area include the portions of the mainland along Great South Bay, Moriches Bay and Shinnecock Bay that are vulnerable to tidal flooding. This tidal flooding is influenced by breaches of the barrier islands.
- Atlantic Ocean Shoreline Segments. These include the eastern portion of the study of between the Village of Southampton and Montauk Point, which are vulnerable to damages from erosion, wave attack, and tidal flooding; similar to the problems along the barrier islands.

Within each of these problem areas, there are opportunities to reestablish many of the natural coastal processes that have been impacted by past human activities that include:

- Longshore Transport (reestablish the natural longshore movement of material)
- Cross-Island Transport (reestablish natural pathways for exchange of sediment from ocean to bay)
- Dune Growth and Evolution (reestablish the processes that allow for natural dune formation and evolution)
- Bay Shoreline Processes (reestablish sediment transport processes along the bay shoreline), and
- Estuarine Circulation (reestablishing circulation patterns within the bay).

2 EXISTING CONDITIONS

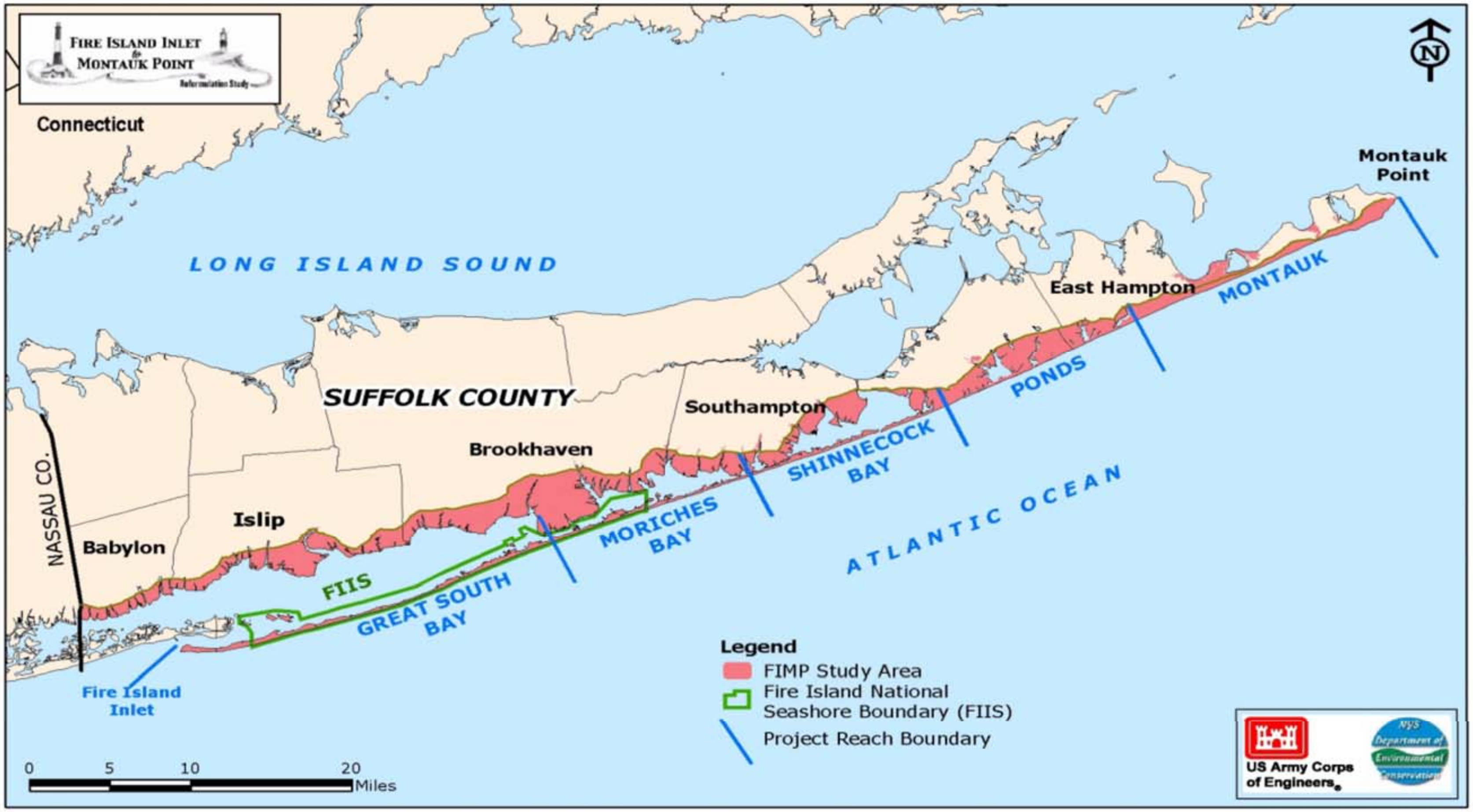
This section provides a summary of the natural and human environment within the FIMP project area and serves as a reference point to understand future without project condition and impacts associated with project alternatives.

2.1 Physical Conditions

2.1.1 Project Reaches

Due to its large size and the physical diversity within its borders, the FIMP study area has been divided into smaller reaches to facilitate study efforts, and for improvement design. Five project reaches subdividing the FIMP study area have been established based on major morphological features. Project reaches are large in scale and are defined by common physical characteristics that reflect environmental site conditions such as waves and underlying geology, and which may influence the design of risk management works. The study shoreline has been divided into five project reaches (Figure 4), as follows:

Project Reach 1 – Great South Bay (GSB)
Project Reach 2 – Moriches Bay (MB)
Project Reach 3 – Shinnecock Bay (SB)
Project Reach 4 – Ponds (P)
Project Reach 5 – Montauk (M)



Fire Island Inlet to Montauk Point Reformulation Study Area:
Project Reach Boundaries

Figure 5. FIMP Study Reaches

2.1.2 Geology

Long Island is part of the Atlantic and Gulf Coastal physiographic province which lies along the eastern border of the United States and lays at the southern boundary of the late Pleistocene glacial advance in the eastern part of North America (Taney, 1961). The Ronkonkoma and Roanoke Point moraine deposits (i.e., mounds of unstratified glacial drift chiefly consisting of boulders, gravel, sand and clay) characterize the topography along the northern side of Long Island, while a gentler southward dipping gradient on the outwash plains makes up much of the southern side of the island (Schwab et al., 1999).

From Montauk Point west to Southampton (approximately 33 miles) headlands formed by Ronkonkoma moraine and outwash deposits are eroded forming a narrow beach and a series of small bays (i.e., ponds). Eroded sediments along this reach are transported westward by wave action. West of Southampton reworked glaciological outwash has formed low-relief, sandy (fine- to medium-grained sand) barrier islands enclosing shallow back-barrier bays. The barrier islands were formed by a combination of spit extension (westward from Southampton) and offshore bar development. The larger bays have historically been intermittently connected to the ocean by tidal inlets. In the normal course of events, inlets would be cut through the barrier island during storms, migrate over time to the west, and eventually close by natural processes (Taney, 1961).

The principal geologic features of the inner continental shelf offshore of Fire Island are summarized by Schwab et al. (2013):

> *(1) a regional unconformity separating Cretaceous-age coastal plain strata from overlying Quaternary sediment; (2) a Pleistocene glaciofluvial sedimentary deposit exposed at the seafloor over much of the inner continental shelf at water depths between ~15 and ~32 m, the seaward limit of the study area; and (3) a series of Holocene sand ridges on the inner continental shelf W of Watch Hill extending across the study area.*

West of Watch Hill, the Holocene (modern) sedimentary deposit is organized into a series of shoreface-connected sand ridges oriented at angles of 30° to 40° to the coast (Schwab et al., 2013). Seismic reflection data collected in 1996 and 2011 by the USGS (Schwab et al. 2013) indicate that the thickness of the Holocene sediment thickness is between 1 and 6 meters. The thickness of the sand ridges is greatest (approximately 6 meters) offshore of central Fire Island and gradually thins to the west (approximately 1 meter thick offshore of Fire Island Inlet).

2.1.3 Barrier Islands & Shorefront Geological Processes

Barrier islands (i.e., barriers) are sandy, ridge-like, features located offshore and parallel to the mainland. As the name implies, barrier islands serve to protect both the mainland and the water body (bay or lagoon) that lies between the mainland and the leeward side of the barrier from ocean waves and filters the offshore signal of high water levels from storm tides. Figure 6 summarizes the principal features of common barrier island systems. The seaward features of the barrier are, from sea to land, comprised of a submerged beach profile, a shoreface, a berm and finally, a coastal dune. This natural shorefront encompasses a range of geometries depending on wave climate, sand supply and condition of the near shore bar. Specifically, the beach may erode under large waves and elevated water levels to assume a storm or “winter” profile. The beach may recover post-storm to assume a “summer” profile.

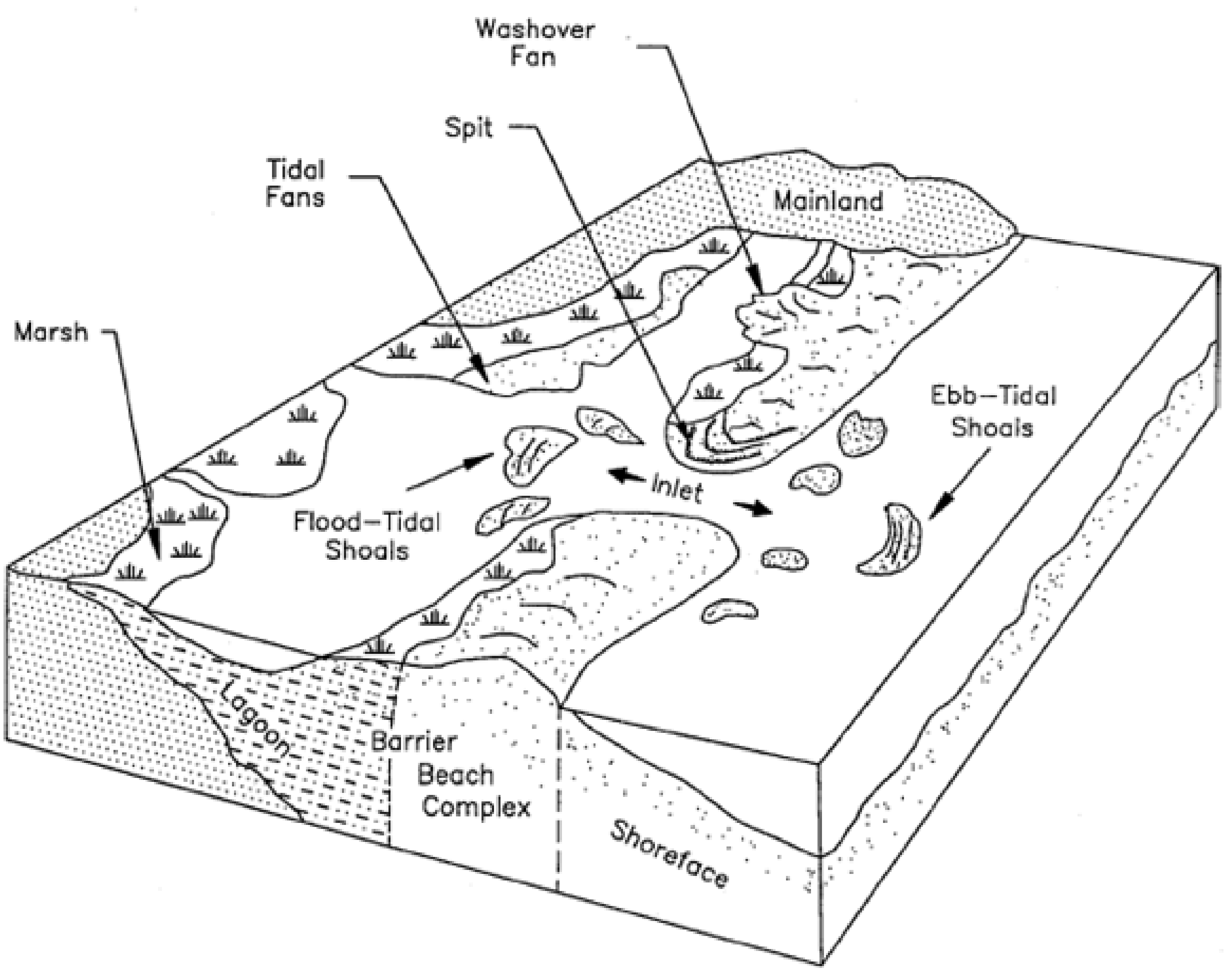


Figure 6. Cross Section of Barrier Island

Dunes are an important feature of barrier geometry. Dunes provide the last line of natural defense on a natural beach and normally have elevations 10 to 15 feet higher than normal high tides. During severe storms dunes may be overtopped (i.e., overwashed) or breached; the latter can lead to the formation of a new tidal inlet. The landward portion of the barrier island extends from the center of the dune area and consists of the back dune face, a leeward beach, a tidal marsh (in some cases) and an underwater profile extending into a lagoon or bay.

The dynamics of island overwashing, breaching and new inlet formation are dictated by the complicated interaction of numerous geomorphologic and hydrodynamic factors. A distinction between island overwash, island breaching and permanent inlet formation is illustrated in Figure 7. Overwash is the flow of water in restricted areas over low parts of barriers that typically occur during high tides or storms. Depending on the storm magnitude and island width, overwash areas of newly transported sand may penetrate no farther than the dunes, or may be spread onto the marshes or into the bay. In general, major overwashes extending into the bay occur only during exceptionally severe storms (storms with greater than 2% annual chance of occurrence). Therefore, overwash has a more significant impact on subaerial and intertidal barrier island resources (e.g., back-bay marshes) than on back-bay areas located away from the barrier.

Breaching refers to the condition where a channel across the island is formed that permits the exchange of ocean and bay waters under normal tidal conditions. The breach may be temporary or permanent (i.e., a new inlet) depending on its size, adjacent bay water depths, potential tidal prism, littoral drift, and water level and wave conditions following the storm. The recent stability of the existing inlets in the study area is largely due to maintenance and stabilization efforts that have included dredging of navigation channels and jetty construction. Breaches that remain open and become new inlets have the greatest influence on decadal or century-long sediment transport dynamics by redirecting/trapping longshore sediment transport into ebb and flood shoals during the period that the breach remains open (USACE-NAN, 1999a). The process of opening-migration-closing of inlets is fundamental to the long-term geologic resilience of barrier islands. Flood shoals serve as platforms for new marsh development. Most of the marshes in Great South, Moriches, and Shinnecock Bays are associated with former flood shoals (Leatherman and Allen, 1985).

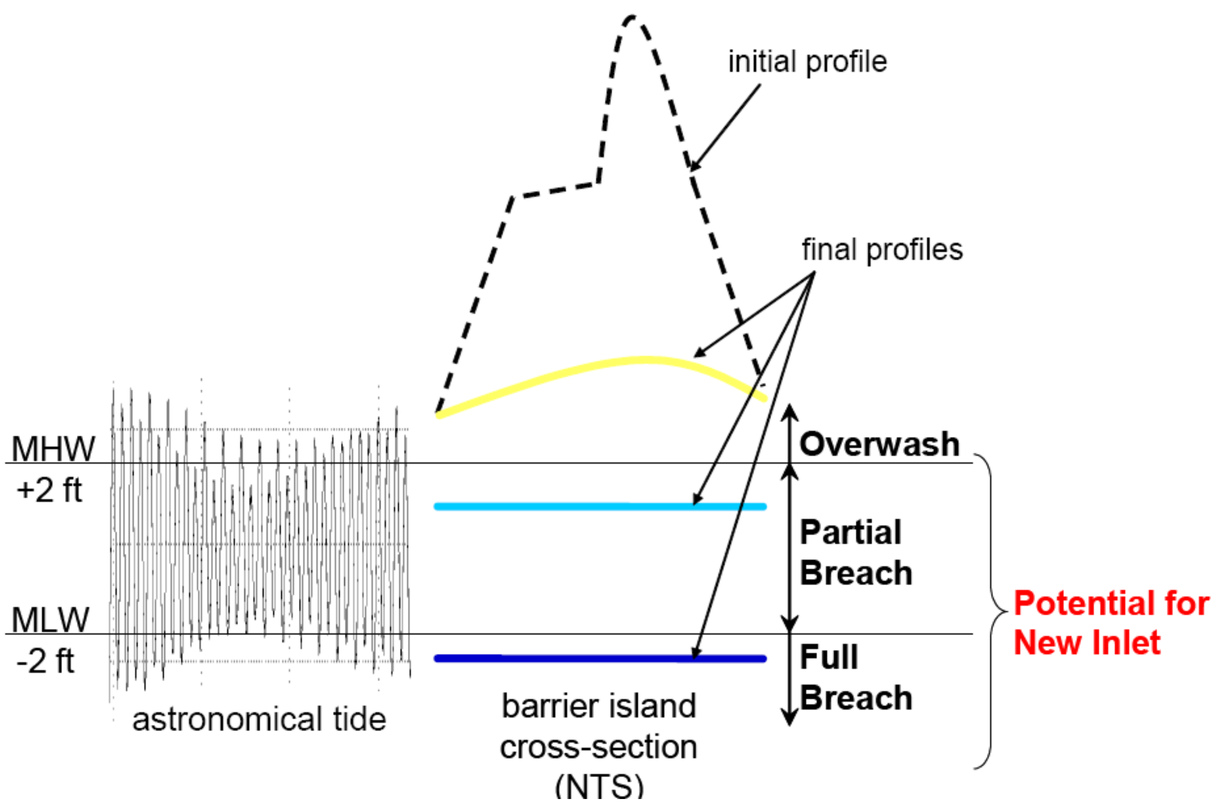


Figure 7. Morphological Responses to Overwash and Breaching

2.1.4 Astronomical Tides

Astronomical tides on the south shore of Long Island are semi-diurnal, rising and falling twice daily. For storm damage assessment, understanding the expected range of astronomical tide along the project length and within the three bays is required. For this study, the ADCIRC long-wave hydrodynamic numerical model was employed to determine astronomical tide amplitudes throughout the project and to determine the maximum expected annual water level associated with astronomical tides. Additional details on the ADCIRC model are provided in Appendix A -Engineering.

2.1.5 Relative Sea Level Change

By definition, sea level change (SLC) is a change (increase or decrease) in the mean level of the ocean. Eustatic sea level rise is an increase in global average sea level brought about by an increase to the volume of the world's oceans (thermal expansion). Relative sea level change takes into consideration the eustatic increases in sea level as well as local land movements of subsidence or lifting. Long Island is one of many areas in which the land is subsiding. This Reformulation effort considers a range of future sea level rise projections, including the historic rate as the low boundary, and accelerated rates of sea level rise, as described below.

Historic information and local MSL trends used for the Study Area are provided by the NOAA/NOS Center for Operational Oceanographic Products and Services (CO-OPS) using the tidal gauge at Sandy Hook, New Jersey. The historic sea level change rate (1935-2013) is approximately 0.0128 ft. per year or about 1.3 ft. per century.

Recent climate research has documented observed global warming for the 20th century and has predicted either continued or accelerated global warming for the 21st century and possibly beyond (IPCC 2013). One impact of continued or accelerated climate warming is continued or accelerated rise of eustatic sea level due to continued thermal expansion of ocean waters and increased volume due to the melting of the Greenland and Antarctic ice masses (IPCC, 2013). A significant increase in relative sea level could result in extensive shoreline erosion and dune erosion. Higher relative sea level elevates flood levels which may result in smaller, more frequent storms that could result in dune erosion and flooding equivalent to larger, less frequent storms.

The current guidance (ETL 1100-2-1 dated 30 Jun 2014) from the Corps states that proposed alternatives should be formulated and evaluated for a range of possible future local relative sea level change rates. The relative sea level rates shall consider as a minimum a low rate based on an extrapolation of the historic rate, and intermediate and high rates which include future acceleration of the eustatic sea level change rate. These rates of rise correspond to 0.7 ft., 1.1 ft., and 2.4 – 6 ft. over 50 years for the low, medium and high rates of relative sea level rise.

New York State has also recently adopted sea level rise scenarios as part of the Community Risk and Resiliency Act. As part of this Act, NYSDEC has identified 5 different projections of sea level rise for three different regions within N.Y. that are tidally influenced. The projections for the Long Island Region are as follows. The 2050s projections are: 8 in. (low), 11 in. (low-medium), 16 in. (medium), 21 in. (high-medium), and 30 in (high). The 2080s projections are: 13 in. (low), 18 in. (low-medium), 29 in. (medium), 39 in. (high-medium), and 58 in. (high).

Most of the analysis contained within this report applies the historic (low) rate of sea level rise. The use of the historical rate of sea level rise for planning purposes is acknowledged to be a conservative approach. Including a higher rate of sea-level rise would result in a larger amount of damages, and could show the need for plans that would only be required under higher accelerated sea level rise conditions. Consistent with Corps guidance, the alternative evaluation was conducted using the historic rate of RSLC in order to select a plan. Following selection of the plan, the TSP has been evaluated to show the effectiveness of the plan under the intermediate and high rate of RSLC.

2.1.6 Storms

Two types of storms are of primary significance along the south shore of Long Island: (1) tropical storms which typically impact the New York area from July through October, and (2) extratropical storms which are primarily winter storms occurring from October to April. Extratropical storms (northeasters) are usually less intense than hurricanes, but tend to have a longer duration. These storms often cause high water levels and intense wave conditions, and are responsible for significant damages and flooding throughout the Long Island coastal region.

Hurricanes are the most powerful tropical storms to reach the New York area with wind speeds in excess of 74 mph (by definition). Records are available for 24 hurricanes having impacted the New York area in the past century. Heavy storm damage usually occurs when high astronomical tides and storm surge coincide for storms approaching the project area from the south-southwest. The combined water levels allow large waves to penetrate inland resulting in extreme erosion and flooding.

Extratropical storms originate outside of the tropics, usually in the mid- to upper-latitudes during winter months. In the New York region, these storms are referred to as "northeasters" due to the predominate direction from which the winds originate. Northeasters are less intense than hurricanes with sustained wind speeds generally below 57 mph. Localized winds may, however, reach hurricane strength. Extratropical storms cover large areas and are slow moving with typical storm duration lasting for a period of days thus persisting through several periods of high astronomical tide. The long duration greatly enhances the ability of northeasters to cause damages.

2.1.7 Shoreline Changes and Erosion

Beach and dune systems are exposed to three types of erosion, namely, long-term erosion resulting from day to day wave and sediment transport conditions, short-term storm-induced erosion, and erosion resulting from long-term sea level rise. Long-term erosion is associated with gradients and/or interruptions in littoral drift (i.e. longshore sediment transport). Storms and sea level rise, on the other hand produce cross-shore sediment transport that erodes the shoreface, beach berm and dunes. Storms can dramatically alter the shoreline geometry in a matter of hours or days. The beach profile, however, tends to recover after storm passage and, with sufficient supplies of sediment, can eventually build back to pre-storm geometry. Net shoreline retreat may occur if there is not enough sand available for a full recovery, particularly when longshore sediment transport is interrupted.

Historic Shoreline Rate-of-Change (SRC) values for the FIMP study are were first documented in Gravens et al. (1999), which examined three non-overlapping time intervals using available shoreline data sets. The first period, representative of the epoch prior to significant human influence on the barriers, is 63 years long (1870 to 1933). The second period, representative of initial development on the barriers and the initiation of human intervention with natural processes, including inlet stabilization and significant beach fill placements, is approximately 46 years long (1933 to 1979). The third period, representative of modern times and reflecting more recent beach nourishment practices, is approximately 15 years long (1979 to 1995). Computed average SRC and associated standard deviation values are summarized in Table 5 for each of three barrier island-scale analysis domains in the study.

It is important to note that these SRC values from Table 5 are average values for relatively long reaches and that the standard deviations in the SRC is between 3 and 4 times larger than the mean. The comparatively large SRC standard deviation indicates significant variation in shoreline change along Fire Island.

Table 5. Average Shoreline Rate of Change and Associated Standard Deviation

Time Period	ANALYSIS REACH		
	Fire Island (i.e., Fire Island to Moriches Inlet)	**Westhampton (i.e., Moriches to Shinnecock Inlet)**	**Montauk (i.e., Shinnecock Inlet to Montauk Point)**
1870-1933	-1.3 (3.6)	+3.3 (2.0)	+0.7 (1.0)
1933-1979	-1.3 (5.9)	-3.6 (3.6)	-1.3 (2.0)
1979-1995	-2.3 (6.2)	-2.6 (9.2)	+0.0 (4.3)

NOTES: Table adapted from Gravens et al., (1999); Standard Deviation in parenthesis; All values in feet/year; All values adjusted to account for beach fill placement

Table 6 shows updated shoreline change rates based additional shoreline and beach profile data through 2001 at the design sub-reach level of detail (Figure 8). These updated estimates, which were also adjusted to remove the effects of beach fill, and refined level of detail were used to evaluate life cycle vulnerability.

Lentz, et al, 2013 analyzed three historical data sets (topography derived from 1969 aerial photography and LIDAR data from October 1999 and December 2009) to extract shoreline change data along Fire Island for three time periods: 1969-1999, 1999-2009 and 1969-2009. Shoreline change results, which include the positive (i.e., accretional) effect of beach fill activity (unlike the values presented in Table 5 and Table 6), show a mean accretional trend between 1969 and 1999 of +2.15 feet/year along Fire Island. The period from 1999 to 2009 is dominated by erosion (-0.62 feet/year) particularly in the eastern reach of the island. Total change results from 1969 to 2009 are more similar to the 1969 to 1999 period (+1 foot/year).

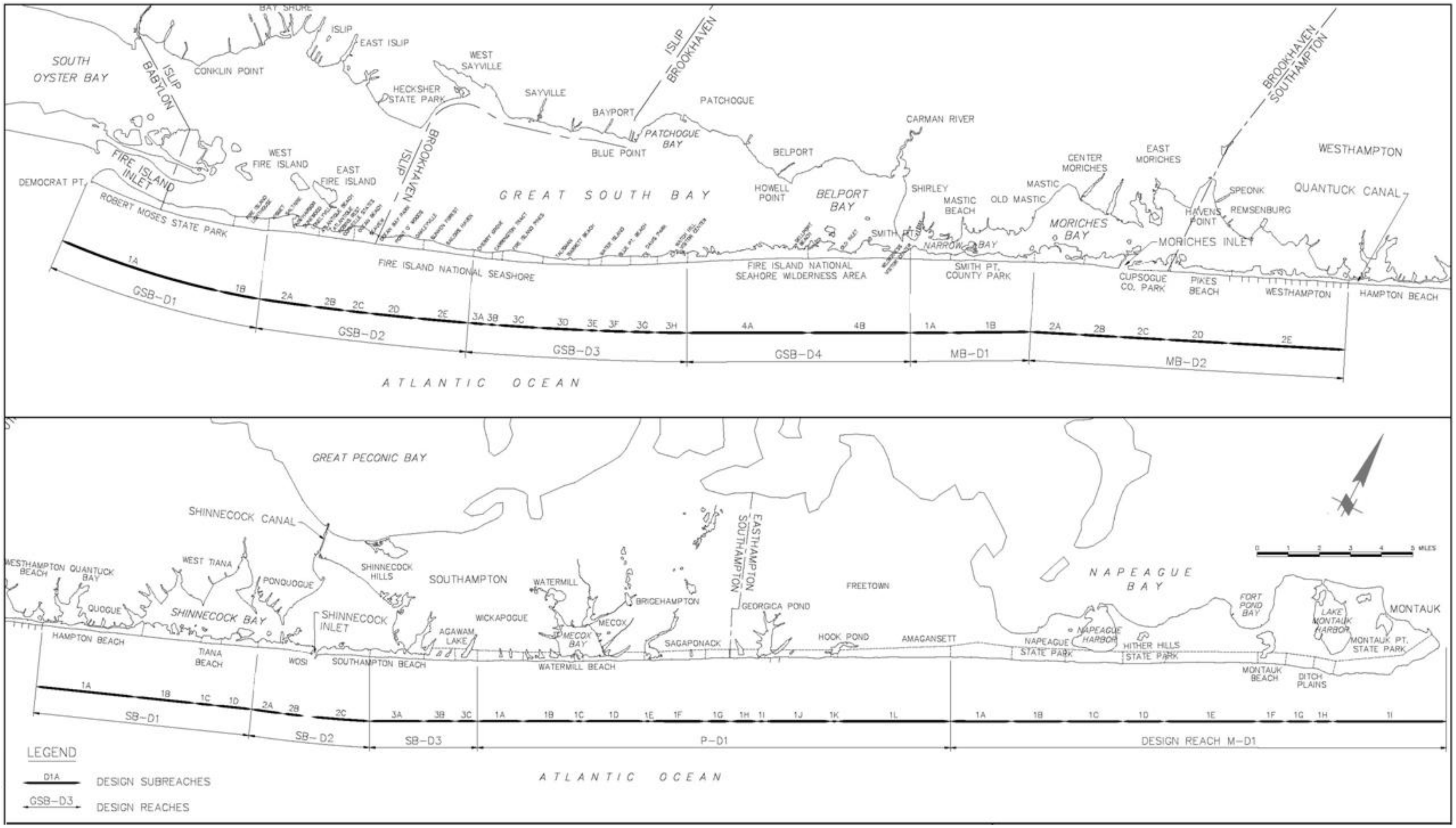


Figure 8. Study Reaches and Design Sub-Reaches

Table 6. Shoreline Rate of Change (1979-2001) by Design Subreach

Design Subreach	Shoreline Change Rate (ft./yr.)
Great South Bay	
GSB-D1A	1
GSB-D1B	4
GSB-D2A	4
GSB-D2B	4
GSB-D2C	1
GSB-D2D	1
GSB-D2E	1
GSB-D3A	1
GSB-D3B	1
GSB-D3C	1
GSB-D3D	1
GSB-D3E	1
GSB-D3F	1
GSB-D3G	1
GSB-D3H	1
GSB-D4A	1
GSB-D4B	2
Moriches Bay	
MB-D1A	2
MB-D1B	2
Moriches Bay (continued)	
MB-D2A	2
MB-D2B	0
MB-D2C	1
MB-D2D	0
MB-D2E	0
Shinnecock Bay	
SB-D1A	1
SB-D1B	3
SB-D1C	3
SB-D1D	3
SB-D2A	0
SB-D2B	0
SB-D2C	0
SB-D3A	1
SB-D3B	1
SB-D3C	1
Ponds	
P-D1A	1
P-D1B	1
P-D1C	2
Ponds (continued)	
P-D1D	2
P-D1E	2
P-D1F	2
P-D1G	4
P-D1H	1
P-D1I	1
P-D1J	1
P-D1K	1
P-D1L	1
Montauk	
M-D1A	1
M-D1B	1
M-D1C	1
M-D1D	1
M-D1E	2
M-D1F	3
M-D1G	3
M-D1H	3
M-D1I	3

2.1.8 Shoreline Undulations

At least part of the alongshore variability in the observed shoreline rate-of-change owes to undulating shoreline features that are locally referred to as longshore sand waves or erosion waves (Gravens et al., 1999). The presence of these features should be considered in the formulation of a project within Fire Island. Gravens et al. (1999) showed that the wavelength of the shoreline undulations generally ranges between 0.6 and 1.2 miles. The total root mean square (rms) shoreline undulation height was determined to be about 104 ft. The landward and seaward rms amplitudes were both quantified at about 52 ft. Gravens et al. (1999) also showed that the shoreline undulations do not appear to propagate from one end of the barrier to the other, although limited alongshore propagation 0.6 to 1.2 miles of the shoreline undulations is possible. An important finding of the study was that the seaward and landward bulges of the shoreline undulations were preferentially positioned along the shoreline. That is, based on the data sets examined, certain locations along the shoreline can be expected to periodically develop large erosion or accretion cusps but not likely both. This finding indicates that the shoreline undulations may be excited by specific environmental forcing conditions (waves from a particular direction) and their location controlled by irregularities in the offshore bathymetry. In support of the assertion that specific environmental forcing excites the shoreline undulations is the finding from the spatial analysis that the shoreline undulations are intermittent features that are more prominent in some data sets than in others. Nonetheless, the data also suggests that undulations may occur at any location along the project shoreline.

The impact of shoreline undulations on a typical beach fill design configuration was shown to be significant and could lead to greater than anticipated maintenance costs or a reduced level of storm risk management at areas of erosional cusps. Explicit consideration of the presence of shoreline undulations in the development of alternative design configurations and the assessment of baseline and future without project conditions is essential for a full understanding of storm risks.

2.1.9 Inlets

There are three stabilized inlets in the Study Area: Fire Island Inlet, Moriches Inlet, and Shinnecock Inlet, all of which are Federal navigation projects. A fourth inlet has formed within the Wilderness Area of the Fire Island National Seashore as a result of a breach in the barrier island during Hurricane Sandy. Coastal inlets play an important role in nearshore processes. Inlets are the openings in coastal barriers through which water, sediments, nutrients, planktonic organisms, and pollutants are exchanged between the open sea and the protected embayments behind the barriers. These existing inlets contribute to flooding in the back-bay that occurs during storm events. In addition, inlets are important economically because harbors are often located in the back bays, requiring that the inlets be maintained for commercial navigation. At many inlets, the greatest maintenance cost is incurred by periodic dredging of the navigation channel.

Tidal inlets experience diurnal or semidiurnal flow reversals and are characterized by large sand bodies that are deposited and shaped by tidal currents and waves. The ebb shoal is a sand mass that accumulates seaward of the mouth of the inlet. It is formed by ebb tidal currents and is modified by wave action. The flood shoal is an accumulation of sand at the bayward opening of an inlet that is mainly shaped by flood currents (USACE, 2002). However, not all of the sediment in the littoral transport stream is trapped at these shoals; a large proportion may be bypassed by a variety of mechanisms, particularly at inlets that have already developed mature shoals with a volume approaching equilibrium.

Typically, jetties are built to stabilize a migrating inlet, to protect a navigation channel from waves, or to reduce the amount of dredging required to maintain a specified channel depth. However, jetties can profoundly affect sand bypassing and other processes at inlets and adjacent shorelines (USACE, 2002). The stabilized inlets do not function as natural inlets in several respects. First, the stabilized inlets are maintained by jetties (only one jetty in the case of Fire Island), are periodically dredged, and do not migrate as natural inlets do. Second, the stabilized FIMP inlets are judged to be more of a sand sink than natural inlets. Natural inlets tend to facilitate bypassing of littoral drift over a series of shallow shoals relatively close to the shore. The jetties act to confine flows within a relatively narrow area compared to natural inlets; they also act to deepen the inlet throat and shift the ebb tidal delta further offshore than a natural inlet. Accordingly, the inlets have acted to trap sand at least during their formative stages. The following paragraphs provide an overview of the most relevant coastal processes at each FIMP area inlet.

2.1.9.1 Shinnecock Inlet

Shinnecock Inlet was formed as a result of a barrier island breach during the "Long Island Express" hurricane of 1938, and has since been stabilized with jetties at its present location and geometry since 1953. The presence and continued evolution of Shinnecock Inlet has strongly influenced adjacent shoreline conditions, particularly west of the inlet. Historic interruption of westerly-directed sediment transport has created a large offset in the shoreline position across the inlet from east to west. Beach material is distributed throughout the inlet and is generally confined to three primary locations: (1) east of the east jetty in a large accretional fillet, (2) ebb-tidal shoal, including updrift and downdrift lobes or bars, (3) flood-tidal shoal. Nevertheless, Shinnecock Inlet has, albeit intermittently, permitted natural bypassing that serves to re-establish littoral transport to the downdrift shoreline. This effect is apparent in the shoreline near Ponquogue where a bulge in the shoreline points to the location where ebb shoal materials are bypassed to shore.

2.1.9.2 Moriches Inlet

The present Moriches Inlet was opened during a storm on 4 March 1931, and the existing jetties were constructed in 1954. A notable offset in the shoreline progressing east to west across the Moriches Inlet reflects shoreline impacts associated with the westerly-directed littoral drift. Nonetheless, shoreline conditions immediately west of Moriches Inlet are generally characterized by a relatively robust barrier system with wide beaches and high dunes. Beach widths increase notably approximately 4,000 feet west of the inlet, and reflect dredged material placement and natural bypassing of Moriches Inlet. It should also be noted that the historic updrift sediment accumulation (fillet) east of Moriches Inlet appears to be less than at Shinnecock Inlet. This condition is likely to have arisen due to four primary factors, namely: (1) the Westhampton groin field reduces transport reaching Moriches Inlet, (2) historical migration of Moriches Inlet left a narrow barrier segment, (3) tidal currents have scoured the bayside shoreline, and (4) a shorter updrift (east) jetty.

2.1.9.3 Fire Island Inlet

Available records indicate that only Fire Island Inlet has existed continuously since the early 1700's, and has been stabilized in its present conditions since 1940. Continued dredging of the inlet has been performed to maintain a navigable channel. Sand dredged from Fire Island Inlet has been placed to the west and north of the inlet to offset the marked downdrift erosion in those areas arising from the interruption of the predominate mode of westerly-directed littoral transport. Fill has also been placed to the east of the inlet to address the chronic erosion problem within Robert Moses State Park.

2.1.9.4 Wilderness Area Breach

Hurricane Sandy resulted in three barrier island breaches within the Study Area. One of the breaches within the Wilderness Area of the Fire Island National Seashore was not closed immediately following the storm. After the initial formation of the breach during Hurricane Sandy the breach grew rapidly for several months before breach growth slowed. DOI has been monitoring the Breach in the Wilderness Area and is preparing an Environmental Impact Statement (Plan/EIS) to determine how best to manage the breach that was created in Fire Island's federally-designated wilderness area. The planning process will include opportunities for public input as well as consultation with federal, state, and local agencies with a regulatory interest or special expertise related to proposed actions.

Observations and modeling results have shown that, at its current size, the breach in the Wilderness Area has not significantly altered tidal elevations in Great South Bay or Moriches Bay by more than one inch. However, the model simulations show that the breach in the Wilderness Area increases storm water levels within Great South Bay and Moriches Bay during storm events.

2.1.10 Bayside Tidal Hydrodynamics

The study area estuarial system, comprised of Great South, Moriches and Shinnecock Bays, are respectively connected to the Atlantic Ocean through Fire Island, Moriches and Shinnecock Inlets, as well as the Breach in the Wilderness Area. Great South and Moriches bays are also connected to each other through narrow tidal waterways of the Long Island Intracoastal Waterway (ICW). A summary of hydrodynamic conditions is presented in the following paragraphs.

Bay water levels are controlled by tidal elevations at Fire Island, Moriches, and Shinnecock Inlets. The uniformity of tide ranges throughout Great South, Moriches, and Shinnecock Bays is a characteristic of the so-called “pumping mode” of inlet-bay hydraulics where water levels within an embayment remain nearly horizontal during ebb and flood tide phases. Bay tides are generally less than and lag the ocean tides. The difference between ocean and bay tides is particularly significant within central and eastern Great South Bay. The tidal range at the ocean end of Fire Island Inlet is approximately 4.3 ft. However, the ocean tidal signal is significantly muted along the long inlet throat. Monitoring at the Fire Island Coast Guard Station suggests a tidal range of 1.6 ft. at this location (i.e., a 50% reduction in approximately 3 miles) compared to bay waters in most of Great South Bay away from the inlet that have an average tidal range on the order of 1 ft., i.e., a 70% reduction. Tidal prism discharge through Fire Island Inlet is the order of 2,300 million cubic feet. The average tidal range in the bay is approximately 1 ft.

The tidal range at the ocean side of Moriches Inlet is approximately 3.6 ft.; the range is decreased to 2.5 ft. across the inlet in the vicinity of the Moriches Coast Guard Station. In areas removed from the inlet, such as Potunk Point and Mastic Beach at the eastern and western limits of Moriches Bay, respectively, the range is decreased to 1.6 to 2 ft. The estimated average tidal range in Moriches Bay obtained using recent available tidal records is on the order of 2 ft. Tidal prism is estimated as on the order of 1,300 million cubic feet.

The reduction in tidal range within Shinnecock Bay is less pronounced due to the configuration of the inlet and flood shoals. The range goes from approximately 3.3 ft. at the ocean side of the inlet to 2.5 ft. in the vicinity of Ponquogue Point. The tide range in the bay averages approximately 2.9 ft. The estimated tidal prism is on the order of 1,300 million cubic feet.

Freshwater enters the estuaries primarily through adjoining tributaries and groundwater seepage. Drainage areas for each bay were estimated as: (1) Great South Bay – 378 square miles, (2) Moriches Bay – 75 square miles, and (3) Shinnecock Bay – 25 square miles. Information concerning freshwater sources is relatively sparse. However, the U.S. Geological Survey (USGS) monitors several tributaries at locations far removed from the bays (the available average daily flow rates for major tributaries). Estimates indicate that nearly 25% of all freshwater entering the estuaries can be attributed to groundwater seepage.

2.1.11 Breach and Overwash Impacts

Breaches and overtopping of the barrier island occur periodically in conjunction with larger storms (generally storms greater than a 2% annual chance of occurrence). During Hurricane Sandy two breaches occurred along Fire Island and one along the reach between Moriches Inlet and Shinnecock Inlet. Overwash occurred along approximately 45 percent of the island. The physical impacts of a breach include:

- Increase in bay tide levels if breach is large enough to expose bay shore to open ocean conditions;
- Increase in bay storm water levels due to presence of large persistent breach or ocean storm water levels overwashing the barrier island;
- Changes in bay circulation patterns, residence times, and salinity due to breaches;
- Increase in sediment shoaling in navigation channels and shellfish areas due to a major breach;
- Increased transport and deposition of sediment to bay including creations of overwash corridors.

Barrier island breaching often results in the formation of flood tidal deltas on the bay side of the barrier. These breaches are likely to provide suitable substrate for future SAV growth or the development of emergent tidal marshes, if the elevation is sufficient. These flood tidal deltas typically benefit a variety of wildlife species, especially shorebirds, by increasing the available foraging and loafing area, and potential nesting sites. Flood tidal deltas and the dynamic sand spits associated with bay inlets also provide optimal habitat for the rare plants, sea beach amaranth and sea beach knotweed. Overwash and breach deposits are beneficial to natural accumulation of sand on the barrier and landward of the barrier. These processes contribute to the deposition of material that facilitates northward migration of the barrier from its present location, and contributes to the long-term stability of the island.

2.1.12 Flooding Impacts

The presence of the existing barrier island system and topography reduces widespread inundation of low lying areas on the mainland. The existing inlets act both as hydraulic conveyances and hydraulic constrictions which limit the storm surge volume entering Great South, Moriches, and Shinnecock Bays. As the surge spreads out away from the inlets, the corresponding flood stage decreases. This attenuation of ocean surges becomes less pronounced for larger storm events which can overwash and breach the barrier island (generally, storms greater than a 2% annual chance of occurrence). Therefore, the flood problem along the mainland is linked to the topographic condition of the barrier system. Flooding occurs as a result of surge propagating through the inlets, but more severe mainland flooding can occur as a result of overtopping or breaching of a barrier island, which brings more storm ocean water into the bay system during the times of moderate to severe storms.

The numerical model framework developed for FIMP is a comprehensive modeling study involving storm surge and barrier island system breaching and morphology. The numerical model includes all the necessary processes to accurately simulate the inlet and barrier island overwash processes and breaching processes in a system-wide and comprehensive manner for the complete FIMP project area, considering the three bay and inlet system. (Irish and Cañizares, (2009); Cañizares and Irish, (2008); Irish and Cañizares R.(2006); Cañizares and Alfageme (2005); Irish, et al., (2004); Canizares, et al., (2004); Irish, et al., (2004); Roelvink, et al., (2003); Cañizares' et al.,(2003).

2.2 Socio-Economic Conditions

The study area includes portions of five towns: (1) Town of Babylon, (2) Town of Islip, (3) Town of Brookhaven, (4) Town of Southampton, and (5) Town of East Hampton. Each of these towns is comprised of incorporated villages and unincorporated hamlets. Hamlets are governed by the town in which it is located, whereas villages have their own local governments. Land use differs throughout the study area. The study area is generally more developed to the west with decreasing development to the east. The eastern towns, including Southampton and East Hampton, have a significant portion of land use devoted to agriculture and a relatively smaller portion devoted to commercial/industrial use.

Town of Babylon: The Town of Babylon includes communities on the mainland including the Villages of Amityville, Lindenhurst, and Babylon and the hamlets of Copiague and West Babylon. Land use in this area generally consists of medium-density detached homes, with high-density residential uses found close to the water's edge. There is very little agricultural use and more commercial/industrial use.

Commercial uses run along most of the length of Montauk Highway. The Babylon portion of the study area also includes several recreational and park uses which front the Great South Bay. In addition, the Town of Babylon includes part of Captree State Park on Captree Island and the easternmost tip of the Jones, Gilgo, and Oak beaches on the barrier island to the west of Fire Island Inlet.

Town of Islip: The study area within Islip is primarily residential, with some large open spaces (e.g., Great River and Connetquot River State Park) and commercial development concentrated along Montauk Highway. Communities in this area include West Bay Shore, Bay Shore, the Village of Brightwaters, Islip and East Islip, Great River, Oakdale, West Sayville, Sayville, and Bayport.

Commercial development includes primarily small- to medium-sized shops and services, some of which are part of strip mall developments. Marine and marine-related commercial development is located near Great South Bay and its tributaries. There is no significant amount of industrial activity south of the Montauk Highway; industrial uses are located just outside of the study area, primarily along Union Boulevard.

Town of Brookhaven: With 260 square miles of land area, Brookhaven is the largest municipality on Long Island. Development in the municipality is generally less dense than Islip (with a notable exception being the area that includes Shirley and Mastic), with a number of undeveloped parcels. Communities in this area include Blue Point, the Village of Patchogue, Bellport, Brookhaven, Shirley, Mastic, Mastic Beach, Center Moriches, and East Moriches.

Within Brookhaven, retail commercial development is found along the Montauk Highway, especially in downtown Patchogue and in Shirley. Industrial uses, including maritime industry and boating, are found along the Patchogue River. There are also major open spaces and recreational amenities, including the Bellport Park Golf Course at South Country Road and South Howell's Point Road, Smith Point County Marina near the Smith Point Bridge, and Wertheim National Wildlife Refuge, between Shirley and Brookhaven. There are also a number of smaller neighborhood parks and playgrounds.

Town of Southampton: The western portion of the Town of Southampton is predominantly residential with open space and recreational uses, particularly along the barrier islands. Some of the larger open spaces are found at the inlets, including Cupsogue Beach County Park on the east side of Moriches Inlet and Shinnecock County Park (which is both east and west of Shinnecock Inlet), but is primarily west of the inlet. Residential development density generally decreases from west to east, with residential lots averaging about 1-2 acres in size in the area between the Villages of Westhampton Dunes and Westhampton Beach. There are also town open spaces (e.g., the Town Beach east of Cupsogue Beach County Park) that are smaller in size than the county parkland. Retail and commercial uses are concentrated along County Road 27 (Montauk Highway) as well as the main streets and commercial roads within the incorporated villages.

Town of East Hampton: The Town of East Hampton encompasses the east half of the South Fork of Long Island and covers 68.7 square miles of land. It is bordered to the west by the Town of Southampton, to the north by the Peconic Bay, and to the east and south by the Atlantic Ocean. The study area extends north to County Road 27 (Montauk Highway) and also includes the Village of East Hampton and hamlets (e.g., Amagansett, Montauk), but does not include the shoreline along Peconic Bay and the villages and hamlets along that shoreline. The western portion of the East Hampton study area is predominantly residential with a moderate distribution of agricultural, open space, and recreational uses. The eastern portion is largely recreational lands and open space with a concentration of low, medium and high-density residential development south of Montauk Highway.

2.2.1 Population

The estimated population (2012) of Suffolk County is slightly below 1,500,000. The eastern end of Suffolk County, including the Towns of East Hampton and Southampton, is less populated but is expected to undergo continued growth. The western portion of the study area contains the majority of the study area's populace and is markedly denser. Of the County population, about 10% or 150,000 live within the study area.

2.2.2 Income

There is considerable variation in the per capita and family income among study area towns as shown in Table 7. Per capita income in most of the study area is slightly above the state average. Median family incomes in the study area towns are all higher than the median family income for New York State.

Table 7. Per Capita and Family Income

Location	Per Capita Income	Median Family Income	Family Size
New York State	$31,796	$69,202	3.20
Suffolk County	$36,588	$99,474	3.36
Town of Babylon	$31,255	$90,853	3.45
Town of Islip	$31,493	$92,482	3.56
Town of Brookhaven	$34,201	$97,520	3.33
Town of Southampton	$47,679	$68,876	3.10
Town of East Hampton	$51,316	$56,607	3.05

Sources: American Community Survey 2007-2011 5-year Estimate
Community Facts, 2010 Census, General Population and Housing Characteristics

2.2.3 Economy

The largest segment of the study area population is employed in the education, health and social services sector. Retail trade, professional/management services and manufacturing also employ a large portion of the population. In the eastern end of the study area more people are employed in agriculture, while fewer are employed in the retail and manufacturing sectors.

2.2.4 Transportation

The study area has a large network of roadways. A number of highways provide east-west access including the Southern State Parkway, Sunrise Highway (Route 27) and Montauk Highway (Route 27A).

There are no major roadways on Fire Island, except at the western end of the island, where the Robert Moses Causeway connects with Ocean Parkway and on the eastern end, where the William Floyd Parkway connects Fire Island with the mainland. Access to Fire Island is mainly by ferry service from Bay Shore, Sayville and Patchogue, as well as private boat access. The beach on Fire Island serves as a primary transportation corridor, including emergency vehicle access.

Dune Road is the major east-west thoroughfare between Moriches Inlet and the western side of Shinnecock Inlet. Dune Road connects to the mainland via Jessup Lane and Beach Lane in Westhampton Beach, by Post Lane in Quogue, and by the Ponquogue Bridge in Ponquogue.

East of Shinnecock Inlet, Dune Road also provides east-west access from the barrier island to the Village of Southampton via Halsey Neck Road, Cooper Neck Lane, First Neck Lane and South Main Street.

East of the Village of Southampton, Montauk Highway (Route 27) is the only major east-west thoroughfare, and therefore, is a critical roadway in egress and ingress to this part of Long Island. There are a number of north-south thoroughfares in the eastern part of Suffolk County and are identified below.

- Moriches-Riverhead Road (Route 51) connects Sunrise Highway with Montauk Highway.
- Westhampton Road (Route 111) connects Sunrise Highway with the Long Island Expressway.
- Nicholls Road (Route 97) connects the Long Island Expressway, Sunrise Highway and Montauk Highway.

In addition to these vehicular routes, the Montauk Branch of the Long Island Railroad (LIRR) provides passenger railroad service from Montauk Point to New York City via Jamaica Station, NY.

The Hurricane Evacuation Study for Suffolk County, completed in 1993, and updated in 2008 included a traffic flow analysis which was used to identify critical roadway links and intersections where congestion impacts the estimated clearance times. This report identifies locations within the region which are known traffic congestion points, which impact evacuation times. The intersections that directly impact evacuation within the study area include the following locations:

- Montauk Highway east of Southampton
- Route 27 (Sunrise Highway) and North Sea Road intersection at Southampton
- Route 111 (Islip Avenue) and Southern State Parkway interchange

- Wellwood Road and Sunrise Highway north of Lindenhurst
- I-495 (Long Island Expressway) westbound
- Ferry service between Fire Island and mainland

2.2.5 Land-Use Controls

While the federal, state and county governments each have regulatory authority, the local governments have regulatory jurisdiction with respect to land management, principally through zoning and also management of environmental features (e.g., freshwater and tidal wetlands). In addition, Fire Island National Seashore (FIIS) is administered by the National Park Service (NPS) under the DOI, a federal agency with land use and environmental management authority.

Established in September, 1991 (36 CFR Part 28), the federal zoning regulations within FIIS provide a set of standards for the use, maintenance, renovation, repair, and development of property within the National Seashore boundaries. NPS has established three districts within its boundary:

- The Community Development District comprises the 17 existing communities and villages on Fire Island, and permits existing uses and development of single-family houses.
- The Seashore District includes all land in FIIS that is not in the Community District. No new development is allowed in the Seashore District, but existing structures may remain.
- The Dune District extends from Mean High Water (MHW) to 40 feet landward of the primary natural high dune crest as mapped by NPS. This district overlaps the other two districts. Only necessary vehicles, such as ambulances, and pedestrians are allowed. Like the Seashore District, existing legal structures may remain and be repaired and maintained.

While NPS is responsible for enforcing the federal standards in the communities and villages, local governments maintain regulatory jurisdiction. As long as local zoning ordinances conform to standards issued by the Secretary of the Interior, the federal power of condemnation is suspended.

Other relevant land use controls include:

- National Flood Insurance Program (NFIP): Administered by FEMA, participation in the NFIP requires that a municipality adopt a local floodplain management ordinance that regulates floodplain development and redevelopment following damage, such as requiring that the first finished floor of new construction be elevated above the base flood elevation. All municipalities within the study area participate in the NFIP.
- The Coastal Barrier Resources Act of 1990: established the Coastal Barrier Resources System (CBRA) to identify undeveloped coastal barriers on the United States coastline. The U.S. Fish and Wildlife Service (USFWS) is the responsible agency for administering CBRA. Coastal barriers include barrier islands, bay barriers, and other geological features that protect landward aquatic habitats from direct wind and waves. CBRA units are prohibited from receiving federal monies or financial assistance or insurance for new development in CBRA areas. The CBRA, however, identifies exceptions to this restriction, including natural stabilization systems; the maintenance of channel improvements, jetties, and roads; necessary oil and gas exploration and development; essential military activities; and scientific studies.

- The Coastal Erosion Hazard Areas Act (ECL Article 34 and 6 NYCRR Part 505) directs the New York State DEC to identify and map coastal areas that are subject to erosion, and landforms such as beaches, bluffs, dunes and nearshore areas that protect coastal lands and development from the adverse impacts of erosion and high water. These areas are identified on Coastal Erosion Hazard Area (CEHA) Maps prepared by the New York State DEC. Lands within CEHA jurisdiction are subject to regulation under Article 34 and Part 505, which limits land use to protect these sensitive areas and limit high risk development. ECL Article 34 and 6 NYCRR Part 505 allow for local municipalities to administer their own local CEHA program, if the local municipality passes a CEHA law, the program is approved by DEC, and the program meets the minimum standards of 6
  NYCRR Part 505. Local programs are required to use the DEC issued CEHA maps. Presently, all the towns within the study area have CEHA regulations in effect.
- The Waterfront Revitalization and Coastal Resources Act (Article 42 of the Executive Law) was enacted in 1981 to implement the State Coastal Management Program (CMP) at the state level. The CMP and Article 42 establish a balanced approach for managing development and providing for the protection of resources within the state's designated coastal area by encouraging local municipalities to prepare Local Waterfront Revitalization Programs (LWRPs) in accordance with state requirements.

2.2.6 Recreation and Public Access

Public access to the beaches and natural areas within the South Shore of Long Island study area has been critical to it being a major destination for visitors from within Nassau and Suffolk County, New York City, and beyond. Significant public investments have been made over time to create local, county, state, and national parks, and the construction of necessary transportation linkages for access. Examples include the Fire Island National Seashore (FIIS), Robert Moses State Park, the Otis G. Pike Wilderness Area, and Smith Point County Park. Robert Moses State Park receives 3.5 million visitors per year.[3] Appendix G provides the Public Access Plan.

While many of these facilities are open to the general public, there are some facilities outside of Fire Island that are effectively restricted to local resident use due to limitations on parking and transportation access or by municipal ordinance. Habitat protection rules can also limit public access to certain times of the years; e.g., to avoid prime nesting seasons for endangered birds.

Another important aspect of public use and access is the public trust interest that local governments hold over underwater lands. There are several New York and Federal laws and agency regulations that serve to achieve various legislative goals related to environmental protection and the public trust. (NYSDOS, 1999)

As part of the Reformulation study in areas where project measures are recommended that include sand placement; e.g., dune and beach berm, etc., a public access assessment will be made to determine the level of existing access, identify gaps and restrictions, and propose necessary measures to ensure that any recreation benefits provided are available to the public at large, and not limited to local residents only,

[3]https://www.governor.ny.gov/news/governor-cuomo-announces-robert-moses-and-jones-beach-state-parks-now-open

while also ensuring that the use of the area is appropriate to its environmental setting and carrying capacity.

2.3 Environmental Resources

This Section is a summary of more detailed descriptions of the natural and human environment that are presented in the Environmental Impact Statement (EIS) and its appendices.

The study area is a complex array of marine, coastal and estuarine ecosystems expected in a barrier island environment. Table 8 provides a summary of the five major ecosystems and specific habitats found within the study area:

- Marine Offshore Ecosystem, which includes the sub tidal marine pelagic and benthic habitats.
- Atlantic Shores and Inlets Ecosystem, which includes the Marine Nearshore, Marine Intertidal, Marine Beach, and Inlet habitats.
- Barrier Island Ecosystem, which includes Dunes and Swales, Terrestrial Upland, Maritime Forest and Bayside Beach habitats.
- Back Bay Ecosystems, which include the Bay Intertidal, Sand Shoals and Mud Flats, Salt Marsh, Bay Subtidal, and Submerged Aquatic Vegetation habitats.
- Mainland Upland Ecosystem, which includes the areas above the Mean High Tide along the Bays and also at the landward toe of the primary dune on the eastern Atlantic shorefront between Southampton and Montauk.

Detailed descriptions of each of the habitats, including specific biota, are provided in the EIS. Several of these habitats are designated as Essential Fish Habitat (EFH) for one or more managed fish species, including Marine Offshore, Marine Nearshore, Marine Intertidal, Inlets, Bay Intertidal, Sand Shoals and Mudflats, Salt Marsh, Bay Subtidal, and Submerged Aquatic Vegetation. The study area contains EFH for various life stages for 27 species of managed fish.

There are 25 Federally/State-listed species in the study area: two mammals, 10 reptiles, 10 birds, and three plant species. The habitats, EFH, species, and impacts are described in detail in the Environmental Impact Statement.

Table 8. Major Ecosystems within Study Area

ECOSYSTEM/HABITAT	DEFINITION
Marine Offshore Ecosystem	
Marine Offshore	Subtidal marine habitat ranging in depth from 10 to 30 meters; includes pelagic and benthic zones
Atlantic Shores and Inlets Ecosystem	
Marine Nearshore	MLW to depth of 10 meters; includes pelagic and benthic zones
Marine Intertidal	Extends from MLW to MHW with a sandy and/or rocky substrate
Marine Beach	Extends from the MHW line on the ocean side to the boundary of the primary Dune and Swale habitat within the Barrier Island Ecosystem; sandy substrate

ECOSYSTEM/HABITAT	DEFINITION
Inlets	Areas of water interchange between bay and ocean zones (e.g., Fire Island Inlet, Moriches Inlet, and Shinnecock Inlet)
Barrier Island Ecosystem	
Dunes and Swales	Primary dune through most landward primary swale system
Terrestrial Upland	Extends from the landward boundary of the primary dunes and swales on the ocean side, to the MHW boundary of the Bay Intertidal habitat on the bay side of the island contains all upland habitats excluding the maritime forest; scrub/shrub are also included in this habitat, along with bayside beach areas
Maritime Forest	Forested area on barrier island defined by salt tolerant vegetation, high salinity and salt spray adapted soils and vegetation assemblages such as trees, shrubs, and herbaceous species (e.g. Sunken Forest)
Bayside Beach	Area between MHW to seaward limit of vegetation or "upland" boundary
Back bay Ecosystem	
Bay Intertidal	Extends from MHW to MLW on the bay side of the barrier island. Habitats such as Salt Marsh, and Sand Shoals and Mud Flats may also be present between MHW and MLW.
Sand Shoals, Bare Sand, Mud Flats	Found within the Intertidal Habitat and exposed at low tide; specific habitat type is defined by the substrate type
Salt Marsh	Bayside vegetation communities dominated and defined by salt-tolerant species; occurs from the landward limit of the high marsh vegetation, sometimes also MHW or slightly landward to the seaward limit of the intertidal marsh vegetation
Bay Subtidal	Bayside aquatic areas below MLW
SAV	Bayside submerged aquatic vegetation (SAV) communities found within the subtidal habitat
Mainland Upland Ecosystem	
Mainland Upland	Area generally extends from the landward limit of the Bay Intertidal MHW line to the landward limit of the study area (i.e., +16 ft. NGVD), which generally correlates with Montauk Highway (Route 27). On the Atlantic shorefront, Mainland Upland begins at the landward toe of the primary dune.

2.3.1 Threatened and Endangered Species

Two Federal agencies, the Fish and Wildlife Service (USFWS), in the Department of the Interior (DOI), and the National Oceanic and Atmospheric Administration (NOAA) Fisheries, in the Department of Commerce, share responsibility for administration of the Endangered Species Act (ESA). The USFWS is responsible for terrestrial and avian listed species, as well as freshwater aquatic species. NOAA, through the Protected Resources Division of the National Marine Fisheries Service (NMFS) is responsible for marine aquatic species. In addition to species protected under the Federal ESA, the State of New York maintains a list of species that are Threatened, Endangered, Rare, or of Special Concern in the State.

Based on habitat and life history assessments, recommendations from the USFWS and NOAA, and site assessments, the following Federally-listed species are likely to occur in the FIMP Project Area and warrant a Biological Assessment:

- Piping Plover (*Chardrius melodus*), Federally Threatened;
- Rosette Tern (*Sterna dougallii*), Federally Endangered;
- Red Knot (*Calidris canutus*) Federally Threatened;
- Seabeach Amaranth (*Amaranthus pumilus*), Federally Threatened;
- Sandplain Gerardia (*Agalinis acuta*), Federally Endangered; and

All five of these Federally listed species nest or carry out a major portion of their life cycle activities (i.e., breeding, resting, foraging) within essentially the same Marine Beach habitat that consists of sand/cobble beaches along the ocean shores, bays, inlets and occasionally in blowout areas located behind dunes.

Atlantic sturgeon (Acipenser oxyrinchus oxyrinchus) may also occur in the project area. The District has received concurrence from NMFS on the Not Likely to Adversely Affect (NLAA) determination conducted for the Federally-listed species of Atlantic sturgeon, whales and marine turtles (DEIS, Appendix B).

2.3.2 Essential Fish Habitat

The NMFS is responsible for enforcing the Magnuson-Stevens Fishery Conservation and Management Act (1996 amendments) (MSA), which, is intended to promote sustainable fisheries. To implement the MSA, the NMFS and the eight regional Fishery Management Councils have identified and described Essential Fish Habitat (EFH) for each managed fish species. EFH can consist of both the water column (pelagic) and the underlying surface (seafloor) of a particular area. Areas designated as EFH contain habitat essential to the long-term survival and health of our nation's fisheries.

Several habitats within the study area, including Marine Offshore, Marine Nearshore, Marine Intertidal, Inlets, Bay Intertidal, Sand Shoals and Mudflats, Salt Marsh, Bay Subtidal, and SAV, have been designated as EFH for one or more managed fish species. In compliance with Section 305(b)(2) of the MSA, the Reformulation Study will include an assessment of the potential effects of the proposed alternatives on Essential Fish Habitat (EFH). This EFH assessment includes all pelagic and benthic fish habitat off of Long Island, 1,000 feet seaward of mean low water (MLW) and coastal and open Atlantic Ocean. The study area contains EFH for various life stages for 27 species of managed fish.

Fish occupation of waters within the project impact areas is highly variable spatially and temporally. Some of the species are strictly offshore, while others may occupy both nearshore and offshore waters. In addition, some species may be suited for the open ocean or pelagic waters, while others may be more oriented to bottom or demersal waters. This can also vary between life stages of Federally managed species. Also, seasonal abundances are highly variable, as many species are highly migratory.

2.3.3 Significant Habitats

The USFWS has identified Shinnecock Bay, Moriches Bay, Great South Bay, Montauk Peninsula, and South Fork Long Island Beaches as Significant Habitats and Complexes of the New York Bight Watershed. These areas have been recognized as regionally significant habitats and species populations. In addition, all of the back bay waters, including Bay Intertidal and Bay Subtidal habitats within the study area have been designated as Significant Coastal Fish and Wildlife Habitats by the New York State Department of State (NYSDOS).

Within the Dunes and Swales habitat, the maritime freshwater interdunal swale community, which occupies the low-lying and wet areas between the dunes, generally supports a variety of plants designated as rare or unique by the NYSDEC Natural Heritage Program and hence, has been designated as a Significant Habitat by NYSDEC.

The rocky intertidal zone of Montauk Point has been designated as a rare community by NYSDEC Natural Heritage Program. The rocky intertidal zone is considered a generally rare habitat and has been assigned a rarity rank of S1, indicating that the habitat is very vulnerable in the state. The Montauk Point habitat is one of the two large, high quality sites in State. There are only approximately 40 rocky intertidal habitats sites in New York. The current trend of this community is probably stable in the short term, but may decline slightly in the future due to moderate threats that include alteration of the natural shoreline, invasive species, and sea level rise (NYSDEC 2006).

The Sunken Forest is one of three locations where maritime forests persist on the eastern seaboard. The Sunken Forest is from 200 to 300 years old and is located within Fire Island National Seashore, near the Sailors Haven marina and visitor center. Because of its uniqueness as a maritime forest community, the Sunken Forest is of particular ecological importance and warrants special protection.

SAV is a unique vegetated intertidal habitat. The establishment of SAV is dependent on suitable water quality, substrate, depth and water currents. SAV is one of the most important features of the Back Bay Ecosystem since it provides nursery areas for finfish and a niche for colonization of epiphytic algae and invertebrates.

2.4 Cultural and Archeological Resources

This section provides a summary of known and potential cultural and architectural resources within the study area. Reconnaissance level cultural resource reviews of the entire study area were conducted in 1998. More intensive investigations consisting of literature review, examination of data inventories, and field investigations were undertaken to characterize resources in the Area of Potential Effect (APE) including the offshore, the onshore barrier islands, and the Mainland and Back Bay areas. The specific details of the studies are provided in the EIS and appendices.

There has also been coordination with the New York State Office of Parks, Recreation and Historic Preservation (NYSOPRHP) to assess potential effect, and develop strategies to avoid or minimize adverse effects.

2.4.1 Offshore Areas

Known and potential submerged archaeological and cultural resources in the offshore zone along the south shore of Long Island from Fire Island Inlet to Montauk Point have been inventoried through a number of studies (USACE/John Milner Associates (JMA), 1998, Tidewater Atlantic Research, Inc. (TAR), 2002). According to the JMA, 1998 report, no underwater, former terrestrial archeological sites have been identified off-shore of Long Island. The report states that the potential for the existence of intact archeological resources with sufficient integrity to be eligible for listing on the NRHP is low given the high energy environment in the off-shore area. The TAR, 2002 report identified five target areas as potentially sensitive for submerged shipwrecks. It recommended that each be avoided by establishing a 150 foot buffer zone around each anomaly's coordinates.

In order to assess the buffer zone effectiveness, the TAR, 2002 report recommended that the target environment at each site be periodically monitored to determine what, if any, change has occurred. In the event that they cannot be avoided, additional investigation is recommended to identify and assess the significance of material generating each signature. Where material is found to be associated with shipwreck remains, it is recommended that sufficient data be collected to support a preliminary determination of NRHP eligibility and identify any additional on-site research that may be necessary. These Phase II investigations could generate data that make positive associations with specific Long Island shipwrecks.

2.4.2 Barrier Islands

This section identifies existing significant cultural resources, including archaeological and architectural resources, on the barrier islands of Long Island's south shore from Fire Island Inlet to Shinnecock Inlet. JMA, 1998 reports two previously recorded historic archaeological sites within the barrier island APE, according to NY SHPO's archaeological site files. Site A103-05-000605, within Robert Moses State Park, was a recreational facility built for handicapped children in the early part of the 20th century; the other site (Site A103-02-1579) is a complex of structures near Whalehouse Point used by the Coast Guard from the mid-19th century to the early 20th century. Both sites are located on sand dunes bordering Great South Beach. The Historic Preservation Field Services Bureau considers both sites to be potentially eligible for listing on the NRHP.

In addition to the sites identified in the JMA report, the Gray & Pape, 2005 study identify 11 other previously identified archaeological sites within FIIS: 1) William Floyd Estate Manor House Area, 2) Point O' Woods Refuse Midden, 3) Blue Point Life Saving Station, 4) Smith Point Coast Guard Station, 5) Forge River Life Saving Station, 6) Fire Island Lighthouse Tract, 7) Fire Island Lighthouse Tract (additional), 8) Razed Factory, 9) Greenburg House Site, 10) Saltaire Dump, and 11) Casino Site, in addition to one new site: an 1826 Fire Island Lighthouse Ruin. Most of these sites are related to maritime, military, or recreation/resort activities of Euroamericans.

The JMA report identifies a high potential for buried archaeological deposits within undefined portions of the study area underlying the beaches and dunes that have not been previously surveyed. Moreover, the Gray & Pape report indicates that the potential is high for the presence of archaeological resources within the large areas of FIIS that have not been surveyed. In areas that may be disturbed, it is recommended that core borings be taken in areas of disturbance that would be examined by a geoarcheologist knowledgeable of coastal sedimentology. If any preserved surfaces are identified in the borings, monitoring of construction activities in those locations for potential archaeological deposits may be necessary.

Resources Listed or Determined Eligible for Listing on the NRHP. Fire Island Light Station (Town of Islip), located about five miles from the western end of Fire Island National Seashore, (FIIS) was listed in the NRHP on September 11, 1981.

Resources Potentially Eligible for Listing on the NRHP. JMA's architectural investigation identified several potentially eligible historic resources within the study area, which were related to the historical settlement and pre-resort development, vacation/resort industry, and maritime histories of the barriers. Reconnaissance field surveys identified 22 potentially eligible resources that meet the 50-year age consideration of the NRHP. Potentially affected architectural properties were considered to be only those visible from the beach itself. It is noted that a formal determination of eligibility requires an intensive survey of each property.

2.4.3 Mainland and Back Bay

This section identifies significant architectural resources along Long Island's back bay shore, based on a historic resources study prepared in March 2006 (Need Ref). The APE consists of the area between the bay shoreline and Montauk Highway to the north.

Individual Properties Potentially Eligible for Listing on the NRHP. The historic resources survey identified 49 properties as being potentially eligible for the NRHP. Most are residential properties associated with the time period of 1840-1960 and most are located in the easternmost parts of the APE. Only one resource (located in Babylon) was identified as being built before 1840. The primary context of the resources was early suburbanization between 1890 and 1920.

Districts Potentially Eligible for Listing on the NRHP. According to National Register Bulletin 15, a district "results from the interrelationship of its resources, which can convey a visual sense of the overall historic environment or be an arrangement of historically or functionally related properties." In addition, a district may be considered eligible if all of the components lack individual distinction, provided that the grouping achieves significance as a whole within its historic context. Within the APE, 10 potentially eligible historic districts were identified. The districts are primarily residential; however, one in Lindenhurst is associated with the maritime and fishing industry. The majority of the residential districts are associated with the primary contexts of early or postwar suburbanization, spanning almost 70 years in history. The district identified in Mastic has a considerable number of vacation or seasonal homes, and the Westhampton Beach district has 13 properties of the 31 associated with the secondary context of resort development. Although resort and vacation community construction historically occurred in the western portion of Suffolk County along the South Shore, today more of those properties are located further east.

2.4.4 Native American Consultation

Within the FIMP study area are two Native American Nations: the Shinnecock Indian Nation and the Unkechaug Indian Nation. The Shinnecock Indian Nation is recognized by the federal government; the Unkechaug Indian Nation does not have Federal status, but is recognized as a Tribe by the State of New York. A third tribal group, the Shirley-Mastics is affiliated with the Unkechaug Indian Nation.

Meetings with representatives of the Nations were held between 2003 and 2006 to communicate the study's goals, discussion of potential impacts to cultural resources, and identification of flood-prone areas for further study.

3 WITHOUT PROJECT FUTURE CONDITION

3.1 General

The Without Project Future Condition (WOPFC) is the most-likely future conditions in the study area in the absence of a proposed project from the current study. The WOPFC serves as the base conditions for the analyses of alternative, including the engineering design, economic evaluation of alternatives, comparison of alternatives, as well as environmental, social and cultural impact assessment.

The WOPFC is a forecast based upon what has actually occurred, is currently occurring, or is expected to occur in the study area if no actions are taken as a result of this study. As it is impossible to predict the future, the without-project condition represents the most likely future scenario (not the only future scenario), based upon reasoned, documentable forecasting of what is most likely to occur, and based on historic practices and trends.

The following assumptions were made to establish the framework of the WOPFC:

1. Storms will occur in a manner and frequency similar to those that have historically occurred.
2. Sea level rise will continue and increase the impact of the storms. There is a range of sea level rise that is possible in the future.
3. Future development will be undertaken consistent with existing regulations.
4. Maintenance of the navigation channels through the existing inlets (Fire Island, Moriches, and Shinnecock Inlets) and in the back bays will continue, consistent with past practices to provide navigation and bypass material.
5. Local interests will continue to maintain the existing beaches through periodic beach fills and beach scraping similar to what is currently being done.
6. The Breach within the Wilderness Area of the Fire Island National Seashore that opened during Hurricane Sandy will remain open indefinitely.
7. Periodic renourishment of the Westhampton Interim Project will continue until 2027 consistent with the terms of the legal settlement.
8. The one-time post-Sandy FIMI Project is constructed (schedule to be completed in 2018).
9. The one-time post-Sandy Downtown Montauk Stabilization Project is constructed (completed in 2016).
10. The Interim Breach Contingency Plan (BCP), that includes a process to close breaches within three (3) months and which was approved as an interim action pending the outcome of the Reformulation study, will not continue. Breaches of the barrier island will continue to be closed (with the exception of the Wilderness Area breach) but will take a year to close in the absence of a streamlined process for Federal participation.

In summary, the without project condition, which serves as the baseline for comparison of the alternatives assumes that the post-Sandy stabilization efforts on Fire Island and Downtown Montauk are in-place, and that the existing breach in the Wilderness Area remains open indefinitely. Maintenance of the three federal navigation projects, and renourishment of the Westhampton Interim project are all expected to continue in the future.

3.2 Physical Conditions

Future coastal conditions are likely to be shaped as much by human intervention as by natural processes. Some actions, such as the renourishment period for Westhampton Interim Project, are clearly defined in existing reports or agreements. Other WOPFC actions, such as breach closures or periodic beach maintenance, are anticipated based on a review of the history of such actions. For these types of projects, unless specific plans or policies are identified which would alter future conditions, it is assumed that past actions are the most reliable indicator of the WOPFC.

Climate Change. The WOPFC anticipates a continuation of sea level rise. As acknowledged previously, this report first considers the historic trend in sea level rise consistent with USACE ETL 1100-2-1 Procedures to Evaluate Sea Level; Change: Impacts, Responses and Adaptation. Because there is variability in the rate of future sea level rise, the planning considers the effectiveness of the selected plan considering a range of possible increases in sea level rise. The WOPFC anticipates that the frequency and intensity of future storms will not change in the WOPFC and that the wave climate will be similar to historic patterns. Sediment transport and rates of long term erosion will also be similar to historic rates, with some changes due to both the maturation and deterioration of existing coastal structures.

Beach and Dune Conditions. Considering the influence of the coastal processes and the human response to these processes, it is expected that the shoreline will continue to be influenced by the regional sediment framework, storm response, localized erosion hot spots, and sea level rise. It is expected that the beach and dune conditions will fluctuate over the next 50 years and possibly "weaken" significantly based upon the timing and intensity of storms. This cycle of beach and dune condition is captured in the life cycle evaluations used for project design and evaluation, which recognize that the beach and dune conditions are variable over time. Two sets of beach and dune conditions have been developed to bracket the range of possible conditions over the WOPFC: Baseline Conditions (BLC) and Future Vulnerable Conditions (FVC). Specifics regarding the BLC and FVC are included in the following section, Problems and Opportunities, Sections 4.4.3.2 and 4.4.3.3.

Local Storm Risk Management Efforts. It is also expected that without Federal involvement in coastal storm risk management, non-Federal efforts will likely continue, including localized "soft" storm risk management measures. These include beach scraping and beach nourishment projects, to maintain a minimum beach width and a dune height of approximately 13 to 16 ft. The local nourishment measures will generally occur when erosion is at or near the dune line, at locations where smaller, local projects have been previously built, such as at Saltaire, Fair Harbor and Dunewood, and at Fire Island Pines. Outside of these communities it is anticipated that this storm risk management will focus on maintaining a minimum height of the dunes, and width for the barrier islands, in order to prevent breaching, and protect the east/west access, either by reducing risk to paved roads, dirt roads, or ensuring access along the beach. The WOPFC anticipates that future regulatory procedures could limit the scale, extent and timing of these measures, and does not anticipate significant coastal storm risk management measures for individual residences or undeveloped areas, such as the major Federal tracts of land on Fire Island. While those efforts will provide some measure of future storm risk mitigation, future loss of beach width and lowering of dunes will result in increased vulnerability to storm damage.

It is expected that in the coastal ponds region, as has historically occurred and in a manner that is consistent with current practices, the Town Trustees will continue to open and close the openings between the ponds and the ocean, generally twice a year. It is expected that there may be some small scale dune rebuilding efforts that are undertaken utilizing material which is available within the flood shoals of these ponds.

Inlets. The WOPFC anticipates that the Federal navigation projects at Fire Island, Moriches and Shinnecock Inlets, as well as the Federal, State, and locally maintained approach and back-bay navigation channels in the area will be maintained through periodic dredging and that these ongoing efforts will not measurably alter the existing hydrodynamics of the inlets and bays. It is expected that the past practices of beach and intertidal placement associated with dredging will continue.

Wilderness Area Breach. The WOPFC anticipates that the breach within the Wilderness Area of the Fire Island National Seashore that opened during Hurricane Sandy will remain open indefinitely. DOI has been monitoring the breach and is preparing an Environmental Impact Statement (Plan/EIS) to determine how best to manage the breach. The planning process will include opportunities for public input as well as consultation with federal, state, and local agencies with a regulatory interest or special expertise related to proposed actions.

Closing Breaches. As noted in the introduction, the WOPFC assumes that breaches in the barrier islands will either close naturally, or will be closed through mechanical means. The only policy identified that specifically considers leaving breaches open is limited to the Wilderness Area of the Fire Island National Seashore. It is expected that in the absence of a streamlined implementation plan, as currently exists with the BCP, that closure would take between 9 and 12 months, as was the case in 1980 and 1992. The breaches are expected to be closed using design standards similar to those established in the BCP.

3.3 Social and Institutional Conditions

The population of Suffolk County and the study area is expected to increase over the period of analysis. Continued increases in both population and income will inevitably lead to increased development, increased traffic congestion, as well as an increased demand for recreation and beach facilities. The high price and demand for shorefront property will create strong economic incentives to reconstruct buildings that have been damaged or destroyed by erosion or waves. The WOPFC anticipates that of the institutional controls, the Coastal Erosion Hazard Area (CEHA) Act, is the most important constraint on rebuilding of storm damaged structures. The CEHA regulations have been instituted along the Atlantic Ocean shoreline within the project area, but do not address development along the bay shoreline. The WOPFC assumes once structure damage exceeds 50% of the structure value (substantially damaged) the building will be rebuilt above regulated Base Flood Elevation (BFE) landward of the Coastal Erosion Hazard Area (CEHA), where it is possible on the existing lot. If the existing lot size will not allow rebuilding landward of the CEHA, it is assumed that buildings will not be rebuilt. It is acknowledged that variances may be granted to reconstruct some substantially damaged buildings within the CEHA, but such conditions are not predicted at this time.

Implementation and enforcement of institutional controls are effective tools to restrict development in "at-risk" or environmentally sensitive areas. In general it is anticipated that existing regulations will be enforced and that future development will not be subject to frequent storm damage through enforcement of these regulations. The WOPFC anticipates limited impacts from new regulations.

The status of other hazard mitigation programs in the study area was reviewed to establish the WOPFC. Many of the communities have prepared Flood Mitigation Plans and may be eligible for FEMA grants through the Hazard Mitigation Grant Program (HMGP) administered by the NY State Emergency Management Office (SEMO). Nonstructural storm damage reduction programs that incorporate floodproofing or other building retrofit measures are the most likely hazard mitigation actions to be implemented under these programs. Following Hurricane Sandy, a number of home elevations have been implemented through these programs. The elevation of homes through these programs has been accounted for, based upon the information available from the local governments. No forecast of future elevation of floodplain structures is projected.

3.4 Environmental Resources

The environment of the FIMP Study area is a complex, dynamic system that is influenced by both natural processes and human policies and programs. Study area habitats will change in the WOPFC in response to numerous factors including ongoing natural succession (natural change in the vegetative communities), sea level rise, coastal erosion and related erosion control activities, periodic overwash and breaching, as well as land and infrastructure development. These factors may impact all of the study area habitats: Offshore, Atlantic Shoreline (nearshore, intertidal, beach, dune), Inlets, Barrier Island (maritime forest, bayside beach, terrestrial upland), Back Bay (intertidal, shoals/mudflats, tidal marsh, subtidal, SAV), and Mainland Upland.

In assessing WOPFC no major changes in offshore habitats are anticipated. Localized dredging of sand for beach nourishment projects is expected to continue in a manner comparable to past practices, where borrow areas locations are dredged once, and are not repetitively disturbed. This includes dredging for the Westhampton Interim Project, potential breach closures, and other locally implemented actions taken in response to continued erosion. Monitoring of prior dredging activities suggests that the benthic communities and other biological resources within these borrow sites will not be altered on a long-term basis. Other possible changes to offshore habitats and natural resources would most likely be associated with changes in fishing trends or fisheries management.

In the WOPFC, the Atlantic shoreline will remain the most dynamic habitat in the study area. The ecological communities that inhabit these areas readily adapt to physical changes in the environment. Shorebirds including the Piping Plover and the Least Tern are probably the most sensitive species relying on this habitat and it is anticipated that continued efforts to protect these species will continue throughout the WOPFC.

The WOPFC habitats and natural resources of the barrier islands will be influenced by continued sea level rise, overwash/breaching and related sediment transport, erosion control and post storm repair activities, and development and redevelopment. It is expected that these human activities would reduce the magnitude of the changes in the barrier island topography, human usage patterns and vegetation communities that would be associated with long-term erosion, storm activity and sea level rise. It is expected that there will continue to be overwash and breaching, but that to different degrees these storm driven processes would be countered by human activities. As a result, it is expected that the physical features associated with overwash and breaching would be limited in magnitude due to human intervention. Over time it is expected that these areas would subsequently vegetate to a level consistent with what has been observed in the study area. The presence of bulkheading along portions of the barrier island is likely to limit the natural succession of habitat in response to sea level rise.

In the WOPFC it is expected that future changes will occur within the estuaries and along the bay shores. It is expected that changes in the estuary will continue as a result of increases in sea level, and also due to future barrier island breaches. As is the case for the barrier island condition, it is expected that the spatial and temporal magnitude of the hydrodynamic changes in the estuary due to breaching and overwash would be reduced by human intervention to reduce the potential for breaching, and through breach closure. While there may be short-term changes in the inlet regime associated with barrier island breaching, the predominant conditions affecting the bay hydrodynamics would be represented by the current inlet conditions.

These physical changes would have short-term impacts on the WOPFC bay water quality. During the period of time that a breach would be open, there would be altered tidal exchange, allowing higher storm water levels and increased flooding and potentially increased wave energy along the mainland during larger storm events, and changed salinity distribution. Because the existing natural resource communities in the bays are currently subject to wide range of water quality conditions, short term hydrodynamic changes associated with breaches are not anticipated to result in long term alterations to bay habitats.

As presented above, barrier island breaching and overwash would contribute to sediment input into the estuaries adjacent to the barrier islands. However, the magnitude of the sediment transport would likely be reduced somewhat by closure efforts. The sediment input to the bay may contribute to both the short-term degradation and the long-term formation of salt marsh and submerged aquatic vegetation beds. The possibility for such habitat creation or degradation is highly dependent upon the location of the breach or overwash and its temporal extent.

The greatest impact to upland habitats in the WOPFC is the continued development associated with the projected increase in population. The need for additional housing and infrastructure is likely to result in a loss of open space and natural habitats within the study area. To some extent this development will be offset by local government efforts for zoning and acquisition of open space. With respect to the Fire Island National Seashore segment, any new development is restricted by law to the existing communities. While development will continue in this area, it is expected that virtually all of it, with the exception of a few scattered parcels, will consist of the replacement of existing structures with new or rebuilt ones.

3.5 Cultural Resources

The key cultural resources in the study area include submerged artifacts, buried artifacts, historic structures and districts.

No significant change is expected in the future, relative to submerged artifacts. Historic resources, such as shipwrecks in the offshore marine environment, are either buried or partially buried. Wooden resources may become buoyant and move, even if buried or partially buried. Future storms could adversely impact partially buried resources but probably would not have an adverse effect on those that are fully buried. Artifacts presently buried or partially buried within the active shorezone (including historic artifacts and historic land surfaces) are likely to be impacted. Future storm activity, and continued erosion within the study area are expected to expose and further the destruction of these resources.

Buildings recognized as historic structures and potentially eligible structures are likely to be impacted in the future. Recognized structures are likely to be preserved and maintained as such. It is likely that a number of the potentially eligible structures would be reduced due to renovations, replacement, or destruction of the buildings. Similar conditions are anticipated for historic districts and landscapes. Over time additional structures will meet the requirements for being evaluated for eligibility.

4 PROBLEMS AND OPPORTUNITIES

4.1 Description of the Problem

The study area comprises a complex coastal area that includes different components, including coastal headlands, barrier islands, tidal inlets back bays, and mainland, each with their specific problems that need to be evaluated for storm damage reduction that compliments and restores the natural coastal processes as an interconnected system.

Nor'easters and hurricanes are the primary source of storm damage to the south shore of Long Island, causing extensive flooding, wave attack, and erosion impacts along the barrier islands and mainland. Hurricane Sandy was a powerful reminder of the impact these storm events can have on the study area. The severity of impacts from large storms (greater than a 2% storm) in the areas surrounding Great South, Moriches and Shinnecock Bays is strongly dependent on the integrity of the barrier islands from Fire Island Inlet to Southampton. In this regard, overwashing and/or breaching of the barrier islands can lead to increased storm damages as bay storm water elevations are increased. In the absence of a Federal project the height and width of the barrier islands may be reduced further due to continued shoreline erosion and rising sea level, exposing the study area to greater risks. Coastal model and economic evaluations have shown that storm damages in the bays are relatively sensitive to condition of the barrier island that in some locations storm damages may double with a 0.5 foot increase in flood elevations.

To analyze and evaluate the impacts from future storm events, this study has utilized a number of different coastal engineering models to characterize the long-term evolution of the beach and dune along the barrier island, predict the breaching of the barrier islands and the magnitude of storm water levels along the ocean and bays. Modeling efforts have been undertaken to characterize the storm response that can be expected in the future under different barrier island topographic conditions.

The storm water level modeling is the cornerstone of the study, since the model output is used to generate ocean and bay stage-frequency curves for input into economic analyses, coastal engineering design, environmental processes, and final alternative selection. A detailed description of all the coastal models applied during the study is found in Appendix A – Engineering. A summary of the three primary modeling analyses used in the study to calculate storm damages are provided in the following sections.

4.2 Storm Surge Modeling

4.2.1 Modeling Approach

Storm water level numerical modeling was performed to determine stage frequency relationships at 49 locations throughout the study area. These 49 locations were selected to capture the variability in storm water levels along the open coast and within the three bays. The storm water level numerical modeling strategy for FIMP addressed a comprehensive list of physical processes (wind conditions, barometric pressure, astronomic tide, wave conditions, morphologic response, [namely barrier island overwash and breaching], and localized wind and wave setup) by merging hydrodynamic, wave, and sediment transport models. The integration of these modeling efforts is shown in Figure 9. Each component shown is described below.

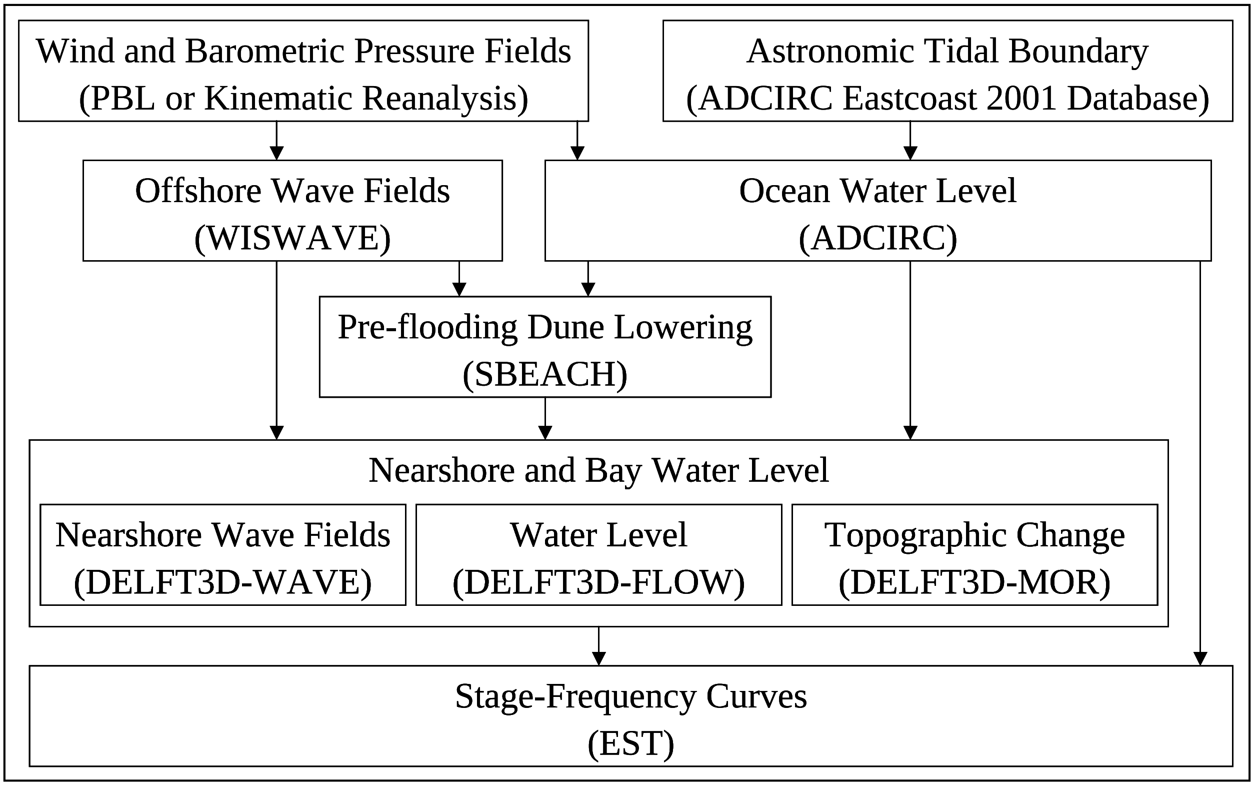


Figure 9. FIMP storm water level modeling and stage-frequency methodology

The six numerical models were applied to accomplish specific requirements for the study. Collectively, these models simulate the impact that each modeled storm has on ocean and bay water elevations, lowering of the dune during the storm, and the morphological response due to a storm. The outputs from these models were input into a statistical modeling tool to estimate the likelihood of storm occurrence. A brief overview of the six numerical models is provided below:

1. A Planetary Boundary Layer (PBL) model for wind field simulation was used to develop wind and pressure fields for tropical storms (Thompson and Cardone, 1996).
2. An Interactive Kinematic Objective Analysis (IKOA) for wind field simulation was used to develop extratropical wind fields through data assimilation, based upon the National Center for Environmental Prediction (NCEP) database.
3. The offshore extreme storm wave conditions were generated using WISWAVE (also WAVAD) (Resio, 1981) a second generation, directional spectral wave model. WISWAVE output was used as input for the DELFT3D modeling and for SBEACH.
4. ADCIRC was used to simulate the ocean and nearshore (outside the surf zone) storm water levels (Luettich et al., 1992). ADCIRC is a long-wave hydrodynamic finite-element model that simulates water surface elevations and currents from astronomic tides, wind, and barometric pressure by solving the two-dimensional, depth-integrated momentum and continuity equations. The grid resolution varies from very coarse at the open ocean boundaries to 50-m in some nearshore locations. ADCIRC was forced with the winds and barometric pressure fields from 1

and 2 above, to capture meteorological effects on water levels, in conjunction with astronomic tidal constituents from the ADCIRC East Coast 2001 Tidal Constituent Database.

5. SBEACH was used for the hydrodynamic modeling, and separately to evaluate the shorefront response for the design and evaluation of beachfill alternatives. In the context of the hydrodynamic modeling, SBEACH was applied to estimate dune lowering that occurred prior to a dune being overtopped. SBEACH (Larson and Kraus 1989a; Larson, Kraus, and Byrnes 1990) is a numerical model for predicting beach, berm, and dune erosion due to storm waves and water levels. For storm water level modeling, SBEACH storm simulations were performed for more than 200 beach profiles cut from the 2000 LIDAR topography. Dune crest elevation change just prior to inundation was extracted from the SBEACH simulation results and put into the DELFT3D topography grid to improve estimates of potential breaching and overwash processes.
6. The DELFT3D Modeling Suite (FLOW, WAVE, MOR) was used to compute the bay water levels under storm conditions, taking into account the contribution of storm surge, waves, winds, and the contribution of overwash and/or breaching. Both the ADCIRC and Delft3D hydrodynamic models underwent extensive calibration before they were used to simulate historic storm events.

Of the six models presented, two models are preferred for use by the Hydrology, Hydraulics and Coastal (HH&C) Community of Practice (CoP) (ADCIRC and SBEACH), and one model is allowed for use by the HH&C CoP (WISWAVE). The statistical process model EST is also allowed by the HH&C CoP (see the HH&C CoP Sharepoint site for model software list and Enterprise Standard (ES -08101) Software Validation for the HH&C CoP). There is no further approval needed to use these models. The Planetary Boundary Model and the Interactive Kinematic Objective Analysis is standard practice for windfield simulation, and has been recently used in the North Atlantic Coast Comprehensive Model Simulations (ERDC/CHL TR-15-14, Cialone, et al.). At the time of the original modeling study, the DEFLT 3D Modeling Suite was the leading modeling package available to allow the simulation of cross-island topographic changes which contribute to barrier island variations, overwash and breaching potential. The complete storm modeling suite architecture was approved by the Coastal and Hydraulic Laboratory, and further reviewed and accepted by a Technical Review Panel (See Appendix A and Sub-Appendix A.2).

4.2.2 Historical Storm Set

Storms are the major drivers for storm damage within the study area. The basis for the modeling effort in this study assumes that storms will occur in a manner similar to what has occurred in the past. A total of 36 historical storm events, 14 tropical storms and 22 extratropical storms, comprise the historical storm set. Historical tropical storms from 1930 through 2001 and extratropical storms from 1950-1998 were considered for the storm set. To develop stage-frequency relationships, several supplemental storms were selected for numerical modeling. These included variation in the timing of major historical events such that different astronomical tide scenarios could be considered.

4.2.3 Stage Frequency Methodology

The Empirical Simulation Techniques (EST) was applied to generate stage frequency curves. EST are a group of nonparametric methods for proceeding directly from hydrometeorological storm data to simulations of future storm activity and coastal impact, without introducing parametric assumptions concerning the probability law formulas and related parameters of the data (Scheffner et al., 1999).

Two EST procedures, one univariate (1-D) and the other multivariate, were used in the FIMP studies. The 1-D EST methodology, using water level as the one dimension, was employed for stage-frequency development for the FIMP study. The multivariate EST was used in conjunction with SBEACH for modeling of beach profile response and estimation of storm-induced coastal changes, primarily for economic life-cycle analyses (see Gravens et al., 1999).

For the FIMP study, the 1-D EST methodology was improved to account for other, equally probably, astronomical tide timings relative to each individual storm's timing. In order to apply this approach, 21 additional alternate tide events were run, to provide an improved estimate of the storm effects under different tide conditions. Along the open coast, the total surge generally can be added to the various tide conditions to develop the total surge effect, however, due to the complicated hydrodynamics of flows through the inlets and over the barrier island ,this approach does not work well within the bays,. With the inclusion of these alternate tide scenarios, final stage-frequency curves were generated to represent stage frequency relationships for the study area, at the 49 locations output from the model.

4.2.4 Shorefront Water Levels

Shorefront water levels are the result of the combined effects of the tide, storm surge, and waves. The storm water level offshore of the surf zone is determined based on the storm water level modeling procedures described above. This storm water level is not representative of the water elevation along the Long Island ocean shoreline where there is an additional increase in water elevation due to wave setup. Wave setup is localized increase in the water surface elevation along the coast caused by the breaking of waves. Wave setup is calculated by SBEACH, described below in Section 4.3, and is one of the 19 response extracted from the SBEACH shorefront numerical model. Wave setup adds an additional 2 to 3 feet of water to the storm tide elevation under the storm conditions evaluated.

The combination of offshore storm water level and wave setup is intended to be representative of the stillwater elevation along the shoreline. The storm water level plus wave setup water elevations are used in the shorefront economic evaluation of inundation damages. It is noted that individual waves can temporarily increase or decrease water elevation and cause wave runup on sloping surfaces. However, wave runup is not included in the flood elevations used to calculate shorefront inundation damages. Figure 10 illustrates the components combining to make up the water elevation at the beach.

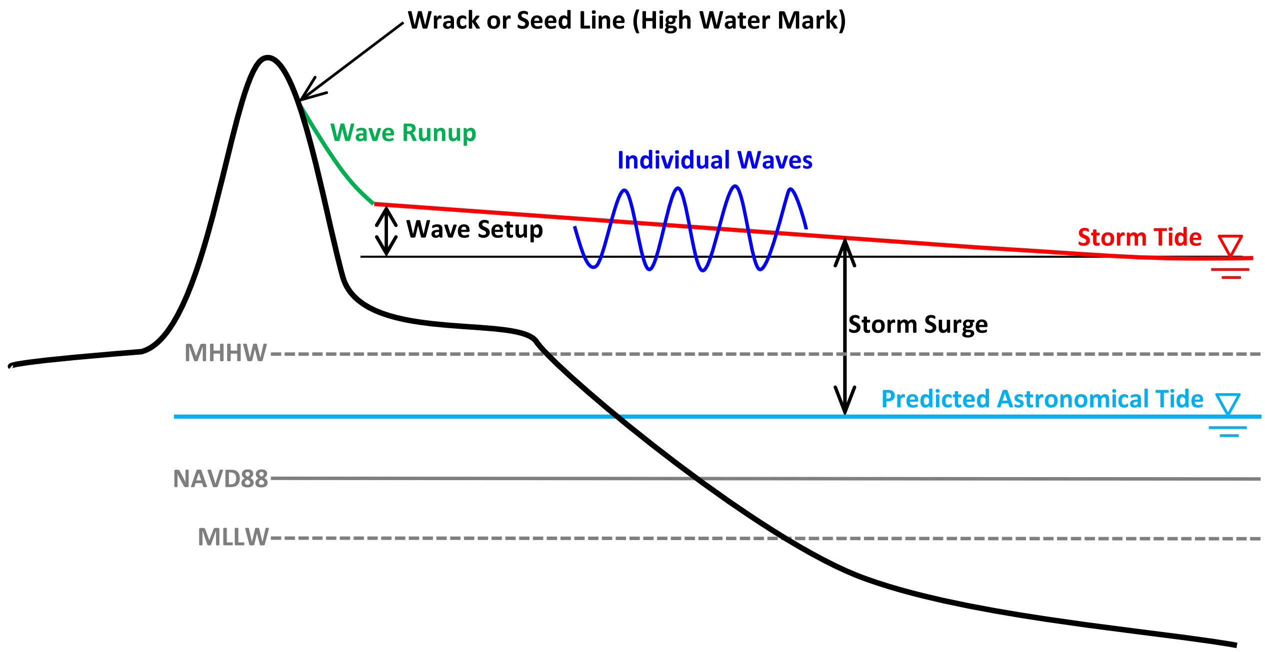


Figure 10. Shorefront Water Levels

4.3 Shorefront Erosion Modeling

An important task of this study was to evaluate storm-induced beach profile change within the study area. The USACE model SBEACH, described earlier, was applied to calculate changes to the beaches and dunes during storm events and the water levels and wave heights landward of the shoreline. Model simulations were performed for 36 storms in the historical storm set, 22 unique beach profiles representative of the variable conditions along the study area, and for a range of possible future with-project and without-project beach profile conditions. A total of 19 SBEACH responses were identified to satisfy input requirements for overtopping and economic analyses. The 19 responses describe the morphological changes to the beach and dune and the wave and water level conditions landward at the shoreline. The modeled responses are subsequently processed using the multivariate Empirical Simulation Technique (EST) (Scheffner et al. 1999), a statistical procedure involving multiple life-cycle simulations for the development of frequency-of-occurrence relationships for nondeterministic multiparameter systems. The final product of the EST analysis is a set of frequency-of-occurrence relationships (i.e. storm water level or "stage"-frequency curves) for key beach and dune erosion responses and wave and water levels at the shoreline.

SBEACH modeling captures the erosion which occurs during a storm event. However, immediately after a storm event, beaches often begin to recover when long-period waves move the sand from the nearshore back onto the beach. When determining how the study area evolves over time, it is important to estimate the amount of recovery expected. The amount of recovery, expressed as a percentage of the volume lost, depends upon a number of factors, including the sediment budget. The estimated amount of beach recovery has been established for various shoreline locations. These recovery amounts have been developed in order to match the long-term erosional trends for each location, and establish whether the area is erosional, stable or accreting in the long-term.

4.4 Overwashing and Breaching Models

As described earlier, the severity of storm impacts in the areas surrounding Great South, Moriches and Shinnecock Bays is dependent on the integrity of the barrier islands from Fire Island Inlet to Southampton. In this regard, overwashing and/or breaching of the barrier islands can lead to exacerbated storm damages as bay storm water elevations are increased. Characterizing the complicated breaching process required the application of a number of models to evaluate the likelihood of overwashing or breaching, and the concomitant impact on bay water elevations. The following elements were reflected in the modeling and engineering analyses, and are described further below.

1. Breach vulnerability to various barrier island topographic conditions.
2. Breach evolution if they are allowed to remain open.
3. Breach impact on bay water levels.
4. Breach impact on sediment exchange and stability of existing inlets.

As mentioned previously, the information presented below has been used as input into several lifecycle economic models, which are used to project the storm damages that are likely to occur in the future. Separate economic models have been developed to consider back bay damages and shorefront damages. However, the back bay damages do consider barrier island changes, and the concomitant change in back bay water elevations. Changes to the barrier island condition, and dune conditions are governed by storm response, post-storm recovery, long-term erosional trends, and shoreline undulations. The results of these models indicate that the risk of breaching will increase in the future due to the combined impacts of sea level rise and barrier island erosion.

The Delft3D model was used to compute the bay water levels under storm conditions, taking into account the contribution of storm surge, waves, winds and the contribution of overwash and/or breaching. The Delft3D model's ability for simulating barrier island overwash and breaching was assessed by comparing model results with available high water marks (HWM) and overwash and breaching data for two of the most significant storms of record: the September 1938 Hurricane and the December 1992 Nor'easter. The intent of the test was specifically to qualitatively validate the ability of the model to reproduce observed overwash and breaching. Figure 11 shows an example of the model's ability to simulate the observed breaching during the 1992 Nor'easter at Pikes Beach. Overall, the model simulations for these historic storms provide very realistic results, particularly when considering the uncertainty in the input hydrodynamic conditions and, more importantly, the pre-storm topography. A detailed description of the numerical modeling and calibration is provided in Appendix A –Engineering.

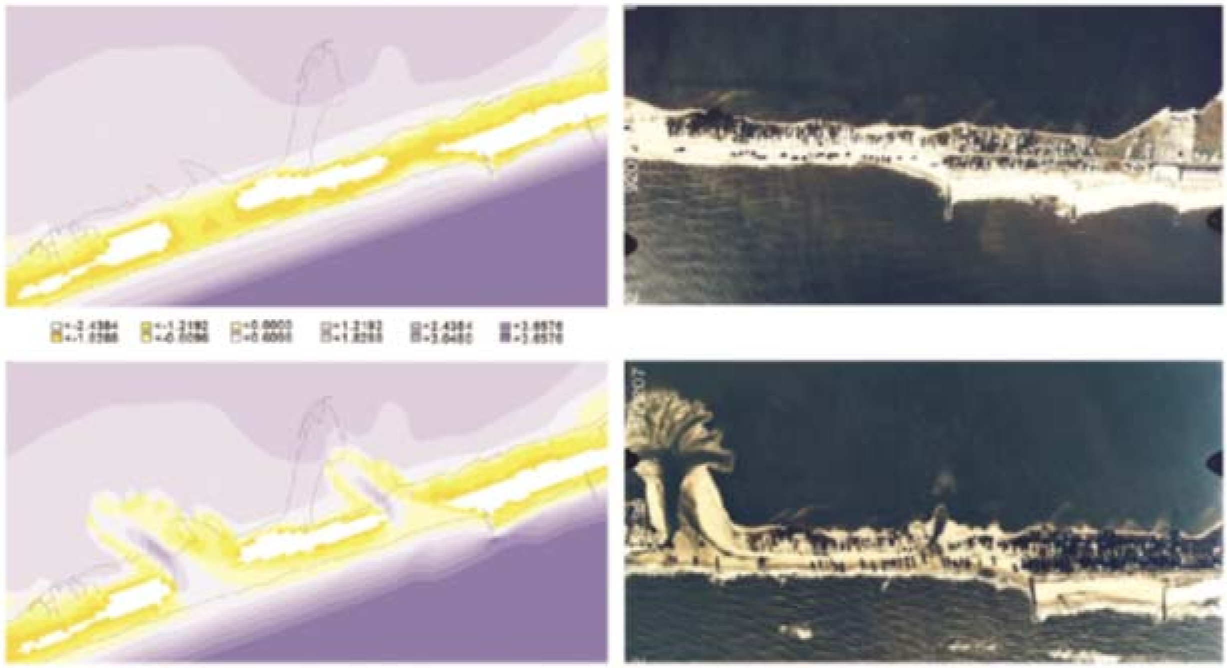


Figure 11. Simulated (left) versus observed (right) breaching during the 1992 Nor'easter at Pikes Beach

4.4.1 Breach Vulnerability

4.4.1.1 Potential Breach Locations

According to records dating to the 16th century, numerous breaches and inlets areas have existed along the study area. The recent stability of the three existing inlets is largely due to maintenance and stabilization efforts that have included dredging of navigation channels and jetty construction. In the application of the model, a number of locations were identified that met the conditions necessary to be prone to breaching, considering dune and beach conditions, and barrier island width. The lifecycle computation of breaches accounts for long-term erosion, which is important in areas with high erosion rates, notably West of Shinnecock Inlet, Smith Point County Park, and west of the Ocean Beach groins. Figure 12 shows the potential locations that are most prone to breaching, considering current dune and beach conditions, and barrier island width based on the model tests.

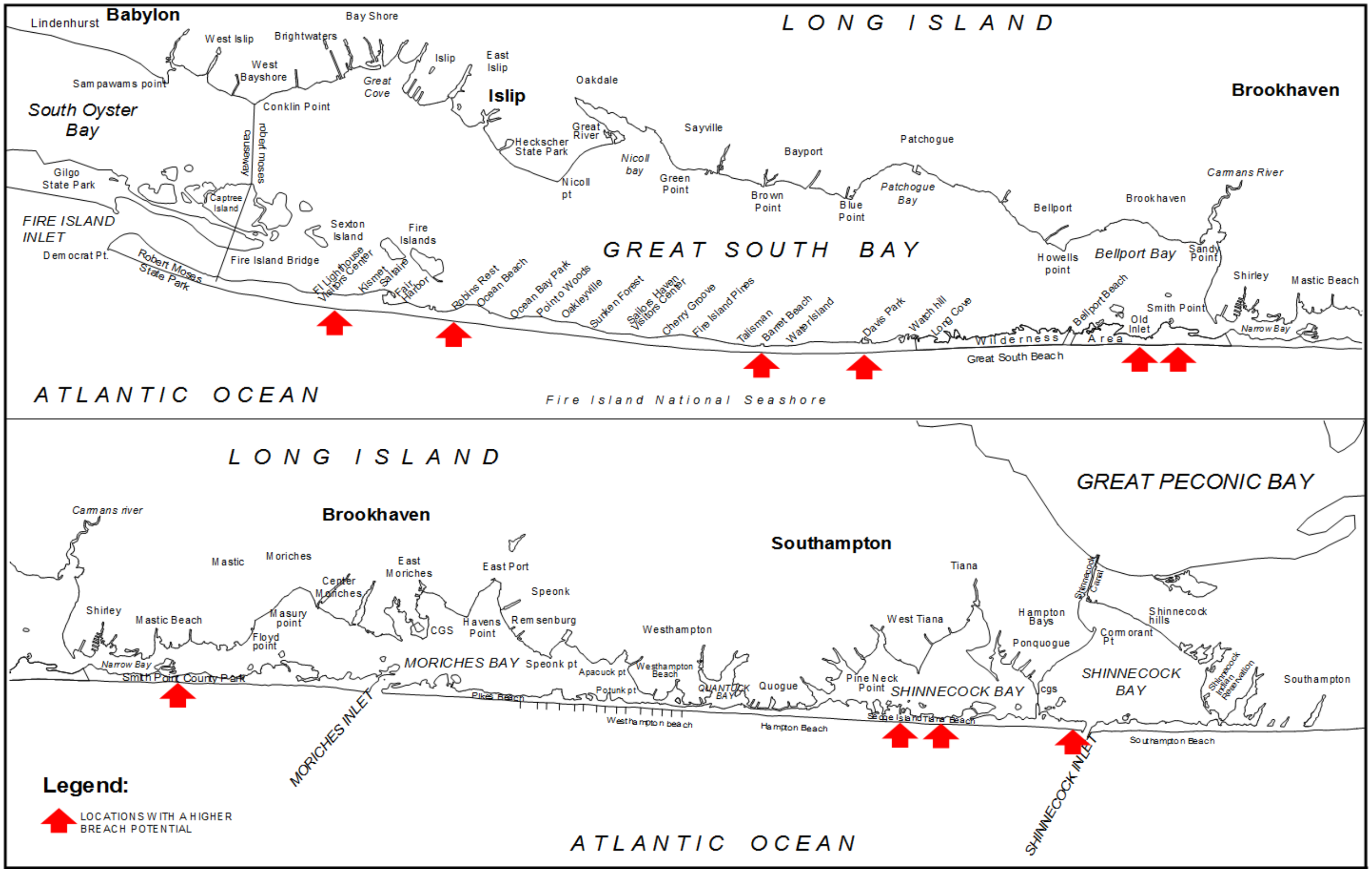


Figure 12. Vulnerable Breach Locations

These areas identified as likely breach locations are based upon recent conditions, current conditions, and reasonably foreseeable future conditions, but should not be taken to imply that other locations in the Study Area would not breach in the future. For purposes of analysis, however, the impact of breaching focuses on these areas. Table 9 lists the ten (10) specific potential breach locations by Reach that are used to analyze the hydrodynamic impacts of the breaches on the back bays. One of the assumptions is that breaches that take place in the same proximity would have a similar effect on the back-bay.

Table 9. Breach locations and breach reach

Breach Area	Potential Breach Locations	Breach Reach*
1	Fire Island Lighthouse Tract	Western Great South Bay
2	Kismet to Corneille States	Western Great South Bay
3	Talisman to Blue Pt. Beach	Central Great South Bay
4	Davis Park	Central Great South Bay
5	Old Inlet West	Eastern Great South Bay
6	Old Inlet East	Eastern Great South Bay
7	Smith Point County Park	Moriches Bay
8	Sedge Island	Western Shinnecock Bay
9	Tiana Beach	Western Shinnecock Bay
10	West of Shinnecock Inlet	Shinnecock Bay

* Breach reach is used to characterize the hydrodynamic response in the bays

4.4.1.2 Probability of Overwash and Breaching

The probability of breaching was determined based on model tests accounting for the dune and beach conditions, and barrier island width and hydraulic conditions at each location. Table 10 shows the expected return periods for which overwash, partial breaching, and full breaching of the barrier island begins to occur for each of the likely breach locations. For this study, two types of breaches are used. A partial breach is a storm-induced barrier island cut that has a scoured depth between MHW and Mean Low Water (MLW) while a full breach is a storm-induced barrier island cut that has a scoured depth at or below Mean Low Water (MLW). A partial breach will allow for water to exchange between the ocean and bay during a portion of the normal tidal cycle while a full breach will allow water exchange during the complete tidal cycle. A partial or full breach may develop into a permanent breach during normal tide conditions following a storm.

In the baseline condition, the probability of breaching is relatively low, but increases significantly in the future vulnerable condition. This difference in response can be attributed to both dune height and beach width, although in areas where a dune is vulnerable, it appears the primary driver is beach width. In conditions where the beach is wide, there are limited forces acting on the dune. If there is no dune lowering, due to wave action, it is rare for the dune to be overtopped. This difference is well characterized in the area west of Shinnecock Inlet. In the baseline conditions, the beach is over 250 ft. wide, and as a result storms result in little dune lowering, and infrequent breaching (325 yr. event for breaching). In the future vulnerable condition, where the dune condition is similar, and the beach is more representative of a typical condition (50 ft. wide), there is a much greater amount of dune lowering, and a significant increase in breach probability (breaching at a 25 yr. event).

Table 10. Return Periods for Overwash/Breaching

	Vulnerable Breach Location									
	Fire Island Lighthouse Tract	Kismet to Corneille Estates	Talisman to Blue Point Beach	Davis Park	Old Inlet, West	Old Inlet, East	Smith Point County Park	Sedge Island	Tiana Beach	West of Shinnecock Inlet
Effective Beach Widths for Input Conditions (ft.)										
Baseline	200	150	150	250	200	200	200	200	200	250
FVC	50	50	50	50	50	50	50	50	50	50
Breach Closed	35	53	50	-13	101	97	109	65	98	96
Baseline Conditions (return period in years)										
Overwash	14	9	20	22	10	5	8	25	7	18
Partial Breach	184	141	213	145	45	24	26	251	72	74
Full Breach	> 500	> 500	> 500	> 500	82	118	145	> 500	336	326
FVC (return period in years)										
Overwash	3	5	5	15	4-Jan	5	4	4	4	4
Partial Breach	34	15	12	73	7	19	9	48	30	8
Full Breach	106	34	31	288	22	84	141	291	266	25
Breach Closed (return period in years)										
Overwash	5	5	5	12	4	5	5	4	4	5
Partial Breach	21	17	39	26	12	34	20	66	44	18
Full Breach	43	37	80	108	67	191	139	291	264	60

4.4.1.3 Lifecycle Considerations

In applying these results in the lifecycle modeling, the breach response can also be considered as the total ocean still water elevation necessary to result in a morphological change. When sea level rise is taken into account, a lower storm surge height would likely trigger a morphological response, suggesting that overwash and breaching would become more frequent with sea level rise. Table 11 provides a summary of how these future changes will alter the risk of breaching over the period of analysis. In some locations, such as Area 2 located to the west of the Ocean Beach groins, high local erosion rates contribute to a significant increase in the risk of a breach in the future. At other locations lower erosion rates or expected future fill placement result in only moderate increases in future breach risk.

The annual breach risk is based on the average results of a large number of possible future storm sequences. When combined with the uncertainties regarding future shoreline change and sea level rise, there is actually a wide range of likely future conditions. One way to express the uncertainty in future breaching is to examine the number of breaches expected over the project period of analysis. Although breaches are possible and may persist at any of the ten locations listed in Table 11, breaches too close to each other are not likely to coexist, one or the other will become dominate. Therefore the results detailing the expected number of breaches occurring during the lifecycle simulations was collated by sub-bay, as presented in Table 12. This table does not include an estimated number of breaches in the Wilderness Area, since it is assumed that the existing breach in the Wilderness Area remains open over the period of analysis. These results indicate that the number of breaches that will occur in the future could vary greatly, depending on the timing and severity of future storms. It should also be noted that once a breach has occurred at a location, the relatively low closure section results in a significant risk of repeated breaching.

Table 11. Variation in Annual Breach Probability over Time

Breach Area	Potential Breach Locations	ANNUAL BREACH PROBABILITY	
		Base year Condition* 2020	Future Condition* 2070
1	Fire Island Lighthouse Tract	0%	4%
2	Kismet to Corneille States	1%	9%
3	Talisman to Blue Pt. Beach	1%	7%
4	Davis Park	0%	1%
5	Old Inlet West	2%	8%
6	Old Inlet East	2%	4%
7	Smith Point County Park	1%	5%
8	Sedge Island	0%	1%
9	Tiana Beach	0%	2%
10	West of Shinnecock Inlet	0%	1%

* Based on results of 25,000 random combinations of future storms, uncertain erosion rates, and sea level rise.

Table 12. Expected Number of Breaches within a 50-yr Planning Period

Breach Area	Potential Breach Locations	Sub-Bay	Expected Number (mean)	25th percentile*	75th percentile*
1	Fire Island Lighthouse Tract	WGSB	1.9	1	3
2	Kismet to Corneille States				
3	Talisman to Blue Pt. Beach	CGSB	2.2	0	4
4	Davis Park				
5	Old Inlet West	EGSB	N/A	N/A	N/A
6	Old Inlet East				
7	Smith Point County Park	MOR	0.9	0	1
8	Sedge Island	WSHN	1.4	0	2
9	Tiana Beach				
10	West of Shinnecock Inlet	SHN	1	0	2

*Based on results of 25,000 random combinations of future storms, uncertain erosion rates, and sea level rise. Simulation percentiles are reported to the nearest whole number

4.4.2 Breach Evolution

Evaluating the likelihood of breach growth after initial formation is a difficult due to the complex processes involved. Drawing upon past experience with breaching, numerical modeling and engineering judgment to project breach evolution, the likelihood for breach growth was evaluated at each of the three bays. These analyses established that the likelihood for a breach to grow is dependent upon the initial condition (whether it is a full breach or partial breach), and upon the time of year a breach occurred (during the winter, nor'easter season, or tropical, summer season). It is recognized that if any area has a full breach, and water is exchanging throughout the full tidal cycle, the breach will grow. However, it is also assumed that there is a limit to how many breaches can be sustained in a bay at any given time, which could limit how many breaches grow, in the instance of multiple breaches.

For a partial breach, it is recognized that there is a probability that the breach does not grow, but closes naturally. The probability that a partial breach will grow is affected by the time of year that the breach occurred. Wave conditions during the winter, extratropical season are more extreme than the typical summer month conditions. Therefore, conditions are such that a partial breach would be more likely to remain open in the winter months than in the summer months. The analysis projects a 50% likelihood of a partial breach closing naturally during the winter months, and a 75% likelihood of a partial breach closing naturally in the summer months.

Historical observations of breach growth were relied on to predict the rate of breach growth in scenarios in which a breach or partial breach is likely to grow. Observations from past breaches in 1980 at Cupsogue, 1992 at Pikes Beach (Figure 13), and 2012 in the Wilderness Area in the study area show that the growth rate is dependent upon the tidal prism of the back bay and can be fit to an exponential curve, to project the width and cross-sectional area of the breach. Two potential breach sizes, small and large, were included for Great South Bay to reflect the uncertainty in potential breach growth. The small breach size is based on the recent observations at the Wilderness Area breach and the large breach size is based on previous observations at Cupsoque and Pikes Beach.

Based upon this analysis, projected growth rates have been developed for each of the potential breach areas, based upon the back bay conditions. The results of this analysis are shown in Table 13 and Table 14, which show the expected width and cross-sectional area for each of the potential breach locations. As described above, it is acknowledged that the breach growth rate for a particular breach is dependent upon whether or not there is another breach into the bay. For a single breach, it is assumed that it would grow to this size, for more than one breach it is assumed that the breaches collectively would grow to this size.

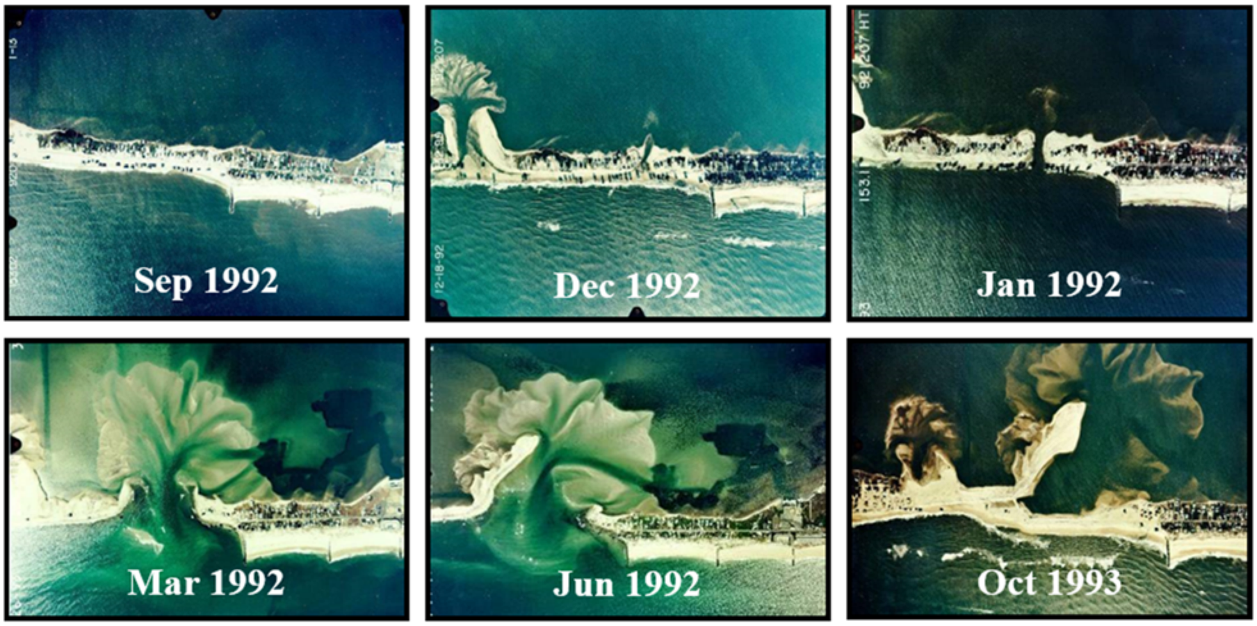


Figure 13. Breach Evolution after 1992 Nor'easter at Pikes Beach

Table 13. Estimated long-term potential breach widths

Project Reach	Range Value	Breach Widths (feet)				
		1 Month	3 Months	6 Months	9 Months	12 Months
GSB-Sm.	Minimum	130	340	550	690	780
	Maximum	240	550	780	870	900
GSB-Lg.	Minimum	720	1,870	3,070	3,830	4,320
	Maximum	1,340	3,070	4,320	4,820	5,030
MB	Minimum	320	830	1,360	1,690	1,910
	Maximum	750	1,600	2,080	2,220	2,270
SB	Minimum	350	920	1,500	1,880	2,120
	Maximum	840	1,770	2,300	2,470	2,510

Table 14. Estimated long-term potential breach cross-sectional areas

Project Reach	Range Value	Breach Areas (sq. feet)				
		1 Month	3 Months	6 Months	9 Months	12 Months
GSB-Sm.	Minimum	890	2,350	3,850	4,820	5,430
	Maximum	1,660	3,850	5,430	6,060	6,320
GSB-Lg.	Minimum	5,040	13,120	21,480	26,820	30,220
	Maximum	9,380	21,480	30,220	33,770	35,210
MB	Minimum	2,230	5,800	9,490	11,850	13,360
	Maximum	5,270	11,180	14,550	15,560	15,870
SB	Minimum	2,470	6,430	10,530	13,150	14,820
	Maximum	5,850	12,400	16,140	17,270	17,600

4.4.3 Breach Impact on Bay Water Elevations

As described previously, the water elevations in the bays during storms are sensitive to the barrier island conditions, which affect the influx of water from overwash and breaches. The modeling and analyses described earlier were used to generate stage frequency curves in the back bay for several different barrier island conditions. To represent the range of possible future conditions, the following scenarios were evaluated:

4.4.3.1 Pre-Sandy Baseline Conditions

Prior to Hurricane Sandy and the Wilderness Area breach, the baseline conditions were defined by three inlets and the barrier island topography captured by the September 2000 LIDAR. Dune height, berm, and barrier island width vary along the barrier island system. The 2000 LIDAR indicate lowest dune heights at Old Inlet, where the dune is about +8.5 ft. NGVD29 and at Smith Point County Park, where the dune is about +10 ft. NGVD29. Vulnerable areas in eastern and central Fire Island are characterized by dune heights around +11 to +12 ft. NGVD29 and +15 ft. NGVD29, respectively. Vulnerable areas along Shinnecock Bay are characterized by dune heights ranging from +11 to +13 ft. NGVD29.

4.4.3.2 Baseline Conditions (BLC)

The BLC conditions are an update to the pre-Sandy baseline conditions, and are used as representative of the existing condition for lifecycle modelling. The baseline condition includes the breach in the Wilderness Area that formed during Hurricane Sandy. The remainder of the barrier island topography is based on the shoreline conditions captured by the 2000 LIDAR. The 2000 LIDAR was selected as representative of the beach condition, as opposed to more recent LIDAR, because this LIDAR set captured a relatively high dune and wide berm along many much of the barrier island. These 2000 conditions are representative of the baseline condition for the project, which assumes the construction of Post-Sandy beach fill projects along Fire Island, Westhampton, West of Shinnecock and Downtown Montauk.

4.4.3.3 Future Vulnerable Conditions (FVC)

The FVC represent a barrier island topography that has a lower dune height and narrower berm width than the baseline condition and is reasonably expected to occur at some point during the 50-year project life. Overall, the future vulnerable condition proposed for the FIMP project area is not extremely different from the baseline conditions. The assumed changes are well within the range of shoreline and profile conditions observed within the past few decades (e.g. erosion and lack of natural beach berm west of Shinnecock Inlet). Weaker, more vulnerable conditions have been historically experienced at several locations, particularly from Westhampton to Moriches Inlet (e.g. conditions prior to the 1938 and 1992 storms). This condition is evaluated to consider the change in storm response under these lower, narrower beach conditions.

4.4.3.4 With Project Conditions (WP)

The WP condition represents a slightly more robust berm and dune condition than the BLC condition. The WP berm width and dune height is defined by the WP design geometry.

4.4.3.5 Breach Closed Conditions (BCC)

The Breach Closed Conditions (BCC) barrier island topography is defined as the minimum breach closure section under consideration for the FIMP study. This breach closure section is defined by a +9.5 ft. NGVD29 dune height and a barrier island width that matches the pre-breach condition. Here, the pre-breach barrier island width is taken as that on the BLC.

4.4.3.6 Breach Open Conditions (BOC)

Breach open conditions for breaches at varying locations (5 breach reaches), and of varied sizes (a breach open for 3 months, and a breach open for 12 months).

Figure 14 and Figure 15 show the differences in the stage frequency curves for a representative location in Great South Bay, Moriches Bay and Shinnecock Bay. Two sets of curves are provided for each station. The first set compares baseline conditions, with project, future vulnerable conditions, and breach closed conditions illustrating the impact the pre-storm barrier island topography has on bay water levels. The second set compares the baseline condition, pre-Sandy baseline condition, and various breach open conditions illustrating the impact unclosed breaches on bay water levels.

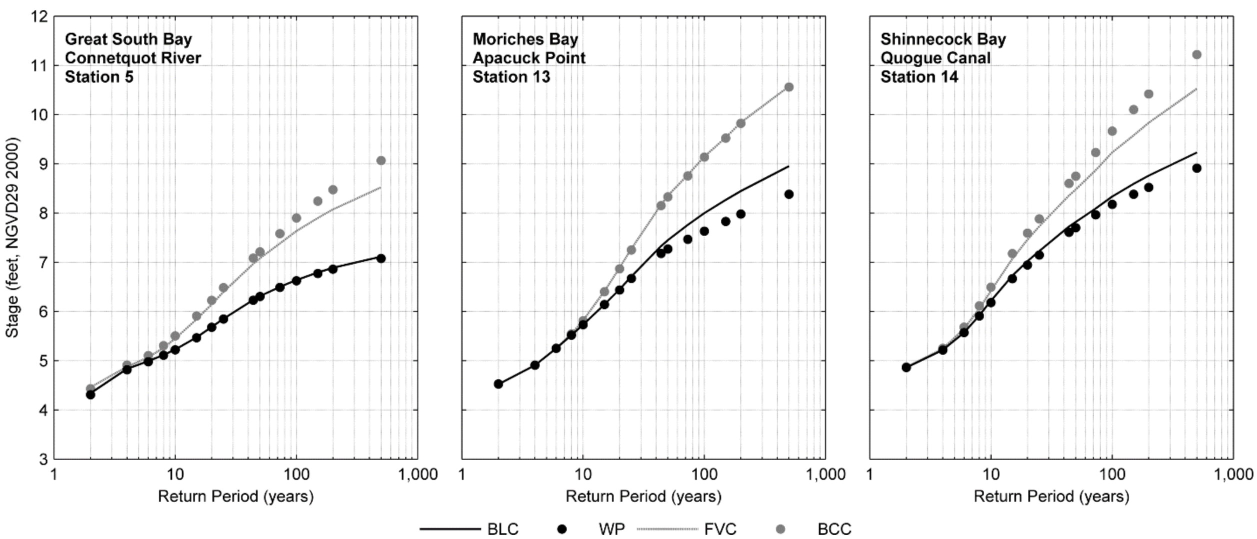


Figure 14. Comparison between BLC, FVC, WP, and BCC stage-frequency curves

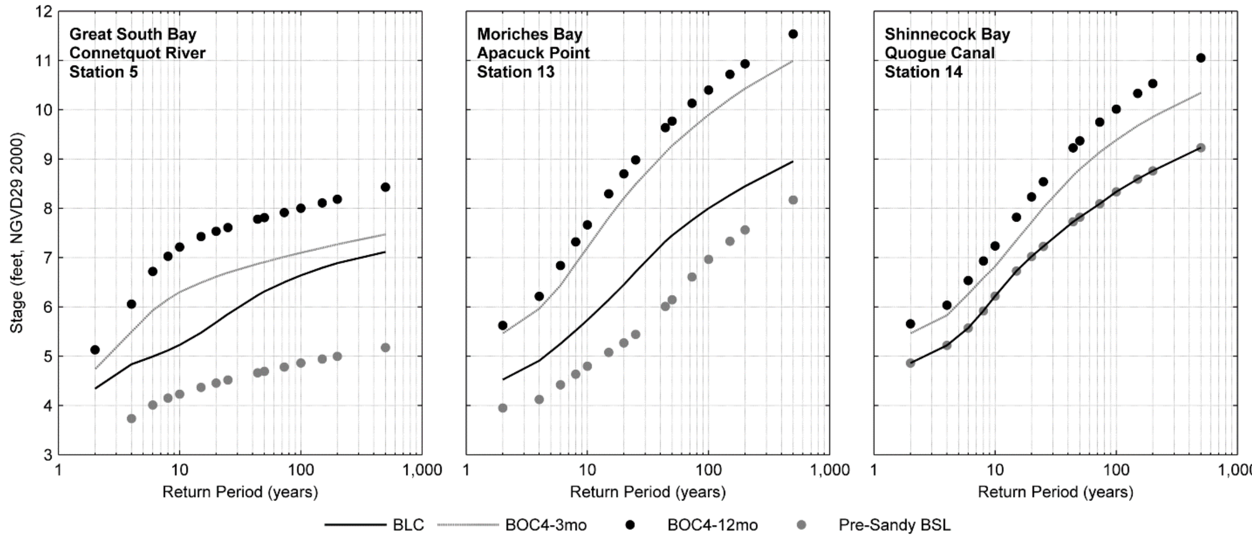


Figure 15. Comparison between BLC and BOC stage-frequency curves

The impact of the barrier island topography and breach open conditions may be described as follows:

For Great South Bay:

- Under FVC, flooding is greater than the baseline condition beginning at a 10 year event, and has the effect of increasing the height of flooding by 1 ft. to 1.5 ft.
- Under BCC, flooding is greater than the BLC and FVC, and can have the effect of increasing flooding up to 2 feet, as compared to the BLC.
- Under BOC, additional breaches can increase this flooding up to 1.5 feet above baseline conditions
- Under Pre-Sandy BLC flooding is 1 to 1.5 feet lower than the new, Post-Sandy, BLC.
- Under FVC, topography and breach closed topography, the elevation of a 500-yr event (+7.1 ft. NGVD) would be experienced with a 50 yr. event.
- Under the 12 month breach-open scenarios, the equivalent of a 500-yr event would be experienced by an 8-yr event in Great South Bay.
- Under breach-open conditions, the expected flooding would be significantly higher than is currently accounted for in the floodplain management regulations.

For Moriches Bay

- The baseline condition stage frequency curves have a greater range as compared to the curves in Great South Bay.
- Under a Future vulnerable condition, flooding is greater than the baseline condition beginning at a 10 year event, and has the effect of increasing the height of flooding by 1 to 1.5 ft.
- Under a breach-closed scenario, flooding is very similar to the baseline condition, and can have the effect of increasing flooding up to 1.5 feet.
- Under Breach Open conditions, the effect is dependent upon the location of the breach; and can result in flooding up to 2 feet above baseline conditions.

- Under Pre-Sandy BLC, flooding is 0.5 to 1.0 feet lower than the new, Post-Sandy, BLC.
- Under FVC topography, and breach closed topography, the elevation of a 500-yr event (+8.9 ft. NGVD) would be experienced with an 80 yr. event, and a 100-yr event experienced with a 40-yr event.
- Under breach-open scenarios, the equivalent of a 500-yr event would be experienced by a 40-yr event, and the equivalent of a 100-yr event could be experienced by a 15-yr event.

For Shinnecock Bay:

- The baseline condition stage frequency curves have a greater range as compared to the curves in Great South Bay or Moriches Bay.
- Under a Future vulnerable condition, flooding is greater than the baseline condition beginning at an 8 year event, and has the effect of increasing the height of flooding by 1 to 1.5 ft.
- Under a breach closed scenario, flooding is greater than the FVC, and can have the effect of increasing flooding of up to 2 feet.
- Under Breach Open conditions, the effect is dependent upon the location of the breach; for a single breach of the barrier island, when open for 3 months can increase flooding 1 to 2 feet above normal.
- Under Breach Open conditions, a single breach of the barrier island, when open for 12 months can increase flooding 2 to 3 feet above the baseline.
- The Breach in the Wilderness Area has no impact on flooding in Shinnecock Bay.
- Although these curves are not as flat as in Great South Bay, these scenarios have a tremendous impact on the flooding regime. Under FVC topography, and breach closed topography, the elevation of a 500-yr event (+9.2 ft. NGVD) would be experienced with a 20 to 40 yr. event, and a 100-yr event experienced with a 10 to 20-yr event.
- Under breach-open scenarios, the equivalent of a 500-yr event would be experienced by a storms ranging from a 35-yr event, and the equivalent of a 100-yr event could be experienced by an 18-yr event.

The best way to illustrate the mainland flooding impact is in floodplain maps. The floodplain maps are described further in the human development section of this chapter and are as shown in the accompanying Plates (Sub-Appendix A1). The floodplain maps illustrate the increase in inundation extent in BLC in a 2-yr event, 10-yr event, and 100-yr event (Baseline Maps). A second set of floodplain maps illustrates the impact the barrier island conditions, FVC and BOC-4 12 month, have on the 100-yr event inundation extents. These Plates illustrate flooding under a range of storm events representative of the baseline conditions as well as the change in flooding for a 100-yr event, under the different barrier island conditions described above. Overall, these figures and the accompanying plates illustrate that there are tremendous changes in the flooding that can occur along the mainland of long Island, when there is the potential for increased water to enter into the bay during a storm that results in a breach, or when a breach is open. A third set of floodplain maps was prepared to show the impact of the breach in the Wilderness Area on the BLC inundation extents. These maps show the increase in the 100-yr event inundation extent caused by the open breach in the Wilderness Area.

4.4.4 Breach Impact on Sediment Exchange and Inlet Stability

4.4.4.1 Sediment Exchange

When an overwash or breach of the barrier island occurs, material moves in the cross-shore direction, which can result in the deposition of sediment into the back bay environment. When a breach occurs, the amount of sediment transport into the bay is dependent upon the location, and the amount of time that a breach remains open. In modeling breaches, and estimating the amount of growth of a breach over time, efforts have been undertaken to also quantify the expected amount of sediment that could be transported into the bay, the expected area of change, (which includes both scour and deposition), and the resulting change in habitats that could be observed as a result of the breach being open. This information has been generated using observations from past breaches (prior to Hurricane Sandy) and interpretation of the modeling effort to provide to estimate the overall volume of material that is expected to enter into the bay, summarized below in Table 15. This has not been updated to reflect observations from the breach in the Wilderness Area.

Table 15. Estimated Bay Deposition Volumes During Breach Growth

Design Subreach		Bay Deposition (cy)				
ID	**Name**	**1 Month**	**3 Months**	**6 Months**	**9 Months**	**12 Months**
GSB-1B	FI Lighthouse Tract	540,000	1,360,000	2,100,000	2,510,000	2,730,000
GSB-2B	Town Beach to Corneille Estates (at Robins Rest)	440,000	1,090,000	1,690,000	2,020,000	2,210,000
GSB-3D	Talisman to Water Island	280,000	690,000	1,060,000	1,270,000	1,380,000
GSB-3G	Davis Park	510,000	1,260,000	1,950,000	2,330,000	2,530,000
MB-1B	Smith Point CP - East	250,000	570,000	810,000	900,000	940,000
SB-1B	Sedge Island	350,000	810,000	1,140,000	1,270,000	1,330,000
SB-1C	Tiana Beach	180,000	410,000	570,000	640,000	670,000
SB-2B	WOSI	160,000	370,000	520,000	580,000	600,000

4.4.4.2 Inlet Stability

As described previously, another likely effect of a breach of the barrier island is the change in deposition rates within the existing inlets. The stability of the inlets is based upon their efficiency and the currents, which are driven by the tidal prism within the bays. A breach of the barrier island impacts this exchange rate, and is likely to increase the existing deposition rates within the inlets. This will warrant increased maintenance of the inlets, or the navigability of the inlets may be compromised.

4.5 Human Development at Risk

The modeling efforts described in the previous sections provide the basis of assessing damages to human development within the study area. Field inspections were conducted to collect data for over 47,000 buildings in the study area and have been updated to reflect current structure values (depreciated replacement costs) and development. Details on the methodology utilized in conducting the inventory are provided in the Appendix D – Benefits.

4.5.1 Shorefront Structures at Risk

Table 16 identifies the number of shoreline structures that would be impacted in each Sub Reach under baseline conditions by erosion associated with a 1% probability storm event, as well as the number of structures that could be impacted by a 1 % probability storm event in the years 2030 and 2060 under the WOPFC.

A total of 370 shoreline structures potentially at risk were identified under the Baseline condition, while 986 and 1316 shoreline structures were identified as potentially at risk in the years 2030 and 2060. More than half of the potentially at risk structures were on Fire Island. The number of structures at risk increases over time, indicating that many structures not currently at risk are likely to be threatened in the future.

Table 16. Shorefront Structures Potentially at Risk from Erosion

Design Subreach/ Project Reach	Name	Baseline Erosion	2030 Erosion	2060 Erosion
GSB-1A	Robert Moses State Park	0	0	0
GSB-2A	Kismet to Lonelyville	111	185	200
GSB-2B	Town Beach to Corneille	39	57	57
GSB-2C	Ocean Beach to Seaview	28	58	68
GSB-2D	OBP to Point O'Woods	58	86	87
GSB-3A	Cherry Grove	2	36	43
GSB-3C	Fire Island Pines	25	65	84
GSB-3D	Talisman to Water Island	0	1	2
GSB-3E	Water Island	0	0	3
GSB-3F	Water Island to Davis Park	0	0	0
GSB-3G	Davis Park	12	40	48
GSB-3H	Watch Hill	0	0	0
GSB-4A	Wilderness Area West	0	0	0
GSB-4B	Old Inlet	0	0	0
Great South Bay		*275*	*528*	*592*
MB-1A	Smith Point CP West	0	0	0
MB-1B	Smith Point CP East	0	0	0
MB-2A	Great Gunn	0	0	0
MB-2B	Moriches Inlet West	0	0	0
MB-2C	Cupsogue Park	0	0	1
MB-2D	Pikes	0	23	125
MB-2E	Westhampton	0	0	1
Moriches Bay		*0*	*23*	*127*
SB-1A	Hampton Beach	0	19	33
SB-1B	Sedge Island	4	41	55
SB-1C	Tiana Beach	12	18	23

Design Subreach/ Project Reach	Name	Baseline Erosion	2030 Erosion	2060 Erosion
SB-1D	Shinnecock Inlet Park West	1	1	2
SB-2A	Ponquogue	0	0	0
SB-2B	WOSI	1	3	3
SB-2C	Shinnecock Inlet - East	0	0	0
SB-3A	Southampton Beach	0	3	5
SB-3B	Southampton	1	5	6
SB-3C	Agawam	16	27	28
Shinnecock Bay		*35*	*117*	*155*
P-1A	Wickapogue	8	13	16
P-1B	Watermill	3	13	16
P-1C	Mecox Bay	1	5	5
P-1D	Mecox to Sagaponack	8	39	50
P-1E	Sagaponack Lake	1	1	2
P-1F	Sagaponack to Potato Road	0	19	23
P-1G	Potato Road	5	22	23
P-1H	Wainscott	4	8	9
P-1I	Georgica Pond	0	0	0
P-1J	Georgica to Hook Pond	8	23	29
P-1K	Hook Pond	0	0	0
P-1L	Hook Pond to Amagansett	0	4	5
Ponds		*38*	*147*	*178*
M-1A	Amagansett	12	56	59
M-1B	Nepeaugue State Park	0	0	0
M-1C	Nepeague Beach	0	2	5
M-1D	Hither Hills SP	0	0	1
M-1E	Hither Hills to Montauk Beach	1	20	35
M-1F	Montauk Beach	7	22	38
M-1G	Montauk Beach to Ditch Plains	0	12	19
M-1H	Ditch Plains	2	50	87
M-1I	Ditch Plains to Montauk Beach	0	9	20
Montauk		*22*	*171*	*264*
Totals		**370**	**986**	**1316**

4.5.2 Back Bay Structures at Risk

The back bay reaches include both the back bay shoreline of the barrier islands and south of Montauk Highway, where the elevations are generally below +16 ft. NGVD. As described previously, there is extensive development in the mainland adjacent to the back bays, particularly in the western areas. Table 17 and Table 18 show the number of structures within each reach by structure type.

Table 17. Structure Types in Study Area, Back Bay Mainland

Project Reach/ Sub-Bay	Structure Type				
	Residential	Commercial	Industrial	Municipal	Utility
EGSB	1900	57	2	12	0
CGSB	6379	489	49	48	4
WGSB	19475	1676	112	110	11
Great South Bay	*27754*	*2222*	*163*	*170*	*15*
MOR	6023	389	10	17	0
Moriches Bay	*6023*	*389*	*10*	*17*	*0*
SHN	583	38	1	6	0
WSHN	2431	132	5	9	1
Shinnecock Bay	*3014*	*170*	*6*	*15*	*1*
Total Back bay	**36,791**	**2,781**	**179**	**202**	**16**
Overall Total	***39,969***				

Table 18. Structure Types in Study Area, Barrier Island Bayside

Project Reach/ Sub-Bay	Structure Type				
	Residential	Commercial	Industrial	Municipal	Utility
EGSB	0	0	0	0	0
CGSB	895	2	0	3	0
WGSB	2412	16	0	3	0
Great South Bay	*3307*	*18*	*0*	*6*	*0*
MOR	258	0	0	0	0
Moriches Bay	*258*	*0*	*0*	*0*	*0*
SHN	0	0	0	0	0
WSHN	76	0	0	0	0
Shinnecock Bay	*76*	*0*	*0*	*0*	*0*
Total Back bay	**3,641**	**18**	**0**	**6**	**0**
Overall Total	***3,665***				

Table 19 and Table 20 provide a summary of the number of structures which fall within different floodplains under the baseline conditions in each project reach and sub bay.

As presented earlier, when the impacts of sea level rise and the changing conditions of the barrier islands are accounted for, the extents of the floodplains are anticipated to grow, and hence the number of buildings potentially impacted by flooding is expected to increase. Table 21 and Table 22 show the change in the number of structures in the floodplain, under different breach scenarios. Also, the separate Sub – Appendix A1 contains Plates which show the buildings located within the various baseline conditions floodplains, and buildings located within the possible future floodplains.

Table 19. Summary of Back Bay Mainland Structures within Baseline Floodplain during Maximum Open Breach

Project Reach/ Sub-Bay	# of Buildings	50% ACE (2 Year) Floodplain Buildings	10% ACE (10 Year) Floodplain Buildings	4% ACE (25 Year) Floodplain Buildings	1% ACE (100 Year) Floodplain Buildings	0.2% ACE (500 Year) Floodplain Buildings
EGSB	1971	28	170	227	319	600
CGSB	6969	232	1020	1071	1398	1482
WGSB	21384	217	2107	3407	4332	4565
Great South Bay	*30324*	*477*	*3297*	*4705*	*6049*	*6647*
MOR	6439	502	1096	1661	1994	2515
Moriches Bay	*6439*	*502*	*1096*	*1661*	*1994*	*2515*
SHN	628	36	73	133	308	409
WSHN	2578	112	378	561	898	1168
Shinnecock Bay	*3206*	*148*	*451*	*694*	*1206*	*1577*
Total Back bay	**39,969**	**1,127**	**4,844**	**7,060**	**9,249**	**10,739**

Table 20. Summary of Back bay Structures Along North Shore of Barrier Island within Floodplain during Maximum Open Breach

Project Reach/ Sub-Bay	# of Buildings	50% ACE (2 Year) Floodplain Buildings	10% ACE (10 Year) Floodplain Buildings	4% ACE (25 Year) Floodplain Buildings	1% ACE (100 Year) Floodplain Buildings	0.2% ACE (500 Year) Floodplain Buildings
EGSB	0	0	0	0	0	0
CGSB	900	129	364	390	423	445
WGSB	2431	329	1529	1649	1703	1760
Great South Bay	*3331*	*458*	*1893*	*2039*	*2126*	*2205*
MOR	258	58	93	140	216	241
Moriches Bay	*258*	*58*	*93*	*140*	*216*	*241*
SHN	0	0	0	0	0	0
WSHN	76	48	73	76	76	76
Shinnecock Bay	*76*	*48*	*73*	*76*	*76*	*76*
Total Backbay	**3,665**	**564**	**2,059**	**2,255**	**2,418**	**2,522**

Table 21. Summary of Structures in Floodplains, Breaches Open for 12 Months in Every Bay – Backbay Mainland

Planning Unit/ Sub-Bay	# of Buildings	50% ACE (2 Year) Floodplain Buildings	10% ACE (10 Year) Floodplain Buildings	4% ACE (25 Year) Floodplain Buildings	1% ACE (100 Year) Floodplain Buildings	0.2% ACE (500 Year) Floodplain Buildings
WGSB	21384	4154	6396	8270	9432	9568
CGSB	6969	1401	2630	2746	3329	3423

Planning Unit/ Sub-Bay	# of Buildings	50% ACE (2 Year) Floodplain Buildings	10% ACE (10 Year) Floodplain Buildings	4% ACE (25 Year) Floodplain Buildings	1% ACE (100 Year) Floodplain Buildings	0.2% ACE (500 Year) Floodplain Buildings
EGSB	1971	318	618	714	903	1036
Great South Bay	*30324*	*5873*	*9644*	*11730*	*13664*	*14027*
MOR	6439	1096	2117	2840	3571	4050
Moriches Bay	*6439*	*1096*	*2117*	*2840*	*3571*	*4050*
WSHN	2578	227	716	996	1408	1641
SHN	628	96	191	272	411	463
Shinnecock Bay	*3206*	*323*	*907*	*1268*	*1819*	*2104*
Total Backbay	**39969**	**7292**	**12668**	**15838**	**19054**	**20181**

Table 22. Summary of Structures in Floodplains, Breaches Open for 12 Months in Every Bay –Barrier Islands Bay Side

Planning Unit/ Sub-Bay	# of Buildings	50% ACE (2 Year) Floodplain Buildings	10% ACE (10 Year) Floodplain Buildings	4% ACE (25 Year) Floodplain Buildings	1% ACE (100 Year) Floodplain Buildings	0.2% ACE (500 Year) Floodplain Buildings
WGSB	2431	1703	2144	2160	2250	2263
CGSB	900	437	628	649	656	692
EGSB	0	0	0	0	0	0
Great South Bay	*3331*	*2140*	*2772*	*2809*	*2906*	*2955*
MOR	258	123	216	243	256	257
Moriches Bay	*258*	*123*	*216*	*243*	*256*	*257*
WSHN	76	54	76	76	76	76
SHN	0	0	0	0	0	0
Shinnecock Bay	*76*	*54*	*76*	*76*	*76*	*76*
Total Backbay	**3665**	**2317**	**3064**	**3128**	**3238**	**3288**

4.5.3 Without Project Damages

The development in the study area is vulnerable to damage from three mechanisms, inundation due to storm water levels, undermining due to storm erosion or shoreline change, and structural failure due to intense force of wave impacts.

For analysis purposes, the study area has been divided into shorefront development and non-shorefront development. Development was considered part of the shorefront analysis if it is subject to damage from inundation, plus waves and/or erosion. Shorefront development was evaluated for all three damage mechanisms for each individual structure under a full range of storm conditions. The largest, or "critical", damage was then identified for each building for a series of storms over the without project future conditions. Development outside of the zone of likely erosion or wave impact was considered part of the non-shorefront analysis. The non-shorefront analysis only evaluates damage due to inundation, and includes development both on the northern side of the barrier island and along the mainland areas.

The storm damage analysis considered physical damage to structures, building contents, and cars, as well as non-physical costs, such as cleanup and temporary housing expenses. Public emergency costs associated with extreme events such as barrier island breaching are also included in the analysis. Appendix D- Benefits includes details of the modeling utilized and the analyses utilized to determine the Without Project Damages. An update of the Without Project Damages post-Sandy is provided in the following paragraphs.

The shorefront and non-shorefront models referred to in the sections above were developed specifically for use in the Fire Island to Montauk Point analyses. The models were approved for this single specific use following review by the National Planning Center of Expertise for Coastal Storm Risk Management (PCX-CSRM) via a memorandum from the Chief of the Office of Water Project Review, Planning and Policy Division, Directorate of Civil Works, dated 12 January, 2016.

As a part of this Reformulation effort, the shorefront damage models have been revised to reflect post-Sandy changes to the existing condition beach morphology such as the dune crest elevation (including natural beach recovery following Hurricane Sandy, and the construction of Coastal Storm risk Management Projects). The model also accounts for changes in the structure inventory due to the destruction of shorefront houses by Sandy. Lifecycle flood inundation models were also revised to reflect post-Sandy changes to the barrier islands including the existing condition beach profile width plus accumulated sea level rise in the years since the models were developed. Models used to calculate damages specifically incurred by open breaches over the project life were revised to reflect current beach profile widths and sea level rise as per the lifecycle inundation model but also to incorporate recently acquired data related to the maximum size of potential breaches in Great South Bay. Revisions to the breach damage model also included updated breach closure costs for all potential breach locations and current mobilization and unit costs applicable in BRP maintenance actions.

All lifecycle simulation models assumed a project base year of 2021 and the current FY interest rate of 3.125%. Subsequent design and schedule analysis has identified that the final construction contracts will not be completed until early 2025. This small change in base year would result in a minor increase in the without project damages, but would have no substantive impact on plan evaluations or benefit to cost ratios.

4.5.4 Shorefront Damages

For structures located along the Atlantic Ocean shorefront, wave attack and erosion combine with inundation to create frequent structural failures. Therefore, in addition to considering damage from inundation, the stability of the shorefront structures was analyzed to relate the wave forces at any depth of storm-induced water elevation to the structural failure and the potential for failure from the combined effects of long-term and storm-induced erosion, including scouring and vertical erosion.

The model simulations calculate damage for each year of the lifecycle. The damage in each year is multiplied by the present worth factor to adjust to base year values. The present worth of damage is summed and multiplied by the capital recovery factor to calculate the equivalent annual damage for each simulated lifecycle. Table 23 provides a summary of the equivalent annual damage for the 50 year period of analysis.

This table illustrates the areas with the highest levels of expected damages along the shorefront. When looking at these numbers, it is important to consider that the damages are aggregated over different size reaches. This table illustrates that the largest amount of shorefront damages are along the area of Fire Island. The table also illustrates that for the shoreline areas east of the barrier islands that the two areas of highest damage per linear foot of shoreline are the areas of Downtown Montauk (Montauk Beach) and Potato Road. This is consistent with the observed damages as a result of Hurricane Sandy.

Table 23. Without Project Shorefront Damages (Oct 2015 PL)

Project Reach		Critical Asset	Name	Approximate Length	Equivalent Annual Damage 2021–2071
GSB	GSB-1	1A	Robert Moses State Park	25,700	$0
		1B	FI Lighthouse Tract	6,700	$0
	GSB-2	2A	Kismet to Lonelyville	8,900	$2,450,219
		2B	Town Beach to Corneille States	5,100	$1,239,598
		2C	Ocean Beach & Seaview	3,800	$383,900
		2D	OBP to Point O' Woods	7,400	$575,047
		2E	Sailors Haven	8,100	$0
	GSB-3	3A	Cherry Grove	3,000	$307,919
		3B	Carrington Tract	1,500	$0
		3C	Fire Island Pines	6,600	$225,681
		3D	Talisman to Water Island	7,300	$16,904
		3E	Water Island	2,000	$26,143
		3F	Water Island to Davis Park	4,700	$555
		3G	Davis Park	4,100	$149,809
		3H	Watch Hill	5,000	$0
	GSB-4	4A	Wilderness Area - West	19,000	$0
		4B	Old Inlet	16,000	$0
				GSB Subtotal:	**$5,375,775**
MB	MB-1	1A	Smith Point CP- West	6,300	$0
		1B	Smith Point CP - East	13,500	$0
	MB-2	2A	Great Gunn	7,600	$0
		2B	Moriches Inlet - West	6,200	$0
		2C	Cupsogue Co Park	7,500	$690
		2D	Pikes	9,700	$250,856
		2E	Westhampton	18,300	$13,476
				MB Subtotal:	**$265,022**
SB	SB-1	1A	Hampton Beach	16,800	$249,013
		1B	Sedge Island	10,200	$1,143,166
		1C	Tiana Beach	3,400	$153,365
		1D	Shinnecock Inlet Park West	6,300	$8,965

Project Reach		Critical Asset	Name	Approximate Length	Equivalent Annual Damage 2021–2071
		2A	Ponquogue	5,300	$56
	SB-2	2B	WOSI	3,900	$10,327
		2C	Shinnecock Inlet - East	9,800	$155,645
		3A	Southampton Beach	9,200	$32,492
		3B	Southampton	5,300	$181,108
		3C	Agawam	3,800	$117,393
				SB Subtotal:	**$2,051,530**
		1A	Wickapogue	7,700	$307,005
		1B	Watermill	8,800	$183,659
		1C	Mecox Bay	1,400	$6,150
		1D	Mecox to Sagaponack	10,400	$258,861
		1E	Sagaponack Lake	1,100	$4,749
		1F	Sagaponack to Potato Rd	9,300	$63,662
		1G	Potato Rd	4,300	$1,092,927
		1H	Wainscott	4,600	$20,291
		1I	Georgica Pond	1,200	$0
		1J	Georgica to Hook Pond	11,200	$679,998
		1K	Hook Pond	1,100	$0
P	P-1	1L	Hook Pond to Amagansett	19,200	$36,195
				Ponds Subtotal:	**$2,653,497**
		1A	Amagansett	10,400	$211,751
		1B	Napeague State Park	9,100	$0
		1C	Napeague Beach	9,900	$81,254
		1D	Hither Hills SP	7,000	$14,858
		1E	Hither Hills to Montauk B	15,800	$662,876
		1F	Montauk Beach	4,700	$1,253,229
		1G	Montauk B to Ditch Plains	4,700	$127,472
		1H	Ditch Plains	3,400	$4,299
M	M-1	1I	Ditch Plains to Montauk Pt	19,300	$146,700
				Montauk Subtotal:	**$2,502,439**
				Total	***$12,848,263***

Discount Rate 3.125%, 50-year period of analysis computed using model SFD

4.5.5 Non-shorefront Damages

The analysis of non-shorefront damage considers the developed areas that are not subject to direct impacts from ocean waves or erosion, but are subject to inundation. The analysis includes areas on the Long Island mainland that are heavily developed, primarily with year round residential structures, and the northern, or bayside portions of the barrier islands that are primarily developed with seasonal housing. This includes the bay shoreline areas from western Great South Bay (near the Nassau, Suffolk County border) east to Shinnecock Bay.

Bayside Damage Criteria

Previously developed relationships between depth of flooding and damage as a percent of value were used to assess the inundation damages to each non-shorefront structure to estimate damage for the full range of flood events. These relationships included a series of generalized functions for residential structure and content damage developed by the USACE-IWR based on post flood inspections. Non-physical damage, including evacuation, temporary housing, and re-occupation/cleanup costs, was related to depth and structure value using a series of 1500 on-site interviews distributed throughout the study area. These interviews were also used to develop physical damage relationships for non-residential structures.

Bayside Damage Models

Lifecycle Simulation Models. In order to develop a true understanding of the impact of flooding, the flood stage vs. damage curves are typically combined with flood frequency data to express damage in average annual terms. Often this is completed using the HEC-FDA program, which can evaluate annual damages for both a baseline and a future condition. HEC-FDA, however, requires that changes in damage conditions occur in a predictable linear manner. Within the FIMP area, flood levels and therefore damages are expected to vary in relation to both future sea level and barrier island conditions. Because future barrier island conditions are strongly influenced by storm activity in prior years, it was determined that a lifecycle approach was needed to allow conditions and damages to vary in response to prior storm events.

Three separate damage simulation models were developed to link the hydrodynamic modeling of flood depths to the stage vs. damage data. The first simulation model was developed to evaluate Breach Open Conditions and the impact a barrier island breach will have on storm damages. The model quantifies the change in damages if a breach is open and provides input to the second model, the Breach Lifecycle Analysis. This model simulates breach occurrence and calculates average annual closure costs (including breach maintenance costs) and breach induced increases in damage over project life. The model was developed to quantify lifecycle impacts and to compare breach management alternatives. The third model is the Lifecycle Damage Analysis, which simulates storms and bay water levels including the impacts of erosion/storms in creating Future Vulnerable Conditions. Each of the models uses the @-Risk add-in to Excel to allow the calculation and processing of multiple lifecycle iterations, each representing a different series of random storms. Uncertainty in other parameters including sea level rise, erosion rates, and stage damage relationships, are also reflected using Monte Carlo sampling techniques. The reported results represent the average of numerous possible future lifecycles (between 12,500 and 25,000 depending on model) to ensure the full range of conditions are reflected in the results.

The Breach Open Condition model calculates the increase in storm damage while a breach is open. The model assumes a breach has occurred and simulates breach condition/size in the following months. Peak water levels are estimated based on the breach size, predicted increase in tide range, and the increased storm water level associated with random storm events. For each peak water level the damage is identified using the stage vs. damage curves. The key inputs to the model are the breach open water levels related to breach size, breach growth and closure rates, and the stage vs. damage relationship. A total of 27 conditions were modeled for each of the 43 reaches for each breach closure alternative. These reflect combinations of 5 different breach location scenarios (No Breach & 4 Breach Open Conditions), breaches occurring in Tropical or Extratropical seasons, and sea level conditions of baseline, 0.5 foot rise and 1.0 foot rise. The model results were tabulated to provide a summary of increased inundation damage for various breach conditions, closure rates and sea level rise conditions.

The Breach Only Lifecycle Model was developed to evaluate the impact of barrier island breaches and alternative closure designs and response times on the average annual storm damage and closure costs. The model considers the impacts of random storm events, and both long term and short term shoreline change at the 10 locations identified as most vulnerable to breaching. Key inputs to the model include stage frequency and storm erosion frequency relationships, post storm profile recovery rates, threshold water level elevations causing overwash, partial breaching and full breaching for various profile conditions, short term profile variability associated with shoreline undulations, and incremental damage associated with increased back bay flood elevations and undermining of barrier island development. The model uses the @-Risk add-in to Excel to simulate the random occurrence of storms in future years, and if the storm water elevation is sufficient to cause an overwash or breaching condition it calculates the associated damages, breach closure cost, or profile maintenance costs. The model tracks changes in the profile condition, and relates the breach and overwash threshold water level elevations to these changes.

The Lifecycle Damage Analysis model was developed to quantify baseline and future condition non-shorefront inundation damage. The model simulates storms and water levels including the impacts of erosion/storms in creating the Future Vulnerable Conditions and the associated increases in bay water levels. A Future Vulnerable Condition (FVC) has been developed based on historic erosion rates, the Existing Conditions Sediment Budget, Baseline Conditions numerical modeling storm water level and morphological results, historic storm impacts, and the assumed without project future condition regarding locally sponsored dune and berm restoration and maintenance projects. The key model inputs include the bay stage frequency relationships for Baseline, Future Vulnerable, With Project and Breach Closed Conditions. The model applies weighting factors to interpolate between Baseline and Future Vulnerable conditions. Breach water level thresholds, ocean stage frequency, storm/long term erosion and recovery rates, temporal shoreline undulations and stage vs. damage relationships are also critical to the analysis.

The model simulates the random occurrence of both tropical and extra-tropical storms, and tracks the impact of storms in altering the beach profile at the 10 locations most vulnerable to overwash and breaching. As the profile at these locations approaches the Future Vulnerable Conditions used to develop the FVC stage vs. frequency relationship, the model interpolates bay water levels between the Baseline condition stage and the FVC stage. For each year, storms are simulated and the damage is identified from the stage vs. damage curves. Table 24 provides a summary of the average damages that were simulated for years 2020 and 2070. The damage in each year is multiplied by the present worth factor to adjust to base year values. The present worth of damage is summed and multiplied by the Capital Recovery Factor to calculate the equivalent annual damage for each simulated lifecycle.

This table illustrates that damages increase over time, and that the greatest amount of damages is expected to occur in the area of Western and Central Great South Bay. Damages are also relatively high for Moriches Bay.

Table 24. Summary of Backbay Inundation Damages (Oct 2015 PL)

Economic Reach			# of Buildings	Sub Bay	Inundation Damages		
Economic Reach	Mainland Reach ID	Name			Year 2021	Year 2071	Equivalent Annual
26.1	GSB-M-1A	Unqua Point (County Line) to Copiague Beach	1,689	WGSB	$4,419,560	$8,442,970	$5,829,790
26.2	GSB-M-1B	Copiague Beach to Venetian Shores Beach	4,685	WGSB	$3,233,390	$6,640,930	$4,353,770
26.3	GSB-M-1C	Venetian Shores Beach to Neguntatogue Creek	2,289	WGSB	$4,421,860	$8,650,290	$5,860,260
25.1	GSB-M-1D	Neguntatogue Creek to Santapogue Point	1,939	WGSB	$1,344,440	$2,950,870	$1,889,010
25.2	GSB-M-1E	Santapogue Point to Sampawams Point (Town Line)	2,406	WGSB	$3,868,010	$7,755,380	$5,173,880
24	GSB-M-2A	Sampawams Point (Town Line) to Great Cove	3,158	WGSB	$1,926,660	$4,548,750	$2,777,080
23.1	GSB-M-2B	Brightwaters	364	WGSB	$157,770	$431,190	$253,390
23.2	GSB-M-2C	Lawrence Creek to Seatuck Refuge	1,718	WGSB	$3,940,110	$8,112,430	$5,356,160
23.3	GSB-M-2D	Seatuck Refuge to Heckscher Park (Nicoll Point)	2,982	WGSB	$1,305,710	$2,979,460	$1,868,800
28		Fire Island Lighthouse to Seaview (Fire Island)	1,994	WGSB	$9,412,980	$17,890,440	$12,387,130
27.1		Ocean Bay Park to Oakleyville (Fire Island)	433	WGSB	$893,660	$1,614,710	$1,162,630
		Subtotal - Western Great South Bay Sub-Bay	*23,657*		*$34,924,150*	*$70,017,420*	*$46,911,900*
27.2		Sailors Haven to Water Island (Fire Island)	712	CGSB	$2,036,670	$3,894,410	$2,706,300
27.3		Water Island to Watch Hill (Fire Island)	188	CGSB	$549,060	$1,091,240	$727,630
22.1	GSB-M-3A	Heckscher Park (Nicoll Point) to Green Point	1,950	CGSB	$8,475,080	$15,781,020	$11,184,010
22.2	GSB-M-3B	Green Point to Blue Point (Town Line)	2,077	CGSB	$3,062,750	$5,672,210	$3,996,200
21.1	GSB-M-4A	Blue Point (Town Line to Tuthill Creek (Blue Point)	513	CGSB	$682,330	$1,294,350	$888,200
21.2	GSB-M-4B	Tuthill Creek to Swan River (Patchogue)	1,629	CGSB	$3,453,290	$6,463,790	$4,383,330
21.3	GSB-M-4C	Swan River to Mud Creek	751	CGSB	$459,820	$1,024,520	$669,570
		Subtotal - Central Great South Bay Sub-Bay	*7,820*		*$18,718,990*	*$35,221,540*	*$24,555,240*
21.4	GSB-M-5A	Mud Creek to Howell Creek	746	EGSB	$1,240,510	$2,373,350	$1,645,570
21.5	GSB-M-5B	Howell Creek to Bellport Marina	224	EGSB	$112,870	$232,780	$151,520
21.6	GSB-M-5C	Bellport Marina to Carmans River	425	EGSB	$797,550	$1,452,700	$1,022,050
20	GSB-M-6A	Carmans River to Smith Point Bridge	571	EGSB	$437,920	$910,800	$601,780
		Subtotal - Eastern Great South Bay Sub-Bay	*1,966*		*$2,588,850*	*$4,969,630*	*$3,420,920*
19		Moriches Inlet to Quantuck Canal (Westhampton Barrier)	241	MOR	$3,890	$8,840	$5,970
18.1	MB-M-1A	Smith Point Bridge to William Floyd Estate	3,068	MOR	$8,369,160	$13,444,670	$10,147,180
18.2	MB-M-1B	William Floyd Estate to Forge River	208	MOR	$391,960	$635,840	$475,670

Economic Reach			# of Buildings	Sub Bay	Inundation Damages		
Economic Reach	**Mainland Reach ID**	**Name**			**Year 2021**	**Year 2071**	**Equivalent Annual**
18.3	MB-M-1C	Forge River to Radio Point	1,332	MOR	$5,028,650	$8,544,430	$6,236,270
17.1	MB-M-2A	Radio Point to Harts Cove	222	MOR	$1,315,760	$2,196,770	$1,610,670
17.2	MB-M-2B	Harts Cove to Seatuck Creek (Town Line)	93	MOR	$17,390	$35,300	$23,330
16.1	MB-M-3A	Seatuck Creek (Town Line) to Fish Creek	134	MOR	$316,260	$588,990	$404,340
16.2	MB-M-3B	Fish Creek to Speonk Point	317	MOR	$1,244,310	$2,189,070	$1,556,970
16.3	MB-M-3C	Speonk Point to Apacuck Point	431	MOR	$1,503,870	$2,802,070	$1,953,760
16.4	MB-M-3D	Apacuck Point to Quantuck Bay	609	MOR	$2,870,080	$4,901,180	$3,553,430
		Subtotal - Moriches Bay Sub-Bay	*6,655*		*$21,061,320*	*$35,347,160*	*$25,967,590*
15		Quantuck Canal to Village Park (Westhampton Barrier)	93	WSHN	$17,610	$47,030	$26,690
13.1	SB-M-1A	Quantuck Bay West	297	WSHN	$3,211,060	$4,833,090	$3,659,390
13.2	SB-M-1B	Quantuck Canal to Phillips Point	586	WSHN	$3,850,880	$6,187,050	$4,560,170
12	SB-M-2A	Phillips Point to Pine Neck Point	783	WSHN	$1,420,060	$2,541,290	$1,785,430
11.1	SB-M-2B	Pine Neck Point to West Point	280	WSHN	$880,510	$1,467,850	$1,074,000
11.2	SB-M-2C	West Point to Ponquogue Point	616	WSHN	$1,190,670	$2,119,790	$1,499,700
		Subtotal - Western Shinnecock Bay Sub-Bay	*2,655*		*$10,570,790*	*$17,196,100*	*$12,605,380*
10.1	SB-M-3A	Ponquogue Point	39	SHN	$123,220	$227,090	$156,130
10.2	SB-M-3B	Cormorant Point	6	SHN	$10,950	$17,690	$13,130
10.3	SB-M-3C	Shinnecock Canal Region	200	SHN	$733,980	$1,155,230	$857,020
10.4	SB-M-3D	Shinnecock Indian Reservation	258	SHN	$634,060	$1,070,700	$781,230
8b	SB-M-4A	Heady Creek	119	SHN	$106,600	$188,840	$130,300
		Subtotal - Shinnecock Bay Sub-Bay	*622*		*$1,608,820*	*$2,659,550*	*$1,937,810*
		Total: Back Bay Area	**43,375**		**$89,472,930**	**$165,411,410**	**$115,398,840**

Discount Rate 3.125%, Period of Analysis 50 years

Table 25 provides a summary of the total without project damages for all damage categories. Following the table is an explanation of each of the damage categories.

Table 25. Summary of Without Project Annual Damages (Oct 2015 PL)

Damage Category	Without Project Damage
Inundation Damages ***(***due to Inlet conditions, wave setup, storm-related breaching and overwash in back bay)	
Mainland Inundation Damages	$98,382,500
Barrier Island Inundation Damages	$17,016,300
Total Inundation Damages	*$115,398,800*
Breach Open Damages (Inundation due to subsequent storms with a breach remaining open)	
Open Breach in the Wilderness Area)	$4,732,600
(Future Breaches)	$3,578,400
Total Breach Open Damages	*$8,311,000*
Shorefront Damages*	$12,848,300
Emergency Costs/Breach Closure Costs	$1,816,000
Total Without Project Damages	$138,374,100

*Breach Related Structure Failures are not included in the total breach failure due to the potential for double count these damages with other barrier island damage categories.

Discount Rate 3.125%, Period of Analysis 50 years

Damages include the effects of the historic rate of Sea Level Rise projected over the Analysis Period

Damage Categories

Inundation Damages: These occur when vulnerable structures are flooded by high tides and water levels in the back-bay, where the water levels are sensitive to the conditions of the barrier islands. This includes the combined inundation damages as a result of flooding through the inlets, setup in the bay, and flooding that occurs as a result of a storm that results in breaching or overwash of the barrier island. Inundation damages have been divided into those occurring on the back-bay mainland and those on the back-bay side of the barrier islands.

Breach – Open Damages: Breach inundation damages occur when structures are flooded by increases in back-bay water elevations caused by breaches in the barrier islands remaining open for a period of time. These are damages that occur due to future storms. The damages are limited to structures in back-bay mainland areas and on the back-bay side of the barrier islands. The total breach inundation damages consist of damages due to the recent breach in the Wilderness Area remaining open during the analysis period, plus future breaches occurring at the other vulnerable locations.

Shorefront: These damages occur only in the shorefront areas of the barrier islands and the mainland area east of the barrier island system, and are not influenced by the condition of the barrier islands. Shorefront damages are caused by cross-shore erosion, wave action, ocean inundation, or combinations thereof. $12.8 Million in damages, representing 8% of the total damages arise due to damages to the shorefront.

Public Emergency Costs: These are costs related to efforts made by local communities and other entities to ensure the safety of the public during storm events. They can include evacuation, the provision of temporary accommodation, the use of special equipment and supplies, and the increased utilization of services of emergency personnel. Public emergency costs also include post-storm cleanup and debris removal. Public emergency costs have not been evaluated at this stage in the study.

Other Damages: There are damages to other items which have not been specifically evaluated at this stage in the study, such as damage to roads, utilities and coastal storm risk management structures, and impacts on locally-based fishing fleets.

In addition to the damage categories outlined above, there are several additional sources of benefit which are to be analyzed separately. These include an increase in recreation use value, and prevention of loss of land. It is anticipated that the inclusion of these additional benefits (along with the damage categories mentioned above which have yet to be specifically evaluated) will not alter the results of the economic analyses completed thus far.

4.6 Damage Sensitivity and Uncertainty

Lifecycle Analysis

As described above, annual damages represent the expected average or mean results. The actual amount of future damages is highly sensitive to the timing and sequence of storms, future events that cannot be predicted. For example, the random occurrence of several large storms early in the lifecycle analysis period will result in higher annual damages than if the storms occur further apart (allowing more profile recovery), or later in the period (have a lower present value). In addition to the uncertainty associated with the timing of storms, some of the model input data has uncertain values, such as the stage damage curves, whether partial breaches will remain open, and sea level rise. The life cycle simulation has incorporated the uncertainty of these parameters by allowing the values to vary in each simulation.

In order to account for uncertainties in the timing and impacts of various storms, calculations are performed for a large number of lifecycles and mean or average value is reported. While the mean values are the appropriate values to use in economic assessments, such as benefit costs ratios, it is also helpful to understand the range of possible future damages. In addition to tracking the mean damages, the lifecycle models are also capable of tracking other statistics, such as the median or damage quartiles.

Wilderness Area Breach

One of the assumptions in the WOPFC is the breach within the Wilderness Area of the Fire Island National Seashore that opened during Hurricane Sandy will remain open indefinitely. It is possible that the breach could close at some point in future, whether by natural coastal processes or mechanically through human intervention. DOI has been monitoring the breach in the Wilderness Area and is preparing an Environmental Impact Statement (Plan/EIS) to determine how best to manage the breach that was created in Fire Island's federally-designated wilderness area.

A sensitivity analysis is being performed to evaluate the impact of this assumption on the WOPFC damages and project benefits. Observations and modeling results have shown that, at its current size, the breach in the Wilderness Area has not significantly altered tidal elevations in Great South Bay or Moriches Bay. However, the storm surge model simulations show that the breach in the Wilderness Area increases storm water levels within Great South Bay and Moriches Bay during storm events. The storm water level model simulations with the breach in the Wilderness Area open were used to update the BLC stage frequency curves for the study area. In some locations in Great South Bay and Moriches Bay the 1% annual exceedance water level increased by 1 foot or more as a result of the Breach in the Wilderness Area. Due to the relatively flat topography in many mainland communities, a 1 foot increase in the storm water levels can significantly increase the floodplain area and number of structures at risk. A detailed comparison of the Pre-Sandy and Post-Sandy 1% annual exceedance inundation extents is provided in the Flood Maps, Subappendix A-1 - Plates.

5 PLAN FORMULATION

The efforts culminating in the tentative selection of the plan for this GRR included plan formulation, evaluation, and comparison that were spread out over the course of 20 years since the initiation of the Reformulation Study in 1994. This Chapter of the GRR contains a summary of the formulation. A detailed description of the plan formulation process prior to Hurricane Sandy is contained in Appendix E - Plan Formulation Appendix.

This Reformulation came about in part due to a referral to the Council on Environmental Quality in response to the 1978 Environmental Impact Statement (EIS) that was prepared for the project subsequent to passage of the National Environmental Policy Act of 1969. The Corps of Engineers agreed to reformulate the project with particular emphasis on identifying and evaluating alternatives that considers cumulative impacts and the overall coastal system. Included within the study area is the Fire Island National Seashore (FIIS). The authorizing law for FIIS specifies that any plan for coastal storm risk management with the boundary of the National Seashore be mutually acceptable with the Secretary of the Interior and the Secretary of the Army.

In May 2009, a draft Formulation Report was provided to the key government partners and stakeholders that identified problems, opportunities, objectives and constraints, analyzed alternatives, and proposed several alternative plans for consideration. Based on the comments received and subsequent discussions among the stakeholders and public, a Tentative Federally Supported Plan (TFSP) was jointly identified by the Corps of Engineers and the Department of Interior as the plan that best achieved the coastal storm risk management objectives, and was acceptable to both the Secretary of the Army and Secretary of the Interior. This TFSP was submitted to the New York State Department of Environmental Conservation (NYSDEC), the non-Federal sponsor, for their concurrence in March 2011.

On October 29, 2012, Hurricane Sandy made landfall near Atlantic City, NJ, where it collided with a blast of arctic air from the north, creating conditions for an extraordinary historic ‘super storm’ along the East Coast with the worst coastal impacts centered on the northern New Jersey, New York City, and the Long Island coastline. Coastal erosion and damages within the FIMP study area as a result of Hurricane Sandy were severe and substantial. There were three breaches of the barrier island (Figure 1, Figure 16, and Figure 17), multiple overwashes, extensive shorefront damages, and back bay flooding. Post-Sandy measurements of volume loss of the beach and dunes on Fire Island indicated that the beach lost 55 percent of its pre-storm volume equating to a loss of 4.5 million cubic yards. A majority of the dunes either were flattened or experienced severe erosion and scarping (Hapke, et.al. 2013).

Figure 16. Breach at Smith Point County Park

Figure 17. Breach at Cupsogue

As a result of Hurricane Sandy, there was an identified need for measures to be implemented quickly along Fire Island, and in Downtown Montauk in order to address these critically eroded areas. As a result, the Corps' in partnership with NYSDEC completed reports, and were approved to construct stabilization efforts on Fire Island and in Downtown Montauk, in accordance with the Disaster Relief Appropriations Act of 2013 (P.L. 113-2). As these stabilization efforts were underway, further refinements were made to the TFSP to address the changed conditions post –Hurricane Sandy.

5.1 Plan Formulation and Evaluation Criteria

The formulation process used in this study is consistent with the national objectives as stated in the Planning Guidance Notebook (ER1105-2-100, USACE, 2000). In general, coastal storm risk management plans must contribute to the National Economic Development (NED) account consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable executive orders and other Federal planning requirements. Plans to address the needs in the study area must be formulated to provide a complete, effective, efficient, and acceptable plan of coastal storm risk management. These criteria, which are defined below, are applied in the evaluation of each of the alternatives considered.

- **Completeness** is defined as "the extent to which a given alternative plan provides and accounts for all necessary investments of other actions to ensure the realization of the planned effects. This may require relating the plan to other types of public or private plans if the other plans are crucial to realization of the contributions of the objective."
- **Effectiveness** is defined as "the extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities."
- **Efficiency** is defined as "the extent to which an alternative plan is the most cost effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the Nation's environment."
- **Acceptability** is defined as "the workability and viability of the alternative plan with respect to acceptance by State and local entities, and the public, and compatibility with existing laws, regulations, and public policies."

In addition it was critical to obtain consensus among the key stakeholders and to integrate the policies of the Corps of Engineers, the Department of Interior, and the State of New York regarding the project objectives, plan formulation approach, and evaluation criteria. In order to capture the requirements for a plan to be mutually acceptable to these parties, a "Vision Statement for the Reformulation Study" (See Appendix L – Pertinent Correspondence) was developed by the three agencies as the approach for plan formulation. It includes the following:

- No plan can reduce all risks,
- Decisions must be based upon sound science, and current understanding of the system,
- Flooding will be addressed with site specific measures that address the various causes of flooding,
- Priority will be given to measures which both provide coastal storm risk management, and restore and enhance coastal processes and ecosystem integrity,

- Preference will be given to Nonstructural measures that restore coastal landforms and natural habitats,
- Project features should avoid or minimize adverse environmental impacts and address long-term demands for public resources,
- Balances dune and beach replenishment considering storm damage reduction and environmental considerations,
- Consideration will be given to alteration of existing shore stabilization structures, inlet stabilization measures, and dredging practices.

5.1.1 Goal of Reformulation Study

The goal of the Reformulation Study is to reduce storm damages and attendant loss of life from flooding, waves and erosion, including reestablishment of the natural coastal processes to the extent possible while minimizing environmental impacts.

5.1.2 Planning Objectives

In support of the goal of the Reformulation study, the planning objectives are:

1. Reduce flooding on the mainland and barrier islands and attendant loss of life, property and economic activity.
2. Reduce damages to structures due to beach and bluff erosion in critical areas.
3. Restore coastal processes and utilize coastal process measures to the maximum extent possible to provide resiliency and reduce storm damages.
4. Ensure that any plan within the jurisdictional boundaries of the National Park Service is compatible with the goals and objectives of the Fire Island National Seashore, and is mutually acceptable to the Secretary of the Army and Secretary of the Interior.

In coordination with the Department of Interior, identify a mutually acceptable plan to manage risk of damages and risks to local residents' health and safety from hurricane and storm tide flooding within the study area.

- Consistent with the "Vision Statement for the Reformulation Study", priority will be given to measures that both provide coastal storm risk management, and restore and enhance coastal processes and ecosystem integrity

5.1.3 Planning Constraints

The formulation and evaluation of alternative plans are constrained by technical, environmental, economic, regional, social and institutional considerations. For plans analyzed in this study, the following constraints have been taken into account.

5.1.3.1 General Constraints:

- Be able to be implemented with respect to financial and institutional capabilities and public consensus;

- Comply with USACE environmental operating procedures.

5.1.3.2 Physical Technical Constraints:

- Plans shall represent sound, safe, and acceptable engineering solutions taking into account the overall littoral system effects;
- Plans shall be designed to be low-maintenance;
- Plans should avoid and minimize impacts to environmental resources with the potential for enhancement;
- Plans shall not affect access to beach;
- Plans shall take into consideration aesthetics and viewshed;
- Plans shall be in compliance with USACE regulations.

5.1.3.3 Economic Constraints:

- Plans must be efficient, make optimal use of resources, and not adversely affect other economic systems;
- Average annual benefits must exceed the average annual costs.

5.1.3.4 Environmental Constraint:

- Plans must avoid and minimize environmental impacts to the maximum degree practicable.

5.1.3.5 Regional and Social Constraints:

- All reasonable opportunities for development within the project scope must be weighed, with consideration of state and local interests;
- The needs of other regions must be considered, and one area cannot be favored to the detriment of another;
- Plans must maintain existing cultural resources to the maximum degree possible and produce the least possible disturbance to the community.

5.1.3.6 Institutional Constraints:

- Plans must be consistent with existing Federal laws;
- Plans must be locally supported and signed by local authorities in the form of a Project Partnership Agreement and guarantee for all items of local cooperation including possible cost sharing;
- Local interests must agree to provide public access to the shore in accordance with Federal and state guidelines and laws;
- The plan must have broad overall support in the region and state.

5.1.3.7 Planning Constraints Specific to the Study

- Any plan within the jurisdictional boundaries of the National Park Service, Fire Island National Seashore must be compatible with the goals and objectives of the Fire Island National Seashore, and be mutually acceptable to the Secretary of the Army and Secretary of the Interior.

5.2 FIMP Formulation Approach

The Vision Statement recognizes the need to achieve a plan that is mutually acceptable to the Secretary of the Army and Secretary of the Interior, and that this requires balancing storm damage reduction needs and opportunities with the environmental needs and opportunities within the study area. An important element of this approach is the concept that alternatives are developed and evaluated to manage coastal storm risks through the least intrusive means possible. In this respect, the evaluation of measures and alternatives considers the range of options starting with the least intrusive and lowest level of investment, and subsequently looks at increasing intensities of measures and alternatives to address the problems. The measures and alternatives fall into the following categories:

1. No action, as represented by the without project future condition. This scenario is presented in the future without project conditions section, and represents what is likely to occur in the absence of a project.
2. Changes in the management of the existing system. These alternatives consider changes in the existing “management” along the shoreline. In the context of this study, this considers land-use management, and also the management of the existing inlets and the current management response to breaches. These alternatives consider coastal storm risk management which can be accomplished without major investments, but through alteration of current practices.
3. Nonstructural measures. By definition, nonstructural measures are those activities which can be undertaken to move what is being damaged out of harm’s way, rather than attempting to alter the movement of water. Nonstructural measures include a variety of techniques presented further in the next Chapter, including land-use, acquisition and relocation, or retrofit of existing structures.
4. Soft structural measures. Soft structural measures generally are those constructed of sand, which are designed to mimic the existing natural storm risk management features. This includes beachfill and reestablishment of coastal processes through the use of sand. This category also includes measures which seek to remove or alter existing hard structures.
5. Hard structural measures. Hard structural measures, in combination with beachfill are only considered in areas after the above alternatives have been investigated. In general, they are only considered as a measure of last resort.

A key element of the Vision Statement is acknowledgement that the existing environment within the project area has been degraded by past human activities, and that reestablishment of the natural coastal processes and habitats provides coastal storm risk management benefits. The Vision recognizes the importance of reestablishing the underlying processes for the long-term sustainability and resiliency of the south shore that include:

- Alongshore sediment transport
- Cross-Island sediment transport
- Dune growth and evolution
- Bayside shoreline processes
- Circulation and water quality

Initially the coastal process features were developed and evaluated separately to evaluate their effectiveness. As the formulation proceeds, the measures were combined into plans that include complementary features for achieving storm damage reduction objectives.

5.3 Plan Evaluation Criteria

As described in further detail in the Plan Formulation Appendix (Appendix E), three sets of criteria were applied in evaluating the alternatives. Each coastal storm risk management alternative was first evaluated relative to the NED criteria, to identify the effectiveness of the proposed alternative in addressing the primary objective. The alternatives were also evaluated relative to the requirements of the Principles and Guidelines, to be complete, effective, efficient, and implementable. In addition alternatives were evaluated with regard to the following evaluation criteria based on the Vision statement:

- The plan or measure provides identifiable reductions in risk from future storm damage.
- The plan or measure is based on sound science and understanding of the system. Measures that may have uncertain or unintended consequences should be monitored and be readily modified or reversed.
- The plan or measure addresses the various causes of flooding, including open coast storm water levels, storm waters propagating through inlets into the bays, wind and wave setup within the bays, and flow into the bays due to periodic overwash or breaching of the barrier islands.
- The plan or measures incorporate appropriate nonstructural features provide storm risk management and to restore coastal processes and ecosystem integrity.
- The plan or measure helps reestablishes coastal landforms and natural habitat.
- The plan avoids or minimizes adverse environmental impacts.
- The plan addresses long-term demands for public resources.
- Dune and beach nourishment measures consider both storm damage reduction, restoration of natural processes, and environmental effects.
- The plan or measure incorporates appropriate alterations of existing shoreline stabilization structures.
- The plan or measure incorporates appropriate alterations of inlet stabilization measures and dredging practices.
- The plan or measure is efficient and represents a cost effective use of resources.

5.4 Iterative Planning Process

The details of Phases 1, 2, and 3 are found in Appendix E - Plan Formulation, with a summary of each of these phases provided in the following sections. The Post-Sandy Modifications and Analysis of the Tentative Federal Selected Plan are provided in Chapter 6.

5.4.1 Phase 1 – Screening of Measures.

Phase 1 screening included both an initial and secondary screening of coastal storm risk management measures. Throughout this process, involved Federal, State and municipal agencies were included in coordination meetings. Multiple meetings were also held with the five towns and incorporated villages within the study area to solicit their input on the alternatives under consideration. A workshop was held with all the project stakeholders to solicit input on the viability of nonstructural measures. The results of the screening reflect the results of engineering, economic, and environmental evaluation, with input as a result of this coordination.

The following measures were examined for applicability for the study area and to select those for further detailed in the development of alternatives during the subsequent study phases:

- No Action
- Nonstructural Measures
- Coastal Process Measures
- Sediment Management (including Inlet Modifications)
- Breach Response Measures
- Removal/Modification of Groins
- Beachfill and Beachfill with Dunes
- Offshore Breakwaters (including Artificial Headlands or T-Groins)
- Seawalls (Rubble-mound)
- Groins
- Dune and Berm With Structures
- Levees and Floodwalls
- Storm Closure Gates

An initial screening of measures was undertaken that considered Performance, Design, Costs and Limitations of each of the Measures to identify the effectiveness of these measures in accomplishing the desired objectives as described in Appendix E - Plan Formulation.

. Based upon this initial screening, measures were either recommended for further screening, or dropped from consideration.

Based on the initial screening of storm management measures, the following were recommended for further consideration:

1. Breach Response including Reactive and Proactive Breach Alternatives
2. Sediment Management and Inlet Modifications
3. Nonstructural Measures (Building Retrofits)
4. Beachfill and Beachfill with Dunes
5. Removal or Modification of Groins
6. Land and Development Management

5.4.2 Phase 2 – First Added Assessment of Alternative

Below is a summary of the coastal storm risk management measures recommended for detailed assessment of alternatives based on the initial Phase 1 screening. Further details to support this analysis are contained in Appendix E - Plan Formulation.

5.4.2.1 Breach Closure including Reactive and Proactive Breach Alternatives

Breach response alternatives were considered, including plans undertaken in response to the occurrence of a breach to close a breach quickly (reactive breach response plans), or in response to conditions where a breach is imminent (proactive breach response plans), for various design cross sections

The reduction in storm damages arising from the implementation of these breach closure alternatives was modeled to quantify back bay inundation damages resulting from open breaches in the barrier islands, and structure failure damage, which results from the loss of buildings on the barrier islands when the land on which they stand is eroded by an expanding breach. This model is also used to quantify the costs associated with closing barrier island breaches, and with maintaining the design section in the post-closure time period. The comparison of costs and benefits are provided in Appendix E – Plan Formulation. All of the alternatives were cost-effective in reducing storm damage, with the +13' NGVD dune alternative providing the greatest storm damage reduction benefits in excess of cost. However, since there are environmental benefits of allowing cross-shore transport, the +9.5 ft. and +11 ft. NGVD alternative were also carried forward for consideration where appropriate.

Also evaluated were similar Proactive Breach Closure Plans, which were intended to take action to prevent breaches from occurring at locations vulnerable to breaching, when a breach is imminent. Like the Reactive Breach Response plans, the Proactive Breach Response plans are not designed to prevent ocean shorefront development from overwash, wave attack or storm induced erosion losses, and allow for a greater level of overwash and dune lowering during a storm, so long as the overwash extent is below the threshold that would result in breaching.

The costs and benefits of the Proactive Breach Response Plans were very similar to the costs and benefits for the Reactive Breach Response Plan, and both plans were advanced for further consideration.

5.4.2.2 Sediment and Inlet Management Alternatives

At each of the three Inlets, Fire Island, Moriches and Shinnecock Inlets, various alternatives were considered to increase sediment bypassing, increase stability to adjacent shorelines and maintain navigability, as described in detail in the Plan Formulation Appendix (Appendix E). Eight alternatives were considered for Shinnecock Inlet, four alternatives for Moriches Inlet and four alternatives at Fire Island Inlet. At each of the Inlets the most cost-effective means to achieve bypassing is through additional dredging of the ebb shoal, outside of the navigation channel, with downdrift placement, which would be undertaken in conjunction with the scheduled Operations and Maintenance (O&M) dredging of each of the inlets (See Figure 18, Figure 19, and Figure 20).

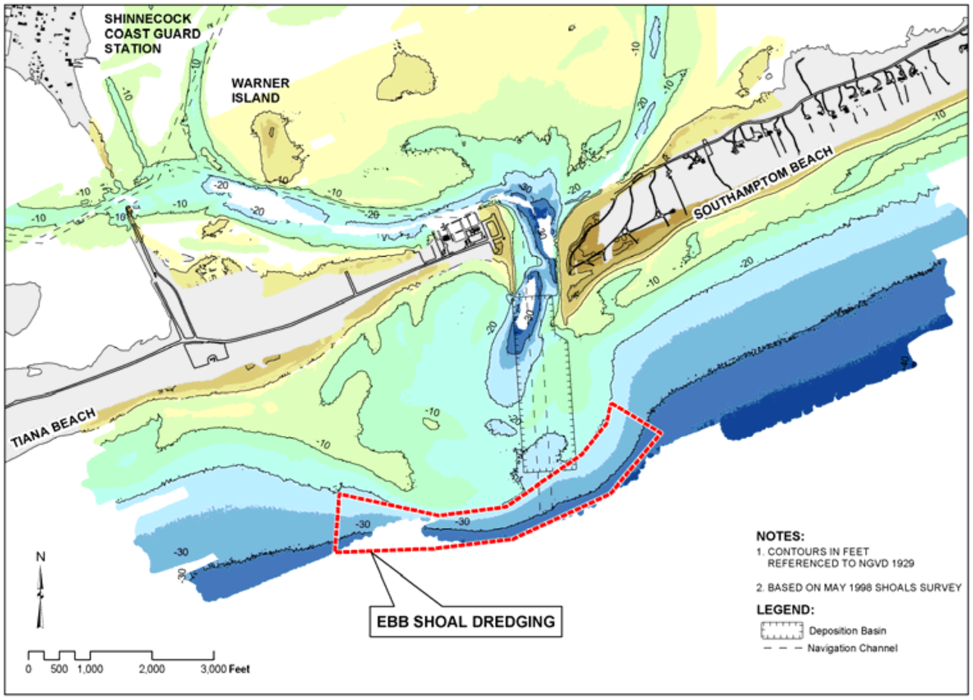


Figure 18. Recommended Alternative for Shinnecock Inlet: -16 ft. MLW Detention Basin + Ebb Shoal Dredging

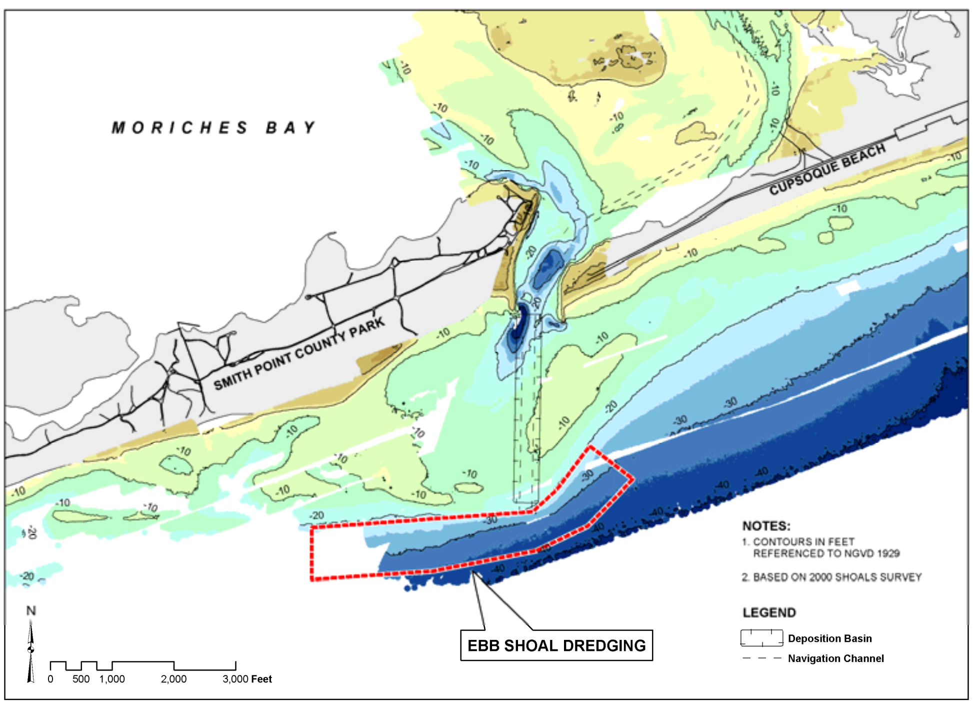


Figure 19. Recommended Alternative for Moriches Inlet: Authorized project + Ebb Shoal Dredging

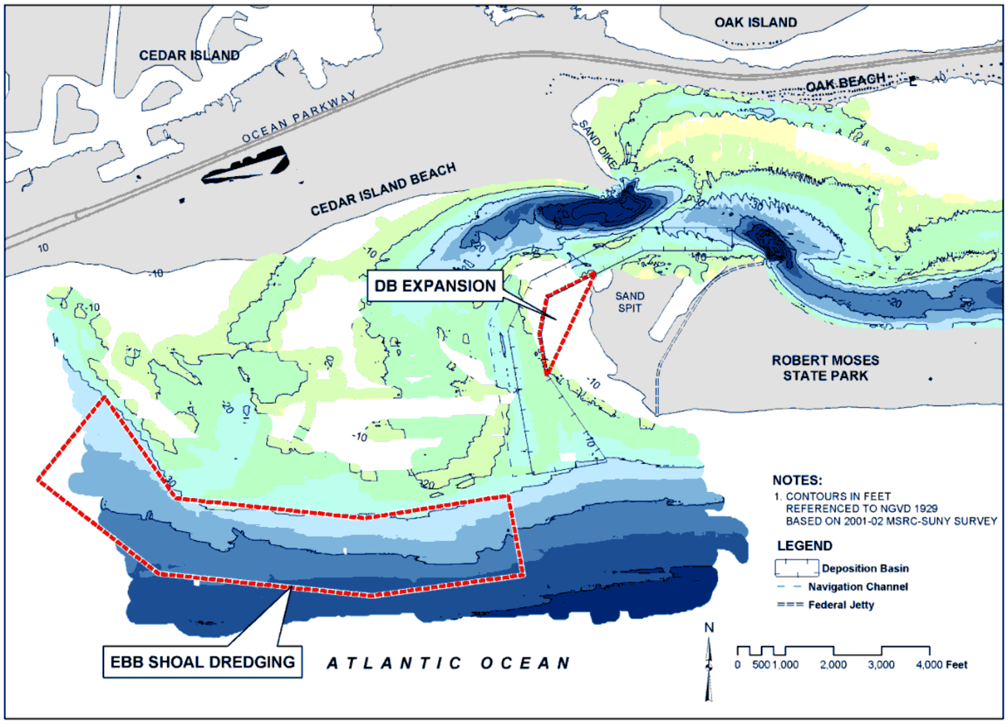


Figure 20. Recommended Alternative for Fire Island Inlet: Authorized Project P + Ebb Shoal Dredging & DB Expansion

5.4.2.3 Evaluation of Storm Damage Reduction Effectiveness

The reduction in storm damages arising from modifying the existing management practices at Fire Island, Moriches, and Shinnecock Inlets was modeled using the Lifecycle Damage Analysis Model to quantify back bay inundation damages, and the Breach Only Lifecycle Model to analyze the resulting change in breach-related damages. Changes to inlet management have been modeled by varying the rate of long-term erosion (through changes in profile recovery) from erosion and renourishment regimes at locations downdrift of the inlets.

As presented above, the inlet management measures were screened to identify the most cost-effective means to accomplish the desired objective at each inlet. The comparison of costs and benefits are provided in the Plan Formulation Appendix.

As stand-alone features, sand bypassing at the inlets did not perform well as economically efficient plans, since the effect of bypassing is to not increase the level of risk reduction that is afforded, but rather to reduce the amount of future erosion. In spite of the inlet bypassing performance as a stand-alone feature, these features are recommended for consideration in combined alternatives. Sand-bypassing provides a cost-effective source of sand for renourishment that is often less expensive and has lesser environmental impacts than removing sand from an offshore borrow area. Sand bypassing is also an integral element of reestablishing natural coastal process, and achieving the Vision Objectives.

5.4.2.4 Nonstructural/Building Retrofit Measures

Nonstructural Measures, include measures which seek to move the buildings being damaged, rather than redirecting the movement of water. Non-structural measures were only considered for buildings on the mainland, where the homes are mostly owner owned and occupied. Table 26 summarizes the assumptions made in considering alternatives for six typical structure types (Table 27). In evaluating alternatives, an algorithm was applied to evaluate six nonstructural approaches for individual buildings in the back bay mainland areas. The measures considered were wet flood proofing, dry flood proofing, elevation, acquisition, flood walls for individual buildings, and rebuilding. Five separate alternatives were considered to provide a 100-year level of storm risk management (plus 2 ft. of freeboard) corresponding to the baseline-condition landward limits of the 2-, 6-, 10-, 25- and 100-year floodplains. After evaluating the measures for each building, the least-cost measure deemed technically feasible was selected. The 2-, 6-, 10-, and 25 -year floodplains alternatives were found to be cost-effective, while 100-year alternative was determined to be cost-prohibitive and was screened out from further consideration. The cost effectiveness of each floodplain alternative was evaluated for the group of structures, not on an individual structure basis.

Table 26. Assumptions inherent to the screening of backbay alternatives for representative buildings

General Assumptions	• Flood velocity is negligible. • Debris impacts will not be considered. • There are limited areas designated as “V-Zone” by FEMA, subject to 3-foot breaking waves. The majority of backbay areas are considered non-V-Zone and thus not subject to wave and erosion impacts. • All buildings selected for treatment will be designed to withstand flooding from a 0.01 exceedance level (100-year probability storm event), plus one two feet of freeboard. • Buildings elevated in non-coastal areas will be raised (finished floor elevation) to the 0.01 exceedance level (100-year probability storm event) plus two feet of freeboard. • Flooding is gradual (no flash flooding)
Foundation Walls	• All basement foundation types are assumed to be unreinforced, 8” concrete masonry units (CMUs).
Raised Structures (Crawlspace)	• No utilities are located in the crawlspace. • Wet flood proofing of raised structures includes the elevation of utilities only, and where necessary, the installation of vents or louvers to allow adequate venting.
Slab-On-Grade Structures	• Wet flood proofing is possible if the expected flood elevation is below the main floor (shallow flooding). This alternative includes the elevation of utilities only. • Consistent with Corps’ flood proofing guidance, structures will not be dry flood proofed for flooding depths greater than 2 feet plus one foot of freeboard for a maximum 3 feet of dry flood proofing.
Structures With Basements	• All basements are unfinished and contain major utilities.
Bi-Levels	• The lower portion of the first floor walls are masonry construction. • The foundation is slab-on-grade. • The main floor can be raised separately from the lower level by lifting off the sill of the masonry wall.

Raised Ranches	• The first floor (lower) walls are masonry. • The foundation is slab-on-grade. • The main floor can be raised separately from the lower level (similar to a structure with a basement).
Split-Levels	• The lower level is slab-on-grade. • The lower portion of the lower level walls are masonry construction. • The main floor level is raised over a crawl space. • The main floor and upper level can be separated from the lower level by raising at the sill.

Table 27. Flood-proofing alternatives identified for backbay unit cost estimating

Typical Structure Type	Flood Level	Storm Risk Management Level		Flood Proofing Alternative
		Condition 1	Condition 2	
Slab-On-Grade	>= Main Floor	Ground < 3	n/a	Sealant & Closures
		Ground >= 3	n/a	Elevate Building
	< Main Floor	< Main Floor	n/a	Raise AC
		>= Main Floor	Ground < 3	Sealant & Closures
			Ground >= 3	Elevate Building
Basement-Subgrade	>= Main Floor	n/a	n/a	Elevate Building
	< Main Floor	< Main Floor	n/a	Fill Basement + Utility Room
		>= Main Floor		Elevate Building
Raised (Crawlspace)	>= Main Floor	n/a	n/a	Elevate Building
	< Main Floor	< Main Floor	n/a	Raise AC + Louvers
		>= Main Floor	n/a	Elevate Building
Basement-Walkout	>= Main Floor	n/a	n/a	Elevate Building
	< Main Floor	< Main Floor	Ground < 3	Interior Floodwall
			Ground >= 3	Raise Lower Floor + Space
		>= Main Floor	n/a	Elevate Building
Bi-Level/Raised Ranch	>= Main Floor	n/a	n/a	Elevate Building
	< Main Floor	< Main Floor	Ground <= 3	Sealant & Closures
			Ground >3	Raise Lower Floor + Space
		>= Main Floor	n/a	Elevate Building
Split Level	>= Main Floor	n/a	n/a	Elevate Building
	< Main Floor	< Main Floor	Ground < 3	Sealant & Closures
			Ground >=3	Elevate Building
		>= Main Floor	n/a	Elevate Building

Separate from the five nonstructural plans, relocation on the existing lot was considered for the back bay areas but was found to be infeasible because back bay land plots tend to be too small and flat to meet the criteria for relocation outside of the floodplain within the existing property boundaries.

Acquisition was also considered as an option for back bay structures, but was found to be generally cost-prohibitive due to high property values in the study area. However, there is an interest in pursuing structure acquisition as an option in select locations that are highly vulnerable under future sea level rise scenarios. USACE regulations require that for the purpose of estimating benefits and costs, acquisition costs be estimated under a flood-free condition, which requires extensive appraisals. Thus, for planning purposes only, acquisition costs have been computed as the sum of the depreciated structure replacement value plus a land cost of $100,000; an administrative cost of $30,000; and a demolition cost of $15,000. On completion of the algorithm, the recommended treatment cost was compared to the acquisition cost and acquisition was identified as the preferred treatment if it was found to be the lowest cost alternative. Under these conditions, land costs were found to preclude most potential acquisition candidates from being recommended for this treatment.

Evaluation of Storm Damage Reduction Effectiveness

A range of four nonstructural plans covering of structures in incrementally larger floodplains were evaluated during the original formulation. The formulation was based on the overall economic justification of groups of structures in each floodplain, and did not explicitly evaluate the benefits for individual structures.

The reduction in storm damages arising from retrofit treatments or other actions applied directly to individual structures was modeled using the Lifecycle Damage Analysis Model, with the stage-damage relationships in each reach modified to reflect the application of the nonstructural methodology described in earlier sections. The detailed analysis of the nonstructural alternative costs and benefits is provided in Appendix E (Plan Formulation). Plans NS-2 and NS-3 provided similar net benefits with Plan NS-2 providing non-structural measures for a 3,411 structures within the baseline 6-yr floodplain, while Plan NS-3 provides non-structural measures for 4,717 structures within the baseyear 10 year floodplain.

Table 28 presents a summary of the number of structures that would receive non-structural treatment types by Reach under the NS-3 Plan, based on the post-Sandy analyses. Overall 4,138 structures would receive non-structural treatment, and includes 4 buy-outs.

Table 28. Number of Structures to receive Nonstructural Measures under Plan NS-3

Treatment Type	Number of Affected Structures			
	Great South Bay	Moriches Bay	Shinnecock Bay	Total
Elevation	1,429	631	364	2,424
Floodproof	1,275	140	35	1,450
Ringwall	45	13	7	65
Rebuild	107	57	31	195
Buyout	2	1	1	4
Sub Bay Total	*2,858*	*842*	*438*	*4,138*
Project Total	**4,138**			

These nonstructural measures are implemented on a volunteer basis. For evaluation purposes the benefits, and costs are shown for all structures which fall within the footprint of the nonstructural plan. This represents the maximum reduction in damages associated with this project alternative. The ability to achieve this reduction however, depends upon the extent of participation in the program.

5.4.2.5 Nonstructural/Raised Road Alternatives

Road raising in selected mainland back bay residential areas was analyzed to explore if coastal storm damage reduction could be achieved for a greater number of buildings at a reduced cost compared to individual building nonstructural plans for a given area. Road raising is a structural measure that can complement the nonstructural plan, in which the road raising acts as a levee structure. In addition to reducing damage to buildings, road raising can reduce outside physical costs such as the flooding of cars, and non-physical costs such as clean up and evacuation. Raised roads can also offer enhancements to local evacuation plans and public safety by reducing the risk of inundation of local roads within the affected area, and providing safer evacuation routes out of the area. Road raising also reduces the need for structural alterations to individual buildings that may disrupt the owners' lives and affect perceptions of property value. Road raising alternatives require consideration of the impoundment of rainwater within the area, and the need to provide access to existing buildings.

The four areas feasible for road-raising are shown in Table 29 which summarizes the road raising alternatives and compares the number of buildings affected by each alternative to the number of buildings protected by the nonstructural alternatives for the same area.

Table 29. Road Raising Areas

Area #	Town	Community	Approx. Length of Raised Road (Ft)	Structures receiving flood risk reduction [1]
4a	Babylon	Amityville	6,600	97
8c	Babylon	Lindenhurst	5,300	240
8d, 8e	Babylon	Lindenhurst	9,000	362
52a	Brookhaven	Mastic Beach	10,500	355
TOTALS			31,500	1,054

The reduction in storm damages resulting from alternatives featuring a combination of nonstructural treatments and road raising in selected areas were analyzed using the Lifecycle Damage Analysis Model, with the stage-damage relationships in each reach modified to reflect the application of the nonstructural algorithm.

The comparison of alternatives evaluated nonstructural plan 2 (6-yr) and 3 (10-yr) alone, and also in combination with the optimum road raising alternative. This comparison demonstrates that the nonstructural plans in combination with road raising are more economically efficient that nonstructural alone. Nonstructural Alternative 3R had similar and net benefits to be effectively equal to Nonstructural Alternative 3R.

5.4.2.6 Beachfill and Beachfill with Dunes

Beachfill (berm only) and beachfill with dunes alternatives have been considered for areas where there is either a risk of breaching or where there are shorefront structures at risk. The alternative design sections considered include:

- Lower Level of Risk Management : a berm width of 90 ft. at elevation +9.5 ft. NGVD and a low dune with a crest width of 25 ft. at an elevation of +13 ft. NGVD;
- "Medium" level of Risk Management: a berm width of 90 ft. at an elevation +9.5 ft. NGVD and medium dune with a crest width of 25 ft. at an elevation of +15 ft. NGVD;
- "Large" level of Risk Management: a design section that includes a dune at an elevation of +17 to +19 ft. NGVD with a 25 ft. crest width. Design berm width is 90 ft. or 120 ft. depending on the Project Reach.

As described in detail in Appendix A (Engineering Appendix) and Appendix E (Plan Formulation Appendix), the location of the proposed dune and berm was evaluated based on three fill alignments. The Unconstrained (UC) Baseline was developed to be not constrained by real estate issues or recent beachfill projects, and is the farthest landward fill alignment, and generally matches the existing topography. A Minimum Real Estate Impacts (MREI) Baseline was defined that includes a realignment of the dune farther seaward in areas where multiple structures would need to be relocated or acquired in a more landward alignment. A third baseline, the Middle (MID) Baseline, is located between these two alignments and is aimed at optimizing the dune alignment in areas where a few structures appear to be located significantly farther seaward than adjacent ones thus pushing the whole beachfill alignment seaward. As described in Appendix E – Plan Formulation, both the MREI alignment, and the MID alignment had comparable costs, when comparing the quantity of sand required over the project life, and the real estate costs.

Evaluation of Storm Damage Reduction Effectiveness

The reduction in storm damages resulting from alternatives that involve the placement of beachfill along the length of the project shorefront have been modeled using the Lifecycle Damage Analysis Model, with appropriate revisions to threshold water levels for breach and overwash, and the effect of the beachfill on back bay stage-frequency relationships. The Breach Only Lifecycle Model was also used to analyze the resulting change in breach-related damages. The three beachfill alternatives evaluated represent dune crest elevations of +13', +15' and +17'/+19' NGVD, all on a baseline selected for minimum real estate impact. This is the first set of alternatives which is designed to reduce damages along the shorefront areas. Appendix E – Plan Formulation presents the modeled annual damages resulting from the implementation of the three beachfill alternatives. In addition to quantified storm damage reduction benefits, the beachfill alternatives will eliminate the need for the numerous local renourishment projects that have averaged 234,000 cubic yards per year of beach fill in the Great South Bay Planning Unit. The value of these benefits has not been included in the BCR.

The plan formulation appendix includes the comparison of alternatives for the Total project and also by reach. The +15 ft. NGVD dune, was the most economically efficient plan, in comparison with the other alternative cross-sections. Only those alternatives involving beachfill along the Great South Bay and Moriches Bay Project Reaches return benefits in excess of costs when considered on an individual basis. Beachfill was not economically justified along Shinnecock Bay, the Ponds Reach or Montauk Reach. The +15 ft. NGVD dune beachfill plan is recommended as a shorefront feature along the Great South Bay and Moriches Bay reaches. For Shinnecock Bay, Ponds and Montauk Reaches, sediment management measures, instead of a berms and berm-dunes would be considered to address areas of high residual risk.

5.4.2.7 Groin Modifications

Groin modifications were considered at Georgica Pond in East Hampton, the existing groin field at Westhampton, and the existing State Groins at Ocean Beach, Fire Island. Groin modifications to shorten the groins were considered to determine the influence that shortening of the structures would have on the release of sediment, and the change in long-term erosion in adjacent areas. In analysis of these alternatives, altering the groins at Georgica Pond and at Ocean Beach do not appear cost-effective for storm damage reduction. Modification of the groins at Westhampton, by shortening 12 groins between 70 and 100 feet could introduce upwards of 2,300,000 CY of sand into the littoral system, which could be cost-effective if shown to significantly reduce expected renourishment requirements for the interim project at Westhampton. The analysis of these three areas is presented below.

Georgica Pond, East Hampton.

There are four rubble mound groins east of Georgica Pond along the shoreline of East Hampton. In 1959, the State of New York constructed two 275 ft. long groins, one 700 ft. east of Georgica Pond and the other 12,000 feet east of Georgica Pond, in the vicinity of Hook Pond. The Army Corps of Engineers constructed two additional groins east of the state groin at Georgica Pond in 1964 and 1965. These groins were 480 ft. long from the landward crest, elevation +14.0 MSL to the seaward crest at elevation +1.5 MSL (NGVD). In 1960, the state placed 370,000 cubic yards over a 9800 ft. length of beach at Georgica Pond

The State and Federal groins at Georgica Pond have not had any maintenance since their construction. The structures have lost their trapezoidal shape and armor stone interlocking, but are still functioning. The East Hampton Town Trustees regularly open and close the inlet to Georgica Pond, for environmental and flood risk management purposes. In some years, the inlet is breached naturally by a storm event, and can also close naturally due to littoral transport of sand.

Based on the recommendations of a technical report commissioned by Suffolk County, report titled "Historical evaluation of shoreline change for the Georgica Pond region, Suffolk County, Long Island, New York", no modifications to the four Georgica Pond groins are recommended at this time. Instead a monitoring program is recommended to determine the long-term effect of the groins at Georgica Pond and possible future modification.

Westhampton Groin Field

Eleven groins were constructed in 1965 by the US Army Corps of Engineers and an additional four groins were constructed in 1969 – 1970 under provisions of the original Fire Island to Montauk Point Beach Erosion Control and Hurricane Protection (FIMP) Project. The groins, spaced approximately 1250 ft. apart, function as intended and continue to provide coastal storm risk management to a once vulnerable reach of barrier island shoreline approximately 2.8 miles in length. The Westhampton groin field had, however, contributed to accelerated erosion directly west of the westernmost groin, culminating in two breaches, Pikes Inlet and Little Pikes Inlet, during the Northeaster of December 1992.

The Westhampton Interim Project was designed to mitigate erosion problems occurring downdrift of the Westhampton groin field. The Interim Project provides for beachfill placement, dune construction west of the groin field, periodic renourishment, the shortening and lowering of the final two groins on the western edge and the construction of one additional groin. A tapered groin system was implemented to promote littoral drift between the wide beaches within the groin field and the areas downdrift. Groins 14 and 15, originally 480 ft. in length were shortened to 417 ft. and 337 ft., respectively. Groin 14A, constructed between groins 14 and 15 in 1997, is 417 ft. in length. Groins 1 through 13 are 480 ft. long.

The Westhampton Interim Project also provides for renourishment within the groin field and the western beach and dune portion, contingent upon the condition of a design cross-section. A renourishment cycle of three years was originally planned and has been recently only been required every four years. Renourishment material placed within the groin field plays two roles: (1) decrease impoundment capacity within the groin field to allow littoral transport to bypass the groin field; and (2) supplies additional renourishment material to downdrift beaches as it erodes from the groin field and enters the littoral system

In the area within the groin field, the performance of the constructed groins has exceeded expectations, resulting in an accretive beach and stable dunes. Similarly, the Westhampton Interim Project has exceeded performance expectations, as indicated by the accretive dunes west of the groin field, the longer than expected renourishment cycle and the decrease in needed renourishment volume.

Given the relatively consistent health of the beach contained within the Westhampton groin field and the beneficial performance of the groin tapering and renourishment provisions of the Westhampton Interim Project, it is recognized that the shortening of groins 1 through 13 has the potential to release a substantial amount of sediment back into the littoral system without diminishing the amount of risk reduction provided by the existing beach and dune. In addition, groin shortening would provide an opportunity to repair the seaward end of these groins, which have not received maintenance since original construction, thereby maintaining functional stability. Tapering along the western mid-portion of the groin field (groins 9 to 13) will also improve transport between the feeder beach and downdrift areas.

These modifications would entail the removal of 70 to 100 ft. of stone from the seaward end of 13 groins at an estimated cost of $5 million (Sep 2007 PL). With a minimum of 500,000 cu yd. of sand estimated to be released, the value of the sand released into the system is about $6 million assuming a purchase price of $12 cu yd. This demonstrates that modifying the existing groins is a cost effective strategy for the providing longshore transport of sand within and downdrift of the Westhampton groin field, and an alternative that aids in reestablishing longshore transport in the system.

Ocean Beach Groins

Two shore perpendicular structures were constructed in the winter of 1970 within the Village of Ocean Beach, on Fire Island. Originally these groins were only constructed of tetrapods, which are concrete armor units, with five lower legs and one upper leg. The tetrapods have a base width of approximately 10 feet and a total height of approximately eight feet. The groins were constructed in an area of higher erosion, to add stability to the ocean shoreline seaward of the Ocean Beach water tower and pumping stations (wells). The water tower has since been moved north to Village owned land and there are plans to relocate the three village owned wells in conjunction with the FIMI project.

The groin modification alternative includes the shortening and lowering of the groins. This partially fulfills the vision objectives, but offers limited reduction in storm damages when considered as a stand-alone alternative. Groin modification itself, can be considered to reestablish coastal processes. Opportunities exist for beneficial reuse of the stone, which may be used for other coastal process features.

5.4.2.8 Land and Development Management

Land and development management alternatives include land use regulations and acquisition alternatives that could be implemented to reduce the risk of coastal storm damages to existing development in high risk areas, and to reduce development pressure in those areas. These at-risk areas generally include areas vulnerable to flooding, and also areas that are vulnerable to erosion.

As described in Appendix E, the existing land use regulations have limited effectiveness in addressing development and redevelopment in these at-risk areas, particularly in areas that are vulnerable to erosion. It is acknowledged that that alternatives implemented under the FIMP could have an effect on this problem.

There is a limited role for the Corps' in the implementation of the land and development management measures, but it is acknowledged that this is an integral component of any plan. It is important to ensure that adequate provisions are in place for the project to perform as expected, and does not result in increased development that is at risk. Land and development management measures are recommended to be considered further in conjunction with the alternative plans, to ensure the functioning of the project, and to consider the longer-term sustainability of the project.

New York is a home rule state and therefore there are no state zoning regulations. Local governments are encouraged to utilize their land use authorities (comprehensive plans, subdivision regulation, zoning and site plan approval), together with other resources, in coordination with the FIMP project and other programs and standards as applicable, to reduce risk.

5.4.2.9 Reestablishing Coastal Processes

As described in detail in Appendix E – Plan Formulation, 24 sites that had the potential to restore coastal process features were identified and evaluated by the interagency team. Of these, 12 were supported and 12 excluded based upon lack of landowner support or cost-effective considerations. These plans include:

- Establishing optimal beach and dune conditions, accounting for footprint, slopes, and vegetative cover. (8 Alternatives evaluated, and 8 supported)
- Reestablishing the beach and dune through removal of buildings in the dune. (7 alternatives evaluated, and 0 alternatives supported, all eliminated based upon landowner support or cost
- Reestablishing the beach and dune through removal of buildings and infrastructure to allow for dune migration. (4 alternatives evaluated for relocating parking lots and dune crossing structures, 4 alternatives supported).
- Removal or modification of coastal structures to allow for more natural beach and dune conditions. (2 alternatives evaluated, 2 excluded based upon landowner support)
- In the interior of the island, measures are considered for restoring secondary dunes and removing areas of disturbance to provide habitat connectivity from Ocean to Bay. (These alternatives were included in the above 3 characterizations).

Along the bayside shoreline, measures were developed to reestablish bayside natural storm risk management features (inclusive of the bay islands). Thirty-three alternatives were considered, with 26 supported and 7 eliminated either for lack of landowner support, or cost considerations.

- Reestablishing bay beaches, wetlands, and subaquatic vegetation. (21 Alternatives evaluated, with 17 supported)
- Reestablishing these bayside habitats through removal or modification of bayside structures (5 alternatives evaluated, with 3 supported and 2 excluded).
- Reestablishing these bayside habitats with the use of bayside structures (7 evaluated, 6 supported, all not supported in the Matrix Analysis).

5.4.2.10 Project Measure Analysis

Table 30 provides a summary of the degree to which each of the Storm Management measures satisfies the interagency vision evaluation criteria. This table shows that there is not one alternative that completely addresses the problems within the project area, or completely addresses the Vision criteria. A combination of alternatives is necessary to address the problems and to meet the Vision objectives.

Table 30. Project Measure Analysis

Evaluation Criteria	Breach Closure	Inlet Management	Non-Structural Retrofit	Beach Fill	Groin Modification	Coastal Process Features
The plan or measure provides identifiable reductions in risk from future storm damage.	Full	Full	Full	Full	Partial	No
The plan or measure is based on sound science and understanding of the system. Measures that may have uncertain consequences should be monitored and be readily modified or reversed. Measures that could have unintended consequences, based upon available science are considered a lower priority.	Full	Full	Full	Full	Partial	Full

Evaluation Criteria	Breach Closure	Inlet Management	Non-Structural Retrofit	Beach Fill	Groin Modification	Coastal Process Features
The plan or measure addresses the various causes of flooding, including open coast water levels, water propagating through inlets into the bays, wind and wave setup within the bays, and flow into the bays due to periodic overwash or breaching of the barrier islands.	Partial	Partial	Full	Partial	Partial	Partial
The plan or measures incorporate appropriate non-structural features provide both storm damage protection and to restore coastal processes and ecosystem integrity	No	Full	Partial	N/A	N/A	Full
The plan or measure helps protect and restore coastal landforms and natural habitat.	Partial	Full	No	Partial	Partial	Full
The plan avoids or minimizes adverse environmental impacts	Partial	Full	Full	Partial	Full	Full
The plan addresses long-term demands for public resources.	Partial	Partial	Full	Full	Full	Full
Dune and beach nourishment measures consider both storm damage reduction, restoration of natural processes, and environmental effects.	Full	Full	No	Partial	N/A	Partial
The plan or measure incorporates appropriate alterations of existing shoreline stabilization structures	N/A	N/A	No	Partial	Full	N/A
The plan or measure incorporates appropriate alterations of inlet stabilization measures and dredging practices	No	Full	No	N/A	N/A	N/A
The plan or measure is efficient and represents a cost effective use of resources	Full	Partial	Full	Partial	Partial	Full

Evaluation Criteria	Breach Closure	Inlet Management	Non-Structural Retrofit	Beach Fill	Groin Modification	Coastal Process Features
The plan or measure reduces risks to public safety.	Full	Full	No	Full	Partial	N/A

5.4.2.11 Summary of First Added Assessment of Alternatives

The analysis of each of these alternatives as stand-alone alternatives, and their effectiveness in managing coastal storm risks in the current framework has been used to identify which of these alternatives are to be carried forward for consideration in developing comprehensive alternative plans. These alternative plans are developed by combining alternatives, and allowing for a range of solutions along a Project Reach, and consideration of performance for the entire system.

Based upon the results of the analyses of individual alternatives, the following are recommended to be carried forward for consideration as input into combined alternative plans.

- Breach Response Plan – +13 ft. dune
- Breach Response Plan – + 9.5 ft. cross-section (primarily for environmentally sensitive areas)
- Inlet bypassing
- Nonstructural Alternative 2
- Nonstructural Alternative 3
- Nonstructural Alternative 2 with Road Raising
- Nonstructural Alternative 3 with Road Raising
- Beachfill Alternative +15 ft. for Great South Bay and Moriches Bay Reaches
- Groin Modification Alternatives at Westhampton
- Coastal Process Features remaining from Phase 2 screening

In addition, Sediment Management Measures would be considered in the Ponds and Montauk Reaches.

5.4.3 Phase 3 – Incremental Alternative Plan Development and Assessment

The NED analyses during Phase 2 identified several cost effective alternatives for coastal storm risk management. As described in more detail in Appendix E – Plan Formulation, no one alternative addresses all the coastal storm risk management needs, and therefore a combination of alternatives is needed in order to achieve the planning objectives. The evaluation of coastal process features identified various alternatives that could be complimentary to, or compatible with other features, and improve the overall resilience and sustainability of the system.

The recommended approach was to give first priority to management options, particularly options that restore natural processes. The second priority is to include nonstructural alternatives, with beach nourishment or other structural alternatives considered last. This formulation approach ensures that Plans are consistent with the NY State Coastal Zone Management policies, the Vision Criteria, and also places a priority on avoiding or minimizing any negative environmental impacts.

Based on the evaluation of the individual alternatives, combined plans were developed. First, Second and Third added plans were developed by incrementally adding Management Alternatives (Plan 1), Nonstructural Alternatives (Plan 2), and Structural Alternatives (Plan 3). After evaluation of these plans, additional plan features were considered to improve the overall functioning of the plan. The scale of the alternatives selected for inclusion was based on the results of the optimization of individual alternatives and the potential for the combined alternatives to more fully satisfy the project objectives and evaluation criteria.

5.4.3.1 Plan 1.

The first series of plans (Plans 1a and 1b) reflect combinations of management alternatives and have combined the Inlet Management and Breach Response Alternatives. The Inlet Management Alternative includes continuation of the authorized project at the inlet, plus additional bypassing of sand from the ebb shoals to offset the erosion deficit downdrift of the inlets. Inlet Management Alternatives are included because they meet both coastal storm risk management objectives, and Vision criteria. Inlet management is compatible with all plans in the Great South Bay, Moriches Bay and Shinnecock Bay reaches. Two of the breach response alternatives have been selected for evaluation in the combined plans. The +13 ft. NGVD BRP is selected because it maximizes the BRP Storm Damage Reduction Benefits. The +9.5 ft. NGVD BRP is selected because it maximizes opportunities to restore cross shore transport.

Plan 1a is based on the combination of the economically optimum Inlet Management Alternative and BRP Alternative (+13 ft. NGVD BRP). Plan 1b combines the optimum Inlet Management Alternative with the +9.5 ft. NGVD BRP Alternative. Appendix E - Plan Formulation Appendix provides a comparison of the Management Only Alternatives for the overall project and also for each of the three bays individually.

Plan 1 includes breach response plans along the barrier island, and inlet bypassing at the inlets achieved by continuation of the authorized projects at the inlets, and the additional bypassing of sand through dredging of the ebb shoal in the amount of 100,000 CY to 390,000 CY per year at each inlet. The analysis of costs and benefits shows that Plan 1 (both 1a, and 1b) is marginally effective.

This plan is not a complete solution, in that it only addresses damages that occur due to a breach remaining open, and as a result reduce only a small percentage of the overall damages. This plan only addresses 10% of the damages. The remaining damages that arise due to a combination of breach occurrence, bayside flooding, and shorefront damages remain unaddressed.

When considering this Plan in comparison with the Vision Criteria, it has its strengths and it shortcomings. The areas where this plan falls short in comparison with the vision objectives are in the following areas:

1. The plan doesn’t address all the contributors to damages.
2. The plan doesn’t fully address the need for nonstructural measures to provide both storm damage reduction and ecosystem integrity.
3. The plan does not fully address the needs for storm risk management and restoration of natural landforms and habitat.
4. The plan does not meet the objective for including appropriate modification of existing structures.

The shortcomings that exist with Plan 1 highlight the need to consider additional plan elements. The shortcomings are addressed in the following alternative plans, with the inclusion of additional plan elements.

5.4.3.2 Plan 2.

The second series of plans (Plan 2a through Plan 2h) reflect the addition of nonstructural measures to Plan 1a and Plan 1b. The inclusion of nonstructural measures is considered essential to address flooding from storm water propagating through inlets into the bays and wind and wave setup within the bays. The nonstructural alternatives selected for consideration in Plan 2 include both Alternative NS2, which provides storm risk management for 3,400 structures, and Alternative NS2R, which supplements the nonstructural features by raising selected roadways. In addition, the NS3 and NS3R Alternatives, which cumulatively provide storm damage reduction benefits to an additional 2,000 buildings over NS2, have also been included. Plan 2 includes breach response, inlet modifications, and mainland nonstructural measures. All of the alternative plans are cost-effective, with a BCR greater than 1.

The plans that provide the greatest net benefits are Alternative 2f and 2h. Alternative 2f, which includes NS2R may appear to be the preferred plan, Alternative 2h includes a significantly larger number of structures included for risk management with a design water elevation that is 0.5 ft. larger than NS2. Since these plans are so close in scale, and provide such similar results, the recommendation is that Alternative 2h represents the best plan from this collection of alternative Plan 2. Alternative 2h includes inlet management at the inlets, a breach response plan with the +13 ft. NGVD cross-section, NS3, which addresses structures in the existing 10-yr floodplain, and road raising at four locations.

When these Plans are considered relative to the Vision, they all provide similar results, since the features are similar in all plans. These plans, with the inclusion of the nonstructural measures along the mainland advance a greater number of Vision Objectives than Plan 1, but still have some shortcomings when compared with the Vision criteria.

The areas where this plan falls short in comparison with the vision objectives are in the following areas:

1. The plan doesn't address all the contributors to damages. While the plan now does address the increased flooding due to breaching, and the flooding in the back-bay, this alternative does not address coastal damages that would occur along the ocean shorefront.
2. While this plan includes a tremendous amount of nonstructural efforts along the mainland, the plan doesn't fully address the need for nonstructural measures to provide both storm damage reduction and ecosystem integrity along the barrier island system.
3. The plan does not fully address the needs for storm risk management and restoration of natural landforms and habitat.
4. The plan does not meet the objective for including appropriate modification of existing structures.

These shortcomings suggest the need to include the next increment of alternatives.

5.4.3.3 Plan 3.

The third series of plans (Plan 3a through Plan 3g) reflects the addition of beach nourishment to Plan 2e through Plan 2h. The inclusion of beach nourishment more fully addresses the various sources of storm damages and also addresses any significant erosion resulting from alterations of the existing shoreline stabilization structures. The nonstructural alternatives selected for inclusion in these plans include the road raising feature.

The beach nourishment alternative included in these Plans is the 15 ft. NGVD dune/ 90 ft. berm width design with the minimum real estate alignment. This design and alignment were identified as having the highest net benefits. Although the minimum real estate alignment was selected for alternative comparison, since the costs and benefits of the middle alignment are close, it is expected that an evaluation including the middle alignment would offer similar results. The analysis also identified that the beach nourishment alternatives are not cost effective in reducing storm damage in the Shinnecock Bay, Ponds, and Montauk Reaches. Plans 3a through 3g therefore have excluded beach nourishment in these reaches. Within the Shinnecock Bay Reach the breach response plan with the +13 ft. NGVD design section has been included. For reaches where dunes and beach berm is provided, breaches would be closed to the design section as part of the project renourishment or major rehabilitation.

Within the Great South Bay and Moriches Bay Reaches there are several environmentally sensitive areas along the barrier island that present a risk of future breaching with damage to back bay development, but with little or no human development on the barrier. These locations include the Otis Pike Wilderness Area (OPWA), areas designated as Major Federal Tracts (MFT) by FIIS, and Smith Point County Park (SPCP). Plans were developed to evaluate the impact of excluding these locations on Storm Damage Reduction Benefits, Costs and BCRs. For Plans 3b through 3g, at any location in the Great South Bay and Moriches Bay reaches where beachfill has been excluded due to environmental concerns, the Breach Contingency Plan with a 9.5 ft. NGVD closure design has been included. The lower level closure design has been selected for these locations as the alternative most compatible with allowing cross island sediment transport. Figure 21 illustrates the conceptual layout of alternative Plans 3a to 3g.

As described in Appendix E – Plan Formulation, plans that combined inlet management, breach response, nonstructural retrofits, and beachfill are economically viable, and to different degrees satisfy the P&G criteria and the Vision criteria. The analysis shows that the relative effectiveness of the beachfill alternative plans is reduced, with each reduction in the alongshore extent of fill (replaced with breach response plans), corresponding with environmentally sensitive areas.

Plans 3a to 3g, with the inclusion of beachfill advance a greater number of Vision Objectives, than Plan 2, (particularly in addressing all the contributors to storm damages) but still have shortcomings when compared with the Vision criteria. When these Plans are considered relative to the Vision, they provide results that vary depending upon the extent of fill that is proposed, particularly as it relates to the criteria to balance storm damage reduction considerations with coastal process considerations. Plan 3a is the alternative which best addresses the coastal storm risk management needs, but includes beachfill throughout the system, and as a result does not rank highly with respect to the Vision criteria for balancing storm damage reduction needs and environmental needs, and also does not rank highly with consideration of the P&G criteria for implementibility, since it is contrary to NPS policies for fill within undeveloped tracts of land. Plan 3g includes beachfill in the developed areas, and replaces beachfill within the major public tracts of land with breach response plans. While this plan is less effective in reducing storm damages, it is a plan which is economically viable, is better aligned with the P&G criteria, as being more consistent with the NPS policies, and better achieves the Vision objectives in that this plan balances storm damage reduction needs and coastal process needs. The breach response plans evaluated as part of this plan are reactive plans. As part of the final design, the breach response protocols can be adjusted to consider opportunities for balancing coastal processes or further reducing the risk, by the establishment of a higher threshold at which action is taken with a proactive breach response plan.

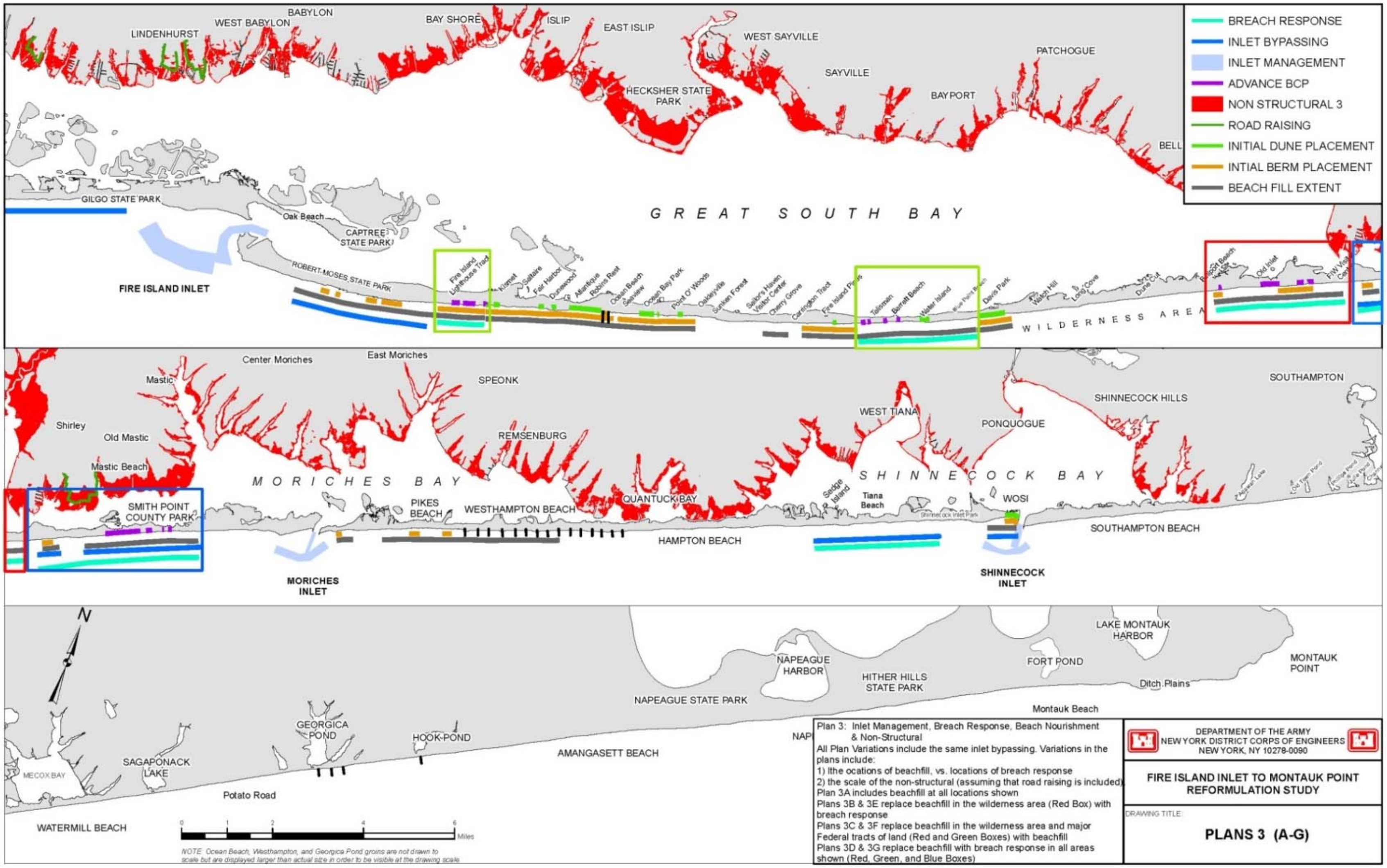


Figure 21. Alternative Plan 3 Overview

5.5 Integration of Features to Advance the Vision Objectives

As described In Appendix E- Plan Formulation, Plan 3a was the plan that appears to best accomplish the coastal storm risk management objectives, while Plan 3g was the plan that best balances the coastal storm risk management, the Principles and Guidelines criteria, and also the Vision Criteria. Plan 3g was identified as the preferred solution because it is efficient in reducing storm damages and it satisfies the requirements for a plan to be mutually acceptable to the Secretary of Interior and Secretary of the Army. Neither plan, however, fully satisfies the Vision Criteria to reestablish the natural coastal processes to the extent possible by altering existing shore stabilization structures, and reestablishing coastal processes. To satisfy these Vision requirements, the plan also integrated the following features to improve the overall functioning and coastal resilience:

- Groin modifications
  - Shortening the Westhampton groin field by 70-100 ft. to reduce renourishment requirement to the shoreline to the west
  - Modifying groins at Ocean Beach in conjunction with relocation of the water supply.
  - Monitoring groins in the area of Georgica to determine if any structure modification is warranted.
- Restoration of Coastal Processes
  - Sand by-passing, as identified above
  - Inclusion of sediment management features in Downtown Montauk (Montauk Beach) and Potato Road
  - Bayside coastal process features
- Integration of Appropriate Land Use and Development Management Measures
- Integration of Considerations of Climate Change and Adaptive Management

5.6 Identification of the Tentative Federally Supported Plan

Based on public meetings and input received from the Department of Interior on the 2009 Formulation Report, a Tentative Federally Supported Plan (TFSP) was identified as modified Plan 3g as described above that included the following:

- Inlet Management –including the optimized Inlet management plans for Fire Island, Moriches, and Shinnecock Inlets
- Breach Response Plan with +13 ft. NGVD dune, proactive response for Shinnecock Bay reach , +9.5 ft. NGVD berm, conditional response within Wilderness Area, Major Federal Tracts, and Smith Point County Park;
- Nonstructural Plan NS3R, which provides for floodproofing structures within 10 year floodplain along with optimized road raising plan at 4 locations;
- Beach berm (90 ft.) with +15 ft. NGVD dune crest along barrier beaches within Great South Bay and Moriches Bay Reaches;
- Groin modifications at Westhampton Beach and Ocean Beach
- Sediment Management Features at Downtown Montauk (Montauk Beach) and Potato Road
- Inclusion of 23 coastal processes nature based restorations projects.

- Land Management recommendations
- 50 years of renourishment with an adaptive management strategy over the project life to address the uncertainties in project implementation

5.7 Post-Hurricane Sandy Modifications

Based upon the May 2009 Report, and subsequent coordination between the Army and DOI, in March 2011, USACE and DOI reached agreement on a Tentative Federally Supported Plan (TFSP). The TFSP was the modified Plan 3g described above, which included refinements to ensure the plan was mutually acceptable to USACE and DOI. The TFSP was identified as the NED Plan, since this is the plan that maximized net benefits, and satisfied the requirement (constraint) to be mutually acceptable with the Secretary of the Army and Secretary of Interior.

In March 2011, the USACE and DOI transmitted a summary of the TFSP to the State of New York to request their concurrence. By letter dated December 29, 2011, the State provided comments on the TFSP and requested clarification and further detail of the proposed project features and implementation steps.

Coordination was ongoing when Hurricane Sandy struck on October 29, 2012, and caused extensive damage to the project area, including extensive overwash, three breaches of the barrier island, and widespread flooding damages along the barrier island and mainland shorelines. Two of the breaches were closed. The breach located within the OP Wilderness Area was not closed, remains open, and is currently being monitored by DOI.

Following Hurricane Sandy, the Corps took the following actions in order to update the TFSP. The team included the following updates:

- The Corps updated the structure inventory and shoreline conditions, based upon post-Sandy changes.
- The Corps updated the hydrodynamic modeling that was done previously, to account for the breach that occurred in the Wilderness Area.
- The Corps updated the economics life-cycle model to account for the existing breach in the Otis Pike Wilderness Area, and also to reflect the new information available about observed / expected breach growth rates.
- The Corps accounted for post-Sandy efforts undertaken by the Corps, and by others. This includes repair of the existing projects, the Fire Island and Downtown Montauk Stabilization Projects, and nonstructural plans that have been implemented in the Project Area.

The Corps updated the TFSP in response to these changed conditions, and the risk and vulnerability within the study area demonstrated by Hurricane Sandy. There were significant changes made in the TFSP, which included:

- The updated, post-Sandy plan identified a dune alignment located further landward along the Middle alignment that reflects the post-Sandy beach and dune condition. (This alignment is consistent with the Fire Island Stabilization Plan, which includes the acquisition or relocation of approximately 40 homes located within the dune).

- The updated, post-Sandy plan recommends a +13 ft. NGVD proactive breach response plan in Smith Point County Park and in the Lighthouse Tract to provide a greater level of risk-reduction to the two heavily impacted areas (these plans are similar in scale to the project features constructed as part of the Fire Island Stabilization Project).
- Rather than a commitment for 50 years of renourishment, the updated, post-Sandy plan has been modified to recommend a 30-yr commitment of renourishment that recognizes the potential for variable beach conditions between renourishment cycles. After 30 years, a breach response plan is recommended for the remainder of the 50 years.
- The updated, post-Sandy plan defines conditional breach response in the Federal tracts of Land (with the exception of the Lighthouse tract) to include a period of up to 60 days to allow for a process to make a decision if a breach on Federally-owned lands will close naturally, or if mechanical closure is required.
- The updated, post-Sandy plan recognizes the improvements in land management regulations that will be recommended for implementation by others to complement the features recommended for FIMP.
- The updated, post-Sandy plan includes a refined set of coastal process features that improve the overall functioning and resilience of the plan.

The updated plan recognizes the need for adaptive management of the project features, for effective long-term management of the system. This updated plan was provided to New York State for their concurrence in May 2013. New York State agreed in concept with this plan in June 2013, recognizing that the plan would need further refinements in order to be finalized. Based upon the sponsor support, the Corps has proceeded with this plan as the Tentatively Selected Plan (TSP). In August 2015, the Corps advised New York State of their intent to proceed with this updated plan as the TSP.

Consistent with the Corps' planning process, the TSP is still subject to refinement, based upon public and agency review. These updates to the plan to arrive at the TSP have not been fully vetted within the Corps and DOI; however, the Corps and DOI have entered into an MOU in July 2014 in which both parties committed to finalizing the FIMP report, consistent with the Vision Statement. The Corps, State and DOI agreed to use the public and agency review process to finalize a TSP that meets the requirements of being mutually acceptable to the Secretary of the Army and Secretary of the Interior.

There are several elements of the TSP that the Corps, DOI, and New York State have agreed to continue to develop concurrent with the public and agency review process that may affect the final plan. This includes 1) the scope and extent of the coastal process features, 2) refinement of breach response protocols, 3) refinement of adaptive management, and 4) refinement of land management. The Corps and DOI recognize that there are additional needs and opportunities to provide for coastal process features which replicate the cross-island transport of sediment, provide barrier island resiliency, and long-term sustainability. With respect to the breach response protocols, the involved agencies have agreed that refinement of the decision-making protocols to better specify how the decisions related to breach closure would be made. Adaptive management is recognized as an important element of the selected plan, but the framework for adaptive management has not been defined. It is the intent of the agencies to identify the conditions under which changes in the plan could be made, and the framework for decision-making that would constitute an adaptive management plan. Land management is recognized as an important tool to manage future risks. The Federal and State agencies have agreed to continue to identify the land management measures that are available to manage these risks, and how these measures will work in conjunction with the TSP.

6 IDENTIFICATION OF THE TENTATIVELY SELECTED PLAN

6.1 Overview

The alternative development described in Section 5 highlighted work out of the "Fire Island to Montauk Point New York Reformulation Study Draft Formulation Report," 2009, pertinent parts of which are provided in Appendix E – Plan Formulation. Post Hurricane Sandy conditions and plan modifications in response to these changes have been incorporated into the TSP. The TSP is summarized below. An overall map of the TSP is shown in Figure 22. Since there is significant variation in the shorefront plan components, an overview of the shorefront TSP plan features is provided in Table 31 and Table 32.

As described above, there are several elements of the TSP that will continue to be refined as part of public and agency review, and as part of the discussions to identify a mutually acceptable plan.

Inlet Modifications

- Continuation of authorized navigation projects, and scheduled O&M dredging with beneficial reuse of sediment at Fire Island, Moriches and Shinnecock Inlets.
- Additional dredging of 73,000 to 379,000 cy from the ebb shoals of each inlet, outside of navigation channel, with downdrift placement undertaken in conjunction with scheduled O&M dredging of the inlets.
- Placement of a +13 ft. NGVD dune and berm, as needed in identified placement areas.
- Monitoring to facilitate adaptive management changes in the future to determine if changes in the volume, changes in the frequency, changes in the dredging or disposal location are required to effectively reestablish the alongshore transport.

Mainland and Nonstructural

- Addresses approximately 4,400 structures within 10 year flood plain using nonstructural measures, primarily through building retrofits, with limited relocations and buy-outs, based upon structure type and condition.
- Also includes road raising in four locations, totaling 5.91 miles in length that provides storm risk management for 1,020 houses.

Barrier Islands- Breach Response

- Proactive Breach Response - is a response plan which is triggered when the beach and dune are lowered below a 25 year design level of risk reduction and provides for restoration to the design condition (+13 ft. NGVD dune and 90 ft. berm). This plan will be utilized on Fire Island in the Lighthouse Tract, Smith Point County Park East (to supplement when needed the sand bypassing), and Smith Point County Park West and also on the Westhampton barrier island fronting Shinnecock Bay.
- Reactive Breach Response - is a response plan which is triggered when a breach has occurred, e.g. the condition where there is an exchange of ocean and bay water during normal

tidal conditions. It will be utilized as needed when a breach occurs, in locations that receive beach and dune placement.

- Conditional Breach Response – is a response plan that applies to the large, Federally-owned tracts within Fire Island National Seashore, where the breach closure team determines whether a breach should be closed, based upon whether or not the breach is closing naturally. Conditional Breach closure provides for a 90 ft. wide berm at elevation +9.5 ft. NGVD only.

Barrier Islands- Breach Response – Beach and Dune Fill

- Provides for a continuous 90 ft. width berm and +15 ft. dune along the developed shorefront areas fronting Great South Bay and Moriches Bay on Fire Island and Westhampton barrier islands.
- On Fire Island the alignment follows the post-Sandy optimized alignment (middle alignment) that includes overfill in the developed locations and minimizes tapers into Federal tracts.
- Renourishment: up to 30 years approximately every 4 years.

Sediment Management at Downtown Montauk (Montauk Beach) and Potato Road

- Provides for placing about 120,000 CY on front face of existing berm at each location approximately every 4 years as advance fill to offset erosion.
- The Potato Road feeder beach is contingent upon implementation of a local pond opening management plan for Georgica Pond.
- These features will be adaptively managed to ensure the volume of sediment placed, and placement configuration is accomplishing the design objectives of offsetting the long-term erosion.

Groin Modifications

- Shorten existing Westhampton groins (1-13) between 70 — 100 ft., to increase sediment transport (0.5M to 2M CY) to the west and reduce renourishment requirements.
- Modify existing Ocean Beach groins (shorten and lower).
- Continued monitoring of the Georgica groins to reaffirm the functioning of the groins.

Coastal Process Features

- Six (6) locations for coastal process features along the bayside shoreline that reestablish the coastal processes consistent with the Reformulation objectives. These measures are necessary to sustain the physical integrity of the natural systems, and to improve the overall resiliency.
- The selection of these sites is based upon an updated evaluation of alternatives following Hurricane Sandy. Additional sites may be developed as a result of agency coordination, to meet the long-term needs of cross-island transport.

Adaptive Management

- Will provide for monitoring and the ability to adjust specific project features to improve effectiveness.
- Climate change will be accounted for with the monitoring of climate change parameters, identification of the effect of climate change on the project design, and identification of adaptation measures that are necessary to accommodate climate changes as it relates to all the project elements.

Integration of Local Land Use Regulations and Management

- Local land management regulations to include enforcement of federal and state zoning requirements, as a necessary component for long-term risk reduction.

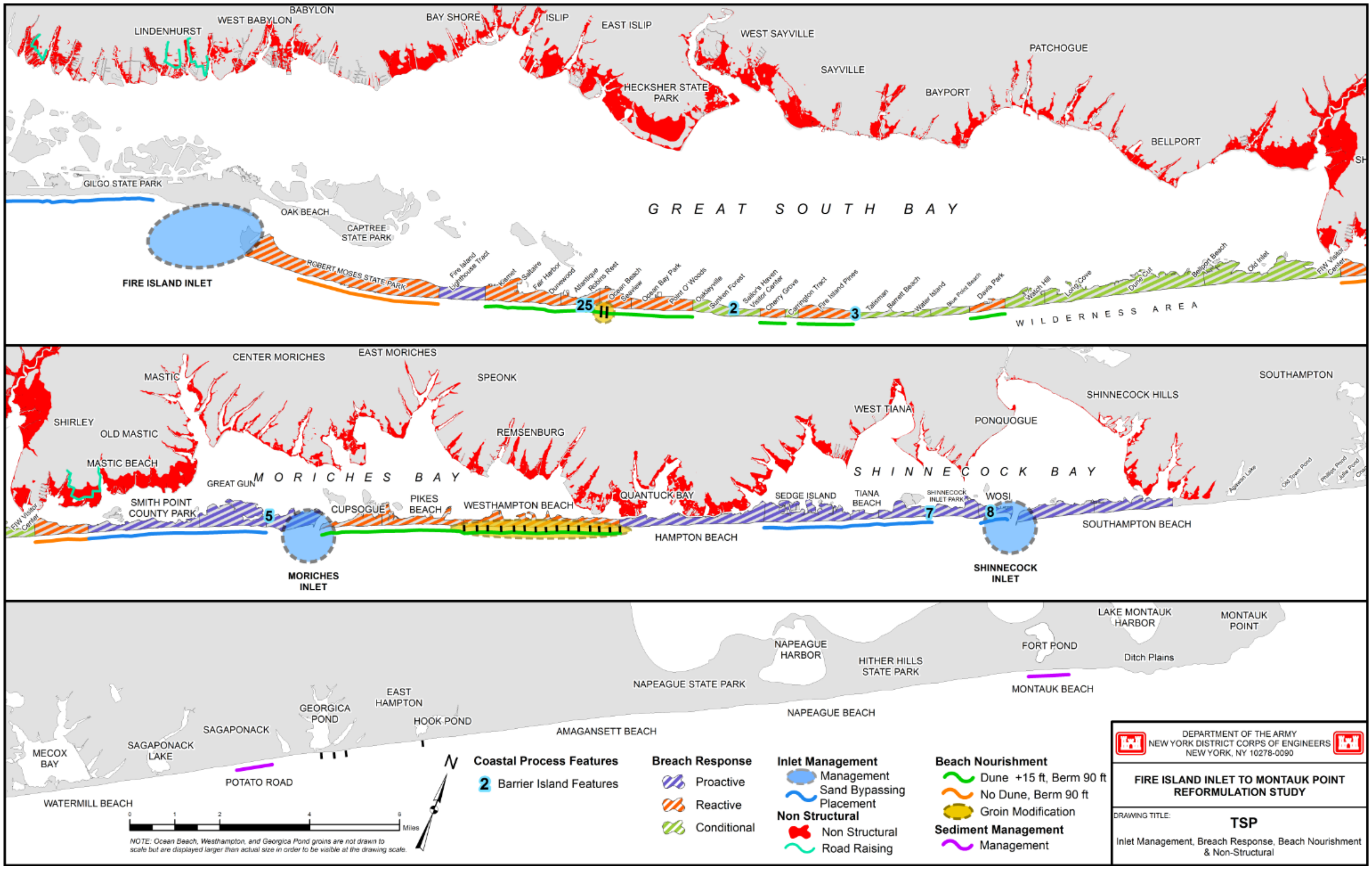


Figure 22. Overall Plan

Table 31. FIMP TSP Shorefront Reach Features – GSB to MB

Reach Designations					TFSP Description		
Project Reach	Design Reach	Design Subreach	Reach Name	Reach Length (ft)	Proposed Plan	Cross Section	Lifecycle Response
Fire Island Inlet and Gilgo Beach					Inlet Dredging and bypassing (FI)		bypassing, 2 yr cycle, 50 yrs
GSB	GSB-1	1A	Robert Moses State Park - West	6,700	Reactive Breach Response	+9.5 ft closure section	Reactive Closure, 50 yrs
		1A	Robert Moses State Park - East	19,000	Beach, no Dune, Renourishment	90 ft wide beach	renourishment for 30 years and reactive BR
		1B	FI Lighthouse Tract	6,700	Proactive Breach Response	+13 ft dune, 90 ft wide berm	Proactive and Reactive BR, 50 yrs
	GSB-2	2A	Kismet to Lonelyville	8,900	Beach, Dune and Renourishment	+15 ft dune, 90 ft wide berm	renourishment for 30 years and reactive BR
		2B	Town Beach to Corneille Estates	5,100	Beach, Dune and Renourishment	+15 ft dune, 90 ft wide berm	renourishment for 30 years and reactive BR
		2C	Ocean Beach & Seaview	3,800	Beach, Dune, Renourish, Groin Modification	+15 ft dune, 90 ft wide berm	renourishment for 30 years and reactive BR
		2D	OBP to Point O' Woods	7,400	Beach, Dune and Renourishment	+15 ft dune, 90 ft wide berm	renourishment for 30 years and reactive BR
		2E	Sailors Haven	8,100	Contingent Breach Response	+9.5 ft closure section	Contingent Closure, 50 yrs
	GSB-3	3A	Cherry Grove	3,000	Beach, Dune and Renourishment	+15 ft dune, 90 ft wide berm	renourishment for 30 years and reactive BR
		3B	Carrington Tract	1,500	Contingent Breach Response	+9.5 ft closure section	Contingent Closure, 50 yrs
		3C	Fire Island Pines	6,600	Beach, Dune and Renourishment	+15 ft dune, 90 ft wide berm	renourishment for 30 years and reactive BR
		3D	Talisman to Water Island	7,300	Contingent Breach Response	+9.5 ft closure section	Contingent Closure, 50 yrs
		3E	Water Island	2,000	Contingent Breach Response	+9.5 ft closure section	Contingent Closure, 50 yrs
		3F	Water Island to Davis Park	4,700	Contingent Breach Response	+9.5 ft closure section	Contingent Closure, 50 yrs
		3G	Davis Park	4,100	Beach, Dune and Renourishment	+15 ft dune, 90 ft wide berm	renourishment for 30 years and reactive BR
		3H	Watch Hill	5,000	Contingent Breach Response	+9.5 ft closure section	Contingent Closure, 50 yrs
	GSB-4	4A	Wilderness Area - West	19,000	Contingent Breach Response	+9.5 ft closure section	Contingent Closure, 50 yrs
		4B	Old Inlet	16,000	Contingent Breach Response	+9.5 ft closure section	Contingent Closure, 50 yrs
MB	MB-1	1A	Smith Point CP- West	6,300	Beach, Dune and Renourishment	90 ft wide beach	renourishment for 30 years and reactive BR
		1B	Smith Point CP - East	13,500	Proactive Breach Response, sand bypassing	+13 ft dune, 90 ft wide berm	sand bypassing placement, 2 yr cycle, 50 yrs; proactive and reactive BR, 50 yrs
	MB-2	2A	Great Gun	7,600	Proactive Breach Response, sand bypassing	+13 ft dune, 90 ft wide berm	sand bypassing placement, 2 yr cycle, 50 yrs; proactive and reactive BR, 50 yrs
		2B	Moriches Inlet - West	6,200	Proactive Breach Response	+13 ft dune, 90 ft wide berm	proactive and reactive BR, 50 yrs
Moriches Inlet					Inlet Bypassing		bypassing, 2 yr cycle, 50 yrs
		2C	Cupsogue Co Park	7,500	Beach, Dune and Renourishment	+15 ft dune, 90 ft wide berm	renourishment for 30 years and reactive BR
		2D	Pikes	9,700	Beach, Dune and Renourishment	+15 ft dune, 90 ft wide berm	renourishment for 30 years and reactive BR
		2E	Westhampton	18,300	Beach, Dune, Renourish, Groin Modification	+15 ft dune, 90 ft wide berm	renourishment for 30 years and reactive BR

Table 32. FIMP TSP Shorefront Reach Features – SB to M

Reach Designations					TFSP Description		
Project Reach	Design Reach	Design Subreach	Reach Name	Reach Length (ft)	Proposed Plan	Cross Section	Lifecycle Response
SB	SB-1	1A	Hampton Beach	16,800	Proactive Breach Response	+13 ft dune, 90 ft wide berm	proactive & reactive response, 50 years
		1B	Sedge Island	10,200	Proactive Breach Response, bypassing	+13 ft dune, 90 ft wide berm	sand bypassing placement, 2 yr cycle, 50 yrs; proactive and reactive BR, 50 yrs
		1C	Tiana Beach	3,400	Proactive Breach Response, bypassing	+13 ft dune, 90 ft wide berm	sand bypassing placement, 2 yr cycle, 50 yrs; proactive and reactive BR, 50 yrs
		1D	Shinnecock Inlet Park West	6,300	Proactive Breach Response, bypassing	+13 ft dune, 90 ft wide berm	sand bypassing placement, 2 yr cycle, 50 yrs; proactive and reactive BR, 50 yrs
	SB-2	2A	Ponquogue	5,300	Proactive Breach Response	+13 ft dune, 90 ft wide berm	proactive and reactive BR, 50 yrs
		2B	WOSI	3,900	Proactive Breach Response, bypassing	+13 ft dune, 90 ft wide berm	sand bypassing placement, 2 yr cycle, 50 yrs; proactive and reactive BR, 50 yrs
Shinnecock Inlet					Inlet Dredging and bypassing		bypassing, 2 yr cycle, 50 yrs
	SB-3	2C	Shinnecock Inlet - East	9,800	Proactive Breach Response	+13 ft dune, 90 ft wide berm	proactive and reactive BR, 50 yrs
		3A	Southampton Beach	9,200	Proactive Breach Response	+13 ft dune, 90 ft wide berm	proactive and reactive BR, 50 yrs
		3B	Southampton	5,300	No Federal Action		
		3C	Agawam	3,800	No Federal Action		
P	P-1	1A	Wickapogue	7,700	No Federal Action		
		1B	Watermill	8,800	No Federal Action		
		1C	Mecox Bay	1,400	No Federal Action		
		1D	Mecox to Sagaponack	10,400	No Federal Action		
		1E	Sagaponack Lake	1,100	No Federal Action		
		1F	Sagaponack to Potato Rd	9,300	No Federal Action		
		1G	Potato Rd	4,300	Sediment Management, Pond Management Plan	+9.5 ft beach	Sediment Management features, 4 yr cycle 50 yrs
		1H	Wainscott	4,600	No Federal Action		
		1I	Georgica Pond	1,200	No Federal Action		
		1J	Georgica to Hook Pond	11,200	No Federal Action		
		1K	Hook Pond	1,100	No Federal Action		
		1L	Hook Pond to Amagansett	19,200	No Federal Action		
M	M-1	1A	Amagansett	10,400	No Federal Action		
		1B	Napeague State Park	9,100	No Federal Action		
		1C	Napeague Beach	9,900	No Federal Action		
		1D	Hither Hills SP	7,000	No Federal Action		
		1E	Hither Hills to Montauk B	15,800	No Federal Action		
		1F	Montauk Beach	4,700	Sediment Management	+9.5 ft beach	Continuation of Stabilization Project (Major Rehab); Sediment Management features, 4 yr cycle 50 yrs
		1G	Montauk B to Ditch Plains	4,700	No Federal Action		
		1H	Ditch Plains	3,400	No Federal Action		
		1I	Ditch Plains to Montauk Pt	19,300	No Federal Action		

6.1.1 Inlet Management Plan

The selected inlet management plans at all three inlets consists of continuation of the existing authorized projects and additional dredging of the ebb shoal, outside of the navigation channel, with downdrift placement (Figure 18, Figure 19, and Figure 20). Ebb shoal dredging would be undertaken in conjunction with scheduled Operations and Maintenance (O&M) dredging of the inlets and would increase sediment bypassing and reduced future renourishment fill requirements.

Fire Island Inlet

- O&M on 2 year interval (Authorized);
- 819,000 cy (per O&M event) dredged from channel and deposition basin and placed downdrift at Gilgo Beach;
- 214,000 cy (per O&M event) dredged from channel and expanded deposition basin and placed updrift at RMSP;
- 327,000 cy (per O&M event) dredged from ebb shoal and placed downdrift at to offset deficit.

Moriches Inlet

- O&M on 1 year interval (Authorized);
- 98,000 cy (per O&M event) dredged from channel and deposition basin and placed downdrift at SPCP;
- 73,000 cy (per O&OM event) dredged from ebb shoal and placed downdrift at Gilgo Beach to offset sediment deficit.

Despite being authorized for O&M on a 1-year interval, Moriches Inlet has only been dredged about once every 4 years. Even if the inlet continues to be dredged once every 4 years there should be sufficient sediment available from the channel, deposition basin, and ebb shoal to meet the renourishment requirements at MB-1A.

Shinnecock Inlet

- O&M on 2 year interval (Authorized);
- 170,000 cy (per O&M event) dredged from channel and deposition basin and placed downdrift at Sedge Island, Tiana Beach, and West of Shinnecock (WOSI);
- 105,000 cy (per O&M event) dredged from ebb shoal and placed downdrift at SPCP to offset sediment deficit.

Placement of sediment downdrift at Sedge Island, Tiana Beach, SPW, and WOSI will maintain the natural longshore transport, increase sediment bypassing, increase stability of these shorelines, and reduce future Proactive BRP fill requirements.

6.1.1.1 Inlet Management – Initial Construction

Initial construction quantities include the estimated quantity to restore the channel to its authorized dimensions as well as dredging of the ebb shoal for bypassing. Initial construction quantities were estimated based on expected sedimentation in the authorized channel over the period between the last dredging operation and start of construction for FIMP in 2018. Table 33 shows the date of last dredging event and the number of years in which sedimentation may occur.

Table 33. Number of Years between Last Inlet Dredging Operation and FIMP

Inlet	Sedimentation (years)	Last Dredging Event
Fire Island Inlet	4	Fall 2014
Moriches Inlet	6	Fall of 2012
Shinnecock Inlet	4	March of 2014

Sedimentation rates at the three inlets are based on the Existing Conditions sediment budget at each inlet. These sedimentation rates may lead to an over estimation of the initial dredging quantities since the anticipated time between dredging events is larger than normal and the sedimentation rates may decrease over time as the inlets shoal. Table 34 presents the initial construction dredging volumes and placement locations for the Inlet Management Plan. Actual dredging volumes and distribution of the fill placement will be refined during PED based on surveys of the inlets and beach prior to construction.

Table 34. Inlet Management Bypassing and Backpassing (Initial Construction)

Location	Subreach	Fill Length (ft.)	Volume (cy)
Fire Island Inlet – Initial Construction			
Gilgo Beach		12,700	2,126,469
RMSP	GSB-1A	12,000	214,531
		Total	**2,341,000**
Moriches Inlet – Initial Construction			
SPCP-West	MB-1A	6,900	67,470
SPCP-East	MB-1B	13,100	330,840
Great Gunn	MB-2A	4,500	113,691
		Total	**512,000**
Shinnecock Inlet – Initial Construction			
SPW	SB-1D	3,400	99,350
WOSI	SB-2B	2,700	449,650
		Total	**275,000**

6.1.1.2 Inlet Management – Life Cycle

Following the initial dredging of the inlets to authorized depths, future maintenance quantities are expected to on average equal the values outlined in the TSP. A summary of the dredging quantities and placement locations for bypassing and backpassing for all future dredging operations is shown in Table 35. As described earlier, if Moriches Inlet is dredged at a longer interval than it is expected that the majority of the dredged material will be placed at SPCP-West.

Table 35. Inlet Management Bypassing and Backpassing (Life Cycle)

Location	Subreach	Fill Length (ft.)	Volume per Operation (cy)
Fire Island Inlet – 2 year Dredging Cycle			
Gilgo Beach		12,700	1,145,469
RMSP	GSB-1A	12,000	214,531
		Total	**1,360,000**
Moriches Inlet – 1 year Dredging Cycle			
SPCP-West	MB-1A	6,900	22,490
SPCP-East	MB-1B	13,100	110,528
Great Gunn	MB-2A	4,500	37,982
		Total	**171,000**
Shinnecock Inlet – 2 year Dredging Cycle			
Sedge Island	SB-1B	5,600	47,419
Tiana Beach	SB-1C	3,400	28,790
SPW	SB-1D	3,400	28,790
WOSI	SB-2B	2,700	170,000
		Total	**275,000**

6.1.2 Nonstructural and Road Raising Plan

The plan for the mainland will remain consistent with the Plan NS-3R that was described in Sections 5.4.2.4-5. As shown in Table 27, the plan provides for storm risk management for a total of 4,138 structures, of which 2,424 would be elevated, 1,450 would receive flood proofing, 56, would receive ringwalls, 195 would be rebuilt and 4 would be bought out.

The number of non-structural treatments by town are as follows:

Babylon	1,444
Islip	944
Brookhaven	1,045
Southampton	705

In addition, the Plan NS-3R provides for road raising that provides coastal storm risk management including road raising which provides storm risk management for an additional 1,054 structures and would be located in the following communities:

Amityville (Babylon)	97
Lindenhurst (Babylon)	602
Mastic Beach (Brookhaven)	355

The locations are conceptually shown in Figure 22 in red based on the 10-year flood plain. The detailed plans are shown in the Plates Appendix.

6.1.3 Breach Response Plans

6.1.3.1 Proactive Breach Response Plan

The Proactive Breach Response Plan is an alternative that includes measures to take action to prevent breaches from occurring at locations vulnerable to breaching, when a breach is imminent. This alternative provides a beach cross-section area that is comparable to the Breach Response Alternatives, and smaller than a beach fill alternative.

These plans are not specifically designed with the intent of minimizing ocean shorefront development from overwash, wave attack or storm induced erosion losses, and the plans allow for a greater level of overwash and dune lowering during a storm, so long as the overwash extent is below the threshold that would result in breaching.

This feature includes the +13 ft. NGVD dune section. A typical Proactive BRP section is shown in Figure 23.

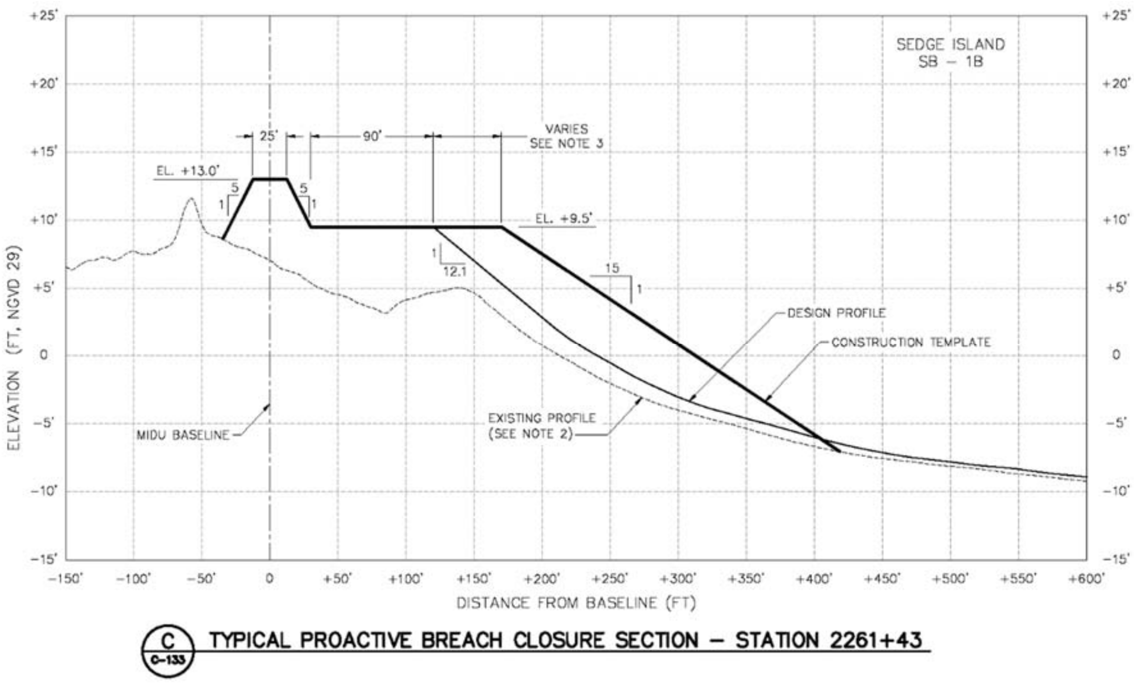


Figure 23. Typical Proactive BRP Section

Initial Construction (Proactive BRP)

Four of the Proactive BRP reaches were recently nourished as part of either FIMI (FILT, SPCP- East, and Great Gunn) or the WOSI Interim Project (WOSI). Due to the relatively low erosion rates at FILT, SPCP-East, and Great Gunn it is not expected that Proactive BRP would be required at any of these locations at the time of initial construction in 2018. However, due to the relatively high erosion rates at WOSI, initial Proactive BRP beach fill placement is expected to be required at this location. Initial construction volumes at WOSI were estimated following the same approach as the Beach Fill Plan reaches based on predicted losses.

At the other Proactive BRP reaches along Shinnecock Bay an assessment was conducted to determine if the existing effective beach width is below the Proactive BRP thresholds warranting beach fill placement during initial construction of FIMP. LIDAR data collected by the USACE on November 14, 2012 (two weeks following Hurricane Sandy) was used to define the existing conditions. The effective beach width at three reaches, Sedge Island, Tiana Beach, and SPW was below the threshold. Initial construction volume estimates at these three locations is derived from quantity takeoffs based on the 2012 LIDAR data and Proactive BRP template. Average-end-area calculations were completed based on profiles spaced 200 feet apart. All Proactive BRP quantities include 15% overfill and 15% contingency/tolerance. No advance fill is included in the Proactive BRP.

A summary of the initial construction quantities for the Proactive BRP is provided in Table 36.

Table 36. Proactive BRP Initial Construction Quantities

Location	Subreach	Sediment Source	Fill Length (ft.)	Volume (cy)
Sedge Island	SB-1B	BA 5Bexp	10,200	1,007,463
Tiana Beach	SB-1C	BA 5Bexp	3,400	131,220
SPW	SB-1D	BA 5Bexp	3,400	187,148
SPW	SB-1D	SI	3,400	99,350
WOSI	SB-2B	SI	2,700	449,650
			Total	**1,875,000**

6.1.3.2 Reactive and Conditional Breach Closure

Reactive Breach Response is to be implemented in response to the occurrence of a breach at any locations along the barrier islands, except the large federally-owned tracts within Fire Island National Seashore. Conditional Breach Response applies to these FIIS tracts, in which the breach response team will assess if the breach is closing naturally or if mechanical closure is required.

The Reactive and Conditional BRP templates are similar, except the Reactive template has a +13’ NGVD dune to reduce the potential for rebreaching. Both breach closure templates have a berm with height of +9.5 ft. NGVD. A typical breach closure section at Old Inlet West and WOSI is shown in Figure 24. Since the intent of the closure is to fill a breach, a specific berm width has not been established. Instead the intent is to generally match the berm width with conditions prior to the breach and within adjacent areas. The design foreshore slope is 1 on 12 which is also the same slope defined for the beach fill design templates. The design profile below MHW would match the representative morphological profile corresponding to each specific location. At a minimum, bayside slopes and shorelines would generally match the preexisting adjacent shorelines. Based on the existing topography the bayside design slope was selected as 1 on 20 from the bayside crest of the berm to an elevation of +6 ft. NGVD. It is recognized that breaches result in the transport of sand that introduces sediment into the bay, and that the mechanical closure of breaches would reduce the amount of sediment that could be transported. The breach closure plans will include an additional quantity of sand on the bayside of the barrier island to replicate this process, to enhance the long-term stability and resiliency of the closure action. The specific dimensions and configuration will be developed as part of the breach closure plan at the time of the closure operation.

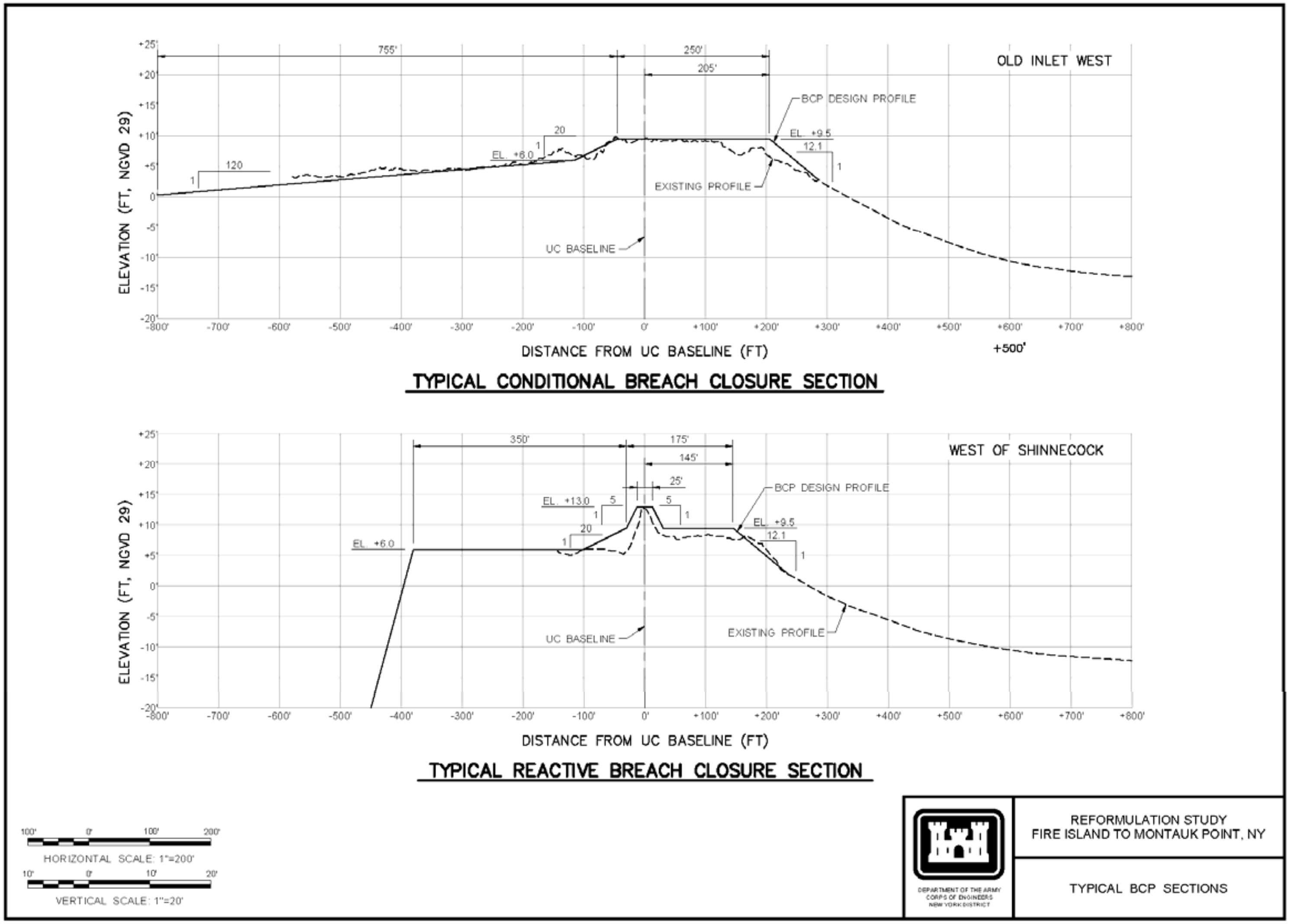


Figure 24. Typical Breach Closure Sections

6.1.4 Beach Fill Plan

Specific locations for backfill are outlined in Table 37.The extend of beachfill east of Fire Island (Cupsogue County Park, Pikes & Westhampton) remained consistent with the earlier TFSP. There have been refinements in the beachfill plan on Fire Island.

The *Berm Only* and *Medium* design templates are used in the selected plan. The *Medium* design template has a dune with a crest width of 25 feet and dune elevation of +15 feet NGVD. Both design templates have a berm width of 90 feet at elevation +9.5 feet NGVD. The proposed design (not construction) foreshore slope (from +9.5 to +2 feet NGVD) is roughly 12.1 on 1. Below MHW (roughly +2 feet NGVD) the submerged morphological profile, representative of each specific reach, is translated and used as the design profile. Figure 25 and Figure 26 shows typical design section for the *Berm Only* and *Medium* design templates. Table 37 provides an overview of the dune elevations by location along the selected plan.

The *Berm Only* template is applicable to areas in which the existing condition dune elevation and width reduce the risk of breaching but have eroded beach berm conditions. The 90 feet design berm provides protection to the existing dunes and ensure vehicular access during emergency response and evacuation. The *Berm Only* template is applied to RMSP (GSB-1A) and SPCP-West (MB-1A).

The *Medium* template was identified as having the highest net benefits and provides for approximately a 50-yr level of risk reduction. The Medium template is applied to the areas with the greatest potential for damages to oceanfront structures.

Advance fill is a sacrificial quantity of sand which acts as an erosional buffer against long-term and storm-induced erosion as well as beach fill losses cause by “spreading out” or diffusion. The required advance berm width was computed based on representative erosion rates and expected renourishment interval, 4 years. The representative erosion rates were calculated based on the historical sediment budget, volumetric changes in measured profiles between 1988 and 2012, the performance of recent beach fill projects, and anticipated beach fill spreading.

The Beach Fill Plan includes taper (transition) to reduce end losses and increase the longevity of the fill. The taper lengths along Fire Island are consistent with the plans for FIMI. Tapers are accounted for in initial and renourishment volume estimates.

Table 37. Beach Fill Locations

Location	Subreach	Plan Component	Max Fill Length (ft.)	Ren. Fill Length (ft.)	Dune Elv. (ft., NGVD)
RMSP	GSB-1A	Beach Fill & Inlet Mgmt.	16,600	12,000	-
Kismet to Lonelyville	GSB-2A	Beach Fill	8,900	8,900	15
Town Beach to Corneille Est.	GSB-2B	Beach Fill	4,500	4,500	15
Ocean Beach to Seaview	GSB-2C	Beach Fill	3,800	3,800	15
OBP to POW	GSB-2D	Beach Fill	7,300	7,300	15
Cherry Grove	GSB-3A	Beach Fill	3,000	3,400	15
Fire Island Pines	GSB-3C	Beach Fill	6,500	7,000	15
Water Island	GSB-3E	Beach Fill	1,200	1,600	15

Location	Subreach	Plan Component	Max Fill Length (ft.)	Ren. Fill Length (ft.)	Dune Elv. (ft., NGVD)
Davis Park	GSB-3G	Beach Fill	4,200	5,000	15
SPCP-West	MB-1A	Beach Fill & Inlet Mgmt.	6,300	6,300	-
Cupsogue	MB-2C	Beach Fill	4,300	2,000	15
Pikes	MB-2D	Beach Fill	9,600	9,600	15
Westhampton	MB-2E	Beach Fill	10,900	10,900	15

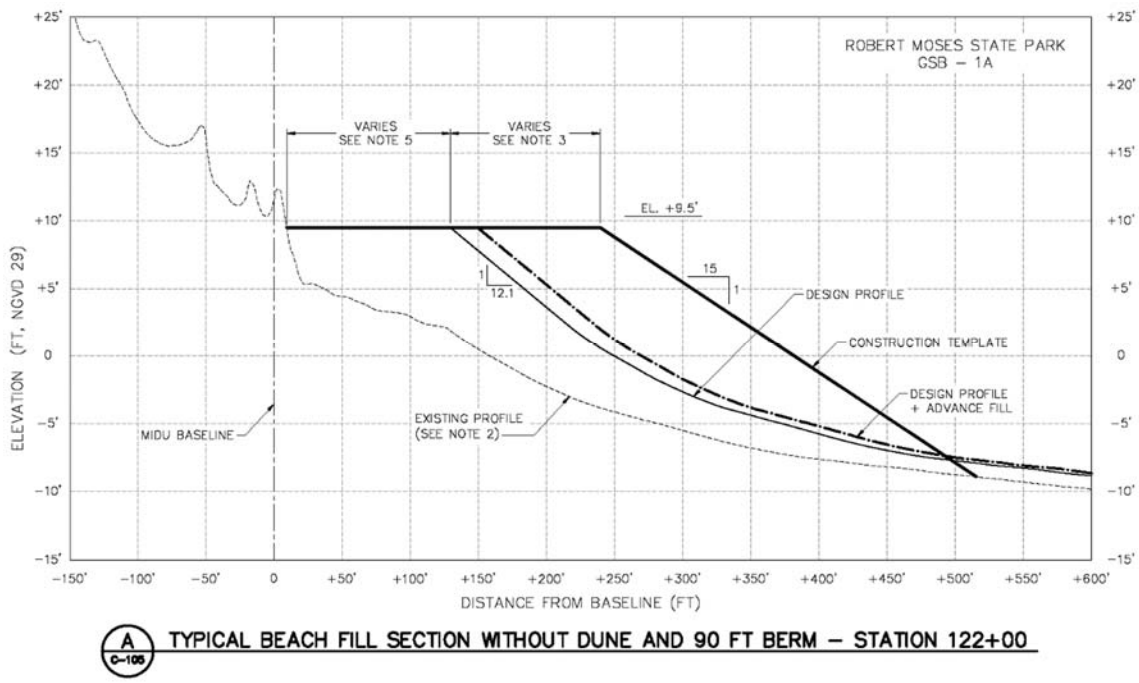


Figure 25. Berm Only Beach Fill Design Profile

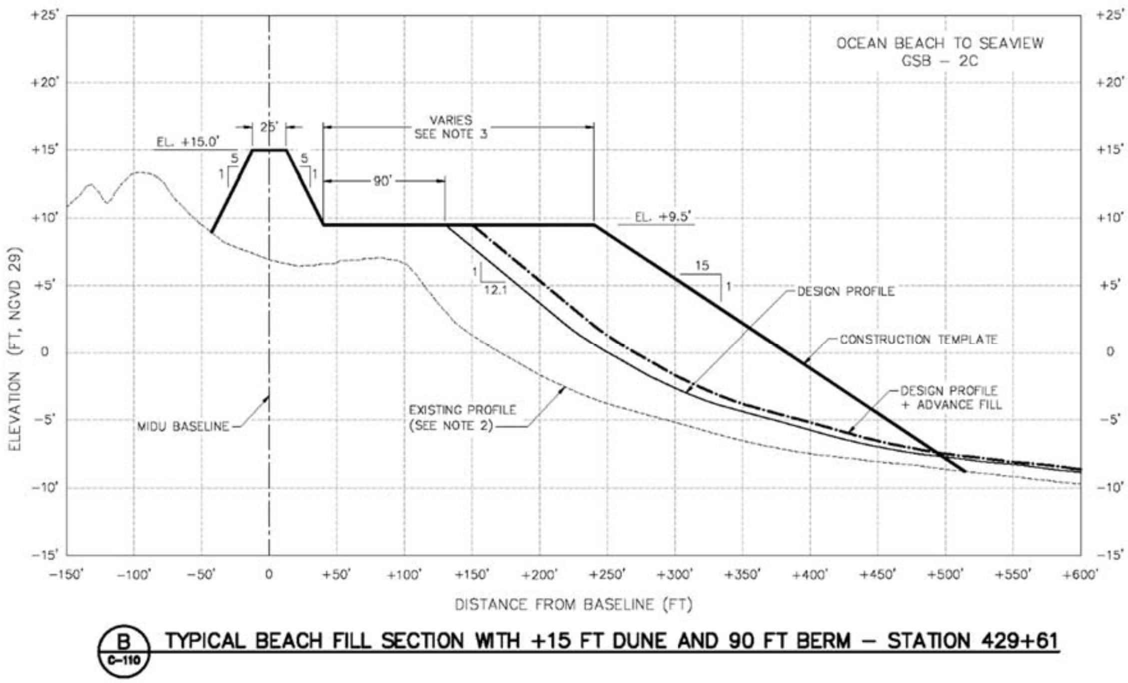


Figure 26. +15 FT NGVD Dune Design Profile

6.1.4.1 Beach Fill Plan – Initial Construction

With the exception of Cupsogue, all of the beach fill design reaches have been recently constructed or are soon to be under construction as part of the Fire Island to Moriches Inlet (FIMI) Stabilization Project or Westhampton Interim Project. Therefore, it is not possible to use the existing beach conditions to estimate initial construction beach fill volumes at the start of the FIMP project in 2018. Instead, initial beach fill volumes were estimated based on predicted sediment losses following the completion of the FIMI and Westhampton Interim projects.

It is noted that advance fill was included in the design and construction of FIMI and the Westhampton Interim Project. Therefore, by restoring sediment losses the initial construction estimates for FIMP indirectly include advance fill. All beach fill quantity estimates include advance fill, 15% overfill, and 15% for contingency/tolerance. A summary of the initial construction quantities for the Beach Fill Plan is shown in Table 38.

Table 38. Beach Fill Plan Initial Construction Quantities

Location	Subreach	Sediment Source	Fill Length (ft.)	Volume (cy)
Kismet to Lonelyville	GSB-2A	2C	8,900	159,432
Town Beach to Corneille Estates	GSB-2B	2C	4,500	40,484
Ocean Beach to Seaview	GSB-2C	2C	3,800	33,538
OBP to POW	GSB-2D	2C	7,300	65,396
Cherry Grove	GSB-3A	2H	3,400	12,117
Fire Island Pines	GSB-3C	2H	7,000	125,751
Water Island	GSB-3E	2H	1,600	5,589

Location	Subreach	Sediment Source	Fill Length (ft.)	Volume (cy)
Davis Park	GSB-3G	2H	5,000	107,029
			Fire Island Subtotal	**549,000**
Cupsogue	MB-2C	4C	2,000	107,265
Pikes	MB-2D	4C	9,600	464,834
Westhampton	MB-2E	4C	10,900	351,015
			Westhampton Subtotal	**923,000**
			Total	**1,472,000**

Notes: RMSP and SPCP-West are not shown here because the required fill material is coming from the Inlet Management Plan.

6.1.4.2 Beach Fill Plan – Life Cycle

The required renourishment fill volumes have been computed based on representative erosion rates and expected renourishment interval, 4 years. The representative erosion rates were calculated based on the historical sediment budget, volumetric changes in measured profiles between 1988 and 2012, the performance of recent beach fill projects, and anticipated beach fill spreading. All beach fill quantity estimates include advance fill, 15% overfill, and 15% for contingency/tolerance.

The renourishment fill volumes assume that the Westhampton groins will be modified in year 4 and sediment losses in Pikes Beach (MB-2D) will subsequently decrease by 40,000 cy/yr. A summary of the renourishment quantities for the Beach Fill Plan is provided Table 39.

Table 39. Beach Fill Plan - Renourishment Quantities Per Operation

Location[1]	Subreach	Sediment Source	Fill Length (ft.)	Volume (cy)
Kismet to Lonelyville	GSB-2A	2C	8,900	318,864
Town Beach to Corneille Estates	GSB-2B	2C	4,500	161,935
Ocean Beach to Seaview	GSB-2C	2C	3,800	134,153
OBP to POW	GSB-2D	2C	7,300	261,584
Cherry Grove	GSB-3A	2H	3,400	48,470
Fire Island Pines	GSB-3C	2H	7,000	503,003
Water Island	GSB-3E	2H	1,600	22,354
Davis Park	GSB-3G	2H	5,000	428,117
			Fire Island Subtotal	**1,878,000**
Cupsogue	MB-2C	4C	2,000	71,510
Pikes[2]	MB-2D	4C	9,600	6,197,792
Westhampton	MB-2E	4C	10,900	468,020
			Westhampton Subtotal	**1,159,000**
			Total	**3,038,000**

[1]RMSP and SPCP-West are not shown here because the required fill material is coming from the Inlet Management Plan.
[2]Renourishment quantities in Pikes Beach will decrease by 160,000 cy per operation after the groin modification is complete.

6.1.5 Sediment Management Plan

The sediment management plans include the establishment of two feeder beaches at Potato Road and Downtown Montauk (Montauk Beach) as shown in Table 40. The construction template is a berm with a variable width at an elevation of +9.5 feet NGVD29. The berm width will be determined based on a fill volume of 120,000 cy. As described previously, the 120,000 CY is designed to offset the long-term erosion within these areas, and to maintain a stable beach configuration. A typical section of the sediment management feature is shown in Figure 27.

Table 40. Sediment Management Fill Volumes

Location	Subreach	Sediment Source	Fill Length (ft.)	Volume (cy)
Potato Road	P-1G	BA 6I	3,300	120,000
Downtown Montauk	M-1F	BA 8D	3,200	120,000
			Total	**240,000**

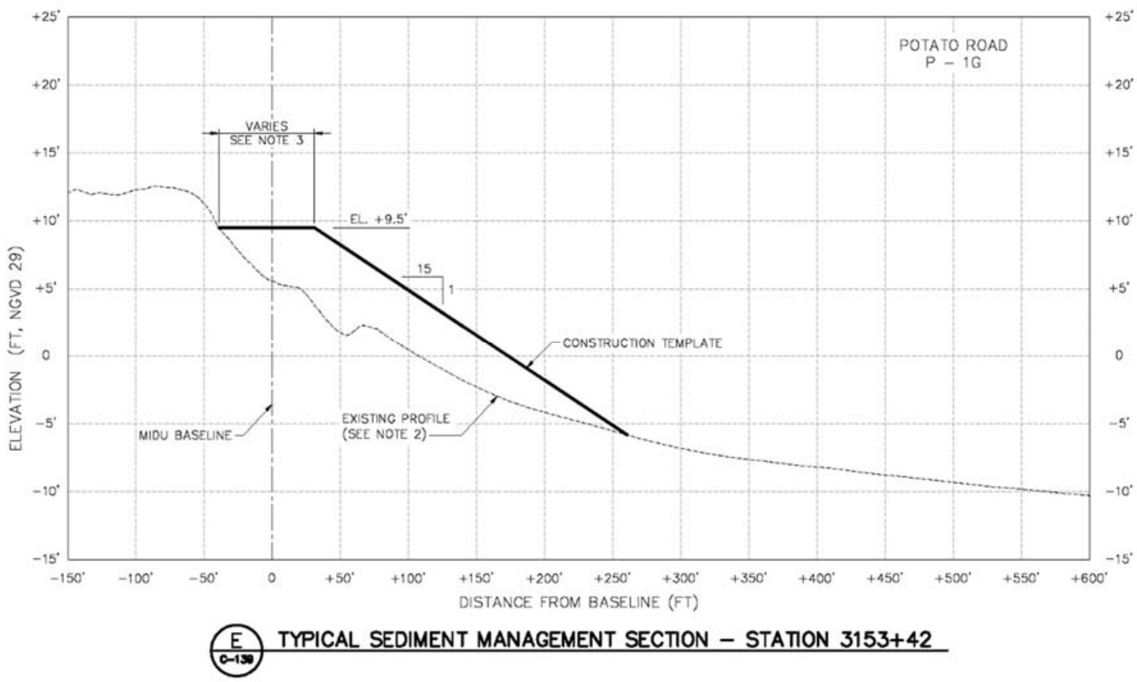


Figure 27. Typical Sediment Management Construction Template

6.1.6 Groin Modification Plan

The groin modification plan is consistent with what was developed in Section 5.5 and the TFSP. It includes:

- Shortening of Westhampton groins 1 through 8 to 380 ft.
- Shortening of Westhampton groins 9 through 13 to 386, 392, 398, 402, and 410 ft., respectively.
- Shortening of 2 groins at Ocean Beach. Final plan to be determined, but will involve some shortening, and possible lowering on the landward side to ensure reliable access over the groin.

6.1.7 Coastal Process Features

As noted earlier in this document, the Reformulation evolved from a multi-purpose project into a single purpose, Coastal Storm Risk Management project with the adoption of P.L. 113-2, following Hurricane

Sandy. Initial formulation considered restoration opportunities within the study area for several reasons: it was an allowable purpose, the restoration was developed to contribute to CSRM, and restoration was a critical element of the Reformulation which met the Vision Objectives, and contributed to the development of a mutually acceptable plan between the Army Corps and the Department of the Interior.

The initial identification of potential restoration sites was undertaken by the interagency study team who provided input on desired sites for restoration and coastal process restoration objectives. Their inclusion in the TFSP was a critical element of a mutually acceptable plan.

Since the project evolved into a single purpose CSRM project which must recommend a mutually acceptable plan, only those natural features which reestablish coastal processes and directly contribute to CSRM are recommended for inclusion in the updated TSP. These Coastal Process Features were identified for locations where they augment the recommended shorefront CSRM measures.

There were several coastal process features identified in the initial formulation that were eliminated because they were made infeasible following Hurricane Sandy, either as a result of landfrom changes, or the construction of the FIMI project. There were also several sites and plans that were eliminated from consideration as coastal process features because the proposed solutions did not contain a direct linakge to coastal storm risk management. The coastal process features that remain are those that contribute to strengthening the resiliency of the barrier island.   In light of these updated evaluation criteria, the interagency team is considering if there are additional locations and alternatives that could be implemented that would achieve these objectives as natural features that contribute to coastal storm risk management.

A summary of the recommended restoration of coastal processes measures are shown in Figure 28 and summarized in Table 41. The coastal process features will be accomplished in conjunction with the associated beach fill contracts.

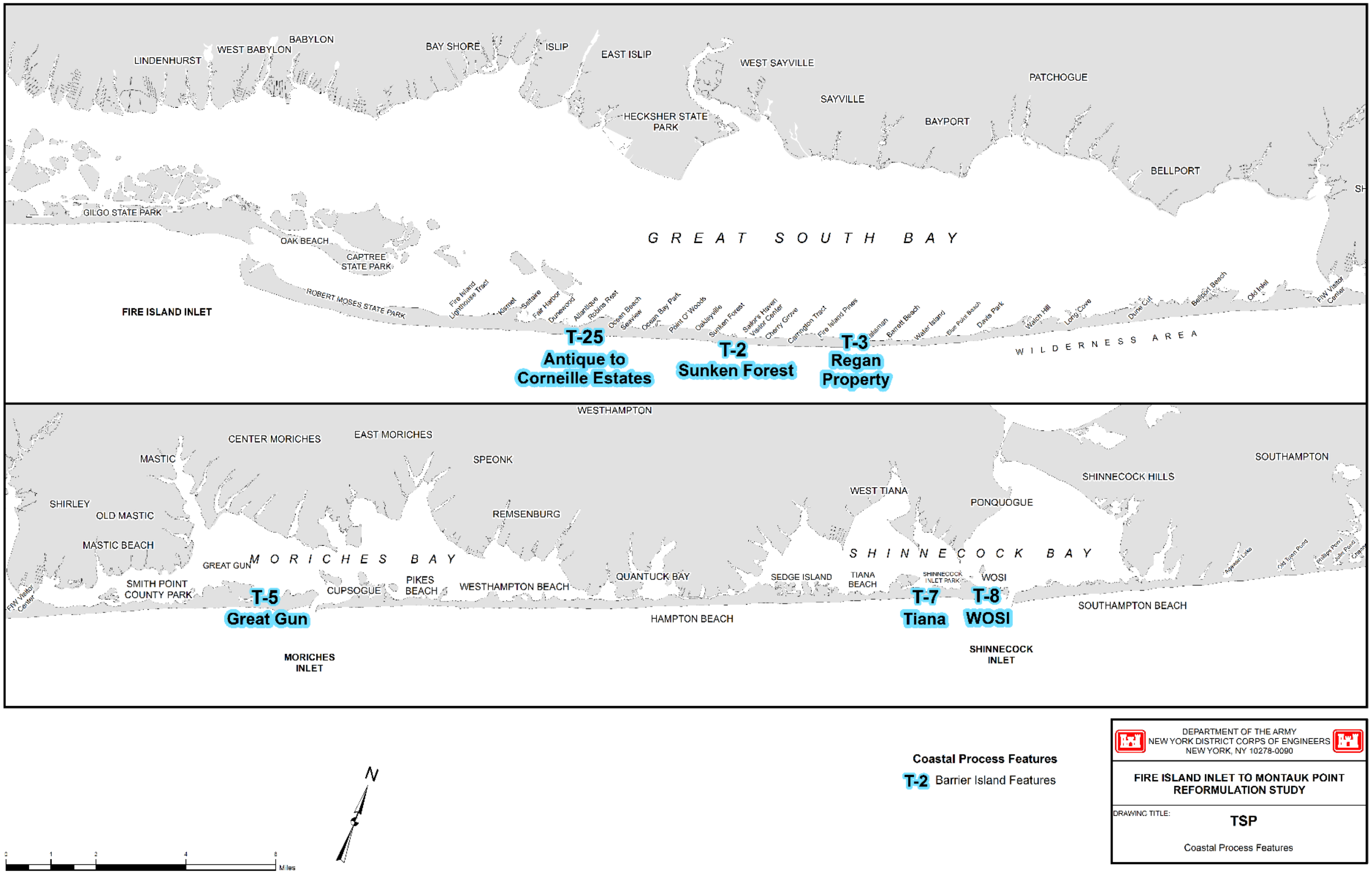


Figure 28. Location of Coastal Project Features

Table 41. Proposed Coastal Process Features Included in the TSP

Site	Alternative ID	Goal/Target	Description
		Barrier Islands	
T-2 Sunken Forest	Combined 1,2,3		
Alternative 1	T-2-1	eroding bayside shoreline	Remove bulkhead adjacent to marina, re-grade shoreline and stabilize using bio-engineering, control *Phragmites*
Alternative 2	T-2-2	upper beach and dune	Enhance upper beach/dune width/slope/height, reduce disturbance by removing the boardwalk and installing a dune walkover, and restoring dune at cuts
Alternative 3	T-2-3	upland and interior dune areas	Restore interior upland and dune areas of the site to natural conditions by removing all hard structures, removing boardwalks and dune walkovers, closing off and re-grading all disturbed areas/roads/trails (except one to provide access from marina)
T-3 Reagan Property	Combined 1,2,3		
Alternative 1	T-3-1	eroding bayside shoreline	Re-grade eroding bayside shoreline and stabilize using bio-engineering (vegetated gabions)
* Alternative 2	T-3-2	upper beach and dune	Enhance upper beach/dune width/slope/height, reduce disturbance by closing off some access roads and trails, removing sand fence, raise boardwalks above dunes and restore
Alternative 3	T-3-3	bulkheaded areas of bayside shoreline	Bury bulkhead, re-grade shoreline and create intertidal area, stabilize shoreline using bio-engineering
T-5 Great Gunn	1		
*Alternative 1	T-5-1	existing salt marsh	Enhance salt marsh by restoring hydrologic connection via culvert beneath the road
T-7 Tiana	Combined 1,2,3		
*Alternative 1	T-7-1	bayside shoreline and upper beach and dune	Restore salt marsh by removing fill material, using herbicide to control Phragmites, re-grading and replanting. Restore dune at access cut and provide access via a dune walkover.
*Alternative 2	T-7-2	upland and interior dune	Remove parking lot, re-grade to natural contours, plant
*Alternative 3	T-7-3	bay submergent	Enhance existing SAV beds

Site	Alternative ID	Goal/Target	Description
	Combined		-
T-8 WOSI			
*Alternative 1	T-8-1	*Phragmites* control throughout site	Enhance the existing salt marsh through the use of herbicides to control *Phragmites.*
T-25 Atlantique to Cornielle	Combined 2		
*Alternative 2	T-25-2	Create salt marsh bayside	Create new salt marsh by regrading upland areas and bay shoreline, plant native salt marsh species

Note: All Alternatives shown for a site are recommended as a combined plan for site. Alternatives marked with * have been identified as top priority measures by the New York District and partner agencies

6.1.8 Land Management and Acquisition Program

The existing Land management efforts, and opportunities to improve land management are described in Appendix H- Land Use. These programs are a collaborative effort between Federal, State and local entities and cannot be unilaterally implemented by the Corps of Engineers. These programs will be implemented as complementary plans to the overall FIMP project. As part of the FIMP Project, permanent easements will be obtained in locations where beachfill is to be placed. These permanent easements also have the effect of restricting development from encroaching on the dune and beach that is constructed as part of the project. The land management appendix recognizes this element of the project as an effective tool that will ensure the constructed dunes are not encroached-upon.

- Improve the effectiveness of the existing regulatory program, by establishing common and clearly communicated boundaries for regulated hazard areas, increasing training of local officials, and coordination to ensure consistent implementation across regulatory boundaries.
- Establish post-storm response plans to guide recovery following major, catastrophic events.

6.2 Borrow Area Investigations

Appendix B- Borrow Areas provides a detailed discussion of the studies that have been undertaken to identify potential sources of suitable sand for both the initial construction and periodic renourishment. Potential borrow areas were evaluated based on a set of screening criteria. These criteria included the evaluation of the availability of adequate data, the sufficiency of quantity in each potential source, beach and dune compatible sediment characteristics, identification of those offshore sources which would minimize adverse wave attenuation, the consideration of geomorphological effects of mining of offshore ridges on barrier island shoreline position and sediment budget, identification of those offshore sources that contained minimal overburden and minimal quantity of fine grained material, and which had minimal adverse environmental effects and minimal effect on cultural resources.

Potential borrow sources identified included upland quarries, maintenance dredge material from navigation channels, the mining of ebb and flood shoals, and offshore borrow areas. Table 5 of Appendix B – Borrow Areas summarizes the results of the Borrow Delineation and Table 6 of Appendix B presents the Available Borrow Volumes.

Appendix B- Borrow Areas recommends utilizing the lowest impact borrow areas first for the initial construction, while continuing to perform pre-and post-dredging monitoring to get a better understanding of the sediment transport processes before utilizing other borrow sites during periodic renourishment. In addition to the three inlets, six borrow areas were selected for initial construction: 2C, 2H, 4C, 5Bexp, 6I, 8D. Figure 29 shows the delineation of the selected borrow areas and Table 42 lists their respective initial construction quantities.

The offshore portion of Borrow Area 2C, which is an offshore sand ridge, is being used for the Fire Island Inlet to Moriches Inlet Interim Project beach and dune construction. The removal of material from this ridge (or other future uses of sand ridges as borrow sources) may interrupt the onshore migration of material from the ridges to the barrier island shore face. USACE acknowledges that the potential for this onshore movement is a plausible process. The impact of the proposed nearshore sand mining on cross-shore transport rate is not yet quantified. Modifications of the nearshore topography of the sand ridges offshore of western Fire Island will be the subject of cooperative monitoring between the USGS and USACE, and will be part of monitoring/adaptive management programs under FIMP.

Table 42. Borrow Areas – Initial Construction

Borrow Area	**Location**	**Volume (cy)**
2C	Kismet to POW	299,000
2H	Cherry Grove to Davis Park	250,000
4C	Cupsogue to Westhampton	923,000
5Bexp	Sedge Island to SPW	1,326,000
6I	Potato Road	120,000
8D	Montauk Beach	120,000
Fire Island Inlet*	Gilgo Beach to RMSP	2,341,000
Moriches Inlet*	SPCP to Great Gunn	512,000
Shinnecock Inlet*	SPW to WOSI	549,000
		Total 6,440,000

*Includes Ebb Shoal.

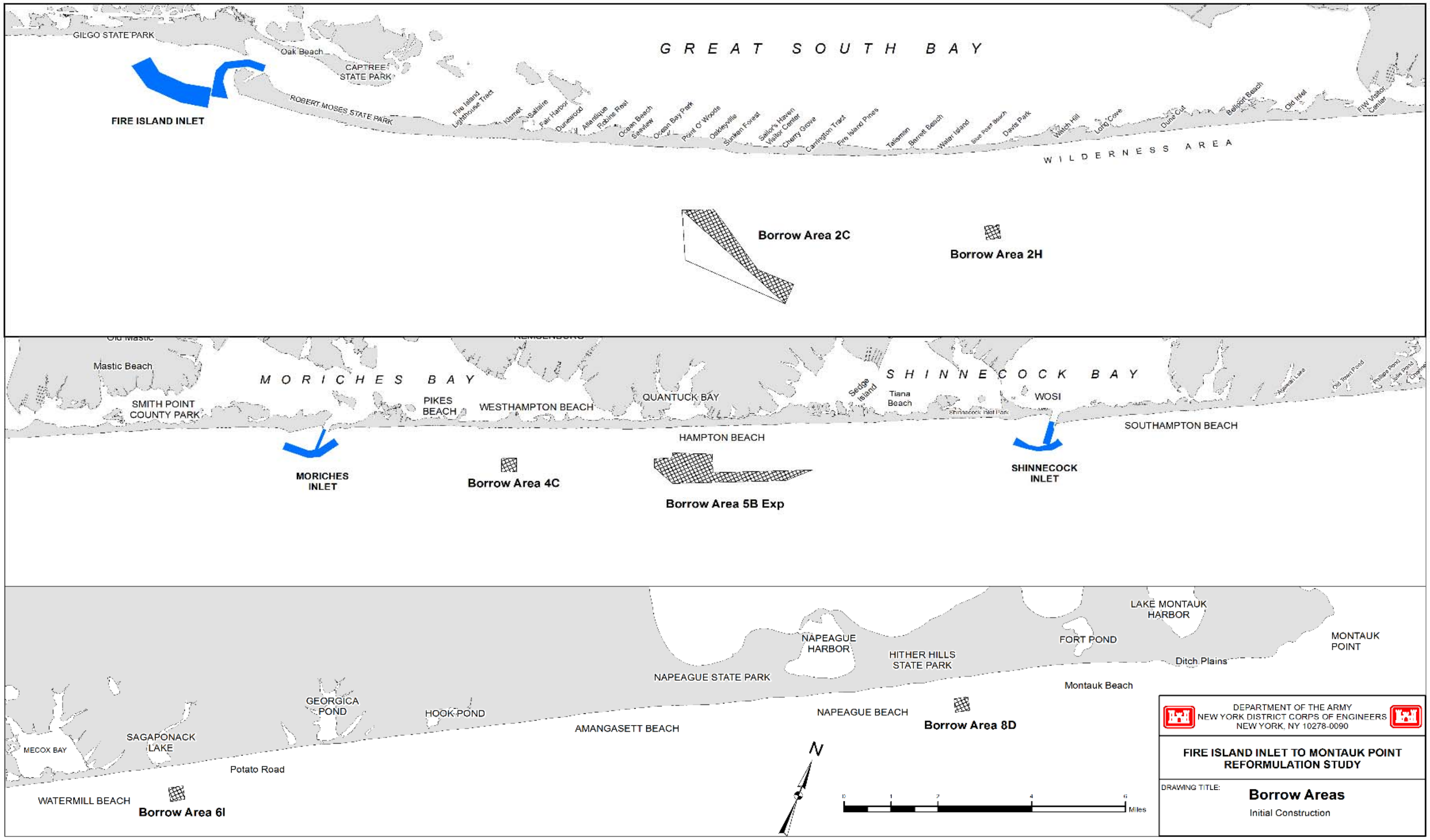


Figure 29. Borrow Areas – Initial Construction

6.3 TSP Plan

The TSP was developed by evaluating a full range of measures against the project objectives. Each of the measures included in the TSP addresses a specific need and objective. The plan formulation considered beach nourishment as incremental to other measures such as nonstructural retrofits for bayside buildings. For the TSP described in Section 6.1, analyses have been undertaken to evaluate the corresponding annualized With-Project damages and benefits for comparison with the project costs. These analyses, summarized in Table 43, identify the cost-effectiveness of the plan. This assessment verifies that the TSP provides annual benefits greater than annual costs.

Table 43. Cost, Damages, and Benefits Summary for Alternatives (Oct 2015 PL)

Formulation Summary	TSP
Initial Project Cost Totals	$1,107,099,500
IDC	$111,733,000
Investment Cost	**$1,218,832,500**
Annualized Cost	$67,168,700
Annualized Total Benefits	$97,224,000
Net Benefits	$28,020,900
BCR	**1.4**

Discount Rate 3.125%, Period of Analysis 50 years

6.4 Environmental Consequences

Table 44 provides a summary of the environmental impacts of the TSP for each of the Resource areas considered, and measures to avoid, lessen, and compensate for any impacts.

Table 44. Summary of TSP Environmental Impacts

Resource	Environmental Impact	Measures to avoid, lessen, mitigate or compensate for environmental impact
Topography, Land Formation, Key Geologic Characteristic	Potential for breaching/overwash will be reduced;	Coastal process features will enhance overall coastal processes
	Borrow Areas – bottom profile will be changed	Utilization plan is designed to minimize impacts on possible onshore movement of sediments.
Water Resources	Temporary, short term increase in suspended sediments and turbidity in surface waters adjacent to project;	Any impacts would be minor and localized during construction.
	Temporary impact on DO at borrow sites	BMP to be utilized to minimize creation of anoxic zones
Wetlands	Net positive impact to estuarine and forested wetlands by reducing barrier island breaching and overwash.	
Vegetation	Net positive impact to vegetation communities by reducing the risk of coastal storm damages	

Resource	Environmental Impact	Measures to avoid, lessen, mitigate or compensate for environmental impact
Fish and Wildlife	Temporary, short term disturbance	Implement BMPs during construction to avoid impacts to wildlife. Have a process in-place for rescue of wildlife if necessary
Rare Species and Habitats	Potential impacts to following species of concern: Plants: Seabeach Amaranth – temporary construction impacts Birds: Piping plover, Red knot	Overall habitat suitability will likely increase along affected beachfront. Avoid nesting season and maintain beach slope consistent with existing beaches.
Cultural	Potential adverse impacts to historic properties from non-structural measures and road-raisings, use of borrow areas, sand placement areas, construction of coastal processes sites.	Execution of a Programmatic Agreement to identify historic properties, determine the effect to the properties by project elements, and determine and implement appropriate measures to avoid, minimize or mitigate any adverse effects.
Land Use and Development, Policy, and Zoning	TSP is consistent and supportive of Federal, state and local land use planning and zoning mechanisms.	
Recreational Resources	Placement of Beachfill would provide storm risk management to existing recreational uses by minimizing beach erosion and storm-induced breaching of barrier island, and would have a positive impact on recreation-related economic activity.	
Socioeconomic Conditions and Environmental Justice	By reducing risk of coastal storm damages, TSP will have positive impact on community services and economic conditions No Environmental Justice impacts	
Cultural	Potential adverse impacts to historic properties from non-structural measures and road-raisings, use of borrow areas, sand placement areas, construction of coastal processes sites	Execution of a Programmatic Agreement to identify historic properties, determine the effect to the properties by project elements, and determine and implement appropriate measures to avoid, minimize or mitigate any adverse effects.
Visual Resources	Insignificant short-term direct impacts	
Transportation	By reducing the risk of coastal storm damages the TSP would have a positive impact on transportation resources within study area.	

Resource	Environmental Impact	Measures to avoid, lessen, mitigate or compensate for environmental impact
	The four road raisings would significantly reduce storm-related disruption to existing road network	
Air Quality and Noise	TSP would temporarily emit diesel fuel emissions relating to dredging activities.	TSP will comply with the General Conformity requirement
	Construction activities would result in short-term minor increases in noise generation. No long-term significant impacts would occur.	

Chapter 5 of the EIS discusses compliance and consistency of the TSP with major relevant policies including:

National Environmental Policy Act

- Fires Island National Seashore Act and General Management Plan
- Endangered and Threatened Species Act
- Coastal Resource Barriers Act and Coastal Barrier Improvement Act of 1990
- Coastal Zone Management Act of 1972
- Section 106 of the National Historic Preservation Act of 1966, as amended
- Clean water Act of 1977
- Clean Air Act of 1972
- New York State Coastal Erosion Hazard Areas Act

6.5 Project First Costs

For the detailed cost estimate, project quantities were developed for both the initial construction and future renourishment. The cost estimate was compiled using the Micro-Computer Aided Cost Estimating System, Second Generation (MCACES 2nd Generation or MII). Dredging costs were calculated using the Corps of Engineers Dredge Estimating Program (CEDEP). The detailed cost estimate for the TSP is a based on combination of MII's Cost Book, estimator-created site specific cost items, local subcontractor quotations, and local material suppliers' quotations.

The individual components in the cost estimate are outlined in the Cost Appendix. Cost contingencies were developed through a standard Cost and Schedule Risk Analysis (CSRA). Table 45 shows the Total Project Cost summary of the Initial Construction. The estimated Project First Cost (Oct 2015 PL) for the TSP Plan is approximately $1.1 billion, which includes approximately $251 million in contingency. The construction cost of $799.5 million include about $603.4 million for Work Breakdown Structure (WBS) #19, Buildings, Grounds and Utilities, for the Mainland Nonstructural building retrofits; $145.3 million for WBS# 17, Beach replenishment, for the initial construction of the beach and dunes; $20.4 million for WBS #10, breakwaters and seawalls, for the groin modifications, and $30.4 million for WBS #02, Relocations, for the road raising as part of the Mainland Nonstructural feature.

Table 45. Total Project Cost Summary (Initial Construction)

PROJECT: FIMP, General Reevaluation Report
PROJECT NO 0
LOCATION: Fire Island to Montauk Point, NY

DISTRICT: New York District **PREPARED: 7/19/2016**
POC: CHIEF, COST ENGINEERING, Mukesh Kumar

This Estimate reflects the scope and schedule in report; FIMP GRR

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)						TOTAL PROJECT COST (FULLY FUNDED)			
						Program Year (Budget EC): 2018	Effective Price Level Date: 1 OCT 17								
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Spent Thru: 10/1/2015 ($K)	TOTAL FIRST COST ($K)	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*		*K*	*L*	*M*	*N*	*O*
02	RELOCATIONS	$23,531	$6,909	29.36%	$30,440	3.7%	$24,392	$7,162	$31,554	$0	$31,554	5.0%	$25,624	$7,523	$33,147
10	BREAKWATER & SEAWALLS	$15,759	$4,627	29.36%	$20,385	3.7%	$16,336	$4,796	$21,132	$0	$21,132	4.4%	$17,061	$5,009	$22,069
17	BEACH REPLENISHMENT	$112,346	$32,985	29.36%	$145,331	3.7%	$116,458	$34,192	$150,650	$0	$150,650	1.6%	$118,275	$34,726	$153,000
19	BUILDINGS, GROUNDS & UTILITIES	$466,424	$136,942	29.36%	$603,366	3.7%	$483,502	$141,956	$625,458	$0	$625,458	10.4%	$533,777	$156,717	$690,494
	CONSTRUCTION ESTIMATE TOTALS:	$618,060	$181,462		$799,522	3.7%	$640,688	$188,106	$828,794	$0	$828,794	8.4%	$694,736	$203,975	$898,711
01	LANDS AND DAMAGES	$51,917	$15,243	29.36%	$67,160	3.7%	$53,818	$15,801	$69,619	$0	$69,619	-3.5%	$51,919	$15,243	$67,162
30	PLANNING, ENGINEERING & DESIGN	$125,200	$36,759	29.36%	$161,959	7.8%	$134,905	$39,608	$174,513	$0	$174,513	5.4%	$142,207	$41,752	$183,960
31	CONSTRUCTION MANAGEMENT	$60,650	$17,807	29.36%	$78,457	7.8%	$65,352	$19,187	$84,539	$0	$84,539	16.6%	$76,232	$22,382	$98,614
	PROJECT COST TOTALS:	$855,828	$251,271	29.36%	$1,107,100		$894,763	$262,702	**$1,157,465**	$0	**$1,157,465**	7.9%	$965,095	$283,352	$1,248,447
	Renourishment and Breach Closure Costs														
17	BEACH REPLENISHMENT	$330,787	$97,119	29.36%	$427,906	3.7%	$342,895	$100,674	$443,568	$0	$443,568	42.4%	$488,141	$143,318	$631,459
	E&D and S&A (includes Monitoring)														
30	PLANNING, ENGINEERING & DESIGN	$50,484	$14,822	29.36%	$65,306	1.2%	$51,073	$14,995	$66,068	$0	$66,068	107.6%	$106,023	$31,128	$137,151
31	CONSTRUCTION MANAGEMENT	$24,940	$7,322	29.36%	$32,262	1.1%	$25,220	$7,405	$32,625	$0	$32,625	149.1%	$62,819	$18,444	$81,263
	RENOURISHMENT COST TOTALS:	$406,211	$119,264	29.36%	$525,475		$419,187	$123,073	**$542,261**	$0	**$542,261**	56.7%	$656,983	$192,890	$849,873

6.6 Real Estate Requirements

This section will detail the real estate needs for the construction of the new proposed elements for the Project. Due to the breadth of real estate already acquired for the previously constructed projects subsumed into FIMP, those real estate interests will only be summarized.

I. *Fee (Standard Estate No. 1)* – The nonstructural component of this project includes the fee acquisition of four residential structures encompassing approximately 0.49 acres of land, 4 parcels, and 4 private owners.

II. *Perpetual Beach Storm Damage Reduction Easement (Standard Estate No. 26)* – Perpetual Beach Storm Damage Reduction Easements must be acquired over approximately 502.87 acres of land, impacting 424 parcels, and 366 private owners and 5 public owners. The location of the Permanent Easements is identified in the Real Estate Plan. Due to State of New York requirements, requisite access to public lands will be authorized through Access Agreements.

III. *Nonstructural Floodproofing Agreement* – A Nonstructural Floodproofing Agreement (the Agreement) must be executed between the Sponsor and the property owner wherever nonstructural floodproofing treatments will be implemented. The purpose of the Agreement is twofold: to serve as a contract between property owner and government, and to restrict future development of the site below a stated elevation. Nonstructural building retrofit measures will be offered to owners of eligible structures on a voluntary basis. Structures identified as eligible will, in addition, have to meet the following criteria:

- Owner is willing to participate in the nonstructural program and execute a Floodproofing Agreement containing a restrictive covenant limiting development of the property below the determined elevation.
- Structure is safe, decent and sanitary condition
- Owner possesses clear title to the property
- Structure and appurtenant land is not contaminated with hazardous, toxic or radioactive waste or materials
- Owner does not owe taxes or other debts to any state or local government entity or to the Federal Government
- Owner has not previously received any disaster assistance for the elevation of the structure
- Property owner is willing to expend costs that may be necessary in connection with the elevation of the structure which are not eligible costs covered by the program (i.e. temporary housing during construction)

Structures categorized within the voluntary program will be elevated or flood proofed only with the owner's consent. Where owners are willing to participate, but structures do not meet the program criteria, if cure is possible, owners will be afforded the opportunity to cure any defect in the structure, otherwise applications for ineligible structures will be denied.

Eminent domain authority will not be used to require landowners in this category to participate in the program; however, tenants who reside in structures to be elevated may be eligible for certain benefits in the accordance with Uniform Relocation Assistance and Real Property Acquisition Policies for Federal and Federally Assisted Programs of 1970. See 49 C.F.R. 24.101(a)(2) for additional detail.

Where owners of eligible properties elect to participate in the Project, the following process shall be implemented:

- Property owner deliver a completed application for structure elevation to the Project Partner. The application must be signed by all owners and lien-holders of the property and structure;
- Project Partner shall ensure property meets all eligibility criteria;
- Property owner shall submit to Project Partner proof of ownership and a current Elevation Certificate;
- Project Partner shall conduct a title search to verify clear title;
- Project Partner shall conduct a Phase I HTRW/asbestos investigation. All asbestos must be abated and disposed of properly.
- Floodproofing Agreement is executed by property owner and Project Partner and recorded with the county clerk.
- Elevation of structure is completed.

IV. *Temporary Work Area Easement (Standard Estate No. 15)* - Temporary work areas may be necessary for this project, but have not yet been identified. The need for temporary work areas will be identified during the Plans and Specs phase. The proposed temporary work areas are typically adjacent to land to be acquired for Project construction.

V. *Borrow Area* – The Project proposes to nourish the beach using sand from various Offshore Borrow Areas located New York State waters. NYSDEC will provide the Corps with authorization to use the Borrow Areas as a sand source through a New York Environmental Conservation Law Section 401 Water Quality Certificate (“WQC”). The WQC functions as a permit allowing the borrow of the necessary volume of sand to complete the Project. The Corp of Engineers has obtained water quality certificates from NYS DEC in support of other projects.

Table 46 summarizes the required Lands, easements and rights of way (LER) for the Project.

Table 46. Required Lands, Easements, and Rights of Way (Oct 2015 PL)

Required Interest	Required Acres	Acres Below the MHWM	Number of Parcels		Number of Owners		Acquisition Cost
			Private	Public	Private	Public	
Beachfill and Breach Response Plan							
Perpetual Beach Storm Damage Reduction Easement	±502.87	±18.83	377	47	366	5	**$5,997,233**
Nonstructural							
Nonstructural Floodproofing Agreement	±216.44	0	4138	TBD	TBD	TBD	**$0.00**
Fee	**±0.49**	0	4	0	4	0	**$2,615,090**
Coastal Process Features (TBD*)							
						Total:	**$9,332,323**

*Real estate requirements for Coastal Process Features will be determined after publication of this report during the plans and specs phase. All Coastal Process Features are to be constructed on public lands. Maps of the Coastal Process Features developed for planning purposes are included in Appendix E- Plan Formulation and also in the EIS.

6.6.1 Appraisal

Consistent with USACE Real Estate Policy Guidance Letter No. 31 – Real Estate Support to Civil Works Planning Paradigm (3x3x3), the New York District as valued the real estate requirements through a cost estimate as the real estate costs will total less than 10% of the total project costs. A 20% contingency is added to the incidental costs of the project to account for uncertainty in progress of the real estate acquisition for a high profile project, and the possibility that the need for condemnation may arise.

Appraised of the required LER……………….. $9,332,323

Date of Value………………………………….. 4 April 2016

6.6.2 LER Owned by the Non-Federal Sponsor

The Non-Federal Sponsor (NFS), the NYSDEC, owns 438.86 acres of land required for the Project, including lands below the mean high water line. In addition, the NYSDEC served as the NFS on the previously constructed Federal projects in this area. The lands acquired for the previously constructed projects are held by NYSDEC's local sponsor, the County of Suffolk. Table 47 shows the real estate obtained to construct the four previously constructed Federal projects in the area:

Table 47. Real Estate Requirements of Previously Constructed Projects

	Easement Acquisitions	Fee Acquisitions	Required Acres	Total Tracts
Fire Island Inlet to Moriches Inlet Stabilization Project*	623	41	546.5	664
Downtown Montauk Stabilization Project	18	0	12.63	18
Westhampton Interim Project	308	0	172.03	308
West of Shinnecock Inlet Interim Project	4	0	56.26	4
Total:	953	41	787.42	994

* Acquisition of real estate required for the Fire Island Inlet to Moriches Inlet Stabilization Project is ongoing.

6.7 Renourishment

The estimated Project First cost of beach replenishment for the 30 year period after initial construction, as shown in Table 45 is $525.5 million (Oct 2015 PL), including about $119 million in contingencies (also see Total Project Cost summary in Appendix C – Cost). This cost is based on 8 cycles of periodic renourishment that would be performed about every 4 years following completion of the initial sand placement to construct the dunes and berms as described earlier, as well as the cost of the additional sand by-passing associated with the dredging of the ebb shoals during the maintenance dredging of Fire Island, Moriches, and Shinnecock Inlets. For years 31 through 50, there would be proactive breach response in those reaches.

6.8 Breach Management

Project costs associated with breach management are incurred when barrier island conditions degrade to the point at which activities are implemented to restore the barrier beach as described in Section 6.1.3 above, and also to close breaches which may occur due to severe storms at any time during the analysis period regardless of prior maintenance activities.

While the individual event costs to close breaches at specific locations is presented in Table 48 and

Table 49, these do not reflect the frequency of occurrence over the life of the project: The total annualized cost of breach closure actions for all locations generated by the lifecycle analyses is $1,361,000 based on an average of 7 breaches occurring during the 30 year analysis period (See Appendix A, Engineering).

Table 48. Breach Closure Cost by BRP Location and Design Template (Large & Standard Breach) (Oct 2015 PL)

Location	Construction Alternative Resulting in Lowest Total Cost	Without Project Closure Cost	BRP Closure Cost
FI Lighthouse Tract	Hopper Dredge	$38,987,425	$31,689,217
Town Beach to Corneille Estates	Cutterhead Dredge	$36,837,420	$18,612,316
Talisman to Water Island	Cutterhead Dredge	$28,710,076	$13,889,596
Davis Park	Cutterhead Dredge	$28,737,131	$13,899,421
Old Inlet West	Cutterhead Dredge	$31,469,134	$15,435,697
Old Inlet East	Cutterhead Dredge	$28,031,824	$14,133,247
Smith Point County Park	Hopper Dredge	$24,599,965	$18,208,062
Sedge Island	Cutterhead Dredge	$16,710,948	$10,254,929

Location	Construction Alternative Resulting in Lowest Total Cost	Without Project Closure Cost	BRP Closure Cost
Tiana Beach	Cutterhead Dredge	$16,194,807	$10,033,388
WOSI	Hopper Dredge	$19,159,535	$15,374,275

Table 49. Breach Closure Cost by BRP Location and Design Template (Small Breach) (Oct 2015 PL)

Location	Construction Alternative Resulting in Lowest Total Cost	Without Project Closure Cost	BRP Closure Cost
FI Lighthouse Tract	Hopper Dredge	$10,919,328	$8,647,621
Town Beach to Corneille Estates	Cutterhead Dredge	$10,746,227	$7,340,820
Talisman to Water Island	Cutterhead Dredge	$9,340,158	$6,677,611
Davis Park	Cutterhead Dredge	$9,345,042	$6,679,387
Old Inlet West	Cutterhead Dredge	$9,861,252	$7,065,152
Old Inlet East	Cutterhead Dredge	$9,240,913	$6,829,861

Discount Rate 3.125%, Period of Analysis 50 years

Proactive breach costs for the project are similarly generated by the lifecycle analysis since they are also dependent on their uncertain frequency of occurrence. The total annualized cost of breach maintenance actions is $86,000, based on an average number of actions during the analysis period. This number includes proactive beach actions at five locations during the full 50-year period, and during the last 20 years of the analysis period at the three beachfill locations following the termination of renourishment activities 30 years after the project base year.

6.9 Coastal Monitoring

A complete description of the proposed monitoring of the FIMP area is included in Appendix D and is summarized below:

- Measure project performance;
- Improve the understanding of the physical processes at work and their interaction with project performance; and
- Plan the timing and volumetric requirements of renourishment and any other required maintenance measures.

The Physical Monitoring Plan recommends inspection, measurement and analysis of the following physical phenomena and coastal processes within the project boundary and project life:

a. General:
   - Periodic site inspection of shoreline condition and structure functionality;
   - Aerial photography;
   - Shoreline changes and sediment budget update;
   - Ocean wave height, period and direction;
   - Water level measurement;
   - Borrow area infilling;

b. Beach Fill:
   - Beachfill/dune profile evolution;
   - Sediment sample collection and analysis;
   - Post-placement fill characterization;
   - Fill compatibility analysis for each renourishment;
c. Inlet Management:
   - Inlet morphology evolution;
   - Ebb/Flood shoal evolution;
   - Deposition basin in-filling rate;
d. Groin Modification:
   - Shoreline and dune evolution including one mile both updrift and downdrift;
   - Volume changes;
   - Regional sediment budget;
e. Breach Response Plan:
   - Storm, overwash and breach impacts;
   - Cross-sectional volume;
f. Sediment Transport Modeling:
   - Inner-shelf bathymetric changes;
   - Sub aerial morphologic change;
   - Wave, current, bed load and suspended sediment concentration measurements;
   - Sediment transport modeling between the inner shelf and western Fire Island

Total Annual Coastal Monitoring costs are $787,000 (Oct 2015 PL).

6.10 Major Rehabilitation

Major rehabilitation costs are for restoring the design profile due to significant storm events beyond those that were designed for in the renourishment cycle. The threshold at which major rehabilitation costs are incurred in based on the storm event that causes the erosion volume to exceed 145 cy/lf along the beach front. This is the average renourishment volume anticipated to be available at the midpoint of the renourishment cycle because the significant storm event has a 50% chance of occurring earlier or later than the cycle midpoint. Total annualized major rehab costs are $1,402,000.

6.11 Operations and Maintenance

An Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R) Manual is included in Appendix J - OMRR&R. This manual outlines the responsibilities of the non-Federal sponsor (State of New York) under the Project Partnership Agreement (PPA) to ensure the project is maintained to perform during extreme events. Specifically, the FIMP OMRR&R outlines requirements for maintaining dunes, beaches and groins. It also outlines the expectations for periodic inspections and beach monitoring. Total annualized O & M costs are $828,600.

6.12 Residual Damages under the TSP

6.12.1 Residual Flood Damages

The evaluation of damages for all of the alternatives and the Final Array of Plans was performed by modifying various inputs to the without project damage analysis. Each of the measures included in the TSP reduced annual damages as described below. Inlet Bypassing primarily reduces storm damages by reducing long term erosion rates. The impact of nonstructural plans is to alter damages to the individual structures and reduce the aggregate damages occurring at each flood stage. Figure 30 provides a sample stage vs damage relationship comparison with and with-out the nonstructural measures for Reach 17.1 which contains about 325 structures located in Moriches Bay. It is important to note that the nonstructural measures target the more frequently flooded structures have the greatest impact at the lower flood stages. Even though the first floor structure itself may be elevated above the flood levels, the building foundation and other property such as cars, garages, and outbuildings will still be flooded and will suffer damage.

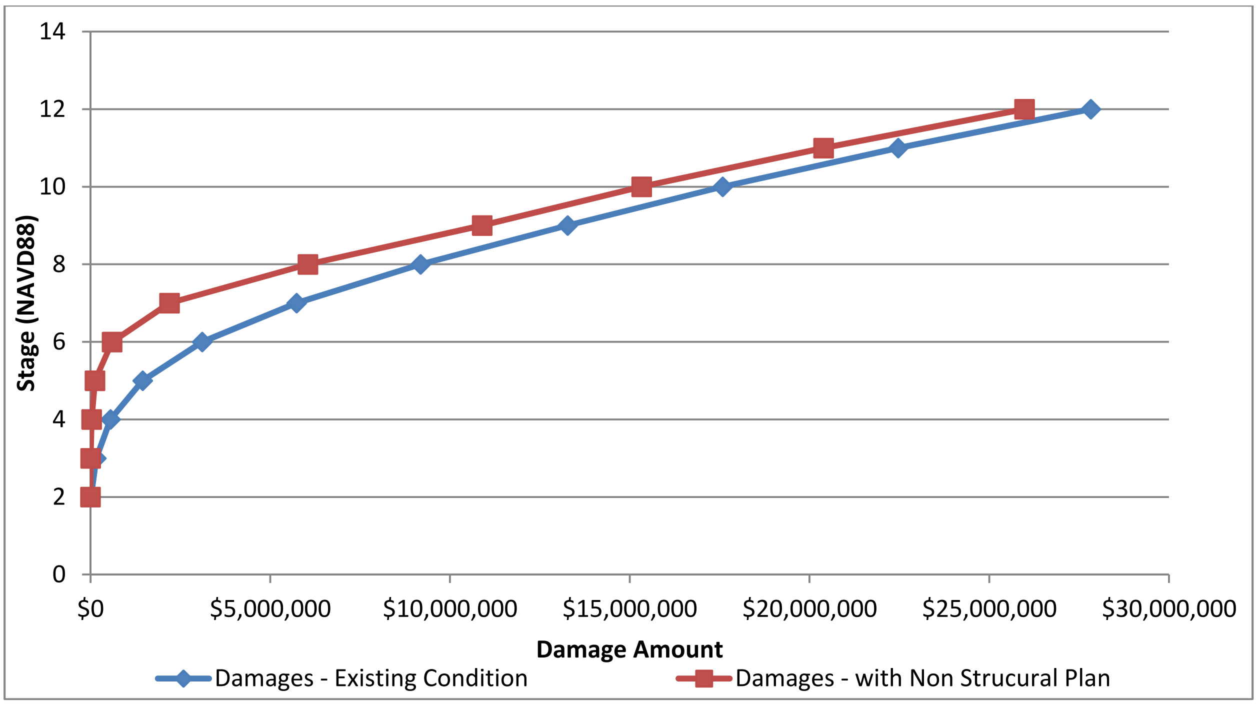


Figure 30. Average Stage Damage Comparison for Reach 17.1

The various breach response measures contained in the TSP reduce storm damages in several ways. The TSP provides for accelerated breach closures relative to the without project condition. By responding and closing breaches more rapidly the breach dimensions will be smaller, allowing the closure to be completed more quickly and at lower cost. By reducing the length of time that a breach is open, there is also a reduction in the potential for higher water levels and flood damage in the bays. The Proactive Response Measures will reduce the likelihood of a breach occurring at those locations and therefore reduce the number and cost of breach closure activities as well as flood stages in the bay.

The placement and maintenance of beach and dune nourishment provides direct reductions in wave propagation and erosion distance for the properties along the ocean shorefront, reduces the volumes of barrier overwash, which in turn reduces flood stages in the bays and the potential for breaching of the barrier islands. The placement of beach nourishment or feeder beaches will offset long term erosion at the placement site and reduce long term erosion rates in the downdrift areas. Table 50 provides a summary of the With- and Without Project damages for the project area.

Table 50. Summary of Without and With Project Damages (Oct 2015 PL)

Damage Category	**Without Project Damage**	**With Project Damage TSP**
Total Project		
Tidal Inundation occurring due to inlet conditions, wave setup, storm-related breaching and overwash in back bay		
Total Mainland Inundation	$98,382,500	$36,407,000
Total Barrier Inundation	$17,016,300	$15,909,000
Total Inundation	$115,398,800	$52,316,000,
Damages (Inundation and Structure Failure) due to a breach remaining open		
Inundation (Open Wilderness Area Breach)	$4,733,300	$4,733,000
Inundation (Future Breaches)	$3,578,400	$116,000
Total Breach Open Damages	$8,311,000	$4,848,000
Shorefront Damages	$12,848,300	$6,681,000
Emergency Costs/Breach Closure (Including Proactive Breach Maintenance Costs)	$1,816,000	$761,000
Total Damage	$138,374,100	$64,607,000

Discount Rate 3.125%, Period of Analysis 50 years

7 ECONOMIC ANALYSIS OF THE TSP

7.1 Overview

The TSP First Cost is approximately $1,142,000,000 (1 Oct 2015 P/L) including a contingency of approximately $248 million, as determined in the Cost and Schedule Risk Analysis (Appendix C- Cost).

7.2 Interest During Construction

Interest During Construction (IDC) is a time value adjustment of money invested before completion of the project. The IDC begins with the final design in PED to determine the total investment in the project and is calculated by computing interest at the applicable project discount rate on the monthly expenditures, from the start of PED to the completion of the project. The project is currently estimated to take 7 years to construct with a PED effort. This value is simply an economic time value adjustment and does not require monetary expenditures. It is used to estimate annual costs for economic evaluation. The interest rate utilized is 3.125% over the construction period

7.3 Annual Cost

The first costs were shown previously in Table 45. The Draft Cost Appendix presents the basis for the project costs. The initial construction costs, interest during construction, and future project costs are shown as annual costs as summarized in Table 51. This includes the costs associated with all the project features. Please note, these costs are shown assuming the historic (low) rate of RSLC.

Table 51. Annual Project Cost (1 Oct 2015 PL)

Project First Cost	$1,107,099,500
IDC	$111,733,000
Total Investment	$1,218,832,500
Annualized Investment Cost*	$50,505,000
Renourishment/ Sediment Mgmt.+	$11,136,000
Inlet Bypassing+	$3,752,000
Proactive Breach Response+	$86,000
Breach Closure	$676,000
Coastal Monitoring	$787,100
O&M	$828,600
Major Rehab	$1,402,000
SLC Adaptation	$0
Project Annual Cost *	$67,168,700

* Annualized over the 50 year period of analysis using the Federal Discount rate of 3.125%
+Included in Initial Cost

7.4 Annual Benefits

The project benefits shown in Table 52 are a combination of reduced storm damages, future costs avoided, and increased recreation use value. Storm damage reduction is simply the difference in the expected annual damages with and without project. Future costs avoided benefits include the full value of without project breach closures. With project breach closures are considered a part of the project costs.

Recreation benefits are based on recreation use and contingent valuation surveys and reflect both the higher values per visit at renourished beaches and the increase in the number of beach visitors. Benefits have only been evaluated for locations that will be receiving both initial and renourishment fill, specifically the community beaches and Smith Point County Park on Fire Island. Because the renourishment fill is only anticipated to be provided for a period 30 years, the total present value of recreation benefits for the 30 year renourishment period have been multiplied by the 50 year capital recovery factor to provide an equivalent annual value over the 50 year period of analysis.

Table 52. Summary of Benefits (1 Oct 2015 PL)

Plan Summary	TSP
Cost Avoided – Breach Closure	$1,816,000
Benefits – Breach Open	$3,463,000
Total Breach Closure Benefits	$5,279,000
Benefits – Back Bay Inundation	$63,083,000
Benefits – Shore Front	$6,167,000
Total Storm Damage Reduction Benefits*	$72,713,000
Recreation Benefits**	$22,695,000
Pre-Base Year Benefits	
Total Benefits	$97,224,000
Net Benefits	$30,055,300

Notes:
1. Benefits Annualized over the 50 year period of analysis using the Federal Discount rate of 3.125%
2. Benefits assumed 2021 base year. . Benefits are expected to increase slightly once the analytical models are rerun with 2025 base year, which is not expected to change conclusions and recommendations.

7.5 Feasibility Assessment

An economic comparison of the annual costs and benefits as presented in Table 53 demonstrates that the NED Plan is a feasible Coastal Storm Risk Management Solution. With Net Benefits of $33 million per year and a Benefit to Cost ratio of 1.5, the TSP as recommended in this report presents a feasible solution that meets the planning objectives and NED criteria.

Table 53. Feasibility Assessment (1 Oct 2015 PL)

Annual Benefits	$97,224,000
Annual Costs	$67,168,700
Net Benefits	$30,055,300
BCR	1.4
Economically Feasible	**Yes**

Discount Rate 3.125%, Period of Analysis 50 years

7.6 Sensitivity Testing

7.6.1 Relative Sea Level Change

Current USACE guidance requires that potential relative sea level change must be considered in every USACE coastal activity as far inland as the extent of estimated tidal influence. The base level of potential relative sea-level change is considered the historically recorded changes for the study site. All economic analyses for which results are tabulated in previous sections of this report were based on this historic rate of sea level change. However, in accordance with Engineering Regulation ER 1100-2-8162 (incorporating Sea Level changes in Civil Works Program, 31 Dec 2015), proposed projects must be also evaluated for a range of possible sea level rise rates: In addition to the historical rate ("low") which is a 0.7 ft. increase over the period of analysis, the project must also be evaluated using "intermediate" and "high" rates derived from modified NRC Curves I and III, which for this Study are estimated to be 1.1 ft. and 2.6 ft. increases, respectively over the fifty year period-of-analysis.

The Equivalent Annual Damages for the Tentatively Selected Plan were re-computed using the "intermediate" and "high" rates of sea level rise in HEC-FDA, for comparison with the baseline analysis using the "low" rate. The results of these analyses are presented in Table 54. Benefit-Cost ratios in Table 54 were derived using costs in Table 51 with the addition of the costs to adapt the project in response to the "intermediate and "high" sea level rise scenarios. The SLC adaption costs capture the additional renourishment required in the Beach Fill Plan to offset losses from SLC based on the Bruun Rule.

Table 54. Cost, Damages, and Benefits Summary for TSP with SLR Scenarios (1 Oct 2015 PL)

	Formulation Summary	**Tentatively Selected Plan (TSP)**		
		Low SLC	**Int. SLC**	**High SLC**
Initial Cost	02 Relocations	$30,440,000	$30,440,000	$30,440,000
	10 Breakwater & Seawalls	$20,385,000	$20,385,000	$20,385,000
	17 Beach Replenishment	$145,331,000	$145,331,000	$145,331,000
	19 Buildings, Grounds & Utilities	$603,366,000	$603,366,000	$603,366,000
	Construction Estimate Totals	*$799,522,000*	*$799,522,000*	*$799,522,000*
	01 Land and Damages	$67,160,000	$67,160,000	$67,160,000
	30 Planning, Engineering & Design	$161,959,000	$161,959,000	$161,959,000
	31 Construction Management	$78,457,000	$78,457,000	$78,457,000
	Project Cost Totals	***$1,107,100,000***	***$1,107,100,000***	***$1,107,100,000***
	IDC	$111,733,000	$111,733,000	$111,733,000
	Investment Cost	**$1,218,832,500**	**$1,218,832,500**	**$1,218,832,500**
Annualized Cost	Investment Cost	$48,501,000	$48,501,000	$48,501,000
	Renourishment / Sediment Management	$11,136,000	$11,136,000	$11,136,000
	Inlet Bypassing	$3,752,000	$3,752,000	$3,752,000
	Proactive Breach Maintenance	$86,000	$91,000	$11,718,000
	Breach Closure Costs	$676,000	$953,000	$2,674,000
	Coastal Monitoring	$787,100	$787,100	$787,100
	Environmental Monitoring	$0	$0	$0
	O&M	$828,600	$828,600	$828,600
	Major Rehab	$1,402,000	$1,402,000	$1,402,000

	Formulation Summary	Tentatively Selected Plan (TSP)		
		Low SLC	Int. SLC	High SLC
	SLC Adaptation	$0	$528,000	$2,206,000
	Total Annual Cost	**$67,168,700**	**$67,978,700**	**$83,004,700**
Damages	Damages – Breach Open	$4,848,000	$13,103,000	$129,443,000
	Damages – Back Bay Inundation	$52,316,000	$71,168,000	$173,247,000
	Damages - Shore Front	$6,681,000	$7,654,000	$12,940,000
	Total Damages	***$63,845,000***	***$91,925,000***	***$315,630,000***
Benefits	Cost Avoided – Breach Closure	$1,816,000	$2,530,000	$6,876,000
	Benefits – Breach Open	$3,463,000	$12,203,000	$173,865,000
	Total Breach Closure Benefits	$5,279,000	$14,733,000	$180,741,000
	Benefits – Back Bay Inundation	$63,083,000	$76,924,000	$134,723,000
	Benefits – Shore Front	$6,167,000	$6,103,000	$5,682,000
	*Total Storm Damage Reduction Benefits**	*$72,713,000*	*$95,230,000*	*$314,270,000*
	Recreation Benefits**	$22,695,000	$22,695,000	$22,695,000
	Total Benefits	**$97,224,000**	**$120,455,000**	**$343,841,000**
	Net Benefits (Damage Reduction Only)	**$30,055,300**	**$52,476,300**	**$260,836,300**
BCR		**1.4**	**1.7**	**4.0**

*Not including breach closure cost avoided

**Not recomputed for higher rates of SLC

NOTES:

1. Benefits Annualized over the 50 year period of analysis using the Federal Discount rate of .3.125%
2. Benefits assumed 2021 base year. . Benefits are expected to increase slightly once the analytical models are rerun with 2025 base year, which is not expected to change conclusions and recommendations.

The "intermediate" and "high" rates of sea level change would increase the without project equivalent annual damages above those resulting from the "low" rate by 7% and 31% respectively. The basic line of protection benefits would rise by 9% and 34% above the baseline benefits using the "intermediate" and "high" rates.

In summary, this demonstrates that the need for CSRM solutions increases, and the economic outputs increase when considering the intermediate and high rate of relative sea level change. The TSP performs well against the historic and more rapid rates of sea level change analyzed in this report, and the project features are adaptable in response to these increases.

8 EXECUTIVE ORDER (EO) 11988 AND PUBLIC LAW 113-2 CONSIDERATIONS

This study has considered the requirements of EO 11988, Flood Plain Management and PL 113-2, the Disaster Relief Appropriations Act of 2013. Specifically, this section of the report addresses:

- The Water Resources Council Floodplain Management implementing guidelines for EO 11988;
- The specific requirements necessary to demonstrate that the project is economically justified, technically feasible, and environmentally acceptable, per PL 113-2;
- The specific requirements necessary to demonstrate resiliency, sustainability, and consistency with the North Atlantic Coast Comprehensive Study (NACCS), per PL 113-2.

8.1 EO 11988

Executive Order 11988 requires federal agencies avoid, to the extent possible, the long and short term adverse impacts associated with the occupancy and modification of flood plains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative. In accomplishing this objective, "each agency shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health, and welfare, and to restore and preserve the natural and beneficial values served by flood plains in carrying out its responsibilities."

The Water Resources Council Floodplain Management Guidelines for implementation of EO 11988, as referenced in USACE ER 1165-2-26, requires an eight step process that agencies should carry out as part of their decision making on projects that have potential impacts to, or are within the floodplain. The eight steps and project-specific responses to them are summarized below.

1. **Determine if a proposed action is in the base floodplain (that area which has a one percent of greater chance of flooding in any given year).** The proposed action is within the base floodplain. However, the project is designed to reduce damages to existing infrastructure located landward of the proposed project.

2. **If the action is in the base flood plain, identify and evaluate practicable alternatives to the action or to location of the action in the base flood plain.** Chapter 5 of this document presents an analysis of potential alternatives. Practicable measures and alternatives were formulated and evaluated against the Corps of Engineers guidance, including nonstructural measures such as retreat, demolition and land acquisition.

3. **If the action must be in the flood plain, advise the general public in the affected area and obtain their views and comments.** There has been extensive coordination with pertinent Federal, State and local agencies. Once the draft report is released, public meetings will be scheduled in the study area during the public review period.

4. **Identify beneficial and adverse impacts due to the action and any expected losses of natural and beneficial flood plain values. Where actions proposed to be located outside the base flood plain will affect the base flood plain, impacts resulting from these actions should also**

be identified. The anticipated impacts associated with the Selected Plan are summarized in Chapters 5 and 6 of this report. The project would not alter or impact the natural or beneficial flood plain values.

5. **If the action is likely to induce development in the base flood plain, determine if a practicable non-flood plain alternative for the development exists.** The project provides benefits solely for existing and previously approved development, and is not likely to induce development. Nonstructural components of the project, and real estate requirements required for construction of the project will reduce the level of development that is at risk.

6. **As part of the planning process under the Principles and Guidelines, determine viable methods to minimize any adverse impacts of the action including any likely induced development for which there is no practicable alternative and methods to restore and preserve the natural and beneficial flood plain values. This should include reevaluation of the "no action" alternative.** There is no mitigation to be expected for the Selected Plan. The project would not induce development in the flood plain and the project will not impact the natural or beneficial flood plain values. Chapter 6 of this report summarizes the alternative identification, screening and selection process. The "no action" alternative was included in the plan formulation phase.

7. **If the final determination is made that no practicable alternative exists to locating the action in the flood plain, advise the general public in the affected area of the findings.** The Draft Interim Feasibility Report and Environmental Impact Statement will be provided for public review and public meetings will be scheduled during the public review period. Each comment received will be addressed and, if appropriate, incorporated into the Final Report. A record of all comments received will also be included in the Pertinent Correspondence Appendix.

8. **Recommend the plan most responsive to the planning objectives established by the study and consistent with the requirements of the Executive Order.** The Recommended Plan is the most responsive to all of the study objectives and the most consistent with the executive order.

8.2 Resiliency, Sustainability, and Consistency with the NACCS

This section has been prepared to address how the NED Plan contributes to the resiliency of the Fire Island to Montauk Pt. Area; how it affects the sustainability of environmental conditions in the affected area; and how it will be consistent with the findings and recommendations of the North Atlantic Coast Comprehensive Study (NACCS).

Resiliency is defined in the February 2013 USACE-NOAA Infrastructures Systems Rebuilding Principles white paper as the ability to adapt to changing conditions and withstand, and rapidly recover from disruption due to emergencies. Sustainability is defined as the ability to continue (in existence or a certain state, or in force or intensity), without interruption or diminution.

8.2.1 Resiliency

One of the planning objectives of the FIMP GRR is to "restore coastal processes and nature based measures to the maximum extent possible to provide resiliency and reduce storm damages". With the exception of the Mainland Nonstructural component that would retrofit of the 4,400 structures located in the 10 year flood plain, the other TSP features, including the Inlet modifications, Breach Responses, Barrier Island beach and dune fill, Sediment Management in Downtown Montauk (Montauk Beach) and Potato Road, Groin Modifications, and the 6 Coastal Process Restoration measures have all been designed with enhancing the resiliency of the coastal system, particularly with regard to future Sea Level change.

In general shore storm risk management projects, such as FIMP, are engineered beaches that are designed, constructed, and periodically renourished to reduce the risk of economic losses arising from coastal storms, primarily along communities with high-value public and private infrastructure immediately landward of the beach. The intent is to replicate the function of beaches in areas that were once part of natural, undeveloped systems that have subsequently experienced significant human development and utilization. Storms reduce the degree of storm risk management provided by the beach fill project; elevated water levels and larger-than-normal waves displace sand from the berm and dune portions of the engineered beach profile and transport it principally in the offshore direction. After the storm, normal tide and wave conditions return, typically resulting in onshore-directed sand transport that rebuilds at least a portion of the berm (i.e., beach). This natural recovery of the beach berm occurs over a period that may range from days to months. Natural rebuilding of the dune is a process that requires years to decades, given its dependence on wind transport and an adequate sand supply on the beach. In the period between the storm and the partial natural recovery, an increased level of storm damage risk exists due to the eroded condition of the project berm and dune relative to the level of risk associated with a constructed, fully maintained project. Consequently, repair of an engineered beach to its design dimensions is usually accomplished as a planned renourishment, which is included in the authorized period of analysis cycle, or as an emergency activity under the USACE Flood Control and Coastal Emergencies authority (PL 84-99), to restore the storm damage risk reduction function for which the project was authorized. This post-storm repair is necessary because the engineered beach may not otherwise fully recover to its authorized dimensions naturally, or at least not in a time frame that would minimize risks due to the deteriorated condition. In this regard, it is apparent that storm risk management projects involving beach replenishment possess intrinsic "resilience", in light of the large volume of sediment that remains within the system after a major disturbance and the associated repair or replenishment that is included to restore the project design dimensions.

8.2.2 Sustainability/Adaptability

As described in both this GRR and in the EIS, the FIMP project 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 National Economic Development account. Environmental concerns are evaluated in the EIS and through coordination and review by the resource agencies including the Environmental Protection Agency, the US Department of Interior, and the New York State Department of Environmental Conservation as part of the feasibility process. Social accounts are intrinsic in beach nourishment projects since they maintain habitat for beach patrons. The nexus of these three pillars indicates that a project is sustainable.

8.2.3 Consistency with the North Atlantic Coast Comprehensive Study (NACCS)

The North Atlantic Coast Comprehensive Study (NACCS, 2015) was released in January 2015 and provides a risk management framework designed to help local communities better understand changing flood risks associated with climate change and to provide tools to help those communities better prepare for future flood risks. In particular it encourages planning for resilient coastal communities that incorporates wherever possible sustainable coastal landscape systems that takes into account, future sea level and climate change scenarios. The process used to identify the TSP utilized the NACCS Risk Management framework that included evaluating alternative solutions and also considering future sea level change and climate change. The FIMP TSP echoes many of the principles of the NACCS, in that it considers the entire area as a system, the formulation considered multiple plan components to address the multiple risks, the plan incorporates non-structural components, reestablishes coastal processes, and has been developed in recognition of balancing the needs for coastal storm risk management with the requirements of the partner agencies.

9 PLAN IMPLEMENTATION

The completion of the GRR is the first step toward implementing the design and construction of the Fire Island to Montauk Point Coastal Storm Risk Management Project. Upon approval by USACE's Assistant Secretary of the Army, Civil Works (ASA[CW]), the project will be considered for design and construction with funding made available through P.L. 113-2.

9.1 Project Partnership – Local Sponsor's Responsibilities

The initial project cost of the FIMP Project will be funded 100% by the Federal Government, consistent with P.L. 113-2. A Project Partnership Agreement (PPA) package will be llprepared, coordinated and executed subsequent to the approval of this document. The PPA serves as the agreement for the next phase of the project. The PPA reflects the recommendations of this General Reevaluation Report. The non-Federal partner, NYSDEC, has indicated support for recommendations presented in this document and its desire to execute a PPA for the FIMP Project Selected Plan by letter dated June 2013.

As the non-Federal project partner, NYSDEC must comply with all applicable Federal laws and policies and other requirements, including but not limited to:

A. In coordination with the Federal Government, who shall provide 100% of the initial project cost, and 65 % of the costs of periodic nourishment:
    1. provide all lands, easements, rights of way and relocations (LERR), including suitable borrow areas, uncontaminated with hazardous and toxic wastes, and perform or ensure performance of any relocations determined by the Federal Government to be necessary for the initial construction, operation, and maintenance of this project.
    2. 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. However, for lands that the Federal Government determines to be subject to the navigational servitude, only the Federal Government shall perform such investigations unless the Federal Government provides the non-Federal project partner with prior specific written direction, in which case the non-Federal project partner shall perform such investigations in accordance with such written direction.
    3. 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.
    4. cost-share of the cost of mitigation and data recovery activities associated with historic preservation, that are in excess of 1 percent of the total amount authorized to be appropriated for the project.

B. For fifty years, operate, maintain, repair, replace, and rehabilitate the completed project, or functional portion of the project, 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. These requirements are generally described in Section 11.4 of this report.

C. 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 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.

D. 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.

E. 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.

F. As between the Federal Government and the non-Federal project partner, 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.

G. Comply with the 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 Unifom1 Relocation Assistance Act of 1987 (Public Law 100-17),and the Unifom1 Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way, required for the 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.

H. 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 issued pursuant thereto, as well as Army regulation 600- 7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army."

I. Participate in and comply with applicable Federal flood plain management and flood insurance programs and comply with the requirements in Section 402 of the Water Resources Development Act of 1986, as amended.

J. Not less than once each year inform affected interests of the extent of storm risk management afforded by the Project.

K. Publicize flood plain 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 flood plain and in adopting such regulations as may be necessary to prevent unwise future development and to ensure compatibility with the degree of storm risk management provided by the project.

L. 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 project lands or the addition of facilities which would degrade the benefits of the project.

M. Provide and maintain necessary access roads, parking areas, and other public use facilities, open and available to all on equal terms.

N. 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 that the Secretary of the Army shall not commence the construction of 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.

O. Quarterly and after storm events, perform surveillance of the beach to determine losses or nourishment material from the project design section and provide the results of such surveillance to the Federal Government.

9.2 Implementation Schedule

Table 55 provides a description of each of the 13 initial construction contracts, while Figure 31 shows the overall initial construction implementation schedule.

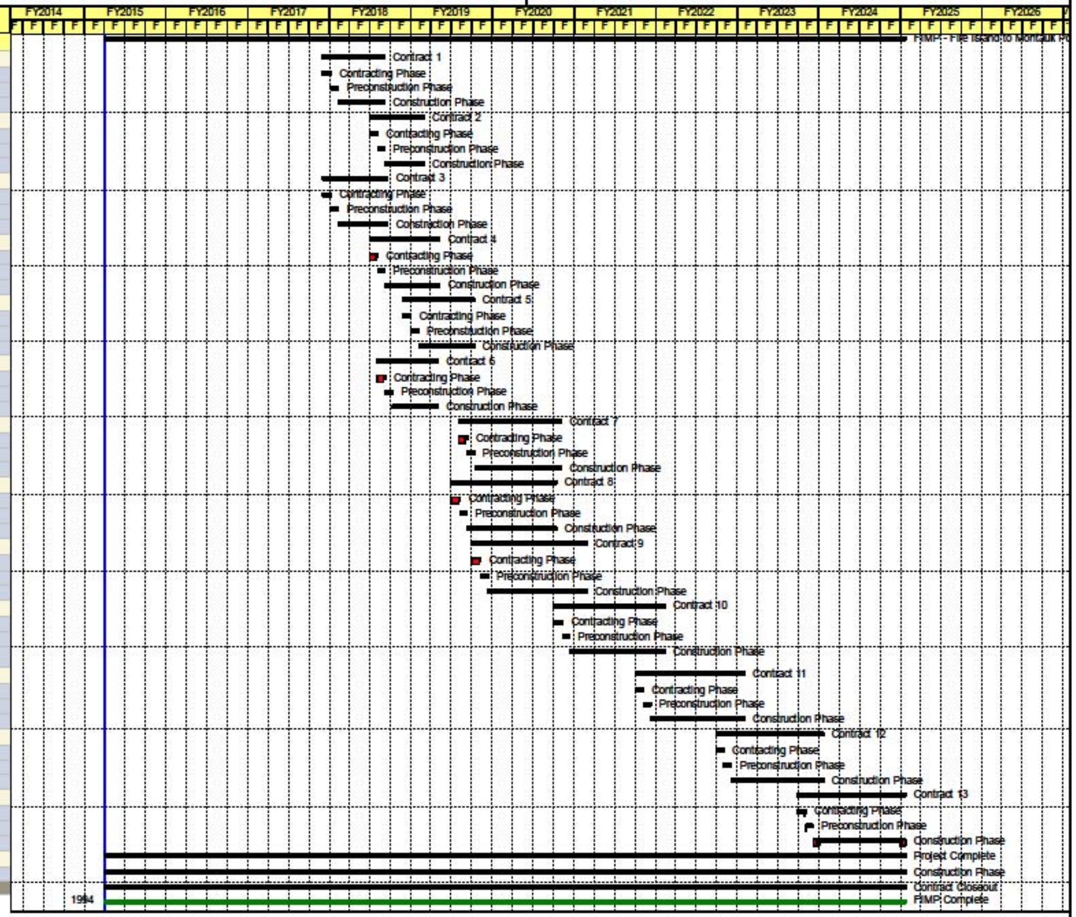
Table 55. FIMP Initial Construction Contracts

Contract #	Contract name	Description of work	Duration (Mo.)	Contract Start (NTP)	Finish
1	Inlet Dredging: Fire Island	Restore authorized channel dimensions and also dredge ebb shoal with placement downdrift beach at Gilgo Beach to offset deficit, and also at Robert Moses State Park (see Table 34)	7	1-Feb-2018	1-Sep-2018
2	Inlet Dredging: Moriches, Shinnecock	Restore authorized channel dimensions in Moriches Inlet and also dredge ebb shoal with placement downdrift at Smith Point County Park and Great Gunn to offset sand deficit; restore authorized channel dimensions in Shinnecock Inlet and also dredge ebb shoal with placement downdrift at Shinnecock Park West and WOSI to offset sand deficit (see Table 34);	6	1-Sep-2018	1-Mar-2019
3	Proactive BRP and Sediment Management	Place sand obtained from offshore borrow sources to construct proactive BRP profile at Sedge Island and Tiana Beach (See Table 36); also construct two feeder beaches at Potato Rd and Downtown Montauk by placing sand obtained from an offshore borrow site at each location (See Table 40). Construct coastal process features at Tiana and WOSI (See Table 41)	8	1-Feb-2018	1-Sep-2018
4	Beach Fill: Westhampton	Place sand obtained from offshore borrow sources to construct beachfill profile at Cupsogue, Pikes, and Westhampton (see Table 38). Construct coastal process features at Great Gunn (See Table 41)	9	1-Sep-2018	1-May-2019
5	Beach Fill: Fire Island	Place sand obtained from offshore borrow sources to construct beachfill profile at Fire Island communities from Kismet to Davis Park (see Table 38); Construct coastal process features at Sunken Forest, Reagan property, and Corneille (See Table 41)	9	1-Feb-2019	1-Oct-2019
6	Groin Modifications: Ocean Beach	Shorten the 2 groins at Ocean Beach	7	1-Oct-2018	1-May-2019

Contract #	Contract name	Description of work	Duration (Mo.)	Contract Start (NTP)	Finish
7	Groin Modifications: Westhampton	Shorten Westhampton groins 1 through 8 to 380 ft.; Shorten Westhampton groins 9 through 13 by between 386 and 410 ft.	13	1-Oct-2019	1-Nov-2020
8	Mainland Non Structural Road Raising	Raise Ht. of 31,400 ft. of roads in Amityville, Lindenhurst, and Mastic Beach	14	1-Sep-2019	1-Oct-2020
9	Mainland Non Structural - Year 1 Building Retrofits	Retrofit approximately 300 homes on the Mainland	15	1-Dec-2019	1-Feb-2021
10	Mainland Non Structural - Year 2 Building Retrofits	Retrofit approximately 800 homes on the Mainland	15	1-Dec-2020	1-Feb-2022
11	Mainland Non Structural - Year 3 Building Retrofits	Retrofit approximately 1200 homes on the Mainland	14	1-Dec-2021	1-Feb-2023
12	Mainland Non Structural - Year 4 Building Retrofits	Retrofit approximately 1300 homes on the Mainland	14	1-Dec-2022	1-Jan-2024
13	Mainland Non Structural - Year 5 Building Retrofits	Retrofit approximately 800 homes on the Mainland	14	1-Dec-2023	1-Jan-2025

FIMP - Master Schedule | TC Standard | 14-Mar-16 10:33

Activity ID	Activity Name	Remaining Duration	Start	Finish
	FIMP - Fire Island to Montauk Point	1994	02-Apr-15	23-Jan-25
	Contract 1	130	01-Dec-17	05-Sep-18
	Contracting Phase	17	01-Dec-17	10-Jan-18
	Preconstruction Phase	15	10-Jan-18	09-Feb-18
	Construction Phase	98	12-Feb-18	05-Sep-18
	Contract 2	126	29-Jun-18	01-Mar-19
	Contracting Phase	19	29-Jun-18	07-Aug-18
	Preconstruction Phase	18	07-Aug-18	06-Sep-18
	Construction Phase	89	07-Sep-18	01-Mar-19
	Contract 3	136	01-Dec-17	18-Sep-18
	Contracting Phase	17	01-Dec-17	10-Jan-18
	Preconstruction Phase	15	10-Jan-18	09-Feb-18
	Construction Phase	104	12-Feb-18	18-Sep-18
	Contract 4	157	29-Jun-18	09-May-19
	Contracting Phase	19	29-Jun-18	07-Aug-18
	Preconstruction Phase	18	07-Aug-18	06-Sep-18
	Construction Phase	120	07-Sep-18	09-May-19
	Contract 5	153	26-Nov-18	11-Oct-19
	Contracting Phase	18	26-Nov-18	02-Jan-19
	Preconstruction Phase	15	02-Jan-19	01-Feb-19
	Construction Phase	120	05-Feb-19	11-Oct-19
	Contract 6	138	01-Aug-18	01-May-19
	Contracting Phase	22	01-Aug-18	10-Sep-18
	Preconstruction Phase	17	10-Sep-18	10-Oct-18
	Construction Phase	99	11-Oct-18	01-May-19
	Contract 7	230	01-Aug-19	04-Nov-20
	Contracting Phase	21	01-Aug-19	10-Sep-19
	Preconstruction Phase	18	10-Sep-19	10-Oct-19
	Construction Phase	191	14-Oct-19	04-Nov-20
	Contract 8	235	01-Jul-19	14-Oct-20
	Contracting Phase	21	01-Jul-19	09-Aug-19
	Preconstruction Phase	17	09-Aug-19	08-Sep-19
	Construction Phase	197	10-Sep-19	14-Oct-20
	Contract 9	250	01-Oct-19	25-Feb-21
	Contracting Phase	20	01-Oct-19	11-Nov-19
	Preconstruction Phase	18	11-Nov-19	11-Dec-19
	Construction Phase	212	13-Dec-19	25-Feb-21
	Contract 10	254	30-Sep-20	10-Feb-22
	Contracting Phase	20	30-Sep-20	10-Nov-20
	Preconstruction Phase	17	10-Nov-20	10-Dec-20
	Construction Phase	217	11-Dec-20	10-Feb-22
	Contract 11	331	30-Sep-21	02-Feb-23
	Contracting Phase	19	30-Sep-21	08-Nov-21
	Preconstruction Phase	17	08-Nov-21	08-Dec-21
	Construction Phase	295	10-Dec-21	02-Feb-23
	Contract 12	340	30-Sep-22	22-Jan-24
	Contracting Phase	24	30-Sep-22	04-Nov-22
	Preconstruction Phase	21	04-Nov-22	04-Dec-22
	Construction Phase	295	05-Dec-22	22-Jan-24
	Contract 13	343	30-Sep-23	23-Jan-25
	Contracting Phase	25	30-Sep-23	06-Nov-23
	Preconstruction Phase	23	06-Nov-23	06-Dec-23
	Construction Phase	295	07-Dec-23	23-Jan-25
	Project Complete	1994	02-Apr-15	22-Jan-25
	Construction Phase	1994	02-Apr-15	22-Jan-25
	Contract Closeout	1994	02-Apr-15	22-Jan-25
Close9999	FIMP Complete	1994	02-Apr-15	22-Jan-25



Remaining Level of Effort | Critical Remaining Work | Summary | Remaining Work | ◆ Milestone

Page 1 of 1

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Figure 31. Tentative Implementation Schedule

9.3 Cost Sharing

The summary of Total Project Cost for the initial construction is provided in Section 6.2 of this report. Table 45 shows the Total Project Cost summary of the Initial Construction. The estimated Project First Cost (Oct 2017 P/L) for the TSP Plan is approximately $1.14 billion, which includes approximately $247 million in contingency. The fully funded Total Initial Project Cost (inflated to mid-point of construction) is approximately $1.24 billion, which includes approximately $269 million in contingency and about $95 million in inflation costs thru the midpoint of construction.

P.L. 113-2 states that "the completion of ongoing construction projects receiving funds provided by this division shall be at full Federal expense with respect to such funds". The total initial construction of the FIMP project has 100% Federal funding (P.L. 113-2), as shown in Table 56. As described in Section 6.6, the total project cost also includes periodic renourishment approximately every 4 years over a 30 year period. The estimated Cost (Present worth - Oct 2015 P/L) for the periodic renourishment is approximately $525 million which includes approximately $119 million in contingency, while the fully funded cost of renourishment (inflated to mid-point of construction) is approximately $850 million, which includes approximately $193 million in contingency and about $250 million in inflation costs thru the midpoint of construction.

In accordance with the Water Resource Development Act of 1986, as amended, periodic renourishment is cost shared 65% federal and 35% non-federal. The total federal Project cost apportionment (Oct 2015 PL) is approximately $1.4 billion, while the non-Federal partner is responsible for $183.9 of the Project cost (Oct 2015 PL). The total fully funded project federal cost apportionment is $1.8 billion, while the non-Federal partner is responsible for $297 million of the fully funded Project cost.

Table 56. Cost Allocation (Oct 2015 PL) ($000)

1 Oct 2015 P/L	**Federal Share**	**Non-federal Share**	**Total**
Initial Construction	$1,107,100	$0	$1,107,100
Periodic Renourishment	$341,559	$183,916	$525,475
TOTAL	$1,448,659	$183,916	$1,632,575
Fully Funded (includes inflation to mid-point of construction)	**Federal Share**	**Non-federal Share**	**Total**
Initial Construction	$1,248,477	$0	1,248,477
Periodic Renourishment	$552,418	$297,456	849,873
TOTAL	$1,800,995	$297,456	$2,198,350

9.4 Views of Non-Federal Partners and Other Agencies

There has been extensive coordination with the Interagency study team for this project, primarily including Department of the Interior (DOI), including representatives of the National Park Service (NPS) Fire Island National Seashore (FIIS), the U.S. Fish and Wildlife Service, and U.S. Geological Survey (USGS); New York State including New York State Department of Environmental Conservation

(NYSDEC), and New York State Department of State; and Suffolk County, including Suffolk County Department of Public Works and Suffolk County Parks. In addition, there has been extensive coordination with the regulatory agencies that would be involved in the permitting of this project, as well as agencies that are undertaken similar efforts within the study area. There also has been extensive coordination with the municipalities and public.

As described throughout the report, there is a requirement that the proposed plan be mutually acceptable to the Secretary of the Army, and Secretary of the Interior. This requirement, along with the requirement that the plan is acceptable to our local sponsor, requires that the Corps, DOI, and NYS all agree with the selected plan. In March 2011, the Corps and DOI agreed to a plan (the TFSP) that was acceptable to both agencies, and presented this plan to NYS for their agreement.

As a result of Hurricane Sandy, the Corps has updated the TFSP to account for post-Sandy changes. NYS has agreed to this plan in concept in July 2013. DOI has not agreed with these plan changes. In July 2014, the Department of the Army and Department of Interior entered into a memorandum of understanding, which identified an agreed-upon path for finalizing the FIMP plan, consistent with the Vision Statement for the FIMP Project. In August of 2015, the Corps transmitted the TSP to the State and agency partners, as described in this report, and stated that the Corps intends to proceed with the public and agency review process for this plan, and to use the input received from the public and agency review to finalize the selected plan, and to seek concurrence with the plan between the three parties.

NYSDEC has agreed with the proposed course of action, to proceed with public review of the report, in order to finalize the report. DOI has also agreed with the proposed course of action to proceed with public review of the draft report, consistent with the tenets of the 2014 MOU.

The Corps, State, and DOI have agreed that sufficient time needs to be allocated following the public and agency review, to give consideration of agency input, and coordination that may be required to support the plan or changes to the plan, that may be needed to achieve agreement between the Corps, DOI and NYS.

There are several elements of the TSP that the Corps, DOI, and New York State have agreed to continue to develop concurrent with the public and agency review process that may affect the final plan. This includes 1) the scope and extent of the coastal process features, 2) refinement of breach response protocols, 3) refinement of adaptive management, and 4) refinement of land management. The Corps and DOI recognize that there are additional needs and opportunities to provide for coastal process features which replicate the cross-island transport of sediment, provide barrier island resiliency, and long-term sustainability. With respect to the breach response protocols, the involved agencies have agreed that refinement of the decision-making protocols to better specify how the decisions related to breach closure would be made. Adaptive management is recognized as an important element of the selected plan, but the framework for adaptive management has not been defined. It is the intent of the agencies to identify the conditions under which changes in the plan could be made, and the framework for decision-making that would constitute an adaptive management plan. Land management is recognized as an important tool to manage future risks. The Federal and State agencies have agreed to continue to identify the land management measures that are available to manage these risks, and how these measures will work in conjunction with the TSP.

10 PUBLIC INVOLVEMENT

The Draft GRR and EIS are scheduled to be released for public review in Summer 2016. Notice will be posted in the Federal Register, local newspapers and there will be public meetings held during the review period.

11 RECOMMENDATIONS

11.1 Prefatory Statement

In making the following recommendations, I have given consideration to all significant aspects of the FIMP Study Area. The aspects considered include engineering feasibility, economic effects, environmental impacts, social concerns, and compatibility of the project with the policies, desires, and capabilities of the local government, State, Federal government, and other interested parties.

11.2 Recommendations

A number of alternatives have been examined as part of the ongoing FIMP Reformulation Effort and a Tentatively Selected Plan has been identified and considered. In accordance with current Planning Guidance and the guidance outlined in P.L. 113-2, the TSP described in this report is acceptable to the non-Federal partner, agencies, and stakeholders as a Coastal Storm Risk Management Project.

I make this recommendation based on findings that the plan constitutes engineering feasibility, economic justification, and environmental acceptability. This recommended project, which is subject to modifications by the ASA(CW), has an project initial cost of $1,107 million (Oct 2015 P/L), which includes $251.3 million in contingency, and a fully funded cost of $1,248.4 million, which includes approximately $109 million in estimated inflation costs through the midpoint of construction. The recommended project also includes 7 cycles of periodic nourishment over a 30 year period at an estimated cost of $525 million (Oct 2015 PL) and $850 million taking account inflation through the midpoint of construction. My recommendation is subject to the non-Federal interests agreeing to execute and comply with the terms of a Project Partnership Agreement following approval of this report.

11.3 Disclaimer

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

David A. Caldwell
Colonel, U.S. Army
Commander

11. REFERENCES

Aretxabaleta, A. L., B. Butman, and N. K. Ganju (2014), Water level response in back-barrier bays unchanged following Hurricane Sandy, Geophys. Res. Lett., 41.

Cañizares R., Alfageme S., Irish, J.L. (2003) "Modeling of morphological changes at Shinnecock Inlet, New York, USA," Proceedings of the Fifth International Symposium on Coastal Engineering and Science of Coastal Sediment Processes (Coastal Sediments '03), Clearwater Beach, Florida, 2003

Cañizares R., Alfageme S., "Process-based Modeling of a Restored Barrier Island: Whiskey Island, Louisiana," Proceedings of the Fifth International Conference on Coastal Dynamics (Coastal Dynamics '05), Barcelona, Spain, 2005

Cañizares R. and Irish, J.L. (2008) "Simulation of storm-induced barrier island morphodynamics and flooding" Coastal Engineering 55 (2008). Pp 1089-1101

Cañizares R., Alfageme S., Gravens, M.B.. (2004) "Modeling of Storm Induced Barrier Island Overwash and Breaching in the Atlantic Coast of Long Island, New York" in Proceedings of the 29th International Conference on Coastal Engineering (ICCE 2004), Lisbon, 2004

Cialone, M., Massey, C., Anderson, M. E., Grzegorzewski, A. S., Jensen, R. E. Cialone, A.,…… Ratcliff, J.J. (2015) "(NACCS) Coastal Storm Model Simulations: Waves and Water Levels. ERDC/CHL TR-15-14

Coastal Planning & Engineering of NY, PC, 2013. "2009 Fire Island Beach Renourishment Project Post-Sandy Storm Report", prepared for Sponsoring Communities on Fire Island, New York.

Gravens, M. B., Rosati, J. D., and Wise, R. A., 1999. "Fire Island Inlet to Montauk Point reformulation study (FIMP): Historical and existing condition coastal processes assessment," prepared for the U.S. Army Engineer District, New York.

Gray and Pape. 2005. Final Report Archeological Overview and Assessment of the Fire Island National Seashore, Suffolk County, New York. Prepared for the National Park Service.

Greeley-Polhemus Group., 1998. "Research on Shipwrecks in the Near Shore Area, Fire Island Inlet to Montauk Point, Long Island, Suffolk County, New York, Reach 1: Interim Project Fire Island to Moriches Inlet. Prepared for the US Army Corps of Engineers, New York District.

Hapke, C. J., Brenner, O., Hehre, R., Reyonlds, B. J., 2013. "Coastal Change from Hurricane Sandy and the 2012-13 Winter Storm Season: Fire Island, New York", Open-File Report 2012-1231, U.S. Department of the Interior, U. S. Geological Survey.

Irish, J.L and Cañizares R. (2009) "Storm-Wave Flow through Tidal Inlets and Its Influence on Bay Flooding" ASCE Journal of Waterway, Port, Coastal and Ocean Engineering March/April 2009. Pp 52-60

Irish, J.L and Cañizares R.(2006) " The Role of Wave Setup in Predicting Back-Bay Storm Water Levels: Long Island, New York, USA" Proceedings of the 30th International Conference on Coastal Engineering (ICCE 2006), San Diego, 2006

Irish, J.L, Cañizares R., Grosskopf, W.G. and Williams, B.P., (2004) "Effect of Hindcasted Waves on Coastal Storm Water Levels During the Blizzard of 2003" Proceedings of the Eigth International Workshop on Wave Hindcasting and Forecasting Oahu, Hawai, 2004

Irish, J. L., Williams, B. P., Militello, A., and D. J. Mark, (2004). "Regional-scale storm-surge modeling of Long Island, New York, USA." in Proceedings of the 29th International Conference on Coastal Engineering (ICCE 2004), Lisbon, 2004

Hapke, C. J., Brenner, O., Hehre, R., Reyonlds, B. J., 2013. "Coastal Change from Hurricane Sandy and the 2012-13 Winter Storm Season: Fire Island, New York", Open-File Report 2012-1231, U.S. Department of the Interior, U. S. Geological Survey.

John Milner Associates. 2000. Cultural Resources Baseline Study, Fire Island to Montauk Point, Suffolk County, New York, Reformulation Study. Prepared for the US Army Corps of Engineers.

Larson and Kraus, 1989a. SBEACH: Numerical Model for Simulating Storm-Induced Beach Change; Report 1, Empirical Foundation and Model Development. TR CERC-89-9, USACE.

Larson, M., and Krause, N. C., and Byrnes, M. R. 1990. "SBEACH: Numerical Model for Simulating Storm-Induced Beach Change; Report 2, Numerical Formulation and Nodel Tests," Technical Report CERC-89-9, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Lentz, E.E, Hapke, C.J., Stockdon, H.F., and Hehre, R.E., 2013. "Improving Understanding of Near-Term Barrier Island Evolution Through Multi-Decadal Assessment of Morpholig Change". Marine Geology, 337 (2013) 125-139.

Luettich, R. A., Westerink, J. J., and Scheffner, N. W. 1992. "ADCIRC: An Advanced Three-Dimensional Circulation Model for Shelves, Coasts and Estuaries; Report 1, Theory and Methodology of ADCIRC-2DDI and ADCIRC-3DL," Technical Report DRP-92-6, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Memorandum of Understanding (MOU) between the U.S. Army and the Department of Interior , July 2014 (Pertinent Correspondence – Appendix L).

Roelvink, J.A., van Kessel, T., Alfageme, S., and Cañizares, R. (2003). "Modeling of barrier island response to storms," Proceedings of the Fifth International Symposium on Coastal Engineering and Science of Coastal Sediment Processes (Coastal Sediments '03), Clearwater Beach, Florida, 2003

Scheffner, N. W., Borgman, L. E., and Mark, D. J, 1996. "Empirical Simulation Technique Based on Storm Surge Frequency Analysis," *Journal of Waterway, Port, Coastal, and Ocean Engineering* 122(2), American Society of Civil Engineers, 93-101.

U.S. Army Corps of Engineers, New York District (USACE-NAN), DRAFT 2000. "Fire Island Inlet to Montauk Point, Long Island, New York: Basis of Design Report)", U.S. Army Corps of Engineers, New York District.

U.S. Army Corps of Engineers, New York District (USACE-NAN), 2009. "Draft Formulation Report", U.S. Army Corps of Engineers, New York District.

U.S. Army Corps of Engineers, 2013. Incorporating Sea Level Change in Civil Works Programs, ER 1110-2-8162, dated 31 December 2013.

USACE 2014a. Fire Island Inlet to Moriches Inlet Stabilization Hurricane Sandy Limited Reevaluation Report. Sep. 2014U.S. Army Corps of Engineers, 2013 a.

USACE 2014b Downtown Montauk Stabilization Hurricane Sandy Limited Reevaluation Report. Sep. 2014