2016

Fire Island Inlet to Montauk Point
New York
Reformulation Study

Draft Plan Formulation Appendix

June 2016

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1. Introduction

A. Purpose

The Plan Formulation Appendix documents the project history and the plan formulation strategy 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.

The goal of the Reformulation study is to identify an economically viable, environmentally acceptable plan that addresses the storm damage reduction 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 shore protection with the boundary of the national Seashore be mutually agreeable with the Secretary of the Interior and Secretary of the Army. This requirement to be mutually agreeable necessitated that the traditional cost effectiveness evaluation of the baseline and future without project conditions be enhanced to incorporate project goals of the FINS.

Significant damages in the study area as a result of Hurricane Sandy, major changes to the landform, development patterns, and understanding of risks in the study area required further analyses and refinements of the mutually agreeable plan. Another result of Hurricane Sandy is that the Corps, in partnership with New York State, has undertaken stabilization efforts on the Fire Island barrier island and in Downtown Montauk, to reestablish a protective beach and dune in these vulnerable areas.

This appendix documents the evaluations and decisions made to identify a mutually agreeable plan prior to the impacts of Hurricane Sandy. It documents the formulation strategy employed, and the evaluation of the CSRM features against traditional USACE formulation criteria, P and G, and Vision Statement criteria. The Appendix concludes with a summary of the plan that maximizes coastal storm risk management opportunities, and the selection of a plan to achieve a mutually agreeable plan, and the final refinements to satisfy all the study objectives to become the Tentative Federally Supported Plan (TFSP).

The Main Report and the Engineering Appendix document the most recent refinements to adapt the TFSP to address Post Sandy changes to the TFSP and confirm its economic viability. The analysis conducted prior to Sandy is presented in this Appendix, in order to provide a succinct summary in the main report. Where appropriate, the Appendix notes where subsequent changes have revised plan elements since the initial formulation process was completed. The specific considerations initially considered remain in the appendix to clarify the evolution of the TFSP, unless otherwise specified.

B. Background

As described in Section 1D, 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 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 reexamines the project that was originally formulated in the 1950's and partially constructed in the 1960'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 effort is to identify an economically viable, environmentally acceptable plan that addresses the coastal storm risk management needs of the Project Area and is acceptable to the key Federal, State, and local stakeholders. Included within the Project Area is the Fire Island National Seashore (FIIS). The authorizing law for FIIS specified that any plan for shore protection, now referred to as Coastal Storm Risk Management (CSRM) within the boundary of the National Seashore be mutually agreeable 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 study from the key Federal and State agencies. The IRG developed and signed 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 Formulation Report was provided to the key government partners and stakeholders that 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 key stakeholders, and from public meetings in summer 2010, a Tentative Federally Supported Plan (TFSP) was developed in 2011. This Appendix, which is largely based on the 2009 report, includes 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 the northern New Jersey, New York City, and the Long Island coastline. The highest water level ever recorded at Battery Park within nearby New York City exceeded predicted tidal elevations of the storm at 9.4 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 beach lost 55 percent of its pre-storm volume equating to a loss of 4.5 million cubic yards (Hapke, et al 2013). A majority of the dunes either were flattened or experienced severe erosion and scarping.

Because of the significant damages to the project as a result of Hurricane Sandy, further analyses and refinements of the TFSP were required, which are discussed in detail in the Main Report and the Engineering Appendix.

C. Study Area Overview

The congressionally authorized Study Area extends from Fire Island Inlet east to Montauk Point along the Atlantic Coast of Suffolk County, Long Island, New York. The study area includes the barrier island chain from Fire Island Inlet to Southampton inclusive of the Atlantic Ocean shorelines, and adjacent back-bay areas along Great South, Moriches, and Shinnecock Bays. The study area continues to the east including the Atlantic Ocean shoreline along the mainland of Long Island extending from Southampton to Montauk Point. This area includes the entire Atlantic Coast of Suffolk County covering a shoreline length of approximately 83 miles. The study area also includes over 200 additional miles of shoreline within the estuary system. The Project Area includes portions of the mainland that are vulnerable to flooding, which generally extend as far landward as Montauk Highway, for an approximate area of 126 square miles. The Project Area is shown in Figure 1.1.

This Project Area represents a complex mosaic of ocean fronting shorelines, barrier islands, tidal inlets, estuaries, and back bay mainland area. The study area functions as an interconnected system driven by large scale processes with respect to hydrodynamic and sediment exchange, supporting diverse biological and natural resources.

Within the Project Area, sand along the ocean shoreline generally moves east to west alongshore, in response to waves, and currents during normal conditions and during storms. This alongshore movement of sand maintains 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 greater than a 2% chance of occurrence) through the episodic transport of sand over the island through overwash or breaching.

Over the years, the study area has become increasingly developed with extensive development on portions of the barrier island and in the mainland floodplain, with over 155,000 year round residents. As development has increased over the past 75 years, activities have been undertaken to provide for and protect infrastructure in the area, and to improve navigation in the area. These past activities have included inlet stabilization, construction of jetties and groins, seawalls, and revetments, beachfill, beach scraping, breach closures, channel dredging in the inlets and bays, bayside bulkheading, and ditching of wetlands for mosquito control.

These activities have been undertaken to address localized problems, and often have been implemented without consideration of regional effects. Collectively, these activities have dramatically altered the existing natural coastal processes. As a result, the area is not functioning as a natural, sustainable system. This leaves over 15,000 structures at risk to major damages from coastal storms such as hurricanes and nor'easters. This risk will continue to grow with continued development, continued erosion, and sea level rise.

The Study Area includes portions of the Towns of Babylon, Islip, Brookhaven, Southampton and Easthampton, as well as 12 incorporated Villages, the entirety of Fire Island National Seashore (FIIS), the Poospatuck Indian Reservation and the Shinnecock Indian Reservation. 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).

It is estimated that over 150,000 people reside in the coastal 100-year floodplain of the South Shore of Suffolk County, which represents 10% of the population of Suffolk County (2000 U.S. Census). The study area is also a popular summer recreation area. In addition to the residential population, there is a large seasonal influx of tourists who recreate in this area, and businesses which support the year round and seasonal population of the area.

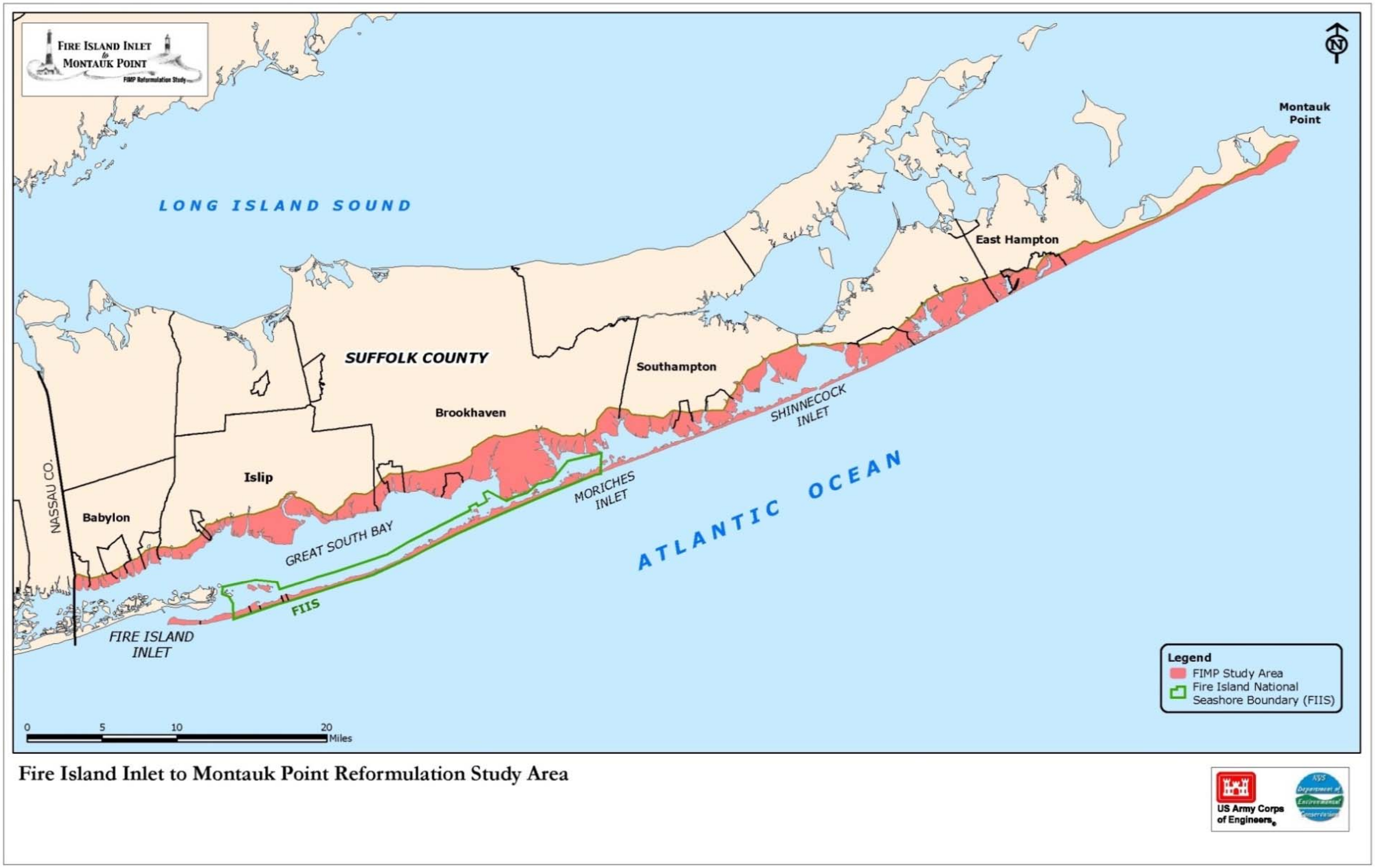


Figure 1.1: Fire Island Inlet to Montauk Point Refrmulation Study Area

D. ***Physical Description and Problem Overview***

As mentioned above, the study area functions as a complex, interconnected system. Shoreline areas to the east provide a source of littoral material to the west. The barrier island serves as a protective barrier to the mainland of the estuary, while the tidal inlets serve as conduits for exchange of water between ocean and bay. The inlets alter sediment transport pathways, resulting in erosion to the west, which can compromise the natural beach and dune conditions, and reduce the effectiveness of the barrier islands as a protective feature.

In order to address the problems associated with storm damages in the study area, one must consider the interconnected functioning of the area. Although it is necessary to consider the system as whole, for presenting the analyses, it is possible to break the area into three distinct regions, or problem areas, described below.

Three distinct regions can be described when assessing the physical conditions and associated problems of coastal storm damage. They include: 1) the barrier island segment of the project in the western portion of the study area, 2) the Back Bay areas behind the barrier island in the western portion of the study area, and 3) the shoreline areas in the eastern portion of the study area. The following paragraphs provide an overview of the physical conditions and coastal storm damage risks in each of these areas.

Western Study Area, Barrier Island Segment. A series of barrier islands characterize the western portion of the study area extending approximately 50 miles from Fire Island Inlet to Southampton. The barrier island chain includes Fire Island which extends approximately 30 miles east from Fire Island Inlet to Moriches Inlet; the 16-mile barrier island containing Westhampton and Tiana Beach extending from Moriches Inlet to Shinnecock Inlet; and the 4-mile long barrier spit extending from Shinnecock Inlet to Southampton. The three intervening inlets (Fire Island Inlet, Moriches Inlet, Shinnecock Inlet) are Federal navigation channels that connect the ocean and the bays. Beaches along the barrier island chain are generally characterized by a well-defined dune system with crest elevations ranging from 6 to 40 feet relative to the National Geodetic Vertical Datum (NGVD). Beach berm widths vary throughout the study area, ranging from approximately 0 ft. to 150 feet, with average beach berm elevations of approximately six to ten feet NGVD.

Public lands throughout the Barrier Island Segment provide areas where natural resources are protected to the greatest extent possible. The National Park Service, Fire Island National Seashore (FIIS) located along the Atlantic Ocean on the Fire Island barrier island, Great South Bay, and Moriches Bay shoreline, seeks, as part of its Mission Statement to preserve natural processes and protect ecological resources. FIIS is approximately 26 miles long, including the 7-mile long Otis Pike Wilderness Area, and includes, at the eastern end, Suffolk County's Smith Point County Park. The property consists of open ocean, marine intertidal, marine beach, dunes and swale, maritime forest, and back-bay habitats, as well as primarily seasonal communities

Along the barrier islands storm damages to developed areas are due to wave attack, erosion of the beach and dune, and flooding of infrastructure on the barrier island that occurs when the beach and dune elevations are exceeded due to hurricanes and nor'easters. There is a long history of buildings being destroyed during storms, which is described further in this chapter. But in addition to storms impacting infrastructure on the barrier island, the barrier island beach and dune system can eroded and create overwashes or breaches (new inlets) of the barrier island. When a breach occurs, it impacts both the barrier island and back bay system not only during the storm, but for an extended period after the storm. When a breach initially opens, it tends to be relatively small, but if not closed quickly, will grow rapidly over time. As these breaches grow they also may migrate (move along the island) and can destroy buildings and other infrastructure on the barrier island. Breaches also impact the hydraulic stability of the existing inlets, which can result in increased sediment deposition in the inlet channels, and compromised navigability of the inlet. Of greatest impact however, is the hydrodynamic impact on the back bay. When a breach occurs, it increases flooding in the Back Bay environment due to storm activity, and this effect continues to increase as the breach grows.

<u>Western Study Area, Back Bay Segment.</u> The study area back bay system lies behind the barrier island chain and is bounded on the north by the Long Island mainland, and includes Great South, Moriches and Shinnecock Bays. Great South Bay is the largest of the study area estuaries extending about 30 miles from Massapequa to the west along South Oyster Bay to Smith Point to the east along Bellport Bay. Moriches Bay is a relatively small estuary comprised of an ocean entrance, western and eastern connections to Great South Bay and Shinnecock Bay, respectively, and a number of tidal rivers and creeks. Moriches Bay extends from Smith Point (inclusive of Narrow Bay) at its western end where it adjoins Great South Bay to Westhampton Beach on it eastern end. Shinnecock Bay is similar to Moriches Bay, and is a relatively small estuarial system and extends from west to east between Quogue, where it connects with Moriches Bay through the Quantuck and Quogue Canals and the Villages of Southampton.

Intense development along the Back Bay Segment's shoreline, has minimized open space and wetland areas. However, there are existing public lands, as well as lands being actively acquired by Suffolk County as open space and parkland. The 2,220-acre William Floyd Estate is a NPS property, managed as a subunit of FIIS. Located in Mastic Beach on the mainland/south shore of Long Island, the estate consists of upland fields and forests and tidal marshes. The largest parcels include those managed by the US Fish and Wildlife Service (Service) which has several properties on the mainland/south shore of Long Island. The Wertheim National Wildlife Refuge (NWR) is located on, and encompasses, the southern portion of the Carmans River and associated estuary. The 2,550 acre Refuge contains extensive salt marshes, which, when combined with the adjacent New York State-owned salt marshes, form the largest continuous salt marsh on Long Island. The Service's Seatuck NWR in Islip is a 196-acre refuge consisting of grasslands, woodlands, and salt and freshwater marshes bordering Champlin Creek and Great South Bay, on the mainland/south shore of Long Island. The Service's Sayville property is a 101-acre parcel consisting of grasslands (including the Federally-listed endangered sandplain gerardia [*Agalinis acuta*]), woodlands, and remnants of a communication facility, on the mainland/south shore of Long Island

Conditions in the Back Bay environment are significantly different than that along the Atlantic Ocean shoreline. Like the ocean shoreline, this area is vulnerable to flooding that occurs as a result of hurricanes and nor'easters. When a storm impacts the area, storm water and waves impact the Ocean shoreline. That storm water is propagated into the bays through the inlets. The passage through the relatively narrow inlets limits the height of flooding in the bays, and also dramatically reduces wave heights in the bay. During storm events there can also be a pronounced water level setup in the bay that occurs due to winds. The height of flooding in the back bay is generally lower than along the ocean, but the impact of flooding in this area is significant. The terrain of the south shore of Long Island is low and flat. Much of the study area has been heavily developed, and in many areas the development was built prior to the flood insurance program, and is subject to frequent flooding. As presented above, these areas flood due to water that enters through the inlets, and is setup in the bay. The problem of flooding, however, is made worse if there is a breach of the barrier island. Breaches of the barrier island provide additional pathways connecting the ocean and the bay which allows for the increased penetration of ocean surges into the bay. When a storm impacts the area, when the barrier island does not breach, there are approximately 9,000 mainland buildings which would be flooded by a 100-year event (a large storm with a 1% chance of occurring in any year). In one condition modeled, which represents a worst-case scenario with a breach into each bay, where these breaches grow unchecked, that same storm would flood almost 10,000 additional buildings, resulting in more than 19,000 mainland buildings flooded. On Fire Island and the Westhampton Barrier, the same breach event would also cause the number of structures on the bayside of the barrier island flooded under a 100-year event to rise from approximately 2,400 to more than 3,200.

This flooding along the Back Bay environment is the greatest source of damages in the project area. Storms impact the low-lying development on a frequent basis, and extensive damages occur to a greater number of buildings during large, infrequent storm events, which breach the barrier island.

<u>Eastern Portion of Study Area.</u> The eastern-most portion of the study area includes the south fork of Long Island. It extends from the Village of Southampton east to Montauk Point covering a distance of approximately 33 miles. Extending west from Montauk Point for a distance of approximately 15 miles, the south shore of Long Island is backed by Block Island Sound (to the east) and Napeague Bay (to the West). Island widths in this part of the project range from about 15,000 feet at Montauk to 4,500 feet at Napeague. Beach widths within this entire eastern portion of the study area range from approximately 50 to 200 feet and are characterized by berm elevations of six to ten feet. Along the western-most 23 miles, the shore is characterized by lower bluffs and/or dunes fronted by beaches of varying width. The easternmost 10-miles of the study area is characterized by a series of bluffs with elevations ranging up to 100 feet. Within the boundaries of the Towns of Southampton and East Hampton, several bodies of water are situated just landward of the shorefront. The largest of these water bodies include Hook Pond, Georgica Pond, Sagaponack Lake, Mecox Bay and Agawam Lake. Water surface areas of these features range from about three to 19 square miles. These ponds, to varying degrees are hydraulically connected to the ocean. Georgica Pond and Mecox Bay are generally opened one to two times a year, usually through mechanical means to allow tidal exchange of water.

The beaches, dunes and bluffs in the eastern portion of the study area front developed areas, recreation areas, and undeveloped natural areas, all of which have different degrees of risk to storm damages. In this area, the risk of storm damage to developed properties and infrastructure is primarily due to wave attack, erosion of the dune, and tidal flooding that occurs when the beach and dune are compromised due to hurricanes and nor'easters. In the areas surrounding the coastal ponds tidal flooding can also occur, as a result of water driven into the ponds from high ocean water-level events. Development in this portion of the project area tends to be less dense, and generally constructed with greater setbacks from the ocean. As a result, damages to the existing infrastructure tends to be more localized.

Sea Level Change. Throughout the entire study area, vulnerability to storm damages is likely to increase in the future due to sea level rise. Sea level rise and its implications are presented in greater detail in Chapter 3. While sea level rise impacts the entire area, it is important to note that the problem of sea level rise is greatest on the back-bay development where small increases in water elevations can impact large numbers of structures.

Summary. As described above the problems along the shorefront include storm damages due to erosion, wave attack, and flooding. Along the barrier island there is also the threat of barrier island overwash and breaching. Along the Back Bay, there is the threat of flooding during no-breach conditions. Tidal flooding becomes worse when there is a breach of the barrier island, which allows for more storm waters from the ocean. These problems have occurred repeatedly in the past, resulting in damages to the built environment. The specific quantification of these problems is described in the Main Report and the Benefits Appendix, Appendix D.

E. Study Area Storm and Construction History

The following sections provide an overview of storms which have impacted the area, the effect that they had, and the actions undertaken to ameliorate the impact of the storms. This history illustrates the potential for storm damage now and in the future, and the likely response to storms in the absence of a long-term project for this area.

The study area has a long history of storm damage. Prior to the 1930's the recorded history of storm impact is largely anecdotal, although references are available that describe the great storm of 1690, which opened Fire Island Inlet; the major hurricane of 1821 which made landfall near Jamaica Bay, and resulted in flooding 9.3 feet above average in New York City;, and the major hurricane in August 1893 which was labeled as "Long Island's Most Destructive Storm". Since 1930, the records are more detailed, and there have been a number of hurricanes and nor'easters that have impacted the area. The storm history indicates periods of time in which a series or cluster of storms have impacted the study area. It is these time periods where it appears that the storms had the greatest impact on the built environment, and where the consequences of the storms were greatest. Since the 1930s there is also a history of human responses after storms to close breaches and restore the beaches and dune.

1930's

The 1930s had a number of significant storms, including the March 1931 nor'easter, and the "Long Island Express" hurricane in 1938, which is the storm of record in the area. The March 1931 nor'easter occurred during a full moon, and is the storm that created Moriches Inlet. It also resulted in widespread erosion along the study area. Prior to this storm there was no inlet into either Moriches or Shinnecock Bays; only Fire Island Inlet prevailed. Prior to the 1938 hurricane, there were a number of low, narrow areas along the barrier beaches with several areas no higher than 6ft. above MSL.

The 1938 hurricane, named the "Long Island Express" had wind gusts up to 135 MPH, and made landfall in the vicinity of Moriches Inlet, at a time nearly coinciding with a high tide. The results of this hurricane were devastating.

Waves 15-30 feet high swept the beaches along the entire south shore of Long Island. The storm surge and waves breached most of the dunes on Fire Island that were less than 16 feet in elevation. Dunes higher than 18 feet were generally left intact although they often showed evidence that they too had been overtopped. The ocean broke through the barrier island in hundreds of places inundating the normally dry land protected by the barrier and flooding the coastal bays and ponds. The storm resulted in 11 new openings of the barrier islands in the study area. The full storm, 200 to 300 miles across lasted only four hours but left 50 people dead and over 1,000 homes destroyed. Damages to property on Long Island was estimated at $87 million.

Coastal towns had water in the streets three to four feet high. Storm waters six feet deep swept through Westhampton from the ocean to Main Street. Westhampton Beach reported 28 deaths, the highest of the Long Island towns, and 157 of the 179 beach front homes were destroyed. In Saltaire 127 houses were destroyed, at Fair Harbor 91 structures destroyed, at Oak Beach 29 homes were lost, Kismet Park lost more than 22 homes, Lonelyville lost 14 homes, and 300 homes were lost at Ocean Beach.

In Southampton along Dune Road, only two homes remained after the storm waves swept the barrier beach. The landmark St. Andrew’s Church on the Dunes in Southampton was destroyed, pieces of the building and furnishings were found spread over a mile wide area. In Bridgehampton more than 50 barns were destroyed between Water Mill and Wainscott. Crops were buried beneath sand from the beach or washed away.

The fishing village at Montauk was swept away during the storm leaving about 150 people homeless, the residents having lost almost all their possessions. More than 80 fishing boats were destroyed or badly damaged. Nets and fish traps were also damaged. The Westhampton Yacht basin lost pleasure boats and work boats. At the Shinnecock Yacht Club the main floor of the club house was destroyed leaving the second story on the ground.

All the bridges in Westhampton and Quogue had been damaged during the storm. In Westhampton the south end of the West Bay Bridge was destroyed. In Quogue, the Beach Lane Bridge was destroyed by flood waters and floating debris; the Ocean Avenue Bridge was damaged but not destroyed. The railroad tracks and highway at Napeague were washed out isolating the east end of the island. Railroad service between Amagansett and Montauk was disrupted for seven days.

Fire Island State Park was severely damaged by the storm, the beach dunes were damaged by the high waves, building were damaged beyond repair and more than two-thirds of the docks were destroyed. Three Coast Guard station including the Moriches and Potunk stations, were destroyed and the remaining fifteen stations from Jones Beach and to the west, were damaged to a lesser degree.

Photos illustrating the overwash, breaching, shorefront damages, and Back Bay flooding as a result of the 1938 hurricane are shown in Figures 1.2 – 1.6.

The human response to the 1938 hurricane was extensive. The Superintendent of Highways for Suffolk County describes the County’s response which included extensive debris removal, rebuilding dunes, rebuilding of public infrastructure, public facilities and the closure of breaches. Ten of the eleven breaches were reportedly closed using trucks and bulldozers. The 11th breach was at Shinnecock Inlet, where the

County decided to stabilize the inlet with a timber crib structure on the western shoreline to create a permanent inlet.   Robert Moses in his 1938 report described the other activities undertaken, including the placement of debris on the beach and in the dunes to act as sediment traps. Robert Moses' 1938 report recommended an alternative to this practice, which included rebuilding a beach and dune, topped by a road, to be constructed with material from the back bay (much like Ocean Parkway on Jones Island). This plan was never implemented in the Project Area.

Figure 1.2: Extensive overtopping of dunes and breaks through the barrier island east of Ponquogue Bridge during the hurricane of September 21, 1938. Shinnecock Inlet, which opened during the storm is shown in the photo.

Figures 1.3 – 1.4: Flooding of Main Street in Westhampton Beach during the September 21, 1938 hurricane

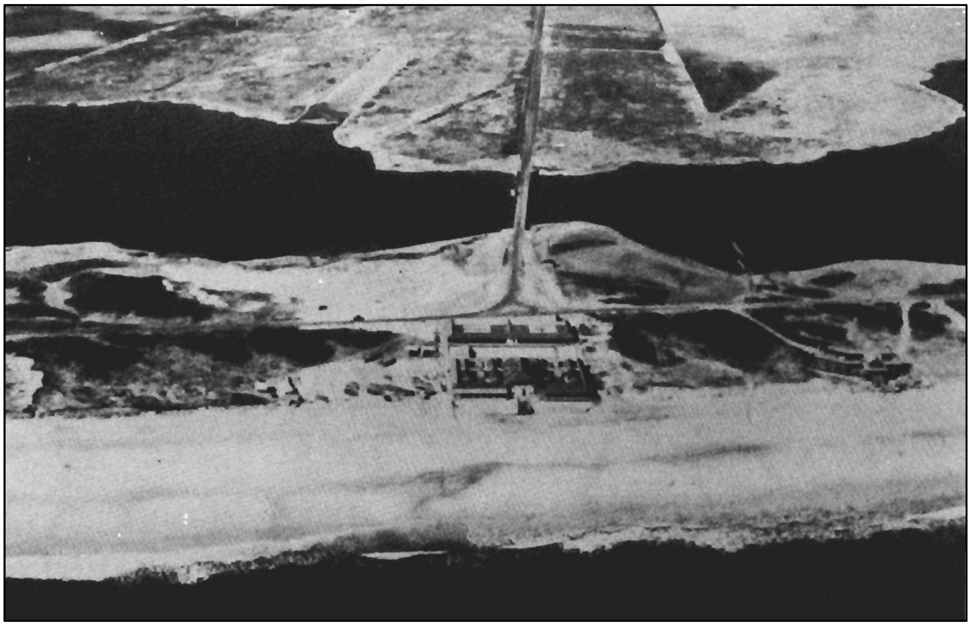


Figure 1.5 – 1.6: The above photos illustrate conditions in the area of Westhampton Beach before and aft.er the Hurricane of 1938. Damages shown in the photo include significant damages to the west bay bridge, and a breach of the barrier island to the east of the bridge.

In the years following the 1938 hurricane, there was increased human investment along the shoreline. In 1941, Fire Island Inlet was stabilized with the east jetty to improve the navigability of the inlet. In the early 1950's Suffolk County and New York State further stabilized Moriches Inlet and Shinnecock Inlet with stone jetties and dredged the inlets for improved navigation access. For Moriches Inlet, these improvements were also intended to improve water quality in the bay. This period also saw an increase in development in the Study Area. Building after World War II resulted in extensive development along the western bay shorelines. NPS documents indicate 1,260 houses and businesses were located on Fire Island in 1955, with an increase to approximately 2,400 by 1962.

<u>1950's and 1960's</u>

The 1950's and 1960's were a period of intense storm activity. Notable storms impacting the area in the 50's and 60's include the November 1950 Nor'easter, the November 1953 nor'easter, Hurricane Carol in 1954, Hurricane Donna in 1960, and the Ash Wednesday Nor'easter of 1962, also known as the "5-High Storm", since the storm resulted in flooding over a period of five high tides. The frequency and intensity of these storms resulted in significant storm effects, and inspired human response to the problem.

The November 1950 nor'easter resulted in ocean tide 5.1 feet above mean sea level at Shinnecock Inlet; 5.2 feet above mean sea level at Montauk Point; and 3.8 feet above mean sea level in Moriches Bay at Westhampton. The Coast Guard reported waves 20 feet high along the south shore. The Suffolk County authorities reported that barrier island dunes with an elevation less than 12 feet above mean sea level were overtopped. Dunes were cut through the barrier at thirteen location between Fire Island Inlet and Moriches Inlet, and three locations east of Quogue. A major breach, 100 feet wide by 6 feet deep, joined the ocean with Moriches Bay at Westhampton Beach

During the November 1953 Nor'easter, the dunes at Westhampton Beach were destroyed by extremely high water levels as the storm arrived during high tide. Wave heights along the shore were estimated at 20 feet high. The ocean broke through the barrier island at five locations from Fire Island to an area 2.5 miles to the east. In the vicinity of Smith Point the beach was breached contributing to the inundation of mainland structures one-quarter mile inland. The dunes between Democrat Point and Moriches inlet were cut back by the wave action a distance of 10 to 50 feet. The jetties at Moriches and Shinnecock Inlets were damaged by the storm, and Shinnecock Inlet was partially shoaled. At Westhampton Beach the ocean broke through the barrier island in eight locations and resulted in the inundation of the mainland to a depth of two feet for one-half mile inland. In East Hampton there were breaches into Georgica Pond, Hook Pond and near the east boundary of the village. There was water one- foot deep 150 feet inland. The high storm waves contributed to the severe structural damage to homes on Fire Island, where structures were inundated or undermined.

During Hurricane Carol in 1954 the ocean broke through the barrier beach between Montauk Point and Fire Island in 14 locations, including 10 at Westhampton Beach. A breach 200 feet wide was cut through the beach west of the West Bay Bridge at Westhampton Beach. The breach was filled and the roadway rebuilt only to be damaged again in the September 11 storm, Hurricane Edna. Deposition of sand from the damaged dunes along Beach Road between Quogue and Shinnecock Inlet isolated the area. Three homes were badly undermined and 100 beach front homes were evacuated. The dunes were also severely eroded at many locations along the barrier including Point O'Woods. In the vicinity of East Hampton, the dunes were breached at several locations into Mecox Bay, Sagaponack Lake, and Georgica and Hook Ponds. The waves broke through at Napeague between Amagansett and Montauk and damaged the railroad tracks disrupting service. The adjacent highway was flooded to a depth of three feet. The ocean broke through the dunes between Fort Pond Bay and Montauk. Severe erosion of the beach and cliffs east of Montauk was reported in addition to damage to the seawall at Montauk Point.

The 1962 Ash Wednesday storm lasted through five consecutive high tides causing severe beach and dune erosion. Each successive high tide was able to reach further inland or into back bay areas as the beaches and sand dunes eroded and were washed away. The storm destroyed 96 barrier beach homes; 53 of the homes at Westhampton Beach; 21 new built homes at Fire Island Pines. In the Town of Southampton 45 houses were extensively damaged. Along Dune Road in Quogue, four houses were completed destroyed and several more were in danger of being swept into the ocean. Many houses not destroyed during the storm were left hanging on the edge of the eroded dunes

A new 300 foot wide inlet was formed through the barrier beach west of the Jessup Lane Bridge at Westhampton Beach. Dune Road was destroyed in several locations isolating unoccupied homes that weren't damaged in the storm. Additional smaller inlets in the barrier island were also formed. The local authorities worked quickly to repair the breaches, using two dredges provided by the county, it took approximately one week to close the major breach working 24 hours each day.

The Federal Government responded to this storm with "Operation Five High" which undertook efforts to rebuild beaches and dunes along the entire Atlantic Ocean shoreline from Virginia to New York. Within the study area there was significant Federal dune and beach rebuilding as part of this program, and a number of smaller efforts undertaken by local governments. As part of Operation Five-High, approximately 2,220,000 CY of sand was placed along 14.7 miles of shoreline in the Study Area. Additional local efforts undertaken included dune rebuilding and emergency protective measures at Cherry Grove, Point O' Woods, Village of Saltaire, Village of Ocean Beach, and the Village of East Hampton. Figures illustrating storm damages from the Five High Storm are shown in Figures 1.7 – 1.10.

After Closure

Before Closure

Figure 1.7 – 1.8. Site of the Inlet breakthrough at Westhampton Beach during the Five High Nor'easter of 1962, which was subsequently closed.

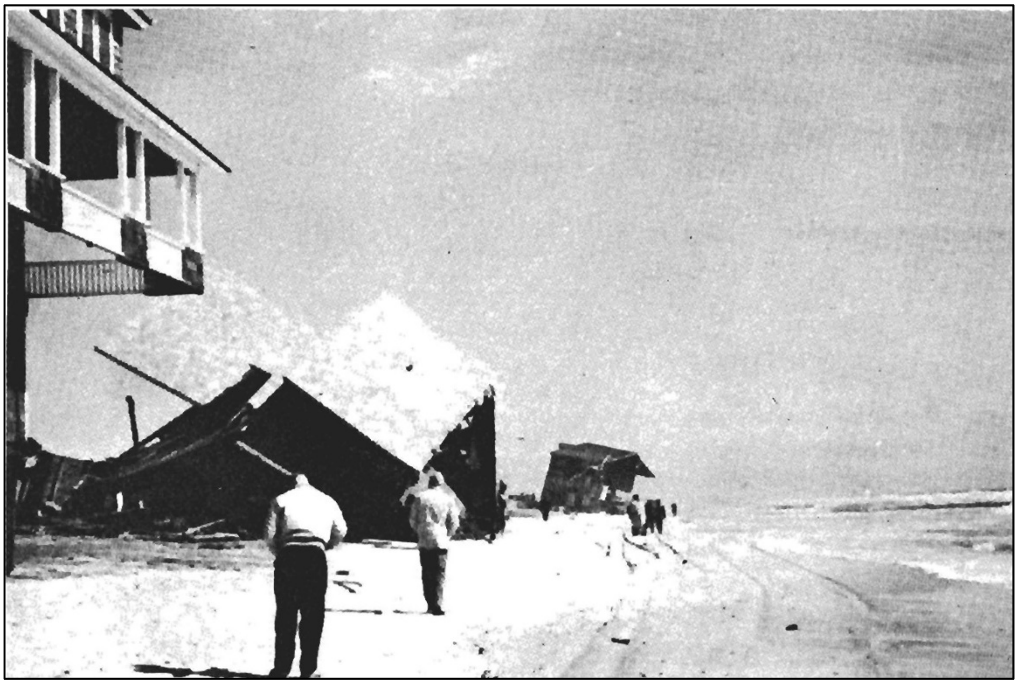


Figure 1.9. Point O' Woods, following the 1962 Five High Nor'easter

Figure 1.10. Fire Island Pines, following the 1962 Five High Nor'easter

The storms in the 1950s were the impetus for the original FIMP Study. The study concluded with the 1958 Survey Report which was endorsed by Congress. Construction of elements of the project followed in the 60s, including the partially constructed groinfield in Westhampton and two groins in East Hampton near Georgica Pond. This time period also saw continued development along the shoreline and additional hard structures built. Groins were constructed by State and local interests in the areas of Ocean Beach on Fire Island and in Easthampton, which were a precursor to the Federal groins. Numerous local and homeowner projects were also constructed, as evidenced by the small groins, bulkheads, and dunes sometimes reinforced with stone, concrete and cars, which are intermittently exposed today.

From 1960 through the 1970's, there were a number of significant legislative actions that influenced management of the coast. This included the introduction of the National Flood Insurance Program in 1968, the introduction of NEPA in 1969, the introduction of the CZMA in 1972, and the authorization of the Fire Island National Seashore in 1964. Within New York State, this period also saw the introduction of the New York State Coastal Erosion Hazard Act Regulations (CEHA). Collectively, these policy guidelines, jurisdictions, and land use regulations govern largely what is in place today. Of these, it is important to particularly note that the creation of the Fire Island National Seashore established a requirement for any beach nourishment plan within the boundaries of Fire Island arising from this study to be mutually agreeable to both the Secretary of the Army and the Secretary of the Interior.

A Nor'easter in January1980 resulted in a breach of the barrier island, just to the east of Moriches Inlet, which remained open for 13 months, until closed in February 1981 at a cost of $12 Million. Hurricane Gloria impacted the study area in 1985, but made landfall at low-tide, sparing Long Island from severe flooding, and resulting in mostly wind damage. Still, 48 houses were reported as destroyed in the Project Area with peak wind gusts of 100 mph.

1990's

There were a series of storm events impacting the project area in the early 1990's including Hurricane Bob in 1991, the Halloween Nor'easter of 1991 (dubbed the "Perfect Storm"), the December 1992 Nor'easter, and the March 1993 "Storm of the Century". The eye of Hurricane Bob passed over Block Island to the east of Long Island, and resulted in a storm surge which caused widespread coastal flooding in low lying areas.

The 1991 October Halloween storm followed an unusual east to west track; when a northeaster joined with the remnants of a hurricane and began to move backwards. The storm circled several hundred miles offshore generating huge waves which battered the shoreline through three high tides. High winds and rough seas destroyed homes on Dune Road in Westhampton Beach as waves washed over the dunes. Along Dune Road in Westhampton and Quogue 19 residences were destroyed, 17 homes seriously damaged and four homes were reported with minor damage. Approximately 4,000 feet of Dune Road required repair. Beach club facilities and hundreds of feet of beach were severely eroded, dunes 15 feet high were washed away. The beach and dunes at Southampton suffered major erosion damage, the remains of several building destroyed in the 1938 hurricane were exposed. Breaches in the barrier island in front of Georgica Pond, Mecox Bay and Sagaponack Lake exposed the waters to the ocean. Near Mecox Bay the dunes were washed over and two houses were damaged. At East Hampton there was severe erosion to the beaches and the dunes, as well as major erosion at the Montauk Lighthouse.

The December 1992 Nor'easter resulted in significant damages along Long Island's ocean shoreline and in the back bays. The most severe damage was along the Westhampton Barrier where 36 houses were lost, and where there were 2 breaches at Westhampton (Pikes Inlet and Little Pikes Inlet). Overwashes of the island were also observed along western Fire Island, at Smith Point County Park, Old Inlet, and in the area just west of Shinnecock Inlet. The dune area, with dunes 15 to 20 feet high, west of the jetties at Shinnecock Inlet in Hampton Bays was leveled and Dune Road was covered with sand 6 to 8 feet deep. Several homes on the bayside were covered with sand up to the roof tops. Homes on the ocean side stood on their wood piles as waves rolled underneath. In Mastic Beach the water reached 2 to 4 feet deep in the streets

Pikes Inlet, initially the larger of the two breaches at Westhampton was closed quickly, while Little Pikes Inlet was left open to possibly close on its own. However, Little Pikes inlet instead grew to 3,000 ft. wide and 20 ft. deep by April 1993. The widening breach had caused damage to an additional 80 homes along Dune Road. The breaches in the barrier island caused an increase in the bay side tidal range and an increase in flooding on the mainland during storms. Eventual emergency closure of the inlet was undertaken in October 1993 at the cost of $10,000,000. Photos illustrating the growth and closure of the breach at Westhampton are shown in Figure 1.11.

The March 1993 resulted in severe wave action that scoured the beaches along the entire barrier island. The dunes were overtopped, lowering the height of the dunes 15 to 20 feet. It was reported that homes were destroyed or severely damaged at Kismet- 7 houses, Saltaire- 18 houses, Fair Harbor- 39 houses, Lonelyville- 2 houses. Extensive flooding was also reported in the area of Remsemburg along Moriches Bay. The severity of the flooding was linked to the breach of the barrier island in Westhampton that had opened in December 1992.

These storms in the early 1990's served as the basis for re-convening the Governor's Coastal Erosion Task Force, which in 1994 established both short-term and long-term policies for the State of New York, and recommended specific actions that included: 1) initiate sand bypassing at the inlets and at the Westhampton groin field; 2) maintain barrier island landform integrity by filling highly vulnerable washover fans and new inlet breaches, and maintaining longshore sand transport; 3) establish a reserve of funds to enable rapid response to critical erosion problems caused by coastal storms, such as breaches in the barrier island; 4) press federal, state, and local governments to elevate or provide protection for key evacuation routes; 5) initiate an erosion monitoring program to provide scientific information to design future projects, modify existing ones as necessary, and refine management practices; and 6) use the Corps of Engineers to expedite the Fire Island Inlet to Montauk Point Reformulation Study.

September 1992

December 1992

January 1993

March 1993

June 1993

October 1993

Figure 1.11: The evolution of the 1992 breach at Westhampton from pre-breach to closure conditions.

Since the early 1990's, actions undertaken to protect infrastructure along the interim beach and dune project in the area of the Village of Westhampton Dunes, and the similar project to protect the area immediately west of Shinnecock Inlet. Consistent with the Task Force findings, there has been a renewed emphasis on bypassing material dredged from the inlets for navigation. A Breach Contingency Plan was also developed to reduce the time to close future breaches, based upon the 11 months it took to close the breach at Westhampton. In the absence of government-led response in other locations along the shoreline, there also have been a number of community-funded and County-funded beachfill and beach scraping projects on Fire Island, and a number of localized stone, steel and geotextile structures constructed throughout the Project area.

The most recent major storm events to impact the project area are Hurricane Irene (2011) and Hurricane Sandy (2012). Hurricane Irene caused coastal flooding along Fire Island as water levels reached 7.0 feet NAVD 88 at Sandy Hook, NJ but did not result in significant erosion. Measured wave heights 15 nautical miles offshore exceeded 25 feet during the peak of the storm.

Hurricane Sandy made landfall near Atlantic City, NJ on October 29th with wind speeds equivalent to a Category 1 hurricane. The orientation of Hurricane Sandy's wind field prior to landfall caused strong winds to blow across the continental shelf towards New York. Because the peak storm surge was in phase with the peak high tide, storm-induced flooding was exacerbated. Hurricane Sandy's unusually large diameter resulted in long fetch lengths generating extreme wave heights at the study area. These three factors (track, timing, and extraordinary size) resulted in record water levels and wave heights in the New York Bight. The maximum water level at the Battery, NY is estimated to have reached elevation 11.6 feet NAVD88 exceeding the previous record by over 4 feet (USACE, 2013).

A team from the USGS went to Fire Island before and after Hurricane Sandy to survey the beach and assess morphological changes. The following excerpt from their field report provides a summary of the impacts along Fire Island immediately aft.er the storm (USGS, 2012):

"The impacts to the island were extensive. The majority of oceanfront homes in the communities within Fire Island National Seashore were damaged or destroyed. Enormous volumes of sand were carried from the beach and dunes to the central portion of the island, forming large overwash deposits, and the island was breached in multiple locations. With few exceptions, lower-relief dunes were overwashed and flattened. High dunes, which are more commonly found within undeveloped portions of the island, experienced severe erosion and overwash. The elevation of the beach was lowered and the dunes form vertical scarps where they survived."

An oblique aerial photo Figure 1.12, taken after Hurricane Sandy at Otis G. Pike Wilderness Area looking east towards Smith Point County Park shows a typical overwash fan and the breach at Old Inlet. An example of dune scarping and berm lowering during Hurricane Sandy is shown in Figure 1.13. Pre- and post-Sandy aerial photos at Ocean Beach show an example of a location where the dunes were overwashed and flattened as well as the extensive damage to ocean front structures as shown in Figure 1.14. Another example dune flattening and severe damage is provided in Figure 1.15 at Davis Park.

Three breaches occurred during Hurricane Sandy. Two of the breaches, at Smith Point County Park and Cupsogue (just east of Moriches Inlet), were closed shortly after the storm following the protocol established by the Breach Contingency Plan. A third breach at Old Inlet within the boundaries of the Otis G. Pike Wilderness Area on Fire Island has not been closed, and remains a relatively stable small tidal inlet. It continues to be monitored by the National Park Service, SOMAS, and USGS. This breach was not included in the initial alternative evaluation documented within this appendix. The Main Report and Economic Appendix document the adaptations made to the models and analysis to reflect the changed without project conditions. NPS is currently preparing an Environmental Impact Statement to consider long-term management of the breach.

Figure 1.12: Post Sandy Photo of Breach at Old Inlet (looking east towards Smith Point County Park)

Figure 1.13: Post Sandy Photo Dune Erosion and Berm Lowering at Fire Island

Figure 1.14: Pre- and Post-Sandy Photo at Ocean Beach

Figure 1.15: Post-Hurricane Sandy Photo at Davis Park

F. 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 elevated storm water levels that cause extensive flooding and erosion, as was recently seen during Hurricane Sandy.

Problems and opportunities pertaining to coastal storm risk management 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 protective beach and dunes, and flooding due to storm waters. The barrier islands can also overwash and breach during storms. An overwash or breach impacts both the barrier island, as well as the Back Bay

- **Back Bay Segments**. These include the potions of the mainland along Great South Bay, Moriches Bay and Shinnecock Bay that are vulnerable to tidal flooding which is exacerbated from breaches of the barrier islands. Impacts of a breach or severe overwash include:

    - Increase in bay tide levels
    - Increase in bay storm water levels
    - Change in bay circulation patterns, residence times, and salinity
    - Increase in sediment shoaling in navigation channels and shellfish areas

- Increased transport and deposition of sediment to bay including creations of overwash corridors.

- **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 this area, the damages are more localized.

Within each of these problem areas, there are opportunities to reestablish many of the natural coastal processes that have impacted by past human activities. These efforts help contribute to CSRM.

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

G. <u>Non-Federal Partners and Stakeholders</u>

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. 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 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.

2. Planning Overview

A. ***Plan Formulation Process***

The goal of the Reformulation Study is to identify a long-term (50- year) solution to reduce the risk of storm damages while maintaining, enhancing or restoring the existing environment. The planning follows the six-step, iterative planning process, which is fundamental to any Corps' formulation process. The six steps are as follows:

1 – Specify Problems and Opportunities
2 - Forecast Conditions Without Project
3 - Formulate Alternative Plans
4 - Evaluate Alternative Effects
5 - Compare Alternative Plans
6 – Select Recommended Plan

The prior chapter provides an overview of the first step (specifying problems and opportunities). Detailed discussions of the Existing and Future without Project Conditions are provided in the Main Report and also in the Engineering Appendix.   The Engineering Appendix also includes details of the modeling that was utilized to determine damages for the Future Without Project Condition.

B. ***Genesis and applicability of the Vision Statement***

The planning process adopted for the FIMP Study has been captured in the "Vision Statement for the Reformulation Study" that integrates the Corps' Planning Guidance with the policies of the Department of the Interior and the State of New York. The 2014 Memorandum of Understanding (MOU) between the Secretary of the Army and Secretary of the Department of Defense reaffirms the commitment to formulate a plan consistent with the Vision, as a means to achieve a mututally acceptable plan.

The Vision Statement was approved by HQUSACE as well as by the Department of Interior and State of New York as the basis for the plan formulation for this study. It asserts 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 protection, and restore and enhance coastal processes and ecosystem integrity,
- Preference will be given to Non-structural measures that protect and restore coastal landforms and natural habitats,
- Project features should avoid or minimize adverse environmental impacts and address long-term demands for public resources,

- Dune and beach replenishment will balance consideration of storm damage reduction and environmental considerations,
- Consideration will be given to alteration of existing shore stabilization structures, inlet stabilization measures, and dredging practices.

C. Planning Objectives

Planning objectives for the Reformulation were identified following an assessment of the problems, needs and opportunities, and existing physical and environmental conditions present in the study area, described in the prior Chapter. The formal planning objectives reflect several overriding principles articulated in USACE regulations and guidance material, and also capture the study-specific objectives, as reflected in the Vision Statement.

Engineering Regulation 1105-2-100 defines the Federal objective of water and related land resources project planning is to contribute to national economic development, consistent with protecting the nation's environment, pursuant to national environmental statutes, applicable executive orders, and other federal planning requirements.

This objective has been established by the U.S Water Resources Council's *Economic and Environmental Principles and Guidelines for Water and related Land Resources Implementation Studies* (P&G's) on 10 March 1983. These P&G's further identifies that alternative plans must be evaluated relative to the requirements for being complete, efficient, effective, and acceptable.

A planning horizon of 50 years was established for this study. This planning horizon is consistent with the Corps authorization for participation in these types of projects and reflects the time period over which activities are expected to be undertaken for purposes of reducing risks to human life and property. For this study, the following general and specific objectives have been identified.

General

- Meet the specified needs and concerns of the general public within the study area
- Incorporate public desires and preferences
- Accommodate changing economic, social, and environmental patterns and changing technologies
- Integrate and complement other programs in the study area
- Establish and document financial and institutional capabilities and public consensus

Specific

- Reduce the threat of potential future damages due to the effects of storm-induced flooding, wave attack, and shore recession
- Mitigate the effect of and reduce or offset current long-term erosion trends
- Minimize impact of improvement projects on environmental resources and adjacent shore areas
- Restore degraded coastal processes to reduce storm damage
- Reduce the need for ongoing protection measures and consider the long-term demand for public resources

D. Planning Constraints

Formulation and evaluation of alternative improvement plans are constrained by technical, environmental, economic, regional, social, and institutional considerations. These constraints must be considered in current and future project planning efforts, as summarized below.

Technical Constraints

- Plans must represent sound, safe, acceptable engineering solutions.
- Plans must be in compliance with sound engineering practice and satisfy Corps of Engineers regulations.
- Plans must be realistic and state-of-the-art. Reliance on future research and development of key components is unacceptable.
- Plans must provide storm damage reduction.

Economic Constraints

- Plans must be efficient. They must represent optimal use of resources overall. Accomplishment of one economic purpose cannot unreasonably impact another economic system.
- The economic justification of the proposed project must be determined by comparing the anticipated annual tangible economic benefits which should be realized over the project life with the average annual costs

Environmental Constraints

- Plans cannot unreasonably impact environmental resources.
- Where a potential adverse impact is established, plans must consider mitigation or replacement measures and should adopt such measures, if justified.
- Where opportunities exist to enhance significant environmental resources, the plan should incorporate all justified measures.

Regional and Social Constraints

- Reasonable opportunities for development within the study scope must be weighed relative to others, and views of State and local public interests must be solicited.
- The needs of other regions must be considered and one area cannot be favored to the unacceptable detriment of another.

Institutional Constraints

- The plan must be consistent with the overriding objectives and approach as identified in the FIMP Vision Statement.
- The State must be willing to participate in a plan to provide storm damage reduction, cost-share in future beach renourishment operations and be responsible for the operations and maintenance of the completed project.
- Federal and State participation must be contracted for the recommended period of time for implementation, although no assurances can be made that future Federal budgets will accommodate the capability funding against competing needs.

- Plans must be consistent with existing Federal, State, and local laws.
- Plans must be locally supported to the extent that local interests must, in the form of a signed local cooperation agreement, guarantee all items of local cooperation including cost sharing.
- Local interests must agree to provide public access to the beach in accordance with Federal guidelines and with requirements of State laws and regulations.
- The plan must be fair and find overall support in the region and State.
- Plans must be consistent with State Coastal Zone Management Policies to the maximum extent practicable and consider such policies in plan formulation.
- Each considered measure must identify environmental impacts and appropriate mitigation.
- 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.

E. FIMP Formulation Approach

The Vision Statement recognizes the need to balance storm damage reduction opportunities with the environmental needs within the study area and evaluate the alternatives as a system. An important element of this approach is the concept that alternatives are developed and evaluated to reduce storm damages through the least intrusive means possible. In this respect, the evaluation of alternatives considers the range of options starting with the least intrusive and lowest level of investment, and subsequently looks at increasing intensities of alternatives to address the problems. The 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, not only does this consider land-use management, but also the management of the existing inlets, and the current management response to breaches. These alternatives consider reductions in storm damages which can be accomplished without major investments, but through alteration of current practices.

3. Non-structural measures. By definition, non-structural 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. Non-structural measures include a variety of techniques presented further in the next Chapters, 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 protective features. This includes beachfill and restoration 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 study area has been degraded by past human activities, and that reestablishing coastal processes could also provide storm damage reduction benefits. The Coastal Process Framework focuses on the reestablishment of the underlying processes for the long-term sustainability of the study area that include:

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

F. Plan Evaluation Criteria

Three sets of criteria have been applied to the alternatives under consideration. Each storm damage reduction alternative was first evaluated relative to the traditional USACE 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. Alternatives were also evaluated with regard to the following evaluation criteria based on the Vision statement, as a means to assess if the plan is mutually acceptable:

- 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 surge, storm surge 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 non-structural features provide both storm damage protection and to restore coastal processes and ecosystem integrity.
- The plan or measures help protect and restore coastal processes.
- 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.

*G. **Iterative Planning Process***

The preceding paragraphs describe the formulation approach to ensure the participation of stakeholders in the planning process. This six-step planning procedure (focusing on plan development, plan evaluation, plan comparison, and plan selection) has been undertaken in a four phase iterative approach. Each phase of investigation developed alternative measures to a level of detail to determine whether the alternative measures should be considered further, or eliminated. The first three phases are documented in this appendix. The fourth phase, Post Sandy Refinement of the Tentatively Selected Plan, is detailed in the Main Report.

The four phases of analysis included the following:

Phase 1 – Initial Screening of Measures
Phase 2 – Evaluation of Individual Storm Damage Reduction Alternatives
Phase 3 –Alternative Plan Identification and identification of a Tentative Federally Supported Plan
Phase 4 – Post-Sandy Refinement and identification of a Tentatively Selected Plan

3. Phase 1, Initial Consideration of Measures

A. Introduction

Phase 1 included both an initial and secondary evaluation 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 also held with all the project stakeholders to solicit input on the viability of non-structural measures. The screening reflects the results of the coordination, and non-Federal sponsor input.

B. Measures Considered

Measures were identified which reduce storm damages and reestablish coastal processes in the project area. The following measures were examined for applicability for the project area and to select those for further detailed consideration in the development of alternatives during the subsequent study phases:

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

An initial screening of measures was undertaken to identify the effectiveness of these measures in accomplishing the desired objectives. Based upon this initial screening, these measures were either recommended for further screening, or dropped from consideration. The following is a summary of the initial screening.

1. No Action

The No Action plan provides no additional measures to provide storm damage protection in the study area. It is essentially the Without-Project Future Condition. It assumes continuation of the Westhampton Interim Project until 2027, emergency breach closures on an as-need basis, continuation of maintenance dredging of the navigation channels in all three inlets, and continuation of locally implemented shore protection measures. This plan fails to meet any of the objectives or needs of the project.

Findings: The No Action plan represents the Without Project Condition against which alternatives plans be evaluated against.

2. Non-Structural Measures

Three main categories of non-structural plans were identified:

- Building retrofits,
- Acquisition of threatened properties
- Land use management options.

Building retrofits include raising the structure above the design flood, providing an impermeable barrier around the structure, wet floodproofing, or relocating the structure out of the flood plain. Wet floodproofing techniques allow floodwaters to enter the crawlspace or unfinished level of the structure but relocate and protect utilities from damage. Acquisition or buyouts of structures in the flood plain prevents all damages to structures and may provide land for public use and conservation. However, buyouts decrease the local tax base by removing land from private ownership. Land use management options include zoning regulations and other measures to control flood plain development, and avoid potential damages associated with flooding. Land use regulation is generally the responsibility of state or local governments, as an element of a Floodplain Management Plan. Non-structural and land use management measures can also supplement the protection provided by other measures, and can be evaluated as combined or stand-alone measures.

Findings: Non-structural measures were recommended for further evaluation.

3. Coastal Process Restoration

As discussed previously, a coastal process framework was established that identified the key physical processes to be reestablished for its contribution to cost effective CSRM:

- alongshore transport
- cross-island transport
- dune growth and evolution
- bay shoreline processes
- estuarine circulation processes

Possible techniques for restoring the natural coastal processes include:

- Reestablish the process by removing or modifying the source of the disturbance
- Reestablish the process by mimicking what occurs naturally and is sustainable by itself
- Reestablish the process by mimicking what occurs naturally, but requires management to achieve the objectives.

Findings: Coastal process alternatives were recommended for further study.

4. Sediment Management (including Inlet Maintenance Modifications)

Sediment Management include measures designed to improve the littoral transport at the three Inlets and also the establishment of feeder beaches, designed to improve the effectiveness of downdrift sediment transport.

Tidal inlets represent littoral drift disruptions. Trapping of longshore sediment transport, either updrift, within the inlet, or in the flood/ebb shoals, create sediment deficits resulting in downdrift shoreline erosion. In addition, inlets also serve as conduits for floodwaters to enter the bays during storm events.

Findings: Sediment management measures were recommended for further study to determine how to best to achieve the multiple objectives of reliable navigation, uninterrupted sediment transport, and minimizing storm surges through the inlets that contribute to bay side flooding.

5. Breach Response Measures

Breaching refers to the condition where severe overwashing forms a new inlet which permits the exchange of ocean and bay waters under normal tidal conditions. The breach may be temporary or permanent depending on a number of factors as discussed in Chapter 5. Breaches left. unchecked, as evidenced by breach closure efforts in 1980 and 1993 just east of Moriches Inlet, can result in significant damages, and additional costs to close the breach (BCP, 1995).

Findings: Breach response measures, including plans for rapid closure and proactive measures, were recommended for further consideration.

6. Beachfill: Dune and Berm Construction

Dune and berm creation, also called beachfill, involves the placement of compatible sand on an eroding shoreline to provide an adequate protective geometry form. Beachfill options include: (1) beach and dune fill, (2) dune fill only, (3) beachfill only or (4) beachfill placement in response to extreme events to close breaches (e.g., BRP). Periodic renourishment is normally required to offset long-term and storm-induced erosion. Beachfill is also used in concert with other structural features (e.g. offshore breakwaters, groins, buried seawalls etc.). The sand may be obtained from an offshore borrow location, or from nearby navigation channels and flood/ebb shoals located in the Inlet system.

Findings: Beachfill measures were recommended for further consideration.

7. Offshore Breakwaters

Offshore breakwaters are typically rubble-mound structures built seaward of the shoreline, and act to reduce wave energy reaching the shoreline. Offshore breakwaters may be built as a long continuous structure or as a series of shorter, segmented structures. Offshore breakwaters are often combined with beach restoration.

Findings: Offshore breakwaters could be considered further in conjunction with the evaluation of Inlet modification alternatives, including the integration of breakwaters and groins in T-groin configurations.

8. Seawalls

Seawalls are generally used to protect upland structures from wave impact and erosion damage. Seawalls normally require extensive toe protection to preclude scour. Vertical seawalls are generally high and are often judged to be socially and aesthetically unacceptable. Moreover, vertical seawalls are vulnerable to catastrophic failures that may be attended by accelerated upland erosion. A rubble-mound seawall consisting of relatively large armor units and armored back slope provides a high level of stability when subjected to direct wave forces. An exposed rock structure in the absence of beach restoration does not abate shoreline erosion, because it does not provide the sand necessary to offset erosion processes. Seawalls are typically located landward of the active littoral zone, therefore, shoreline erosion is not affected. An alternative to a conventional rubble-mound or vertical seawall is a buried rubble-mound seawall placed landward of the shoreline; the rubble-mound seawall is often coupled with beach restoration. The buried seawall has the appearance of a sand dune and is only exposed during severe events. When used in concert with beachfill, the seawall provides the last-line-of-defense storm protection, while the beach restoration combats long-term shoreline erosion.

Findings: Seawalls as stand-alone measures are not recommended for further consideration. Seawalls, in the form of a reinforced dune, should be considered further in combination with beachfill in the secondary screening.

9. Groins

Groins are coastal structures, normally constructed perpendicular to the shoreline, which act to interrupt longshore sediment transport. Groins generally extend from the dune/beach interface to water depths of 10 to 12 feet below MSL. Groins are often constructed in series or fields to provide protection for continuous shoreline segments. Erosion downdrift of a groin field can be mitigated through the use of low, tapered groin transitions and/or beach nourishment. Groin fields can also be designed to transition to areas of lower erosion losses or to terminal structures, such as jetties. Groin compartments should be filled initially in order to promote sand bypassing throughout the groin field. Groins are vulnerable to storm-induced or offshore erosion losses. These losses may be reduced by the use of T-groins that may be an effective solution in areas of severe erosion, such as in the vicinity of tidal inlets. T-groins combine the features of traditional groins and breakwaters by reducing both alongshore and cross-shore beach erosion losses.

Findings: Groins, as stand-alone features, were not recommended for further consideration, but could be considered, along with T-groins, in the context of the Inlet management modification alternatives.

10. Dune and Berm Construction (Beachfill) with Structures

In areas of severe erosion, life-cycle costs for beach restoration can be very costly. In these areas beachfill along with structure such as a seawalls, groins and breakwaters can provide protection against severe storms or stabilize the beachfill against long-term erosion

Findings: As stated previously seawalls, in the form of a reinforced dune, should be considered further in combination with beachfill in the secondary screening. Also groins and breakwaters, as standalone features were not recommended for further consideration, but could be considered, along with T-groins, in the context of the Inlet management modification alternatives.

11. Removal/Modification of Groins

Groins serve to protect the shoreline fronted by these structures, but may adversely impact downdrift shorelines. Adverse impacts of groin fields may be mitigated through beachfill placement and/or groin transitions or it may be best to remove or modify existing groins. The functioning of the existing groin fields within the study area must be evaluated to determine whether groin removal or modification is advisable.

Findings: The removal or modification of the existing groins within the study area will be evaluated further.

12. Levees and Floodwalls

Levees and floodwalls could be considered to protect the Back Bay/mainland areas from tidal inundation, but would require closure gates across the many tidal creeks and also significant roadway and bridge relocations. The levee/floodwall line of protection would also require extensive interior drainage systems to impound and/or pump storm water runoff. During the initial screening, levees and floodwalls were eliminated from further consideration as not being economically viable and also not supported by sponsors and stakeholders.

Findings: Levees and floodwalls were recommended for further consideration only in the limited context of road raising, as a possible complement to mainland non-structural building retrofits.

13. Storm Closure Gates

Flood control closure gates are designed to prevent storm surges from entering tidal inlets and/or canals and causing flooding to the back bay and Mainland. Possible locations for storm closure gates include Fire Island, Moriches and Shinnecock Inlets, and also Narrow Bay and the Quogue and Quantuck Canals. Closure gates exist can either be mobile systems that can be raised, lowered or otherwise removed when there is no threat of coastal flooding, or fixed systems, which restrict flow during storms by inducing hydraulic losses and/or limiting flow area.

The initial screening considered the relative cost and effectiveness of closure gates at the locations described above. The initial screening concluded that the cost for these structures exceeds the maximum benefits that could be derived. There were also concerns about the environmental impact of these alternatives. Consideration was also given to constructing water control structures at the coastal ponds to control the inflow and outflow of water as an alternative to the present practice of opening and closing of the ponds. These inlet closure structures would be a necessary component of any plan that includes beachfill fronting the ponds. Due to the strong preference by the Town Trustees to continue to manage the ponds as they historically have, water control structures at the ponds were eliminated from consideration.

Findings: Storm closure gate measures were not recommended for further consideration.

C. Measures Retained

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

1. Non-structural Measures
2. Breach Response Measures
3. Sediment Management (including Inlet Modifications)
4. Dune and Berm Construction
5. Dune and Berm Construction with Structures
6. Removal/Modification of Groins
7. Mainland Road Raising
8. Coastal Process Features

D. Secondary Screening of Storm Damage Reduction Measures

The eight measures recommended for further consideration during the initial screening were evaluated further with considerations of performance, design, costs, and potential impacts to the environment:

1. *Non-structural Measures*

The non-structural measures identified during the initial screening were further developed and evaluated in coordination with the stakeholders as to their effectiveness in meeting the project objectives including:

- Reduce damages from coastal storms to existing and future development
- Minimize adverse environmental impacts
- Preserve or enhance ecological resources
- Preserve community character and recreation access

The evaluation was conducted on a project reach basis (Great South Bay, Moriches Bay, Shinnecock Bay, Ponds, and Montauk), with Great South Bay split into a barrier island and a mainland sub-section, to account for differing conditions in the two areas.

Table 3.1 summarizes the results of the evaluation of the non-structural measures that were identified. For the mainland reaches, all of the non-structural alternatives were found to meet or potentially meet the project objectives. On the barrier islands, free standing barriers and wet/ dry floodproofing were not recommended for further consideration since retrofits would still leave structures vulnerable to ocean hazards. Similarly, free standing barriers are prohibited in dune areas and the Coastal Erosion Hazard area (CEHA).

Table 3.2 also indicates which government entity would have lead responsibility for the non-structural measures. Implementing and enforcing Land Use and Regulatory could be accomplished by State and local authorities based on the Flood Plain Management Plan.

Based upon the findings of this screening, it was recommended to further develop the non-structural alternatives in two main categories, 1) building retrofit alternatives along the mainland, and 2) land and development management alternatives that could be implemented to reduce development pressures, and the existing development in high hazard areas, where retrofits are not applicable.

Table 3.1 Summary of Non-Structural Technique Evaluation

NON-STRUCTURAL TECHNIQUE	RECOMMENDED FOR FURTHER EVALUATION UNDER:		
	FIMP Reformulation Plan	Non-Federal Flood Plain Management Plan	
	USACE*	State	Local
Land Use and Regulatory Measures			
Zoning/Land Use Controls		+	+
New Infrastructure Controls		+	+
Landform and Habitat Regulations		+	+
Construction Standards and Practices		+	+
Tax Incentives		+	+
Building Retrofit Measures			
Relocation	+	+	+
Elevation	+	+	+
Free-Standing Barriers (mainland only)	+		
Dry Floodproofing (mainland only)	+	+	+
Utilities Protection	+	+	+
Land Acquisition			
Purchase of Property	+	+	+
Exchange of Property		+	+
Transfer of Development Rights		+	+
Easements and Deed Restrictions	+	+	+
Other			
Wetlands Protection & Restoration	+	+	+
Vegetative Stabilization	+	+	+
Post-Storm Response Planning	+	+	+
* It is acknowledged that there are other Federal agencies (including the NPS, within the jurisdictional boundaries of FIIS; FEMA; and USFWS) that have a Federal Role in these activities			

2. ***Breach Response***

The secondary screening of breach-response measures focused on identifying barrier island areas with a higher breaching risk and the costs associated with breach response timeframes.

Although breach closure may be required at any location along the barrier islands fronting Great South Bay, Moriches Bay, and Shinnecock Bay, Table 3.2 identifies the locations where breaching risk is more likely based on storm surge modeling simulations (USACE, 2005).

Table 3.2 Likely Breach Locations

Location	Design Reach		Federal Tract
FI Lighthouse Tract	GSB-1B	FI Lighthouse Tract	Yes-Major
Robins Rest	GSB-2B	Town Beach to Corneille Estates	Yes-Small & adjacent to developed areas
Barrett Beach	GSB-3D	Talisman to Water Island	Yes-Major
Davis Park	GSB-3G	Davis Park	No
Old Inlet West	GSB-4B	Old Inlet	Yes-Major
Old Inlet East	GSB-4B	Old Inlet	Yes-Major
Smith Point CP	MB-1B	Smith Point CP – East	No
Sedge Island	SB-1B	Sedge Island	No
Tiana Beach	SB-1C	Tiana Beach	No
West of Shinnecock	SB-2B	WOSI	No

Note: based on Baseline (circa 2000) conditions

Breach stability analyses indicated a tendency for new breaches in the project area to remain open. Survey data for the 1980 and 1992 breaches at Cupsogue and Pikes Beach, respectively, were used to estimate breach growth characteristics. Breach cross-sectional area typically stabilizes as the scouring potential associated with tidal flow velocities balances forces attempting to close the breach. As tidal flow velocities decrease with increasing breach area, the rate of breach growth is initially rapid and slowly approaches an equilibrium condition. As part of this analysis, consideration was also be given for variations in the design cross-section, and the implementation criteria, such as a trigger point where action is taken. The development of alternatives as presented in this Section was completed prior to Hurricane Sandy, and are based upon information available at that time.

Preliminary cost estimates were developed for closures initiated at the following time frames after breach opening: 45 days, 3, 6, 9, and 12 months. At all the potential breach locations, it was determined that it is more cost effective to close a breach as soon as possible. Rapid breach closure was recommended for further evaluation during the next Assessment phase.

3. ***Sediment Management (Inlet Modifications)***

The secondary screening of sediment management considered several inlet modification alternatives, including dredging of inlet shoals and the navigation channel, excavating updrift deposits with downdrift placement, and structural modifications to aid natural bypassing and reduce downdrift erosion (spur jetties, T-groins, etc.) The goal of the inlet modification alternatives was to develop alternatives that provide both reliable navigation through the Federal navigation channels and also maximize sand bypassing in order to restore littoral transport and reduce downdrift shoreline erosion.

The secondary screening analysis was conducted by the Coastal Technical Management Group (CTMG) which included representatives of NYS-DEC, NYS-DOS, and DOI (National Park Service) utilizing the screening criteria in Table 3.3, with each of the 5 categories having equal weight.

Table 3.3 Screening Criteria – Inlet Modifications Alternatives

Environmental Criteria	
1.	Fish and Wildlife
2.	Rare and Endangered Species
3.	Water Quality
4.	Tidal and Freshwater Wetlands
5.	Sediment Pathways
6.	Non-Structural Components
Economic Criteria	
7.	Lifecycle Costs
8.	Flooding Risk
9.	Commercial Fisheries
10.	Waterfront Development and Commercial Fishing Facilities
11.	Land Use and Ownership
Recreational Criteria	
12.	Recreational Fish and Wildlife Resources
13.	Water and Foreshore Related Recreation Resources
Engineering Criteria	
14.	Capacity
15.	Source Flexibility
16.	Placement Flexibility
17.	Continuity
18.	Performance
19.	Reversibility
Cultural and Social Criteria	
20.	Historic, Cultural, and Scenic Resources
21.	Local Concerns and Public Relations

A performance score was computed based on how well each alternative met the stated needs (accounting for risk and uncertainty inherent to each alternative). Based on the scores the following alternative inlet management measures were selected for further consideration during Phase 2:

Shinnecock Inlet

Alt. 1: Authorized Project (AP) + Dredging the Ebb Shoal
Alt. 2: AP + Nearshore Structures
Alt. 3: AP + Offshore Dredging
Alt. 4: AP + Semi-fixed Bypass System
Alt. 5: AP with Reduced Dimensions of Deposition Basin
Alt. 6: AP + Dredging the Flood Shoal
Alt. 7: AP + Shortening the East Jetty
Alt. 8: AP + West Jetty Spur

Moriches Inlet

Alt. 1: Authorized Project (AP) + Dredging the Ebb Shoal
Alt. 2: AP + Dredging the Ebb Shoal
Alt. 3: AP + Semi-fixed Bypass System
Alt. 4: AP + Dredging the Flood Shoal

Fire Island Inlet

Alt. 1: Existing Practice/ Authorized Project (AP)
Alt. 2: AP + Dredging the Ebb Shoal
Alt. 3: AP + Optimized Deposition Basin
Alt. 4: AP + Dredging the Flood Shoal

4. *Beachfill: Dune and Berm Construction*

The initial screening of measures recommended consideration of beachfill across the entire project area.

The secondary screening of beachfill measures focused on identifying specific project reaches where beachfill could be economically justified.

Conceptual beachfill cost estimates were developed at the time of the Phase 1 screening (2009 PL) for each project reach using a typical beachfill template (90 ft. wide berm and 15 ft. NGVD dune). Costs are presented in terms of dollars per foot of beach restored (Table 3.4) and compared with the annual damages calculated for that reach in the without project condition. Beachfill on the barrier islands had the potential to be economically justified particularly when the benefits to the mainland are included. The only areas east of Shinnecock Inlet where beachfill might be economically viable were in Downtown Montauk and in the vicinity of Georgica Pond. In the remainder of the study area, beachfill will not be further evaluated.

Recommendation: Beachfill should be considered along the barrier island reaches, and evaluated further in the areas of Georgica Pond and Downtown Montauk.

Table 3.4 Approximate Beachfill Cost by Project Reach

Project Reach	Name	Annualized Cost per ft.
GSB	Great South Bay	$260/ft.
MB	Moriches Bay	$165/ft.
SB	Shinnecock Bay	$520/ft.
P	Ponds	$655/ft.
M	Montauk	$510/ft.

5. *Dune and Berm Construction with Structures*

The secondary screening of beachfill alternatives identified locations where beachfill would be considered further based on the infrastructure at risk. Using these results a secondary screening of structural measures was undertaken to identify if there are locations where structural measures would be warranted. The structural alternatives work by either reducing erosion (groins and breakwaters) or increasing the protection (reinforced dunes).

The secondary screening compared the relative costs of the beachfill alone and the structural alternatives, when considering the erosion rates in the area, and the associated reliability of the storm damage reduction features. The analysis concluded that the reinforced dune was not competitive with Beachfill-only for any of the design reaches.

The analysis also determined that breakwaters are not cost effective. Groins were only potentially cost-effective if erosion rates are higher than 14 ft. per year. The only design reach within the FIMP study area with erosion rates are that high is the West of Shinnecock Inlet sub reach, where the average erosion rate of about 25 ft./yr. Further evaluation of placing groins west of Shinnecock Inlet will be considered in the Phase 2 analysis.

6. ***Removal/Modification of Groins***

The initial screening recommended further evaluation of removal or modification of one or more of the 26 groins in the study area. Existing groins are located in the Towns of East Hampton and Southampton (8), at Westhampton Beach (16) and along Fire Island (2).

The secondary screening involved a conceptual level analysis on the costs and benefits of total groin removal compared to beach nourishment, which determined that total groin removal would increase annualized costs with no readily identifiable benefit in terms of beachfill performance.

Total groin removal was not recommended for further consideration as an alternative due to cost of removal and expected performance, but modification of the existing groins were recommended for further consideration. .

7. ***Mainland Road Raising***

As described in the initial screening of alternatives, levee / floodwall measures were not recommended for further, comprehensive evaluation. Consideration was given to areas where road raising could serve as a localized protection measure.

For the secondary screening, road raising was analyzed to determine if opportunities exist to reduce flooding risk to homes. Road raising could potentially provide greater storm damage reduction benefits at a lower cost than individual-building nonstructural protection plans. Raised roads can also enhance local evacuation plans and public safety by providing safer evacuation routes out of the area. Road raising could also be more acceptable to residents in some communities since it reduces the need for structural alterations to individual buildings that may disrupt the owners' lives and affect perceptions of property value.

Based on a review of topography, density of vulnerable structures, layout of residential streets, and environmental considerations such as the need to avoid wetland impacts, 24 potential road raising locations were identified and then further refined five areas identified for detailed analysis: Areas 4a, 8c, 8d/8e, 9b, and 52a. In these locations, it is likely that road raising would result in substantial cost savings compared to retrofit treatments.

Based upon this screening, road raising was recommended for consideration in 5 specific locations, in conjunction with the non-structural alternatives. The areas proposed for road raising include East Massapequa, Amityville, Lindenhurst, and Mastic Beach.

8. ***Coastal Process Features***

The interagency study team evaluated potential ways to reestablish the five coastal processes that were identified as being critical to maintaining the natural coastal features and reducing coastal storm damages:

Longshore Sediment Transport.

Reestablishment of the longshore process can help to maintain a more natural shoreline condition, and a more natural beach profile. Reestablishing these processes can reduce the need for future activities to address erosion in these areas. Reestablishing longshore transport can be undertaken through a number of options. The most effective way to restore longshore transport is removal of the barrier that is disrupting the transport. If removal of the barrier is not possible, modification of the structure (such as shortening or notching) could be considered. If neither of these options are viable, it may be possible to replicate the processes that would have naturally occurred (i.e. bypassing sand at the inlets).

Cross-Island Transport

Opportunities to reestablish this process are similar to those identified for longshore transport. The preferred approach would be to allow these processes to continue unimpeded, or promote the occurrence of these processes in areas where they have been negatively impacted. If these processes can't be restored through this process, it may be possible to replicate the processes as they would have naturally occurred (i.e. the construction of overwash habitats).

Dune Development and Evolution.

In much of the study area, the long-term trend is erosional. Under a natural condition, the dunes would migrate over time, but in many areas this does not occur due to the need to maintain a beach and dune to protect existing development. Significant amounts of dune habitat have been degraded due to building near or on the dunes. Opportunities for restoring the natural dune process include removing structures to allow for improved dune functioning and the necessary space to allow for dune evolution.

Bayside shoreline Processes.

Possible ways to restore bayside processes is by removing or modifying bayside bulkheading, fill or other structures that interfere with the shoreline process, and also by introducing needed sediment to offset the impact of the disturbance.

Estuarine Circulation

The magnitude of human changes within the estuary and the complexity of the interaction between the physical processes and the environment limit the opportunities for reestablishing estuarine circulation processes.

The measures considered for reestablishing coastal processes include the following:

- Atlantic Ocean shorefront
  - Establish optimal beach and dune conditions, by considering footprint, slope, and % vegetative cover.
  - Restore beach and dune through removal of buildings and infrastructure that would also allow for dune migration.
  - Remove or modify coastal structures to restore natural beach and dune conditions.

- Interior of the island (to restore secondary dunes and connectivity from Ocean to Bay).

- Bayside shoreline
  - Reestablish bay beaches, wetlands, and subaquatic vegetation.
  - Reestablish bayside habitats through removal or modification of bayside structures.

Initial formulation efforts were multipurpose, and restoration sites were identified by the interagency study team and evaluated utilizing the HEP model. Eighteen sites were identified based_upon their ability to contribute to an identified restoration objective and their potential to contribute to storm damage reduction. Since the GRR is now being completed under the authority of PL113-2, restoration is no longer a project purpose. As a result, only those features initially considered as restoration which meet the project objective to reestablish coastal processes as coastal storm risk management features have been carried forward for consideration in the GRR. The Main Report provides further detail of the sites that were carried forward for their contribution to reestablishment of coastal processes.

E. Phase 1 Recommendations

The following measures were recommended for further development in the Phase 2, Evaluation of Individual Storm Damage Reduction Measures:

- Breach Response Measures along the barrier islands
- Sediment Management, including Inlet Management Modifications
- Non-structural
- Retrofit Measures
- Non-structural Land and development management
- Non-structural Road Raising along the mainland

- Beachfill and Dunes
- Groin Modifications
- Coastal Process Features at locations throughout the Study Area

Consistent with the Formulation Approach to develop and consider alternatives through the least intrusive means possible, the storm reduction management measures were grouped into the following categories, each of which would also consider Coastal Process Features:

I. Changes in the Management of the existing system
   a. Breach Response Measures along the barrier islands
   b. Sediment Management, including Inlet Management Modifications
   c. Non-structural Land and development management

II. Non-Structural Measures
   a. Non-structural Retrofit Measures
   b. Acquisition and Relocation
   c. Road Raising along the mainland

III. Soft Structural Measures
   a. Beachfill and Dunes
   b. Groin modifications

IV. Hard Structures

All other features (i.e., storm closure gates, coastal structures only) were eliminated from further consideration due to their failure to meet the objectives of the Reformulation Study.

4. Phase 2, Evaluation of Individual Storm Damage Reduction Alternatives

In Phase 2, the recommended coastal storm risk management measures identified during Phase I are developed to a greater level of detail which include alternative layouts for each of the Measures, considerations of costs and benefits, and the degree to which the alternatives accomplish the project evaluation criteria. The original formulation is documented here to document the comparison of the costs and benefits of each feature and its relative scale. The price level and interest rates have not been adjusted for reproduction in the appendix since the changes would not influence the screening decisions made. Economic analysis of the final plan is presented in the Main Report and Economic Appendix at the current price level and discount rate to demonstrate the economic justification of the final plan.

As introduced in the Plan Formulation overview section, project evaluation criteria were established from unique project requirements of formulating a mutually acceptable plan for the area and USACE policies. The criteria include the Vision Statement, Principles and Guidelines, and traditional USACE cost effectiveness criteria. The addition of the Vision Criteria are intended to assess the extent to which a plan is mutually acceptable between DOI and the Army.

A. Breach Response

Breach Response measures may be implemented either in response to the occurrence of a breach (responsive breach closure) or in response to conditions where a breach is imminent (proactive breach closure plans). The variables considered include: 1) the design cross-section, 2) the implementing method (reactive or proactive), and 3) the lifecycle maintenance of the alternative.

1. *Reactive Breach Closure*

Three breach closure cross-sections were evaluated for each of the 10 vulnerable locations identified during the Phase 1 screening, as shown in Figure 4-1. The smallest breach closure template is a berm with a height of +9.5 ft. NGVD. Two larger breach closure templates were also developed that include a trapezoidal dune at elevations +11’ NGVD and +13’NGVD, respectively. Table 4.1 shows the cross sectional areas for each design templates for the 10 vulnerable locations. The berm widths match the conditions prior to the breach. The foreshore slope is assumed to be 1 on 12 which is the same slope as for the beachfill design templates. The design profile below MHW matches the representative morphological profile corresponding to each specific location. The bayside slopes are assumed to be 1 on 20 from the bayside crest of the berm to an elevation of +6 ft. NGVD.

A breach at Davis Park would have the largest cross sectional fill requirement, while a breach at WOSI would have the smallest. It should be noted, however, that the total volume requirement is based upon the combination of breach width (which varies over time) and design template area. A large area at Davis Park does not necessarily require the largest breach closure volume, since it is dependent upon growth rate, and time to closure.

Typical cross-sections for a breach closure at Old Inlet West and West of Shinnecock Inlet are shown in Figure 4.2, while the breach closure sure plan layouts at Old inlet West and West of Shinnecock are shown in Figures 4.3 and 4.4, respectively.

In identifying the closure costs, a number of scenarios were evaluated, considering time to closure, volume of material required, mobilization costs, and the cost per CY for material placement.

Continued maintenance of the breach closure template was also assumed, subsequent to a breach closure in order to maintain the protection afforded by the closure section, without waiting for another breach. Since maintenance of the post-closure profile was assumed to be a component of each BCP Alternative, the lifecycle simulation models also evaluated the annualized costs of actions to restore the profile to the design section. The analyses allowed the post-closure profile at each location to degrade over time, and then implement restoration activities when certain conditions have been reached.

Table 4.1 Breach Closure Plan Design Template Cross Sectional Area (sq. ft.)

	No Dune	+11 ft. NGVD Dune	+13 ft. NGVD Dune
FI Lighthouse Tract	9,811	9,860	9,960
Town Beach to Corneille Estates	12,918	12,967	13,067
Talisman to Water Island	15,367	15,416	15,516
Davis Park	15,389	15,438	15,839
Old Inlet West	14,727	14,776	14,876
Old Inlet East	12,327	12,376	12,476
Smith Point County Park	13,927	13,976	14,076
Sedge Island	14,127	14,176	14,276
Tiana Beach	13,327	13,376	13,476
WOSI	7,324	7,373	7,473

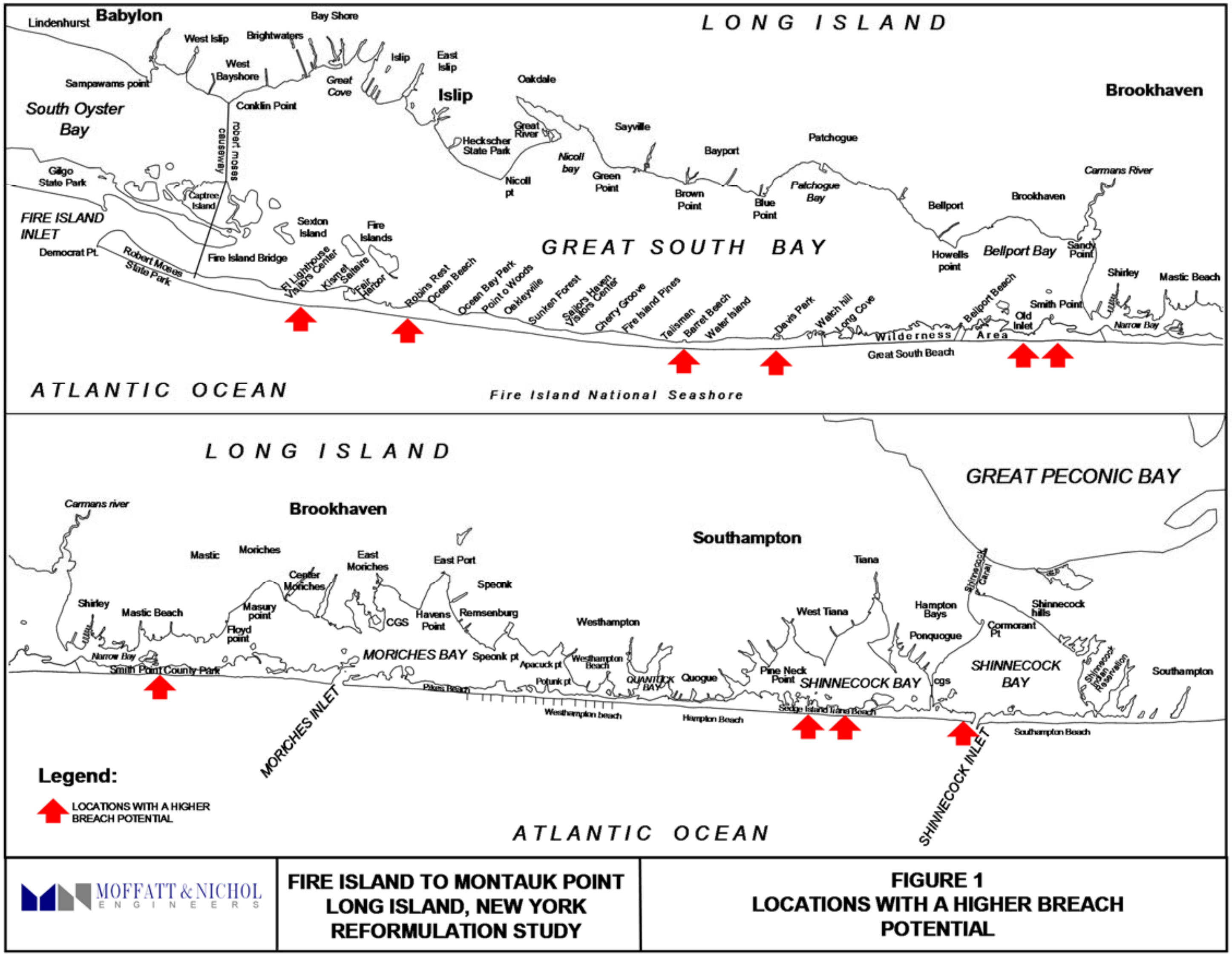


Figure 4.1: Vulnerable Breach Locations

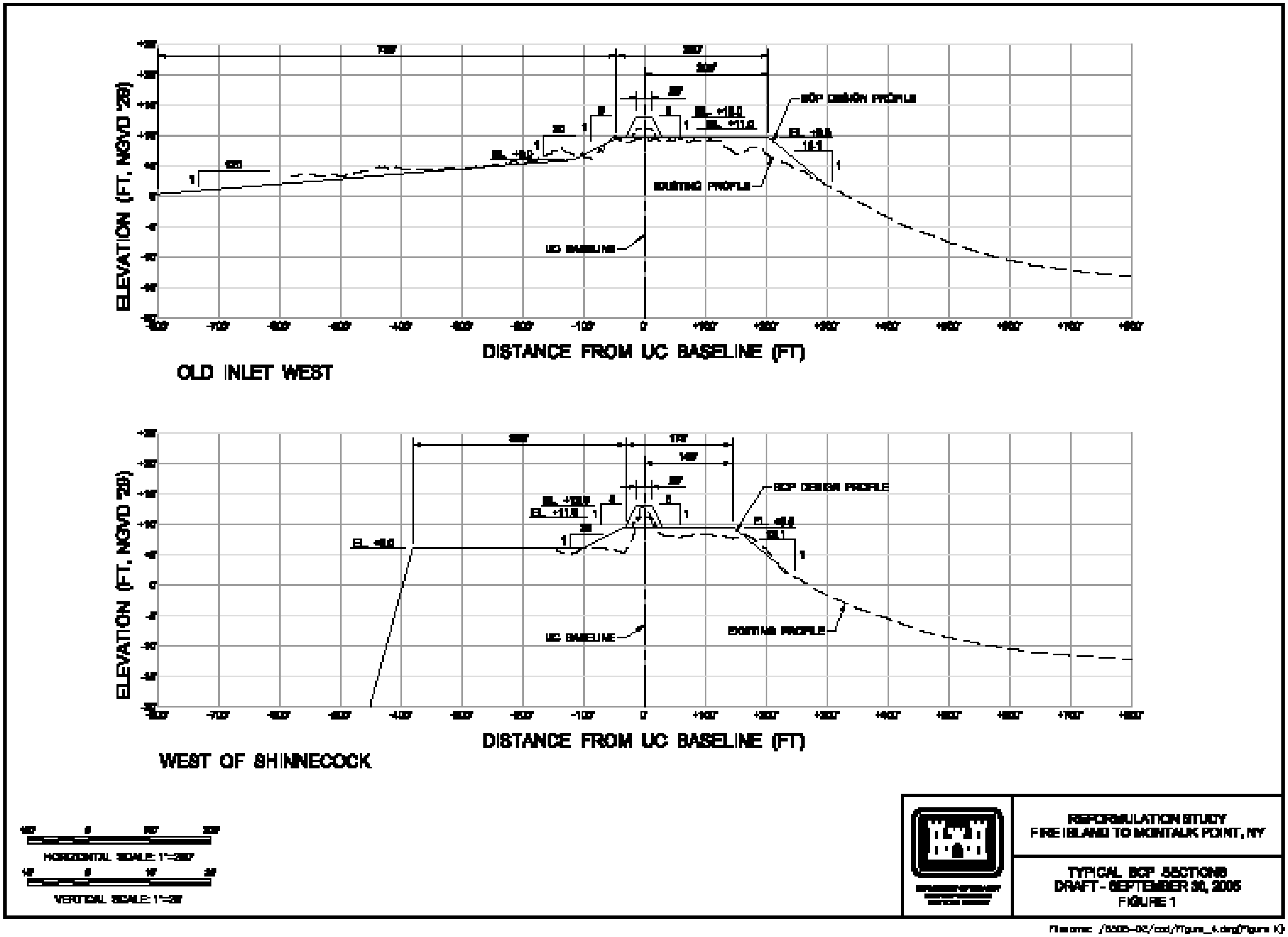


Figure 4.2: Typical Breach Closure Sections

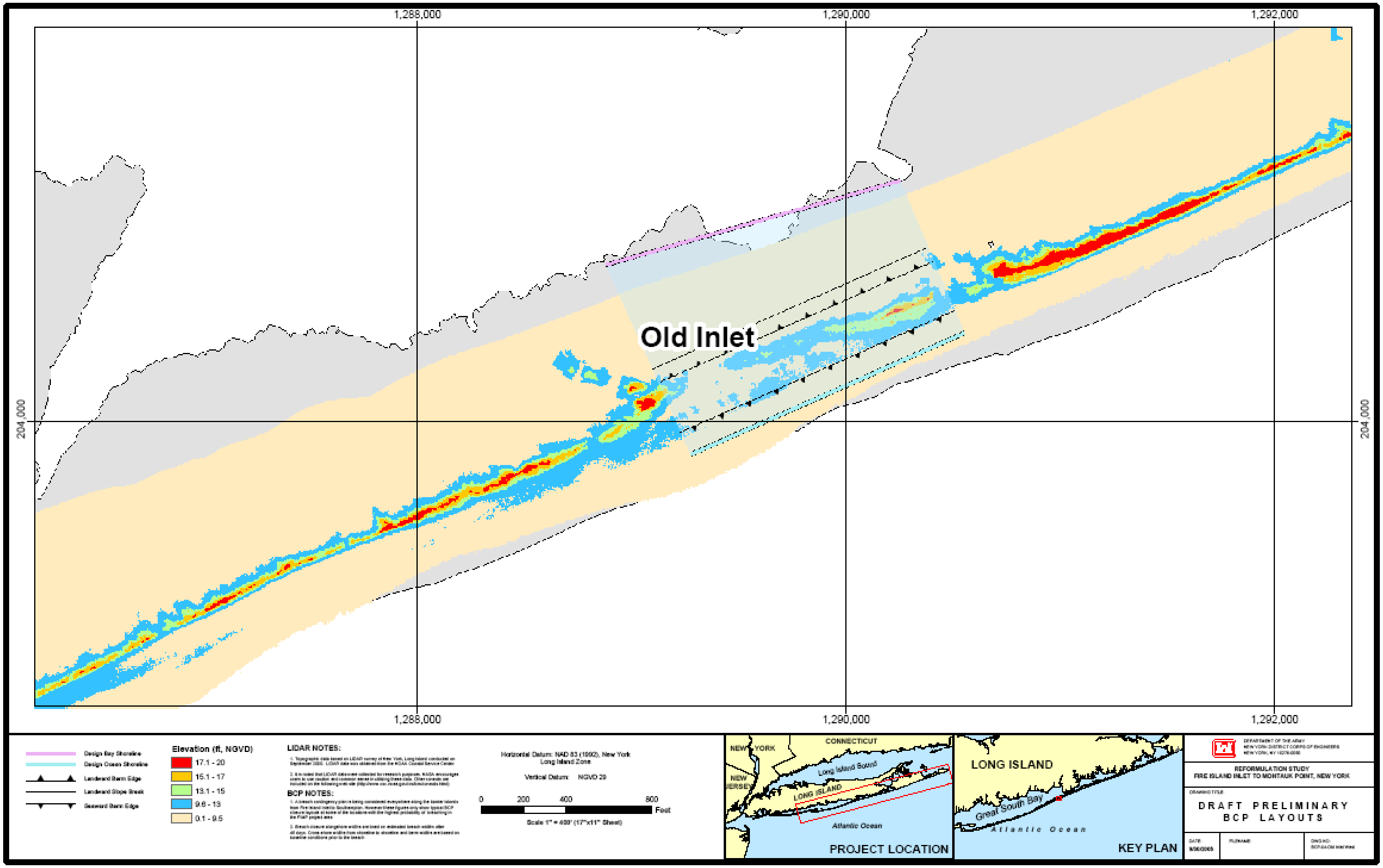


Figure 4.3: Typical Breach Closure Plan Layout at Old Inlet West

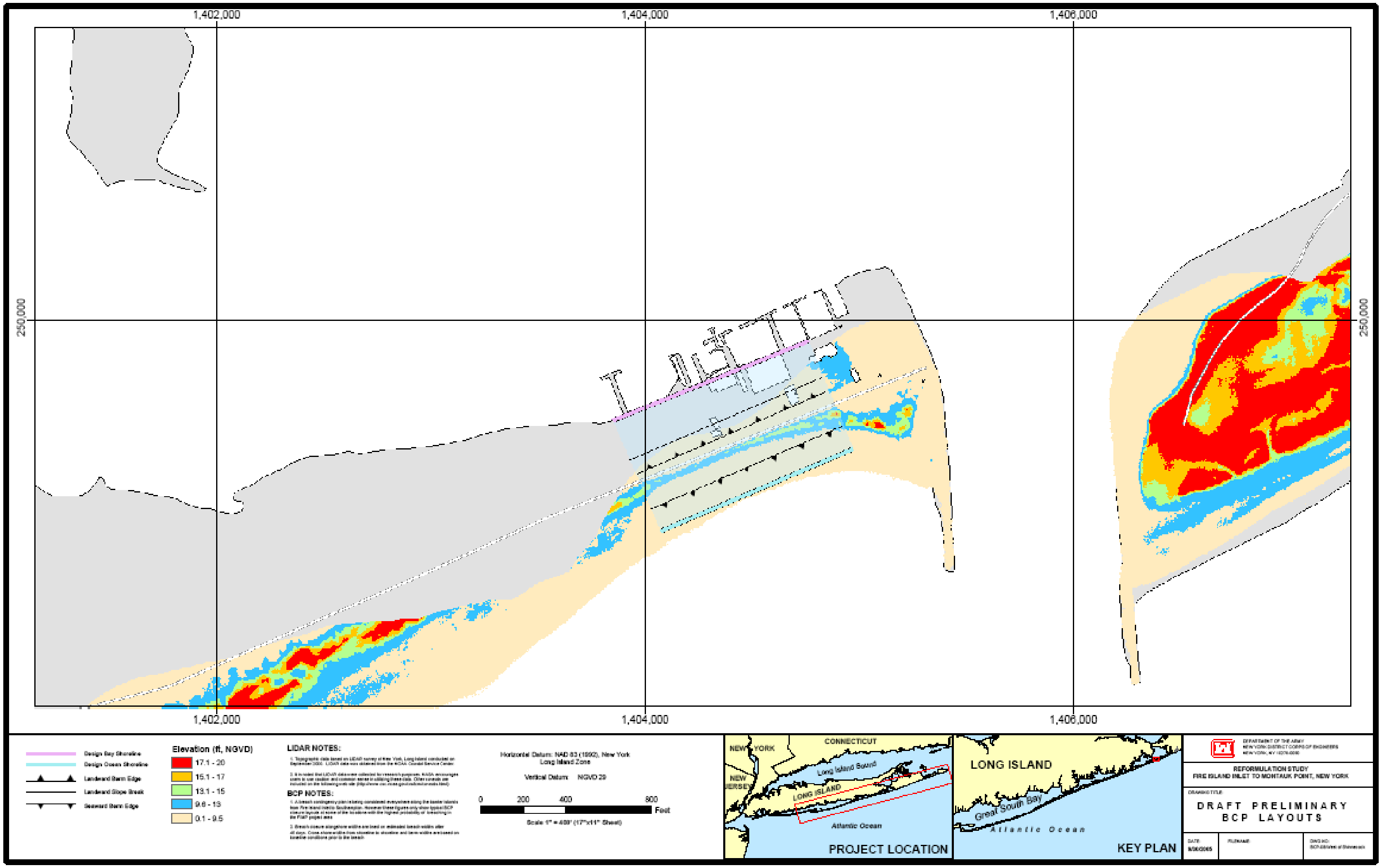


Figure 4.4: Typical Breach Closure Plan Layout at WOSI

2. ***Proactive Breach Closure***

The Proactive Breach Closure 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 Closure Alternatives, and smaller than a beachfill alternative.

These Proactive Breach closure plans allows for overwash and dune lowering during a storm, as long as it is below the established the threshold that would likely result in a breach. It is not designed to protecting ocean shorefront development from overwash, wave attack or storm induced erosion losses.

Based upon the results of the Reactive Breach Closure Alternatives, the Proactive Breach Closure alternative evaluated only the plan with the + 9.5 ft. NGVD berm and +13 ft. dune section. The berm width is generally 90 ft. wide but would be adjusted to match the existing, adjacent shoreline. The fill alignment is generally consistent with the unconstrained dune alignment (or as far landward as possible accounting for real estate requirements).

The proactive plans have been developed considering that a greater alongshore length of fill would be necessary, in comparison with the responsive plan, since the exact location of a breach is unknown.

The threshold conditions (beach and dune width and height that would trigger a response) have been established at each location based upon conditions where a storm with a 10% chance of occurring in a given year could cause a breach (Table 4.2). The effective widths include the width of the beach berm and dune. In general a proactive breach closure response would take place undertaken to restore the island template when conditions are degraded to a future vulnerable condition having an effective width of 50 ft. Further refinements to the thresholds can be made based upon the level of risk that is acceptable at a given location.

Table 4.2 Proactive BCP, Effective Widths, and Threshold for Action

Location	Description	Baseline Effective Width (Ft.)	FVC Effective Width (Ft.)	Threshold Effective Width (Ft.)	Closure Effective Width (Ft.)
1	Fire Island Lighthouse	200	50	35	142
2	Kismet/Corneille	150	50	53	111
3	Talisman/Blue Point	150	50	54	104
4	Davis Park	250	50	0	154
5	Old Inlet W	200	50	N/A	N/A
6	Old Inlet E	200	50	N/A	N/A
7	SPCP	200	50	109	210
8	Sedge Island	200	50	50	136
9	Tiana	200	50	50	224
10	WOSI	250	50	100	185

The decision tree for implementation of the proactive beachfill response plan is shown in figure 8.6. This highlights the decision-making that was applied in the evaluation of the proactive breach response plan. Figure 4.5 highlights that proactive breach response plans were not considered within the Wilderness Area in order to more closely align with the management strategies for this area.

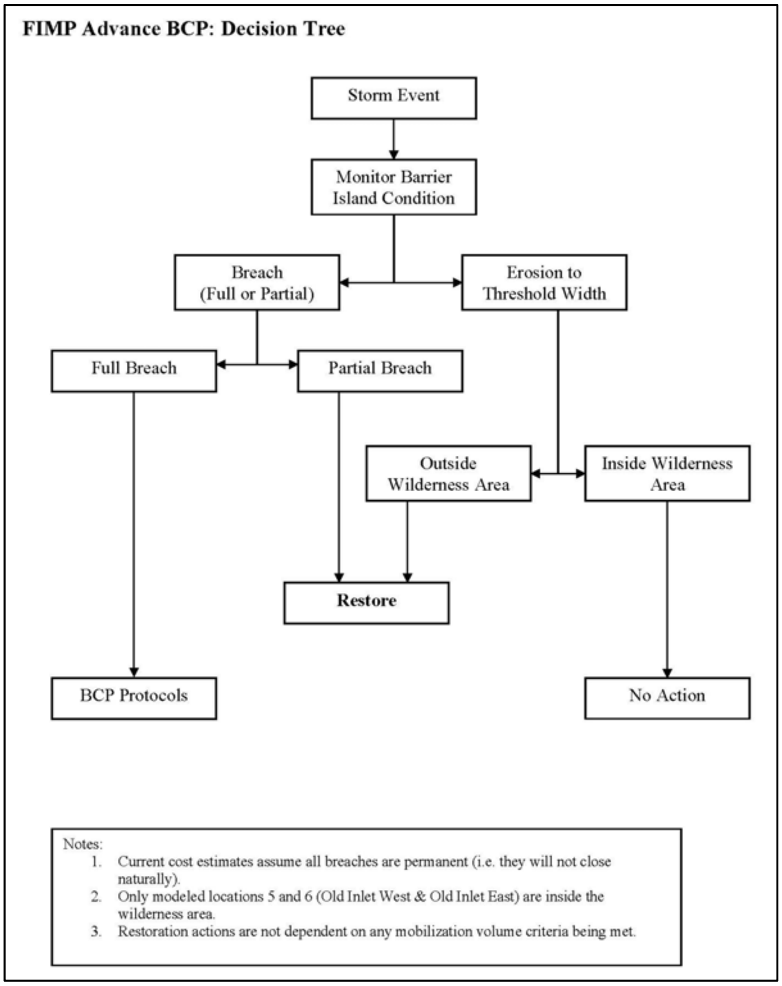


Figure 4.5. FIMP Advance BCP Decision Tree

In summary, the proactive breach closure plan would only be implemented when the barrier island cross-section falls below the threshold condition; the proactive breach closure plan has no advanced fill volume at construction, and the proactive breach closure plan is a plan with less rigorously structured renourishment requirements.

Evaluation of Storm Damage Reduction Effectiveness

The storm damage reduction arising from implementation of the various breach closure alternatives was modeled to quantify Back Bay inundation damages resulting from open breaches in the barrier island as well as the loss of buildings on the barrier islands when the land on which they stand is eroded by an expanding breach. The 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 three alternative Breach Response closure templates were evaluated and the resulting damages compared to those associated with the without-project condition. The BCP alternatives only function to prevent breaches from remaining open. As such, the benefits are limited to reducing flooding due to breaches remaining open, and damages to structures on the barrier island, which represents a small portion of the overall damages in the study area. All breach closure alternatives assumed a delay of nine months before the start of closure. The results of the analyses are presented in Table 4.3, which presents the net benefits and benefit-cost ratios of the three breach closure alternatives, as well as the for the Proactive Breach closure alternative with a 13 ft. dune.

Table 4.3 shows that all the alternatives analyzed are cost-effective in reducing storm damage, and that the +13’ dune Breach response alternative provides the greatest storm damage reduction benefits in excess of cost, as well as the lowest annual costs as compared to the other breach response alternatives. The reason is that the “berm only” and “11’ dune” alternatives would breach more frequently and also require greater maintenance. The proactive breach response plan generates similar net benefits to those provided by the +13 ft. Breach Response plan. Since the costs and benefits for these 2 plans are similar, the decision on whether the plan is responsive or proactive can be finalized in the optimization process. For example, including a proactive response could take advantage of cost-savings associated with sharing mobilization costs, and also be part of a budgeted program, rather than depending upon emergency funding. These refinements can also consider the trigger point for taking action. In addition the 9.5 ft. NGVD alternative is carried forward for consideration for environmentally sensitive areas, where it may be desirable to promote some level of cross-shore transport.

Table 4.3 – Net Benefits and BCRs: Breach Closure Alternatives

	Reactive Breach Closure	Reactive Breach Closure	Reactive Breach Closure	Proactive Breach Closure
	9.5’berm/ no dune	9.5’ berm/ 11’ dune	9.5 ft. berm/ 13’ dune	9.5 ft. berm/ 13’ dune
Total Project				
Total Annual Cost	$1,796,000	$1,410, 000	$1,160, 000	$1,400,000
Total Benefits	$11,219, 000	$11,311, 000	$11,358, 000	$11,579,600
Net Benefits	$9,423, 000	$9,900,366	$10,198, 000	$10,179, 000
Benefit-Cost Ratio	**6.2**	**8.0**	**9.8**	**8.3**
Great South Bay				
Total Annual Cost	$1,295, 000	$700,934	$588, 000	
Total Benefits	$8,823, 000	$8,904, 000	$8,936, 000	
Net Benefits	$7,528, 000	$8,204, 000	$8,348, 000	

Benefit-Cost Ratio	**6.8**	**12.7**	**15.2**	
Moriches Bay				
Total Annual Cost	$520, 000	$420, 000	$390, 000	
Total Benefits	$2,039, 000	$2,050, 000	$2,062, 000	
Net Benefits	$1,518, 000	$1,636, 000	$1,672, 000	
Benefit-Cost Ratio	**3.9**	**4.9**	**5.3**	
Shinnecock Bay				
Total Annual Cost	$263, 000	$261,000	$178, 000	
Total Benefits	$357, 000	$351, 000	$360, 000	
Net Benefits	$95, 000	$90, 000	$182,000	
Benefit-Cost Ratio	**1.4**	**1.3**	**2.0**	

Interest Rate 5.125%, Project Life 50 years

Opportunities to incorporate Coastal Process Features:

Features that could complement a breach closure responses measures to provide a more sustainable, resilient system include:

1) Creation of bayside beach, marsh or SAV in conjunction with a breach closure operation to mimic features likely to form in the absence of breach closure
2) Establish bayside habitat in conjunction with a proactive breach response
3) Establish ocean-front dune in breach closure locations to provide for continuous ocean to bay connectivity
4) Provide for Adaptive Management to ensure the continuity of desirable habitats, and control invasive species

Land Use and Development Management Challenges and Opportunities.

The breach response plans introduce some land use and development management challenges that would not be realized in the without project condition. Presently, the existing land use and development management measures offer no controls that would limit rebuilding in a breach area, subsequent to a breach closure, outside of the existing CEHA area. Land management measures should consider restricting redevelopment in locations that are likely to remain as vulnerable to breaching and overwash over the project life, to reduce repeated damages to structures, facilitate the continued breach response requirements, and to provide for a desirable habitat mosaic. This could be achieved both with improvements in the land use regulations, and with acquisition alternatives.

Evaluation of Planning Criteria

Below is a summary of the extent to which the Breach Response Measure satisfies the study planning evaluation criteria and objectives:

Cost Effectiveness Criteria. Table 4.3 shows that the breach response plan is a cost-effective storm damage reduction measure with a BCR of over 9.0 for the 13 ft. NGVD dune alternative. The breach response plans can be either responsive or proactive depending upon the implementing criteria with similar costs and benefits for the +13 ft. NGVD dune plan

P&G Criteria. The breach response plans alone do not represent a complete solution, as they only address a small portion of the damages associated with a breach being open. In the context of this limitation, the breach response measures are effective and efficient, particularly the +13 Ft. NGVD dune plan. The breach response measures are generally implementable, although within the Federal tracts of land on Fire Island, the NPS reserves the right to approve a breach closure based upon their assessment of natural resources impacts and storm damage reduction needs.

Vision Criteria. Table 4.4 provides an assessment of extent to which the Breach Closure Response Measure satisfies each of 12 Vision criteria. The assessment indicates that while the Breach Closure Response measure alone does not achieve all the Vision objectives, it is not inconsistent with any of the objectives.

Summary and Findings: Breach Closure Response Measures.

1. Breach closure response measures provide cost-effective storm damage reduction strategies as compared to allowing a breach to remain open.
2. Breach closure response measures can be either responsive or proactive, depending upon the implementing criteria.
3. The Breach response closure alternative with a +13 ft. NGVD dune template provides the most net benefits. In areas where cross-shore transport is desired, the breach closure at elevation +9.5 ft. NGVD without a dune can be considered.
4. Breach response Measures partially fulfill the vision objectives. Coastal Process features have been identified that could be integrated with breach closures to advance the vision objectives.
5. Subsequent negotiations with partner agencies resulted in a third breach response for application within the Federal tracts of land. The Main Report, Benefits Appendix, and Engineering Appendix refine the analysis to incorporate the Conditional Breach Response, where an assessment is made to determine if the breach is closing naturally, or if mechanical closure is needed.

Table 4.4 – Assessment of Achieving Vision Criteria for Breach Closure Alternatives

Evaluation Criteria	Assessment	Rating
The plan or measure provides identifiable reductions in risk from future storm damage.	Provides quantified reduction in storm damage.	Full
The plan or measure is based on sound science and an 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 considered a lower priority.	Breach closure has been the general practice in the Study Area dating back to the 1938 storm. Options to allow natural closure are less certain due to uncertainties in future storms and sediment buildup.	Full
The plan or measure addresses the various causes of flooding, including open coast storm surge, storm surge 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.	Rapid response significantly reduces the risk of increased flooding in the bays following a breach. Some closure designs may reduce the flood risk associated with repetitive breaching and overwash.	Partial
The plan or measures incorporate appropriate non-structural features provide both storm damage protection and to restore coastal processes and ecosystem integrity	Compatible with non-structural components to limit redevelopment in breach vulnerable areas and helps avoid major changes in the flood elevations used to define floodplain management regulations.	No
The plan or measure help protect and restore coastal landforms and natural habitat.	Designs restore the barrier width and provide varying levels of dune restoration. Rapid closure will reduce volumes of sand captured in flood and ebb shoals when compared to without project conditions.	Partial
The plan avoids or minimizes adverse environmental impacts	Response protocols have been developed to minimize any adverse environmental impacts.	Partial
The plan addresses long-term demands for public resources.	Because closure designs use relatively small quantities of fill, future monitoring and some profile restoration is considered necessary to prevent repetitive breaching.	Partial
Dune and beach nourishment measures consider both storm damage reduction, restoration of natural processes, and environmental effects.	Closure restores the littoral transport and provides storm damage reduction. Potential reduction in cross shore transport.	Full
The plan or measure incorporates appropriate alterations of existing shoreline stabilization structures	Not Applicable	No
The plan or measure incorporates appropriate alterations of inlet stabilization measures and dredging practices	Not Applicable	No
The plan or measure is efficient and represents a cost effective use of resources	Measures are highly cost effective	Full
The plan or measure reduces risks to public safety.	Closure reduces the risk of hazardous storm surges in the bay and will reduce the potential for excessive shoaling of navigation inlets.	Full

B. Sediment and Inlet Management Measures

At each of the three inlets, multiple alternatives were identified for evaluation in addition to the existing authorized project to increase sediment bypassing, increase stability to adjacent shorelines and maintain navigability. The analysis of alternatives utilized a fatal flaw analysis, and a screening analysis to focus on alternatives to be developed more fully. This resulted in the consideration of eight alternatives for Shinnecock Inlet, four alternatives for Moriches Inlet and four alternatives at Fire Island Inlet. These alternatives were modeled and priced to identify the optimal means to accomplish the objectives identified above. The result of this analysis is the recommendation that the most cost-effective means to achieve bypassing is through additional dredging of the ebb shoal, outside of the navigation channel, with downdrift placement. This operation would be undertaken in conjunction with the scheduled Operations and Maintenance (O&M) dredging of the inlets.

Table 4.5 lists the alternatives identified during the Phase 1 screening process for each of the three Inlets for consideration as to whether enhanced sand bypassing or modified inlet designs could potentially limit future storm damages and/or enhance the performance of plan alternatives.

Table 4.5 Inlet Modification Alternatives

LOCATION	INLET ALTERNATIVES
Shinnecock Inlet	Alt 1. Authorized Project (AP) + Dredging the Ebb Shoal
	Alt 2. AP + Dredging the Flood Shoal
	Alt 3. AP + Offshore Dredging for West Beach
	Alt 4. AP with Reduced Dimensions of Deposition Basin
	Alt 5. AP + Semi-fixed Bypass System (Either Stationary or Truck-Mounted)
	Alt 6. AP + Shortening the East Jetty
	Alt 7. AP + West Jetty Spur
	Alt 8. AP + Nearshore Structures
Moriches Inlet	Alt 1: Authorized Project (AP)
	Alt 2: AP + Dredging the Ebb Shoal
	Alt 3: AP + Dredging the Flood Shoal
	Alt 4: AP + Semi-fixed Bypass System (Either Stationary or Truck-Mounted)
Fire Island Inlet	Alt 1: Authorized Project (AP) / Existing Practice (EP)
	Alt 2: AP/EP + Dredging the Ebb Shoal
	Alt 3: AP/EP + Existing Practice plus Dredging the Flood Shoal
	Alt 4: Existing Practice Plus Discharge Farther West
	Alt 5: Optimized Channel and/or Deposition Basin Configuration

1. *Shinnecock Inlet*

Table 4.6 shows the 2009 comparative analysis of the costs for each of the alternatives considered for Shinnecock Inlet with the cost of the current practice of dredging the authorized project dimensions every four years. The least expensive alternatives (Alt 1A and 2A) maintain the authorized Project features and offset the existing sediment deficit (52,000 cy/yr) by dredging the ebb shoal or the flood shoal on a 4 year cycle.

Table 4.6 Summary of Costs for Shinnecock Inlet Alternatives

Plan	First Costs ($1,000's)	Average Annual Costs ($1000's)
Existing Conditions (dredging every 4 years)	-	*$2,646*
Alt 1A. AP + Ebb Shoal Dredging every 4 years	-	$2,059
Alt 1B. AP + Ebb Shoal Dredging every 2 years	-	$2,851
Alt 2A. AP + Flood Shoal Dredging every 4 years	-	$2,059
Alt 2B. AP + Flood Shoal Dredging every 2 years	-	$2,888
Alt 3. AP + Offshore Dredging for West Beach	-	$3,978
Alt 4A. -18 ft. MLW Deposition Basin	-	$2,911
Alt 4B. -16 ft. MLW Deposition Basin	-	$3,459
Alt 5. AP + Semi-fixed Bypass System	$4,633	$3,462
Alt 6. AP + Shortening the East Jetty	$2,167	$5,085
Alt 7. AP + West Jetty Spur	$6,629	$3,042
Alt 8. AP + Nearshore Structures (T-groins)	$25,642	$3,868

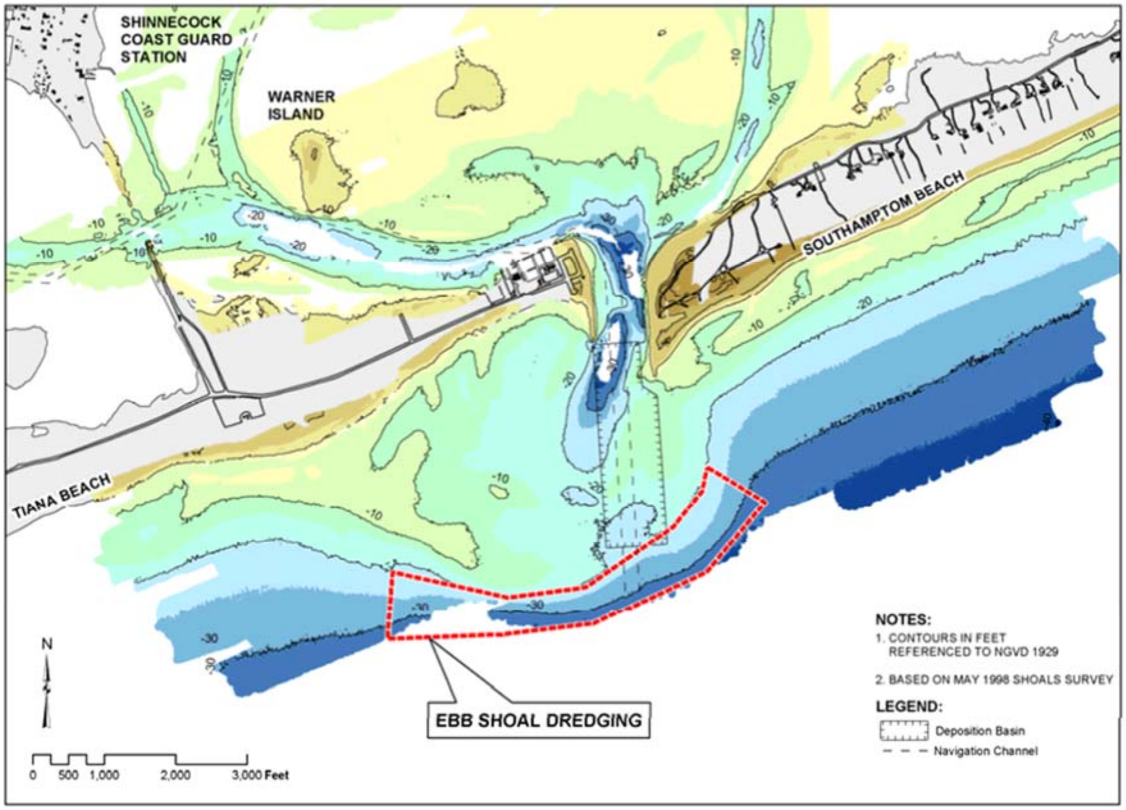


Figure 4.6 Recommended Alternative for SI: -16 ft. MLW DB + Ebb Shoal Dredging

Alt 1 and 2 entail little risk and uncertainty since they essentially continue the current practice using proven dredging technology with known costs, schedules, performance, and environmental effects. Neither alternative requires a new capital improvement or significant upfront costs. Of the two shoals, dredging the ebb shoal is the preferred option since it has fewer environmental concerns and more certainty with regard to effects on the sediment budget. Dredging the ebb shoal and placement downdrift would offset the existing longshore sediment transport deficit and restore (in terms of average volume per year) longshore sediment transport processes downdrift of the inlet. The continued dredging of the deposition basin would mitigate local erosion of the West Beach. Through regular monitoring surveys, performance would be continuously evaluated and modifications could be made to the specific location and volume of sand placed. For example, ebb shoal material could be occasionally placed on the West Beach if necessary. Continued dredging of the deposition basin to -20 ft. MLW would maintain navigation reliability through the inlet.

One potential disadvantage of dredging the shoals is lack of bypassing continuity, particularly on a 4 year cycle. However, a 2-year cycle could be combined with a shallower deposition basin (at -16 ft. MLW) to provide a cost effective solution that would improve continuity and eliminate the long shore transport (LST) deficit across the inlet. Only shortening the east jetty (dredging on 1 year cycle) or a bypassing plant could provide for more continued bypassing. However, both would be more expensive, less reliable, and irreversible. A two-year dredging cycle would also be much closer to the 1.5-year cycle originally anticipated in the current project authorization. This trade-off between more continuous bypassing and slightly increased average annual costs could be managed and modified, if necessary, in the future depending on actual performance and costs.

A summary of the analyses for the other alternatives are as follows.

Authorized Project Plus Flood Shoal dredging (Alt 2). While similar in cost to Alternative 1, modeling results suggest that flood shoal dredging could increase the tidal prism through the Inlet with the potential to increase flood elevations. In addition flood shoal sands tend to be finer than the ebb shoal sediments and therefore less desirable from a littoral transport perspective. Flood shoal dredging would also be performed closer to environmentally sensitive areas.

Authorized Project Plus Offshore dredging For West Beach (Alt. 3). In addition to being more costly, under this alternative accumulation of sand in the shoals and adjacent beaches would continue. Unlike Alternative 1 (ebb shoal dredging), this alternative does not "balance" the sediment budget by reducing accumulation within the inlet.

Authorized Project Plus a semi-fixed bypassing plan (Alt. 5). In combination with continued dredging of the deposition basin, the semi-fixed bypassing plan would mitigate local erosion of the West Beach and partially offset the existing longshore sediment transport deficit. However, some accumulation of sand in the shoals and adjacent beaches would continue and downdrift erosion would not be fully mitigated unless there is also placement from offshore. Continued accumulation in the ebb shoal is consistent with experience at Indian River Inlet, where recent surveys suggest that the ebb shoal has continued to grow despite continuous bypassing. Another issue is that the actual bypassing rate for the plant at Indian River has been lower than anticipate, an issue that would have to be reassessed if this alternative was to be further considered. Finally, the initial investment required would not be recoverable.

Authorized Project Plus Shortening the east jetty (Alt. 6). While shortening the east jetty would partially offsets the littoral sand transport deficit and partially mitigates local erosion of the West Beach, navigation through the inlet would likely be adversely impacted due to the increased influx of sediments from the east. Modeling results indicate that under large storm conditions channel depths could be reduced rapidly. The jetty could obviously be shortened a smaller distance to better balance navigation and dredging/bypassing needs. In addition to the higher cost associated with this alternative, there is significant amount uncertainty about the actual effect that shortening the jetty would have on shoaling and navigation conditions within the channel and deposition basin.

Authorized Project Plus a spur of the west jetty (Alt. 7). While this alternative could stabilize the West Beach, sand placement is likely to be required in the future. Modeling results also indicate that accumulation in the deposition basin would be reduced with some of the material carried farther offshore and deposited on the seaward edge of the downdrift ebb shoal lobe due to the increased training of the ebb jet as a result of spur construction. This alternative is also more costly and there are environmental concerns associated with constructing a coastal structure.

Authorized Project Plus constructing the T-groins (Alt. 8). This alternative would likely allow sand to be directly bypassed to the beaches downdrift of the Inlet, and likely eliminate the chronic erosion problem along the West Beach. However, it is uncertain what their net effect would be on the sediment budget and whether or not the existing longshore sediment transport deficit would be reduced. Similar to Alt 7, this alternative is also more costly and there are environmental concerns associated with constructing a coastal structure

2. ***Moriches Inlet***

Table 4.7 compares the costs for each of the alternatives considered for Moriches Inlet with the cost of the current practice of dredging the authorized project dimensions every four years. Similar to Shinnecock Inlet, the least expensive alternatives are those that maintain the Authorized Project features and offset the existing LST deficit (73,000 cy/yr) by dredging the ebb shoal or the flood shoal (Figure 4.7). Due largely to funding availability, maintenance dredging takes place about every four years on average (*Existing Conditions)* which does not provide for reliable navigation. To provide reliable navigation would require annual dredging, as was recommended in the design of the authorized project.

Table 4.7 Summary of Costs for Moriches Inlet Alternatives

Plan	First Costs ($1,000s)	Average Annual Costs ($1,000s)
Existing Conditions (dredging every 4 years)	-	*$2,983*
Alt 1. Authorized Project (1 yr cycle)	-	$5,709
Alt 2. AP + Ebb Shoal Dredging (1 yr cycle)	-	$4,966
Alt 3. AP + Flood Shoal Dredging (1 yr cycle)	-	$4,966
Alt 4. AP + Semi-fixed Bypass System	$4,633	$6,320

Discount Rate: 5.0125%, Sept 07 PL, 50 year study period.

Similar to Shinnecock Inlet, dredging the authorized project and the ebb shoal on a regular cycle (1 year) is the most cost effective alternative to achieve the project objectives of reliable navigation and bypassing sand to the downdrift beaches. It also has less risk and uncertainty as compared to other alternatives since it utilizes existing dredging technology with known costs, schedules, performance, and environmental impacts.

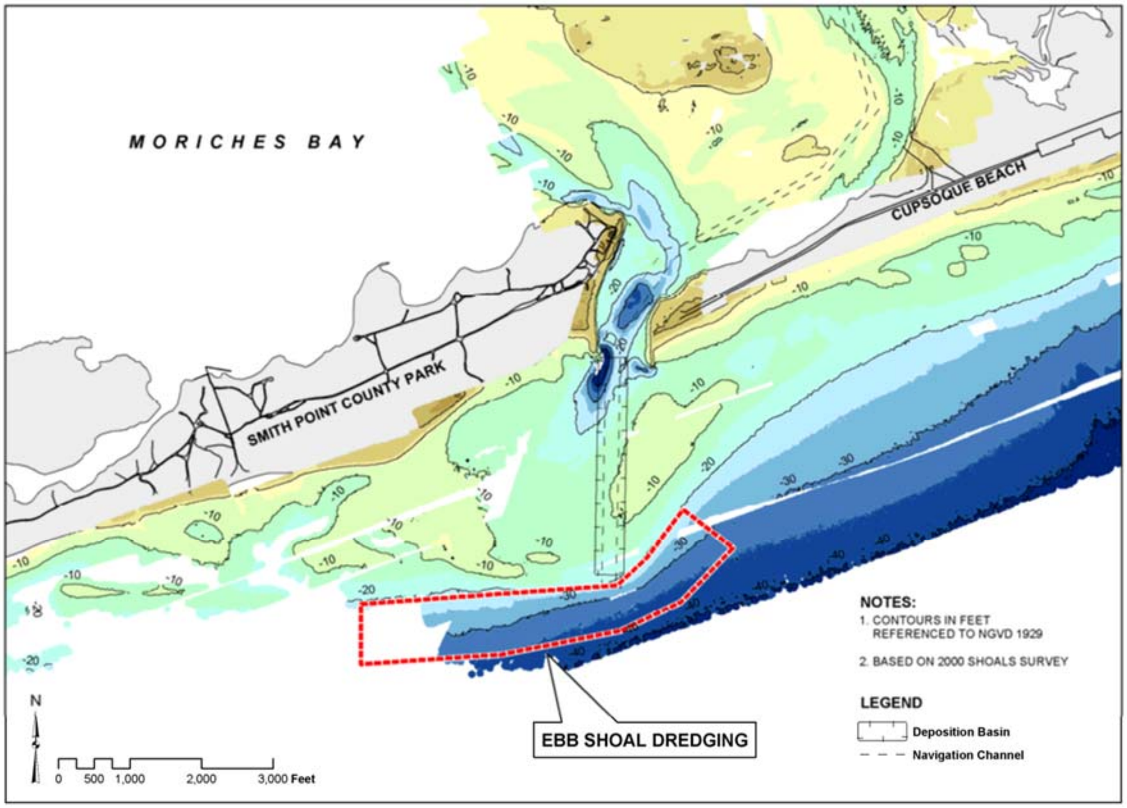


Figure 4.7 Recommended Alternative for MI: AP + Ebb Shoal Dredging

Arguably, increasing the deposition basin dimensions could be used to maintain a channel for at least one year or perhaps even two and thus to reduce average annual costs and improve navigation. However, a larger deposition basin may have unintended effects on the sediment budget for the inlet. Nonetheless, actual performance of the project on a 1-year dredging cycle should be monitored and, if needed, the dimensions and/or layout of the deposition basin could be reassessed. Dredging the flood shoal (Alt. 3) instead of the ebb shoal has similar drawbacks at Moriches as it does at Shinnecock Inlet.

The main drawbacks of the semi-fixed bypass system (Alt. 4) are essentially the same as described for Shinnecock Inlet. At Moriches Inlet the net westerly longshore sediment transport immediately updrift of the inlet is 238,000 m^3/yr, which is more than double the capacity of this type of bypassing systems (estimated at 100,000 m^3/yr). Therefore, with a semi-fixed bypassing plant annual dredging in the channel and deposition basin will continue to be required, albeit at a reduced rate. More importantly, sediment would continue to accumulate in the inlet shoals since the system would not capture and transfer all of the littoral drift. The resulting deficit would still have to be offset by periodic dredging from other sources (e.g., offshore). Note that combining ebb shoal dredging with a semi-fixed bypassing plant would also offset the LST deficit, but at a higher cost than dredging alone. A semi-fixed bypassing plant would provide for more continuous bypassing. However, continuity is not as much of issue for the dredging alternatives in this case given the recommended yearly dredging cycle. Dredging also allows for flexibility by, for example, potentially extending the interval between dredging events during relatively calm wave years such as the 1998 to 2000 period. Finally, it provides the ability to implement a full range of alternatives at throughout the project life.

3. *Fire Island Inlet*

Table 4.8 summarizes the costs for each shortlisted alternative. Note that Alternative 1 essentially represents continuation of the existing practice under the current, multi-purpose, project authorization. According to the table, all four alternatives have similar costs although 1 and 4 area slightly more costly because the need to offset the estimated LST deficit (145,000 m^3/yr or 190,000 cy/yr) by means offshore dredging instead of dredging the ebb shoal or flood shoal.

Table 4.8 Summary of Costs for Fire Island Inlet Alternatives

Plan	First Cost ($1,000s)	Average Annual Costs ($1,000s)
Alt 1: Authorized Project Dimensions (APD) / Existing Practice (EP)	-	$11,648
Alt 2: APD/EP + Dredging the Ebb Shoal	-	$10,054
Alt 3: APD/EP + Dredging the Flood Shoal	-	$10,054
Alt 4: Optimized Channel and/or Deposition Basin Configuration	-	$11,648

Discount Rate: 5.0125%, Sept 07 PL, 50 year study period.

Available morphological data, model simulations, and sediment budget analyses do not suggest any significant benefits (e.g., increased bypassing, reduced maintenance dredging or improved navigation) associated with a complete realignment of the channel and/or deposition basin. However, a slightly wider deposition basin at the western tip of the existing sand spit will limit encroachment of this feature into the navigation channel at the end of each dredging cycle. Therefore, the recommended plan for Fire Island Inlet consists of combining Alternatives 1 and 4 (see Figure 8.9) and continuing the recent practice of placing all of the dredged material at least three miles west of Democrat Point.

Future placement of some of the dredged material along Robert Moses State Park (i.e., backpassing) on as needed basis depending on future shoreline changes and infrastructure protection requirements. A more detailed breakdown of the costs for this recommended plan is presented in Table 8.19. Note that the slight change in the deposition basin will not change the costs compared to Alternative 2 initial dredging in the expansion area will likely be offset with less dredging along the deposition basin farther offshore.

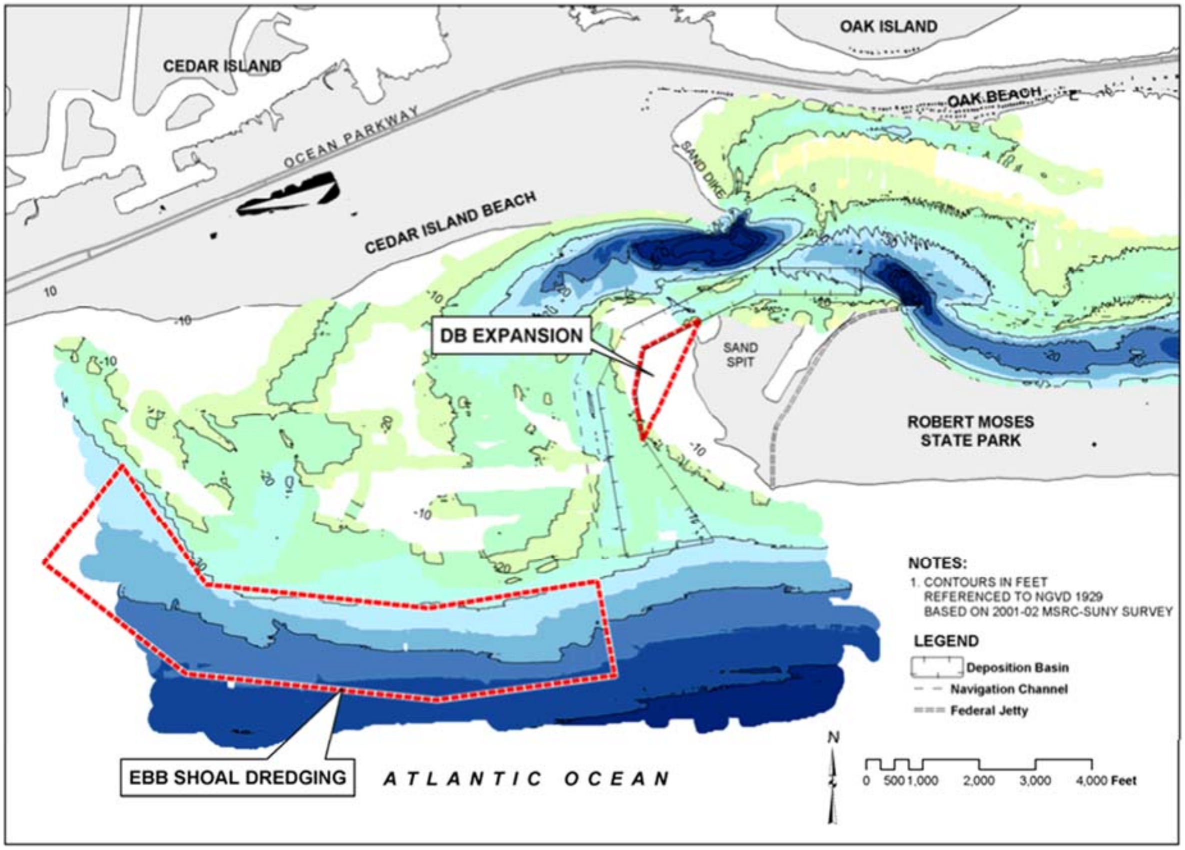


Figure 4.8 Recommended Alternative for FII: AP + Ebb Shoal Dredging & DB Expansion

As in the case of Shinnecock and Moriches Inlet, this alternative provides the most reliable, flexible, and cost- effective means for maintaining navigation and offsetting the existing LST deficit. Given the volumes and distances involved the only other feasible alternative would be to dredge the flood shoal or offshore. Dredging offshore would be more expensive and would not directly eliminate the existing sediment sink at Fire Island Inlet. Dredging the flood shoal may be technically feasible, but its dynamics are poorly understood at this time due to lack of comprehensive bathymetry data, and geomorphic, hydrodynamic, and environmental impacts associated with dredging this feature may be significant. Moreover, dredging the flood shoal, particularly in areas east of the Robert Moses Causeway, would be more costly than dredging the ebb shoal because of the increased transport distance.

<u>Evaluation of Storm Damage Reduction Effectiveness</u>

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. Table 4.9 shows the annual benefits associated with the recommended sediment management changes at the three inlets, as compared to the without project

Table 4.9 Annual Benefits: Inlet Management Alternative

Benefit Category	Inlet Management
Total Project	
Tidal Inundation	
Mainland	$278,100
Barrier	$42,500
Total Inundation	*$320,600*
Breach	
Inundation	$127,900
Structure Failure	$0
Total Breach	*$127,900*
Shorefront Damage	$0
Public Emergency	
Other	
Total Storm Damage Reduction	*$448,500*
Costs Avoided	
Breach Closure	$336,900
Beach Maintenance	
Other	
Land Loss	
Total Benefits	***$785,400***

Discount Rate: 5.0125%, Sept 07 PL, 50 year study period.

Table 4.10 Incremental Annual Cost: Inlet Management Alternative

	Annual Cost	**Incremental Annual Cost**
Fire Island Inlet		
Existing Practice (dredging every2 years)	*$7,077,000*	
Ebb Shoal & Deposition Basin (expanded) dredging on 2-yr cycle	$9,077,000	$2,220,000
Moriches Inlet		
Existing Practice (dredging every 4 years)	*$1,022,000*	
Ebb Shoal & Deposition Basin (AP dimensions) dredging on 1-yr cycle	$2,803,000	$3,353,000
Shinnecock Inlet		
Existing Practice (dredging every 4 years)	*$1,033,000*	
Ebb Shoal & Deposition Basin (at -16 ft. MLW) dredging on 2-yr cycle	$1,726,000	$1,221,000
Project Total		**$6,794,000**

Discount Rate: 5.0125%, Sept 07 PL, 50 year study period.

condition, while Table 4.10 shows the incremental annual cost increase of implementing the Inlet Management alternative. By restoring the longshore littoral transport processes, the recommended inlet management modifications also contribute to restoring coastal processes. In addition the General Management Plan for Fire Island National Seashore specifies that bypassing be a component of any storm damage reduction plan being considered for Fire Island. Also, the State of New York's Coastal Zone Management policies require consideration of alternatives to restore natural protective features t prior to considering other storm damage reduction alternatives. The Corps' RSM initiative recognizes the scarcity of sand as resource, and the need to efficiently use this material to achieve multiple purpose objectives.

Bypassing can also be considered as a cost-effective source of material for renourishment of a project and as a way to reduce the frequency of renourishment of areas with high erosion due to sediment deficits. In addition to sediment management measures at the inlets, there may be other sediment management measures, such as creating feeder beaches to provide for a balanced longshore sediment transport, which will considered in the beachfill section.

Restoration measures that are compatible with this approach include:
2) Reestablishment of ocean dune habitat, in conjunction with sediment management alternatives, to provide optimal beach and dune habitat
3) Reestablishment of Ocean Beach and Dune habitat through removal or modification of coastal structures, to increase the extent of longshore transport processes.

Planning Evaluation Criteria Considerations

Below is a summary of the extent to which the Inlet Sediment Management Measures satisfy the study planning evaluation criteria and objectives:

NED Criteria. Although the economic analysis does not conclusively show that Inlet sediment management measures are cost-effective coastal storm risk management alternatives, sediment management measures at the inlets is recommended to be carried forward for further development and considered in conjunction with other storm damage reduction measures. There are federal and state policy considerations for the inclusion of bypassing as an alternative, along with coastal process opportunities that make bypassing a viable measure. As a standalone measure, bypassing has limited effectiveness, but in combination with other plans, bypassing is an effective source of sediment.

P&G Criteria. Inlet sediment bypassing measures alone do not represent a complete solution, as it only addresses a small portion of the storm damages that arise due to the interruption of longshore transport nor is it effective or efficient as a stand-alone option. Inlet sediment bypassing is strongly supported by the key stakeholders and is recommended to be a component of the recommended plan.

Vision Criteria. Table 4.11 provides an assessment of the extent to which the Inlet Sediment Management Measures satisfy each of the 12 Vision criteria. The assessment indicates that while the Inlet Sediment Management Measures alone do not achieve all the Vision objectives, they are not inconsistent with any of the objectives.

Table 4.11 Assessment of Achieving Vision Criteria for Inlet Management Measures

Evaluation Criteria	Assessment	Rating
The plan or measure provides identifiable reduction in risk from future storm damage.	Measures help to avoid excessive erosion in areas affected by inlets. Some of these affects have been quantified as reduced flooding.	Full
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	The inlet management measures are based on the observed historical inlet responses and extensive modeling of inlet dynamics and morphology. The historic records and modeling are considered less reliable for alternatives incorporating significant structural modifications of the	Full
The plan or measure addresses the various causes of flooding, including open coast storm	Measures to improve sediment management may reduce flooding by	Partial
surge, storm surge 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.	preventing local areas of accelerated erosion, thus reducing flooding associated with periodic overwash or breaching of barrier islands.	
The plan or measures incorporate appropriate non-structural features provide both storm damage protection and to restore coastal processes and ecosystem integrity	The measures modify sediment management procedures to restore transport and will help maintain both storm damage protection and ecosystem integrity.	Full
The plan or measure help protect and restore coastal landforms and natural habitat.	The measures help to reduce or eliminate deficits in longshore sediment transport and are important for the protection of landforms and habitat.	Full
The plan avoids or minimizes adverse environmental impacts	Construction activities are scheduled to avoid or minimize impacts	Full
The plan addresses long-term demands for public resources.	The measures will require continued maintenance into the future to provide both safe navigation and coastal process restoration.	Partial
Dune and beach nourishment measures consider both storm damage reduction, restoration of natural processes, and environmental effects.	Locations for placement of bypassed sediment provide both storm damage reduction and restoration.	Full
The plan or measure incorporates appropriate alterations of existing shoreline stabilization Structures.	NA	NA

The plan or measure incorporates appropriate alterations of inlet stabilization measures and dredging practices.	Measures to alter dredging practices were considered more appropriate than structural changes to the inlets.	Full
The plan or measure is efficient and represents a cost effective use of resources.	The measures provide significant economic and process restoration	Partial
The plan or measure reduces risks to public safety.	The measures maintain navigation safety contribute to increased storm protection	Full

Summary and Findings: Inlet Sediment Management Measures

1. The recommended sediment management measures at each of the inlets essentially continues the maintenance dredging of the authorized Inlet navigation projects with the addition of bypassing sand from the ebb shoal. If included in the selected plan, monitoring should be performed and adaptive management included allowing for changes in the sediment management of the Inlets as required, particularly the volume requirements, timing and locations for dredging and placement.
2. The sediment management plans advance, and partially fulfill the vision objectives.
3. The sediment management alternatives do not introduce any specific land use and development management challenges.

C. Nonstructural (Building Retrofit) Measures

The following non-structural flood proofing measures were considered for providing 100 year level protection (plus 2 ft. of freeboard) for buildings on the main land,) that corresponded to the baseline-condition landward limits of the 2-, 6-, 10-, 25- and 100-year floodplains:

1. Dry Flood Proofing. Dry Flood Proofing measures allow flood waters to reach the structure but diminish the flood threat by preventing the water from getting inside the structure walls. Dry Flood Proofing measures considered in this screening make the portion of a building that is below the flood level watertight through attaching watertight closures to the structure in doorway and window openings. Detached levees and floodwalls were not considered due to the density of structures in the floodplains.

2. Wet Flood Proofing: allowing flood water to enter lower, non-living space areas of the structure via vents and openings to reduce hydrostatic pressure and in turn reduce flood-related damages to the structure's foundation. This technique can be used along with the protection of utilities and other critical equipment, which can include permanently raising machinery, critical equipment, heating and cooling units, electrical outlets, switches, and panels and merchandise/stock above the estimated flood water height. It can also involve construction of interior or exterior floodwalls, utility rooms, or additional living space to compensate for space subject to flooding, and the use of flood resistant materials.

3. Elevation: raising the lowest finished floor of a building to a height above the design flood level. This option was considered both as a stand-alone measure and in conjunction with additional construction. In some cases, the structure is lifted in place and foundation walls are extended up to the new level of the lowest floor. In other cases, the structure is elevated on piers, posts, or piles;

4. Acquisition: removal of the structure from the floodplain through demolition. Lands are then preserved for open space uses;

5. Relocation: moving the structure out of the floodplain, either within the existing property boundary (if sufficient space is available) or to another property;

6. Rebuild: demolishing a flood-prone structure and replacing it with a new structure built to comply with local regulations regarding new construction and substantial improvements in a floodplain, and therefore is at a lower risk. The rebuild option was considered only where the costs were found to be less than those associated with an otherwise recommended treatment.

Table 4.12 summarizes the assumptions that were utilized in evaluating and identifying suitable non-structural measures for the various types of structures found in the back bay areas. For each structural

Table 4.12 Assumptions inherent to the screening of back bay 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 back bay areas are considered non-V-Zone and thus not subject to wave and erosion impacts. • All buildings selected for treatment will be protected to the 100-year level, plus two (2) feet of freeboard. • Buildings elevated in non-coastal areas will be raised (finished floor elevation) to the 100-year water surface plus 2 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 protection (See Attachment 1 for supporting calculations).
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.

type, Table 4-13 identifies the flood proofing measure that would be appropriate, assuming 2 different flooding conditions (flood levels above the main floor and flood levels below main floor), and also considering two different protection levels. Table 4.14 presents the first cost of construction for alternatives Nonstructural 1 through 4 (also called NS-1, NS-2, NS-3, and NS-4). Costs for the baseline 100-year plan (which was determined to be cost-prohibitive) are included for comparison purposes only.

Table 4.13 Flood-proofing alternatives identified for back bay unit cost estimating

Typical Structure Type	Flood Level	Protection Level Condition 1	Protection Level Condition 2	Flood Proofing Alternative
Slab-On-Grade	>= Main Floor	Protection Level – Ground < 3	n/a	Sealant & Closures
		Protection Level – Ground >= 3	n/a	Elevate Building
	< Main Floor	< Main Floor	n/a	Raise AC
		>= Main Floor	Protection Level – Ground < 3	Sealant & Closures
			Protection Level – Ground >= 3	Elevate Building
Basement-Subgrade	>= Main Floor	n/a	n/a	Elevate Building
	< Main Floor	< Main Floor		Fill Basement + Utility Room
		>= Main Floor	n/a	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	Protection Level – Ground < 3	Interior Floodwall
			Protection Level – 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	Protection Level – Ground <= 3	Sealant & Closures
			Protection Level – 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	Protection Level – Ground < 3	Sealant & Closures
			Protection Level – Ground >=3	Elevate Building
		>= Main Floor	n/a	Elevate Building

Separate from the five non-structural 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

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, structure acquisition may be considered as an option. 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.

A reevaluation of the acquisition option could be applied, whereby acquired land could be considered for coastal process features. Building acquisition instead of elevation is also an option in the few mainland areas designated as "V" or "high velocity" zones on the FEMA Flood Insurance Rate Maps. There are approximately 290 V-zone buildings currently proposed for elevation under the 100-year protection plan. To acquire these structures would increase the plan cost by approximately $72 million dollars, and thus is not likely to be cost-effective over elevation.

Table 4.14 presents the first cost of construction for alternatives Nonstructural 1 through 4 (also called NS-1, NS-2, NS-3, and NS-4). Costs for the baseline 100-year plan (which was determined to be cost-prohibitive) are included for comparison purposes only.

Table 4.14 Comparison of Alternative Non-Structural First Costs

Project Reach	Econ. Reach	Number of Buildings, Reach Total	Design Water Elevation*	2yr Water Elevation	Number of Buildings, 2yr Plan	First Cost, 2yr Plan	6yr Water Elevation	Number of Buildings, 6yr Plan	First Cost, 6yr Plan	10yr Water Elevation	Number of Buildings, 10yr Plan	First Cost, 10yr Plan	25yr Water Elevation	Number of Buildings, 25yr Plan	First Cost, 25yr Plan	100yr Water Elevation
(Quogue to	8b	119	10.26	4.71	0	$0	5.15	0	$0	5.62	0	$0	6.65	3	549,500	9.26
	10.1	39	9.19	4.76	2	$170,500	5.24	8	$2,153,000	5.71	8	$2,153,000	6.55	18	$3,518,000	8.19
	10.2	6	9.46	4.91	2	$200,000	5.43	2	$220,000	5.92	2	$220,000	6.73	2	$200,000	8.46
	10.3	204	10.06	4.89	18	$2,998,000	5.31	29	$4,833,500	5.84	29	$4,833,500	6.87	51	$7,091,500	9.06
	10.4	260	10.26	4.71	12	$1,530,000	5.15	31	$4,360,500	5.62	31	$4,360,500	6.65	55	$6,723,000	9.26
	11.1	281	9.91	4.87	8	$923,000	5.54	28	$3,833,500	6.03	71	$9,389,500	6.95	71	$9,049,500	8.91
	11.2	626	9.70	4.78	3	$358,000	5.45	27	$3,741,500	5.93	27	$3,741,500	6.85	85	$13,553,000	8.70
	12	786	9.39	4.95	4	$541,500	5.53	19	$2,876,500	6.16	73	$13,529,000	7.19	140	$22,181,500	8.39
	13.1	297	9.67	5.02	48	$7,500,000	5.89	48	$8,417,000	6.64	94	$15,874,000	7.67	118	$16,927,500	8.67
	13.2	588	9.67	5.02	47	$7,069,000	5.89	47	$7,874,000	6.64	109	$18,097,500	7.67	138	$19,606,000	8.67
	Subtotal	*3,206*			*144*	*$21,290,000*		*239*	*$38,309,500*		*444*	*$72,198,500*		*681*	*$99,399,500*	
Bay (Smith	16.1	137	8.21	4.22	3	$367,500	4.85	3	$404,500	5.24	6	$906,000	5.87	6	$795,000	7.21
	16.2	318	8.27	4.13	62	$10,859,000	4.68	64	$10,943,000	5.07	85	$14,861,500	5.70	85	$15,044,500	7.27
	16.3	432	8.44	4.09	46	$8,461,500	4.65	46	$8,346,500	5.06	65	$11,040,000	5.75	65	$11,021,000	7.44
	16.4	611	8.44	4.09	66	$12,106,000	4.65	66	$11,985,000	5.06	116	$21,484,000	5.75	116	$21,842,000	7.44
	17.1	226	7.76	4.26	31	$8,540,000	4.96	31	$9,129,000	5.35	46	$10,644,000	6.01	77	$17,294,000	6.76
	17.2	94	8.21	4.22	0	$0	4.85	0	$0	5.24	1	$113,500	5.87	1	$113,000	7.21
	18.1	3,070	7.94	3.91	140	$18,116,000	4.70	356	$46,507,500	5.30	543	$66,688,500	6.10	924	$82,689,000	6.94
	18.2	208	8.47	4.22	16	$1,722,500	5.07	25	$3,252,000	5.85	25	$3,252,000	6.66	41	$4,438,500	7.47
	18.3	1,343	8.49	4.24	124	$16,865,500	5.11	194	$29,781,000	5.75	194	$29,781,000	6.57	329	$62,346,000	7.49
	Subtotal	*6,439*			*488*	*$77,038,000*		*785*	*$120,348,500*		*1,081*	*$158,770,500*		*1,644*	*$215,583,000*	
South Bay	20	571	6.71	3.15	0	$0	4.02	30	$2,607,500	4.44	30	$2,607,500	5.01	80	$5,474,500	5.71
	21.1	517	6.29	3.10	4	$463,000	4.23	48	$5,492,000	4.51	74	$8,438,000	4.88	81	$9,136,500	5.29
	21.2	1,641	6.29	3.10	24	$4,803,500	4.23	168	$30,232,000	4.51	203	$34,391,500	4.88	223	$36,508,500	5.29
	21.3	755	6.29	3.10	0	$0	4.23	9	$1,960,000	4.51	19	$4,438,500	4.88	21	$6,930,500	5.29
	21.4	747	6.37	3.20	9	$1,970,500	4.02	78	$9,267,500	4.36	79	$9,376,000	4.83	79	$8,471,000	5.37
	21.5	225	6.37	3.20	1	$130,000	4.02	5	$664,000	4.36	6	$754,500	4.83	13	$1,263,000	5.37
	21.6	428	6.65	3.22	13	$1,457,500	3.89	13	$1,611,500	4.18	50	$6,566,000	4.82	50	$5,879,000	5.65
	22.1	1,961	6.30	3.21	156	$18,626,000	4.34	474	$58,724,000	4.61	491	$60,712,500	4.93	495	$54,373,500	5.30
	22.2	2,095	6.20	3.19	38	$4,545,000	4.31	163	$22,450,500	4.54	196	$26,750,500	4.85	214	$27,815,500	5.20
	23.1	364	5.48	3.09	1	$95,500	3.74	1	$118,500	3.97	1	$118,500	4.22	12	$684,500	4.48
	23.2	1,746	5.48	3.09	59	$6,312,000	3.74	101	$12,231,000	3.97	122	$15,471,000	4.22	311	$27,682,500	4.48
	23.3	2,985	5.46	3.14	21	$1,871,000	3.64	30	$3,094,000	3.89	31	$3,241,000	4.18	166	$8,687,500	4.46
	24	3,175	6.07	3.28	16	$2,056,500	3.80	22	$2,649,500	4.02	158	$19,113,000	4.48	189	$20,839,000	5.07
	25.1	1,960	6.56	3.37	6	$802,000	4.45	135	$11,242,500	4.71	138	$11,484,000	5.07	262	$17,718,000	5.56
	25.2	2,413	6.07	3.28	40	$8,141,500	3.80	42	$7,761,500	4.02	494	$48,298,000	4.48	507	$45,380,000	5.07
	26.1	1,715	7.69	3.95	23	$2,860,000	5.00	370	$42,486,500	5.36	371	$42,504,000	5.96	405	$41,352,000	6.69
	26.2	4,703	6.56	3.37	17	$1,963,500	4.45	282	$22,306,000	4.71	313	$23,473,500	5.07	704	$40,586,000	5.56
	26.3	2,323	6.56	3.37	17	$2,246,000	4.45	416	$41,886,500	4.71	416	$41,886,500	5.07	779	$63,293,500	5.56
	Subtotal	*30,324*			*445*	*$58,343,500*		*2,387*	*$276,785,000*		*3,192*	*$359,624,500*		*4,591*	*$422,075,000*	
Reaches		**39,969**			**1,077**	**$156,671,500**		**3,411**	**$435,443,000**		**4,717**	**$590,593,500**		**6,916**	**$737,057,500**	

Discount Rate: 5.0125%, Sept 07 PL, 50 year study period

1) *Note: Design Water Elevation is 100-yr water elevation + 1 Foot freeboard

(For structures in V Zones, Design Water Elevation is listed elevation + 4 feet)

2) 100-year plan (Baseline condition) was determined to be cost-ineffective and is included for comparison purposes only.

Evaluation of Storm Damage Reduction Effectiveness.

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 four nonstructural alternatives analyzed were based on applying protection to back bay mainland structures in the baseline 2-year, 6-year, 10-year, and 25-year floodplains. This protection corresponds to nonstructural plans NS-1, NS-2, NS-3, and NS-4 respectively. Table 4.15 presents a summary of the number of buildings affected by each plan, by Reach.

Table 4.15 Structures Protected by Nonstructural Alternatives

Planning Unit	Nonstructural 1	Nonstructural 2	Nonstructural 3	Nonstructural 4
Great South Bay	445	2,387	3,192	44,591
Moriches Bay	488	785	1,081	1,644
Shinnecock Bay	144	239	444	681
Project Total	*1,077*	*3,411*	*4,717*	*6,916*

These non-structural alternatives 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 non-structural 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.

Table 4.16 presents the modeled annual damages resulting from the implementation of the four nonstructural alternatives.

Table 4.16 Annual Damages: Nonstructural Alternatives

Damage Category	Nonstructural 1	Nonstructural 2	Nonstructural 3	Nonstructural 4
Total Project				
Tidal Inundation				
Mainland	$52,392,700	$36,102,000	$29,230,500	$22,880,500
Barrier	$12,998,600	$12,998,600	$12,998,600	$12,998,600
Total Inundation	$65,391,300	$49,100,900	$42,229,100	$35,879,100
Breach				
Inundation	$9,242,500	$9,242,500	$9,242,500	$9,242,500
Structure Failure	$395,700	$395,700	$395,700	$395,700
Total Breach	*$9,638,200*	*$9,638,200*	*$9,638,200*	*$9,638,200*
Shorefront	$7,388,900	$7,388,900	$7,388,900	$7,388,900
Public Emergency				
Other				
Total Storm Damage				

Discount Rate: 5.0125%, Sept 07 PL, 50 year study period.

These damages have been compared with those associated with the without-project condition to generate the nonstructural project benefits, which are presented in Table 4.17. As shown in the table, these plans reduce the storm damages to flood-prone structures in the mainland back bay areas, but do not reduce damages on the barrier islands or in mainland shorefront areas. Although they appear not to address damages arising due to barrier island breaching, mainland inundation damages caused by breaching would be reduced somewhat by nonstructural plans.

Table 4.17 Annual Benefits: Nonstructural Alternatives

Benefit Category	Nonstructural 1	Nonstructural 2	Nonstructural 3	Nonstructural 4
Total Project				
Tidal Inundation				
Mainland	$21,842,800	$38,133,300	$45,005,000	$51,355,000
Barrier	0	0	0	0
Total Inundation	*$21,842,800*	*$38,133,300*	$45,005,000	*$51,355,000*
Breach				
Inundation	$0	$0	$0	$0
Structure Failure	$0	$0	$0	$0
Total Breach				
Shorefront Damage	$0	$0	$0	$0
Public Emergency				
Other				
Total Storm Damage Reduction				
Costs Avoided	$0	$0	$0	$0
Breach Closure	$0	$0	$0	$0
Beach Maintenance				
Other				
Land Loss				
Total Benefits	***$21,842,800***	***$38,133,300***	**$45,005,000**	***$51,355,000***

Discount Rate: 5.0125%, Sept 07 PL, 50 year study period.

The costs associated with the application of nonstructural treatments and actions are presented in Table 4.18. The total investment costs include contingencies, and allowances for Engineering and Design, Supervision and Administration, and temporary accommodation for the occupants of structures undergoing significant nonstructural treatments. The total investment costs also reflect opportunity costs associated with interest during construction.

Table 4.18 Annual Costs: Nonstructural Alternatives

Cost Category	Nonstructural 1	Nonstructural 2	Nonstructural 3	Nonstructural 4
Total Project				
Total First Cost	$156,671,500	$435,443,000	$590,593,500	$737,058,000
Total IDC	$3,142,368	$13,817,329	$18,734,435	$15,208,000
Total Investment Cost	*$159,813,900*	*$449,260,329*	*$609,327,935*	*$752,266,000*
Interest and Amortization	$8,923,700	$25,085,829	$34,023,695	$42,005,100
Operation & Maintenance	$0	$0	$0	$0
BCP Maintenance	$0	$0	$0	$0
Monitoring	$0	$0	$0	$0
Renourishment	$0	$0	$0	$0
Total Budgeted Cost	$8,923,700	$25,085,829	$34,023,695	$42,005,100
Annual Breach Closure Cost	$1,372,884	$1,372,884	$1,372,884	$1,372,884
Major Rehabilitation				
Total Additional Cost	$1,372,884	$1,372,884	$1,372,884	$1,372,884
Total Annual Cost	***$10,296,600***	***$26,458,713***	***$35,396,579***	***$43,378,000***

Discount Rate: 5.0125%, Sept 07 PL, 50 year study period.

Table 4.19, which presents the net benefits and benefit-cost ratios of the four nonstructural alternatives shows that all the alternatives analyzed are cost-effective in reducing storm damage. Nonstructural Alternative 2 appears to provide the greatest storm damage reduction benefits in excess of cost. A closer inspection of the results shows that the differences in net excess benefits between nonstructural 2 and 3 is very small, and alternative 3 provides significantly greater protection to a larger number of structures. The difference in the design criteria for these 2 alternatives is also very small, generally less than 0.5 ft. difference in the storm surge height). This small difference is difficult to resolve with the accuracy of the existing data. Given this small difference in design criteria, and the relatively small difference in net excess benefits between these alternatives, both Nonstructural Alternative 2 and 3 have been identified as the plans that maximize net excess benefits, and are recommended for consideration in combination with other alternatives.

Table 4.19 Net Benefits and BCRs: Nonstructural Alternatives

	Nonstructural 1	Nonstructural 2	Nonstructural 3	Nonstructural 4
Total Project				
Total Annual Cost	$9,106,258	$26,458,713	$35,396,579	$37,814,205
Total Benefits	$21,842,762	$38,133,250	$45,005,002	$51,354,953
Net Benefits	$12,736,503	$11,674,536	$9,608,423	$13,540,748
Benefit-Cost Ratio	**2.4**	**1.4**	**1.3**	**1.4**
Great South Bay				
Total Annual Cost	$3,763,342	$16,824,750	$21,597,012	$21,770,091
Total Benefits	$7,779,888	$21,015,677	$24,846,235	$28,375,917
Net Benefits	$4,016,545	$4,190,927	$3,249,222	$6,605,827
Benefit-Cost Ratio	**2.1**	**1.3**	**1.2**	**1.3**
Moriches Bay				
Total Annual Cost	$4,086,723	$11,304,862	$9,333,069	$10,862,206
Total Benefits	$8,983,402	$10,989,258	$12,434,091	$14,327,878
Net Benefits	$4,896,679	-$315,605	$3,101,022	$3,465,672
Benefit-Cost Ratio	**2.2**	**0.97**	**1.3**	**1.3**
Shinnecock Bay				
Total Annual Cost	$1,213,068	$2,344,561	$4,267,127	$5,035,052
Total Benefits	$5,079,472	$6,128,315	$7,724,677	$8,651,157
Net Benefits	$3,866,405	$3,783,754	$3,457,549	$3,616,105
Benefit-Cost Ratio	**4.2**	**2.6**	**1.8**	**1.7**

Discount Rate: 5.0125%, Sept 07 PL, 50 year study period.

D. Nonstructural/Raised Road Alternatives

Non-structural and Raised Road Alternatives

Road raising in selected mainland back bay residential areas was analyzed to explore whether it could achieve storm damage reduction for a greater number of buildings at a reduced cost compared to individual-building nonstructural protection plans for a given area. In addition to reducing damage to structures, 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 protected area, and providing safer evacuation routes out of the area. Road rising may also be more acceptable to residents in some communities since it reduces the need for structural alterations to individual buildings that may disrupt the owners' lives and affect perceptions of property value.

Based on a review of topography, the density of vulnerable structures, the layout of residential streets, and environmental considerations such as the need to avoid wetland impacts, 24 potential road raising locations were identified. This list of locations was further refined based on minimizing the average length of road rising required for structure protected. Five areas were consequently selected for detailed analysis: Areas 4a, 8c, 8d/8e, 9b, and 52a. An earlier stage of this study demonstrated that road raising in these areas would result in substantial cost savings compared to retrofit treatments. A more detailed process to optimize the crest elevations in these areas has since been completed, incorporating revised back bay stage-frequency relationships.

The optimization process examined crest elevations ranging from +5.25' to +7.5' (NGVD 29) for the various areas, and determined that road-raising is not cost effective for area 9b. The process identified +7' as the optimum road crest elevation for four remaining areas. This elevation would provide greater than a 100-year level of protection against still water flooding in the future condition. In each of the four areas, crest elevations lower than +7' would also result in positive net benefits and could be implemented as components of a federal project. Theoretically, there are additional benefits to be gained from a slightly higher crest elevation in some areas; however, +7' has been judged to be the highest acceptable elevation for all four sites, since higher elevations would cause problems with the roadway side slopes encroaching further onto adjacent properties, and would necessitate excessive gradients on many adjoining residential driveways.

The four areas feasible for road-raising are shown in Table 4.20, which summarizes the road raising alternatives and compares the number of buildings protected by each alternative to the number of buildings protected by the nonstructural alternatives for the same area.

Table 4.20 Road Raising Areas

Area #	Town	Community	Approx. Length of Raised Road (Ft.)	Structures Protected[1]	Nonstructural Treatments In Same Area[2]	Total First Cost[3]
4a	Babylon	Amityville	6,600	97	24	$2,541,000
8c	Babylon	Lindenhurst	5,300	240	42	$3,038,000
8d8e	Babylon	Lindenhurst	9,000	362	16	$4,829,000
52a	Brookhaven	Mastic Beach	10,500	355	234	$3,950,000

Discount Rate: 5.0125%, Sept 07 PL, 50 year study period.

1. Structures enclosed by raised road and high ground with ground elevations below the raised road crest.
2. Nonstructural Plan 3.
3. Includes contingency, Engineering & Design, Supervision & Administration

<u>Evaluation of CSRM Effectiveness</u>

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. Two combined nonstructural/road raising alternatives were analyzed, which represent the optimized raised road elevation nonstructural plans 2 and 3.

Analysis of the two nonstructural/raised road alternatives shows that both the alternatives analyzed are cost-effective in reducing storm damage. Similar to the nonstructural evaluation, Nonstructural Alternatives 2R and 3R provide benefits in excess of cost. Although these plans did not consider road raising in combination with NS-1 and NS-4, it would be expected that road raising would be viable in combination with those measures.

Table 4.21, which presents the net benefits and benefit-cost ratios of the two nonstructural/raised road alternatives shows that both the alternatives analyzed are cost-effective in reducing storm damage. Similar to the nonstructural evaluation, Nonstructural Alternative 2R provides the greatest storm damage reduction benefits in excess of cost, but Nonstructural Alternative 3R is so close in design criteria and net benefits to be effectively equal to Nonstructural Alternative 3R.

Table 4.21 Net Benefits and BCRs: Nonstructural/Road Raising Alternatives

	Nonstructural 2R	Nonstructural 3R
Total Project		
Total Annual Cost	$25,680, 000	$34,257, 000
Total Benefits	$39,743, 000	$46,237, 000
Net Benefits	$14,062, 000	$11,980, 000
Benefit-Cost Ratio	**1.7**	**1.3**
Great South Bay		
Total Annual Cost	$16,773, 000	$21,785, 000
Total Benefits	$22,099, 000	$25,941, 000
Net Benefits	$5,326, 000	$4,156, 000
Benefit-Cost Ratio	**1.3**	**1.2**
Moriches Bay		
Total Annual Cost	$6,439, 000	$8,027, 000
Total Benefits	$11,515, 000	$12,572, 000
Net Benefits	$5,076, 000	$4,544, 000
Benefit-Cost Ratio	**1.8**	**1.6**
Shinnecock Bay		
Total Annual Cost	$2,345, 000	$4,267, 000
Total Benefits	$6,128, 000	$7,725, 000
Net Benefits	$3,784, 000	$3,458, 000
Benefit-Cost Ratio	**2.6**	**1.8**

Discount Rate: 5.0125%, Sept 07 PL, 50 year study period.

Opportunities to Incorporate Coastal Process Features

There are several types of coastal process features that are compatible with the non-structural, retrofit alternatives. Given that these alternatives have been developed for the mainland floodplain area, there is limited geographic overlap with the coastal process features that focus on barrier island habitats. Non-structural measures, however, offer the opportunity for coastal process features in instances where there are opportunities to restore the land in conjunction with an acquisition or relocation plan. As discussed above, the cost of acquisition is significantly higher than the cost of retrofit. These additional costs would have to be borne by the coastal process features.

Land and Development Management Challenges and Opportunities.
The non-structural plans do not introduce land use and development management challenges, but instead introduce additional land use and development management opportunities that could be considered in conjunction with these alternatives. If there is a local desire for land acquisition rather than retrofit alternatives, these alternatives could consider if the additional costs for acquisition would be warranted to provide coastal process features.

Evaluation of Non-Structural Measures

Cost Effectiveness Criteria. The analyses above shows that non-structural alternatives, and non-structural in combination with road raising are cost-effective storm damage reduction alternatives that contribute to reducing the damages primarily associated with flooding along the mainland back bay areas, independent of a barrier island breaching.

P&G Criteria. Mainland retrofit plans alone do not represent a complete solution, as they only address the damages that arise due to the relatively frequent flooding of the mainland. Relative to the purpose they are accomplishing, these alternatives are effective and efficient. These alternatives are also implementable, and generally supported by all parties.

Vision Criteria. Table 4.22 provides an assessment of the extent to which the Inlet Sediment Management Measures satisfy each of the 12 Vision criteria. The assessment indicates that while the Inlet Sediment Management Measures alone does not achieve all the Vision objectives, it is not inconsistent with any of the objectives.

Table 4.22 Assessment of Achieving Vision Criteria for Nonstructural/Road Raising Alternatives

Evaluation Criteria	Assessment	Rating
The plan or measure provides identifiable reductions in risk from future storm damage.	Reductions in storm damage to the specific structures and contents are quantifiable.	Full
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 considered a lower priority.	Retrofits are a standard method for flood mitigation. Some individual structures may present design challenges, requiring a comparatively large cost contingency.	Full
The plan or measure addresses the various causes of flooding, including open coast storm surge, storm surge 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 measures reduce physical impacts of flooding from the various sources for a limited number of structures. They do not address general floodplain impacts such as traffic delays, damage to cars and other physical property outside of the living areas, or non-physical costs such as flood evacuation or cleanup.	Full
The plan or measures incorporate appropriate non-structural features provide both storm damage protection and to restore coastal processes and ecosystem integrity	The non-structural features are specific to storm damage reduction.	Partial
The plan or measure help protect and restore coastal landforms and natural habitat.	The measures have no direct impact. Indirectly they may reduce the need for structural features.	No
The plan avoids or minimizes adverse environmental impacts	The plan minimizes environmental impacts.	Full
The plan addresses long-term demands for public resources.	There is no long term public involvement beyond monitoring to ensure that the use of the structure is consistent with any restrictions.	Full
Dune and beach nourishment measures consider both storm damage reduction, restoration of natural processes, and environmental effects.	NA	No
The plan or measure incorporates appropriate alterations of existing shoreline stabilization structures	NA	No
The plan or measure incorporates appropriate alterations of inlet stabilization measures and dredging practices	NA	No
The plan or measure is efficient and represents a cost effective use of resources	Measures are cost efficient when targeted to frequently flooded structures.	Full
The plan or measure reduces risks to public safety.	Measures reduce damage only. It is important to maintain evacuation plans so that residents do not remain in homes that are inaccessible during a flood event.	No

Summary of Non-Structural Alternatives.

The analysis above shows that non-structural alternatives are cost-effective storm damage reduction alternatives that contribute to reducing the damages primarily associated with flooding along the mainland Back Bay areas, independent of a barrier island breach.

Non-Structural alternatives are recommended for further evaluation with alternatives NS-2, and NS-3, in conjunction with the road raising alternatives, which maximize net benefits.

The mainland non-structural alternatives partially fulfill the vision objectives.

E. Beachfill Alternatives

Beachfill (berm only) and beachfill with dunes have been designed for the Atlantic Ocean shorefront as storm damage reduction features. Varying scales of protection have been developed suitable for locations across the study area. The alternative design sections are summarized as follows:

- "Small" fill template or Lower Level of Risk Reduction (LLR): 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 Reduction template (MLR): 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 reduction template (LLR): design section 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.

The location of the proposed dune and berm was also evaluated based on three fill alignment plans. 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. There is a difference in alignment in most of the developed communities on Fire Island with the exception of Cherry Grove and Water Island, where no Real Estate would be impacted by the unconstrained baseline alignment. A third baseline, the Middle (MID) Baseline, 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.

The consideration of scale and alignment allows for optimization relative to the protection afforded, and optimization of the location of the protective feature. In order to conduct the optimization to determine the appropriate scale of protection, it was necessary to consider the three scales of alternative at the same alignment. This first analysis utilized the most seaward alignment for comparison of plan alternatives. Upon identification of a preferred scale, consideration was given for variations in alignment.

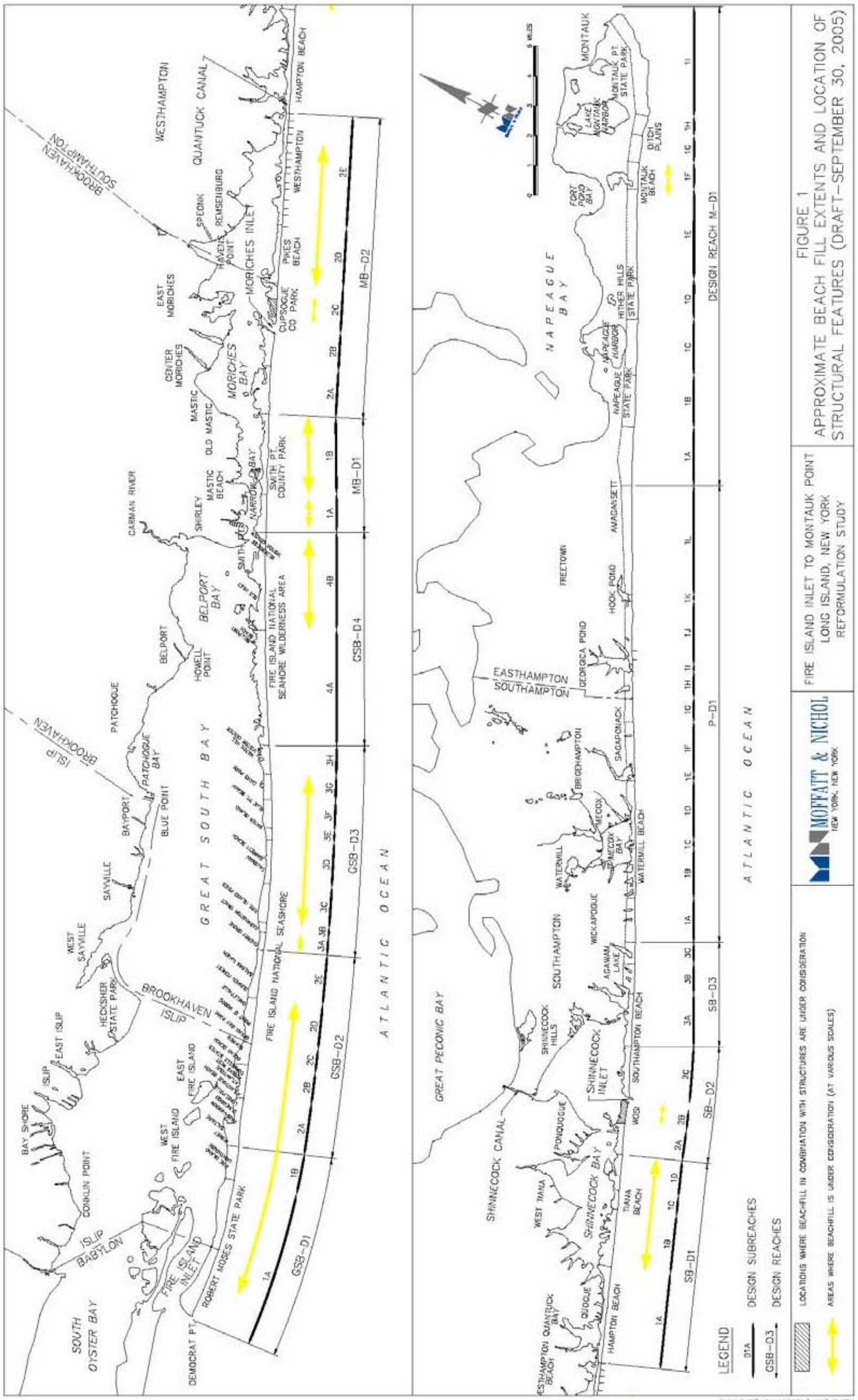
Design.

In areas where there is either an insignificant risk of breaching, no oceanfront structures, or relatively few structures (areas of low damages), beachfill was not considered (e.g., Sunken Forest, Wilderness Area – West, Great Gun, Hampton Beach, and most of the shoreline between Shinnecock Inlet and Montauk with the exception of the Potato Rd. Reach and Montauk Beach). Within the Pikes and Westhampton Reaches, which cover the extent of the Westhampton Interim Storm Damage Protection Project, two plans were considered, one with dimensions equal to the Interim project (i.e., dune at +15ft. and a 90 ft. berm) and a *Large* template with a dune at +17 ft. and a 120 ft. berm. A *Small* plan was not considered within these two reaches. Figure 4.9 shows the approximate extents of proposed fill placement within the FIMP area. Table 4.23 lists the reaches where beachfill was considered as an alternative as well as the range of template dimensions under consideration. Note that this table also indicates the number of fill alignments being considered in a particular reach as well as the length of dune and/or berm fill required under baseline conditions.

Table 4.23 Reaches where Beachfill is Being Considered

Design SubReach	Name	Subreach Length [ft.]	Max. Fill Length [ft.]	No. of Alignments	Design Sections (Dune height/Berm width)
GSB-1A	RMSP	25,700	16,458	1	-/90
GSB-1B	FILT	6,700	5,468	1	13/90
GSB-2A	Kismet to Lonelyville	8,900	8,880	3	13/90, 15/90, 17/90
GSB-2B	Town Beach to Corneille	5,100	4,557	3	13/90, 15/90, 17/90
GSB-2C	Ocean Beach to Seaview	3,800	3,696	3	13/90, 15/90, 17/90
GSB-2D	OBP to POW	7,400	7,267	3	13/90, 15/90, 17/90
GSB-3A	Cherry Grove	3,000	2,929	1	13/90, 15/90, 17/90
GSB-3C	Fire Island Pines	6,600	6,424	3	13/90, 15/90, 17/90
GSB-3D	Talisman to Water Island	7,300	7,076	1	13/90
GSB-3E	Water Island	2,000	1,202	1	13/90, 15/90, 17/90
GSB-3F	Water Island to Davis Park	5,500	5,445	1	13/90
GSB-3G	Davis Park	4,100	4,042	3	13/90, 15/90, 17/90
GSB-4B	Old Inlet	16,000	15,023	1	13/90
MB-1A	SPCP-TWA	6,300	1,889	1	-/90
MB-1B	SPCP	13,500	13,174	1	13/90
MB-2C	Cupsogue	7,500	2,000	1	13/90
MB-2D	WHPTIN Pikes	9,700	9,630	1	15/90, 17/120
MB-2E	WHPTIN East	18,300	10,908	1	15/90, 17/120
SB-1B	Sedge Island	10,200	4,967	1	13/90
SB-1C	Tiana	3,400	3,361	1	13/90
SB-1D	Shinnecock Inlet Park-West	6,300	6,288	1	13/90
SB-2B	WOSI	3,900	3,875	1	13/90/,15/90, 17/120
P-1G	Potato Road	4,300	3,500	1	13/90/,15/90, 17/120
M-1F	Montauk Beach	4,700	4,636	1	13/90/,15/90, 17/120

Figure 4.9 Reach Designation and Beach Restoration Locations



Figures 4.10, 4.11 and 4.12 show typical design sections for a few reaches considered representative of the complete set of reaches where fill placement is being considered. Specifically, Figure 4.10 shows typical profiles and design templates at Robert Moses State Park (GSB-1A) and Old Inlet (GSB-4B). RMSP is a unique design in that there is no dune required or proposed, only a 90 ft. berm. A similar template is proposed at Smith County Park in the area fronting the seawall that provides protection to the existing park facilities as well as the beach fronting the TWA memorial. Old Inlet is representative of the proposed beachfill plan in non-developed areas (including FINS tracts) subject to breaching risk.

Note that in some cases, the existing (i.e., Sept. 2000) berm and/or dune already provide the required level of protection along part or all of a specific reach. Nonetheless, it is necessary to have a plan in place that allows for rebuilding this minimum section in case of erosion or significant storm damage. Also, note that the figures focus on the sub-aerial and foreshore part of the profile to clearly depict the various templates and alignments being proposed. The proposed design (not construction) foreshore slope (from +9.5 to +2 ft. NGVD) for the design profile is roughly 12.1 on 1. This number is based on a recent analysis of existing profiles in the FIMP area (based on LIDAR Sept. 2000 data) completed by M&N and CHL. Below MHW (roughly +2 ft. NGVD) the submerged morphological profile representative of each specific reach is translated and used as the design profile. In other words, it is assumed that over a short period of time the fill will reach an equilibrium profile (from the edge of the berm to the depth of closure) similar to the "existing" profile.

Figure 4.11 shows a typical section and range of plans for a FI community (in this case the Kismet to Lonelyville reach, GSB-2A). The figure shows design sections for two possible alignments, which are explained in detail in the next section.

Figure 8.12 shows typical profiles and the proposed range of plans for the West of Shinnecock and Montauk Beach reaches, while Figure 4.13 shows a typical beachfill layout at WOSI. Note that as of Sept. 2000, the berm at WOSI was relatively wide as a result of fill placement in 1998 and relatively mild weather between those two dates. Finally, note that at Montauk Beach, protection of the existing structures would require a significant amount of fill, even if a higher and narrower section was considered (i.e., 19/90). This is because the structures are very close to the seaward edge of the existing dunes and the beaches within the Ponds and Montauk reaches are relatively narrow and steep. A similar condition is observed at Potato Road.

Figure 4.10 Typical Beachfill Section at GSB-1A, GSB-4B

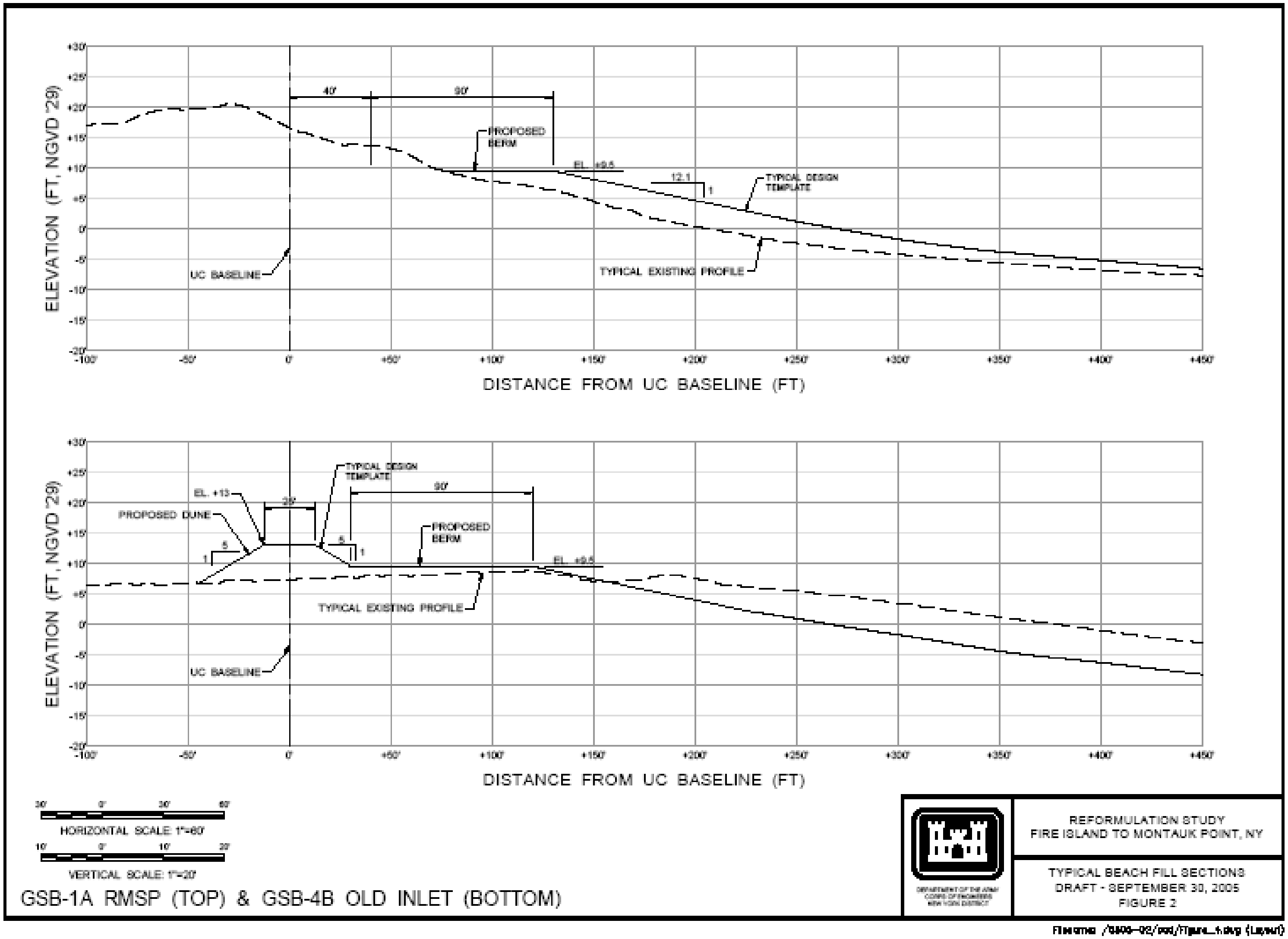


Figure 4.11 Typical Beachfill Section at GSB-2A

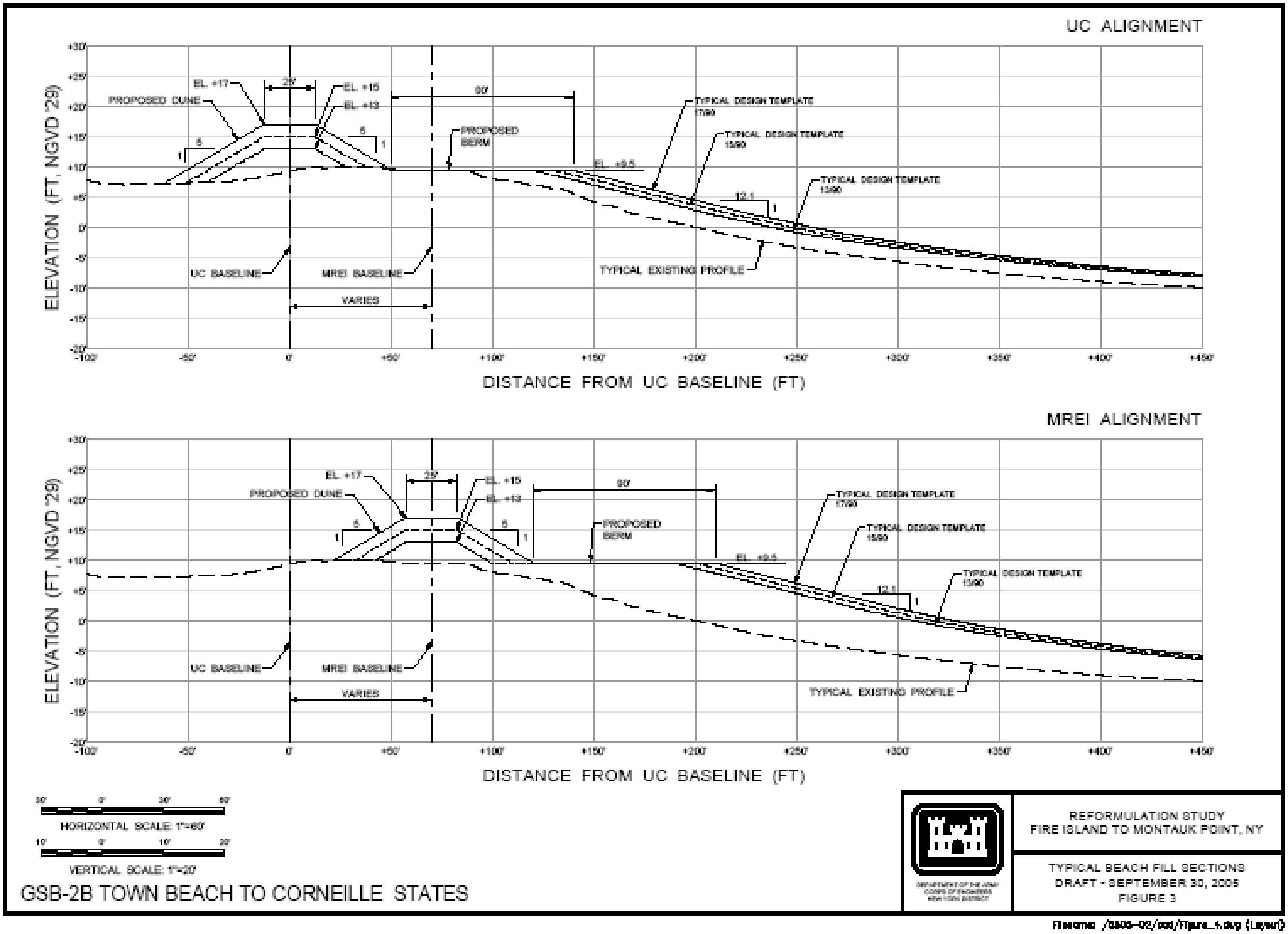


Figure 4.12 Typical Beachfill Section at WOSI

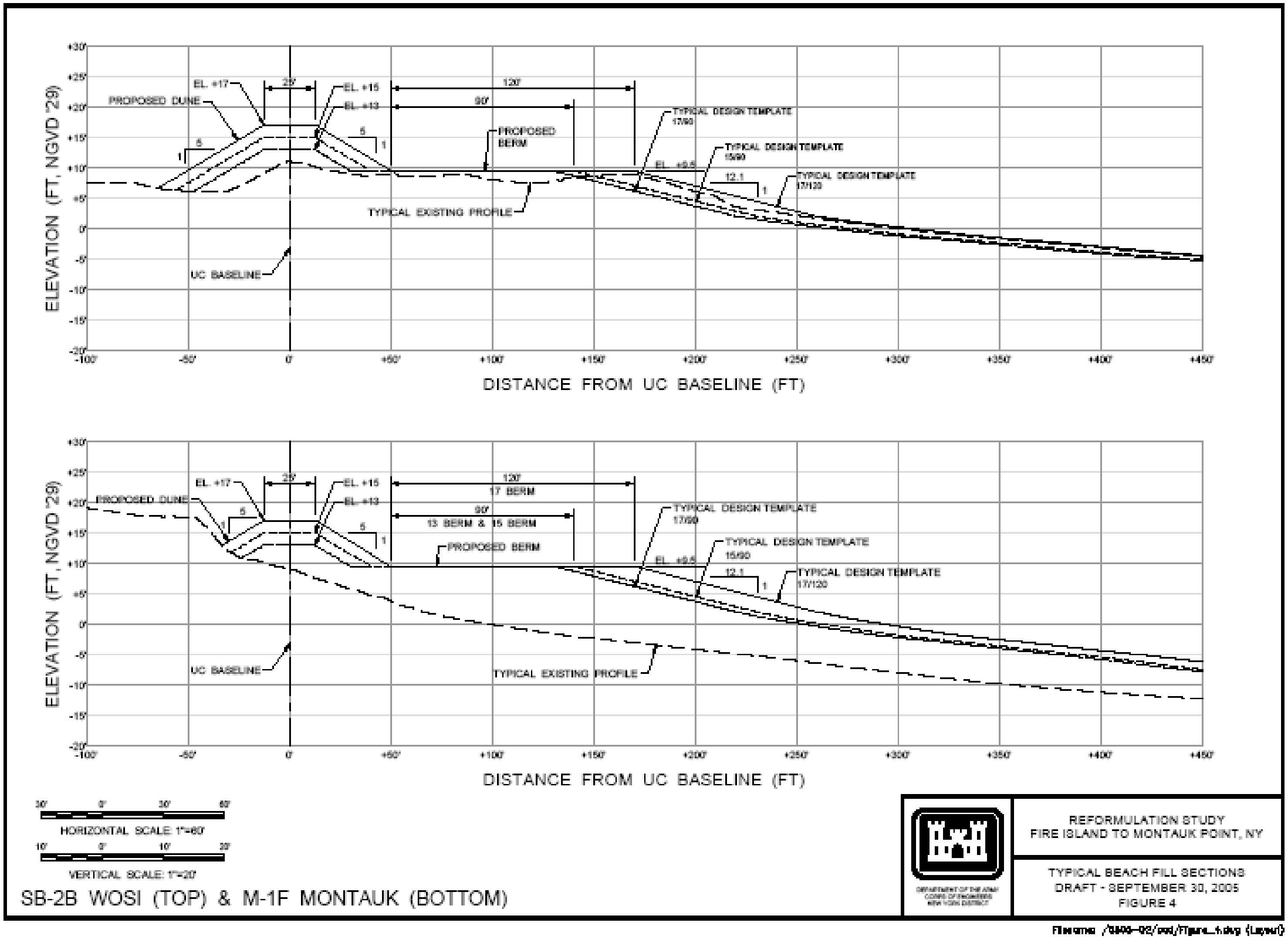
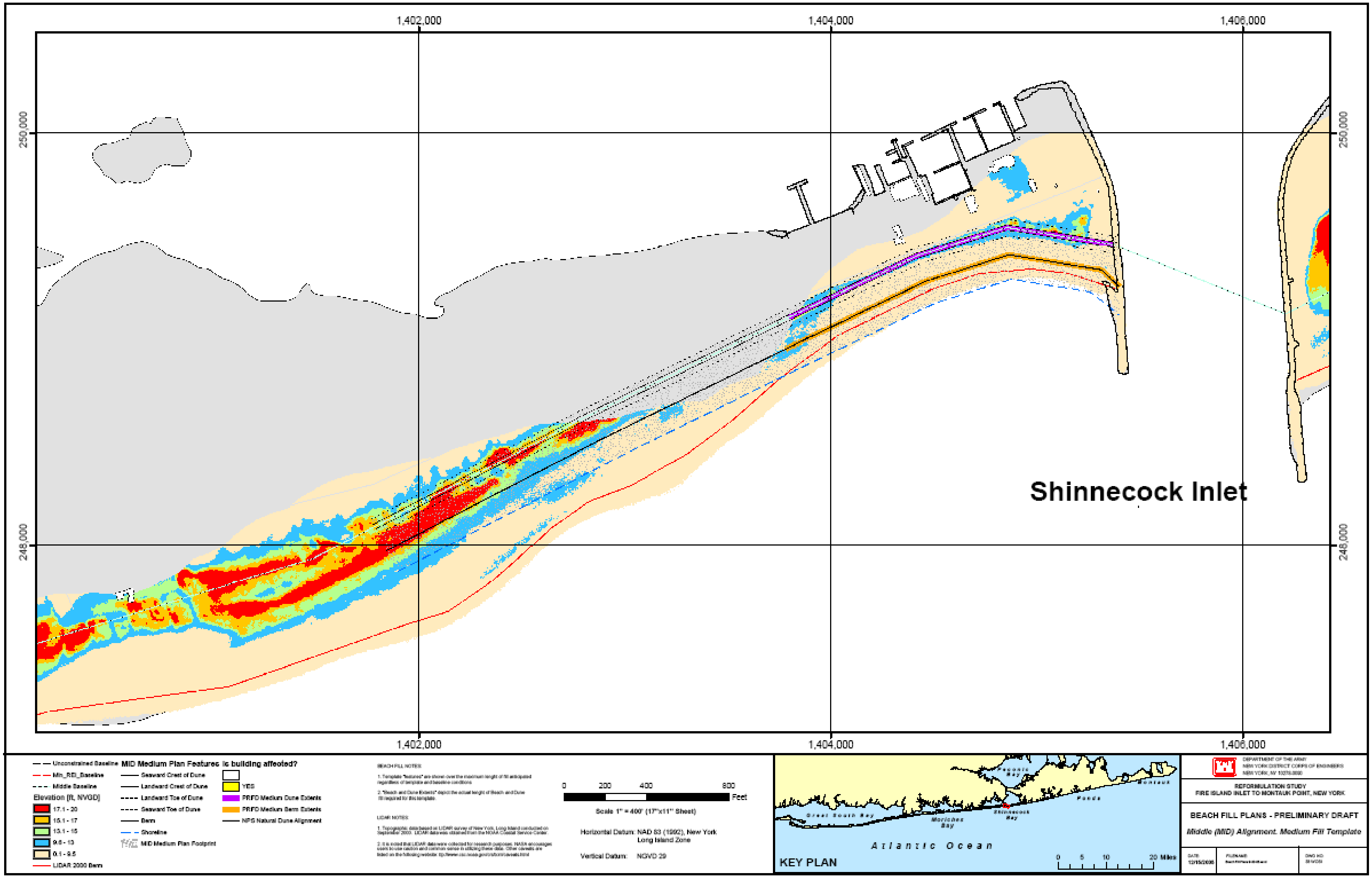


Figure 4.13 Typical Beachfill Layout at WOSI: Medium Template, MID Dune Alignment



Fill

Tables 4.24, 4.25, and 4.26 summarize the length of berm and dune that would need to be placed for the three scales of alternatives at the MREI Alignment. These lengths were determined by comparing the proposed layout (including an estimate of advance fill) with the existing topography and location of the berm. For example, if the design template includes a dune at 17 ft. with a 25 ft. crest, only areas with lower or narrower dunes were considered. Out of a total 153,000 ft. (29 miles) of shoreline where it is anticipated that beachfill may be required at some point during the project life, 43,000 ft. of dune and 65,000 of berm is required for the *MREI-Large* plan and 21,000 ft. of dune and 44,000 of berm for the UC-Small plan, and 31,568 ft. of dune and 57,909 ft. of berm is required for the *MID-Medium* plan.

Table 4.24 Required Berm and Dune Fill Lengths (MREI-Small Plan)

Design SubReach	Name	Max. Fill Length [ft.]	Required Dune Length [ft.]	Required Berm Length [ft.]
GSB-1A	RMSP	16,458		5,795
GSB-1B	FILT	5,468	2,614	5,468
GSB-2A	Kismet to Lonelyville	8,880		8,880
GSB-2B	Town Beach to Corneille	4,557	2,100	4,555
GSB-2C	Ocean Beach to Seaview	3,696		3,151
GSB-2D	OBP to POW	7,267		7,305
GSB-3A	Cherry Grove Fire Island Pines	2,929		0
GSB-3C	Talisman to Water Island	6,424	1,492	6,424
GSB-3D	Water Island	7,076	262	0
GSB-3E	Water Island to Davis Park	1,202		0
GSB-3F	Davis Park	5,445		0
GSB-3G	Old Inlet	4,042	3,932	3,881
GSB-4B	SPCP-TWA	15,023		8,161
MB-1A	SPCP	1,889	5,280	2,366
MB-1B	Cupsogue	13,174		4,054
MB-2C	WHPTIN Pikes	2,000		1,845
MB-2D	WHPTIN East	9,630		3,651
MB-2E	Sedge Island	10,908	801	0
SB-1B	Tiana	4,967	998	1,057
SB-1C	Shinnecock Inlet Park-West	3,361		1,527
SB-1D	WOSI	6,288	852	1,312
SB-2B	Potato Road	3,875	1261	1,806
P-1G	Montauk Beach	3,500	1,878	3,500
M-1F		4,636		4,287
Total		**152,696**	**21,470**	**79,026**

Table 4.25 Required Berm and Dune Fill Lengths (MREI-Medium Plan)

Design SubReach	Name	Max. Fill Length [ft.]	Required Dune Length [ft.]	Required Berm Length [ft.]
GSB-1A	RMSP	16,458	0	5,795
GSB-1B	FILT	5,468	2,614	5,468
GSB-2A	Kismet to Lonelyville	8,880	2,167	8,880
GSB-2B	Town Beach to Corneille	4,557	3,700	4,555
GSB-2C	Ocean Beach to Seaview	3,696	0	3,151
GSB-2D	OBP to POW	7,267	2,397	7,305
GSB-3A	Cherry Grove	2,929	0	0
GSB-3C	Fire Island Pines	6,424	424	6,424
GSB-3D	Talisman to Water Island	7,076	1,679	0
GSB-3E	Water Island	1,202	1,097	0
GSB-3F	Water Island to Davis Park	5,445	0	0
GSB-3G	Davis Park	4,042	2,918	3,881
GSB-4B	Old Inlet	15,023	3,932	8,161
MB-1A	SPCP-TWA	1,889	0	2,366
MB-1B	SPCP	13,174	5,280	4,054
MB-2C	Cupsogue	2,000	0	1,845
MB-2D	WHPTIN Pikes	9,630	0	3,651
MB-2E	WHPTIN East	10,908	0	0
SB-1B	Sedge Island	4,967	801	1,057
SB-1C	Tiana	3,361	998	1,527
SB-1D	Shinnecock Inlet Park-West	6,288	1,034	1,312
SB-2B	WOSI	3,875	1,671	1,806
P-1G	Potato Road	3,500	1,261	3,500
M-1F	Montauk Beach	4,636	1,878	4,287
Total		**152,696**	**33,853**	**79,026**

Table 4.26 Required Berm and Dune Fill Lengths (MREI-Large Plan)

Design SubReach	Name	Max. Fill Length [ft.]	Required Dune Length [ft.]	Required Berm Length [ft.]
GSB-1A	RMSP	16,458		5,795
GSB-1B	FILT	5,468	2614	5,468
GSB-2A	Kismet to Lonelyville	8,880	4926	8,880
GSB-2B	Town Beach to Corneille	4,557	3882	4,555
GSB-2C	Ocean Beach to Seaview	3,696	850	3,151
GSB-2D	OBP to POW	7,267	3423	7,305
GSB-3A	Cherry Grove	2,929		0
GSB-3C	Fire Island Pines	6,424	2143	6,424
GSB-3D	Talisman to Water Island	7,076	1679	0
GSB-3E	Water Island	1,202	1265	0
GSB-3F	Water Island to Davis Park	5,445		0
GSB-3G	Davis Park	4,042	3720	3,881
GSB-4B	Old Inlet	15,023	3932	8,161
MB-1A	SPCP-TWA	1,889		2,366
MB-1B	SPCP	13,174	5280	4,054
MB-2C	Cupsogue	2,000		1,845
MB-2D	WHPTIN Pikes	9,630	799	3,685
MB-2E	WHPTIN East	10,908		0
SB-1B	Sedge Island	4,967	801	1,057
SB-1C	Tiana	3,361	998	1,527
SB-1D	Shinnecock Inlet Park-West	6,288		1,312
SB-2B	WOSI	3,875	2852	1,806
	Potato Road	3,500	1950	3,500
	Montauk Beach			
Total		**152,696**	**42,992**	**79,060**

Beachfill Volumes

Fill volumes were computed for each design reach for all three beachfill plans described above. Baseline Conditions were based on the September 2000 LIDAR survey for the sub aerial part of the profile and the CHL representative morphological profile for the submerged portion. LIDAR survey profiles were extracted every 200 feet over the length of the project area (between 279 and 392 profiles were utilized depending on the beachfill plan). Fill was assumed only in areas where the berm and/or dune were found to be narrower and/or lower than the design template. The *Design Fill* volume per design reach was computed as the average dune or berm fill area required in each reach based on the values competed for each individual profile, multiplied by the length of berm or dune fill required in that reach. In addition to the base amount of *Design Fill* needed, *Advance Fill* volume was computed based on representative erosion rates and expected renourishment interval. The length of berm required by reach was multiplied by the active profile depth (36.5 ft.) and the advance fill width (computed as the erosion rate times the renourishment interval) to come up with advance fill volume. A 15% tolerance was included based on the subtotal (design and advanced fill) as well as an overfill allowance of 1.10 to account for differences between the borrow area materials and the natural beach sand.

Initial fill volumes (i.e., design fill plus advance fill), future renourishment volumes over the project life, and total volumes for all three plans are presented in Tables 4.27 through 4.29. Note that the future renourishment volumes are only a rough estimate based on erosion rates, renourishment interval, and, more importantly, the initial berm length. In other words, in reaches where no initial berm is required under a certain plan (e.g., SPCP or WHPTIN East), no future renourishment volume was assumed. Obviously this may result in underestimation of the total renourishment volume required over the life of the project. An alternative approach would be to assume that future renourishment will be required over the maximum length of each design sub reach. This assumption, which is perhaps too conservative, would almost triple the amount of renourishment volume shown in the tables below.

Table 4.27 Required Fill Volume (MREI-Small Plan)

Design SubReach	Name	Renourish. Interval [years]	Initial Fill Volume [cy]	Renourish. Volume [cy]	TOTAL [cy]
GSB-1A	RMSP	4	546,677	4,866,667	5,413,344
GSB-1B	FILT	4	164,051	2,439,336	2,603,386
GSB-2A	Kismet to Lonelyville	4	1,953,328	3,961,467	5,914,795
GSB-2B	Town Beach to Corneille	4	1,206,756	2,032,036	3,238,792
GSB-2C	Ocean Beach to Seaview	4	426,637	1,405,696	1,832,333
GSB-2D	OBP to POW	4	1,463,368	3,258,842	4,722,209
GSB-3A	Cherry Grove	0	0	0	0
GSB-3C	Fire Island Pines	4	1,517,357	5,731,636	7,248,993
GSB-3D	Talisman to Water Island	4	3,126	312,278	315,404
GSB-3E	Water Island	4	603	107,245	107,848
GSB-3F	Water Island to Davis Park	4	0	0	0
GSB-3G	Davis Park	4	527,200	346,271	873,471
GSB-4B	Old Inlet	4	982,602	1,487,895	2,470,498
MB-1A	SPCP-TWA	4	231,138	422,218	653,356
MB-1B	SPCP	4	429,835	2,350,827	2,780,662
MB-2C	Cupsogue	4	168,112	861,866	1,029,978
MB-2D	WHPTIN Pikes	4	305,654	7,732,890	8,400,854
MB-2E	WHPTIN East	4	0	5,839,416	5,839,416
SB-1B	Sedge Island	4	101,790	471,539	573,329
SB-1C	Tiana	4	255,812	1,499,379	1,755,191
SB-1D	Shinnecock Inlet Park-West	4	192,522	585,298	777,820
SB-2B	WOSI	2	190,298	8,643,403	8,833,700
P-1G	Potato Road	4	881,839	4,684,167	5,566,005
M-1F	Montauk Beach	4	1,083,162	3,824,957	4,908,119
TOTAL		4	**12,631,865**	**62,865,328**	**75,859,503**

Table 4.28 Required Fill Volume (MREI-Medium Plan)

Design SubReach	Name	Renourish. Interval [years]	Initial Fill Volume [cy]	Renourish. Volume [cy]	TOTAL [cy]
GSB-1A	RMSP	4	546,677	4,866,667	5,413,344
GSB-1B	FILT	4	164,051	2,439,336	2,603,386
GSB-2A	Kismet to Lonelyville Town	4	2,138,765	3,961,467	6,100,231
GSB-2B	Beach to Corneille Ocean	4	1,337,322	2,032,036	3,369,358
GSB-2C	Beach to Seaview OBP to	4	485,444	1,405,696	1,891,140
GSB-2D	POW	4	1,529,389	3,258,842	4,788,231
GSB-3A	Cherry Grove	0	0	0	0
GSB-3C	Fire Island Pines Talisman	4	1,508,445	5,731,636	7,240,080
GSB-3D	to Water Island Water Island	4	3,519	312,278	315,797
GSB-3E	Water Island to Davis Park	4	2,849	107,245	110,094
GSB-3F	Davis Park	4	0	0	0
GSB-3G	Old Inlet	4	597,144	346,271	943,416
GSB-4B	SPCP-TWA	4	982,602	1,487,895	2,470,498
MB-1A	SPCP	4	231,138	422,218	653,356
MB-1B	Cupsogue	4	429,835	2,350,827	2,780,662
MB-2C	WHPTIN Pikes	4	168,112	861,866	1,029,978
MB-2D	WHPTIN East	4	305,654	7,732,890	8,038,544
MB-2E	Sedge Island	4	0	5,839,416	5,839,416
SB-1B	Tiana	4	101,790	471,539	573,329
SB-1C	Shinnecock Inlet Park-West	4	255,812	1,499,379	1,755,191
SB-1D	WOSI	4	192,522	585,298	777,820
	Potato Road	2	219,700	8,643,403	8,863,102
	[illegible]	4	[illegible]	[illegible]	[illegible]
TOTAL		**n/a**	**13,261,765**	**62,865,328**	**76,127,093**

Table 4.29 Required Fill Volume (MREI-Large Plan)

Design SubReach	Name	Renourish. Interval [yrs]	Initial Fill Volume [cy]	Renourish. Volume [cy]	TOTAL [cy]
GSB-1A	RMSP	4	546,677	4,866,667	5,413,344
GSB-1B	FILT	4	164,051	2,439,336	2,603,386
GSB-2A	Kismet to Lonelyville	4	2,354,098	3,961,467	6,315,565
GSB-2B	Town Beach to Corneille	4	1,452,989	2,032,036	3,485,025
GSB-2C	Ocean Beach to Seaview	4	560,674	1,405,696	1,966,370
GSB-2D	OBP to POW	4	1,783,203	3,258,842	5,042,045
GSB-3A	Cherry Grove	0	0	0	0
GSB-3C	Fire Island Pines	4	1,773,462	5,731,636	7,505,098
GSB-3D	Talisman to Water Island	4	3,519	312,278	315,797
GSB-3E	Water Island	4	10,082	107,245	117,327
GSB-3F	Water Island to Davis Park	4	0	0	0
GSB-3G	Davis Park	4	756,931	346,271	1,103,202
GSB-4B	Old Inlet	4	982,602	1,487,895	2,470,498
MB-1A	SPCP-TWA	4	231,138	422,218	653,356
MB-1B	SPCP	4	429,835	2,350,827	2,780,662
MB-2C	Cupsogue	4	168,112	861,866	1,029,978
MB-2D	WHPTIN Pikes	4	623,489	7,732,890	8,356,379
MB-2E	WHPTIN East	4	0	5,839,416	5,839,416
SB-1B	Sedge Island	4	101,790	471,539	573,329
SB-1C	Tiana	4	255,812	1,499,379	1,755,191
SB-1D	Shinnecock Inlet Park-West	4	192,522	585,298	777,820
SB-2B	WOSI	2	363,007	8,643,403	9,006,410
P-1G	Potato Road	4	1,224,602	4,684,167	5,908,768
M-1F	Montauk Beach	4	1,400,604	3,824,957	5,225,560
TOTAL		**n/a**	**15,379,199**	**62,865,328**	**78,244,526**

As expected, the Small design template results in the least fill volume required; the Large design template combined with the MREI baseline results in the most. Also worth noting are the relatively large volumes required at Potato Road and Montauk Beach despite the fact that these are relatively small reaches. This result is directly related to the fact that significant erosion is expected within these two reaches over the project life. Other reaches requiring a significant amount of fill over the project life are western Fire Island Communities, Fire Island Pines, Pikes Beach, and WOSI.

All cost estimates are based on October 2007 price levels. A $2,000,000 mobilization/demobilization cost is assumed per dredging contract. This is larger than the $1,000,000 mobilization/demobilization cost assumed for the BCP because the beachfill contracts are larger and cover a much greater distance per contract.

The costs for the Total Project as well as per Project Reach were examined. The essential difference lies in the distribution of dredging contracts and thus, mobilization and demobilization costs. Under the Total Project plan, dredging contracts are assigned based on volumes and distances between project locations, regardless of project reach delineation. Each dredging contract required a volume of approximately 2 million cubic yards. Under the Project Reach plan, dredging contracts are assigned to individual project reaches. In this case, dredging contracts were assigned within project reaches based on a volume of approximately 2 million cubic yards. The following provides a summary of the key cost assumptions.

First costs include dredging, mobilization, and demobilization for the initial fill volumes estimated. First cost estimates also include a 15% contingency. Engineering and design costs are assumed to be 7% of the construction cost. Supervision and administration costs are also assumed to be a percentage of the construction cost, ranging from 6.47% to 7.09%. Dredging costs per cubic yard by reach/borrow area and mobilization costs per dredging contract were provided by CENAN, using CEDEP (Corps of Engineers Dredge Estimating Program). The program assumes the use of 2500 CY hopper dredges working 24 hours per day, 7 days per week with two daily 12-hours shifts. CEDEP incorporates influencing factors such as hopper capacity and safe load, area of borrow site, distance to borrow site, and current fuel, labor, and equipment costs, etc. Due to the larger number of contracts required, first costs are always greater when using the Project Reach plan as compared to the Total Project Plan.

Renourishment costs include dredging, mobilization, and demobilization; the same dredging unit costs are assumed for both initial fill and renourishment fill. Renourishment costs include a 15% contingency, 7% for E&D, and the S&A percentage computed as given above. Most reaches are renourished every four years; only WOSI is renourished every 2 years.

Berm and Fill Maintenance Costs

Berm maintenance cost is the cost of moving fill to address shoreline undulations and erosion hotspots. The cost is assumed to be $15 per linear foot of fill annually and is applicable to all reaches. Fill maintenance costs are the miscellaneous costs of maintaining the beach, such as tilling. Annual fill maintenance costs are assumed to be $2 per linear foot of fill for all reaches. The unit cost of berm and fill maintenance is based upon the analysis performed by CP&E in 2002.

Annual Costs

Annual costs incorporate the initial fill cost, renourishment costs, and berm and fill maintenance costs. Annual costs assume a project life of 50 years and an interest rate of 5.125%. Annual costs under the Total Project plan range from $17,500,000 per year for the UC-Small alternative to $22,600,000 for the MREI-Large alternative.

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’ 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. Table 4.30 presents the modeled annual damages resulting from the implementation of the three beachfill alternatives. In addition to storm damage reduction benefits the beachfill alternatives will eliminate the need for the numerous local renourishment projects. The sediment budget analysis has identified that these non-Federal projects have placed an average of 180,000 cubic meters per year (234,000 cubic yards per year) of beachfill in the Great South Bay Planning Unit, considered as a local beachfill cost-avoided benefit.

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’ 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. Table 4.30 presents the modeled annual damages resulting from the implementation of the three beachfill alternatives.

These damages have been compared with those associated with the without-project condition to generate the project benefits, which are presented in Table 4.31. In addition to storm damage reduction benefits the beachfill alternatives will eliminate the need for the numerous local renourishment projects. The sediment budget analysis has identified that these non-Federal projects have placed an average of 180,000 cubic meters per year (234,000 cubic yards per year) of beachfill in the Great South Bay Reach. Eliminating the need for these efforts will provide annual savings estimated at $2,400,000 (shown as a local beachfill cost-avoided benefit).

Table 4.30 Annual Damages: Beachfill Alternatives

Damage Category	Beachfill +13'	Beachfill +15'	Beachfill +17'
Total Project			
Tidal Inundation			
Mainland	$65,154,300	$62,179,600	$62,179,600
Barrier	$11,279,800	$10,497,600	$10,497,600
Total Inundation	*$76,434,000*	*$72,677,200*	*$72,677,200*
Breach			
Inundation	$59,000	$3,000	$0
Structure Failure	$37,500	1,600	$0
Total Breach	*$96,500*	*$4,600*	*$0*
Shorefront	$3,718,800	$3,204,000	$2,946,600
Public Emergency			
Other			
Total Storm Damage	***$80,249,300***	***$75,885,800***	***$75,623,800***

Discount Rate: 5.0125%, FY 08 PL, 50 year study period.

Table 4.31 Annual Benefits: Beachfill Alternatives

Benefit Category	Beachfill +13'	Beachfill +15'	Beachfill +17'
Total Project			
Tidal Inundation			
Mainland	$9,081,200	$12,055,900	$12,055,900
Barrier	$1,718,800	$2,501,100	$2,501,100
Total Inundation	*$9,628,000*	*$14,557,000*	*$14,557,000*
Breach			
Inundation	$9,183,500	$9,239,400	$9,242,500
Structure Failure	$358,200	$394,100	$395,700
Total Breach	*$9,541,700*	*$9,633,500*	*$9,638,200*
Shorefront Damage	$3,670,000	$4,184,800	$4,442,200
Public Emergency			
Other			
Total Storm Damage Reduction	*$22,839,700*	*$28,375,300*	*$28,637,400*
Costs Avoided			
Breach Closure	$2,159,900	$2,159,900	$2,159,900
Local Beachfill	$2,400,000	$2,400,000	$2,400,000
Other			
Recreation			
Land Loss			
Total Benefits	***$27,399,600***	***$32,935,200***	***$33,197,300***

Discount Rate: 5.0125%, FY 08 PL, 50 year study period.

The total annual costs associated with the beachfill alternatives are presented in Table 4.32. The total investment costs include real estate costs, contingencies, and allowances for Engineering and Design, Supervision and Administration. The total investment costs also reflect opportunity costs associated with interest during construction.

Table 4.32 Annual Costs: Beachfill Alternatives

Cost Category	Beachfill +13'	Beachfill +15'	Beachfill +17'
Total Project			
Total First Cost	$188,203,700	$197,689,400	$220,024,700
Total IDC	$15,675,100	$16,470,900	$18,347,900
Total Investment Cost	*$203,878,800*	*$214,160,300*	*$238,372,600*
Interest and Amortization	$11,384,200	$11,958,300	$13,310,265
Operation & Maintenance	$2,883,000	$2,883,000	$2,883,000
BCP Maintenance	0	0	0
Monitoring			
Renourishment	$18,535,300	$18,544,800	$18,512,360
Total Budgeted Cost	*$32,802,500*	*$33,386,000*	*$34,705,600*
Annual Breach Closure Cost	0	0	0
Major Rehabilitation	Pending	Pending	Pending
Total Additional Cost	*$0*	*$0*	*$0*
Total Annual Cost	***$32,802,500***	***$33,386,000***	***$34,705,60***

Discount Rate: 5.0125%, FY 08 PL, 50 year study period

Table 4.33 indicates that all three alternatives would be cost-effective in reducing storm damage with the +15 ft. Plan as the Alternative which maximizes net benefits. However, on closer inspection it is apparent that beachfill alternatives do not approach cost- effectiveness for some individual component areas of the project. 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. Therefore the most cost-effective beachfill alternatives would not include the placement of fill in the Shinnecock Bay, Ponds, or Montauk Project Reaches. Hence, the beachfill alternative to be carried forward for further consideration is that including fill to a +15' NGVD crest elevation in Great South Bay and Moriches Bay Project reaches.

Table 4.33 Net Benefits and BCRs: Beachfill Alternatives

	Beachfill +13'	Beachfill +15'	Beachfill +17'
Total Project			
Total Annual Cost	$32,802,494	$33,386,047	$34,705,592
Total Benefits	$28,990,046	$33,412,259	$33,703,635
Net Benefits	-$3,812,449	$26,212	-$1,001,958
Benefit-Cost Ratio	0.88	1.00	0.97
Great South Bay			
Total Annual Cost	$18,278,991	$18,768,383	$19,580,150
Total Benefits	$21,293,935	$24,292,757	$24,498,020
Net Benefits	$3,014,944	$5,524,374	$4,917,871
Benefit-Cost Ratio	1.16	1.3	1.3
Moriches Bay			
Total Annual Cost	$6,242,411	$6,242,104	$6,556,257
Total Benefits	$5,717,182	$6,551,623	$6,572,147
Net Benefits	-$525,229	$309,519	$15,890
Benefit-Cost Ratio	0.92	1.05	1.00
Shinnecock Bay			
Total Annual Cost	$5,035,565	$5,068,009	$5,126,690
Total Benefits	$1,443,115	$1,955,522	$1,982,837
Net Benefits	-$3,592,450	-$3,112,487	-$3,143,853
Benefit-Cost Ratio	0.29	0.39	0.39
Ponds			
Total Annual Cost	$2,327,357	$2,332,877	$2,505,470
Total Benefits	$268,523	$306,882	$326,063
Net Benefits	-$2,058,834	-$2,025,994	-$2,179,407
Benefit-Cost Ratio	0.12	0.13	0.13
Montauk			
Total Annual Cost	$2,191,690	$2,233,898	$2,344,466
Total Benefits	$267,291	$305,474	$324,567
Net Benefits	-$1,924,399	-$1,928,423	-$2,019,899
Benefit-Cost Ratio	0.12	0.14	0.14

Discount Rate: 5.0125%, FY 08 PL, 50 year study period.

Alignment

As mentioned above, this analysis was undertaken for alternative alignments located on the most-seaward alignment. In terms of economic analysis, the benefits provided from a similar scale project located further landward would be comparable. Therefore in evaluating the cost-effectiveness of various alignments it is possible to simply compare the annual costs of the alternate alignments with the alternative costs presented above.

In addition to developing alternatives along the MREI alignment, alternatives were also developed for the unconstrained and middle alignments. To do a comparison of costs for comparable protection (i.e. the medium-scale plan), the volumes and costs for this medium-scale plan were developed along the unconstrained alignment, and the middle alignment. The associated volume and material costs are provided in Table 4.34.

Table 4.34 Sand Volumes for Alternative Alignments

Design Reach	Reach Name	UC Small	Mid Medium	MREI Medium	MREI Large
GSB-1A	RMSP	502,580	502,581	502,580	502,580
GSB-1B	FILT	117,705	117,705	117,705	117,705
GSB-2A	Kismet to Lonelyville	657,997	1,239,987	1,932,004	2,137,202
GSB-2B	Town Beach to Corneille Estates	239,393	882,642	1,194,991	1,306,581
GSB-2C	Ocean Beach to Seaview	0	86,366	438,078	509,797
GSB-2D	OBP to POW	481,606	847,987	1,458,417	1,613,662
GSB-3A	Cherry Grove	0	0	0	0
GSB-3C	Fire Island Pines	840,961	1,114,379	1,504,322	1,631,764
GSB-3D	Talisman to Water Island	3,977	4,230	4,919	4,917
GSB-3E	Water Island	305	3,193	3,193	8,516
GSB-3F	Water Island to Davis Park	0	0	0	0
GSB-3G	Davis Park	74,720	262,029	609,481	714,220
GSB-4B	Old Inlet	693,505	693,507	693,507	693,505
MB-1A	SPCP-TWA	127,908	127,908	127,908	127,908
MB-1B	SPCP	24,881	24,881	24,881	24,881
MB-2C	Cupsogue	45,458	45,458	45,458	45,458
MB-2D	WHPTIN Pikes	152,144	152,144	242,969	345,400
MB-2E	WHPTIN East	0	0	0	0
SB-1B	Sedge Island	131,461	131,461	131,461	131,461
SB-1C	Tiana	260,987	260,987	260,987	260,987
SB-1D	Shinnecock Inlet Park- West	234,248	234,248	234,248	234,248
SB-2B	WOSI	4,529	189,440	191,710	288,155
P-1G	Potato Road	774,617	837,847	837,847	1,085,586
M-1F	Montauk Beach	1,016,285	1,106,488	1,142,115	1,339,345
Total		**6,385,268**	**8,865,469**	**11,698,780**	**13,123,879**

Real Estate Impacts of Alternative Beachfill Plans

Table 4.35 shows the number of structures under two acquisition scenarios – acquiring all structures on the dune, or not acquiring structures located on the landward slope of the dune. This estimate is based on a structures database based on the 1995 base maps, updated by visual inspection based upon 2004 aerials.

Typically, the entire dune footprint is identified as the needed real estate plus an additional buffer of 25 ft. landward of the landward toe of the dune to provide a buffer consistent with the State's CEHA definition of a dune.

Table 4.35 Real Estate Impacts

Structures on the Back Dune Slope?	**Number of Structures Impacted by Beachfill Plan**		
	UC-Small	**MID-Medium**	**MREI-Large**
NO	256	199	66
YES	262	62	22

Cost were developed for each of these plans using a gross method for mass valuation that took into consideration comparable sales in the area, adjusted to current price levels. This approach is a reasonable estimate of costs when differentiating between alternatives on this scale, but is not sufficient for providing the accuracy necessary for supporting a final, recommended plan. A gross appraisal will be conducted for the selected alternative.

A summary of the annual costs is shown in Table 4.36, which indicates that for the 15 ft. dune alternative, at a middle alignment, the annual costs are similar if structures are allowed to remain on the back slope of the dune, but not if all structures on the dune were acquired.

Table 4.36 **Comparison of Total Annual Costs for Different Alignments**

Cost Category	Beachfill +15' MREI'	Beachfill +15' MID seaward	Beachfill +15' Mid - All
Total Annual Cost	***$33,386,000***	***$30,556,600***	***$31,400,000***

Discount Rate: 5.0125%, FY 08 PL, 50 year study period.

Compatibility with Coastal Process Features

In general, the majority of the proposed coastal process features are compatible with the beach renourishment alternatives. In many instances the proposed coastal process features would help contribute to the CSRM effectiveness, take advantage of reduced costs associated with the construction of the two measures together, and ensure that a desirable mosaic of habitats exists. Coastal process features that could be implemented in conjunction with beachfill include:

1) Reestablishment of bayside habitats (bay beach, wetland, SAV) to strenghten the integrity of the island as stand-alone measures, or in conjunction with the addition or removal of shoreline stabilization structures.
2) Reestablish ocean-front beach and dune and removal of coastal structures, or through the removal of buildings and infrastructure to restore dune habitat, and allow for more natural dune functioning.

Evaluation of Beachfill Alternatives.

Beachfill Alternatives were evaluated in relationship to the planning criteria developed to reflect the Project objectives and the project approach delineated in the "Vision Statement for the Reformulation Study". This systematic assessment ensures that the Vision Statement approach is fully integrated into the development and selection of the FIMP Plan. Table 4.37 provides a summary of the evaluation of these measures relative to the established criteria. The Main Report and other appendices present the analysis post Sandy refinements to the alignment and renourishment schedule. The FIMI Stabilization Project altered the without project conditions for initial construction, acquisition and alignment.

Table 4.37 Assessment of Achieving Vision Criteria for Beachfill Alternatives

Evaluation Criteria	Assessment	Rating
The plan or measure provides identifiable reductions in risk from future storm damage.	Reduces potential for breach and overwash; protects structures directly on the shorefront	Full
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.	Beachfill has been widely used on south shore of Long Island and other locations. It is based on sound science and is readily reversible.	Full
The plan or measure addresses the various causes of flooding, including open coast storm surge, storm surge 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.	Addresses open coast storm surge and periodic overwash and breaching of barrier islands.	Partial
The plan or measures incorporate appropriate non-structural features provide both storm damage protection and to restore coastal processes and ecosystem integrity	While it is not a non-structural measure, it does help to restore littoral transport.	N/A
The plan or measure help protect and restore coastal landforms and natural habitat.	At selected locations, reduces erosion and thus protects adjacent habitat.	Partial
The plan avoids or minimizes adverse environmental impacts	The selection of borrow areas, limits in dredging windows and other mitigation measures will reduce impacts.	Partial
The plan addresses long-term demands for public resources.	Plan will require renourishment and future expenditure.	Full
Dune and beach nourishment measures consider both storm damage reduction, restoration of natural processes, and environmental effects.	Promotes dune formation and longshore transport. In some areas, it reduces cross-shore transport because of higher dunes. Significant environmental effects will be minimized by selective implementation and avoidance of certain areas.	Partial
The plan or measure incorporates appropriate alterations of existing shoreline stabilization structures	(See discussion of Groins). Use of beach nourishment likely to be a prerequisite for alteration of existing shoreline stabilization structures.	Partial
The plan or measure incorporates appropriate alterations of inlet stabilization measures and dredging practices	See discussion of Inlets	N/A
The plan or measure is efficient and represents a cost effective use of resources	The benefit/cost ratio has been established, and the alternatives are cost-effective in certain section of study area, but not the entire area.	Partial

The plan or measure reduces risks to public safety.	The plan reduces breaching and overwash; reduces damages to shorefront buildings; reduces debris volumes; and eliminates potential hazard of buildings on public beach (by moving the beach shoreward of existing structures).	Full

Areas for Sediment Management Consideration.

As described in the sediment management section, there could be additional areas, where consideration of sediment management measures may be warranted. The result of the analysis of beachfill alternatives shows that beachfill is not supported in areas along Shinnecock Bay, the Ponds, or Montauk.

Knowing this, a last added analysis was considered to determine if there are any areas of high damage in the without project condition, where sediment management measures would be warranted to ensure the long-term continuity of longshore sediment transport. With this criteria, 2 locations were evident, the area of downtown Montauk and the area of Potato Road, which were evaluated for beachfill alternatives, based upon the high damages that occur in these areas.

The Littoral Sediment Transport (LST) material for regional sediment budget balance assumes the continued bluff erosion at Montauk to supply material to the west. As the bluff at both Montauk Point and eastern Atlantic shoreline are gradually stabilized, the constant source of littoral material will diminish within the study period. The LST rate is estimated at 120,000 CY/year based on the recent (c.2001) regional sediment. It is proposed that 25% of the LST rate be supplemented on Montauk Beach and the Area of Potato Road as feeder beach. This supplemental sediment source would provide a constant LST source east of Shinnecock Inlet and, therefore, erosion control benefit in this region. This Feeder Beach would include advance fill of 120,000 CY placed during initial construction and 120,000 CY placed every four years in concert with future renourishment operation.

In these areas, these Sediment Management Alternatives would offset the long-term erosion trend, maintain the current protection in these areas, and prevent conditions from getting worse. These features were evaluated in the economics model to determine the economic effect of reducing the long-term erosion trend. The results of this analysis show that in these two areas, sediment management measures are economically viable. In the area of Potato Road, the implementation of this plan would be contingent upon the development of a local management plan for Georgica Pond to address the effects of the pond opening and measures to minimize the consequences of this.

Land and Development Management Challenges and Opportunities.

The beachfill plans introduce a number of land use and development management challenges, and also land use and development management opportunities that could be considered in conjunction with these alternatives.

Along the shorefront area, the existing land management regulations that limit the investment in this high risk area have not proven to be effective. The stabilization of the shoreline with a beachfill and dune plan could increase the need for these land management measures to function properly, to avoid an increase in the level of infrastructure that is at risk in these areas. The focus of these efforts would be to ensure the existing regulations are functioning as intended to limit the level of investment in these high hazard areas.

Also in conjunction with these beachfill plans, there is the opportunity to address existing development that is at risk, and opportunities for reducing the amount of infrastructure at risk, over time. The construction of a beachfill project requires permanent easements. There are several locations where beach nourishment is included to protect public infrastructure, most notably in Robert Moses State Park, and Smith Point County Park. Opportunities exist to provide for relocation of public infrastructure in these areas to reduce the long-term requirement for renourishment.

Similarly, the beachfill alternatives have been developed to consider different beachfill alignments. To build these more landward alignments would require acquisition of buildings, prior to construction.

Summary of Beachfill Alternatives.

The analysis above shows that beachfill alternatives are cost-effective storm damage reduction alternatives that contribute to reducing the damages associated with shorefront damages, and flooding along the Back Bay that occurs due to barrier island breaching.

Beachfill alternatives are recommended for further evaluation with the Medium fill plan at the MREI alignment, along the Great South Bay Reach and Moriches Bay Reach. If locally supported, the Medium Plan along the middle alignment could also be developed further.

In the areas of Potato Road and Downtown Montauk, although a traditional beachfill plan is not supported, a sediment management measure, which offsets the long-term erosion rate, would be supported. The long shore transport (LST) material for regional sediment budget balance depends on the assumption that bluff erosion at Montauk Point would supply necessary source. As the bluff at both Montauk Point and eastern Atlantic shoreline are gradually stabilized, the constant source of littoral material will diminish within the study period. The LST rate is estimated at 120,000 CY/year based on the (c.2001) regional sediment budget. It is proposed that 25% of the LST rate be supplemented on Montauk Beach as feeder beach. This supplemental sediment source would provide a constant LST source east of Shinnecock Inlet and, therefore, erosion control benefit in this region. An advance fill of 120,000 CY will be placed during initial construction and 120,000 CY placed every four years in concert with future renourishment operation.

The beachfill alternatives partially fulfill the vision objectives. The vision objectives could be better accomplished with the inclusion of coastal process features, and further consideration of locations along the Great South Bay Reach and Moriches Bay Reach where beachfill could be eliminated and replaced with a breach response plan.

F. Groin Modification Alternatives

The screening of alternatives recommended further evaluation of groin modifications, as storm damage reduction alternatives. 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 first determine the influence that shortening of the structures would have on the release of sediment, and the resulting 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 as favorable 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, 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 exist four rubble mound groins east of Georgica Pond along the shoreline of East Hampton. 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. These two groins were constructed in 1959. 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). Fill was placed by the state in 1960, 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 control purposes. In some years, the inlet is breached naturally by a storm event, and can also close naturally due to littoral transport of sand. The full impact to the coastal processes and littoral transport of material due to the opening and closing of the inlet, and the attendant creation of the flood and an ephemeral ebb shoal is not fully known at this time.

Various parties have studied the area of shoreline in the vicinity of Georgica Pond in the past. Multiple sediment budgets exist with the most recent thorough sediment budget incorporating shoreline changes up to 1995. These sediment budgets show that the gross littoral transport is three to four times larger than the net littoral transport. While average net transport is westward, single storm events and seasonal or yearly trends can set the net transport into a reversal, or to the east.

The shoreline erosion rates, up to 1995, are lower in the Southampton and East Hampton area compared to the rates of other locations in the FIMP study area. The Existing sediment budget erosion rates also shows erosion in the regional sediment budget, could not describe specifically the erosion rates in the immediate vicinity of the groins at Georgica Pond. An erosion rate of 15 feet per year is assigned to the area for use in estimating renourishment volumetric requirements and placement intervals. The objectives of the recommended alternative in the vicinity of Georgica pond is to provide storm damage prevention benefits in a cost-effective manner, reduce adverse impacts, and encourage the restoration of coastal littoral processes. Alternatives proposed already include:

- a no-action alternative,
- beachfill placement,
- removal of groins,
- modification of groins,
- change in management practices of Georgica Pond opening and closing,
- combinations of these alternatives.

As presented in the prior Chapter, the Alternative Screening conducted a conceptual level analysis on the costs and benefits of groin removal compared to beach nourishment. For that conceptual screening, only the complete removal of the groins at Georgica Pond was examined. The report noted that a complete investigation into the feasibility or impacts of groin removal would require (1) historical shoreline and volumetric changes east and west of the structures before and aft.er construction, (2) the contribution of the groins toward any irregularities in the existing beach layout, and (3) the groin impacts determined by the implementation of the GENESIS shoreline change model. The report also notes that it must be determined that existing storm protection in areas where groin removal would occur will not be adversely affected. The study concluded, based on a comparison with beachfill, groin removal results in increased annualized costs with no readily identifiable benefit in terms of beachfill performance. Total groin removal will not be further considered as an alternative.

Thorough engineering analyses of historical and recent shoreline change trends and their relation to the updrift groin field, the periodic tidal inlet at Georgica Pond, and the nearshore remnant shoal features must be completed in order to determine the appropriate type(s) and level of design required. As part of a legal dispute ongoing between Suffolk County and private landowners, Suffolk County acquired from Woods Hole Group such an engineering study for this area. This study is summarized in the technical report titled "Historical evaluation of shoreline change for the Georgica Pond region, Suffolk County, Long Island, New York." The engineering study conducted by Woods Hole Group included all pertinent components needed to make a quantitative assessment of coastal engineering issues upon which preliminary engineering design recommendations may be based. Specifically, this study included the following components: 1) Bathymetric data collection; 2) Historical shoreline change analysis; 3) Wave climatology and wave transformation evaluation, including numerical modeling; 4) Engineering assessment of causes of erosion. Conclusions cited in the report include:

- Federal groins in the vicinity of Georgica Pond do not significantly contribute to erosion well downdrift of the Pond. Instead, long-term background erosion most significantly contributes to erosion observed well downdrift of the Pond.
- Wave-driven sediment transport patterns in the vicinity and downdrift of Georgica Pond are as influenced by natural offshore bathymetric features as they are by the groin field updrift of the Pond.

Based on the conclusions of this report, a no-action alternative is recommended. However, a monitoring program will be included as part of the recommended plan to determine the long-term effect of the groins at Georgica Pond and possible future modification.

Westhampton Groin Field

Provisions of the original Fire Island to Montauk Point Beach Erosion and Hurricane Protection (FIMP) Project provided for the construction of 23 rubble mound groins at Westhampton Beach, east of Moriches Inlet. Eleven groins were constructed in 1965 - 1966 and an additional 4 groins were constructed in 1969 - 1970. The remaining 8 groins, as provided for in the original FIMP project, were never constructed. The groins, spaced approximately 1250 ft. apart, function as intended and continue to provide protection to a once vulnerable reach of barrier island shoreline approximately 2.8 miles in length. Construction of the Westhampton groin field had, however, resulted in 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 beachfill 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 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) decreases 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

When considering the area within the groin field, the performance of the constructed groins has exceeded expectations, resulting in an accretive beach and well-protected dunes. Similarly, the Westhampton Interim Project has exceeded performance expectations, as indicated by the accretive dunes west of the groin field, the lengthening of the renourishment cycle and the decrease in needed renourishment volume.

Restoration of longshore transport alternatives in the vicinity of the Westhampton groin field was considered. Possible alternatives include:

- a no-action alternative,
- beachfill placement,

- removal of groins,
- modification of groins,
- combinations of these alternatives.

The objective of the selected alternative will be to provide storm damage prevention benefits in a cost-effective manner, reduce adverse impacts, and encourage the restoration of coastal littoral processes for both the areas contained within the groin field as well as the vulnerable areas directly downdrift. Given the relative and proven consistent health of the beach contained within the groin field and the beneficial performance of the groin tapering and renourishment provisions of the Westhampton Interim Project, a combined alternative that incorporates the shortening of groins in the eastern and middle portions of the groin field, the tapering of groins on the western edge of the groin field, in addition to continued renourishment was analyzed to evaluate the plan as a cost-effective solution. The specific elements of this possible alternative are as follows:

- Shortening of groins 1 through 8 to 380 ft.
- Shortening of groins 9 through 13 to 386, 392, 398, 402, and 410 ft. respectively
- Continued renourishment through the tapered section and westward as needed

Shortening of groins 1 through 13 has the potential to release a substantial amount of sediment back into the littoral system, providing a one-time release of sediment as the shoreline within the confines of the well-filled groin-compartments retreats in response to the modified groin lengths. 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. Finally, tapering along the western mid-portion of the groin field (groins 9 to 13) will improve transport between the feeder beach and downdrift areas.

To analyze the benefits of this proposed alternative, an estimate of the amount of sediment that would be released through groin shortening was developed. Considered from an elevation of –15 ft. NGVD, it is estimated that this alternative has the potential to release 150,000 cu yd. into the littoral system. Considered from an elevation of –30 ft. NGVD, it is estimated that this alternative has the potential to release 5,000,000 cu yd. into the littoral system.

The above alternative involves the removal of 70 to 100 ft. of stone from the seaward end of 13 groins. Total length of removal considered is equal to 1210 ft. The cross-sectional area of the seaward head (which is approximately 100 ft. in length) is approximately 560 sq. ft. This alternative therefore entails the removal of approximately 675,000 cu ft. of 16-ton armor stone. Removal of this quantity of armor stone would require a 25-ton capacity crane and attendant equipment to remove the stone from the beach to an approved disposal location. If the removal of the stone is conceptually priced at $400,000 per groin, the total construction cost for the shortening of 12 groins is approximately $5,000,000. The amount of sediment estimated to be released, 500,000 cu yd., can be purchased at an approximate cost of $12 cu yd., yielding a total cost of $6,000,000. The benefit of sediment released to downdrift beach is higher than the estimated construction cost. It is, therefore, concluded that the modification (shortening) of the existing groins represent the most cost effective strategy for the protection of the beaches within and downdrift of the Westhampton groin field.

Ocean Beach Groins

Two shore perpendicular structures were constructed in the winter of 1970 within the Village of Ocean Beach, on Fire Island. Ocean Beach and the State of New York built two groins at the western end of this community. 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 been moved north in the Village, within Village owned land, however the three wells remain just landward of the eastern groin, within three village owned facilities. A separate Village maintenance facility is also located in the same Village property containing the wells. The groins are also in a location of the Fire Island shoreline that makes a change in orientation, and has a higher background erosion rates than areas to the east. The existing groins consist of two rows of tetrapods, spaced approximately 10 feet apart in the nearshore portion of the western groin, and 20 feet apart in the offshore portions of both groins. The nearshore portion of the eastern groin consists of only armor stone, while the space between the offshore portions of the western groin has been filled with armor stone. Both groins are 200 feet long from landward crest to seaward crest, with the offshore portion about 85 feet of the total length. The landward crest of the eastern groin is approximately 130 feet from the seaward limit of Ocean View Walk, and the landward crest of the western groin is approximately 50 feet from the seaward limit of Ocean View Walk. Ocean View Walk was eroded in the western area before the groins were constructed. The groins are approximately 660 feet apart along the shoreline, and the western groin is about 200 ft. from the border of the Village of Ocean Beach and Corneille Estates. Based on 2006 aerial photography, the beach width, measured updrift of the groins, from the dune toe to the approximate mean high water line varies from 132 to 142 feet (the beach width is fairly stable). Generally, beach widths farther east of the two groins are larger, and farther west of the two groins are considerably narrower. Over a shoreline length of 1000 ft. from west and east of the two groins, the dune toe moves, in relationship to the seaward limit of Ocean View Walk, approximately 140 feet, for a change in shoreline alignment relative to Ocean View Walk of about 14 degrees. This follows a general change in alignment of the shoreline and dune toe along this section of the Fire Island shoreline.

Several historical shoreline datasets (1933, 1979, 1995 and 2001) were analyzed to determine the effect that these structures have had on adjacent shorelines and to assess the feasibility of removing them as part of this project. Shoreline comparisons suggest that shoreline downdrift of the groins between Corneille States and Kismet (2.5 miles which is the approximate extent of the alongshore groin impacts, as explained below) eroded at an average rate of roughly 3 ft./yr between 1979 and 2001 despite the placement of 1.3 million cubic yards of fill during that period. The shoreline updrift of the groins has been relatively stable or even accreting. In addition to the direct comparison between shoreline datasets, an even-odd function analysis was performed to determine the alongshore extent of the groin impacts.

This analysis separates the shoreline position change data into symmetric (even) and anti-symmetric (odd) functions. In theory, the even function represents changes due to background erosion and sea level rise that occur symmetrically on both sides of the groins while the odd function account for anti-symmetric changes due updrift structure impoundment and downdrift erosion. Application of this method to the available shoreline change datasets and interpretation of the results suggest that the groins extent of influence is between 1.5 and 2.5 miles both updrift and downdrift of the structures. The analysis also suggests that background erosion in this area (i.e., what the erosion rate would be in absence of the groins) is on the order of 2 ft./yr.

From this analysis and a general understanding of shoreline behavior in the presence of this type of coastal structure it follows that, should the groins be removed, erosion rates downdrift would be reduced to background levels. However, erosion along the stable/accreting shoreline to the east would also increase, particularly the areas immediately adjacent to the groins (i.e., Ocean Beach), increasing the uncertainty in shoreline location, and therefore increasing the risk of storm damage to the Village-owned pumping facilities. Although the cost to modify the Ocean Beach groins is relatively inexpensive, the cost to relocate the Village's three pumping facilities would be over 5.0 million dollars assuming the property is available at no cost to move the facilities. Removing the groins was originally not considered viable to provide a net reduction in the cost of providing protection to the western Fire Island communities, from Oakleyville to Kismet. Moreover, visual inspection of the structures suggests that they are in relatively poor functional condition (i.e., relatively short, low and permeable) and are not as effective in trapping longshore sediment transport as first constructed. As a result, it was not recommended that the two groins at Ocean Beach be modified for purposes of Storm Damage Reduction. Since the implementation of the FIMI Stabilization Project, however, the wells have been removed, and removal of the Ocean Beach Groins will be considered, as addressed in the Main Report.

If there is a desire to remove or modify these structures in order to achieve other objectives, such as reestablishing coastal processes, to advance Vision objectives, or advance the objectives of the National Park Service, the following would need to be considered. The removal or modification of these groins would need to be implemented in conjunction with a more comprehensive storm damage reduction alternative (beachfill), and would need to include the removal, relocation, or replacement of the existing well-field. With any of the proposed beachfill alternatives, the existing groin field would be largely covered. As a result, the effect of removing the groin field would largely come into play in the future after the cessation of renourishment. In this scenario, groin modification could be accomplished in the future, subsequent to the relocation of the water supply.

Based upon the above, the recommendation would be modification of the Westhampton Groin field. Table 4.38 presents the costs for groin modification of the Westhampton Groin field.

Table 4.38. Modification of Westhampton Groins.

Construction Cost	$5,000,000
Contingency	$1,500,000
E&D	$455,000
S&A	$585,000
Total First Cost	*$7,500,000*
IDC	$142,441
Total Investment Cost	*$7,642,441*
Interest & Amortization	$426,754
O&M	$0
BCP Maintenance	$0
Monitoring	$0
Renourishment	$0
Total Budgeted Cost	*$426,754*
Annual Breach Closure Cost	$0
Major Rehabilitation	$0
Total Annual Cost	***$426,754***

Discount Rate: 5.0125%, Sept 07 PL, 50 year study period.

Evaluation of Groin Modification Alternatives.

Groin Modification Alternatives were evaluated in relationship to the planning criteria developed to reflect the Project objectives and the project approach delineated in the "Vision Statement for the Reformulation Study". This systematic assessment ensures that the Vision Statement approach is fully integrated into the development and selection of the FIMP Plan. Table 4.39 provides a summary of the evaluation of these measures relative to the established criteria.

Table 4.39 Assessment of Achieving Vision Criteria Groin Modification Alternatives

Evaluation Criteria	Assessment	Rating
The plan or measure provides identifiable reductions in risk from future storm damage.	Plan will reduce risk in certain locations. There is a potential tradeoff in risk levels between locations.	Partial
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	Groin modifications are fairly well understood and were successfully implemented at western limit of Westhampton groin field. Physical changes are not easily reversed. Continued monitoring and beachfill may be required.	Partial
The plan or measure addresses the various causes of flooding, including open coast storm surge, storm surge 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.	Plan addresses open coast storm surge and flow into the bays due to periodic overwash or breaching of the barrier islands. Upon shortening of the groin in Ocean Beach, sand would move to fill scour at the potential breach location at Robins Rest. Shortening the groin in Westhampton would reduce risk and renourishment requirements in Fire Island Interim Project (FIIP) study area.	Partial
The plan or measures incorporate appropriate non-structural features provide both storm damage protection and to restore coastal processes and ecosystem integrity.	N/A	N/A
The plan or measure help protect and restore coastal landforms and natural habitat.	Would help restore natural landforms.	Partial
The plan avoids or minimizes adverse environmental impacts.	No significant impacts.	Full
The plan addresses long-term demands for public resources.	May reduce need for long-term Renourishment.	Full
Dune and beach nourishment measures consider both storm damage reduction, restoration of natural processes, and	N/A	N/A
The plan or measure incorporates appropriate alterations of existing shoreline stabilization structures.	Yes	Full
The plan or measure incorporates appropriate alterations of inlet stabilization measures and dredging practices.	N/A	N/A
The plan or measure is efficient and represents a cost effective use of resources.	It appears to be cost-effective in certain areas.	Partial
The plan or measure reduces risks to public safety.	Reduces erosion risk	Partial

Summary of Groin Modification Findings

The analysis above shows that groin modification alternatives for the Westhampton Groin field are cost-effective storm damage reduction alternatives that can reduce the long-term volumes of sand required for the areas to the west of the groins, without compromising the protection that is provided to homes within the groin field.

Groin modification alternatives are not recommended for storm damage reduction at Georgica Pond. Removal of the Ocean Beach Groins was originally rejected due to cost considerations, but conditions have changed since the original formulation was done. Since modification of the groins at Ocean Beach could help restore alongshore the Village water supply has been relocated, the Main Report, which discusses Post Sandy refinements to the plan, will consider groin modification at Ocean Beach.

The groin modification alternative partially fulfills the vision objectives, but offers limited reduction in storm damages when considered as a stand-alone alternative.

The groin modification alternatives do not directly present land management or development management challenges, but as presented, to implement the groin modification alternative, specifically in the vicinity of Ocean Beach would require measures to reduce the risks to existing development.

G. *Land and Development Management*

General

Land and development management alternatives include land use regulations and acquisition alternatives that could be implemented to reduce the risk of 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 presented in the without project conditions section of this report, the existing land use regulations are not effective in addressing development and redevelopment in these at-risk areas, particularly in areas that are vulnerable to erosion. There is a concern that alternatives implemented under this Project could exacerbate this problem. The following is provided as a review of the land-use regulations, the additional challenges and opportunities inherent with the different alternatives, and opportunities to more effectively address the development and redevelopment concerns in the hazard areas.

State and local governments have authorities and responsibilities for managing risk that should be utilized in coordination with federal storm risk management efforts. The FIMP project will not eliminate all flood risks so additional measures by other public sector and private interests are necessary to help achieve resilience. Mechanisms available to local interests to better understand and reduce risk include comprehensive land use plans, Local Waterfront Revitalization Programs (LWRPs), and local Hazard Mitigation Plans, to name a few. Other land-use management regulations, discussed below, are recommended to reduce risk to development in high hazard areas or reduce development pressures in those areas.

Existing Programs

The following is a summary of the existing land-use regulations with a focus on the major programs including NYS CEHA, FIIS – Dune District, and FEMA floodplain management. 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 through management of environmental features (e.g., freshwater and tidal wetlands). In addition, FIIS is administered by the NPS under the DOI, a federal agency with land use and environmental management authority.

In New York State, the primary responsibility for zoning land use regulations rests with local municipalities, including towns and incorporated cities or villages, under the system known as “home rule”. However, in the case of shorefront areas potentially subject to flooding or coastal erosion, and for Fire Island in particular, a number of other federal and state zoning and other land use regulations pertain, as described below.

<u>Fire Island National Seashore</u>

When Congress enacted FIIS-enabling legislation, the law mandated the Secretary of the Interior to establish federal zoning regulations. These regulations provide standards for local zoning to protect and preserve Fire Island, and they exist solely as an overarching law to which local ordinances must conform.

Federal zoning regulations provide a set of standards for the use, maintenance, renovation, repair, and development of property within FIIS. NPS has established three districts within its boundary:

a. the Community Development District;
b. the Seashore District; and
c. the Dune District.

The Community Development District comprises 17 communities and encompasses the existing communities and villages. In the Community Development District, existing uses and development of single-family houses are allowed. 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 which has been mapped by NPS. This district overlaps the other two districts. Only pedestrians, and necessary vehicles such as ambulances, are allowed in the Dune District. Like the Seashore District, existing legal structures may remain and may be repaired and maintained. The existing dune district was established based upon the dune condition in 1976 and adopted by Congress. The dune district has not been re-mapped, and presently is not an accurate representation of the existing dune. NPS developed federal zoning standards that became effective September 30, 1991 under 36 CFR Part 28. These set standards that local zoning must meet to be exempt from the condemnation authority of the Secretary of the Interior.

These standards include controlling population density and protecting natural resources, limiting development to single-family homes, and prohibiting any new commercial or industrial uses. NPS is not responsible for enforcing the federal zoning standards in the communities and villages, despite the presence of federal regulations. It is the responsibility of the local governments to maintain regulatory jurisdiction. The federal government ensures local compliance with the federal law by maintaining the power of condemnation; in cases where the law is not met, FIIS has statutory authority to purchase and condemn the non-compliant building. While local zoning ordinances conform to standards issued by the Secretary of the Interior, the federal power of condemnation is suspended. In practice, this authority has been seldom exercised, and Congress has not given funding to FIIS for this purpose in recent years.

FEMA

Other agencies also have responsibility to affect land use regulation in the project area. An organization that indirectly affects land use regulation is the Federal Emergency Management Agency (FEMA). Any community seeking to register with the Federal Insurance Association, which allows homeowners to obtain flood insurance, must join FEMA's National Flood Insurance Program (NFIP). Participation in the NFIP requires a municipality to adopt a local floodplain management ordinance that regulates floodplain development and redevelopment following damage. The intent of the local ordinance is to reduce damage to buildings and property through the establishment of base flood elevations, building code requirements, and restrictions on allowable development in floodplain areas. Specific provisions include the requirement that the first finished floor or new construction must be elevated above the base flood elevation. All municipalities within the study area participate in the NFIP.

USFWS

The Coastal Barrier Resources Act of 1990 established the Coastal Barrier Resources System (CBRA), which consists of specifically identified 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 in areas. The CBRA, however, identifies exceptions to this restriction, including non-structural shoreline stabilization similar to natural stabilization systems; the maintenance of channel improvements, jetties, and roads; necessary oil and gas exploration and development; essential military activities; and scientific studies.

NYS CEHA

In 1981, the Coastal Erosion Hazard Area (CEHA) Act, Article 34 of Environmental Conservation Law was enacted to provide for the identification and regulation of critical erosion hazard areas along New York's coastlines, in order to minimize damage from erosion. Article 34 established statutory authority for identifying these erosion hazard areas, restricting development in these areas, and establishing criteria for the development of a statewide.

Coastal Erosion Management (CEM) regulatory program. 6 NYCRR Part 505, the Coastal Erosion Management Regulations, provides the framework and criteria which allow the State and local governments to administer a local CEM program that is consistent with Article 34 for affected shoreline communities. Under Article 34 and Part 505, CEHA consists of two separate jurisdictions, which include the Natural Protective Feature Area (NPFA), which is defined by the natural protective features (dune, beach, bluff and near shore areas) found along a particular stretch of shoreline, and the Structural Hazard Area (SHA), which is delineated landward of the NPFA along shorelines with a long term annual rate of shoreline recession greater than one foot per year.

Currently no SHA has been identified within the study area. Therefore, the terms CEHA and NPFA are used interchangeably throughout this report because only the NPFA jurisdiction is applicable within the study area. However, SHA may be delineated within the project area in the future if technical data determines it to be appropriate.

CEHA jurisdiction extends from the seaward limit of the near shore area (1,000 feet seaward of mean low water or a water depth of 15 feet; whichever is greater) to the landward edge of the most landward natural protective feature. For most of the reformulation study area, the primary dune is the most landward natural protective feature. The primary dune extends 25 feet landward from the landward toe, as identified on the Coastal Erosion Hazard Area maps and is the landward limit of CEHA jurisdiction. Where the landward most natural protective feature is a bluff or a beach, the CEHA jurisdiction extends 25 feet landward from the crest of a bluff or 100 feet landward from the change of vegetation or physiographic form on a beach. Presently, all of the towns within the study area have in effect either a State CEHA program administered by the Department of Environmental Conservation or a certified local law administered locally. The Village of Saltaire, Ocean Beach, and the Town of Brookhaven administer the program under their local laws.

<u>NYS CMP</u>

In 1981, the New York State Legislature enacted the Waterfront Revitalization and Coastal Resources Act (Article 42 of the Executive Law) 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.

Land Use and Development Challenges

It is acknowledged that within the study area this existing collection of land use regulations is not adequate to address the development pressures, nor to effectively address building and rebuilding in the high hazard areas along the coast.

As presented throughout this Chapter, there is a concern that certain alternatives could create additional land and development challenges or intensify the existing challenges that exist. Alternately, there are alternatives that provide opportunities for reducing these pressures. Throughout this Chapter, each alternative presents the land-use challenges and opportunities. The following is a summary of the alternatives, and land-use challenges and opportunities associated with them.

Breach Response. The breach response plans introduce some land use and development management challenges that would not be realized in the without project condition. Existing land management measures do not address rebuilding in breach locations, or locations that are likely to remain vulnerable to breaches in the future. Land and development management measures should consider the need for restricting redevelopment in locations that are likely to remain as vulnerable to breaching and overwash. Not only will this address reducing development at risk, but it is also important to facilitate continued breach response requirements, and can help provide a desirable habitat mosaic by maintaining an open bay to ocean connection.

Inlet Management. The inlet management plans do not introduce any specific land use and development management challenges.

Non-Structural. The non-structural plans do not introduce land use and development management challenges, but instead introduce additional land use and development management opportunities that could be considered in conjunction with these alternatives. As has been presented, there could be a larger benefit obtained by acquiring rather than retrofitting structures in some situations, including instances where 1) buildings are in sparsely developed areas, where habitat connectivity could be achieved, or 2) buildings located at such low ground elevations that under future sea level rise conditions would be in the intertidal zone. If there is a local desire for structure acquisition rather than retrofit alternatives, these alternatives could be considered if the additional costs for acquisition would be warranted to provide restoration of habitat to the underlying area.

Beachfill. Beachfill plans introduce a number of land use and development management challenges as well as opportunities that could be considered in conjunction with these alternatives.

Along the shorefront area, the existing land management regulations that limit the investment in the primary dune have not proven to be effective. There a number of existing structures within the dune, partially due to structures that existed prior to the implementation of these regulations, and also partially due to long-term changes in the dune position; and development continues to occur in the primary dune. In the absence of a project, it is likely that the number of pre-existing, non-conforming structures would be reduced as a result of storms that would destroy these buildings beyond repair, with the acknowledgement that additional buildings would be at risk, due to the long-term evolution of the dune position. With a beachfill project in place, it is much less likely that the structures in the CEHA would be destroyed, and would likely persist.

Additionally, there is a concern that there could be increased incentive to develop these areas if there is a beachfill and dune project that reduces the likelihood of storm damages. The stabilization of the shoreline with a beachfill and dune plan would increase the need for effective land management measures which function properly to avoid an increase in the level of infrastructure that is at risk in these areas.

It must be noted that these beachfill plans also create opportunities to address existing development that is at risk, and opportunities for reducing the amount of development and infrastructure at risk, over time.

There are several locations where beach nourishment is included to protect public infrastructure, most notably in Robert Moses State Park, and Smith Point County Park. Opportunities exist to provide for relocation of public infrastructure in these areas to reduce the long-term requirement for renourishment.

As presented in this chapter, the beachfill alternatives have also been developed to consider different beachfill alignments. The construction of a beachfill and dune project requires real estate easements to be obtained to construct and maintain the beach and dune. These easements would preclude development in the footprint of the project. As presented previously, the construction of a more landward alignment would require acquisition of buildings, prior to construction, and would effectively achieve the goal of reducing the number of structures in the high-risk area. This, however, would likely require extensive condemnation to achieve this. Rather than trying to acquire structures up-front, at project initiation, the possibility exists for alternatives which improve land management regulations, or could acquire structures over time to reduce the level of development at risk along the shorefront.

Groin modification. The groin modification alternatives do not directly present land management or development management challenges. However, the implementation of the groin modification alternative in the vicinity of Ocean Beach could increase the vulnerability of the existing development and would require measures to reduce the risks to existing development, and would require the relocation of public infrastructure which is at risk.

Land and Development Management Opportunities

Table 3.1 in Section 3C shows the possible land and development management alternatives that could implemented to address the existing land use challenges, and the challenges that may become more apparent with a plan resulting from this study. This table was used at meetings with local municipalities and stakeholder groups to develop recommendations on alternatives that could be implemented to address these challenges.

These discussions have resulted in a framework for providing potential improvements to the existing set of regulations that are presently in place, as outlined in the following steps:

Step 1: Improve the effectiveness of the existing regulatory program by establishing common funding sources and common boundaries for regulated hazard areas, increasing training of local officials, and ensuring consistent implementation across regulatory boundaries. Specific actions include:

- Update the Existing Dune District in FIIS to reflect the current dune location and to be consistent with the CEHA program.
- CEHA – Provide adequate funding to update maps and for monitoring of local implementation of CEHA.

Step 2: Modify CEHA statute to reduce potential litigation claims which makes enforcement of CEHA burdensome on local municipalities. .

Step 3: Establish programs for the State local communities to acquire vacant parcels or buildings that are at risk. Examples include Voluntary *sales with retained occupancy or lease-back programs* that have been utilized by FIIS.

Step 4: Establish regional entity responsible for land management, land acquisition and having the authority to act as a local sponsor for cost shared projects.

Step 5: Prepare post-storm response plans that requires any rebuilding of following a major storm be sustainable, taking into account climate change and future risks of storms.

While there is a limited role for the Corps' in the implementation of the land and development management measures, 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.

H. <u>Evaluation of Coastal Storm Risk Management Measures.</u>

Based upon the analyses of each of the storm damage reduction measures, the alternatives recommended for further consideration as components of a combined alternative plans include the following:

- 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
- Sediment Management Measures in the Ponds and Montauk Reach
- Groin Modification Alternatives at Westhampton

The project evaluation criteria for all the plans are shown in Table 4.40, which illustrates that while no one measure meets all of the objectives, a careful combination of the project measures can be identified to satisfy the objectives.

Table 4.40 **Assessment of Achieving Vision Criteria for Alternative Plans**

Evaluation Criteria	Breach Closure	Inlet Management	Non-Structural Retrofit	Beach Fill	Groin Modification
The plan or measure provides identifiable reductions in risk from future storm damage.	Full	Full	Full	Full	Partial
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	Full	Full	Full	Full	Partial
The plan or measure addresses the various causes of flooding, including open coast storm surge, storm surge 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
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
The plan or measure help protect and restore coastal landforms and natural habitat.	Partial	Full	No	Partial	Partial
The plan avoids or minimizes adverse environmental impacts	Partial	Full	Full	Partial	Full
The plan addresses long-term demands for public resources.	Partial	Partial	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
The plan or measure incorporates appropriate alterations of existing shoreline stabilization structures	N/A	N/A	No	Partial	Full
The plan or measure incorporates appropriate alterations of inlet stabilization measures and dredging practices	No	Full	No	N/A	N/A
The plan or measure is efficient and represents a cost effective use of resources	Full	Partial	Full	Partial	Partial
The plan or measure reduces risks to public safety.	Full	Full	No	Full	Partial

I. Evaluation of Coastal Process Measures.

A Coastal Processes Framework was developed by an interagency team and provides for reestablishing five coastal processes which are critical to the development and sustainability of the various coastal features (such as beaches, dunes, barrier islands and bluffs) that together form the natural system. In a natural ecosystem, features such as barrier islands and dunes protect coastal lands and property, and reduce danger to human life, stemming from flooding and erosion, while establishing habitats important to coastal species. These processes have been interrupted, and the intent of these measures is to reestablish these processes in order to manage coastal risks, by providing a resilient, sustainable system. The five Coastal Processes identified by the Restoration Framework as vital to maintain the natural coastal features are: Longshore Sediment Transport; Cross-Island Sediment Transport; Dune Development and Evolution; Estuarine Circulation; and Bayside Shoreline Processes.

The Design of coastal process features focused on measures that contribute to reestablishing these coastal processes consistent with the Reformulation objectives. As described previously, these coastal process alternatives were originally formulated as plans that achieve both ecosystem restoration objectives and coastal storm risk management objectives, and were combined with the traditional CSRM features to provide an integrated solution for coastal storm risk management. Following Hurricane Sandy, there has been a focus on coastal process features that are included based upon their CSRM contribution. This section of the report has been revised to reflect this current approach of natural features that contribute to coastal storm risk management. These are an important element of the Reformulation effort to achieve the Vision Objectives, and identification of a mutually agreeable plan between the Army and the Department of the Interior.

Sand Bypassing. As discussed in Section 3 the three stabilized inlets, Shinnecock, Moriches and Fire Island, disrupt the natural longshore transport of sand which result in sediment deficiencies down drift (west) of the inlets. Sand bypassing at the inlets, while evaluated as a traditional CSRM alternative is recognized as a coastal process feature. Sand bypassing provides a source of sand to downdrift beaches which reestablishes sediment supply to allow for more natural beach profile response.

Coastal Process Features to Reduce Breach Response Needs. The interagency team identified two locations vulnerable to breaching, where the bayside shoreline had been directly impacted by past dredging activities. At these two locations, dredging of channels has created a more vulnerable beach condition due to the proximity of deep water adjacent to the bay shoreline, where filling and recontouring these areas could reduce the potential for breaching. Table 4.41 identifies the bayside sites where restoring the natural protective features would strengthen the barrier island at points identified as having a high risk of breaching.

Table 4.41 Bayside Coastal Process Restoration Alternatives.

Restoration Site	Alt. ID	Target/Goal	Description
Tiana	Tiana-1	Bayside Shoreline Improvements	Enhance bayside shoreline with soft. bioengineering structures and intertidal zone plantings, increasing species diversity with invasive species control
	Tiana-2	Beach and Dune Improvements	Buyouts with dune restoration and replanting
	Tiana-3	Bayside, Beach, and Dune Improvements	Combines features of Tiana 1& 2
Smith's Point County Park (SPCP)	SPCP-1	Bayside and Upland Improvements	Enhance existing bay intertidal habitat and upland communities by controlling common reed and restoration of salt marsh
	SPCP-2	Bayside Shoreline Improvements	Enhance existing bay intertidal and create an overwash lobe for shorebird foraging/nesting habitat and bayside sediment input
	SPCP-3	Bayside shoreline and Upland Improvements, Create Sand Lobe	Combines features of SPCP 1 & 2 and also removes dredged fill material and restores sand roads/trails in upland

Coastal Process Features in Conjunction with Breach Response.

In addition to the measures to directly reduce the potential for breach reduction due to past dredging, coastal process features were also evaluated for each of the 10 most vulnerable breach locations to identify features that could be implemented in conjunction with a breach closure. Breach response measures include the deposition of sand material in breached areas to rebuild the barrier island to topographic conditions similar to pre-beach conditions. Created foredune areas vary in size depending upon the site, and would be of adequate slope to either maintain a sparsely vegetated overwash area (+9.5 ft NGVD section), or in the larger cross-section (+13 ft NGVD section) provide vegetative composition to stabilize dune areas and achieve high quality habitat and vegetation that would still be subject to overwash, but on a less frequent basis. The breach response plans are generally designed to rebuild the breach cross-section to match the pre-storm bayside shoreline condition. The opportunity exists to provide a wider barrier island, and replicate the bayside features that could form with a breach that is left to remain open for a longer period of time. These features would contribute to cross-island transport, and would provide a source of sediment to improve bay shoreline processes. These features will not be developed separately, but instead will be considered in the development of breach response cross-sections, with the acknowledgement that specific designs for implementation would have to be based upon actual site conditions at the time of breach closure.

Complementary Coastal Process Features achieved by Reestablishing Habitats

These coastal process features were originally conceived as natural features that would achieve both habitat outputs, as well as coastal storm risk management outputs, and were evaluated first on their habitat contribution. Since the project has evolved into a coastal storm risk management project which must recommend a mutually agreeable plan, these features have been identified as natural features that contribute to coastal storm risk management through the reestablishment of these coastal processes. The detailed analysis which was completed in the initial study phase is not documented here, only a summary of the analysis and the conclusions of that analysis are presented. Following Hurricane Sandy, each of these candidate features were reevaluated based upon the ability of the features to contribute to CSRM, and a subset of the sites have been recommended for inclusion. This post-Sandy reevaluation is described in the main report. Based upon this changed criteria for inclusion of coastal process features, the interagency team is also revisiting the initial list of candidate sites, and opportunities for reestablishing coastal processes with complementary natural features that would contribute to coastal storm risk management, and help achieve the vision criteria to arrive at a mutually acceptable plan. It is likely that additional sites, and alternate plans will be considered between the draft and final report.

The process for developing coastal process features was as follows:

- Identify and screen potential sites for coastal process features.
- Develop preliminary alternate designs for these sites selected during initial screening

The identification of potential sites for coastal process features was undertaken by the interagency study team who provided input on candidate sites for coastal processes and identification of the objectives at each sites. The potential sites were ultimately screened down to 18 sites based upon the site's ability to contribute to coastal storm risk management, with the application of natural features.

At each of these 18 sites, several complementary alternatives were developed that resulted in a total of 57 coastal process alternatives (Table 4.42). Factors considered in evaluating the coastal process features included:

- Does the natural feature increase the CSRM effectiveness of the alternative,
- Are there cost efficiencies in implementing the measures in combination with other CSRM features,
- Does the restoration provide a desirable mosaic of habitats that could be altered by the CSRM measure?

Table 4.42 Summary of Coastal Process Measures

	Alternative ID	Goal/Target	Description
T-2 Sunken Forest			
Alternative 1	T-2-1	eroding bayside shoreline	Remove bulkhead adjacent to marina, regrade 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 regrading all disturbed areas/roads/trails (except one to provide access from marina)
Alternative 4	T-2-4	Marina	Remove marina and hard structures directly attached to the marina, regrade shoreline in marina footprint, stabilize with plantings
T-3 Reagan Property			
Alternative 1	T-3-1	eroding bayside shoreline	Regrade 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 dune
Alternative 3	T-3-3	bulkheaded areas of bayside shoreline	Bury bulkhead, regrade shoreline and create intertidal area, stabilize shoreline using bio-engineering
T-5 Great Gun			
Alternative 1	T-5-1	existing salt marsh	Enhance salt marsh by restoring hydrologic connection via culvert beneath the road
Alternative 2	T-5-2	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 dune at access areas and cuts
Alternative 3	T-5-3	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 regrading all disturbed areas/roads/trails (except one to provide access from marina)
Alternative 4	T-5-4	Marina	Remove marina and hard structures directly attached to the marina, regrade shoreline in marina footprint, stabilize with plantings
T-7 Tiana			
Alternative 1	T-7-1	bayside shoreline and upper beach and dune	Restore salt marsh by removing fill material, using herbicide to control *Phragmites*, regrading and replanting. Restore dune at access cut and provide access via a dune walkover.

Alternative 2	T-7-2	upland and interior dune areas	Remove parking lot, regrade to natural contours, plant
Alternative 3	T-7-3	bay submergent vegetation	Enhance existing SAV beds
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*.
Alternative 2	T-8-2	Enhancement of bay shoreline and upper beach and dune	Reduce disturbance on site by raising the existing oceanside boardwalk and restoring the dune, regrading the bayside shoreline slope, and placing a walkover at the existing bayside shoreline access cut
Alternative 3	T-8-3	Remove hard structures	Remove parking lot and walkway on oceanside, regrade site to natural contours, plant
Alternative 4	T-8-4	salt marsh creation	Create new salt marsh in the area located to the west of the existing parking lot by lowering elevations of upland areas, making a cut in the bay shoreline to introduce tidal flow, and planting native salt marsh species.
T-9 Georgica Pond			
Alternative 1	T-9-1	*Phragmites* control in Georgica only	Control *Phragmites* in Georgica Pond by manually removing *Phragmites* and lowering elevations along the shoreline to improve tidal flow, and spot planting of native marsh species
Alternative 2	T-9-2	*Phragmites* control in Cove	Control *Phragmites* in coves adjacent to Georgica Pond by manually removing *Phrag* and lowering elevations along the shoreline to improve tidal flow and spot planting native salt marsh species in excavated areas
Alternative 3	T-9-3	Groin removal, upper beach and dune	Enhance upper beach/dune width/slope/height, reduce disturbance by removing sand fence, replacing the dune at the open cut, removing all groins, and installing a tide gate to manage tidal flow
T-10 East Inlet Island			
Alternative 1	T-10-1	Create shorebird nesting habitat	Regrade portions of dunegrass to remove *Phragmites* and dense vegetation and create conditions more favorable for shorebird nesting
Alternative 2	T-10-2	Control *Phragmites* in salt marsh	Control *Phragmites* throughout island using herbicides, no filling of existing *Phragmites*-dominated marsh and no regrading of the site
Alternative 3	T-10-3	Stabilize shoreline	Regrade and stabilize shoreline with vegetated gabion bio-engineering
T-11 John Boyle Island			
Alternative 1	T-11-1	Create shorebird nesting habitat	Regrade portions of the dunegrass community to remove dense vegetation to create shorebird nesting habitat, control *Phragmites* throughout site
Alternative 2	T-11-2	Create heron habitat	Convert portions of dunegrass to tree covered upland to create heron nesting habitat
Alternative 3	T-11-3	Stabilize shoreline	Regrade and stabilize shoreline with vegetated gabion bio-engineering
T-14 Ocean Beach			
Alternative 1	T-14-1	Remove hard structures on beach	Remove groins and relocate water supply well

Alternative 2	T-14-2	Enhancement of upper beach/dune	Enhance upper beach/dune width/slope/height, reduce disturbance by removing sand fence, raising boardwalks above dunes and restoring dune
Alternative 3	T-14-3	Buy outs and restoration of impacted footprint	Reduce disturbance through buy-outs and structure removal and the restoration of upper beach/dune width/slope/height in these areas
T-15 New Made Island			
Alternative 1	T-21-1	Create shorebird nesting habitat	Fill existing *Phragmites*-dominated baybeach to control *Phragmites* and create open dune habitat favorable for shorebird nesting
Alternative 2	T-21-2	Create heron nesting habitat	Add topsoil to existing dunegrass community to create tree covered upland habitat for heron
Alternative 3	T-21-3	Stabilize shoreline	Regrade and stabilize shoreline with vegetated gabion bio-engineering
T-22 Islip Meadows			
Alternative 1	T-22-1	Improve and manage hydrology	Restore hydrologic connection by removing sediment, install flap gates to manage tidal flow
Alternative 2	T-22-2	Reconfigure tidal channels	Excavate marsh to reconfigure existing tidal channels
Alternative 3	T-22-3	Tidal pool creation, *Phragmites* control	Ditch plugging and pool creation, *Phragmites* control using herbicides
T-23 Seatuck Refuge			
Alternative 1	T-23-1	Improve and manage hydrology	Restore hydrologic connection, install culverts, control *Phragmites* using hydrology, convert disturbed areas to salt marsh
Alternative 2	T-23-2	Reconfigure tidal channels	Reconfigure existing tidal channels, control *Phragmites* with herbicides
Alternative 3	T-23-3	Remove bulkhead, create salt marsh in footprint	Remove bulkhead, regrade shoreline, and restore marsh through plantings
T-24 Davis Park			
Alternative 1	T-24-1	Create dune	Restore dune and beach at large vehicle access cut
Alternative 2	T-24-2	Enhance upper beach/dune	Enhance upper beach/dune slope, width and height throughout the site
Alternative 3	T-24-3	Buy outs and restoration of impacted footprint	Reduce disturbance through buy-outs and structure removal and the restoration of upper beach/dune width/slope/height in these areas, restore portions of disturbed upland surrounding marina.
T-25 Atlantique to Cornielle			
Alternative 1	T-25-1	Create sand lobe on bayside	Deposit sediment and regrade are to create bayside sand bar
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

Alternative 3	T-25-3	Enhance upper beach/dune	Enhance upper beach/dune slope, height and width throughout site, reduce human disturbance by closing off some access roads/trails
T-26 Kismet			
Alternative 1	T-26-1	Enhance upper beach/dune	Enhance upper beach/dune slope, width and height throughout the site, reduce disturbance by removing sand fence, raising pedestrian access walkovers and restoring dunes at access points
Alternative 2	T-26-2	Buy outs of structures within CEHA line and restoration of impacted area	Reduce disturbance through buy-outs and removal of structures located within the CEHA line, and the restoration of upper beach/dune width/slope/height in these areas
Alternative 3	T-26-3	Buy outs of structures within 50 feet landward of CEHA line) and restoration of impacted area	Reduce disturbance through buy-outs and removal of additional structures located within 50 feet landward of CEHA line, and the restoration of upper beach/dune width/slope/height in these areas
T-27 Warner Island East			
Alternative 1	T-27-1	Create shorebird nesting habitat	Fill BAYBEACH to create shorebird nesting habitat
Alternative 2	T-27-2	Create heron habitat	Fill BAYBEACH to create heron nesting habitat
Alternative 3	T-27-3	Stabilize shoreline	Regrade and stabilize shoreline with vegetated gabion bio-engineering
T-28 Atlantique			
Alternative 1	T-28-1	Enhance upper beach/dune	Enhance upper beach/dune slope, width and height throughout the site, reduce disturbance by removing sand fence, raising pedestrian access walkovers and restoring dunes at access points
Alternative 2	T-28-2	Buy outs of structures within CEHA line and restoration of impacted area	Reduce disturbance through buy-outs and removal of structures located within the CEHA line, and the restoration of upper beach/dune width/slope/height in these areas
Alternative 3	T-28-3	Buy outs of structures within 50 feet landward of CEHA line) and restoration of impacted area	Reduce disturbance through buy-outs and removal of additional structures located within 50 feet landward of CEHA line, and the restoration of upper beach/dune width/slope/height in these areas
T-29 Fair Harbor			
Alternative 1	T-29-1	Enhance upper beach/dune	Enhance upper beach/dune slope, width and height throughout the site, reduce disturbance by removing sand fence, raising pedestrian access walkovers and restoring dunes at access points
Alternative 2	T-29-2	Buy outs of structures within CEHA line and restoration of impacted area	Reduce disturbance through buy-outs and removal of structures located within the CEHA line, and the restoration of upper beach/dune width/slope/height in these areas
Alternative 3	T-29-3	Buy outs of structures within 50 feet landward of CEHA line) and restoration of impacted area	Reduce disturbance through buy-outs and removal of additional structures located within 50 feet landward of CEHA line, and the restoration of upper beach/dune width/slope/height in these areas

Table 4.43 provides a summary of the costs of the base alternatives for each of these alternatives.

Table 4.43 Base Alternative Costs

Site	**Cost**			
	Alt 1	Alt 2	Alt 3	Alt 4
T-2 Sunken Forest	$215,905	$394,935	$1,543,156	$1,667,989
T-3 Reagan Property	$104,469	$316,775	$177,278	
T-5 Great Gunn	$89,204	$123,526	$286,646	$667,547
T-7 Tiana	$111,503	$18,035	$51,911	
T-8 WOSI	$10,047	$155,711	$36,145	$983,987
T-9 Georgica Pond	$7,365,951	$1,469,471	$3,033,590	
T-10 East Inlet Island	$59,508	$17,862	$277,038	
T-11 John Boyle Island	$36,131	$83,106	$115,281	
T-14 Ocean Beach	$6,078,274	$475,323	$3,059,913	
T-15 New Made Island	$142,659	$88,710	$84,481	
T-22 Islip Meadows	$166,807	$3,314,792	$71,141	
T-23 Seatuck Refuge	$573,327	$3,282,674	$1,081,836	
T-24 Davis Park	$54,989	$1,303,528	$927,702	
T-25 Atlantique to Corneille	$530,030	$110,971	$398,704	
T-26 Kismet	$489,906	$6,849,535	$2,821,805	
T-27 Warner Island East	$824,882	$655,396	$615,802	
T-28 Atlantique	$374,300	$2,973,782	$15,138,472	
T-29 Fair Harbor	$444,077	$7,655,675	$17,380,299	

Application of the assessment tool: Coastal Feature Matrices

A site ranking matrix was developed to qualitatively describe the breadth of environmental factors affecting the dynamic FIMP coastal ecosystem, as well as pertinent socioeconomic, political, and biological factors that must be considered when evaluating the feasibility of various coastal features. The matrix provided a comparative evaluation that considers non-quantifiable yet equally important environmental factors, such as the value an alternative may have in sustaining or increasing endangered species populations, how effectively an alternative helped restore one of the five critical coastal processes, and its value in connecting habitat fragments to be considered. It also permitted important non-ecological factors such as local jurisdictional boundaries, consistency with state/local plans/policies, and ownership to play a role in the selection process. In total, the inclusion of this qualitative matrix allows for consideration a proposed action based on a collective consideration of qualitative inputs.

The results of the prioritization are provided Table 4.44. This table identifies the alternatives that were originally recommended for inclusion prior to the post-Hurricane Sandy reevaluation of the coastal process features.

Table 4.45 Coastal Process Matrix Evaluation

Transect	Site	Alt	COMBINED ANNUAL COST	Matrix Score	Matrix Rank (1 to 57)	Result of Analysis
2	Sunken Forest	1	$11,599	34.3	48	included
2	Sunken Forest	2	$21,217	26.8	57	included
2	Sunken Forest	3	$82,902	31.3	51	included
~~2~~	~~Sunken Forest~~	~~4~~	~~$89,608~~	~~47.9~~	~~15~~	~~not supported~~
3	Reagan Property	1	$5,612	35.5	45	included
3	Reagan Property	2	$17,018	35.0	47	included
3	Reagan Property	3	$9,524	38.8	35	included
5	Great Gunn	1	$4,792	50.7	7	included
5	Great Gunn	2	$6,636	43.2	24	included
5	Great Gunn	3	$15,399	27.0	56	included
~~5~~	~~Great Gunn~~	~~4~~	~~$35,862~~	~~49.9~~	~~8~~	~~not supported~~
7	Tiana	1	$5,990	50.9	6	included
7	Tiana	2	$969	39.4	34	included
7	Tiana	3	$2,789	54.3	2	included
8	WOSI	1	$540	41.3	30	included
8	WOSI	2	$8,365	40.3	32	included
8	WOSI	3	$1,942	38.8	35	included
8	WOSI	4	$52,862	49.7	9	included
~~9~~	~~Georgica Pond~~	~~1~~	~~$395,716~~	~~36.2~~	~~43~~	~~not supported~~
~~9~~	~~Georgica Pond~~	~~2~~	~~$78,943~~	~~36.4~~	~~42~~	~~not supported~~
~~9~~	~~Georgica Pond~~	~~3~~	~~$162,971~~	~~40.9~~	~~31~~	~~not supported~~
10	East Inlet Island	1	$3,197	45.1	21	included
10	East Inlet Island	2	$960	38.6	38	included
~~10~~	~~East Inlet Island~~	~~3~~	~~$14,883~~	~~28.7~~	~~54~~	~~not supported~~
11	John Boyle Island	1	$1,941	41.3	29	included
~~11~~	~~John Boyle Island~~	~~2~~	~~$4,465~~	~~28.9~~	~~53~~	~~not supported~~
11	John Boyle Island	3	$6,193	27.8	55	included
~~14~~	~~Ocean Beach~~	~~1~~	~~$326,539~~	~~49.5~~	~~11~~	~~not supported~~
~~14~~	~~Ocean Beach~~	~~2~~	~~$25,535~~	~~41.6~~	~~28~~	~~not supported~~
~~14~~	~~Ocean Beach~~	~~3~~	~~$164,386~~	~~56.3~~	~~1~~	~~not supported~~
15	New Made Island	1	$7,664	44.3	23	included
~~15~~	~~New Made Island~~	~~2~~	~~$4,766~~	~~33.3~~	~~49~~	~~not supported~~
~~15~~	~~New Made Island~~	~~3~~	~~$4,538~~	~~29.4~~	~~52~~	~~not supported~~
22	Islip Meadows	1	$8,961	41.9	27	included
~~22~~	~~Islip Meadows~~	~~2~~	~~$178,078~~	~~45.2~~	~~20~~	~~not supported~~
22	Islip Meadows	3	$3,822	46.0	16	included
23	Seatuck Refuge	1	$30,800	44.4	22	included
23	Seatuck Refuge	2	$176,353	48.0	14	included
23	Seatuck Refuge	3	$58,119	52.1	4	included
~~24~~	~~Davis Park~~	~~1~~	~~$2,954~~	~~37.6~~	~~39~~	~~not supported~~
~~24~~	~~Davis Park~~	~~2~~	~~$70,029~~	~~35.9~~	~~44~~	~~not supported~~
~~24~~	~~Davis Park~~	~~3~~	~~$49,838~~	~~46.0~~	~~16~~	~~not supported~~
~~25~~	~~Atlantique to Corneille~~	~~1~~	~~$28,474~~	~~46.0~~	~~16~~	~~not supported~~
25	Atlantique to Corneille	2	$5,962	36.7	41	included

25	Atlantique to Corneille	3	$21,419	38.6	37	included
~~26~~	~~Kismet~~	~~1~~	~~$26,319~~	~~43.2~~	~~25~~	~~not supported~~
~~26~~	~~Kismet~~	~~2~~	~~$367,973~~	~~51.0~~	~~5~~	~~not supported~~
~~26~~	~~Kismet~~	~~3~~	~~$151,594~~	~~45.5~~	~~19~~	~~not supported~~
27	Warner Island East	1	$44,315	43.1	26	included
~~27~~	~~Warner Island East~~	~~2~~	~~$35,209~~	~~35.3~~	~~46~~	~~not supported~~
~~27~~	~~Warner Island East~~	~~3~~	~~$33,082~~	~~32.3~~	~~50~~	~~not supported~~
~~28~~	~~Atlantique~~	~~1~~	~~$20,108~~	~~39.9~~	~~33~~	~~not supported~~
~~28~~	~~Atlantique~~	~~2~~	~~$159,758~~	~~53.6~~	~~3~~	~~not supported~~
~~28~~	~~Atlantique~~	~~3~~	~~$813,273~~	~~48.8~~	~~13~~	~~not supported~~
~~29~~	~~Fair Harbor~~	~~1~~	~~$23,857~~	~~37.0~~	~~40~~	~~not supported~~
~~29~~	~~Fair Harbor~~	~~2~~	~~$411,280~~	~~49.6~~	~~10~~	~~not supported~~
~~29~~	~~Fair Harbor~~	~~3~~	~~$933,709~~	~~49.1~~	~~12~~	~~not supported~~

Summary of Coastal Process Feature findings.

The above table illustrates the findings prior to the Hurricane Sandy Reanalysis. While these results are presented in terms of “base-plans” that the expectation is that these measures are combined. This list accounts for land owner support of these alternatives at that time. If an alternative was identified as clearly not having land-owner support, it was eliminated from consideration.

5. Phase 3, Alternative Plan Evaluation

The prior chapters present the results of the screening of alternatives, and the evaluation of the detailed design alternatives. This chapter of the report presents the integration of the alternatives and the effects of combining these measures.

A. *Identification of Coastal Storm Risk Management Alternatives by Reach*

The Cost Effectiveness analyses identified that a wide range of the individual alternatives are cost effective options for Coastal Storm Risk Management. The analyses also illustrate that no one alternative addresses all the storm damage reduction problems: addressing multiple problems requires multiple solutions. In this respect, many of the alternatives complement each other, and Alternative Plans benefit from combinations of alternatives.

The combinations of Alternative Plans have been developed in accordance with the procedures in the Planning Overview Chapter and the FIMP Project Vision Statement. The approach gives first priority to management options, particularly options that restore natural processes. The second priority is to include non-structural 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, and also places a priority on avoiding or minimizing any negative environmental impacts. This approach also considers the entire area as a system.

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), Non- Structural Alternatives (Plan 2), and Structural Alternatives (Plan 3). 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.

1. *Plan 1.*

The first series of plans (Plans 1.a and 1.b) reflect combinations of Management Alternatives & have combined the Inlet Management and BRP Alternatives. The Inlet Management Alternative includes continuation of the authorized project at the inlet, plus additional bypassing of sand from the ebb shoal to offset the erosion deficit. Inlet Management Alternatives are included because they meet both Restoration and Storm Damage Reduction objectives and reestablishes coastal processes. Inlet Management is compatible with all plans in the Great South Bay, Moriches Bay and Shinnecock Bay reaches. Two of the BRP alternatives have been selected for evaluation in the combined Plans. The 13 ft. NGVD BRP Closure Alternative is selected because it maximizes the BRP Storm Damage Reduction Benefits. The 9.5 ft. NGVD BRP Closure Alternative is selected because it maximizes opportunities to restore cross shore transport. Plan 1 is illustrated in Figure 5.1

Plan 1.a is based on the combination of the economically optimum Inlet Management Alternative and BRP Alternative (13 ft. NGVD BRP). Plan 1.b combines the optimum Inlet Management Alternative with the 9.5 ft. NGVD BRP Alternative. Tables 5.1 through 5.3 provide summaries of the Storm Damage Reduction Benefits, Costs and Benefit Cost Ratios for the Management Only Plans. Plans are presented for both comprehensive plans covering the Great South Bay (GSB), Moriches Bay (MB) and Shinnecock Bay (SB), and for each of the three bays separately.

Table 5.1 Annual Benefits

Plan 1 – Management Only

	Plan 1a	**Plan 1b**
Benefit Category	Inlet Management BCP 13	Inlet Management BCP 9.5
Inundation	$0	$0
Mainland	$280,000	$280,000
Barrier	$40,000	$40,000
Total Inundation	*$320,000*	*$320,000*
Breach		
Inundation	$8,980,000	$8,840,000
Structure Failure	$230,000	$240,000
Total Breach	*$9,210,000*	*$9,080,000*
Shorefront	$0	$0
Total Storm Damage Reduction	*$9,530,000*	*$9,400,000*
Costs Avoided		
Breach Closure	$2,160,000	$2,160,000
Beach Maintenance	$0	$0
Total Benefits	***$11,690,000***	***$11,560,000***

Discount Rate: 5.0125%, FY 08 PL, 50 year study period.

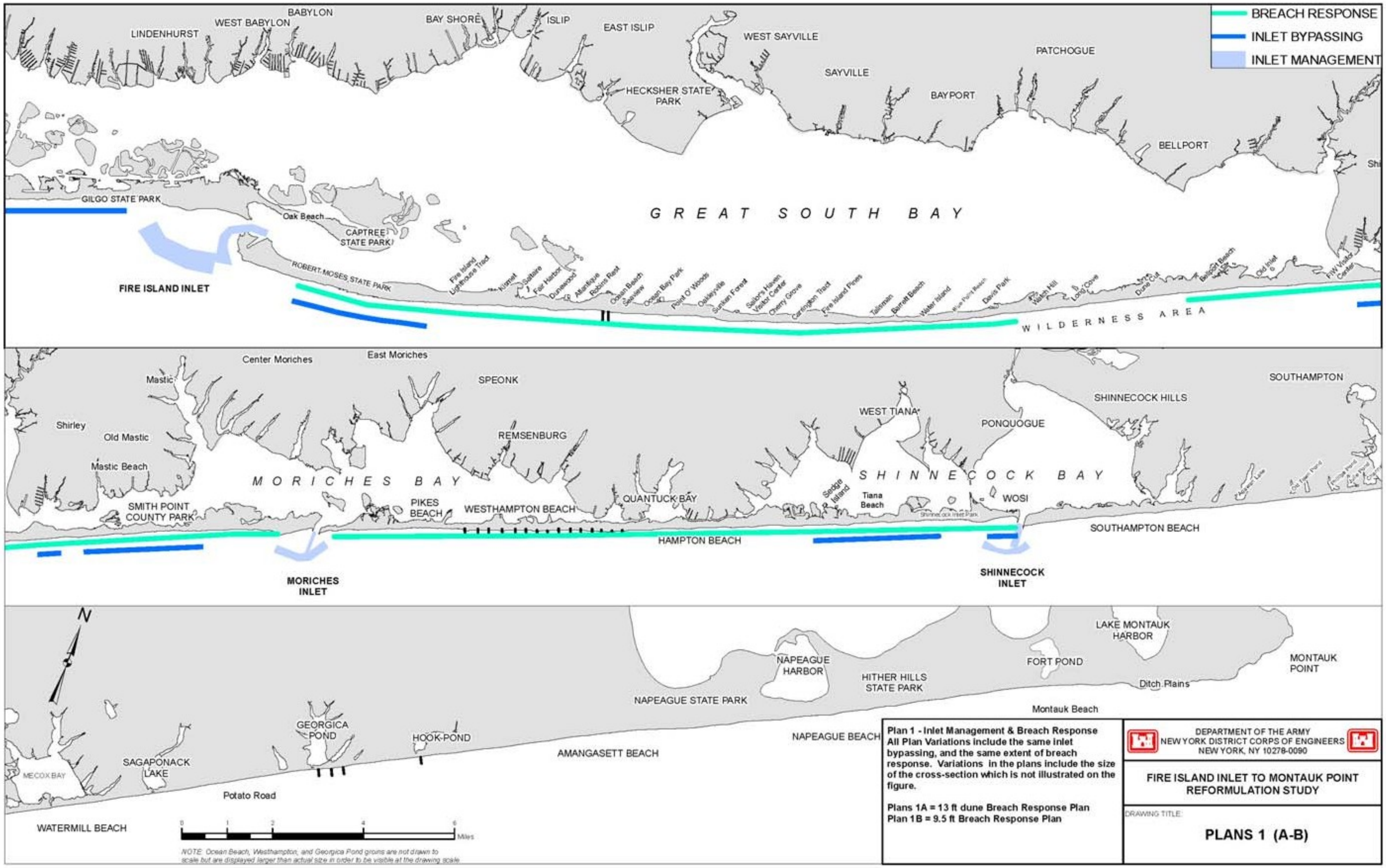


Figure 5.1 Plan 1 Overview

Table 5.2 Annual Cost

Plan1 – Management Only

	Plan 1.a	Plan 1.b
Cost Category	Inlet Management BCP 13	Inlet Management BCP 9.5
Beachfill	$0	$0
Nonstructural	$0	$0
Road Raising	$0	$0
Total First Cost	$0	$0
Total IDC	$0	$0
Total Investment Cost	$0	$0
Interest and Amortization	$0	$0
Operation & Maintenance	$7,000,000	$7,300,000
Renourishment	$0	$0
Subtotal	*$7,000,000*	*$7,300,000*
Annual Breach Closure Cost	$800,000	$1,100,000
Major Rehabilitation	$0	$0
Total Annual Cost	***$7,800,000***	***$8,400,000***

Discount Rate: 5.0125%, FY 08 PL, 50 year study period.

Table 5.3 Net Benefits and BCR, By Project Reach

Plan 1 – Management Only,

	Plan 1.a	Plan 1.b
Component	Inlet Management BCP 13	Inlet Management BCP 9.5
Total Project		
Total Annual Cost	$7,800,000	$8,400,000
Total Benefits	$11,700,000	$11,600,000
Net Benefits	$3,900,000	$3,200,000
Benefit-Cost Ratio	1.5	1.38
Project Reaches		
Great South Bay		
Total Annual Cost	$2,800,000	$3,200,000
Total Benefits	$9,100,000	$8,900,000
Net Benefits	$6,300,000	$5,700,000
Benefit-Cost Ratio	3.2	2.78
Moriches Bay		
Total Annual Cost	$3,700,000	$3,800,000
Total Benefits	$2,100,000	$2,100,000
Net Benefits	-$1,600,000	-$1,700,000
Benefit-Cost Ratio	0.56	0.55
Shinnecock Bay		
Total Annual Cost	$1,400,000	$1,400,000
Total Benefits	$500,000	$500,000
Net Benefits	-$900,000	-$900,000
Benefit-Cost Ratio	0.35	0.35

Discount Rate: 5.0125%, FY 08 PL, 50 year study period.

Cost Effectiveness Evaluation

The Management Plans provide Storm Damage Reduction by increasing longshore sediment transport, which reduces erosion on the barrier islands, and by reducing the potential impact of breaches. The reduction in shoreline erosion associated with increased longshore sediment transport will provide a wide range of benefits to both the natural and built environments including a reduction in storm damage due to breaching, increases in future Back Bay flooding and reduced erosion and wave damage to shorefront development. The management alternatives will also have a positive impact on maintaining future beach widths at several important recreation sites including Robert Moses State Park, Smith Point County Park, and Tiana Beach, including Shinnecock County Park and Town Park. Overall this plan is economically viable; however, when excluding the impact of recreation, the economic analysis of the Management Plans indicates that at some locations the Plans provide a Benefit to Cost Ratio (BCR) of less than 1. This is generally a result of the high cost of the increased bypassing relative to the measurable Storm Damage Reduction Benefits. Because bypassing is such a critical component to restoring physical processes in the study area it has been incorporated into the remaining plans.

P&G Evaluation. The existing Principles and Guidelines establish that alternative plans should be complete, effective, efficient and implementable. This evaluation discusses how well these alternative plans meet these objectives. The alternatives that combine inlet bypassing and breach response plans are not complete solutions. These plans address the storm damage problems associated with a breach being open, and help to address the chronic erosion in the vicinity of inlets, but only address 10% of the damages that are likely to occur in the study area, and have a high level of residual damages. Under this alternative there would still remain a high level of damages to the shorefront, a high likelihood of recurring breaches, and a high likelihood of damages due to flooding along the bayside shoreline. Based purely on the storm damage reduction these plans are marginally effective, and marginally efficient. These alternative plans are implementable. NYS, though the Governor's Coastal Erosion Task Force supports bypassing and breach closure. The specific details related to breach closure will need to be coordinated with the USFWS, and FIIS, to ensure that the closure procedures are consistent with their requirements.

Vision Evaluation of Plan 1 Alternatives

The Plan 1 alternatives (Plan 1a and Plan 1b) were evaluated in relationship to the planning criteria developed to reflect the Project objectives and the project approach delineated in the "Vision Statement for the Reformulation Study". This systematic assessment ensures that the Vision Statement approach is fully integrated into the development and selection of the FIMP Plan, and builds on the evaluation of individual plan components provided in Chapter 4. Table 5.4 provides a summary of the evaluation of these measures relative to the established criteria.

Table 5.4 Plan 1 (Plan 1.a and 1.b): Inlet Management Measures + BCP

Evaluation Criteria	Assessment	Rating
The plan provides identifiable reductions in risk from future storm damage.	The Plans help to avoid excessive erosion in areas affected by inlets. This provides reduced risk of bayside flooding and reduced erosion at beaches downdrift of the Inlet or breach locations.	Full
The plan 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.	The selected sediment management measures are based on the observed historical inlet responses and extensive modeling of inlet dynamics and morphology. Breach closure has been the general practice in study area since the response to the 1938	Full
The plan addresses the various causes of flooding, including open coast storm surge, storm surge 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.	Sediment management may reduce flooding by preventing local areas of accelerated erosion, thus reducing flooding associated with periodic overwash or breaching of barrier islands.	Partial
The plan incorporates appropriate non-structural features to provide both storm damage protection and to restore coastal processes and ecosystem integrity	The Plan represents enhanced management of existing resources. The inlet and sediment management measures maintain both storm damage protection and directly restores longshore sediment transport, contributing to ecosystem integrity. The BCP provides enhanced breach response decision making. In some cases the more rapid breach closure will reduce cross shore sediment	Partial
The plan or measure help protect and restore coastal landforms and natural habitat.	Sediment management helps to reduce or eliminate deficits in longshore sediment transport and is important for the protection of landforms and habitat. The BCP decision process help protect some existing barrier and bayside habitats, but may reduce the extent of bayside	Partial
The plan avoids or minimizes adverse environmental impacts	The use of improved sediment and breach management reduces the volume of breach closure or other dredging, reducing impacts.	Full

	Construction activities for inlet management are scheduled to avoid or minimize impacts. For breach closure, response protocols have been developed to minimize any adverse impacts.	
The plan addresses long-term demands for public resources.	The plan incorporates required navigation maintenance to provide future cost efficiencies. Future monitoring and restoration to maintain the beach profile to prevent repetitive breaching and limit future	Full
Dune and beach nourishment measures consider both storm damage reduction, restoration of natural processes, and environmental effects.	Locations for placement of bypassed sediment provide both storm damage reduction and restoration. The BCP decision process balances CSRM needs and environmental effects.	Full
The plan incorporates appropriate alterations of existing shoreline stabilization structures	NA	NA
The plan incorporates appropriate alterations of inlet stabilization measures and dredging practices	Measures to alter dredging practices were considered more appropriate than structural changes to the inlets.	Full
The plan is efficient and represents a cost effective use of resources	The measures provide significant economic and process restoration. BCP measures are highly cost effective in providing CSRM.	Partial
The plan reduces risks to public safety.	Inlet management measures maintain navigation safety and contribute to increased storm protection, and BCP reduces risk of hazardous storm surge in the bay and excessive shoaling of navigation inlets.	Full

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 per year at each inlet. The results of the above analysis, 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:

- The plan doesn't address all the contributors to damages
- The plan doesn't fully address the need for non-structural measures to provide both storm damage reduction and ecosystem integrity
- The plan does not fully address the needs for protection and restoration of natural landforms and habitat
- 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.

2. ***Plan 2.***

The second series of plans (Plan 2.a through Plan 2.h) reflect the addition of non-structural protection to Plan 1.a and Plan 1.b. The inclusion of non-structural protection is considered essential to address flooding from storm surge propagating through inlets into the bays and wind and wave setup within the bays. The Non Structural Alternatives selected for consideration in Plan 2 include both the economically optimum Alternative NS2, which provides protection to 3,400 structures, and Alternative NS2-r, which supplements the non-structural features by raising selected roadways. In addition, the NS3 and NS3-r Alternatives, which cumulatively provide Storm Damage Reduction Benefits to an additional 2,000 buildings over NS2, have also been included. These plans are shown in Figure 5.2.

Tables 5.5 through 5.7 present the Storm Damage Reduction Benefits, Annual Costs and Benefit Cost Ratios for Plans 2.a through 2.h. Plans 2.a through 2.d include combinations of the Management and Non-structural Alternatives without the Road Raising features, while plans 2.e through 2.h include the same combinations but with the addition of Road Raising at four locations as described in Chapter 4. Each of the overall Plans provides a BCR of 1.3 or higher, and each of the Project Reaches has a BCR of greater than 1.1.

As seen in Tables 5.5 through 5.7, combining Inlet Management and Non-structural Alternatives to develop Alternative Plans does not alter which Breach Closure design and which Non-structural Alternative provide the most Storm Damage Reduction Benefits in excess of costs. The primary Storm Damage Reduction Benefits of Plans 2.a through 2.h are the reduction of structure and content damage due to high frequency flooding of residential development within the bays. This high frequency flooding is generally a result of surge through the inlets and wind setup within the bays. With the exception of the locations proposed for road raising, Plans 2.a through 2.h will have very little impact on actual water levels, and will not provide substantial reductions in emergency response & evacuation costs or car damage.

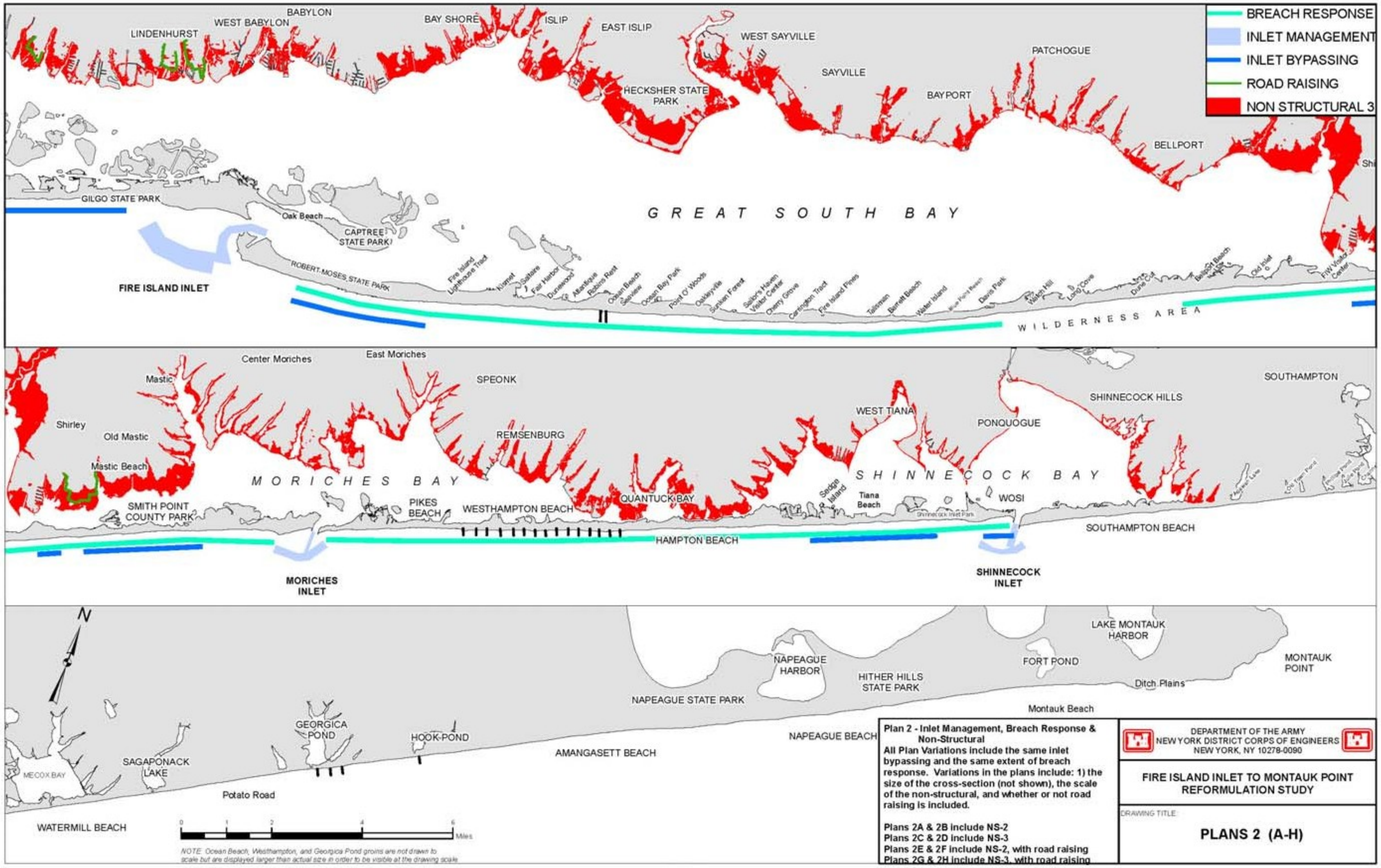


Figure 5.2 Alternative Plan 2 Overview

Table 5.5 – Annual Benefits

Plan 2 – Management & Non-Structural Plans

Benefit Category	Plan 2a	Plan 2b	Plan 2c	Plan 2d	Plan 2e	Plan 2f	Plan 2g	Plan 2h
	Inlet Management BCP 9.5, NS 2	Inlet Management BCP 13, NS 2	Inlet Management BCP 9.5, NS 3	Inlet Management BCP 13, NS 3	Inlet Management BCP 9.5, NS2, Road Raising	Inlet Management BCP 13, NS2, Road Raising	Inlet Management BCP 9.5, NS 3, Road Raising	Inlet Management BCP 13, NS 3, Road Raising
Inundation								
Mainland	$38,410,000	38,410,000	$45,270,000	$45,270,000	$40,020,000	$40,020,000	$46,500,000	$46,500,000
Barrier	$40,000	$40,000	$40,000	$40,000	$40,000	$40,000	$40,000	$40,000
Total Inundation	*$38,450,000*	*$38,450,000*	*$45,310,000*	*$45,310,000*	*$40,060,000*	*$40,060,000*	*$46,540,000*	*$46,540,000*
Breach								
Inundation	$8,840,000	$8,980,000	$8,840,000	$8,980,000	$8,840,000	$8,980,000	$8,840,000	$8,980,000
Structure Failure	$240,000	$230,000	$240,000	$230,000	$240,000	$230,000	$240,000	$230,000
Total Breach	*$9,080,000*	*$9,210,000*	*$9,080,000*	*$9,210,000*	*$9,080,000*	*$9,210,000*	*$9,080,000*	*$9,210,000*
Shorefront	$0	$0	$0	$0	$0	$0	$0	$0
Total Storm Damage Reduction	*$47,530,000*	*$47,660,000*	*$54,390,000*	*$54,520,000*	*$49,140,000*	*$49,270,000*	*$55,620,000*	*$55,750,000*
Costs Avoided								
Breach Closure	$2,160,000	$2,160,000	$2,160,000	$2,160,000	$2,160,000	$2,160,000	$2,160,000	$2,160,000
Beach Maintenance	$0	$0	$0	$0	$0	$0	$0	$0
Total Benefits	***$49,690,000***	***$49,820,000***	***$56,550,000***	***$56,680,000***	***$51,300,000***	***$51,430,000***	***$57,780,000***	***$57,910,000***

Discount Rate: 5.0125%, FY 08 PL, 50 year study period.

Table 5.6 – Annual Cost

Plan 2 – Management & Non-Structural Plans

Cost Category	**Plan 2a** Inlet Management BCP 9.5, NS 2	**Plan 2b** Inlet Management BCP 13, NS 2	**Plan 2c** Inlet Management BCP 9.5, NS 3	**Plan 2d** Inlet Management BCP 13, NS 3	**Plan 2e** Inlet Management BCP 9.5, NS2, Road Raising	**Plan 2f** Inlet Management BCP 13, NS2, Road Raising	**Plan 2g** Inlet Management BCP 9.5, NS 3, Road Raising	**Plan 2h** Inlet Management BCP 13, NS 3, Road Raising
Beachfill	$0	$0	$0	$0	$0	$0	$0	$0
Nonstructural	$435,400,000	$435,400,000	$590,500,000	$590,500,000	$407,000,000	$407,000,000	$550,600,000	$550,600,000
Road Raising	$0	$0	$0	$0	$15,000,000	$15,000,000	$15,000,000	$15,000,000
Total First Cost	*$435,400,000*	*$435,400,000*	*$590,500,000*	*$590,500,000*	*$422,000,000*	*$422,000,000*	*$565,600,000*	*$565,600,000*
Total IDC	$13,800,000	$13,800,000	$18,700,000	$18,700,000	$13,300,000	$13,300,000	$17,800,000	$17,800,000
Total Investment Cost	*$449,300,000*	*$449,300,000*	*$609,300,000*	*$609,300,000*	*$435,300,000*	*$435,300,000*	*$583,500,000*	*$583,500,000*
Interest and Amortization	$25,100,000	$25,100,000	$34,000,000	$34,000,000	$24,300,000	$24,300,000	$32,600,000	$32,600,000
Operation & Maintenance	$7,100,000	$7,300,000	$7,300,000	$7,100,000	$7,300,000	$7,100,000	$7,300,000	$7,100,000
Renourishment	$0	$0	$0	$0	$0	$0	$0	$0
Subtotal	*$32,400,000*	*$32,100,000*	*$41,300,000*	*$41,100,000*	*$31,600,000*	*$31,400,000*	*$39,900,000*	*$39,600,000*
Annual Breach Closure Cost	$1,100,000	$800,000	$1,100,000	$800,000	$1,100,000	$800,000	$1,100,000	$800,000
Major Rehabilitation	$0	$0	$0	$0	$0	$0	$0	$0
Total Annual Cost	***$33,500,000***	***$32,900,000***	***$42,400,000***	***$41,800,000***	***$32,700,000***	***$32,100,000***	***$41,000,000***	***$40,400,000***

Discount Rate: 5.0125%, FY 08 PL, 50 year study period.

Table 5.7 Net Benefits and BCR, By Project Reach

Plan 2 – Management & Non-Structural Plans

Component	Plan 2a	Plan 2b	Plan 2c	Plan 2d	Plan 2e	Plan 2f	Plan 2g	Plan 2h
	Inlet Management BCP 9.5, NS 2	Inlet Management BCP 13, NS 2	Inlet Management BCP 9.5, NS 3	Inlet Management BCP 13, NS 3	Inlet Management BCP 9.5, NS2, Road Raising	Inlet Management BCP 13, NS2, Road Raising	Inlet Management BCP 9.5, NS 3, Road Raising	Inlet Management BCP 13, NS 3, Road Raising
Total Project								
Total Annual Cost	$33,500,000	$32,900,000	$42,400,000	$41,800,000	$32,700,000	$32,100,000	$41,000,000	$40,400,000
Total Benefits	$49,700,000	$49,800,000	$56,500,000	$56,700,000	$51,300,000	$51,400,000	$57,800,000	$57,900,000
Net Benefits	$16,200,000	$16,900,000	$14,100,000	$14,800,000	$18,600,000	$19,300,000	$16,800,000	$17,500,000
Benefit-Cost Ratio	1.5	1.5	1.3	1.4	1.6	1.6	1.4	1.4
Project Reaches								
Great South Bay								
Total Annual Cost	$19,200,000	$18,800,000	$24,000,000	$23,500,000	$19,100,000	$18,700,000	$23,800,000	$23,400,000
Total Benefits	$30,000,000	$30,100,000	$33,800,000	$33,900,000	$31,100,000	$31,200,000	$34,900,000	$35,000,000
Net Benefits	$10,800,000	$11,300,000	$9,900,000	$10,400,000	$11,900,000	$12,500,000	$11,100,000	$11,600,000
Benefit-Cost Ratio	1.6	1.6	1.4	1.4	1.6	1.7	1.5	1.5
Moriches Bay								
Total Annual Cost	$10,700,000	$10,500,000	$12,800,000	$12,700,000	$9,900,000	$9,800,000	$11,500,000	$11,400,000
Total Benefits	$13,100,000	$13,100,000	$14,500,000	$14,500,000	$13,600,000	$13,600,000	$14,700,000	$14,700,000
Net Benefits	$2,400,000	$2,600,000	$1,700,000	$1,800,000	$3,700,000	$3,800,000	$3,200,000	$3,300,000
Benefit-Cost Ratio	1.2	1.2	1.1	1.1	1.4	1.4	1.3	1.3
Shinnecock Bay								
Total Annual Cost	$3,600,000	$3,500,000	$5,500,000	$5,500,000	$3,600,000	$3,500,000	$5,500,000	$5,500,000
Total Benefits	$6,600,000	$6,600,000	$8,200,000	$8,200,000	$6,600,000	$6,600,000	$8,200,000	$8,200,000
Benefit-Cost Ratio	$3,000,000	$3,100,000	$2,700,000	$2,700,000	$3,000,000	$3,100,000	$2,700,000	$2,700,000
Benefit-Cost Ratio	1.8	1.9	1.5	1.5	1.8	1.9	1.5	1.5

Discount Rate: 5.0125%, FY 08 PL, 50 year study period.

Evaluation of Plan 2 Alternatives

<u>Cost Effectiveness Evaluation.</u> The analysis of these alternatives show that all of the alternatives that include breach response, inlet modifications, and mainland non-structural measures 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 NS-2 with road raising may appear to be the preferred plan, but as discussed in Chapter 4, Alternative 2h includes a significantly larger number of structures to be protected with a design water elevation that is 0.5 ft. larger than NS-2. Since these plans are so close in scale, and provide such similar results, Alternative 2h represents the best plan from this collection of alternative Plan 2.

<u>P&G Evaluation.</u> The existing Principles and Guidelines establish that alternative plans should be complete, effective, efficient and implementable. This evaluation discusses how well these alternative plans meet these objectives. These alternatives that combine inlet bypassing, breach response plans, and mainland non-structural alternatives are still not complete solutions. These plans address the storm damage problems associated with a breach being open, address the chronic erosion in the vicinity of inlets, and address damages due to flooding along the bayside shoreline. Combined, these plans address approximately 50% of the damages that are likely to occur in the study area. While these plans are better, they still have a relatively high level of residual damages. Under this alternative there would still remain a high level of damages to the shorefront, and a high likelihood of recurring breaches. Based purely on the storm damage reduction these plans are effective, and efficient. These alternative plans are implementable. As discussed previously, there is general support for bypassing and breach closure, with specific details that need to be coordinated with the USFWS, and FIIS, to ensure that the closure procedures are consistent with their requirements. There are no institutional limitations in implementing Non-structural measures. It must be recognized however, that non-structural plans to retrofit 5,000 buildings, is a difficult undertaking, which requires voluntary participation, and would likely require multiple decades to implement.

<u>Vision Criteria Evaluation.</u> The alternatives of Plan 2 (2a to 2h) were evaluated in relationship to the planning criteria developed to reflect the Project objectives and the project approach delineated in the "Vision Statement for the Reformulation Study". This systematic assessment ensures that the Vision Statement approach is fully integrated into the development and selection of the FIMP Plan. Table 5.8 provides a summary of the evaluation of these measures relative to the established criteria.

Table 5.8 Plan 2 Alternatives (Inlet Management and BCP plus Non-Structural Retrofit)

Evaluation Criteria	Assessment	Rating
The plan or measure provides identifiable reductions in risk from future storm damage.	Inlet management helps avoid excessive erosion in areas affected by inlets. Breach closure provides quantified reduction in storm damage. Non-structural retrofit provides quantifiable reductions in storm damage to the specific structures and contents.	Full

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 considered a lower priority.	The sediment management and BCP components are based on proven application within the Project area. Non-Structural building retrofits are a standard method for flood mitigation. Some individual structures may present design challenges, requiring a comparatively large cost contingency.	Full

The plan or measure addresses the various causes of flooding, including open coast storm surge, storm surge 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 sediment management and BCP components will reduce some flooding from direct ocean storm surge and from periodic overwash or breaching. The non-structural retrofit and road-raising components address bayside flooding from all causes except open coast storm surge, including storm surge propagating through the inlets and wind and wave setup within the bays.	Partial
The plan incorporates appropriate non-structural features to provide both storm damage protection and to restore coastal processes and ecosystem integrity	The plan provides management and non-structural components that contribute to CSRM and help to restore coastal processes and ecosystem integrity.	Partial
The plan helps protect and restore coastal landforms and natural habitat.	The plan will reduce or eliminate deficits in longshore sediment transport and will restore the barrier island landform aft.er a breach. As noted in Table 10.4, more rapid breach closure could reduce the volume cross island transport contributing to the formation of spits and shoals.	Partial
The plan avoids or minimizes adverse environmental impacts	The use of improved sediment and breach management reduces the volume of breach closure or other dredging, reducing impacts. The use of non-structural retrofits may reduce the reliance on structural measures that have larger impacts.	Full

The plan addresses long-term demands for public resources.	The plan incorporates required navigation maintenance to provide future cost efficiencies. Future monitoring and restoration to maintain the beach profile to prevent repetitive breaching and limit future expenses. The non-structural features require no long term public involvement beyond monitoring. The benefits of the non-structural protection will minimize the need for structural	Full
Dune and beach nourishment measures consider both storm damage reduction, restoration of natural processes, and environmental effects.	Locations for placement of bypassed sediment provide both storm damage reduction and restoration. The BCP decision process balances CSRM needs and environmental effects. Non-structural retrofit has no effect.	Full
The plan or measure incorporates appropriate alterations of existing shoreline stabilization structures	N/A	No
The plan incorporates appropriate alterations of inlet stabilization measures and dredging practices	Measures to alter dredging practices were considered more appropriate than structural changes to the inlets. Non-structural retrofit has no effect.	Full.
The plan is efficient and represents a cost effective use of resources	The sediment management measures provide significant economic benefit and environmental process restoration. BCP measures are extremely cost-effective. Non-structural measures are highly cost-effective when targeted to frequently flooded structures.	Full

The plan reduces risks to public safety.	Inlet management measures maintain navigation safety and contribute to increased storm protection, while the BCP reduces risk of hazardous storm surge in the bay and excessive shoaling in navigation inlets. Non-structural measures reduce damage only. It is important to maintain evacuation plans so that residents do not remain in homes that are inaccessible during a flood event. (Note: Plans 2.e through 2.f contain road-raising in limited areas, which may improve evacuation and access by reducing inundation of roads within protected areas and providing means of egress.)	Full

Plan 2 Summary

Plan 2 includes breach response, inlet modifications, and mainland non-structural 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 NS-2 may appear to be the preferred plan, but as discussed in Chapter 4, Alternative 2H includes a significantly larger number of structures to be protected with a design water elevation that is 0.5 ft. larger than NS-2. Since these plans are so close in scale, and provide such similar results, the recommendation would be that Alternative 2H represents the best plan from this collection of alternative plan 2. Alternative 2H includes inlet management at the inlets (consistent with each alternative), a breach response plan with the +13 ft. cross-section, non-structural plan 3, which addresses structures in the existing 10-yr floodplain, and road raising at 4 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 non-structural 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 non-structural efforts along the mainland, the plan doesn't fully address the need for non-structural 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 protection 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. These short- comings can be addressed with the inclusion of the next increment of effort.

3. ***Plan 3***

The third series of plans (Plan 3.a through Plan 3.g) reflects the addition of Beach Nourishment to Plans 2.e through Plan 2.h. The inclusion of Beach Nourishment will more fully address the various sources of flooding and will also address any significant erosion resulting from alterations of the existing shoreline stabilization structures. The Non-structural Alternatives selected for inclusion in these Plans include the Road Raising feature, which provides significant benefits above Plans 2.a through 2.d that exclude this feature.

The Beach Nourishment Alternative included in these Plans is the 15 ft. dune/ 90 ft. berm width design with the minimum real estate alignment. This design and alignment were identified as having the highest net benefits in Chapter 4. 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 in Chapter 4 also identified that the Beach Nourishment Alternatives are not cost effective in reducing storm damage in the Shinnecock Bay, Ponds, and Montauk Reaches. Plans 3.a through 3.g therefore have excluded beach nourishment in these reaches. Within the Shinnecock Bay reach the Breach Contingency Plan with the +13 ft. design section has been included. For Reaches protected by Beach Nourishment, breaches would be closed to the design section as part of the project maintenance 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 significant 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 the Fire Island National Seashore (FIIS), and the 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 3.b through 3.g, 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. closure design has been included. The lower level closure design has been selected for these locations as the alternative most compatible with special environmental concerns. Figure 5.3 illustrates the conceptual layout of alternative plans 3a to 3g.

Tables 5.9 through 5.11 present the Storm Damage Reduction Benefits, Annual Costs and Benefit Cost Ratios for Plans 3.a through 3.g

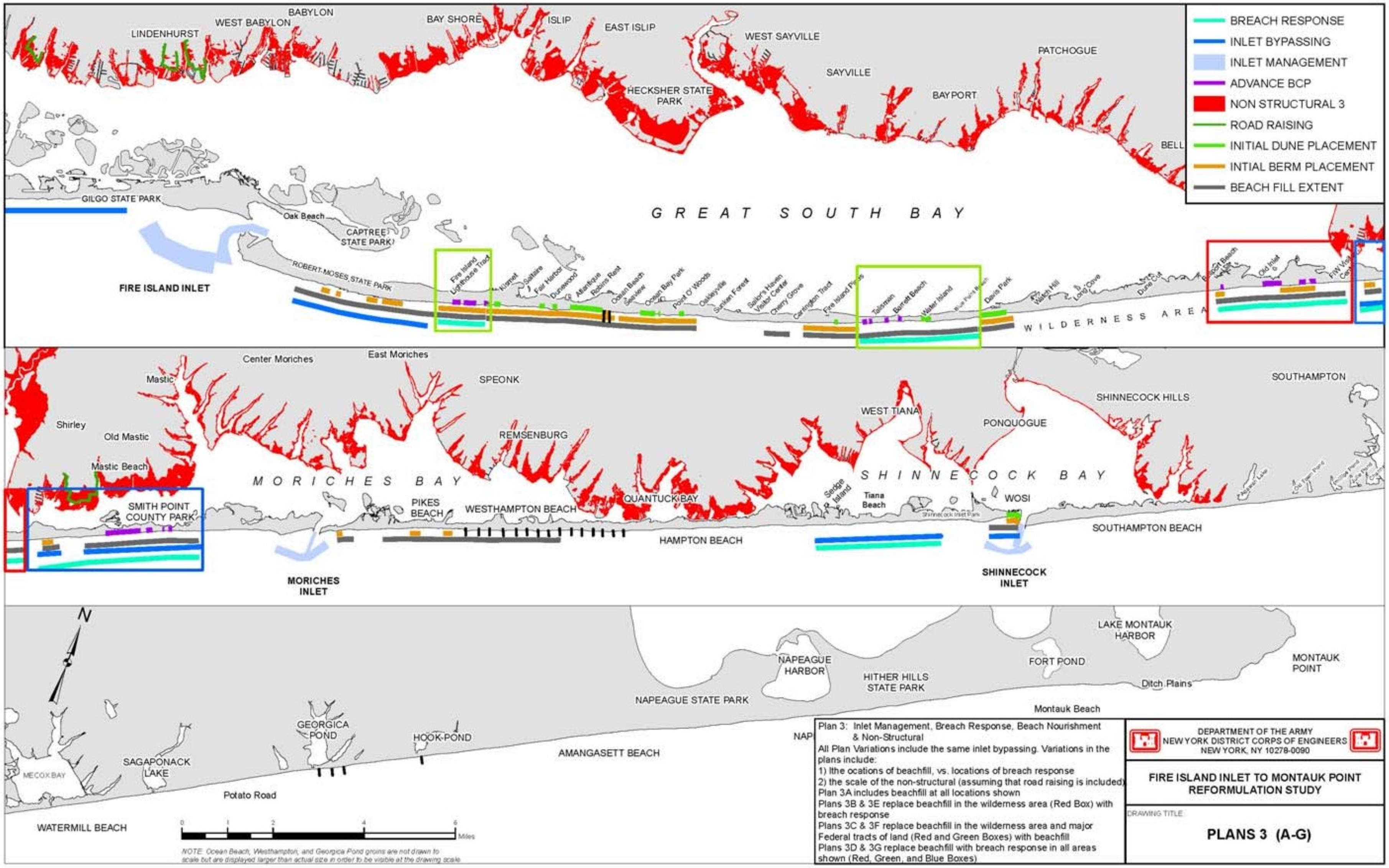


Figure 5.3 Alternative Plan 3 Overview

Table 5.9 – Annual Benefits

Plan 3 – Management, Non-Structural and Beach Nourishment Plans

	Plan 3.a	Plan 3.b	Plan 3.c	Plan 3.d	Plan 3.e	Plan 3.f	Plan 3.g
Benefit Category	Inlet Mgmt, BCP 13 @SB, NS2R, 15ft. Dune @ GSB & MB	Inlet Mgmt, BCP 13 @ SB, BCP 9.5 @ OPWA, NS2R, 15 ft. Dune @ GSB & MB	Inlet Mgmt, BCP 13 @ SB, BCP 9.5 @ OPWA & MFT., NS2R, 15 ft. Dune @ GSB & MB	Inlet Mgmt, BCP 13 @ SB, BCP 9.5 @ OPWA, MFT. & SPCP, NS2R, 15 ft. Dune @ GSB & MB	Inlet Mgmt, BCP 13 @ SB, BCP 9.5 @ OPWA, NS3R, 15 ft. Dune @ GSB & MB	Inlet Mgmt, BCP 13 @ SB, BCP 9.5 @ OPWA & MFT., NS3R, 15 ft. Dune @ GSB & MB	Inlet Mgmt, BCP 13 @ SB, BCP 9.5 @ OPWA, MFT, & SPCP, NS3R, 15 ft. Dune @ GSB & MB
Inundation							
Mainland	$49,020,000	$48,340,000	$46,390,000	$43,260,000	$54,320,000	$52,560,000	$49,600,000
Barrier	$2,510,000	$2,460,000	$1,960,000	$1,890,000	$2,460,000	$1,960,000	$1,890,000
Total Inundation	*$51,540,000*	*$50,800,000*	*$48,350,000*	*$45,160,000*	*$56,780,000*	*$54,510,000*	*$51,500,000*
Breach							
Inundation	$9,230,000	$9,040,000	$8,990,000	$8,920,000	$9,040,000	$8,990,000	$8,920,000
Structure Failure	$370,000	$370,000	$360,000	$360,000	$370,000	$360,000	$360,000
Total Breach	*$9,600,000*	*$9,410,000*	*$9,350,000*	*$9,280,000*	*$9,410,000*	*$9,350,000*	*$9,280,000*
Shorefront	$3,260,000	$3,260,000	$3,250,000	$3,180,000	$3,260,000	$3,250,000	$3,180,000
Total Storm Damage Reduction	*$64,770,000*	*$63,470,000*	*$60,950,000*	*$57,620,000*	*$69,450,000*	*$67,110,000*	*$63,960,000*
Costs Avoided							
Breach Closure	$2,160,000	$2,160,000	$2,160,000	$2,160,000	$2,160,000	$2,160,000	$2,160,000
Beach Maintenance	$2,400,000	$2,400,000	$2,400,000	$2,400,000	$2,400,000	$2,400,000	$2,400,000
Total Benefits	***$68,960,000***	***$68,040,000***	***$65,500,000***	***$62,180,000***	***$74,020,000***	***$71,760,000***	***$68,520,000***

Interest Rate 5.125%, Project Life 50 years

Table 5.10 – Annual Cost

Plan 3 – Management, Non-Structural and Beach Nourishment Plans

	Plan 3.a	**Plan 3.b**	**Plan 3.c**	**Plan 3.d**	**Plan 3.e**	**Plan 3.f**	**Plan 3.g**
Cost Category	Inlet Mgmt, BCP 13 @SB, NS2R, 15ft. Dune @ GSB & MB	Inlet Mgmt, BCP 13 @ SB, BCP 9.5 @ OPWA, NS2R, 15 ft. Dune @ GSB & MB	Inlet Mgmt, BCP 13 @ SB, BCP 9.5 @ OPWA & MFT., NS2R, 15 ft. Dune @ GSB & MB	Inlet Mgmt, BCP 13 @ SB, BCP 9.5 @ OPWA, MFT., & SPCP, NS2R, 15 ft. Dune @ GSB & MB	Inlet Mgmt, BCP 13 @ SB, BCP 9.5 @ OPWA, NS3R, 15 ft. Dune @ GSB & MB	Inlet Mgmt, BCP 13 @ SB, BCP 9.5 @ OPWA & MFT., NS3R, 15 ft. Dune @ GSB & MB	Inlet Mgmt, BCP 13 @ SB, BCP 9.5 @ OPWA, MFT., & SPCP, NS3R, 15 ft. Dune @ GSB & MB
Beachfill	$160,200,000	$148,700,000	$146,000,000	$139,200,000	$148,700,000	$146,000,000	$139,200,000
Nonstructural	$407,200,000	$407,200,000	$407,200,000	$407,200,000	$550,800,000	$550,800,000	$550,800,000
Road Raising	$14,900,000	$14,900,000	$14,900,000	$14,900,000	$14,900,000	$14,900,000	$14,900,000
Total First Cost	*$582,400,000*	*$570,800,000*	*$568,000,000*	*$561,400,000*	*$714,500,000*	*$711,800,000*	*$705,000,000*
Total IDC	$26,600,000	$25,700,000	$25,400,000	$24,900,000	$30,200,000	$30,000,000	$29,400,000
Total Investment Cost	*$609,000,000*	*$596,500,000*	*$593,400,000*	*$586,300,000*	*$744,700,000*	*$741,800,000*	*$734,400,000*
Interest and Amortization	$34,000,000	$33,300,000	$33,100,000	$32,700,000	$41,600,000	$41,400,000	$41,000,000
Operation & Maintenance	*$9,300,000*	*$9,200,000*	*$9,100,000*	*$8,900,000*	*$9,200,000*	*$9,100,000*	*$8,900,000*
Renourishment	*$12,900,000*	*$12,500,000*	*$11,600,000*	*$11,000,000*	*$12,500,000*	*$11,600,000*	*$11,000,000*
Subtotal	*$56,200,000*	*$55,000,000*	*$53,800,000*	*$52,600,000*	*$63,300,000*	*$62,100,000*	*$60,900,000*
Annual Breach Closure Cost	*$0*	*$500,000*	*$600,000*	*$1,000,,000*	*$500,000*	*$600,000*	*$1,000,,000*
Major Rehabilitation	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*
Total Annual Cost	*$56,200,000*	*$55,600,000*	*$54,500,000*	*$53,600,000*	*$63,800,000*	*$62,800,000*	*$61,900,000*

Interest Rate 5.125%, Project Life 50 years

Table 5.11 Net Benefits and BCR, By Project Reach

Plan 3 – Management, Non-Structural and Beach Nourishment Plans

Component	Plan 3.a	Plan 3.b	Plan 3.c	Plan 3.d	Plan 3.e	Plan 3.f	Plan 3.g
	Inlet Mgmt, BCP 13 @SB, NS2R, 15ft. Dune @ GSB & MB	Inlet Mgmt, BCP 13 @ SB, BCP 9.5 @ OPWA, NS2R, 15 ft. Dune @ GSB & MB	Inlet Mgmt, BCP 13 @ SB, BCP 9.5 @ OPWA & MFT., NS2R, 15 ft. Dune @ GSB & MB	Inlet Mgmt, BCP 13 @ SB, BCP 9.5 @ OPWA, MFT., & SPCP, NS2R, 15 ft. Dune @ GSB & MB	Inlet Mgmt, BCP 13 @ SB, BCP 9.5 @ OPWA, NS3R, 15 ft. Dune @ GSB & MB	Inlet Mgmt, BCP 13 @ SB, BCP 9.5 @ OPWA & MFT., NS3R, 15 ft. Dune @ GSB & MB	Inlet Mgmt, BCP 13 @ SB, BCP 9.5 @ OPWA, MFT., & SPCP, NS3R, 15 ft. Dune @ GSB & MB
Total Project							
Total Annual Cost	$56,200,000	$55,600,000	$54,500,000	$53,600,000	$63,800,000	$62,800,000	$61,900,000
Total Benefits	$69,000,000	$68,000,000	$65,500,000	$62,200,000	$74,000,000	$71,700,000	$68,500,000
Net Benefits	$12,800,000	$12,500,000	$11,000,000	$8,600,000	$10,200,000	$8,900,000	$6,600,000
Benefit-Cost Ratio	1.2	1.2	1.2	1.2	1.2	1.1	1.1
Project Reaches							
Great South Bay							
Total Annual Cost	$36,900,000	$36,200,000	$35,200,000	$35,200,000	$40,900,000	$39,900,000	$39,900,000
Total Benefits	$44,900,000	$44,300,000	$41,800,000	$41,300,000	$47,800,000	$45,500,000	$45,000,000
Net Benefits	$8,100,000	$8,100,000	$6,600,000	$6,200,000	$6,800,000	$5,600,000	$5,200,000
Benefit-Cost Ratio	1.2	1.2	1.2	1.2	1.2	1.1	1.1
Moriches Bay							
Total Annual Cost	$15,700,000	$15,700,000	$15,700,000	$14,800,000	$17,300,000	$17,300,000	$16,400,000
Total Benefits	$17,400,000	$17,100,000	$17,100,000	$14,200,000	$18,100,000	$18,000,000	$15,300,000
Net Benefits	$1,700,000	$1,400,000	$1,400,000	-$600,000	$800,000	$700,000	-$1,100,000
Benefit-Cost Ratio	1.1	1.1	1.1	1.0	1.0	1.0	0.9
Shinnecock Bay							
Total Annual Cost	$3,500,000	$3,500,000	$3,500,000	$3,500,000	$5,500,000	$5,500,000	$5,500,000
Total Benefits	$6,600,000	$6,600,000	$6,600,000	$6,600,000	$8,200,000	$8,200,000	$8,200,000
Benefit-Cost Ratio	$3,100,000	$3,100,000	$3,100,000	$3,100,000	$2,700,000	$2,700,000	$2,700,000
Benefit-Cost Ratio	1.9	1.9	1.9	1.9	1.5	1.5	1.5

Cost Effectiveness Analysis. The analysis of plans with beach nourishment reveals that all of the plans are economically viable. Plan 3.a provides greater storm damage reduction benefits than Plan 2f, but the net Storm Damage Reduction Benefits that are less than those of Plan 2.f. Although beach nourishment is cost-effective in providing storm damage reduction as a first-added or stand-alone measure, there is some duplication in benefits between the BCP and non-structural measures of Plan 2f, and the additional beachfill in Plan 3.

The results of this analysis also indicate that eliminating sections of beach nourishment from the Great South Bay and Moriches Bay reaches, and replacing these features with breach response, results in increases in damages that are greater than the reductions in cost. Plan 3.d, for example results in an approximately $7,000,000 increase in annual damage and a $3,000,000 decrease in annual cost relative to Plan 3.a. These breach response alternatives were evaluated considering a responsive plan, and a breach maintenance plan that requires a significant amount of dune lowering and beach loss, prior to action being taken (and no maintenance in the wilderness area). If the triggers for implementation were adjusted to establish action being taken when the beach and dune contains a greater volume of material than presently considered, the costs for breach response would be higher but less than for beach nourishment. Similarly, as the trigger for breach response gets larger, the benefits would increase, and eventually approach the benefits for beachfill. Therefore, the costs and benefits are bracketed by the alternatives that have been evaluated. This illustrates that the breach triggers could be increased in scale to account for a larger breach threshold trigger and remain economically viable, so long as the annual costs are less than the beachfill plan.

An important result of this analysis to note is that when the non-structural and beach nourishment components of the project are combined, the overall project remains economically justified for all combinations evaluated. This result was anticipated because the non-structural plan is targeted to the structures that flood most frequently, meaning that most of the damage reduced by the non-structural components is caused by flow through the inlets and local wind and wave setup, not by overwash or breaching of the barrier islands. In contrast, the back bay damage reduction for the beach nourishment component is related to damage from more extreme events that cause overwash or breaching. The results are plans that are highly complementary in addressing damage from both high frequency repetitive flooding, and the potential for elevated water levels during larger, less frequent events.

There are concerns regarding the rate at which the non-structural measures could be constructed, and the overall time required for full construction. Practical constraints include the availability of funding, availability of trained construction workforce, and development of effective implementation strategies. Thus, full implementation of the non-structural measures is expected to take a significant period of time.

The BCP and beachfill measures are typically considered to be constructible more rapidly. When these factors are considered, this would further emphasize the relative benefits, in comparison to the other alternatives.

P&G Evaluation. The existing Principles and Guidelines establish that alternative plans should be complete, effective, efficient and implementable. This evaluation discusses how well these alternative plans meet these objectives. These alternatives that combine inlet bypassing, breach response plans, mainland non-structural alternatives, and shorefront solutions are not complete solutions, but are as complete as any of the alternatives evaluated. These plans address the storm damage problems associated with a breach being open, address the chronic erosion in the vicinity of inlets, address damages due to flooding along the bayside shoreline, address damages that occur due to breach formation, and address shorefront damages. Combined, these plans address approximately 75% of the damages that are likely to occur in the study area. While these plans are the most effective in reducing damages, they still have residual damages. Under this alternative there would still remain the potential for damages due to events that exceed the design, and damages in areas where there are no project features. Based on the storm damage reduction these plans are effective, and efficient. These alternative plans vary in being implementable. As discussed previously, there is general support for bypassing and breach closure, with specific details that need to be coordinated with the USFWS, and FIIS, to ensure that the closure procedures are consistent with their requirements. There are no institutional limitations in implementing Non-structural measures, although the size and voluntary nature of the alternative makes implementing the alternative more difficult. The beachfill component introduces challenges regarding implementation. Generally in community areas beachfill is accepted. Along Fire Island, particularly in areas fronting the Wilderness Area and Major Federal Tracts of Lands there are park service policies which dissuade this practice. In general, alternatives which do not place beachfill in these areas would be considered to be more implementable.

4. ***Evaluation of Plan 3 Alternatives***

The alternatives of Plan 3 (3a to 3g) were evaluated in relationship to the planning criteria developed to reflect the Project objectives and the project approach delineated in the "Vision Statement for the Reformulation Study". This systematic assessment ensures that the Vision Statement approach is fully integrated into the development and selection of the FIMP Plan. Table 5.12 provides a summary of the evaluation of these measures relative to the established criteria.

Table 5.12 Plan 3 Alternatives (Inlet Management and BCP, Non-Structural Retrofit, Beach Nourishment)

Evaluation Criteria	Assessment	Rating
The plan or measure provides identifiable reductions in risk from future storm damage.	Inlet management helps avoid excessive erosion in areas affected by inlets. Breach closure provides quantified reduction in storm damage. Non- structural retrofit provides quantifiable reductions in storm damage to the specific structures and contents. Beach nourishment provides direct protection for structures directly on the shorefront and reduces overwash and breaching.	Full
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 considered a lower priority.	The sediment management and BCP components are based on proven application within the Project area. Non- Structural building retrofits are a standard method for flood mitigation. Some individual structures may present design challenges, requiring a comparatively large cost contingency. Beachfill has been widely used in the project area and other locations, and is readily reversible.	Full
The plan or measure addresses the various causes of flooding, including open coast storm surge, storm surge 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 sediment management and BCP components will reduce some flooding from direct ocean storm surge and from periodic overwash or breaching. , The non-structural retrofit and road-raising components address bayside flooding from all causes except open cast storm surge, including storm surge propagating through the inlets and wind and wave setup within the bays. Beach nourishment addresses open coast storm surge and flow into the bays due to periodic overwash and breaching of barrier islands.	Full
The plan incorporates appropriate non- structural features to provide both storm damage protection and to restore coastal processes and ecosystem integrity	The plan provides management and non- structural components that contribute to CSRM and help to restore coastal processes and ecosystem integrity. The beach nourishment measures help restore littoral transport by reducing sediment deficits. Some alternatives provided beach nourishment only in selected locations, allowing significant cross-shore transport where appropriate.	Partial

The plan helps protect and restore coastal landforms and natural habitat.	The plan will reduce or eliminate deficits in longshore sediment transport and will restore the barrier island landform aft.er a breach. As noted in Table 10.4, more rapid breach closure could reduce the volume of cross island transport contributing to the formation of spits and shoals. The non-structural measures have no direct impact on coastal landforms or natural habitat. At selected locations, beach nourishment will reduce erosion and thus protect adjacent habitat.	Partial
The plan avoids or minimizes adverse environmental impacts	The use of improved sediment and breach management reduces the volume of breach closure or other dredging, reducing impacts. The use of non- structural retrofits may reduce the need for reliance on structural measures that have larger impacts. Some plans avoid renourishment impacts to the Major Federal Tracts on Fire Island, Otis G. Pike Wilderness Area, and/or Smith Point County Park. The selection of borrow areas, limits in dredging windows, and other mitigation measures will reduce impacts of renourishment.	Full
The plan addresses long-term demands for public resources.	The plan incorporates required navigation maintenance to provide future cost efficiencies. Future monitoring and restoration to maintain the beach profile to prevent repetitive breaching and limit future expenses. The non-structural features require no long term public involvement beyond monitoring. The benefits of the non-structural protection will minimize the need for structural protection. The assessment of beach renourishment in Table 10.7 considers periodic renourishment over the project life. Future levels of renourishment, including the profile design and level of maintenance, could be reduced to account for the benefit of non-structural retrofits and remain cost-effective.	Partial

Dune and beach nourishment measures consider both storm damage reduction, restoration of natural processes, and environmental effects.	Locations for placement of bypassed sediment provide both storm damage reduction and restoration. The BCP decision process balances CSRM needs and environmental effects. Non- structural retrofit has no effect. Beach nourishment promotes dune formation and longshore transport. It may reduce the frequency of breach closure because of higher dunes. Significant environmental effects will be minimized by selection and avoidance of certain areas.	Partial
The plan or measure incorporates appropriate alterations of existing shoreline stabilization structures	Use of beach nourishment likely to be a prerequisite for alteration of existing shoreline stabilization structures.	Partial
The plan incorporates appropriate alterations of inlet stabilization measures and dredging practices	Measures to alter dredging practices were considered more appropriate than structural changes to the inlets. Non-structural retrofit and beach nourishment have no effect.	Full.
The plan is efficient and represents a cost effective use of resources	The sediment management measures provide significant economic benefit and environmental process restoration. BCP measures are extremely cost-effective. Non-structural measures are highly cost- effective when targeted to frequently flooded structures. Beach nourishment is cost-effective in certain sections of the study area. The combination plan has a net positive benefit-cost ratio.	Full

The plan reduces risks to public safety.	Inlet management measures maintain navigation safety and contribute to increased storm protection, while the BCP reduces risk of hazardous storm surge in the bay and excessive shoaling in navigation inlets. Non- structural measures reduce damage only. It is important to maintain evacuation plans so that residents do not remain in homes that are inaccessible during a flood event. (Note: Plans 2.e through 2.f contain road-raising in limited areas, which may improve evacuation and access by reducing inundation of roads within protected areas and providing means of egress). Beach nourishment reduces breaching and overwash; reduces damage to shorefront buildings; reduces debris volumes; and eliminates potential hazard of buildings on the public beach (by moving the beach shoreward of existing buildings. Adequate beach width is needed to allow access for school buses, firefighting trucks and construction vehicles. The beachfront is their primary route to access the community areas.	Full

Plan 3 Summary

As discussed in the text above, a review of the analysis of these alternatives shows that the plans of combined inlet management, breach response, non-structural 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. This analysis does show that plans that do not include fill in the Federal tracts of land are economically viable. The plans that provide the greatest net benefits are the alternatives that include fill in the environmentally sensitive areas.

The plans, 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 ecosystem restoration considerations. Plan 3a is the alternative which best addresses the Storm Damage Reduction needs, but includes beachfill throughout , 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. Alternative 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 ecosystem restoration needs. It is also acknowledged that the breach response plans evaluated as part of this plan represent a scenario that introduces the greatest risk. As part of the final design, the breach response protocols can be adjusted to consider opportunities for further reducing the risk, by the establishment of a higher threshold at which action is taken.

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

1. While this plan includes a tremendous amount of non-structural retrofits along the mainland, the plan doesn't fully address the need for non-structural measures to provide both storm damage reduction and ecosystem integrity along the barrier island system.
2. The plan does not fully address the needs for protection and restoration of natural landforms and habitat.
3. The plan does not meet the objective for including appropriate modification of existing structures.
4. The extent to which the plans balance the need for storm damage reduction and habitat restoration, depends largely upon the alongshore extent of the dune fill. As discussed

above, eliminating fill in the environmentally sensitive areas and focusing on protection within the community areas balances this consideration.

5. This plan does not fulfill the Vision objective of addressing the long-term demand for public resources, in that the plan requires a continued commitment to beach renourishment over the life of the project.

It is clear that the alternatives that were developed to meet the storm damage reduction efforts are not sufficient to address these Vision criteria. Addressing these criteria requires the consideration of additional alternatives that are described in the following Chapter.

II. Summary of Alternative Integration

A comparison of Alternative Plans 1, 2 and 3 are included in Table 5.13 below, which shows that Alternative Plan 3 is the plan that more completely addresses the cost effectiveness criteria, the P&G criteria and the Vision Criteria. From the Alternative Plans evaluated within the framework of Plan 3, Plan 3a is the plan that best accomplishes the storm damage reduction objectives, while plan 3g is identified as the plan that best balances the storm damage reduction objectives, the P&G criteria, and the Vision Criteria.

Based upon this analysis of this evaluation, Plan 3a is identified as the plan that best accomplishes the coastal storm risk management objectives, based upon the integration of the alternatives. Plan 3g is identified as the plan that best meets the three objectives of cost effectiveness, the P&G and the Vision.

While these plans address the issues of storm damage reduction, and Plan 3g also advances the P&G requirements, and the Vision Criteria, these plans still do not achieve all of the objectives of the Vision Statement. The following short-comings are identified, and used as the basis for considering additional alternatives in the next Chapter. In the following Chapter, alternative 3a is included for comparison, but Alternative 3g is used to establish the point of departure for considering plan variations to consider the following:

1. The plan doesn't fully address the need for non-structural measures to provide both storm damage reduction and ecosystem integrity along the barrier island system,
2. The plan does not fully address the need for protection and restoration of natural landforms and habitat,
3. The plan does not meet the objective for including appropriate modification of existing structures.

This plan requires a continued commitment to beach renourishment over the life of the project and does not fulfill the Vision objective of addressing the long-term demand for public resources.

Table 5.13 Summary of Alternative Integration Analysis

Evaluation Criteria	Plan 1	Plan 2	Plan 3a	Plan 3g
Cost Effectiveness Criteria	Marginal	Full	**BEST**	Full
P&G Criteria				
- Complete	No	Partial	Yes	Yes
- Effective	Marginal	Yes	Yes	Yes
- Efficient	Marginal	Yes	Yes	Yes
- Implementable	Yes	Yes	Marginal	Yes
Vision Criteria				
The plan or measure provides identifiable reductions in risk from future storm damage.	Full	Full	Full	Full
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
The plan or measure addresses the various causes of flooding, including open coast storm surge, storm surge 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	Full
The plan or measures incorporate appropriate non-structural features provide both storm damage protection and to restore coastal processes and ecosystem integrity	Partial	Partial	Partial	Partial
The plan or measure help protect and restore coastal landforms and natural habitat.	Partial	Partial	Partial	Partial
The plan avoids or minimizes adverse environmental impacts	Full	Full	Partial	Full
The plan addresses long-term demands for public resources.	Full	Full	Partial	Partial
Dune and beach nourishment measures consider both storm damage reduction, restoration of natural processes, and environmental effects.	Full	Full	Partial	Full
The plan or measure incorporates appropriate alterations of existing shoreline stabilization structures	N/A	N/A	Partial	Partial
The plan or measure incorporates appropriate alterations of inlet stabilization measures and dredging practices	Full	Full	Full	Full
The plan or measure is efficient and represents a cost effective use of resources	Partial	Full	Full	Full
The plan or measure reduces risks to public safety.	Full	Full	Full	Full

6. Integration of Features to Advance the Vision Objectives

The results of the integration of the features identifies Plan 3a as the plan that best accomplishes the coastal storm risk management objectives, while Plan 3g is identified as the plan that best balances the coastal storm risk management objectives, the P&G criteria, and the Vision Criteria. This analysis also shows that none of these alternative plans, standing alone, fully meet the Vision Criteria.

A Summary of these two plans is as follows:

Plan 3a is the plan that functions optimally in reducing storm damages, (the plan that maximizes net benefits). Plan 3a includes inlet bypassing at the three inlets, NS-3 with road raising, continuous (as needed) beachfill along Great South Bay, and Moriches bay, and a breach response plan along Shinnecock Bay.

Plan 3g, is the combination of storm damage reduction alternatives that balances the objectives of storm damage reduction, P&G criteria, and Vision Criteria. This plan includes inlet bypassing at the three inlets, NS-3 with road raising, beachfill fronting the communities along Great South Bay, and Moriches Bay, and a breach response plan along unprotected areas of Great South Bay, Moriches Bay, and Shinnecock Bay

These plans accomplish much of the Vision Objectives, but fall short in the following Vision Criteria:

- The plan or measure incorporates appropriate alterations of existing shoreline stabilization structures
- The plan helps protect and restore coastal landforms and natural habitat.
- The plan incorporates appropriate non-structural features to provide both storm damage protection and to restore coastal processes and ecosystem integrity
- The plan addresses long-term demands for public resources.

This chapter considers the integration of additional alternatives to satisfy these Vision requirements. This chapter considers the following.

1. Integration of groin modification alternatives.
2. Integration of coastal process features
3. Integration of appropriate land use and development management alternatives
4. Consideration of the life cycle management of these plans.

    Consideration of Climate Change

    Considerations for Adaptive Management

A. ***Integration of Groin modification alternatives.***

In Chapters 4 and 5 of this appendix, groin modification alternatives were evaluated in the context of storm damage reduction. As described above, the Vision Statement advocates appropriate modification of coastal structures.

Groin modifications for CSRM. As presented in Chapter 4, the evaluation of groin modifications for purposes of storm damage reduction concluded that the existing groin field at Westhampton could be modified by shortening the groins and providing for increased sediment transport to the west, which in turn reduces the need for renourishment in this area. This groin modification would be considered as a storm damage reduction feature. For the groins at Georgica Pond, this analysis determined that the groins should not be modified because studies have shown that they have little measured impact on the downdrift shoreline. Instead, an intensive monitoring plan could be adopted to confirm the effect that the groins are having on the downdrift shorelines, to allow for consideration of future modification. At Ocean Beach, the findings for purposes of CSRM was to not modify the Ocean Beach groins, because of the critical infrastructure located immediately landward of the dune. This analysis acknowledged that modification of the groins at Ocean Beach could help restore alongshore transport, and should be evaluated. Any removal or modification of groins at Ocean Beach would need to include an alternative for the Village of Ocean Beach that would compensate for any negative effects of removal, and under any modification scenario would require the relocation of the Village water supply. Lastly it was recognized that groin modification would have limited effectiveness under any beachfill plans in Alternative 3, because the groins would be largely buried.

In order to improve the effectiveness of plans 3a and 3g in meeting the Vision Criteria, specifically to accomplish the objective of “integrating appropriate modification of shoreline stabilization structures”, the following should be included, and could be considered in both Plans 3a and 3g.

1) The groin field at Westhampton be modified by shortening the groins a length of 70-100 ft. for reducing the renourishment commitment to areas to the west.
2) The groins in the area of Georgica should continue to be monitored to determine if any structure modification is warranted.
3) Modification of the groins at Ocean Beach be undertaken upon relocation of the water-supply. This alternative becomes a factor when considered in conjunction with the desire to reduce the long-term need for renourishment.

A. Integration of Coastal Process Features

Alternative Plans 3a and 3g, developed through the combination of coastal storm risk management alternatives do not fully meet the Vision objectives that "The plan helps protect and restore coastal landforms and natural habitat." The plans partially fulfill this requirements, because sand-bypassing is considered as a coastal process feature that reestablishes the alongshore transport. Plan 3g is also better than plan 3a in accomplishing this objective, since it includes provisions for minimal intervention in the public tracts of lands along Fire Island.

As described in the prior Chapter, the evaluation of coastal process features considered alternatives that would complement the traditional coastal storm risk management alternatives. The criteria used in considering the complementary nature of the coastal process features were: 1) does the restoration increase the SDR effectiveness of the alternative, 2) are there cost efficiencies in implementing the these alternatives, and 3) does the coastal process feature provide a desirable mosaic of habitats that could be altered by the overall project?

As described previously, these coastal process alternatives were originally formulated as plans that achieve both ecosystem restoration objectives and coastal storm risk management objectives, and were combined with the traditional CSRM features to provide an integrated solution for coastal storm risk management. The features described in the prior chapter were included as complementary features. Following Hurricane Sandy, there has been a focus on coastal process features that are included based upon their CSRM contribution. These features are an important element of the Reformulation effort to achieve the Vision Objectives, and identification of a mutually agreeable plan between the Army and the Department of the Interior.

III. Integration of Appropriate Land Use and Development Management Measures

Alternative Plans 3a and 3g that solely combine the storm damage reduction alternatives do not fully meet the Vision Criteria that "the plan incorporates appropriate non-structural features to provide both storm damage protection and to restore coastal processes and ecosystem integrity". Plans 3a and 3g partially fulfill this requirement in that they include a significant non-structural component to reduce storm damages along the mainland shoreline. These plans, however, do not include non-structural measures along the shorefront, which can reduce the potential for storm damages, and help to restore ecosystem integrity.

As discussed in Chapter 4, the land and development management alternatives generally include: 1) land management alternatives, and 2) acquisition alternatives. The implementation of these land use regulations is the responsibility of the local municipalities in conjunction with New York State, and within the FIIS, the National Park Service.

As discussed in Chapter 4, there are existing challenges in implementing the land management regulations that exist in the study area, and Alternative Plans 3a and 3g could make it more difficult to implement these regulations, or in some instances could reduce the challenges in implementing these regulations (most notable in this connection is the requirement that for construction of the beach and dune that all properties in the footprint of the project be in public ownership or permanent easement).

The existing land use regulations were reviewed; and based upon that review, it is recommended that the following alternatives be included and considered an incremental component of this overall project in order for Alternative Plans 3a and 3g to function as intended.

Step 1: Improving the effectiveness of the existing regulatory program, by establishing a common funding source, establishing common and clearly communicated boundaries for regulated hazard areas, increasing training of local officials, and coordination to ensure consistent implementation across regulatory boundaries.

- Step 2: Modification of statutes to allow for more effective implementation of the existing laws.
- Step 3: Establishing a funding mechanism to acquire vacant parcels, or buildings that are at risk
- Step 4: Establishment of post-storm response plans to guide recovery following major, catastrophic events.

Step 1. Improving the effectiveness of the existing land-use regulations through establishment of common funding, and improved implementation of the law, generally includes the following:

Update the Existing Dune District in FINS

The FIIS enabling legislation set the established dune location in 1978; this line does not reflect the current dune location. Effective implementation of the regulation would benefit from a common definition of the dune, and a common regulatory jurisdiction with the CEHA Program. The federal law should be revised to create the same definition of a dune and the same requirement as contained in CEHA for a 10-year remapping process. This common mapping would require the identification of an agreement on a common defining feature. Presently, the CEHA jurisdiction as identified on the CEHA maps is based upon the landward toe of the primary dune, plus 25 feet. The federal dune district is based upon the dune crest plus forty feet. Furthermore, the NYS process provides for a public hearing as input into the process, which is not a provision of the Federal dune district. Since the CEHA mechanism has been applied throughout the state, provides for public input, and is more current than the dune district, it is recommended that the provisions within the FIIS enabling legislation be changed to identify that the dune district have the same criteria as the CEHA jurisdiction, and be allowed to change with changes in the CEHA designation.

CEHA Improvements.

CEHA improvements include map updates, additional funding to implement the program, and provisions for improved DEC monitoring of local implementation of CEHA. These improvements are described below:

Updating CEHA Maps across the FIMP Area. CEHA law and regulations require the review and revision of the Coastal Erosion Hazard Areas every 10 years. Given the dynamic nature of New York's coastal systems, timely map revisions are essential to ensure that the State's sensitive coastal natural protective features such as beaches, bluffs, and dunes are properly protected. The NYSDEC is currently in the process of reviewing and revising the Coastal Erosion Hazard Areas throughout New York State, including within the FIMP project area. The one exception is Fire Island, which is scheduled for map revisions after completion of the FIMI project. Revisions following major man-made or natural events or major storms as well as routine revisions of CEHA scheduled every ten years are necessary to provide local government and property owners the information they need to make informed decisions with respect to land management and also to effectively implement the CEHA program.

Improve DEC monitoring and support of local implementation of CEHA and establish adequate funding for effective implementation of CEHA. Based on State law, the DEC has delegated the implementation of CEHA to local communities who have requested this delegation and have met the requirements of state law and regulation. DEC monitors all delegated programs for compliance by collecting annual permitting information from each community so that any local deficiencies can be addressed. This review assists communities in assuring that their management of the program meets state requirements and results in the protection of the natural protective features that are instrumental in the protection of people and their properties. These reviews assist in the improvement of management and communication, assist in consistent implementation of the program, and where necessary, provide the State with information regarding whether a community's delegation needs to be withdrawn. The State provides detailed annual reviews for a small number of communities each year that are having issues in implementing their program. DEC also provides training to local communities as requested or needed for their proper implementation of the program. The State's CEHA program could be further expanded to provide more oversight of locally administered CEHA programs and more information about CEHA for municipalities that have chosen not to administer their own local CEHA program. This expanded program would allow for better technical and legal support for municipalities who administer their program which in turn would improve their effectiveness. It would also make non delegated coastal communities more aware of CEHA and the importance of its proper implementation.

Step 2. Modification of statutes to allow for more effective implementation of the existing laws.

CEHA Statutory changes. Make statutory and rule changes to enhance enforcement authority and provide indemnification by New York State for properly administered local CEHA programs against takings claims to reduce the influence of potential litigation costs, including potential takings claims, on local program decision making. Presently, local municipalities are responsible for providing the legal defense in the instance where CEHA variance requests are taken to court. Often the cost of defending these lawsuits is comparable to the costs associated with acquiring properties, and beyond the means of the municipalities. State indemnification for properly administered CEHA programs would mitigate this issue.

Step 3: Establishing a funding mechanism to acquire vacant parcels, or buildings that are at risk

Improved implementation of the land use regulations can help address inappropriate building and rebuilding in the CEHA area. It is acknowledged however, that even with such improvements, these programs would benefit from a funding mechanism made available to purchase vacant developable property, or for acquisition of vulnerable shorefront structures. This could serve as a means to acquire properties when enforcement of the regulations establishes a "taking", or in a broader application could be applied to reduce the number of structures within the CEHA and other high risk coastal locations that would be vulnerable to storm damages. Creation and application of an acquisition fund should be considered as a way that could create a model for addressing these issues.

Acquisition of structures as a stand-alone alternative was evaluated as a possible alternative along the shorefront. Analyses were undertaken to identify buildings falling within different hazard areas, and also at risk from storm damages. It should be noted that because CEHA is mapped based on natural features, there may be structures within the CEHA (on the back crest of a high, wide dune) that are less vulnerable to damages than a similar structure on a low, narrow dune. In conjunction with this analysis, an extensive Real Estate analysis was undertaken to identify an approximate acquisition cost for structures which fall within the CEHA.

In evaluating the acquisition alternatives, it became clear that acquisition could not be supported on NED analysis alone. The NED analysis evaluates the potential damages to a building, whereas the costs to acquire a building must consider the value of the structure and the property.

Within the study area, the Real Estate cost to acquire a structure was on average 4 to 5 times the value of the structure, which means that 25% of the real estate value is derived from the building. This cost differential makes it impossible to support acquisition on purely NED criteria, since it is impossible for the building to be damaged enough to offset the Real Estate costs. It should be noted that since the CEHA maps identify a primary dune as extending 25 feet landward of the landward toe regardless of the size and height that there may be structures within the CEHA (on the back crest of a high, wide dune) that are less vulnerable to damages than a similar structure on a low, narrow dune. It is possible that acquisition would also:

1. Provide additional habitat and recreational values by restoring the beach and dune to a more natural condition.

2. Provide cost savings if the volume of material required for nourishment could be lowered,

3. Provide benefits associated with having a sustainable solution that would effectively reduce the need for long-term maintenance beyond the project life.

Recognizing this, and recognizing that environmental benefits could accrue from acquisition of buildings and restoration of the land, selective acquisition is considered further in the context of restoration alternatives. Recognizing the benefits of providing a more sustainable, long-term plan for the area, this is also something that could be considered further as a measure to be implemented as part of the overall collaborative plan.

It is acknowledged that the scope of the acquisition plan could range from a plan to acquire properties when there is a determination of a taking, to a broader scope that would allow for the acquisition of structures from willing-sellers in high-risk areas, and could also include an acquisition plan for breach vulnerable areas. With this larger concept, there are a number of acquisition scenarios that could be developed as an incentive for increased participation. An example is presented below.

<u>Voluntary sales with retained occupancy or lease-back programs.</u> In the past, FINS has purchased noncommercial residence at fair market value, reduced by up to 25% allowing for the right to no more than 25 years of retained occupancy, unless the house is destroyed. Federal leaseback programs are generally very restrictive but state, county or local programs may have provisions for retained occupancies or less restrictive lease-back arrangements. This type of program could encourage voluntary participation by landowners. Landowners who recognize the hazards presented by their location may find such programs attractive as it provides them a fixed sum upfront based upon a pre-storm appraisal and the opportunity to continue to use the

structure for the term or until it is destroyed. It allows homeowners to spread their risks, as a post-storm value for a destroyed and eroded parcel would be far less. The advantage for the public is that while structures will remain on the dunes and continue to inhibit natural dune growth; this voluntary approach could substantially reduce the controversies around immediate condemnation, reduces acquisition costs by at least 25%, and particularly for the secondary line of houses, will facilitate dune advancement over time, ultimately achieving a more sustainable dune.

The entity or entities that would be responsible for purchasing property must be determined. On Fire Island, this would logically be the National Park Service using federal appropriations. FEMA could also acquire property and is a potential source of funding for acquisition. In order to address regulatory issues, DEC, who has authority to purchase lands, could be the agency to acquire property. For other state purposes and in other locations, DEC, OGS, and OPRHP have authority to accept donations or purchase lands and would need access to the acquisition funds. For regional purposes, Suffolk County might be a logical body; having significant experience in recent years with acquisition of parcels from willing sellers. Current laws, policies and practices may need to be modified for the project to be viable.

Step 4. Establishment of post-storm response plans

It is acknowledged that no plan will reduce all risks. It is likely that over the project life, a storm will occur which will compromise the design, and result in damages. This could occur in areas that are protected, or areas that are not protected as a result of this project. One option under consideration is the development and implementation of local post-storm redevelopment plans, which would provide direction for the rebuilding of communities in a more sustainable manner and recognizing the storm risks.

While there is a limited role for the Corps' in the implementation of the land and development management measures, 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. It is advised that the above land and development management measures 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.

A. Consideration of the Life Cycle Management of these Plans

Alternative Plans 3a and 3g, were developed with a 50-year project life, and 50 years of renourishment. These plans do not meet the Vision objectives that "the plan addresses long-term demands for public resources." These plans do not include provisions that would change the need for continued renourishment within the project life, or alter the conditions so that a different solution could be expected following the 50-year project life.

In order to achieve a reduction in the long-term commitment for renourishment, alternatives would need to be implemented that would reduce the development that is at risk, or remove development to allow for a more efficient use of resources. The integration of land and development management regulations identifies improvements in the application of land use regulations, acquisition planning, and post-storm response planning that could help to reduce the infrastructure at risk along the shorefront.

With this as a component of the overall plan, there are several approaches which could be undertaken in the life-cycle management of the project to achieve this. The options that have been identified include:

1 – A scheduled reduction in the scale of protection for the beachfill in a timeframe that coincides with the real estate acquisition planning. Under this scenario a beachfill plan would be maintained for a shorter period of time, during which period purchase offers would be made to owners of property on which shorefront structures at risk are situated. Aft.er this period of time, the scale of protection would be reduced or eliminated, thus reducing the commitment of resources for continued renourishment. The benefit of this approach is that the reduction in protection is not dependent upon the acquisition actually occurring.

2 – A scheduled relocation of the proposed line of protection that coincides with the implementation of the acquisition. Under this scenario, the beachfill plan would be linked with the proposed acquisition plan. Aft.er a period of time, the footprint of the project would be maintained in a more landward location on a scheduled timeframe. The difficulty with this initiative is that the movement of the dune on a prescribed timeframe would require guaranteed acquisition, which could not be guaranteed with a willing-seller program, and would require condemnation.

3 – Adaptive Management. Under this scenario, the beachfill plan and the acquisition plan could proceed independently, on parallel tracks. Adaptive Management would not dictate a defined timeframe for implementation, but would provide for a process, where on a periodic basis, coinciding with the scheduled renourishment, the constructed project would be revisited to identify whether opportunities exist for adjustment of the maintained profile based upon the relative success in implementing the acquisition plan.

Under any of these scenarios, it is important to 1) identify the time scale that would be necessary for the implementation of alternatives, and 2) identify the effect that these changes would have on project benefit realization and implementation costs.

It is recognized that the acquisition of shorefront property through a willing-seller program is not an instantaneous action, particularly with consideration for acquisition strategies that could allow for a homeowner to sell their property but be allowed to use the property for some period of time. The timeframes necessary for implementation of these measures tend to be estimated in decades, not in years. Along the shorefront, consideration must be given for: the funding availability for acquisition, the timing of interest in selling, and the staffing to process these acquisitions. When consideration was given for the time necessary to implement the non-structural alternatives along the mainland, accounting for staffing this effort, and funding these programs, it was estimated that implementation of the mainland non-structural program would require 25 to 30 years. Discussions have also been held with agencies responsible for the relocation of public infrastructure along the shorefront. Input from these agencies indicates that major public works improvements, whether relocation or otherwise typically require 10 to 20 years from conception to execution.

These timeframes suggest that if there is interest in reducing the long-term commitment to public investment in renourishment, a beachfill with a duration of 20 to 30 years could be considered in conjunction with an acquisition plan. As the project duration is shortened, it impacts the project economics. A sensitivity analysis was conducted which established that Alternative 3, built and maintained for 30 years, and subsequently replaced with a breach response plan, would have little effect on the project economics. Achieving this objective, however, would require a larger investment in Real Estate to provide an alternative form of risk reduction for houses along the shorefront (these costs were not considered in the cost).

The challenge with developing a plan that integrates the land management, acquisition, and scheduled renourishment of the project is the uncertainty that exists. These elements introduce uncertainty to a situation that is already uncertain due to the complexities of evaluating the system, projecting renourishment, projecting the functioning of the inlets, and the unknowns regarding future climate change. With all these uncertainties it is suggested that the implementation of the project adopt an incremental adaptive management approach. This approach would establish 1) data collection that would be implemented to have an improved understanding of the physical, social and environmental setting, 2) modeling efforts (engineering and formulation) to analyze the data, and 3) an adaptive management framework that would establish the overall objectives, decision rules, and identify the adaptations to the plan that could be accomplished with the project. This adaptation strategy is based upon the concept that with the passage of time the trends become established and more appropriate strategies can be executed. It is expected that this adaptation strategy would require a periodic review of the project execution (10-yr basis) and recommendations for the adaptation of the project, based upon the findings.

It is expected that the adaptive management plan would integrate the lifecycle management of the project, as it relates to the following elements:

- Inlet Management: Improved understanding of inlet functioning, the volume and frequency of bypassing, and the optimal alternatives for achieving the long-term objectives for inlet management.
- Breach Response. Improved understanding of breaching processes and consequences, refinement of the breach triggers and the implementing procedures, optimization of maintenance requirements, and the improved integration of habitat improvements.

- Beachfill. Improved understanding of beachfill performance, refinement of renourishment triggers and allowable variability in design, accounting for alignment changes based upon non-structural plan implementation, consideration of durations.
- Non-Structural. Improved delineation of structure vulnerability, and identification design details, identification of implementation effectiveness, identification of acquisition effectiveness, identification of the effectiveness of land management regulations
- Climate Change. As presented in the without project damages section, damages are likely to increase in the future without the project. Under historic or moderate increases in sea level rise, it is likely that adaptive management measures could accommodate these changes. Under more extreme rates of sea level rise, or more dramatic climate change conditions, adaptive management would allow for consideration in the relative effectiveness of the different solutions.

IV. Summary of Alternative Plan Comparison (that was presented to Partner Agencies in May 2009 and the Public in Summer 2010)

1. There are several Alternative Plans that meet the objective of cost-effective storm damage reduction.
2. The plan that that maximizes net benefits is Plan 3a, which includes inlet bypassing, NS-3 with road raising, continuous (as needed) beachfill along Great South Bay, and Moriches bay, and a breach response plan along Shinnecock Bay.
3. Alternative 3g, which includes inlet bypassing, NS-3 with road raising, beachfill fronting the communities along Great South Bay, and Moriches Bay, and a breach response plan along unprotected areas of Great South Bay, Moriches Bay, and Shinnecock Bay is the combination of storm damage reduction alternatives that best balances the objectives of storm damage reduction, P&G criteria, and Vision Criteria.
4. Plans 3a and 3g do not meet all the objectives of the Vision.
5. Plan 3g can achieve the objectives of the Vision Statement with the following modifications:
    i. Inclusion of the groin modification plan at Westhampton, and Ocean Beach
    ii. Inclusion of coastal process features
    iii. Inclusion of Land Management Measures
    iv. Inclusion of an acquisition program along the barrier island
    v. Includes an incremental adaptive management strategy over the project life to address the uncertainties in project implementation.

V. Identification of the Tentative Federally Supported Plan (TFSP)

In addition to meeting the planning objectives, any recommended plan for Fire Island to Montauk Point must be agreed to by USACE, DOI and the State of New York, the non-federal partner, who also represents the local governments. In March 2011, USACE and DOI, following a series of meetings spanning almost 18 months, reached agreement on a TFSP that was largely based on the modified Plan 3 G described above, and requested concurrence by the State of New York in a joint letter dated March 11, 2011.

By letter dated December 29, 2011, the State provided comments to the TFSP. On June 28, 2012, the State provided additional comments. Prior to providing formal responses to the State's comments, Hurricane Sandy struck on October 29, causing extensive damage to the project area.

The Corps provided a response to the State by letter dated May 16, 2012, which addressed the State's comments, and identified the changes proposed to address post-Sandy impacts. In response, the state provided a letter dated June 14, 2013 supporting the TFSP, and the stabilization efforts intended to provide a short-term solution to the Hurricane Sandy damages.

Below is a summary of the TFSP.

Summary of Tentative Federal Selected Plan (TFSP)

A. Beach and Dune Fill Component.

- Continuous beach and dune fill along the developed shorefront areas fronting Great South Bay and Moriches Bay, where necessary, to meet this design threshold
- Alignment: Beachfill configured along the MREI
- +15 ft. NGVD dune, 90 ft. berm at +9.5 ft. NGVD in developed areas & minor federal tracts
- Renourishment: 50 years, approximate 4-year cycle, along same length of shoreline

B. Non-Structural Plan

- 100-year level of protection for structures inside 10-year flood plain
- Building retrofit measures are proposed, include limited relocation or buyouts, based upon structure type and condition
- locations of road raising, totaling 5.91 miles in length, directly protects 1,020 houses
- Over 4,400 structures are included for non-structural treatment
- Estimated construction period is 20 years

C. Inlet Modification Plan

- Shinnecock Inlet: Continuation of authorized project + Ebb shoal dredging; -16' deposition basin; 2 year cycle; additional 100,000 CY/yr
- Moriches Inlet: Continuation of authorized project + Ebb shoal dredging; 1 year cycle; additional 100,000 CY/yr
- Fire Island Inlet: Continuation of authorized project + Ebb shoal dredging; deposition basin expansion, with additional updrift disposal; 2 year interval; additional 100,000 CY/yr

D. Groin Modification Plan

- Shortening of Westhampton groins (1-15) between 70 — 100 ft., which will increase sediment transport (0.5M to 2M CY) to the west and reduce renourishment requirements
- Modification of the Ocean Beach Groins (shortening/lowering)

E. Breach Response Plan (BRP)

- Conditional Breach Response Plan in Fire Island undeveloped areas, with threshold details currently under development

- Proactive Breach Response Plan (restores beach to the design condition when the shoreline is degraded to an effective width of 50 ft.) for areas along Shinnecock Bay, where a beachfill plan is not recommended

- Breach Closure Template: +13' NGVD dune, berm height +9.5 ft. NGVD, berm width generally 90 ft. wide, but vary depending on conditions prior to the breach and within adjacent areas

F. Sediment Management Plans

- Two areas of high damages were identified where a conventional beach nourishment project was not economically viable: Downtown Montauk, and Potato Road

- In these areas Sediment Management Alternatives were evaluated to offset the long-term erosion trend, to maintain the current protection, and prevent conditions from getting worse, and also serve as feeder beaches.

- Recommend placing approximately 120,000 CY on front face of existing berm at each location approximately every 4 years as advance fill. Implementation in the Potato Road area is contingent upon the development of a local management plan for Georgica Pond to address the effects and minimize the consequences of the pond opening.

G. Coastal Process Features

- Measures that contribute to the reestablishment of coastal processes in the area, which enhance resiliency and sustainability of the barrier island were identified for implementation in coordination with CSRM features.

H. Adaptive Management

- An adaptive management plan will formalize mechanisms for reviewing and revising the lifecycle management of elements of the project, relating to the following elements: Inlet Management, Breach Response, Beachfill, Borrow Area, Non-Structural, Coastal Process Features, Land Management Policies and Climate Change.
- 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.