Fire Island Inlet to Moriches Inlet Stabilization

Non-Shorefront Coastal Inundation Damage
Coastal Storm Damage Reduction
Benefit Calculation Support Documentation

1.0 Introduction

This document describes the context within which the FIMI Stabilization effort was formulated, and describes planning model developed to quantify inundation related storm damages and storm damage reduction benefits for the non shorefront areas of the Reformulation Study of the Atlantic Coast of New York, Fire Island Inlet to Montauk Inlet Storm Damage Reduction Project. The intent is to provide sufficient information on the model to familiarize a reviewer with the modeling steps and assumptions used. The model certification process was conducted previously, and documented in greater detail in accordance with the Planning Models Improvement Program (PMIP).

1.1 FIMI Project Overview

The FIMI project is an expedited approach to construct a stabilization effort independent of the FIMP Reformulation Study. It is a one-time placement of sediment, with a project life of twenty years, in one portion of the study area of the larger FIMP project. The proposed action is the only plan considered in this Stabilization report, and is compared to no action in the justification. The beachfill plan and profile identified in the FIMP effort is the only alternative evaluated within FIMI.

Stabilization efforts were focused on FIMI as this reach is the most impacted when barrier island overwash and breach inundate the back-bay, exposing the back bay structures to considerable damages.

This Stabilization effort is being undertaken in response to the highly vulnerable condition following Hurricane Sandy's erosive forces, where expedited action is needed to stabilize this area. This FIMI stabilization effort (Reach 1) has been developed as a one-time, initial construction project to repair damages caused by Hurricane Sandy and to stabilize the island. This report demonstrates that the Stabilization Project has its own independent utility, and as developed, does not limit the options available in the Reformulation Study or pre-suppose the outcome of the Reformulation Study.

1.2 FIMI Relationship to FIMP

The Fire Island Inlet to Montauk Point, New York, Combined Beach Erosion Control and Hurricane Protection Project (FIMP) was first authorized by the River and Harbor Act of 14 July 1960 in accordance with House Document (HD) 425, 86th Congress, 2d Session, dated 21 June 1960, which established the authorized project. The project is being reformulated by the U.S. Army Corps of Engineers, New York District (USACE) as the lead Federal agency to identify a comprehensive long-term solution to manage the risk of coastal storm damages along the south shore of Long Island in a manner which balances the risks to human life and property while maintaining, enhancing, and restoring ecosystem integrity and coastal biodiversity.

The overall FIMP reformulation study was undertaken to evaluate alternatives to determine Federal interest in participating in one or more of these alternatives, and identify a mutually agreeable joint Federal/state/locally supported plan for addressing the storm risk management needs in the study area. In addition to addressing the USACE's national objectives of storm risk management and environmental sustainability, this collaborative effort identified alternatives for implementation by other Federal, state and local agencies to achieve broader study objectives.

The FIMP Reformulation Study is in the final stages of documenting the process for development of the TFSP. The Reformulation study evaluated several combinations of features to identify the plan that meets the USACE goals and missions and is mutually agreeable to the Department of the Interior, as required by law in the Fire Island National Seashore authorizing act.

The TFSP from the FIMP plan was advanced following economic evaluation consistent with Corps guidelines and will be detailed in the subsequent GRR. The TFSP includes multiple features to achieve CSDR in the study area, including beachfill and renourishment. The FIMI effort examined beachfill only, with no renourishment, as the only plan to stabilize the barrier island.

1.3 Summary of FIMP Plan Formulation

Evaluation of design and placement of proposed CSDR features in the Study Area identified that a wide range of the individual alternatives are cost effective options for Storm Risk management. The analysis also indicated that no one alternative addresses all the storm risk management problems. Rather, addressing multiple problems requires multiple solutions. In this respect, many of the alternatives considered complement each other, and Alternative Plans benefit from combinations of alternatives. This reformulation process recommended the following features be integrated into overall Plans of improvement:

- Inlet bypassing Plans
- Breach Response Plans (Responsive Plan at +9.5 ft NGVD, Responsive or Proactive Plans at +13 ft NGVD)
- Non-Structural Plans (6-year and 10-year levels of risk management) - defined as those activities to minimize potential damages through elevation, relocation, flood proofing, buyout, etc
- Beachfill (13 ft Dune and 15 ft Dune) - soft structural measures, generally are those constructed of sand and are designed to “augment and/or” mimic the existing natural protective features

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.

FIMP Plan 1

The first plan considered for FIMP combined 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 is compatible with all plans in the Great South Bay, Moriches Bay and Shinnecock Bay reaches. Plan 1 was further refined into Plan 1.a, which combines the economically optimum Inlet Management Alternative and BCP Alternative (13 feet NGVD BCP). Plan 1.b combines the optimum Inlet Management Alternative with the 9.5 feet NGVD BCP Alternative.

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

FIMP Plan 2

The second series of plans considered for FIMP added non-structural protection to Plan 1's variations of inlet management and BCP alternatives. The inclusion of non-structural protection was essential to address flooding from storm surge propagating through inlets into the bays and wind and wave setup within the bays. Plan 2 was further refined into Plans 2.a through 2.d to vary the 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.

Plan 2 includes breach response, inlet modifications, and mainland non-structural measures. All of the alternative plans are cost-effective. The plans that provide the greatest net benefits are Alternative 2F and 2H. Alternative 2H includes inlet management at the inlets (consistent with each alternative), a breach response plan with the +13 feet NGVD cross-section, non-structural plan 3, which addresses structures in the existing 10-yr floodplain, and road raising at 4 locations.

FIMP Plan 3

The third series of plans considered for FIMP added beach nourishment to Plan 2 alternatives, refining Plans 2e through 2h into Plans 3a through Plan 3.g. 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 were demonstrated to provide significant benefits above Plans without this feature.

The Beach Nourishment Alternative included in these Plans is the + 15 feet NGVD dune/ 90 foot berm width design with the minimum real estate alignment. Within the Shinnecock Bay reach the Breach Contingency Plan with the +13 feet NGVD 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 (FINS), and the Smith Point County Park (SPCP). Plans were developed to evaluate the impact of excluding these locations on Storm Risk management 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 feet NGVD 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.

1.4 TFSP Determination

Plan 3, with the inclusion of beachfill, was demonstrated to advance a greater number of objectives than plan 2, (particularly in addressing all the contributors to storm damages) but still have shortcomings when compared with the criteria. The results of the series of Plans 3a through 3g varied depending upon the extent of fill that is proposed, particularly as it relates to the criteria to balance storm risk management considerations with ecosystem restoration considerations. Plan 3A is the alternative which best addresses the Storm Risk management needs, but includes beachfill throughout, and as a result does not rank highly with respect to the criteria for balancing storm risk management needs and environmental needs, and also does not rank highly with consideration of the P&G criteria for implementability, 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 managing the risk of 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 project objectives in that this plan balances storm risk management needs and ecosystem restoration needs.

2.0 Purpose of FIMI Stabilization Plan

On October 29, 2012 as a consequence of severe coastal erosion during Hurricane Sandy, the dune and berm system along Fire Island reach in the FIMI study area is now depleted and particularly vulnerable to overwash and breaching during future storm events, which increases the potential for devastating storm damage to shore and particularly back-bay communities. In response to extensive storm damages and increased vulnerability to future events, consistent with the Disaster Relief Appropriations Act of 2013 (Public Law. 113-2; herein P.L. 113-2), and recognizing the urgency to repair and implement immediate storm protection measures, particularly in the Fire Island to Moriches Inlet (FIMI) study area, USACE has proposed an approach to expedite implementation of construction of necessary stabilization efforts independent of the FIMP Reformulation Study. This approach has gained widespread approval from New York State, Suffolk County, N.Y. and the local municipalities, who recognize the extreme vulnerability of the coast, and the need to move quickly to address this need. This approach has also gained approval from Steven L. Stockton, P.E., Director of Civil Works, USACE in a memorandum dated 8 January 2014.

The post-Sandy Fire Island Stabilization Project, which encompasses Fire Island to Moriches Inlet, was developed based upon the Engineering, Economic, Environmental, and Planning efforts that have been undertaken through the ongoing FIMP Reformulation Study that compared alternatives referenced in Chapter 7 of this report to identify the recommended scale and scope of a beachfill project from the TSP, as an independent stabilization effort. Stabilization efforts were focused on FIMI as this reach is the most populated and subject to barrier island overwash and breach thereby exposing the back-bay to considerable damages. There is a more urgent need to advance the stabilization of this reach due to its vulnerability and potential for major damage and risk to life and property.

This stabilization effort has been developed as a one-time, stand-alone construction project to repair damages caused by Hurricane Sandy and to stabilize the island. This report demonstrates that the FIMI Stabilization Project has its own independent utility, and as developed, does not limit the options available in the overall FIMP Reformulation Study or pre-suppose the outcome of the Reformulation Study. After the initial placement of sand, the project is expected to erode, and diminish in its protective capacity, eventually returning to a pre-project condition. In the absence of a future decision, the area is expected to continue to be managed consistent with current practices.

2.1 Effective Project Life

The Stabilization Project has been evaluated over a 50 year period to determine that 20 year is the period of time over which there is a measurable difference between the without project future condition and with-project condition. This difference is based upon a combination of factors including the effects of both sand placement and structure acquisition. The Project is designed with advance fill to ensure that the design conditions are maintained for a period of 5 years, under normal conditions. After this time, the project will erode into the design template, and offer residual, diminished protection. It is difficult to project the amount of time that residual protection from the fill will remain. It is estimated, under typical conditions, that the residual effect of the fill placement could last another 5 years. Even after the residual effect of beachfill has diminished, there is a longer residual effect that is provided by the acquisition and relocation of structures. Based upon the setback distances and background erosion rate, it has been projected that the residual effects of relocating these buildings would be an additional 10 years. The economics modeling has confirmed that the WOPFC and with-project condition results converge after 20 years, supporting a period of analysis of 20 years.

The subject post-Sandy Fire Island Stabilization Project, which encompasses Fire Island to Moriches Inlet, which is also known as the Fire Island to Moriches Inlet Project (FIMI) was developed based upon the Engineering, Economic, Environmental, and Planning efforts that have been undertaken through the on-going FIMP Reformulation Study that compared alternatives to identify the recommended scale and scope of a beachfill project from the TFSP, as an independent stabilization effort. The FIMI Plan was derived from utilizing background material and existing information/data that is currently included in the FIMP study to expedite the FIMI HSLRR in accordance with the HQUSACE above referenced approved Strategy Paper (dated January 8, 2014) and in response to PL 113-2.

2.2 Relevant Benefit Streams

In general when a breach occurs, flood elevations and damages in the back-bay and mainland increase. The overall reformulation for the FIMP project includes measures to reduce vulnerability in these Bay Shore communities. However, until those measures are implemented there is significant concern about the potential for increased damages should additional barrier breaches occur.

For analysis purposes, the study area has been divided into shorefront development and non-shorefront development. Development was considered part of the shorefront analysis if it is subject to damage from storm surge inundation, plus waves and/or erosion. Shorefront development was evaluated for all three damage mechanisms for each individual structure under a full range of storm conditions. The largest, or "critical", damage was then identified for each building for a series of storms over the without project future conditions.

Development outside of the zone of likely erosion or wave impact was considered part of the non-shorefront analysis. The non-shorefront analysis only evaluates damage due to inundation, and includes development both on the northern side of the barrier island and along the mainland areas.

The storm damage analysis considered physical damage to structures, building contents, and cars, as well as non-physical costs, such as cleanup and temporary housing expenses. Public emergency costs associated with extreme events such as barrier island breaching are also included in the analysis.

To model the with-project damages and hence allow benefits to be computed, revisions were made to key inputs in the lifecycle simulation models. Beach fill at the relevant locations was simulated by adjusting the effective baseline beach width and the threshold water surface elevations at which overwash, partial breaches, and full breaches are triggered. Similar revisions were applied to the with-project breach-only model, which was also revised to reference the modeled breach-open inundation damages arising from a breach closure period of three months, which reflects an assumed implementation of breach response protocols under PL84-99, with the project in place.

2.3 Emphasis on Non-Shorefront Model and Benefit Estimation

The impact of Hurricane Sandy in the study area necessitated a stabilization effort to protect vulnerable areas from further storm impacts. Given the need for the accelerated analysis to propose and justify the one time sediment placement, the shoreline benefit modeling and benefit calculation was not practicable. GRR efforts underway at the time of Hurricane Sandy were not applicable to the one time placement and shorter study period without significant reanalysis.

Given that the shoreline damages were not necessary to justify the stabilization effort, the PDT emphasized the model certification process and application of the non shorefront model for project justification.

3.0 Purpose of Non Shorefront Coastal Inundation Model

The model has been developed to analyze a highly unusual set of conditions specific to the Project area. The key capability of the model is the ability to simulate changes in the vulnerability of the study area especially with respect to future overwash or breaching.

The Non-shorefront coastal inundation damage model has been developed to quantify the impact of storms on development along Great South Bay, Moriches Bay, and Shinnecock Bay in the Study area. Unlike the immediate shorefront area, buildings located in the landward sections of the barrier island and the mainland bays are subject to significant inundation damage, but erosion and waves are unlikely to reach thresholds for significant structural damage or failure. Since structural failures do not alter the database of structures in response to storm events, the model can apply traditional tools (HEC-FDA) to develop aggregated stage damage curves with uncertainty for use in the evaluation of inundation damages.

The extent and frequency of inundation in the study area changes as barrier island conditions evolve in response to storms and other factors, and bay water levels are sensitive to conditions of the barrier island beach and dunes. Engineering analysis[1] identified ten barrier locations that are particularly vulnerable to overwash or breaching, which would then impact the bay water levels should they breach. The model was therefore developed to track storm erosion, long term and short term shoreline change, and coastal management (beach nourishment, inlet bypassing, breach formation and closure) impacts to the barrier condition at the vulnerable locations, and to estimate the resulting changes in the bay stage frequency relationships and the associated inundation damages.

The model is also designed to account for changes in future inundation due to the impacts of sea level rise, and changes in damages associated with project alternatives that alter the stage damage relationship such as elevating buildings or roads.

3.1 Model Assumptions

The model development required specific assumptions about the study area, the probability of storms impacting the area, and the interrelationship of the physical features in the area.

- Physical conditions in the area change in the extent and frequency of inundation as barrier island conditions evolve in response to storms and other factors.
- Barrier island response to storms is assumed to be consistent with the historic erosion rates and water levels.
- Two storms from a probabilistic distribution of historic storms occur per year, one tropical and one extra-tropical.
- A breach or overwash occurs when a pre-established threshold Future Vulnerable condition is reached in any of ten locations identified as vulnerable to breaching and overwash.

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[1] Baseline Conditions Storm Surge Modelling and Stage Frequency Generation: Fire Island to Montauk Point Reformulation Study, Draft Report, 13 July 2006, documents the analysis conducted for the USACE and subjected to peer review. Engineering results were lauded and are used here, not summarized.

- The post storm recovery was modeled so that the sum of the average annual shoreline change would match the measured long term shoreline change rate.
- Three breach conditions were considered, no breach, a small breach, and a large breach, with the breach sizes varying by bay.
- Structures are assumed to be rebuilt post breach repair in the same condition and value as pre-breach.
- Multiple breaches continuing to expand in any sub-bay were assumed to be an unlikely occurrence, only one breach within a sub bay is assumed to be viable.

3.2 Model Description

The storm damage model consists of Excel spreadsheets with a series of individual worksheet tabs or pages containing inputs or outputs. Simulations are performed using the @Risk (Palisade Corporation) add-in to Excel. @Risk allows various inputs, such as the stage damage relationship applicable to each reach, to be input as probability distributions rather than a single value. It will repetitively recalculate the spreadsheet, allowing each of the uncertain inputs to vary independently (or in accordance with defined correlation coefficients) and collect the results of each iterative calculation and report the mean values and other statistics, such as the distribution of results.

Three damage simulation spreadsheets form the individual model components are used to estimate damages:

1. Simulation Component 1- Breach Open Event
    - Quantifies damages for breach open conditions.
    - Provides input to Component 2.
2. Simulation Component 2- Breach Lifecycle Analysis
    - Simulates storms and ocean water levels and subsequent breach occurrences. Calculates closure costs and damages over project life
    - For comparison of breach closure alternatives.
3. Simulation Component 3- Lifecycle Damage Analysis
    - Simulates storms and bay water levels including the impacts of erosion/storms in creating Future Vulnerable Conditions.
    - To quantify baseline and future condition non-shorefront Storm Damage.

The three model components each perform a different function in the analysis. Attempts to combine the components proved unwieldy and it was determined that they were best kept as separate files. Component 1 was developed to evaluate Breach Open Conditions and what impact a barrier island breach will have on storm damages. This model quantifies the increase in damages if a breach is open and provides input to Component 2, the Breach Lifecycle Analysis. This model simulates breach occurrence and calculates average annual closure costs and breach induced increases in backbay inundation damage over the project life. This model was developed to quantify lifecycle impacts and to compare breach management alternatives. Component 3 performs the lifecycle inundation damage analysis for the backbay mainland areas and non-shorefront areas on the barrier islands, which simulates storms and bay water levels including the impacts of erosion/storms in creating Future Vulnerable Conditions and calculates annual damage on a reach by reach basis. The results from model Components 2 and 3 were used to compile damages for with and without project conditions and hence compute benefits to facilitate the selection of the NED plan.

Although each of the model components has different outputs and uses different input data, the models share a similar approach to generate storms.

3.3 Damage Calculation With HEC FDA

Components 2 and 3 required aggregate damage and the associated uncertainty bands for every economic reach at each stage as input. These were developed external to the model using the Hydraulic Engineering Center Flood Damage Assessment (HEC-FDA) program. This program applies standard flood depth vs damage relationships to individual buildings and aggregates the information to create stage vs damage relationships. FDA develops uncertainty bands based on Monte- Carlo simulations incorporating uncertainty in several input factors including the value and elevation of the individual buildings.

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

3.3.1 Structure Inventory

During prior reformulation efforts in 1982, field inspections were conducted to collect data for the buildings in the study area. In general the inland limit of the investigation was elevation 16 feet NGVD. The non-shorefront dataset originally encompassed 43,614 structures, consisting of:

- 40,032 residential structures
- 2,797 commercial units
- 163 industrial units
- 179 municipal structures

Two field-survey updates were subsequently performed; one in 1999 for barrier island structures, and one in 2005 for mainland buildings throughout the project area. The results of the 2005 survey were used to develop a factor to update the previous 1997 price level to a 2005 price level. A universal update factor was used to update the value of all structures to a September 2013 price level from October 2005. This factor of 1.269 was based on the historical Building Cost Index published by the Engineering News-Record.

Table 1
Non-Shorefront Structure Inventory Summary

		Great South Bay	Moriches Bay	Shinnecock Bay	*Category Totals*
Residential	Number of Buildings	31,061	6,281	3,090	*40,432*
	Structure Value	$9,168,254,103	$1,647,886,655	$1,047,346,254	*$11,863,487,012*
	% Number	92.3%	93.8%	94.2%	*93%*
	% Value	79.1%	82.1%	89.7%	*80%*
	Average Value	$295,169	$262,361	$338,947	*$293,418*
	Average Square Foot Value*	$132	$135	$134	
Commercial	Number of Buildings	2,241	386	170	*2,797*
	Structure Value	$1,819,790,247	$341,390,094	$103,076,810	*$2,264,257,151*
	% Number	6.7%	5.8%	5.2%	*6%*
	% Value	15.7%	17.0%	8.8%	*15%*
	Average Value	$812,044	$884,430	$606,334	*$809,531*
	Average Square Foot Value*	$217	$226	$194	
Municipal	Number of Buildings	174	17	15	*206*
	Structure Value	$476,921,913	$13,439,377	$13,905,985	*$504,267,275*
	% Number	0.5%	0.3%	0.5%	*0%*
	% Value	4.1%	0.7%	1.2%	*3%*
	Average Value	$2,740,931	$790,552	$927,066	*$2,447,899*
	Average Square Foot Value*	$170	$255	$204	
Industrial	Number of Buildings	163	10	6	*179*
	Structure Value	$120,865,184	$4,644,888	$2,713,840	*$128,223,912*
	% Number	0.5%	0.1%	0.2%	*0%*
	% Value	1.0%	0.2%	0.2%	*1%*
	Average Value	$741,504	$464,489	$452,307	*$716,335*
	Average Square Foot Value*	$67	$70	$63	
Totals	Bay Total Number	33,639	6,694	3,281	
	Bay Total Value	$11,585,831,447	$2,007,361,014	$1,167,042,889	
	Bay Average Value	$344,417	$299,875	$355,697	
	Project Area Total Number	43,614			
	Project Area Total Value	$14,760,235,350			
	Project Area Average Value	$338,429			

**Backbay Mainland Only - Discount Rate 3.50%, Price Level: October 2013*

Prior to Hurricane Sandy, the most recent analyses of storm damages were completed in 2009 as part of the ongoing FIMP Reformation Study efforts. In support of the Hurricane Sandy FIMI Stabilization Limited Reevaluation Report, the study economics were updated to current price levels and provided for the FIMI study area only. Shorefront damage models were revised to reflect post-Sandy changes to the existing condition beach morphology such as the dune crest elevation and to account for changes in the structure inventory due to the destruction of shorefront houses by Sandy. Lifecycle flood inundation models were revised to reflect post-Sandy changes to the barrier islands including the existing condition beach profile width plus accumulated sea level rise in the years since the models were developed. Models used to calculate damages specifically incurred by open breaches over the project life were revised to reflect current beach profile widths and sea level rise as per the lifecycle inundation model but also to incorporate recently acquired data related to the maximum size of potential breaches in Great South Bay. Revisions to the breach damage model also included updated breach closure costs for all potential breach locations and current mobilization and unit costs applicable in BCP maintenance actions.

All lifecycle simulation models were adjusted to incorporate a revised project base year of 2015 and the current FY interest rate of 3.50%. The damages resulting from all revised simulation models were also updated using an index factor derived from the Engineering News-Record Building Cost Index, to account for increases in structure inventory value from 2005-2013 which have not been subject to detailed surveys or analysis for this interim report.

3.3.2 Recent Efforts to Confirm Structure Inventory

Structure inventory was confirmed as stable in 2009 and again in 2013 through consultation with local municipalities and windshield surveys of the communities. Following Sandy, several programs which encourage and partially fund house raising may be available to frequently flooded structures. FEMA repetitive Damage sufferers can qualify for up to a $30,000 grant to elevate their homes. Given that costs to raise a typical structure generally run much higher than $30,000, it is unlikely that many eligible homeowners would have participated in this effort in the interim. To ensure that significant structures have not been elevated in the interim years, the building permits in the applicable areas were consulted to investigate any elevation permits. Significant alteration to the study area inventory was not found.

3.4 Nuisance Flooding uncorrected by the project

Frequent, nuisance flooding results from tidal conditions in the area, particularly for structures built along bulkheaded canals. The with project condition will not alleviate this flooding, since the project reduces the risk of overwash and breaching of the barrier island, which exacerbates inundation in the back bay project area. Proximity to the bay and ocean and accessibility of the urban center of New York City make this area highly desirable, and the nuisance flooding does not appear to drive residents from the area. The damage to individual structures in these high frequency events is relatively minor compared to the combined land and structure value, or the cost of elevating the homes.

The Reformulation study, which was in formulation prior to the impact of Hurricane Sandy and the recommendation of a stabilization effort, will include non structural measures to address the frequent tidal flooding.

4.0 Model Components

4.1 Simulation Component 1- Breach Open Event

The purpose of this component is to quantify any increased Storm Damage that would occur while a breach is open. This analysis assumes a breach has occurred and only evaluates impacts while a breach is open. A series of conditions identified as BOC1 to BOC4 were evaluated for hydrodynamic impacts of simulated breach conditions/size for every month after the breach. Monthly peak water levels were simulated representing the change in tide and storm surge conditions.

The key inputs to the analysis are the Breach Open Condition (BOC) water levels related to breach size, breach growth & closure rates, and the stage versus damage. The development of this data is presented in Attachment C of the model certification documentation, the Memorandum "Summary of Draft Breach Open Conditions Stage-Frequency Results" (USACE, 3 March 2006).

A number of different conditions were modeled. These include: No Breach & BOC 1-4 occurring in Tropical or Ex-tropical seasons, each with Sea Level Rise (SLR) of 0, 0.5 & 1.0 feet. (27 conditions for each economic reach for each closure time). The approach by which four BOCs were identified for modeling purposes is described in detail in the memorandum "BOC Methodology" (Moffatt and Nichol, 3 March 2006), which is also included in Attachment C of the Model Certification documentation.

The bay stage was used to lookup the associated damage using stage damage curves developed in the HEC-FDA model. A higher bay stage, which results from a breach condition in the project area, would return a higher damage from the stage damage curve for the area as compared to a non breach condition in the study area. This data was then used to identify increased damage due to breaches.

The output of this component is the inundation damage for the 12 months following a breach for the without-project condition, and for three months following the breach for the with-project condition. The increase in damage due to increased water levels while a breach was open was isolated by modeling values with and without a breach. Each reach and each condition were simulated for 25,000 iterations and the mean damage results incorporated into component 2 (the lifecycle analysis of breach damage and costs) Tabs labeled No Breach and BOC1 through BOC4.

Results from Simulation Component 1 were generated early in the overall model application process, prior to the implementation of the lifecycle simulations. The results from Component 1 were collated into tables in separate Excel files, which were then used to populate Component 2.

4.2 Simulation Component 2- Breach Lifecycle Analysis

The purpose of this component is to allow comparisons of the costs and storm damages associated with various breach closure alternatives. Unlike Component 1, which only evaluates what happens after a breach is formed; this component simulates random storm induced formation of breaches, the annualized costs associated with closure and closure maintenance, and the annualized values of damages while the breach is open.

In general terms, the analysis simulates breach occurrence triggered by random storms over the period of analysis. The occurrence of a breach is related to specific storm surge thresholds, which vary over the lifecycle depending on changes in the barrier conditions and the level of design of any prior breach closures. The analysis applies the externally determined breach closure costs to each breaching event, and calculates average annual costs. Average annual breach induced damages are calculated using the difference in damages with and without for each breach occurrence.

Component 2 is necessary because of the complexity of the breach lifecycle approach. The excel page limitations at the time the mode components were developed made it impossible to compare costs and storm damages associated with various breach closure alternatives within the life cycle damage analysis simulation effort (Model Component 3). With fewer breach closure alternatives, Model Component 2 and 3 could have been combined. Many of the calculations in Component 3 are therefore directly analogous to the calculations in Component 2.

The key inputs to the analysis are the breach threshold water levels, ocean stage frequency curves, storm/long term erosion plus post storm recovery rates, temporal shoreline undulations, beach nourishment and closure maintenance activities, breach closure costs, and the breach induced damages determined in Component 1.

Various conditions have been modeled including different breach closure response times representing a delay of 9 months (no pre-approved breach response plan) and a delay of 45 days. In general, a more rapid response reduces the volume of material and the cost for the closure, while also reducing the potential for an increase in storm damage while the breach is open. For the rapid closure (45 day delay) scenario, three different closure templates were evaluated consisting of a 9.5 ft berm only template, and the 9.5 ft berm plus 11 & 13 ft dune features. The alternative dune features were evaluated to determine if the cost of the dune feature was justified based on the reduction in repetitive breaching.

The outputs of this component are total and average annual closure costs, maintenance costs and breach induced storm damage for alternative response times and closure templates.

4.3 Simulation Component 3- Lifecycle Damage Analysis

The purpose of this component is to quantify baseline and future condition non- shorefront Storm Damage due to inundation in Great South Bay, Moriches Bay and Shinnecock Bay. The critical part to this analysis is to predict bay stage levels for the various storms and barrier conditions that could occur over the period of analysis. The bay stages can then be used to identify the amount of damage expected in any storm. Aggregate damage and the associated uncertainty bands for every economic reach at each stage were developed external to the model using the Hydraulic Engineering Center Flood Damage Assessment (HEC-FDA) program. This program applies standard flood depth vs damage relationships to individual buildings and aggregates the information to create stage vs damage relationships. FDA develops uncertainty bands based on Monte- Carlo simulations incorporating uncertainty in several input factors including the value and elevation of the individual buildings.

The general approach to the analysis was to simulate a series of storms representing possible future conditions and to identify the bay water levels associated with each event. Bay stage curves have been developed for several barrier island conditions, so it is necessary to also track the impacts of barrier island erosion, including storms and storm induced breaching in creating a Future Vulnerable Condition (FVC) or a Breach Closed Condition (BCC). The lifecycle simulation tracks the degradation of the ten locations on the barrier island considered most vulnerable to breaching or overwash. The condition of each of these locations relative to baseline and FVC conditions is indexed on a percentage basis, and a weighted index is used to interpolate between the baseline and FVC frequency curves to establish the bay stage for each reach. Damages for each storm are identified using a relatively simple lookup table with interpolation between the stages analyzed in HEC-FDA. Damage uncertainty is incorporated by randomly sampling within the HEC-FDA generated uncertainty data.

The key inputs for the analysis include the bay stage frequency relationships for Baseline, Future Vulnerable Conditions (FVC), With Project Conditions & Breach Closed Conditions (BCC). The analysis also requires the open coast stage frequency data, storm erosion frequency and post storm recovery data, temporal shoreline undulation data, weighting factors, beach nourishment activities and breach water level thresholds for the ten vulnerable locations. In addition, the stage vs damage relationships developed in HEC-FDA, definition of the project base year, period of analysis and desired discount rate must be included.

The stage versus frequency curves used in the Fire-Island to Montauk Point simulation models were developed in accordance with applicable Corps guidance, specifically EM 1110-2-1619, 1 October 2013. Development of the stage-frequency curves is described in the report “Baseline Conditions Storm Surge Modelling and Stage Frequency Generation: Fire Island to Montauk Point Reformulation Study” (USACE-NYD, 13 July, 2006). Key extracts of that document are included in Attachment C of the Model Certification documentation.

The primary output for this component is the mean average annual damage by reach. This is determined by averaging the results of numerous lifecycle simulations (12,500 was typical) to capture the variability of storm patterns and uncertainty in the input data. In addition to the mean annual damage, a number of other pieces of information were collected and analyzed, such as the average base year damage and statistics on breach occurrence.

A large number of conditions have been modeled including without project, with project inlet management, Non-structural, and a wide range of beach nourishment alternatives. The simulation of inlet management alternatives involved altering the frequency and width of periodic beach fill placement to reflect changes in bypassing practices and the adjustment of shoreline change data to reflect the adjustment in sediment budget deficit. The simulation of beach nourishment alternatives needed to be flexible to allow the analysis of limited fill placement plans, where certain environmentally sensitive areas could be excluded from the plan. This was accomplished by altering the characteristics and renourishment at each of the vulnerable locations. The simulation of Non-structural alternatives involved importing the modified structure database into HEC-FDA, recalculating the stage damage relationships and then importing that data back into the model components.

The simulations are executed using the @Risk add-in to Excel, which will re-calculate the spreadsheet a specified number of times, collecting the results of requested cells. The program also performs statistical analysis of the requested results including the mean value of all of the lifecycles simulated.

4.4 Damage Categories

Inundation Damages. These occur when vulnerable structures are flooded by high tides and storm surges in the back-bay, where the water levels are sensitive to the conditions of the barrier islands. In order to illustrate the relative contribution of barrier island breaching and overwash to the total damages, these inundation damages have been separated out to show those damages which occur due to flooding through the inlets, and wave setup in the bay; and those damages that arise due to the increased flooding during the storm event that results in breaching and overwash. This breakout has been developed by evaluating the damages that occur if the barrier island is in a condition to preclude breaching and overwash. For each of these categories, inundation damages have been divided into those occurring on the back-bay mainland and those on the back-bay side of the barrier islands.

Breach - Inundation. Breach inundation damages occur when structures are flooded by increases in back-bay water elevations caused by breaches in the barrier islands remaining open for a period of time. These damages are limited to structures in back-bay mainland areas and on the back-bay side of the barrier islands.

The without project assumption is that the breach closure will begin 9 months after the breach occurs and that the breach will be closed 12 months after the breach occurs. The maximum breach size and growth rate were based on prior observations. Hydrodynamic models evaluated the impact of various open breach dimensions at locations throughout the bays. The simulations of breach open conditions allowed the breach to grow at an asymptotic rate up to the estimated maximum stable breach area. Simulations were based on the following breach characteristics.

Table 2 -Breach Characteristic Summary

Breach Growth Rate Parameter			
Bay	Min	Most Likely	Max
Great South Bay	0.15	0.20	0.30
Moriches Bay	0.15	0.30	0.40

Max Stable Breach Area (Sq Ft)		
Bay	Min	Max
Great South Bay	6,000	33,500
Moriches Bay	16,000	16,000

Breach - Structure Failure. These damages occur on the barrier islands only and occur when structures are undermined and lost to erosion when breaches in the barrier islands are allowed to grow in directions parallel to the shoreline.

Shorefront. These damages occur only in the shorefront areas of the barrier islands and the mainland area east of the barrier island system, and are caused by cross-shore erosion, wave action, ocean inundation, or combinations thereof.

Public Emergency. These are costs related to efforts made by local communities and other entities to ensure the safety of the public during storm events. Public emergency costs have not been specifically evaluated at this stage in the study.

Other. These damages include other items which have not been specifically evaluated at this stage in the study, such as damage to roads, utilities and coastal protection structures, and impacts on locally-based fishing fleets.

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

Table 4 helps to illustrate the storm damages that can occur, as a basis for presenting the alternatives that are available to address these problems, and the relative magnitude of each problem. This illustrates that of the $97 Million in annual damages calculated $72 Million (74%) of the damages is because of flooding of the back-bay areas that is likely to occur due to overwashing or breaching (regardless of the barrier island condition). These are the damages that need to be addressed with alternatives that directly affect these mainland areas. Another $15 Million (15%) in damages are incurred by flooding on the back-bay side of the barrier islands.

$8.2 Million in damages (8%) are due to damages that occur when a breach remains open. These are damages that can be reduced with alternatives to both reduce the likelihood of breaching, and respond to close breaches quickly.

$2.3Million in damages, representing 2% of the total damages occur due to damages to the shorefront. These damages are reduced by the alternatives to reduce the potential for breaching, as well as with alternatives specifically developed to address shorefront damages.

4.5 Damage Sensitivity and Uncertainty

As described above, annual damages represent the expected average or mean results. The actual amount of future damages is highly sensitive to the timing and sequence of storms, future events that cannot be predicted. The life cycle simulation has incorporated the uncertainty of these parameters by allowing the values to vary in each simulation. In order to account for uncertainties in the timing and impacts of various storms, calculations are performed for a large number of lifecycles and mean or average value is reported.

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

4.6 Potential Double Counting of Damages

Model Component 2 includes damages incurred by structures located in the potential breach growth area on the backbay side of the barrier islands as “breach collapse damages”. These structures are assumed to be completely lost to erosion when breaches occur but then rebuilt following the breach repair. These structures are also included in the structure inventory used in Component 3 models intended to capture lifecycle inundation damages on the barrier island backbay, and hence there exists the possibility of double counting damages to these structures in that Component 3 models may add their inundation damage to the erosion damage already captured in Component 2. It is recommended that users should whether to consider the structures as part of the breach collapse damages (and hence eliminate them from the inventory contributing to the Component 3 models), or as part of the non-shorefront inundation model damages (and hence set the breach collapse values to zero in Component 2).

4.7 Modeling of With-Project Conditions

☐ While the lifecycle simulation models were initially developed as without-project condition models, they have been used to model damages under with-project conditions, and hence to compute benefits in order to ultimately identify the NED plan, by incorporating the following edits and modifications: The residual damages for projects featuring beachfill have been modeled primarily by making edits to the table in the 'Barrier Degradation' tab of the lifecycle models. The user may make edits to key parameters including profile widths, threshold water levels for breach and overwash, and the post-storm profile recovery

☐ Renourishment actions for beachfill plans can be modeled by editing the renourishment parameters in the yellow shaded cells at the top of each of the 10 locations in the 'Simulate' tab.

☐ The nonstructural components of all evaluated plans have been modeled by modifying the baseline structure inventory input to HEC-FDA and then copying the resulting modified stage-damage functions into the 'FDA S-D Output' tab in the lifecycle model.

4.8 Description of Input Data

The model components require several types of input data as described above for the individual components. In general, necessary data includes:

☐ Stage Damage with uncertainty for each reach.

☐ Reach specific data including still water stage on ocean and bay, storm recession distance, and post storm recovery rates, Sea level rise rates with uncertainty bands. The frequency data can be developed using standard engineering models.

☐ Location specific data including any renourishment criteria, breaching thresholds, breach growth conditions, maintenance requirements for the breach closure, value of development in the breach location.

The Life Cycle Analysis component is limited in that once a breach has occurred in the bay in which the reach is located. All future analysis assumes the Breach Closed Condition (BCC) for identifying the bay stage. This implies that the breach closure is maintained at some level of protection.

Table 3: Simulated Non-Shorefront Without-Project Inundation Annual Damages by Design Reach -Generated by Model Component 3

Number	Mainland Reach ID	Name	Buildings #	Sub Bay	Equivalent Annual Inundation Damages
26.1	GSB-M-1A	Unqua Point (County Line) to Copiague Beach	1,715	WGSB	$4,941,000
26.2	GSB-M-1B	Copiague Beach to Venetian Shores Beach	4,703	WGSB	$3,413,000
26.3	GSB-M-1C	Venetian Shores Beach to Neguntatogue Creek	2,323	WGSB	$5,237,000
25.1	GSB-M-1D	Neguntatogue Creek to Santapogue Point	1,960	WGSB	$1,510,000
25.2	GSB-M-1E	Santapogue Point to Sampawams Point (Town Line)	2,413	WGSB	$4,375,000
24	GSB-M-2A	Sampawams Point (Town Line) to Great Cove	3,175	WGSB	$2,104,000
23.1	GSB-M-2B	Brightwaters	364	WGSB	$186,000
23.2	GSB-M-2C	Lawrence Creek to Seatuck Refuge	1,746	WGSB	$4,367,000
23.3	GSB-M-2D	Seatuck Refuge to Heckscher Park (Nicoll Point)	2,985	WGSB	$1,419,000
28		Fire Island Lighthouse to Seaview (Fire Island)	1,998	WGSB	$10,836,000
27.1		Ocean Bay Park to Oakleyville (Fire Island)	433	WGSB	$995,000
		Subtotal - Western Great South Bay Sub-Bay	***23,815***		**$39,383,000**
27.2		Sailors Haven to Water Island (Fire Island)	712	CGSB	$2,242,000
27.3		Water Island to Watch Hill (Fire Island)	188	CGSB	$585,000
22.1	GSB-M-3A	Heckscher Park (Nicoll Point) to Green Point	1,961	CGSB	$9,239,000
22.2	GSB-M-3B	Green Point to Blue Point (Town Line)	2,095	CGSB	$3,502,000
21.1	GSB-M-4A	Blue Point (Town Line to Tuthill Creek (BluePoint)	517	CGSB	$794,000
21.2	GSB-M-4B	Tuthill Creek to Swan River (Patchogue)	1,641	CGSB	$3,911,000
21.3	GSB-M-4C	Swan River to Mud Creek	755	CGSB	$461,000
		Subtotal - Central Great South Bay Sub-Bay	**7,869**		***$20,734,000***
21.4	GSB-M-5A	Mud Creek to Howell Creek	747	EGSB	$1,353,000
21.5	GSB-M-5B	Howell Creek to Bellport Marina	225	EGSB	$120,000
21.6	GSB-M-5C	Bellport Marina to Carmans River	428	EGSB	$845,000
20	GSB-M-6A	Carmans River to Smith Point Bridge	571	EGSB	$479,000
		Subtotal - Eastern Great South Bay Sub-Bay	***1,971***		***$2,796,000***
19		Moriches Inlet to Quantuck Canal	258	MOR	$5,000

Number	Mainland Reach ID	Name	Buildings #	Sub Bay	Equivalent Annual Inundation Damages
		(Westhampton Barrier)			
18.1	MB-M-1A	Smith Point Bridge to William Floyd Estate	3,070	MOR	$9,176,000
18.2	MB-M-1B	William Floyd Estate to Forge River	208	MOR	$422,000
18.3	MB-M-1C	Forge River to Radio Point	1,343	MOR	$5,737,000
17.1	MB-M-2A	Radio Point to Harts Cove	226	MOR	$1,434,000
17.2	MB-M-2B	Harts Cove to Seatuck Creek (Town Line)	94	MOR	$22,000
16.1	MB-M-3A	Seatuck Creek (Town Line) to Fish Creek	137	MOR	$366,000
16.2	MB-M-3B	Fish Creek to Speonk Point	318	MOR	$1,427,000
16.3	MB-M-3C	Speonk Point to Apacuck Point	432	MOR	$1,668,000
16.4	MB-M-3D	Apacuck Point to Quantuck Bay	611	MOR	$3,158,000
		Subtotal - Moriches Bay Sub-Bay	***6,697***		***$23,416,000***
		Total: Back-bay Area	**40,352**		$86,329,000

Discount Rate 3.50%, Period of Analysis: 20 yrs, Price Level: October 2013

Table 4: Summary of Without Project Equivalent Annual Damages

Damage Category	**Without Project Equivalent Annual Damage**
Inundation from inlet and back-bay wave, breaching, and overwash:	
Mainland	$71,666,000[a]
Barrier	$14,663,000[a]
Subtotal Inundation	*$86,329,000*
Damages due to a breach remaining open:	
Inundation	$7,601,000[b]
Structure Failure (barrier island)	$507,000[b]
Subtotal Breach Open Damages	*$8,229,000*
Shorefront Damages (Fire Island Sub-Reaches only)	*$2,250,000*[c]
Total Storm Damage	**$96,688,000**

a: Generated by Model Component 3
b: Generated by Model Component 2
c: Generated by the Shorefront Damage Model Component – subject to a separate model certification exercise.

Discount Rate 3.50%, Period of Analysis: 20 yrs, Price Level: October 2013

5.0 Sea Level Rise:

In addition to considering the statistical uncertainty of damages discussed above, the analysis also considered the sensitivity of the results to the potential for accelerated rates of future sea level rise (SLR). The mean damages are based on a projection of the historic mean Sea level rise trend of 0.0127 feet/year at Sandy Hook, New Jersey, as specified in EC-1165-2-211. There are various projections of accelerated sea level rise which would significantly increase the storm damage risk within the study area. In order to evaluate the impact of potentially higher rates, additional lifecycle simulations were performed using a sea level rise rate of .026 feet/year, or 1.3 feet in 50 years. While the impacts of accelerated SLR on the annual damages varied considerably between the reaches (from about a 30% to a 70% increase), the overall impact of such an accelerated sea level rise is about a 45% increase in the without project damages. The sea level rise analysis was conducted for the on-going FIMP reformulation and evaluated the impacts over a 50 year evaluation length. The Stabilization effort considered the sea level rise impacts over a 20 year evaluation period, so that the impacts were not overstated.

It is acknowledged that there are projections for larger increases in sea level rise, an increase of up to 2.7 feet over 50 years period of analysis. This scenario was not evaluated. This increase is so large that it is unlikely that the analysis framework we have established would predict accurate results. As an example, in Great South Bay, an increase of 2.7 feet in sea level rise would result in the flooding due to a 2-yr event (with 2.7 feet of SLR included) to have a flooding effect greater than the currently modeled 500-yr event. Under such extreme changes in sea level rise, it is highly likely that the assumptions made for actions to occur in the WOPFC would not be valid.

6.0 Project Costs & Economics

Economics of the Fire Island Inlet to Moriches Inlet Plan: Because of Hurricane Sandy's impacts on the barrier island portion of the study area and the resulting degradation of the existing dune and berm features, the barrier island is exceptionally vulnerable to future severe storm impacts. The resultant degradation of the protection afforded the back-bay by the barrier island makes it imperative to immediately implement restorative measures and project betterments to the barrier island to prevent future catastrophic damage to the study area. Therefore, a beachfill stabilization plan within the FIMI project area is being developed as a separate effort. The following paragraphs detail the costs and benefits of the FIMI project features.

6.1 Cost

An overview of the cost of the Stabilization plan features identified above are provided in this section and Table 5: Total Project Cost. The cost estimates form the basis for the economic analysis and benefit cost ratio. All cost estimates are based on October 2013 price levels.

6.1.1 First Costs

First costs include charges arising from the acquisition or construction of each individual component, as well as the cost of easements, planning and environmental compliance, engineering and design, monitoring, engineering during construction, construction management (supervision & administration), and contingencies.

Real Estate

The market value of 41 oceanfront structures that would be acquired under the MIDU alignment was obtained from a market gross appraisal completed on June 10, 2013. The market gross appraisal reflects the value of the real estate post-Hurricane Sandy. The estimated market Gross Appraisal value is, as of June 10, 2013, $46,025,000 (including a 40% contingency). The cost estimate for relocation of six (6) structures and relocation/reconstruction of the Ocean Beach well complex component required as part of the initial construction are estimated as $3,601,347, relied on the following:

- Structure relocations will be performed in conjunction with the beach replenishment contract and therefore additional barging costs for mobilization /demobilization are not included.
- Quantities are primarily based on the structure square foot areas obtained from Tax maps and aerial photographs.
- Unit pricing based on utilizing RSMeans® construction cost data with a 30% city cost index adjustment

Administration costs for real estate acquisitions, relocations, and easements were compiled from the Appraisal dated 10 June 2013 and total $ 1,687,400. The total Real Estate cost for Lands & Damages is $ 68,421,848. Since Federal funds will be applied in New York State, the Baseline Cost Estimate for Real Estate will be reviewed as the project progresses, and make adjustments to costs as necessary. The Baseline Cost for Real Estate includes Easement costs for the authorized project.

Administrative and Acquisition Costs:	
Administrative Costs: Perpetual Beach Storm Risk Management Easements (663), Access Agreements (252) Temporary Construction Easements (27) And Staging Right-of-Entries(2): (***Total 691 Properties***)……………………………..…….	$ 1,191,000
Administration of 6-home On-Site relocations ………………………………………..	$ 49,000
Administration of Fee Acquisitions: ***(41 homes)***………………………………………..	$ 294,000
	$ 1,534,000
Contingency : 10%	153,400
	$ 1,687,400
Fee Acquisition Costs:	
Purchase of Privately-Owned Homes (41 Properties)	$46,025,000
Perpetual Beach Easement Costs – 410 privately owned properties	$16,588,101
Damage Costs (17 Pools and Decks)…………………………………………	$ 285,000
Damages to 7 Pools @ $25k = $175k	
Damages to 4 Small Decks @ $5 = 20k	
Damages to 6 Large Decks @ $15k = $90k	*$*235,000
	$63,133,101
Public Law 91-646 Relocation Assistance:	
Relocation Construction Cost for 6 homes………………………………	$1,001,347
Relocation and Reconstruction of Ocean Beach Well System…………………..	$ 2,600,000
	$ 3,601,347
TOTAL $68,421,848	

Beachfill
The Project consists of beachfill along Fire Island to reinforce the existing dune and berm system and the acquisition and relocation of ocean front structures.

The construction includes beachfill at Robert Moses State Park, Fire Island Lighthouse Tract, all of the communities outside of Federal Tracts, and Smith Point County Park. Beachfill is not included in any Major Federal Tracts, except Fire Island Lighthouse. The beachfill sand will be obtained from two offshore borrow areas at the western and eastern ends of the project area.

Beachfill construction costs include dredging, mobilization, and demobilization required for the construction the selected plan. Dredging costs per cubic yard by reach/borrow area and mobilization costs per dredging contract were provided by the USACE, using CEDEP (Corps of Engineers Dredge Estimating Program). The program assumes the use of 6,500 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. A $6,000,000 mobilization/demobilization cost is assumed per dredging contract. Engineering and design (E&D) and supervision and administration (S&A) costs are estimated to be 0.95% and 4.34% respectively of the total construction cost.

The total first cost for this beachfill (including Real Estate) is $207,100,000. The complete Cost Estimate details are presented in Appendix H of this report.

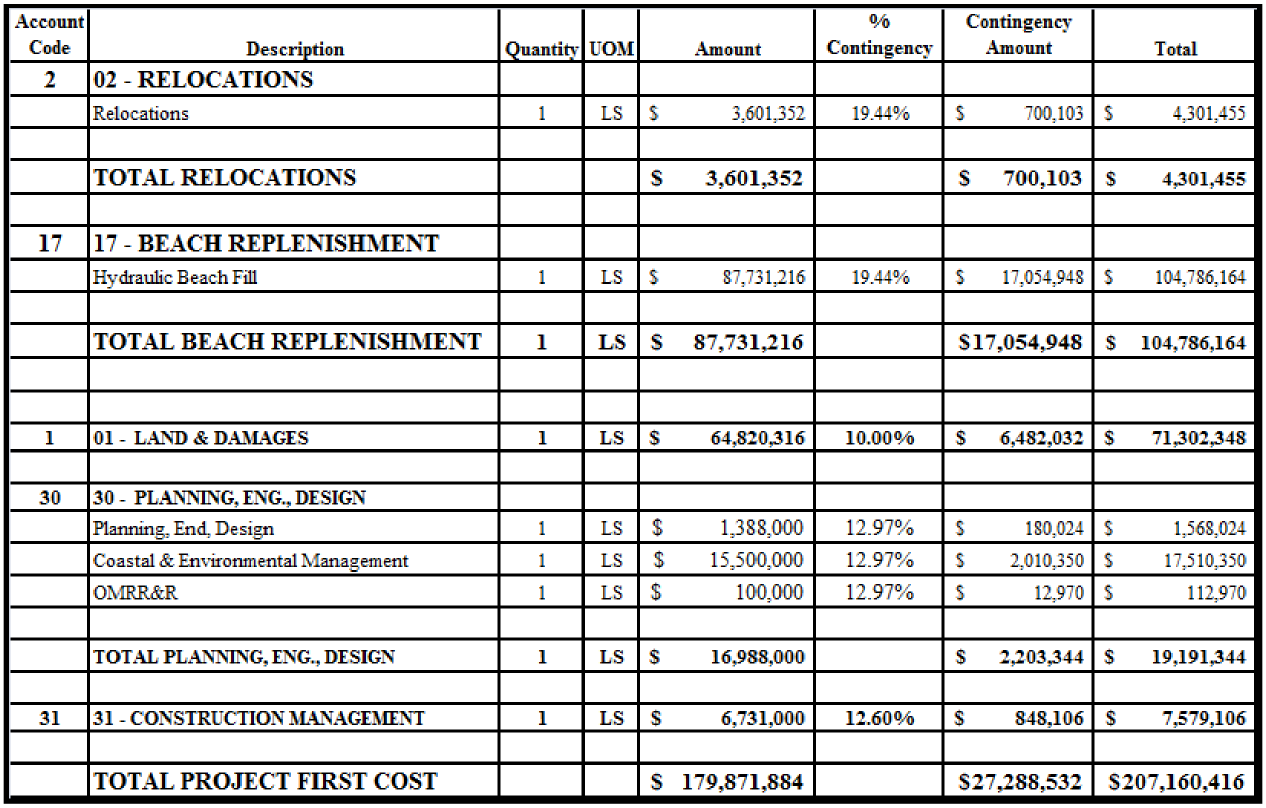
6.1.2 Breach Response

Breach Response Costs have been calculated, and are shown below for purposes of the economic analysis, but are not included in the project costs. Breach closure is expected to occur in the without project condition and in the with-project condition, but with different probabilities of occurrence and different response protocols. These costs are developed to show the differences in expected breach closure costs, under the two scenarios and are factored into a calculation of costs avoided. If FIMI is constructed under an approved PL 113-2 HSLRR, any necessary breach response would be implemented under PL 84-99.

The breach closure costs are a function of the breach growth rate, dredging production rates, washout losses, and the dredging costs. The cost of closing a breach increases non-linearly as the breach grows in size because not only is a greater volume of sediment required to fill the breach cross-section but washout losses increase. In general it is less expensive to close a breach with a 30” cutter head dredge because it has a faster dredging production rate than a smaller hopper dredge and, consequently, is capable of closure a breach faster. Breach Response Costs have been calculated, and are shown below for purposes of the economic analysis, but are not included in the project costs. Breach closure is expected to occur in the without project condition and in the with-project condition, but with different probability of occurrence. These costs are developed to show the differences in expected breach closure costs, under the two scenarios and are factored into a calculation of costs avoided.

Historical breach observations in Great South and Moriches Bay were used to determine appropriate breach growth rates. The unit costs of dredge placement applied for breach closure cost estimates are similar to the unit prices determined with CEDEP for initial construction and a $4 million mobilization / demobilization cost is applied for each breach (assuming a 3,800 cy hopper dredge).

Table 5: Total Project Cost



Account Code	Description	Quantity	UOM	Amount	% Contingency	Contingency Amount	Total
2	**02 - RELOCATIONS**						
	Relocations	1	LS	$ 3,601,352	19.44%	$ 700,103	$ 4,301,455
	TOTAL RELOCATIONS			**$ 3,601,352**		**$ 700,103**	**$ 4,301,455**
17	**17 - BEACH REPLENISHMENT**						
	Hydraulic Beach Fill	1	LS	$ 87,731,216	19.44%	$ 17,054,948	$ 104,786,164
	TOTAL BEACH REPLENISHMENT	**1**	**LS**	**$ 87,731,216**		**$17,054,948**	**$ 104,786,164**
1	**01 - LAND & DAMAGES**	**1**	**LS**	**$ 64,820,316**	**10.00%**	**$ 6,482,032**	**$ 71,302,348**
30	**30 - PLANNING, ENG., DESIGN**						
	Planning, End, Design	1	LS	$ 1,388,000	12.97%	$ 180,024	$ 1,568,024
	Coastal & Environmental Management	1	LS	$ 15,500,000	12.97%	$ 2,010,350	$ 17,510,350
	OMRR&R	1	LS	$ 100,000	12.97%	$ 12,970	$ 112,970
	TOTAL PLANNING, ENG., DESIGN	**1**	**LS**	**$ 16,988,000**		**$ 2,203,344**	**$ 19,191,344**
31	**31 - CONSTRUCTION MANAGEMENT**	**1**	**LS**	**$ 6,731,000**	**12.60%**	**$ 848,106**	**$ 7,579,106**
	TOTAL PROJECT FIRST COST			**$ 179,871,884**		**$27,288,532**	**$207,160,416**

6.1.3 Annual Costs

Annual costs incorporate the first costs, beachfill, and berm and fill maintenance costs. Annual costs assume a project life of 20 years and an interest rate of 3.50%. Annual costs are presented in Table 6.

Table 6: Annual Costs

Cost Category	
Beach Fill	$207,100,000
Nonstructural	$0
Road Raising	$0
Total First Cost	*$207,100,000*
Total IDC*	$3,553,000
Total Investment Cost	*$210,714,000*
Interest and Amortization	$14,826,000
Operation & Maintenance**	$6,000
BCP Maintenance***	$561,000
Inlet Bypassing	$0
Renourishment	$0
Subtotal (Annual)	*$15,392,000*
Annual Breach Closure Cost ***	*$2,088,000*
Major Rehabilitation	*$0*
Total Annual Cost	***$17,480,000***
* Calculated at 12 months (September 2014 to August 2015)	
****** OMRR&R costs are assumed to be nominal for this project, since it is a one-time action project. $10k cost in each of the first 10 years, amortized over the 20 year project life.	
*** Breach Response Costs are shown in the table for purposes of economic analysis. These are not included in the Project Costs.	

6.2 Benefits

To model the with-project damages and hence allow benefits to be computed, revisions were made to key inputs in the lifecycle simulation models. Beach fill at the relevant locations was simulated by adjusting the effective baseline beach width and the threshold water surface elevations at which overwash, partial breaches, and full breaches are triggered. Similar revisions were applied to the with-project breach-only model, which was also revised to reference the modeled breach-open inundation damages arising from a breach closure period of three months, which reflects an assumed implementation of breach response protocols under PL84-99, with the project in place.

Table 7 presents the residual with-project damages resulting from the implementation of the project. Table 8 presents the Storm Risk Management Benefits. The Benefit Cost Ratio for the project is presented in Table 9. The results of analyses assume a project life of 20 years and an interest rate of 3.5%. The benefit category 'Structure Failure" covers the loss of homes buildings on the barrier island located on land likely to be lost as breaches grow in the interval before they can be closed. Costs avoided include the projected outlay on breach closure actions and beach maintenance activities which are still assumed to occur under without project conditions. The analysis of the plan for the FIMI project area shows that the project is economically justified as a one-time action.

Table 7: FIMI Project Residual Storm Damages

Benefit Category	**Annual Equivalent Damage**
Inundation	
Mainland	$65,921,000
Barrier	$12,093,000
Total Inundation	*$78,013,000*
Breach	
Inundation	$346,000
Structure Failure	$202,000
Total Breach	*$584,000*
Shorefront*	$2,250,000
Total With-Project Storm Damage	***$80,811,000***

*Residual Damage Analysis not yet finalized

Table 8: FIMI Project Benefits

Benefit Category	*Annual Equivalent Damage Avoided*
Inundation	
Mainland	***$5,745,000***
Barrier	***$2,571,000***
Total Inundation	***$8,316,000***
Breach	
Inundation	***$7,254,000***
Structure Failure	***$305,000***
Total Breach	***$7,559,000***
Shorefront*	***$0***
Total Storm Damage Reduction	***$15,875,000***
Costs Avoided	
Breach Closure	***$2,930,000***
Beach Maintenance	***$0***
Total Annual Benefits	***$18,805,000***

Table 9: FIMI Benefit to Cost Ratio

Component	
Total Annual Cost	$17,480,000
Total Benefits	$18,805,000
Net Benefits	$1,325,000
Benefit-Cost Ratio	1.1

7.0 Summary

The FIMI project is an expedited approach to construct a stabilization effort independent of the FIMP Reformulation Study. It is a one-time placement of sediment, with a project life of twenty years, in one portion of the study area of the larger FIMP project. The proposed action is the only plan considered in this Stabilization report, and is compared to no action in the justification. The beachfill plan and profile identified in the FIMP effort is the only alternative evaluated within FIMI.

Stabilization efforts were focused on FIMI as this reach is the most impacted when barrier island overwash and breach inundate the back-bay, exposing the back bay structures to considerable damages.

This Stabilization effort is being undertaken in response to the highly vulnerable condition following Hurricane Sandy's erosive forces, where expedited action is needed to stabilize this area. This FIMI stabilization effort (Reach 1) has been developed as a one-time, initial construction project to repair damages caused by Hurricane Sandy and to stabilize the island. This report demonstrates that the Stabilization Project has its own independent utility, and as developed, does not limit the options available in the Reformulation Study or pre-suppose the outcome of the Reformulation Study.

This summary section reproduces the documentation prepared for model certification and documents the economic modeling that affirms that the project is economically justified.

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