Leonardo, Raritan Bay and Sandy Hook Bay, New Jersey Coastal Storm Risk Management Feasibility Study

Draft Feasibility Report

And Environmental Assessment

March 2015

**New Jersey
Department of
Environmental Protection**

**U.S. Army Corps of Engineers
North Atlantic Division
New York District**

Leonardo, Raritan Bay and Sandy Hook Bay, New Jersey Coastal Storm Risk Management Feasibility Study

Draft Feasibility Report
March 2015

PERTINENT DATA

DESCRIPTION

The US Army Corps of Engineers (USACE) Coastal Storm Risk Management (CSRM) Tentatively Selected Plan (TSP) provides for nonstructural treatment of up to 25 structures within the community of Leonardo located in Middletown Township, NJ to address damages from coastal storms. This number will undergo further refinement during plan optimization following the receipt of agency and public feedback, which will result in between 10 to 25 structures to be recommended for treatment.

LOCATION

Leonardo is located within Middletown Township, in Monmouth County, NJ.

FEATURES

The recommended nonstructural treatment for the 25 structures is structure elevation to a level of the one percent flood still water elevation (+11.9 feet NAVD88) plus historic sea level rise (0.7 feet) plus wave contribution (varies for each structure) plus 1 feet or 3 feet of freeboard for structures in the AE and VE zones, respectively. After treatment, the final main floor elevation of elevated structures will range between +15.2 feet (ft) North Atlantic Vertical Datum of 1988 (NAVD88) to +18.4 ft NAVD88, depending on the specific location of each structure and associated base flood elevation. As defined by Federal Emergency Management Agency (FEMA), the base flood elevation is the elevation of surface water resulting from a flood that has a 1% chance of equaling or exceeding that level in any given year. The base flood elevations for affected structures range from +11 ft NAVD88 to +14 ft NAVD88. Each structure will be elevated a minimum of one foot above the base flood elevation to meet the latest building standards for construction in a floodplain. To achieve this height, structures will be elevated anywhere between 1.8 ft to 10.6 ft from their existing elevations.

ECONOMICS

Coastal Storm Risk Management	
Initial Project Cost (October 2014 price level)	$5,463,000
Annualized Initial Cost*	$227,000
Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R) Costs**	$0
Total Annual Cost*	$227,000
Average Annual Benefits*	$287,000
Average Annual Net Benefits*	$59,000
Benefit-to-Cost Ratio	1.3

*Annualized at 3.375% over a 50-yr period

** OMRR&R costs are not anticipated, as nonstructural treatments will not result in OMRR&R responsibilities for the non-Federal cost share partner.

REAL ESTATE REQUIREMENTS

The project will require temporary work easements and temporary relocation of residents while the nonstructural construction is underway. No permanent acquisitions are needed.

Real Estate Costs (Oct. 2014 Price Levels)

Real Estate Cost Category	*Federal Share*	*Non-Federal Share*	Total
Incidental Costs	$18,000	$85,000	$103,000
Acquisition Costs (Temporary Relocations)	$0	$443,000	$443,000
Subtotal*	**$18,000**	**$528,000**	**$545,000**
Contingency (20%)	$4,000	$106,000	$110,000
Total Lands & Damages*	**$21,000**	**$633,000**	**$654,000**

*All of the dollar amounts in this table have been rounded to the nearest thousand for display purposes, resulting in minor discrepancies between the expected totals and the displayed totals. Please see the Real Estate Plan for the unrounded amounts.

COST APPORTIONMENT

The project will be cost-shared 65% Federal and 35% non-Federal. Mitigation is not anticipated because this is a nonstructural project and there will be no significant impacts to environmental and historical resources. OMRR&R responsibilities are not anticipated for the non-Federal partner, and there will be no additional operations and maintenance expenses for the individual property owners as a result of project implementation.

Cost Apportionment (Oct. 2014 Price Level)

	Cost Category	*Federal Share*	*Non-Federal Share*	Total
Coastal Storm Risk Management-Nonstructural Treatments	Initial Project Costs	$3,551,000	$1,912,000	$5,463,000
	Real Estate Costs (LERRDS)	$21,000**	$633,000	$633,000
	Cash Contribution	$3,551,000	$1,279,000	$4,830,000
	OMRR&R Costs		$0*	$0
Total		$3,551,000	$1,912,000	$5,463,000

*OMRR&R costs are not anticipated, as nonstructural treatments will not result in OMRR&R responsibilities for the non-Federal cost share partner.

**The Federal share of Real Estate costs does not reduce the Federal cash contribution and is shown for information purposes only.

Executive Summary

This study has determined that periodic hurricanes and coastal storms pose a severe threat to life and property in Leonardo, NJ. There is potential to manage coastal storm risks in Leonardo. In response to these problems and opportunities, plan formulation activities considered a range of structural and nonstructural measures. Through an iterative plan formulation process, potential coastal storm risk management measures were identified, evaluated, and compared.

Alternative coastal storm risk management plans that survived the initial screening of alternatives included only small-scale nonstructural solutions, due to the heterogeneity of the study area topography. As defined by USACE, nonstructural measures reduce flood damages without significantly altering the nature of extent of flooding (*ie.*, elevating structures out of the floodplain), whereas structural measures are physical modifications designed to reduce the frequency of damaging levels of flood inundation (*ie*, walls, diversion channels, *etc*).[1]

Prior to Hurricane Sandy, 19 structures were identified for nonstructural treatment and coordinated with non-Federal partners. After Hurricane Sandy it was determined by the Township of Middletown that 12 out of the 19 structures were substantially damaged.[2] In an assessment of the post-Hurricane Sandy landscape, it was found that despite changes to the floodplain, stage frequency curves, and economics analyses, the fundamental conditions underlying the plan formulation still pointed to a small nonstructural solution. The remaining 7 structures were included in the post-Hurricane Sandy assessment. Using the best available data, up to 25 structures have been tentatively identified for potential inclusion in the Tentatively Selected Plan (TSP) for Leonardo.

This number will undergo further refinement during plan optimization, following the receipt of agency and public feedback, which will result in 10 to 25 structures to be recommended for treatment. The recommended nonstructural treatment for the 25 structures is structure elevation to a level of the one percent flood still water elevation (+11.9 feet North Atlantic Vertical Datum of 1988 (NAVD88)) plus historic sea level rise (0.7 feet) plus wave contribution (varies for each structure) plus 1 feet or 3 feet of freeboard for structures in the AE and VE

[1] Engineer Regulation 1105-2-100, Planning Guidance Notebook (USACE 2000), Paragraph 3-3.a

[2] FEMA uses the term “substantially damaged” to identify structures that may be eligible for Increased Cost of Compliance funds through a homeowners’ National Flood Insurance Program flood insurance policy to floodproof the structure. If deemed substantially damaged, the structure must be elevated or rebuilt a minimum of one foot above the one percent flood level, or base flood elevation.

zones, respectively. After treatment, the final main floor elevation of elevated structures will range between +15.2 ft NAVD88 to +18.4 ft NAVD88, depending on the specific location of each structure and associated base flood elevation. To achieve this height, structures will be raised anywhere between 1.8 ft to 10.6 ft from their existing elevations, dependent upon their current, individual main floor elevations.

The estimated total first cost for project implementation is $5,463,000 (October 2014 Price Level), to be cost shared 65% Federal and 35% non-Federal. Annual net benefits are in the amount of $59,000 and the benefit-to-cost ratio is 1.3.

The non-Federal project partner, New Jersey Department of Environmental Protection (NJDEP), has indicated its support for the TSP and is willing to enter into a Project Partnership Agreement (PPA) with the Federal Government for the implementation of the Recommended Plan, which will be identified in the Final Feasibility Report.

Leonardo, Raritan Bay and Sandy Hook Bay, New Jersey
Coastal Storm Risk Management Feasibility Study

Table of Contents

List of Figures

List of Tables

Appendices

Chapter 1: Introduction

1.1 Study Purpose and Scope

The U.S. Army Corps of Engineers (USACE), New York District (CENAN) prepared this draft feasibility report for the Leonardo, Raritan Bay and Sandy Hook Bay, New Jersey Coastal Storm Risk Management Feasibility Study (Leonardo CSRM Study). It includes input from the non-Federal study partner, local governments, natural resource agencies, non-governmental organizations, and the public. This report presents potential solutions to manage coastal storm risk in the community of Leonardo (Figure 1).

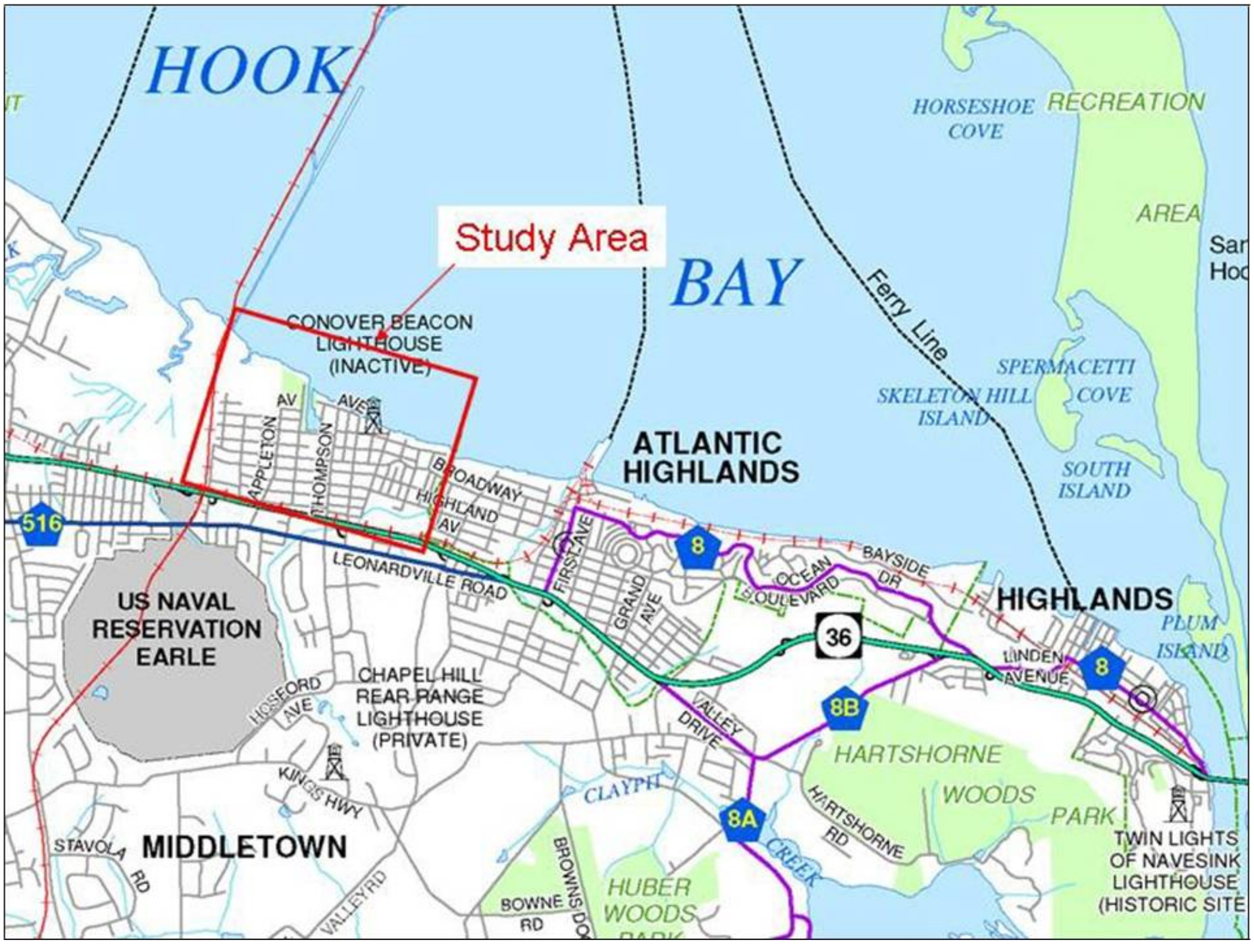

Figure 1: Study Area

The Federal objective of water and related land resources project planning is to contribute to national economic development (NED) consistent with managing and reducing risk to the nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements (Principles and Guidelines (P&G), 1983). Water and related land resources projects are formulated to alleviate problems and take advantage of opportunities in ways that contribute to this objective. Pursuant to this, this feasibility report will: (1) summarize the current and potential water resource problems, needs, and opportunities for coastal storm risk management in Leonardo; (2) present and discuss the results of the plan formulation for water resource management solutions; (3) identify specific details of the Tentatively Selected Plan (TSP), including inherent risks and (4) determine the extent of Federal interest and local support for the plan.

1.2 Need for Action

The community of Leonardo is located within Middletown Township in Monmouth County, New Jersey. Because of its location and topography, Leonardo is subject to recurrent flooding from the Sandy Hook bay and associated tidal creeks. Damages from the recurrent flooding, as well as shore erosion and wave attack, threaten the resilience of this bayshore community.

1.3 Study Authority

The Leonardo CSRM Study was authorized by a resolution of the Committee on Public Works and Transportation of the U.S. House of Representatives adopted August 1, 1990:

> *Resolved by the Committee on Public Works and Transportation of the United States House of Representatives, That the Board of Engineers for Rivers and Harbors is requested to review the report of the Chief of Engineers on Raritan Bay and Sandy Hook Bay, New Jersey, published as House Document No. 464, Eighty-seventh Congress, Second Session, and other pertinent reports, to determine the advisability of modifications to the recommendations contained therein to provide erosion control and storm damage prevention for the Raritan Bay and Sandy Hook Bay.*

This study authority covered the Raritan Bay and Sandy Hook Bay area, from South Amboy at the entrance to the Raritan River at the western end to Highlands at the eastern end. In response to the study authority, the Raritan Bay and Sandy Hook Bay, New Jersey Combined Hurricane Storm Damage Reduction and Shore Protection Reconnaissance Study Report (1993) concluded that within the study area coastal storm risk management projects in Leonardo and five other communities appeared to be economically viable and were recommended for further investigation.

The Reconnaissance Report recommended that Leonardo and the other identified communities could proceed to interim feasibility studies after a “pre-feasibility” study was conducted. It was indicated that such a study was to further demonstrate the extent of Federal interest in a site-specific plan and to provide a better basis for estimating the feasibility phase cost. The pre-feasibility study for Leonardo (1999) identified a potential plan that appeared economically and environmentally feasible. The Feasibility Cost Sharing Agreement (FCSA) with the New Jersey Department of Environmental Protection (NJDEP) for the Leonardo CSRM Study was executed in 1999.

Prior to Hurricane Sandy, the Leonardo CSRM Study was close to completion. The effects of Hurricane Sandy are described in Section 3.1 (Problem Statement) of this report. The Leonardo CSRM Study was included in Interim Report 2 in response to the Hurricane Sandy Disaster Relief Appropriations Act (P.L. 113-2), as a project under study to receive $1,000,000 to complete the feasibility study. A FCSA amendment for $1,000,000 to complete the feasibility study was executed on 23 August 2013.

1.4 Prior Studies, Reports, and Existing Water Projects

Prior Reports Studies and Reports

Prior reports on the Leonardo study area have examined the feasibility of actions related to navigation, shore stabilization, and coastal storm damages.

Preliminary Examination of Navy Breakwater (1946). This study concluded that breakwaters and dredging desired by the U.S. Navy were not justified from a commercial navigation standpoint and recommended project construction with military funds.

Survey Report (1960). A coastal storm risk management (formerly called “shore protection”) project at Leonardo was not found to be economically justified after detailed investigation, although the preliminary analysis indicated the possibility for improvement.

Reconnaissance Report for Raritan Bay and Sandy Hook Bay, New Jersey (1993). The Reconnaissance Report for Raritan Bay and Sandy Hook Bay, a 21-mile stretch located between Sandy Hook and the mouth of the Raritan River, focused on the community of Port Monmouth, a section of Middletown Township, and identified potential Federal interest for the communities of Leonardo (Middletown Township), Highlands, Union Beach, Keyport, and Cliffwood Beach. Considering the complexity of coastal processes and interior drainage in the area, and lack of data, a pre- feasibility study having a greater level of detail was undertaken to verify interest in conducting feasibility level studies. A favorable pre-feasibility study for Leonardo was completed in February 1999, leading to a FCSA in 1999 for the current study.

Existing Federal Projects

There are no existing USACE Coastal Storm Risk Management projects within the Leonardo study area. The closest USACE projects are the navigation channel at Leonardo, the coastal storm risk management projects in Laurence Harbor to the west and Keansburg, North Middletown and Port Monmouth, to the east, along with the Cheesequake Creek at Laurence Harbor and Shoal Harbor and Compton Creek navigation channels at Belford to the west and on the Shrewsbury River, to the east (Figure 2). The Leonardo navigation channel in Sandy Hook Bay was authorized by the Rivers and Harbors Acts of 1945 and 1950, and provides for an entrance channel 8 ft deep, 150 ft wide, and approximately 2,500 ft long, from the 8 ft contour in Sandy Hook Bay to the entrance of the small boat harbor at Leonardo. In addition to provide access to small recreational vessels, the channel is also used to transport distillate fuel oil (approximately 379 tons for the five year average annual commercial tonnage). Several small critical shoals are developing on the south side of the channel, near the head of navigation, as a result of Hurricane Sandy. Funds under P.L. 113-2 were used to remove approximately 35,000 cubic yards (cy) of sand to restore function to the project in 2014.

The existing coastal storm risk management project encompasses 2.7 miles of shoreline in the Borough of Keansburg and North Middletown (located in Middletown Township), Monmouth County, and 0.6 miles of shoreline in Laurence Harbor (located in Old Bridge Township), Middlesex County. In 1966, the USACE constructed a beach berm and levees at Laurence Harbor. In 1973, the USACE completed the construction of a beach berm, groins, levees, pump station, floodwall, and a storm closure gate in Keansburg and East Keansburg. The project in Keansburg, North Middletown and Laurence Harbor was damaged by Hurricane Sandy in 2012 and has been repaired and restored pursuant to P.L. 84-99, Flood Control and Coastal Emergencies (33 U.S.C. 701n) and P.L. 113-2. There is also a USACE coastal storm risk management project under construction at Port Monmouth between Leonardo and Keansburg. While the beachfill portion of Port Monmouth is complete, the structural components, including levees, floodwalls, a tide gate, pump stations, road closure gates, and environmental mitigation, are scheduled for completion in 2015.

The navigation project in Shrewsbury River was authorized by the Rivers and Harbors Act of 1919. There is no commerce on the project, but it is used by the Sea Streak ferry that connects to New York City. P.L. 113-2 funds were used to dredge 100,000 cy of sand from the Shrewsbury River Federal navigation channel in 2014. The navigation project at Belford is the Shoal Harbor and Compton Creek Federal Navigation Project, which was authorized by the Rivers and Harbors Act of 1935. The existing project, used for fishing operations, is two miles long from deep water in Sandy Hook Bay up through Compton Creek. It ranges from 8-12 ft deep at Mean Low Water (MLW), narrows from 150 ft wide in the bay to 75 ft wide in Compton Creek. P.L. 113-2 funds were used to dredge 160,000 cy of sand in 2014.

Proposed coastal storm risk management actions for Leonardo would not affect or be affected by the existing USACE projects at Leonardo, Keansburg, North Middletown, Laurence Harbor, Belford, Port Monmouth, and the Shrewsbury River.

Figure 2: Existing USACE projects in the vicinity of Leonardo. Navigation projects are in green and coastal storm risk management projects are in yellow. The study area is outlined in red.

1.5 Study Area

The **study area** is the area within which significant project impacts may occur. The study area and its existing conditions are described in this section. Due to the small geographic scale of the Leonardo study area, it was treated as a single planning and economic reach. The bayshore of the study area is approximately 6,500 ft long.

The Leonardo study area is located in Middletown Township, NJ, within the Raritan Bay and Sandy Hook Bay greater study area (see Figure 1). Leonardo occupies a 0.5 square mile area of land along the coast of Sandy Hook Bay and is dominated by a small knoll with a maximum elevation of +39 ft NAVD88. The study area is defined by the Sandy Hook Bay to the north, Wagner Creek to the east, New Jersey State Route 36 to the south, and the Naval Weapons Station Earle to the west in the vicinity of Ware Creek. All creeks in the study area flow north into Sandy Hook Bay.

1.6 Project Area

The **project area** is the area in which measures will likely be built. Because the TSP is nonstructural (see Chapter 4), it encompasses the entire study area. A more detailed view of the study/project area is presented in Figure 3.

Source: NJOIT, OGIS, New Jersey 2007 - 2008 High Resolution Orthophotography; NJDOT, Roads 2008

Figure 3: Project Area

1.7 Non-Federal Partner

The non-Federal cost sharing partner is the New Jersey Department of Environmental Protection (NJDEP). In April 1999, the USACE and the NJDEP executed a FCSA for the study, after a favorable Pre-Feasibility Report was completed for the Leonardo study area. Though not the non-Federal cost sharing partner, the Township of Middletown is an active participant in the study and serves as the local sponsor.

The study will be completed with funds authorized by the Disaster Relief Appropriation Act of 2013 (P.L. 113-2) at full Federal expense. The study is estimated to cost $1,000,000 to complete. A FCSA Amendment was executed with the NJDEP in August 2013.

Both the NJDEP and the Township of Middletown support the proposed TSP.

1.8 The Planning Process

In compliance with the USACE planning process, this draft Feasibility Report is being released for concurrent public and agency (USACE) review of the TSP.[3] For the TSP, the study team has evaluated an array of alternatives to arrive at a general description of the TSP (type of treatment - floodwalls vs. beachfill vs. nonstructural treatments such as house elevations, the linear extent of the project, etc), with the exact dimensions to be determined in a process called optimization. Optimization of the TSP happens after comments from public review and agency review are received and incorporated into the draft report package. Through optimization, the TSP becomes the Recommended Plan. Following final rounds of agency reviews, the study team will prepare a Final Feasibility Report to present the Recommended Plan.

[3] http://planning.usace.army.mil/toolbox/smart.cfm?Section=4&Part=0

Chapter 2: Existing Conditions

Existing conditions, which serve as the basis for the characterization of problem identification and projection of future without project conditions, are described in this section.

2.1 Topography and Shorefront

The topography of Leonardo is characterized by low, flat terrain. Elevations range from 0 ft NAVD88 along the Raritan Bay coastline to a maximum of approximately +39 ft NAVD88 in the extreme southeastern and southwestern portions of the study area. Wide stretches of swampy marshlands are located along the creeks and a portion of the shoreline.

Existing characteristic dimensions of the beach at Leonardo are presented from beach profile surveys conducted in fall 1998 and remain in a similar condition today. Dune elevations in the study area vary between +9 ft NAVD88 and +14 ft NAVD88, averaging at approximately +11 ft NAVD88.[4] The average shorefront berm elevation is approximately +4 ft NAVD88. The berm width varies from 100 ft (near the marina) to 0 ft (near Wagner Creek). The narrowest berm widths occur in reaches fronted by structures (bulkheads or revetments). The average onshore slope is approximately 1V:10H. The average slope break between the onshore and offshore slopes occurs at approximately MLW (Mean Low Water = -2.7 ft NAVD88). The average structure elevation of the bulkheads and revetments present in the eastern portion of the shoreline is approximately +9 ft NAVD88.

2.2 Describing Storms and Flood Levels

Floods are often defined according to their likelihood of occurring in any given year at a specific location. The most commonly used definition is the “100-year flood.” This refers to a flood level or peak that has a 1 in 100, or 1 percent chance of being equaled or exceeded in any year (i.e., 1 percent “annual exceedance probability”). Therefore, the 100-year flood is also referred to as the “1 percent flood,” or as having a “recurrence interval” or “return period” of 100 years.

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

[4] Post-Hurricane Sandy LiDAR data for Leonardo will be incorporated into the analysis during optimization.

In addition, the probability of a certain flood occurring will increase for a longer period of time. For example, over the life of an average 30-year mortgage, a home located within the 100-year flood zone has a 26 percent chance of being flooded at least once. Even more significantly, a house in a 10- year flood zone is almost certain to be flooded at least once (96 percent chance) in the same 30-year mortgage cycle. The probability (P) that one or more of a certain-size flood occurring during any period will exceed a given flood threshold can be estimated as

$$P = 1 - \left[1 - \frac{1}{T}\right]^n$$

where *T* is the return period of a given flood (e.g., 100 years, 50 years, 25 years) and n is the number of years in the period. The probability of flooding by various return period floods in any given year and over the life of a 30-year mortgage is summarized in Table 1.

Table 1: Examples of Flooding by Various Return Periods

Return Period (years)	Chance of flooding in any given year	Percent chance of flooding during 30-year mortgage
10	10 in 100 (10%)	96%
50	2 in 100 (2%)	46%
100	1 in 100 (1%)	26%
500	0.2 in 100 (0.2%)	6%

Because of the potential confusion, recent USACE guidance documents and policy letters recommend use of the annual exceedance probability terminology instead of the recurrence interval or return period terminology. For example, one would discuss the "1-percent-annual-exceedance-probability flood" or "1-percent-chance-exceedance flood," which may be shortened to "1 percent flood" as opposed to the "100-year flood." This report uses the short form "1 percent flood."

2.3 Water Surface Elevation

Stage-frequency curves for existing conditions were acquired from FEMA for the study area. The FEMA curves were not manipulated, although they were adjusted to present the stage data into the North Atlantic Vertical Datum of 1988 (NAVD88) datum, because the FEMA curves are referenced to the Mean Sea Level (MSL) datum, which is a difference of 0.24 ft from the

NAVD88 datum.[5] The Sandy Hook gauge is close to the Leonardo study area. The FEMA stage and wave frequency curves for a range of return periods, from the 20 percent flood to the 0.1 percent flood, are presented in Table 2.

Table 2: FEMA Stage and Wave Frequency Curves for Existing Conditions

Annual Chance of Exceedance (%)	FEMA 2014 Mean Still Water Elevation in ft. MSL	FEMA 2014 Mean Still Water Elevation in ft. NAVD88	Significant Wave Height, Hs, in ft.	Peak Wave Period, Tp, in seconds
20%	6.4	6.6	2.8	3.8
10%	7.7	7.9	3.1	3.9
6.7%	8.4	8.6	3.3	4.0
5%	8.9	9.1	3.4	4.0
4%	9.3	9.5	3.5	4.1
2%	10.4	10.6	3.7	4.2
1.3%	11.1	11.3	3.9	4.3
1%	11.7	11.9	4.0	4.3
0.4%	13.4	13.6	4.6	4.5
0.2%	14.8	15.0	4.8	4.7
0.1%	16.2	16.4	5.1	4.8

2.4 Land Use and Development

Leonardo is a fully developed, permanent year round residential community characterized by single family residences. Commercial development is concentrated along Route 36. The majority of land development within Leonardo is more than 40 years old. Structures were mostly constructed prior to the implementation of the National Flood Insurance Program in 1968 and adoption of the associated Floodplain Management Regulations. The shoreline includes a mix of public and private land. The western shoreline (Beach Avenue and areas further west) is characterized by narrow beaches while the eastern area (east of Beach Avenue) contains a mixture of private bulkheads.

Historically, the bayshore played a role as a market and distribution center for the agricultural goods produced on the fertile soils of the County's interior. The bayshore's local commercial

[5] Mean Sea Level is a tidal datum and reflects the average of hourly heights observed over the National Tidal Datum Epoch (NTDE), each of which lasts 19 years, as defined by the National Ocean Service. The current NTDE is 1983 through 2001. The North Atlantic Vertical Datum (1988) is a geodetic datum, which is defined by the National Geodetic Survey (NGS) as "A set of constants (bench marks) used for calculating the coordinates of points on the Earth." Geodetic datum relationships to tidal datums are established at tide stations by connecting tidal bench mark networks to the National Spatial Reference System (NSRS) maintained by NGS. http://www.ngs.noaa.gov/datums/vertical/

resources were developed circa 1886. These included shellfish, clay (used in brick and tile manufacturing) and the waterfront as a tourist attraction.

There is a private marina at Wagner Creek as well as a state-operated marina in the center of the community. The state marina contains 179 berths with a maximum draft of 6 ft and a maximum length of 45 ft. The marina has charter/head boats, a launch ramp, winter wet storage, gas and diesel fuel, a holding tank pump out station, ice, bait and tackle, a luncheonette and shower/sanitary facilities. Relatively little has changed in Leonardo since 1969 with regard to interior drainage and tidal flood risk management.

2.5 Economy

The economy of Monmouth County has undergone extensive growth until recent years with much of the development concentrated along the major transportation routes. The majority of non-residential development has been for office and research facilities, in part due to the availability of comparatively inexpensive land with good access to the Northern New Jersey – New York City markets. Prior to Hurricane Sandy, sectors of the above markets had been experiencing sustained growth. Although detailed data regarding the local impact of the recent economic downturn is not available, it is likely that the local conditions will parallel the regional and national trends regarding recession or recovery. The median household income in Leonardo is $60,486 or $35,806 per capita. Approximately 8% of families and 10% of the population live below the poverty level.

2.6 Population

According to the year 2010 Census, the population of Leonardo was 2,757 persons. Of these, 1,904 (69.1%) are of working age (16 years or older) and 1,421 (55.8%) are in the civilian labor force. The median age of the population in Leonardo is 40.2 years. Between 2000 and 2010, the population of Leonardo decreased by 2.3%. The total number of housing units in Leonardo is 1,055; of these, approximately 320 structures are in the study area of which approximately 190 structures are subject to damages resulting from a 1% annual chance storm. According to the Census Bureau, the median value of all owner occupied units is $320,400. The total depreciated structure value in the study area is approximately $47 million at October 2013 price levels. Further details on socioeconomic conditions are in the Economics Appendix.

2.7 Transportation

The study area is conveniently accessible to major population centers through a network of modern highways. The Garden State Parkway and Route 9 run northward to New York State and southward to Cape May, New Jersey. Interstate-287 extends westward beyond Middlesex County, and the New Jersey Turnpike (Interstate-95) provides additional north-south access. Direct access from these major corridors to the bayshore is provided by Route 36. The study area is also serviced by the New Jersey Coast Line of New Jersey Transit, which provides passenger rail and bus access to Newark and New York City, and by ferry service to downtown Manhattan.

2.8 Environmental Conditions

Most of the wetlands within Leonardo have been subjected to human-induced alterations, including soil removal; dredge spoil deposition, brick/asphalt/concrete waste fill, repeated burning, and ditching. Despite wetland losses and disturbance, a number of wetland communities remain in the study area. Approximately 19.5 acres of jurisdictional wetlands were delineated within the 390-acre survey area in 2001. The wetlands communities are dominated by mono-specific stands of *Phragmites australis* (8.2 acres) and palustrine forest/scrub-shrub (6.2 acres), which are dispersed throughout the northwest, central, and eastern sections of the study area. In addition, three non-jurisdictional wetland habitats covering approximately 22.6 acres of the study area were identified that include estuarine subtidal open water, estuarine intertidal unconsolidated shore with sand substrate (i.e., beach), and estuarine intertidal unconsolidated bottom with mud substrate (i.e., mudflat).

In addition to the presence of wetlands, other environmental considerations that are important to plan formulation include the presence of threatened and endangered species (TES), cultural resources, and hazardous, toxic, and radioactive waste (HTRW). Piping plovers and seabeach amaranth, which are on the list of Federally threatened and endangered species, are nearby but not within the study area. In terms of cultural resources, the study area was historically occupied by the Delaware prior to European settlement. Cultural resource studies were undertaken and no significant resources were identified. HTRW sampling did not reveal substances of concern (volatile organic or semi-volatile organic compounds, pesticides, etc.) in subsurface soils at concentrations in excess of NJDEP Soil Cleanup Criteria (SCC). More details on environmental conditions can be found in the Environmental Assessment (EA).

Leonardo has experienced tidal flooding associated with storm surges along the banks of Wagner Creek. Ten existing storm water outfalls discharge directly into Wagner Creek. Wagner Creek additionally accepts drainage from upland areas to the south of Leonardo. The entire area of the proposed action is located within the designated New Jersey coastal zone boundaries, and therefore any proposed action requires a Federal consistency determination.

Chapter 3: Plan Formulation

3.1 Problem Identification

Problem Statement: *The community of Leonardo experiences damages from flooding and shoreline erosion associated due to coastal storms including hurricanes and nor'easters.*

Much of the topography of Leonardo is low and flat, making considerable sections of the community vulnerable to coastal storm damages. The average shorefront elevation is +4 ft NAVD88. There are stretches of swampy marshlands located along the creeks and a portion of the shoreline.

Historically, Leonardo has experienced most of its problems from tidal surges caused by severe storms resulting in the inundation of structures between the low-lying marsh near Ware Creek and Wagner Creek. Tidal floodwaters come over the shoreline and enter the marina and creeks, quickly spreading over the broad low-lying floodplain throughout the area. Past local efforts have been directed toward providing beach fill to reduce impacts from waves on shorefront properties. A bay stage of +9 ft NAVD88, approximately equal to a five percent flood event (like the December 1992 storm), results in severe flooding impacting over 100 structures and blocking many of the roads in Leonardo. Water levels at Leonardo reached +11.7 ft NAVD88 during Hurricane Sandy. In the aftermath of Hurricane Sandy, approximately 250 FEMA claims were filed in Leonardo.[6]

According to Preliminary Flood Insurance Rate Maps (PFIRMs) (2014) released by FEMA,[7] there are 260 structures in the AE zone[8] and 43 structures in the VE zone,[9] for a total of 303 structures in the one percent floodplain in Leonardo (Figure 4). The FEMA base flood elevations for affected structures range from +11 ft NAVD88 to 14 ft NAVD88.

Coastal Storm Impacts

Historical storms impacting the area include the September 14, 1944, hurricane; extratropical storms of November 25, 1950, and November 6-7, 1953; Hurricane Donna (September 12, 1960); the March 6-8, 1962 Nor'easter; the March 12, 1984 Nor'easter; the December 11,

[6] https://docs.google.com/spreadsheet/pub?key=0Ajo5KVzgSHJ5dEdoLS1OR2piUXcwQVFSeGgtWkZqVWc&output=html

[7] FEMA released an update to the PFIRM on January 30, 2015. The 2015 update will be incorporated into the optimization process.

[8] AE = Base flood elevations have been established and mandatory flood insurance purchase requirements and floodplain management standards apply.

[9] VE = Base flood elevations have been established and area is subject to additional hazards due to storm-induced velocity wave action. Mandatory flood insurance purchase requirements and floodplain management standards apply.

1992 Nor'easter; the March 12, 2010 storm, the 1993 Blizzard (March 12-14), and most recently, Hurricane Sandy from October 29-30, 2012.

These storms resulted in transportation problems such as damaged roads and bridges, damage or destruction of shoreline structures, utility lines and sewers; and the damage of homes and commercial properties. Overall, these problems have resulted in extensive financial losses to upland properties, numerous evacuations during storms, and a significant constraint to commerce and regional economic development.

These storms produce water levels and waves that cause extensive flooding and erosion in the study area. The shoreline composition has been greatly altered with time. In the past, storm-induced erosion has removed much of the beachfront and has accelerated deterioration of the existing coastal storm risk management and drainage structures. In addition to physical alterations, tidal surges often block existing stormwater drainage systems, resulting in prolonged and extensive interior flooding to the 303 structures within the one percent floodplain (Figure 4).

<u>Erosion</u>. The Leonardo shoreline has been subjected to long-term erosion and infrequent maintenance. Prior to the 1950s, a 4-groin field was constructed by the local government to limit erosion; however, this has resulted in accelerated erosion downstream or to the east. From 1957 to 1988, erosion increased from the marina to the last of the 4-groin field and then decreased from that groin to Wagner Creek where natural sand bypassing was reestablished. From 1988 to 1999, several significant storm events occurred (i.e., December 1992 nor'easter and March 1993 blizzard), which resulted in the reduction in shoreline width during this period. The major storms were followed by a fill operation that placed approximately 60,400 cy of sand in the dune reach, widening the existing shoreline by approximately 100 ft.

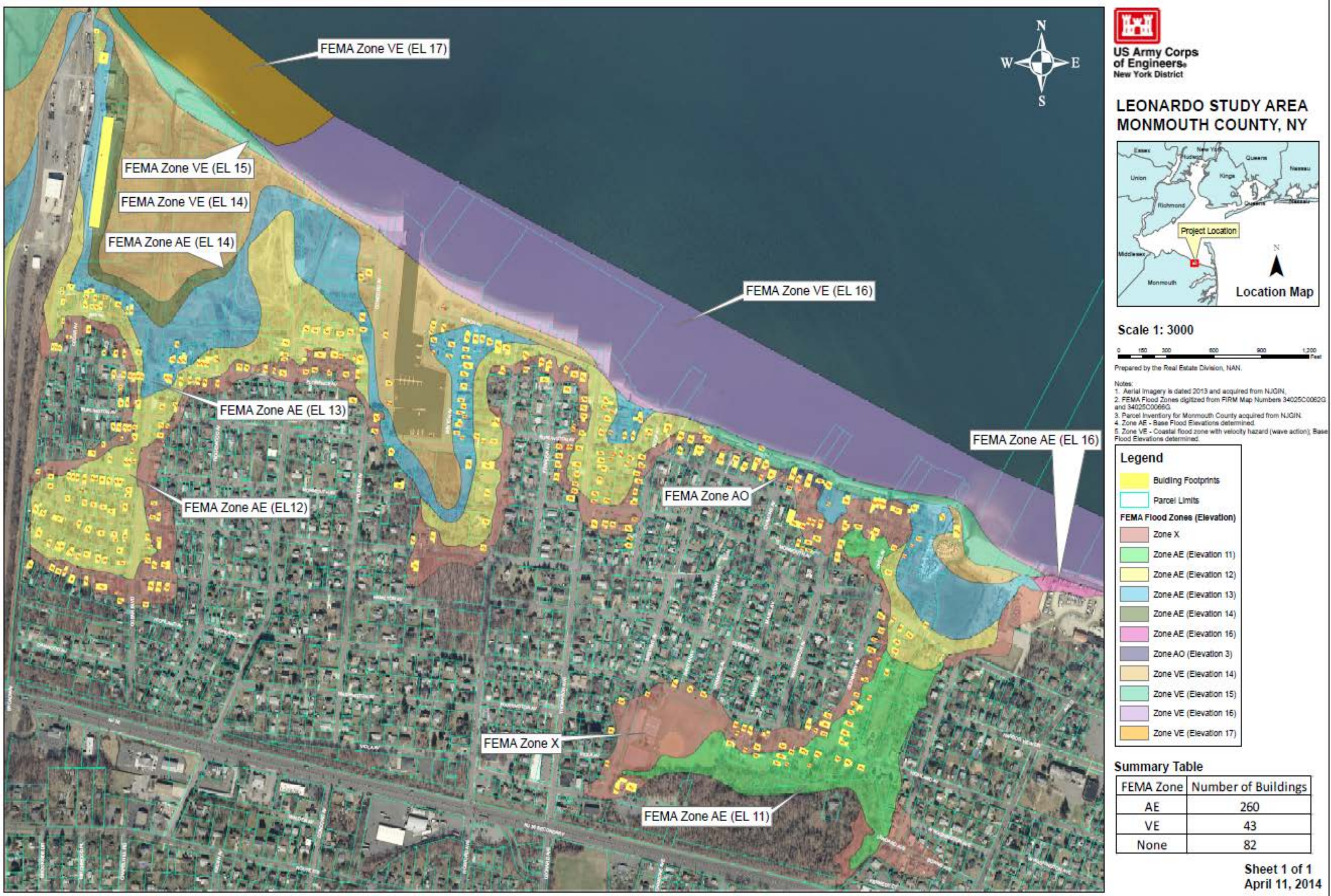

Figure 4: PFIRM (2014) for the Leonardo Study Area

The structures between the pier at U.S. Naval Weapons Station and the Leonardo Marina are sufficiently set back such that they are not subject to direct wave action and wave-related damages. The dune and beach area east of the marina entrance is backed by Beach Ave, utility poles, and buried utility lines. The houses located behind Beach Avenue are sufficiently set back from the road such that they are not subject to wave-related damages; however, the road itself and utilities are subject to storm-induced erosion and undermining. The bulkhead area to the east of Leonard Avenue is subject to structure failure from direct wave breaking on the structures, storm wave-induced scour of the grade fronting the bulkhead, and wave-induced scour of the grade on the landward side of the bulkhead. However, the houses in this section of the shorefront are sufficiently set back from the bulkhead line and are at an elevation high enough to not be impacted by waves themselves.

3.2 Future Without Project Conditions

The future without project conditions at Leonardo within the period of analysis (2017-2067)[10] are identified as continued flooding and wave impacts from future storm episodes, and continued maintenance and reconstruction of coastal storm risk management facilities following storm events. It is assumed that, over the long term, the beach profile and shape will be maintained by the community in a condition similar to the existing conditions.

The annual equivalent damages for the future without project conditions in Leonardo are a little over $1,000,000, including: 1) structure and content damages in the one percent floodplain; 2) bulkhead/seawall replacement costs anticipated within 10 years; 3) emergency and clean up costs during major storm events; 4) evacuation and temporary relocation costs; 5) impacts to beach recreation; 6) roads and utilities damages; 7) automobile damages; 8) Flood Insurance Agency (FIA) administrative costs avoided; and 9) reduced damages to the marina. Of the 303 structures in the one percent floodplain, approximately 80 sustain flood damages at their main floor elevations. Additional details about the future without project conditions can be found in the Economics Appendix.

Relative Sea Level Change (RSLC)

The Department of the Army Engineer Regulation ER 1100-2-8162 (31 Dec 2013) requires that future sea level rise (SLR) projections must be incorporated into the planning, engineering design, construction and operation of all civil works projects. The study team should evaluate structural and nonstructural components of the proposed alternatives in consideration of the "low," "intermediate," and "high" potential rates of future SLR for both "with" and "without

[10] The 50-yr period begins when construction of the project is completed, in 2017.

project" conditions. This range of potential rates of SLR is based on findings by the National Research Council (NRC, 1987) and the Intergovernmental Panel for Climate Change (IPCC, 2007). The historic rate of future sea-level rise is determined directly from gauge data gathered in the vicinity of the study area. Tide conditions at Sandy Hook (National Oceanic and Atmospheric Administration (NOAA) Station #8531680) best represent the conditions experienced in Leonardo. A 75-year record (1932 to 2006) of tide data gathered at Sandy Hook, NJ indicates a mean sea level trend (eustatic SLR + the local rate of VLM) of +3.9 mm/year, or 0.014 ft/year.

RSLC considers the effects of (1) the eustatic, or global, average of the annual increase in water surface elevation due to the global warming trend, and (2) the "regional" rate of vertical land movement (VLM) that can result from localized geological processes, including the shifting of tectonic plates, the rebounding of the Earth's crust in locations previously covered by glaciers, the compaction of sedimentary strata and the withdrawal of subsurface fluids. Figure 5 shows the low, intermediate, and high estimates for sea level rise based on the Sandy Hook gauge through the 50-yr period of analysis (2017-2067).

Figure 5: Anticipated Rates of Sea Level Rise based on the Sandy Hook Gauge

The Leonardo CSRM study assumes the historic rate of sea level rise, at 0.014 ft/year resulting in a 0.7 ft increase in sea level over the 50-year period of economic analysis of the project. However, it is possible that relative sea level may rise at an accelerated rate above the currently anticipated increase. The effects of accelerated sea level rise upon plan formulation will be investigated during plan optimization, which will occur after receipt of public input on the draft report. More details on RSLC can be found in the Engineering Appendix.

3.3 Opportunities

There are **opportunities** in the community of Leonardo to:

1. *Reduce coastal storm risk to residents, property, and infrastructure*.
2. *Reduce storm-induced shoreline erosion*.

The greatest need in the study area is for effective coastal storm risk management that provides acceptable levels of risk reduction from the impacts of storm inundation. Due to the low elevations of the land along the area’s creeks and marshes, as well as the dimensions of existing CSRM structures, effective coastal storm risk management against high bay surges from both the bay and its adjoining creeks is a necessary component of a complete coastal storm risk management plan. Many roadways providing access within the study area are subject to frequent flooding, limiting transportation during flood events.

3.4 Federal Action

Per the 1983 Principles and Guidelines, 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.” Water and related land resources project plans are formulated to alleviate problems and take advantage of opportunities in ways that contribute to this objective. Contributions to **National Economic Development** (NED) are increases in the net value of the national output of goods and services, expressed in monetary units, are also considered.

3.5 Planning Goal & Objectives

Goal: Reduce the risk of hurricane and storm surge flooding and associated damages to the community of Leonardo.

In support of the goal, the **planning objectives** are to:

1. Manage the risk of damages from hurricane and storm surge flooding to the community of Leonardo through 2067.

Measurement: estimated annual damages, as calculated by the Hydrologic Engineering Center – Flood Damage Analysis (HEC-FDA) model

2. Reduce storm-induced shoreline erosion in the community of Leonardo through 2067.
   Measurement: estimated annual erosion, as observed[11]
3. Develop a plan consistent with and complementary to the New Jersey Coastal Zone Management Program, the Monmouth County Growth Management Guide, and the Monmouth County Bayshore Waterfront Access Plan.
   Measurement: compliance or noncompliance with local plans
4. Encourage resilient and sustainable risk management solutions for Leonardo through 2067.
   Measurement: qualitative analysis of engineering robustness and rapidity (the speed with which functionality can be restored to a system or project after a disruption)

A planning consideration for the Leonardo CSRM study is the release of USACE Engineering and Construction Bulletin No. 2013-33, which states that rebuilding projects using P.L. 113-2 funds must meet a minimum standard of one foot above the base flood elevation (BFE) determined by FEMA. The bulletin further states that when local, State, or other Federal standards exceed the BFE+1 standard, Federal agencies should follow the higher standard. Additional detail on ECB 2013-33 can be found in Section 3.9.2 of this report.

3.6 Planning Constraints

Constraints are restrictions that limit the extent of the planning process. They can be divided into **universal planning constraints** and **study-specific planning constraints**. Universal planning constraints are the legal and policy constraints to be included in every planning study. Study-specific planning constraints are statements of things unique to a specific planning study that alternative plans should avoid. Constraints are designed to avoid undesirable changes between without- and with-plan conditions.

Universal planning constraints include:

General constraints:

1. The plan should meet the needs and concerns of the public within the study area;
2. The plan should respond to the public desires and preferences.

[11] Shoreline erosion was included as a benefit because the purpose was included in the study authority. No benefits from reducing shoreline erosion were included in the benefit-to-cost ratios.

3. The plan should be flexible to accommodate changing economic, social and environmental patterns and changing technologies.
4. The plan should integrate with and be complementary to other related programs in the study area.
5. The plan should be able to be implemented with respect to financial and institutional capabilities and public consensus.
6. The plan should conform with the USACE environmental operating procedures.

Technical constraints:

1. Plans should represent sound, safe, and acceptable engineering solutions taking into account the overall littoral system effects.
2. Plans should be in compliance with USACE regulations.
3. Plans should be realistic and state-of-the-art while not relying on future research or development.
4. Plans should provide features that minimize the effect of shoreline erosion processes.

Economic constraints:

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

Environmental constraint:

1. Plans should avoid and minimize environmental impacts to the maximum degree practicable.
2. Plans should not adversely impact threatened or endangered species, and their habitat.
3. Plans should be compliant with all Federal environmental laws, Executive Orders, and guidance.

Regional and Social constraints:

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

Institutional constraints:

1. Plans should be consistent with existing federal, state, and local laws.

2. Plans should be locally supported and signed by local authorities in the form of a local cooperation agreement and guarantee for all items of local cooperation including possible cost sharing.
3. Local interests should agree to provide public access to the shore in accordance with Federal and state guidelines and laws.
4. The plan should be fair and find overall support in the region and state.

Study-specific constraints planning include:

1. Naval Weapons Station Earle. Any coastal storm risk management project at Leonardo should not interfere with the operations of the Naval Weapons Station Earle, which provides ordnance for the Navy and Coast Guard, as well as commercially owned vessels from a multitude of nations. Water access to Naval Weapons Station Earle is at Sea Breeze Avenue, where the approximately two mile long trestle connecting to finger piers begins, at the western edge of the study area.

2. Plans should minimize disruptions to the operations of the Leonardo Federal navigation project. The project provides a depth of 8 ft Mean Low Water from Sandy Hook Bay to the marina at Leonardo. It is 150 ft wide and about 2,500 ft long.

3.7 Management Measures

Plans are composed of **measures**. A **measure** is a feature (a *structural element* that requires construction or assembly on-site) or an activity (a *nonstructural action*) that can be implemented at a specific geographic site to address one or more planning objectives. They can be used individually or combined with other management measures to form alternative plans. Measures were developed to address problems and to capitalize upon opportunities. The following sections briefly describe the objectives for and the evaluation of potential planning measures as previously described in the reconnaissance report (March 1993), the pre-feasibility report (February 1999), and the Preliminary Alternatives Screening (P7) Report (June 2003).

3.7.1 Structural Measures

The following sections briefly describe various structural measures considered as elements of a comprehensive solution.

Floodwalls and Levees

Floodwalls and levees are intended to provide coastal storm risk management against coastal and riverine flooding in the absence of waves. These structures can be cost-effective measures against flooding when placed landward of direct wave exposure. Used in this manner, floodwalls and levees provide coastal storm risk management to interior structures. Raising roadways spanning low-lying areas and tying into high ground may also act as barriers against flooding. While floodwalls and levees can provide a cost-effective means to manage and reduce flooding of low-lying areas, runoff trapped behind the alignment can often affect the hydrology and drainage of interior areas. Interior drainage features (such as pumping/piping systems) are required to convey interior runoff through the alignment, thus reducing the potential for continued flooding of interior areas. Floodwalls and levees are appropriate and effective features in land portions of a complete line of coastal storm risk management.

Seawalls

Seawalls are typically made of stone and offer coastal storm risk management against storm surges along the shoreline. Seawalls also limit landward movement of the shoreline and minimize overtopping floodwaters. Costs can be high depending on the extent and severity of existing shoreline problems. Seawalls could be effective in providing coastal storm risk management; however, seawalls may increase erosion in adjacent areas of the beach not lined by seawalls.

Groins

Groins are typically rock or wooden structures that extend perpendicular to the shoreline into the bay or ocean. They work to trap sand and create a more stable shoreline. Groins alone would not meet coastal storm risk management objectives and would likely cause down drift erosion without concomitant beach nourishment. The use of groins may be appropriate in alternatives that include beach nourishment.

Revetments

A revetment is usually made up of stone and is placed in such a way to manage the risk of shoreline erosion caused by wave action. These structures can stabilize existing slopes, if they are already high enough to provide risk management against frequent overtopping. Because the existing elevation of the beaches and bluffs is not sufficient to provide risk management against overtopping, this feature was not considered further.

Beach Nourishment (with dunes and berms)

Beach nourishment involves the placement of sand on an eroding shoreline to restore its form and to provide coastal storm risk management. A beach fill typically includes a berm backed by a higher dune. These elements combine to manage erosion and storm inundation damages to leeward areas. Beach nourishment represents an in-kind method for reducing flooding and erosion damages by enhancing the height and width of the existing beach. Beach nourishment requires a long-term commitment to offset long-term shoreline erosion and may be costly along highly erosive shorelines.

Beach Nourishment (with berm only—no dune or seawall)

Beach fill including a berm without a dune would not block bay views but would not meet coastal storm risk management objectives of addressing storm inundation. The lack of a dune would allow storm surges to overtop the berm and damages from storms would still result. Consequently, this feature was not considered further.

Beach Nourishment with Groins

Structures such as terminal groins placed at the ends of a beach nourishment project can reduce erosion rates and minimize the potential impact of sand migration into any nearby tidal wetlands. Groins can work to reduce long-term nourishment requirements and, together with beach nourishment, can provide coastal storm risk management against erosion and storm inundation.

Wetland Restoration

Wetlands provide a buffer for floodwater storage. These low-lying areas can store tidal storm floodwater as well as interior runoff. When storm tides decrease, stored waters can be released into the Bay. Restoration of former wetland areas also provides valuable habitat for flora and fauna. This alternative was not considered further because there is limited space for wetland restoration to provide adequate coastal storm risk management.

Storm Closure Gates

Storm closure gates operate such that vehicular or marine access through a coastal storm risk management alignment is sustained during normal conditions in the open position, but bay surge would be blocked during storm conditions in the closed position. A storm closure gate at the marina entrance would reduce the potential for flooding through the marina under storm conditions but would provide normal navigation traffic during normal conditions. Similarly, closure gates allow for unimpeded vehicular traffic under normal conditions (when the gates are open), while providing coastal storm risk management during storm events (when the gates are closed).

3.7.2 Nonstructural Measures

The following sections briefly describe various nonstructural techniques considered as elements of a comprehensive solution.

Buy-out

Permanent evacuation of areas subject to erosion and/or storm inundation involves the acquisition of the impacted land and its structures either by purchase or by exercising the powers of eminent domain. Following this action, all development in these areas is either demolished or relocated. Before Hurricane Sandy, the cost of this plan including land and relocation was deemed to be prohibitively expensive and was dropped from consideration as a comprehensive solution. However, more limited buy-outs (to be investigated on an individual structure basis) may be a viable means of enhancing or supplementing the coastal storm risk management provided by other features, especially considering the change of home prices in affected areas post-Hurricane Sandy.

Zoning

Through proper land use regulation, floodplains can be managed to ensure that their use is compatible with the severity of the flood hazard. Several means of regulation are available, including zoning ordinances, subdivision regulations, and building and housing codes. Their purpose is to reduce losses by controlling the future use of floodplain lands and would not be effective in mitigating the existing hazard. It should be noted that zoning is a local issue and is not within the jurisdiction of the Federal government. However, any Federal project will have a floodplain management plan component that includes requirements on the use of flood prone lands.

Flood proofing

Flood proofing or building retrofit is a body of techniques for preventing flood damages by making adjustments to both structures and their contents. Such adjustments can be applied by an individual or as part of a collective action. Flood proofing involves keeping water out (dry flood proofing) as well as reducing the effects of water entry (wet flood proofing). Flood proofing techniques can also include elevating structures above the design flood level. Flood proofing techniques can be undertaken when structures are under construction, during remodeling or expansion activities, or during a structure retrofit. While flood proofing measures can work to reduce damages to structures and their contents, residents must still be evacuated during flood conditions to ensure their safety.

Elevation (raising) of frequently flooded structures

This technique lifts an existing structure. Elevation can be performed using fill material, on extended foundation walls, on piers, post, piles, and columns.

Ringwalls/structural peripheral wall

This technique is applicable on a small-scale basis. As nonstructural measures, berms and floodwalls are intended to reduce the frequency of flooding but not eliminate floodplain management and flood insurance requirements.

Rebuilding

If the estimated cost of any other nonstructural alternative exceeds the estimated cost to demolish a structure and rebuild an equivalent structure, rebuilding the structure above the design flood elevation may be an economically viable nonstructural alternative.

3.7.3 Screening of Measures

Management measures were retained for further consideration based on their ability to meet the following **measures screening criteria**:

1. Does the measure meet objectives?
2. Does the measure avoid constraints?
3. Is the measure feasible to design and construct?
4. Is the measure economically feasible?

Each alternative plan of coastal storm risk management for Leonardo described in the following sections requires the use of a combination of initially screened measures to address the variety of conditions that exist. Based on the screening, the following features are applicable to a comprehensive plan:

- Floodwalls and levees;
- Seawalls;
- Beach nourishment (with dunes and berms);
- Beach nourishment (with groins);
- Storm closure gates;
- Evacuation (limited buy-outs only);
- Zoning (federal requirements on use of flood prone lands); and
- Flood proofing/building retrofit.

Initial screenings provided the following insights on the measures that remain for consideration:

1) Structural Measures:

(a) Floodwalls/Levees – Manages risk to structures against riverine and coastal flooding but traps interior water. These measures would also include pump stations to alleviate interior flooding. For levees and pump stations, there are concerns about operability and maintenance related to division of responsibilities between local jurisdictional entities, as well as the associated logistics.

(b) Shore stabilization - In combination with beach nourishment, these structures can provide long-term coastal storm risk management. Costs can be high depending on the extent and severity of existing shoreline problems.

(c) Beach nourishment - Some long-term costs but provides erosion and storm inundation control. Highly dependent on readily available offshore or upland sources of sand.

(d) Beach Nourishment with shore structures - Reduces erosion and long-term nourishment, but is usually more costly initially than beach nourishment alone.

(e) Closure gates – A project feature at road crossings where road raising and transitioning are limited. Closure gates must be actively operated and maintained. There are concerns over operability and maintenance of these stream closure structures related to division of responsibilities between local jurisdictional entities and associated logistics.

(f) Storm gates - As with closure gates, concerns over operability and maintenance of these stream closure structures related to division of responsibilities between local jurisdictional entities, as well as the associated logistics.

2) Nonstructural Measures:

(a) Buyouts - Susceptible development would be demolished or relocated. This was deemed very costly on a large scale.

(b) Zoning - This would curtail future use of floodplain lands but does little to mitigate present hazards.

(c) Flood proofing/building retrofit – This measure manages risk of flood damages to the treated structures and their contents. However, it does not address flood damages to roads and other infrastructure.

3.8 Key Uncertainties

1. Relative Sea Level Change (RSLC) scenario – The study team has determined that the historic rate of sea level rise is the most appropriate to apply to the Leonardo CSRM study, using the best information available now. A sensitivity analysis of the alternatives to sea level rise was conducted, in which the additional damages that would be included based on a high rate of sea level rise were extrapolated. These additional damages correlate to increased benefits (approximately +$291,000 in annual benefits). When the increased benefits were added to the annual net benefits for structural alternatives (ranging from -$522,000 to -$821,000), the net benefits for structural alternatives were still negative, even holding the costs constant. No matter which scenario of sea level rise was used, the proposed solution would be nonstructural. The assumed rate of RSLC affects the number of structures to be recommended for nonstructural treatment; the three scenarios will be evaluated more extensively as part of optimization. The study team will continue to coordinate with the CSRM Center of Expertise and the USACE National Nonstructural Flood Proofing Committee. The alternatives will be evaluated in more detail against the RSLC scenarios (historic, intermediate, and high) as part of optimization in the detailed feasibility level investigations phase of this study following the receipt of agency and public feedback.

2. The Value Engineering (VE) study of the alternatives has not been conducted yet. Value engineering studies for the feasibility phase were repealed in Section 1004 of the Water Resources Reform and Development Act (WRRDA) of 2014 for feasibility studies, but implementation guidance has not been issued yet. Until implementation guidance is issued, the team is assuming that VE is still required. However, if the project implementation cost is under $10 million, the team may pursue a VE waiver based on small cost of the project.

3. Update of benefits. Post-Hurricane Sandy, a structure inventory update was conducted of the study area. The analysis of the updated information is ongoing, including identification of properties that have received rebuilding permits and confirmation of rebuilding requirements. Based on these requirements, some of the structures may be elevated prior to study completion, reducing the number of structures eligible for inclusion in this Federal project.

3.9 Focused Array of Alternatives

Measures that warranted continued consideration were assembled into **alternative plans**. An alternative plan (also known as, "**plan**" or "**alternative**") is a set of one or more management measures functioning together to address one or more planning objectives. Measures were grouped by theme into the following **design strategies,** which formed the basis of the alternatives.

- **Hard Structural Strategy - Seawall**
  Measures include levees, floodwalls, closure gates, seawalls, road raising, and storm water pumps (for interior drainage).
- **Soft Structural Strategy - Beach and Dune Fill**
  This strategy consists of beach and dune fill. At Leonardo, beach fill and dune is appropriate for only the shorefront element of the project area, requiring hard structural measures at other areas within the project area for a complete plan.
- **Nonstructural Strategy**
  This strategy consists of elevating or relocating structures prone to flooding; using ringwalls around vulnerable structures and streets; and utilizing wet and dry flood proofing of structures.

The design strategies were used to guide the development of **alternative plans**. Existing coastal storm risk management systems, businesses, homes, and other structures were considered when combining features into strategies. Permutations of measures resulted in the development of six structural alternatives and five nonstructural plans for a total of 11 preliminary plans for assessment. Primary features and impacts for each of these alternatives were evaluated.

3.9.1 Rationale for Alternatives Formulation

The principal elements considered in the development of the alternatives included engineering feasibility, environmental impacts, economic implications, social consequences, technical criteria, and reliability:[12] For the purpose of alternatives comparison, a design elevation of +13.1 ft NAVD88 was used, which consisted of the one percent flood stillwater elevation based on 1998 stage frequency data (+10.7 ft NAVD88) plus the historic sea level rise (0.7 ft) plus 50% of the wave setup contribution (0.7 ft – the same for each structure in nonstructural alternatives) plus 1 ft of freeboard. The design elevation for the one percent flood will be referred to as the "one percent flood design elevation." The design elevation has been updated for the TSP and is displayed in Table 7.

[12] The elevations and storm frequencies described in this section are from 1998. They have been preserved to tell the story of how the study team arrived at the conclusion of a small nonstructural solution for the Tentatively Selected Plan (TSP). Changes in the existing condition post-Hurricane Sandy do not alter the general determination of a small nonstructural plan, but the current conditions are used to inform the update of the TSP.

Engineering Feasibility. Consideration was given to nonstructural and structural measures. Sound engineering judgment was utilized in selecting the structural components for each alternative. Existing topography, wetlands, structures, roadways, and drainage patterns were some of the constraints that had to be accommodated in the design process. The structural alternatives were designed for storm inundation from the one percent flood design elevation to facilitate comparisons between alternatives; the final recommendation could be higher or lower based on the optimization process that follows the release of the draft feasibility report for public review.

Environmental Impacts. Each alternative, at most, would result in minimal long-term tidal wetland impact. Acreage impact assessments were made based upon preliminary delineations of wetlands which were later more rigorously refined. Some wildlife may be affected as a result of construction along with temporary noise and traffic pollution.

Economic Implications. Construction costs were estimated for each alternative. These costs were developed for screening purposes only and did not reflect detailed designs and environmental assessments accomplished later for the more likely alternatives. All plans were initially designed to provide the same level of performance (to the level of the percent flood design elevation) so that cost comparisons could provide reasonable screening criteria.

Social Consequences. The public may experience negative impacts of property acquisitions, environmental impacts, visual aesthetics (floodwalls or levees), and inconvenience due to construction, but the minimization of flooding or flood damage will greatly improve the quality of life.

Technical Criteria. Alternative plans were developed to manage the risk from storm inundation associated with one percent floods.[13] These types of events would result in a stage of up to +11.4 ft NAVD88. Initial assessments of structural alternatives included seawall crest elevations of +14.9 ft NAVD88 and a dune crest elevation of +15.9 ft NAVD88. These were used for the comparison of the alternatives for the stage associated with a one percent flood, wave run-up and wave overtopping. In addition, initial assessments of nonstructural alternatives included measures for structures in the 20 percent, four percent and one percent floodplain against the one percent flood, wave run-up and wave overtopping.

[13] Design elevations in the description of alternatives are from the 2009 analysis (which used stag-frequency curves from 1998). They are retained in the description of alternatives to demonstrate that the structural and nonstructural alternatives were evaluated against the same design events. For the evaluation of alternatives after Hurricane Sandy, design elevations based on updated stage-frequency were used for the small nonstructural alternatives that were retained for consideration. The updated design elevations can be found in the description of the TSP in Section 4 of this report.

Reliability. For this level of analysis it was assumed that both the alignments and interior design would be highly reliable in reducing damage for all bay floods below elevation +13.1 ft NAVD88. More detailed design analysis may indicate that local drainage may result in some level of continued or residual flooding. Also, detailed analysis of the alignment features could indicate that variations or uncertainty in some design conditions, such as storm surge elevation and overtopping, could present a risk of damage below the top elevation of the risk management structures. These uncertainties could combine to reduce the estimated benefits.

3.9.2 Descriptions of Alternative Plans

A total of twelve alternatives, including the No Action alternative, were considered. Of these, six were structural alternatives and five were nonstructural alternatives. The six structural alternatives were:

- Alternative S1 – Seawall with gate across the marina;
- Alternative S2 – Beach Fill with gate across the marina;
- Alternative S3 – Combination Beach Fill and Seawall with gate across the marina;
- Alternative S4 – Combination Beach Fill and Seawall with gate across the marina, coastal storm risk management provided only west of Brevent Avenue;
- Alternative S5 – Limited structural plan with no gate across the marina; and
- Alternative S6 – Road Raising;

Each of the six structural plans consisted of an alignment that would reduce storm inundation in low-lying developed areas. Beach fill and seawalls or both represent the most feasible alternatives to provide structural coastal storm risk management for Leonardo. Structural Plans S1 through S5 also require interior drainage improvements to avoid trapping runoff behind the alignment. For these alternatives, it was assumed that a series of small storm water pumps would meet the interior drainage needs. Alternatives S1-S4 also include flood proofing or elevating structures that lie outside of the alignment.

The five nonstructural alternatives, which assumed elevation of structures to the level of a one percent flood design elevation (with the exception of N4), were:

- Alternative N1 – Structures in the 20 percent floodplain;
- Alternative N2 – Structures in the four percent floodplain;
- Alternative N3 – Structures in the one percent floodplain;

- Alternative N4 – Structures in the 20 percent floodplain, elevated to the level of a 10 percent flood design elevation; and
- Alternative N5 – Structures with a main floor at or below +9.4 ft NAVD88.

Alternatives N1 to N3 are variants of a general strategy to elevate structures to the one percent flood design elevation. The subset of structures selected for treatment against the one percent flood is based on the frequency with which the structures are affected by storm inundation. The intent of Alternative N4 is to examine whether reduction of flood damages is more cost effective than elevating the structures to the one percent flood design elevation. Alternative 5 represents a different approach to forming the subset of structures, using the elevation of the main floor within the structures rather the associated ground elevation.

Elevation of structures to the one percent flood design elevation (as described in Alternatives N1, N2, N3 and N5) is consistent with the Engineering and Construction Bulletin No. 2013-33, which states, "The Hurricane Sandy Rebuilding Task Force (TF) announced on 4 April 2013 that all Hurricane Sandy-related rebuilding projects funded by Public Law 113-2 must meet a single uniform flood risk reduction standard (FRRS) of one foot above the best available and most recent base flood elevation (BFE) information provided by the Federal Emergency Management Agency (FEMA)." The bulletin further states, "Where Federal, state and local standards exceed this standard, Federal agencies will be guided by the higher standard. The FRRS applies to USACE vertical infrastructure and nonstructural flood proofing projects located in the Hurricane Sandy recovery area as described by the guidelines presented in this ECB."

The 12 alternatives, including the No Action Alternative, are described in the following text. The first costs and annual costs of the alternatives are shown in Table 3, after the descriptions of the alternatives.

- **No Action Alternative:**

This plan includes additional Federal actions taken to provide for coastal storm risk management, namely, grants from FEMA to support disaster recovery for homeowners and businesses. This plan fails to meet the USACE study objectives or needs for the majority of the study area. It will, however, provide the baseline against which project benefits are measured. The period of analysis is 2017-2067.

Alternative S1: Seawall

Alternative S1 would manage risk to the entire area from the pier at Naval Weapons Station Earle, in the vicinity of Cedar Avenue to Wagner Creek with levees, floodwalls, closure gates, seawalls, a road raising, and by implementation of a nonstructural component (Figure 6). The main feature would be a long seawall extending from the state marina to Wagner Creek. Alternative S1 would be designed for to the one percent flood design elevation.

The alignment would start from high ground near Florence Avenue running east along the coast and tying back into high ground near Wagner Creek. The alignment would be made up of approximately 100 ft of levee, 2,100 ft of floodwall, 3,800 ft of seawall, and three closure gates, including two 30' x 8' vehicular swing gates allowing access to the end of Concord Avenue and to the marina boat ramp, and a 45-ft wide buoyant swing gate structure at the marina entrance. The fourth 40-ft wide by 5-ft high swing gate would allow access to the boatyard at Wagner Creek.

Four small below-grade pump chambers (50 cubic feet per second (cfs) each) would collect and discharge any interior runoff from each of four sub-drainage basins behind the alignment. In addition, this alternative would include elevation of the road at the intersection of Ocean Boulevard and Burlington Avenue for approximately 400 ft and would include elevating (flood proofing) approximately 50 structures in the one percent floodplain that would not be included by the structural alignment.

Alternative S2: Beach Fill

Similar to Alternative S1, Alternative S2 would manage risk to the entire area from the pier at Naval Weapons Station Earle in the vicinity of Cedar Avenue to Wagner Creek with beach fill, a levee, a floodwall, a seawall, a road raising, three closure gates, and a nonstructural component. The main feature would be the beach and dune segment (see Figure 7). Alternative S2 was designed to the one percent flood design elevation.

The alignment would start from high ground near Florence Avenue running east along the coast and tying back into high ground near Wagner Creek. The components would include 100 ft of levee, 2,100 feet of concrete-encased steel sheet pile floodwall, 400 ft of seawall, 3,450 ft of beach and dune, and two 600-ft stone groins. Two 30' x 8' vehicular swing gates would allow for access to the end of Concord Avenue and to the marina boat ramp, and a 45-ft wide buoyant swing gate structure would cross the marina entrance.

Four small below-grade pump chambers (50 cfs each) would collect and discharge any interior runoff from each of four sub-drainage basins behind the alignment. In addition, this alternative would include elevating the road at the intersection of Ocean Boulevard and Burlington Avenue for approximately 400 ft and would include elevating (flood proofing) approximately 50 structures in the one percent floodplain that would not be included by the structural alignment.

Alternative S3: Beach Fill and Seawall to Brevent Avenue

Alternative S3 would combine elements of alternatives S1 and S2 into a plan that would include both beach fill and seawall components. The extent of the alignment would be the same as for Alternatives S1 and S2 and include levees, floodwalls, seawalls, protective beaches, a dune with a terminal groin, four closure gates, road raising, and a nonstructural component (see Figure 8). Alternative S3 was designed to the one percent flood design elevation.

The alignment would start from high ground near Florence Avenue running east along the coast and tying back into high ground near Wagner Creek. The components would include 100 ft of levee, 2,100 ft of concrete-encased steel sheet pile floodwall, 2,700 ft of seawall, 1,150 feet of beach and dune, and a 600-ft stone groin. Two 30' x 8' vehicular swing gates would allow for access to the end of Concord Avenue and to the marina boat ramp, and a 45-ft wide buoyant swing gate structure would cross the marina entrance. The alignment would end at the boatyard near Wagner Creek and include a 40-ft wide by 5-ft high swing gate for boatyard access.

Four small below-grade pump chambers (50 cfs each) would collect and discharge any interior runoff from each of four sub-drainage basins behind the alignment. In addition, this alternative would include elevating the road at the intersection of Ocean Boulevard and Burlington Avenue for approximately 400 ft and would include elevating (flood proofing) approximately 50 structures in the one percent floodplain that would not be included by the structural alignment.

Alternative S4: Beach Fill and Seawall to Brevent Avenue

Alternative S4 would be similar to Alternative S3 but would not cover the area from Brevent Avenue to Wagner Creek, a distance of approximately 1,700 ft. This alternative would include construction of levees, floodwalls, and seawalls, a protective beach and dune with terminal groins, road rising, and a nonstructural component. The western limit of the alignment would be at Florence Avenue near Ridgewood Avenue. The eastern limit of the alignment would tie into Brevent Avenue (see Figure 9). Alternative S4 was designed to the one percent flood design elevation.

Similar to the previous alternatives, the alignment would start with a 100-ft earthen levee. The alignment would include 2,250 ft of concrete-encased steel sheet pile floodwall, 400 ft of seawall, and a beach and dune segment spanning 1,150 ft ending at a 600-ft long terminal stone groin. Two 30' x 8' vehicular swing gates would allow for access to the end of Concord

Avenue and to the marina boat ramp, and a 45-ft wide buoyant swing gate structure would be located at the marina entrance.

Three small below-grade pump chambers (50 cfs each) would collect and discharge any interior runoff from each of four sub-drainage basins behind the alignment. In addition, this alternative would include elevation of an approximately 400 ft section of road at the intersection of Ocean Boulevard and Burlington Avenue and would include elevating (flood proofing) approximately 30 structures in the one percent floodplain that would not be included by the structural alignment.

Alternative S5: Limited Structural Plan

Alternative S5, with similar beach and dune fill and seawall as Alternative S4, includes an alignment from the area from the east side of the state marina to Brevent Avenue. This would include construction of a floodwall, beach, and seawall. The western limit of the alignment would be at Concord Avenue. The eastern limit of the alignment would tie into the north end of Brevent Avenue (see Figure 10). Alternative S5 was designed to the one percent flood design elevation.

The shore alignment consists of 400 ft of stone seawall, followed by 1,150 ft of beach and dune, terminating at a 600-ft stone groin. The remaining alignment includes 900 ft of seawall to Brevent Avenue. The western tieback to high ground would consist of a 1,300 ft of concrete-encased steel sheetpile floodwall, terminating at a tie-off levee. Access through the floodwall to the marina and parking lots would be provided by swing closure gates. Two small below-grade pump chambers (50 cfs each) would collect and discharge any interior runoff from the sub-drainage basins behind the alignment.

Alternative S6: Limited Road Raising

This alternative would consist solely of raising the intersection of Ocean Boulevard and Burlington Avenue, for approximately 400 ft of roadway (Figure 11). This would prevent higher storm surges from entering low-lying areas landward of the Ocean Boulevard intersection with Burlington Avenue, while providing for the free flow of traffic at all times. Interior runoff trapped by the raised road would drain out through drop inlets connected to a drain pipe fitted with a flap gate. It was subsequently determined that the flooding problem addressed by this alternative was related to interior drainage rather than costal storms. S6 was not carried further but is included in this discussion to document the study history.

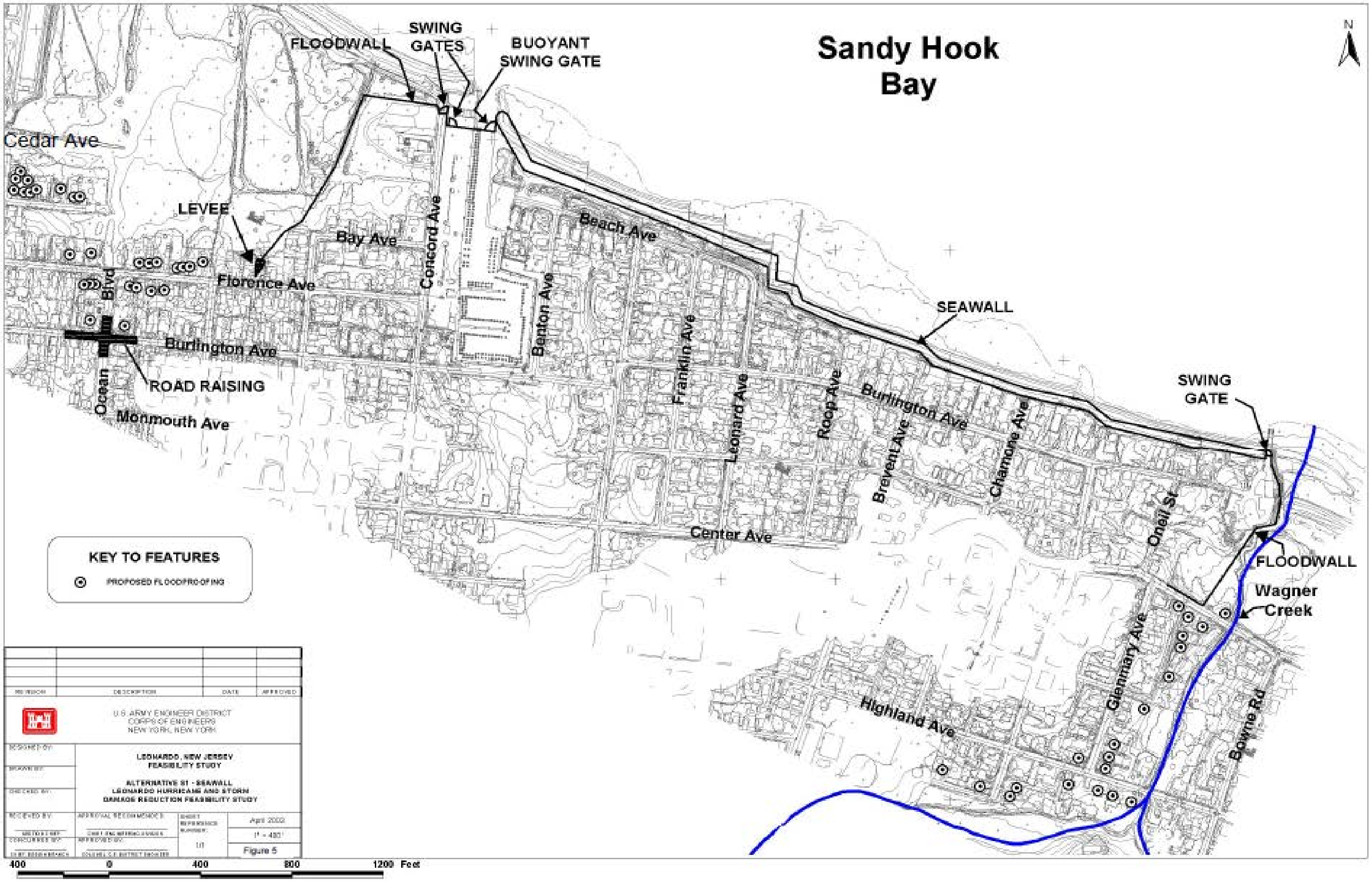

Figure 6: Alternative S1 – Seawall with gate across the marina

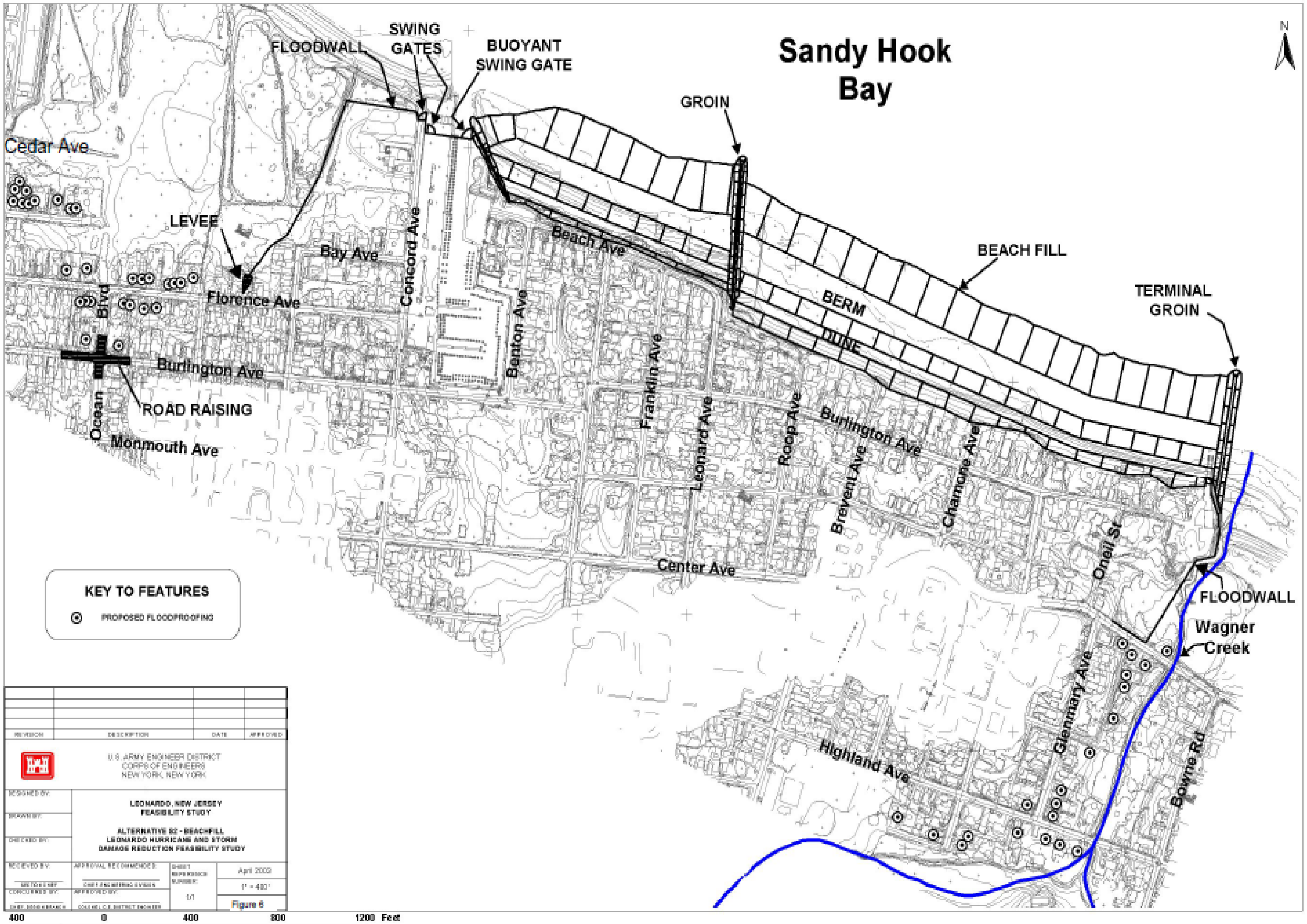

Figure 7: Alternative S2 – Beach Fill with gate across the marina

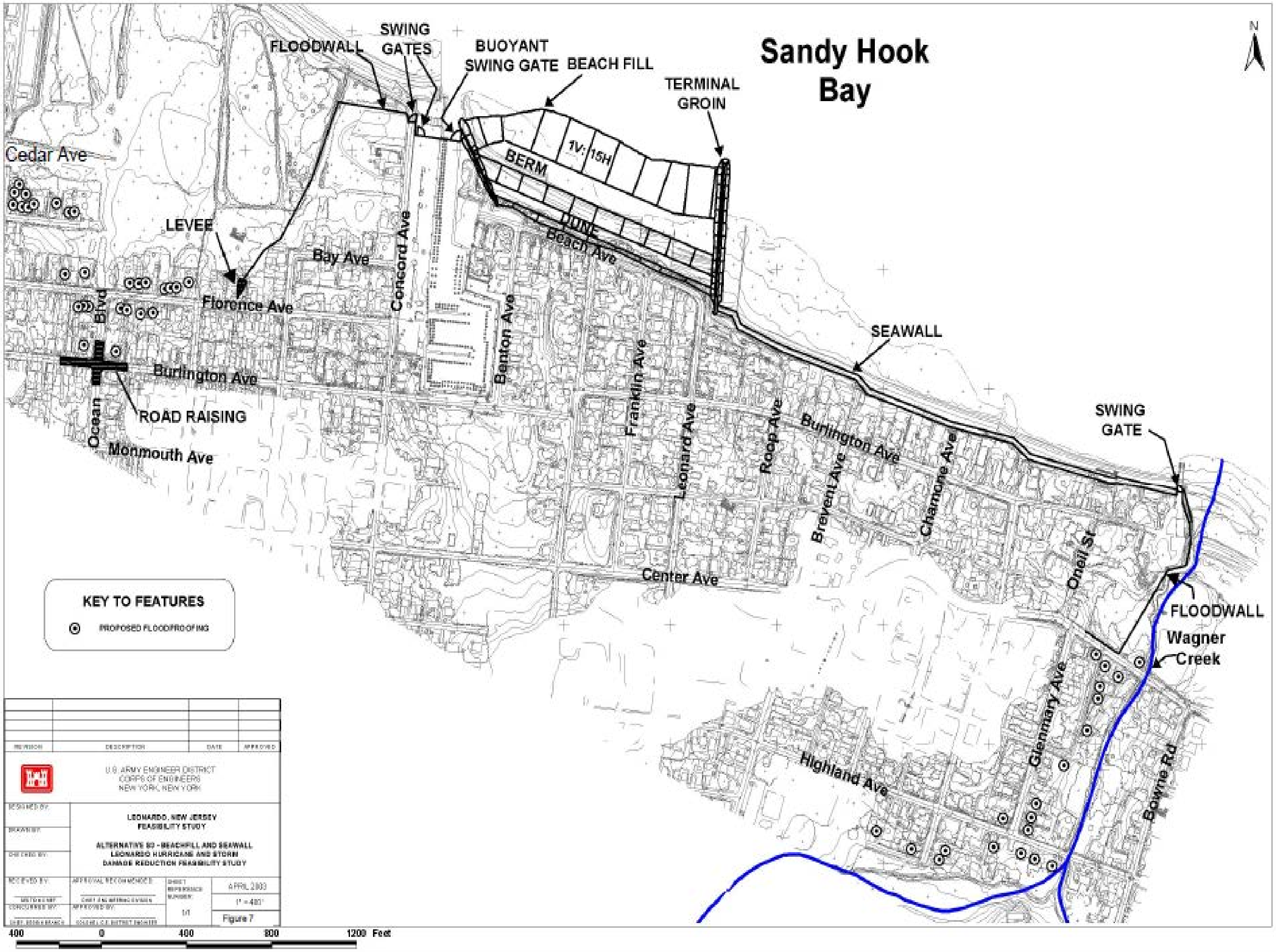

Figure 8: Alternative S3 – Combination Beach Fill and Seawall with gate across the marina

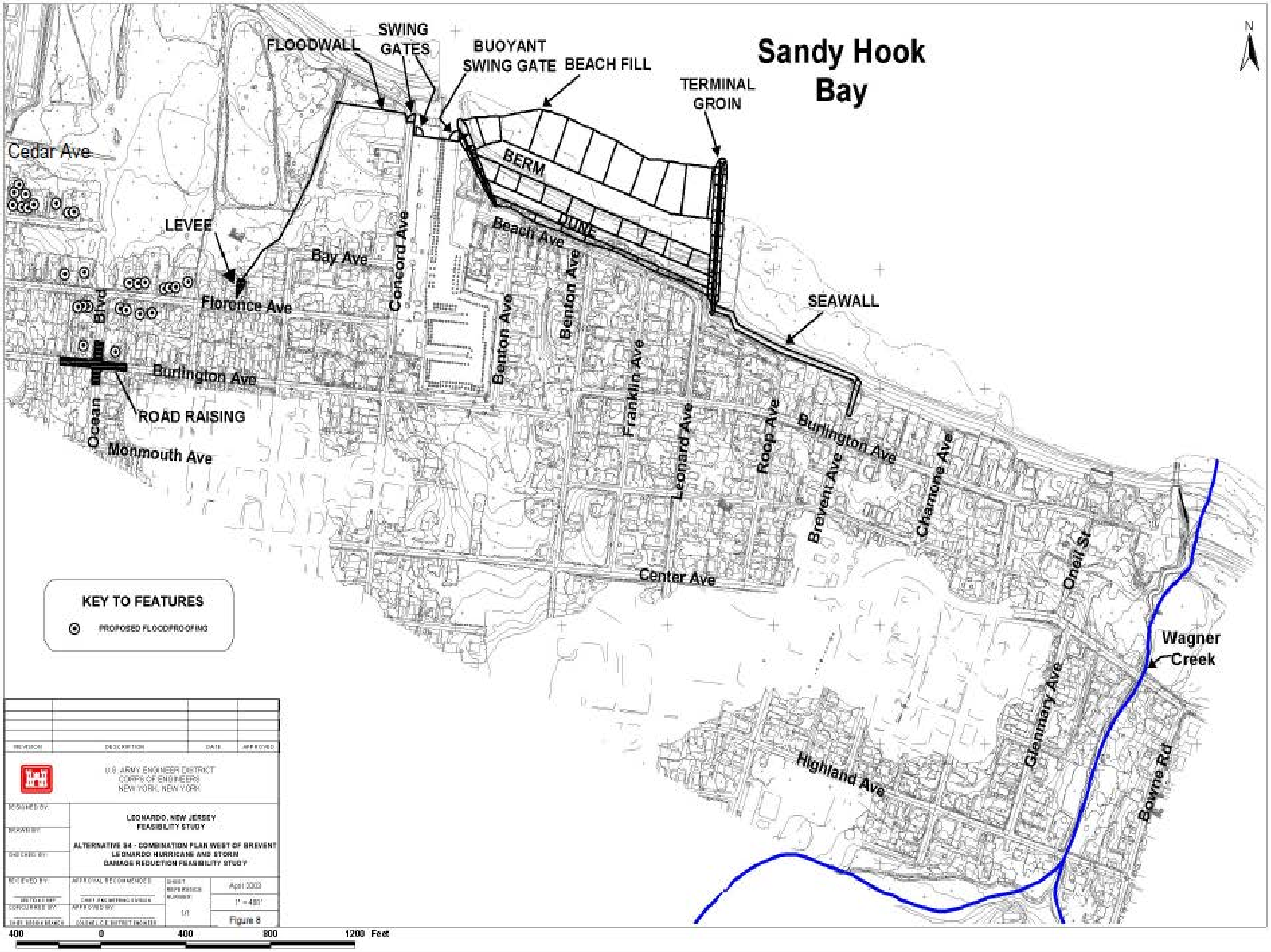

Figure 9: Alternative S4 – Combination Beach Fill and Seawall with gate across the marina, coastal storm risk management provided only west of Brevent Avenue

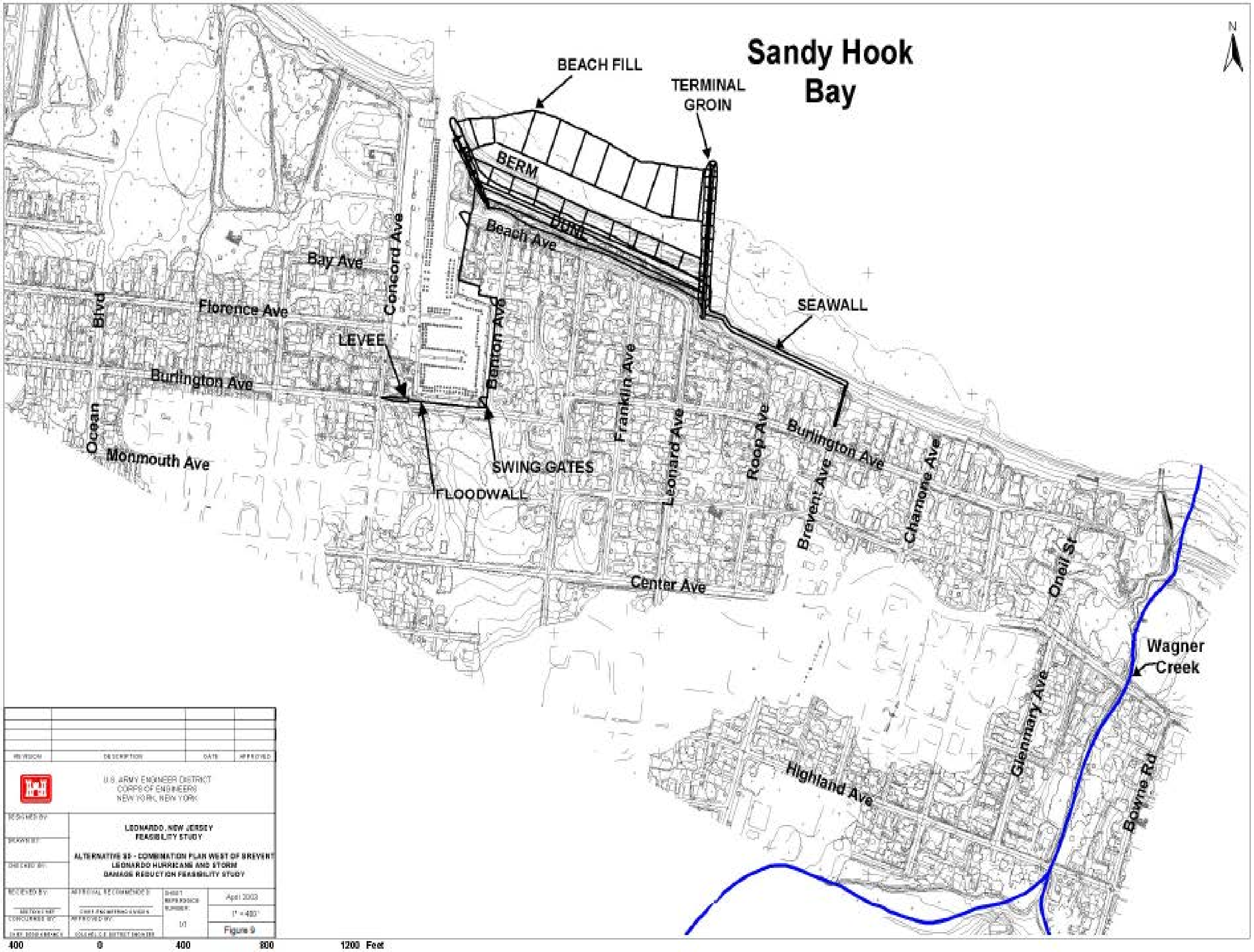

Figure 10: Alternative S5 – Limited structural plan with no gate across the marina

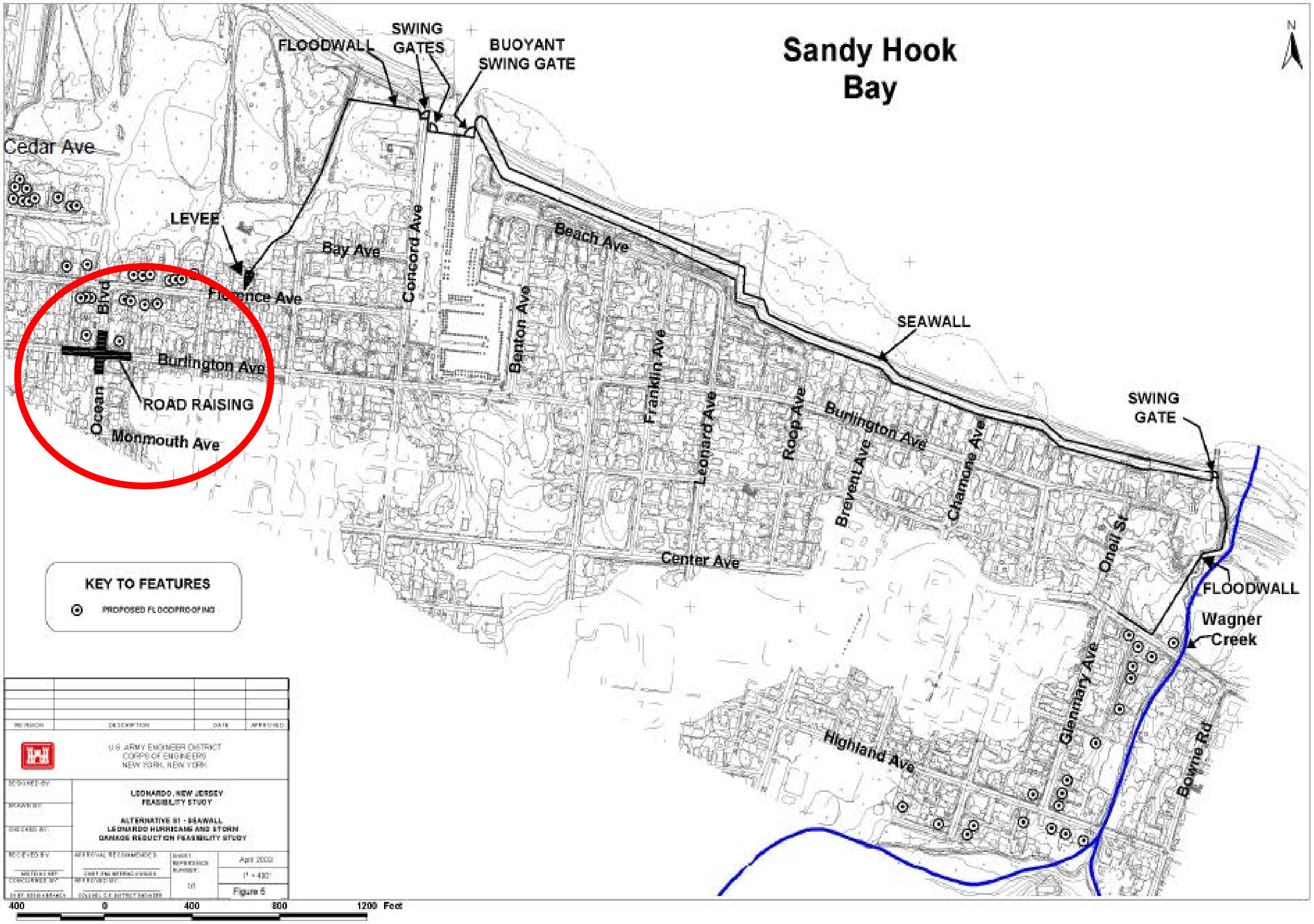

Figure 11: Alternative S6 - Road Raising

Nonstructural Alternatives

Five nonstructural plans involving flood proofing/building retrofitting of structures were evaluated. The five nonstructural alternative plans considered would provide coastal storm risk management to structures within the 20 percent, four percent and one percent floodplains based on the following criteria:

1) The design elevation of +13.1 ft NAVD88 was used for the first three plans. It consisted of the one percent flood stillwater elevation in 1998 (+10.7 ft NAVD88) plus the historic sea level rise (0.7 ft) plus 50% of the wave setup contribution (0.7 ft – the same for each structure in nonstructural alternatives) plus 1 ft of freeboard.
2) A fourth plan within the 20 percent floodplain was developed for the 10 percent flood design elevation (+9.9 ft NAVD88). The design elevation differed from the one percent flood design elevation only in the Stillwater elevation.
3) A fifth nonstructural plan was developed based on main floor elevation. The fifth nonstructural plan includes managing risk to structures with the main floor less than or equal to +9.4 ft NAVD88 (4 percent flood) to +13.1 ft NAVD88.

The following assumptions were used in calculating flood proofing options:

- Residences slated for elevation had the basements filled so that the structures could be raised without inducing structural damage where there was uncertainty as to whether the foundation walls could support the added loading.
- Bi-level residences were considered slab on grade construction with the first floor assumed to be at ground level.
- Damage commenced upon flood levels reaching the base of the foundation of a structure.

The flood proofing designs that were evaluated provided coastal storm risk management against floodwater inundation only. It was not expected that structures identified for flood proofing/elevating would be subject to wave impacts.

In general, all structures (except those included in plan N4) requiring flood proofing in each floodplain were treated to the one percent flood design elevation, which surpassed the New Jersey and Township of Middletown requirements for construction in the one percent floodplain at that time.[14] Flood proofing and other nonstructural alternatives were only evaluated for residential structures. Residential structures within the floodplains that already meet the design elevation requirements were excluded from the plans.

Alternative N1

Alternative N1 is a nonstructural plan for structures in the 20 percent floodplain where structures have a 20% chance of flooding in any given year. The 20 percent floodplain includes all structures that have ground elevations below +6.9 ft NAVD88. The structures would be elevated to the design elevation of +13.1 ft NAVD88 was used, which consisted of the one percent flood stillwater elevation in 1998 (+10.7 ft NAVD88) plus the historic sea level rise (.7 ft) plus 50% of the wave setup contribution (0.7 ft – the same for each structure in nonstructural alternatives) plus 1 ft of freeboard. Preliminary assessments indicated that 23 elevations would be required. The layout of the structures included in Alternative N1 is shown in Figure 12.

Alternative N2

Alternative N2 is a nonstructural plan for structures in the four percent floodplain where structures have a 4% chance of flooding in any given year. The four percent floodplain includes all structures that have ground elevations below +9.4 ft NAVD88. The structures would be elevated to the design elevation of +13.1 ft NAVD88 was used, which consisted of the one percent flood stillwater elevation in 1998 (+10.7 ft NAVD88) plus the historic sea level rise (.7 ft) plus 50% of the wave setup contribution (0.7 ft – the same for each structure in nonstructural alternatives) plus 1 ft of freeboard. Preliminary assessments indicated that 99 elevations would be required. The layout of the structures included in Alternative N2 is shown in Figure 13.

Alternative N3

Alternative N3 is a nonstructural plan for structures in the one percent floodplain where structures have a 1% chance of flooding in any given year. The one percent floodplain includes all structures that have ground elevations below +11.4 ft NAVD88. The structures would be elevated to the design elevation of +13.1 ft NAVD88 was used, which consisted of the one percent flood stillwater elevation in 1998 (+10.7 ft NAVD88) plus the historic sea level rise (0.7 ft) plus 50% of the wave setup contribution (0.7 ft – the same for each structure in nonstructural alternatives) plus 1 ft of freeboard. Preliminary assessments indicated that 160

[14] FEMA requires construction of structure main floor elevation to base flood elevation (BFE). State and local governments may have more strict restrictions for new construction or rebuilding, to 1, 2, or 3 feet above BFE. For the VE zone, FEMA requires the lowest structural member to be at or above the BFE.

elevations would be required. The layout of the structures included in Alternative N3 is shown in Figure 14.

Alternative N4

Alternative N4 is a nonstructural plan. Similar to Alternative N1, Alternative N4 manages risk to structures within the 20 percent floodplain. However, Alternative N4 has evaluated a lower level of flood risk management for structures in the 20 percent floodplain. Instead of treating individual structures to the one percent design elevation (as was the case for Alternatives N1, N2 and N3), this alternative (N4) would only provide coastal storm risk management to the 10 percent flood design elevation (+9.9 ft NAVD88). This alternative was developed to determine if nonstructural treatments to a lower level of performance would be more cost effective than treatment to bring these structures to a minimum of the one percent flood design elevation. It is important to note that even if the lower level of performance were more cost effective, such an alternative would carry high residual risks for the structures involved and would not be implementable as local building codes requiring elevation to one ft above base flood elevation would not be met. Preliminary assessments indicated that 18 elevations would be required. The layout of the structures included in Alternative N4 is shown in Figure 15.

Alternative N5

Alternatives N1 through N4 were developed based on the number of structures within a given floodplain. However, many structures in the study area have elevated main floors such that, while they may be located within an area that experiences frequent flooding, the structures themselves do not suffer significant recurring damages. Thus, an alternate approach was taken to identify structures for nonstructural treatment: structures were identified for nonstructural improvement by main floor elevation.

Alternative N5 is a nonstructural plan that includes treating structures with the main floor less than or equal to +9.4 ft NAVD88 (four percent flood). In order to identify those structures most susceptible to damage, only those structures with a ground elevation less than +7.9 feet NAVD were considered. The structures included in this alternative would be elevated to manage risk against a one percent flood design elevation (+13.1 ft NAVD88). Structures with a main floor elevation above +9.4 ft NAVD88 would be expected to experience only limited damage up to the four percent flood. Preliminary assessments indicated that 25 elevations would be required. The layout of the structures included in Alternative N5 is shown in Figure 16.

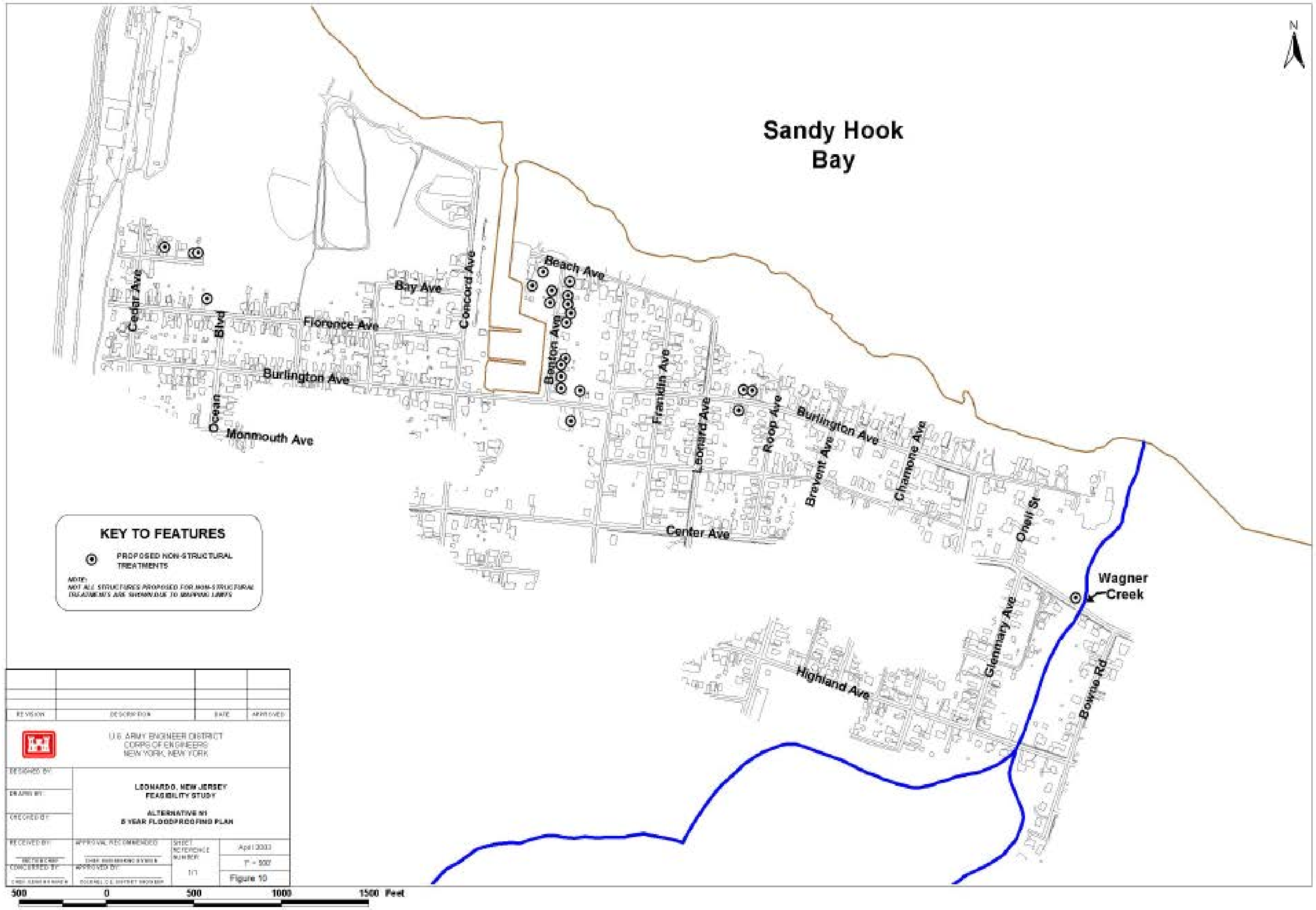

Figure 12: Alternative N1 – 23 Structures in the 20 percent floodplain

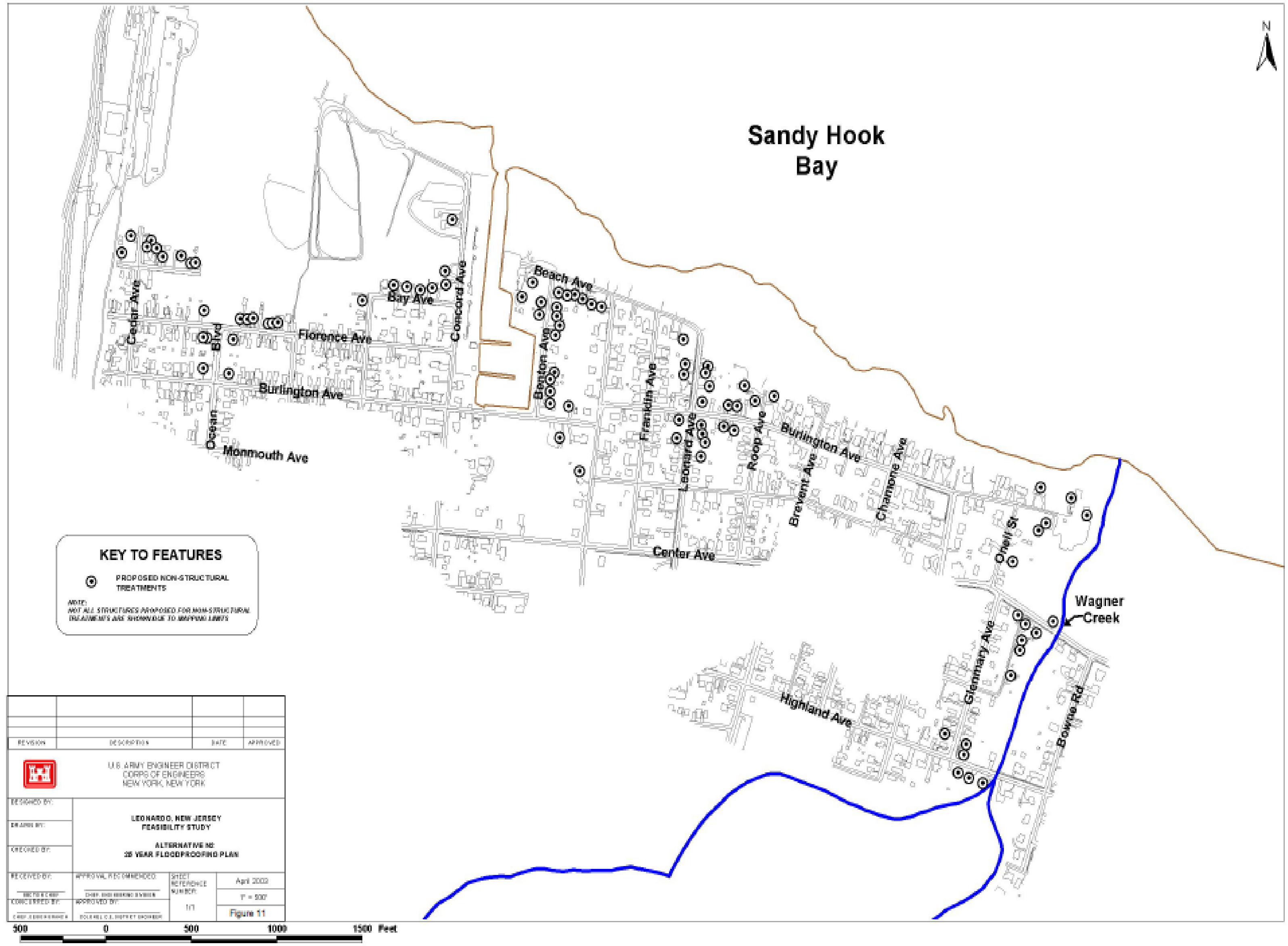

Figure 13: Alternative N2 – 99 Structures in the four percent floodplain

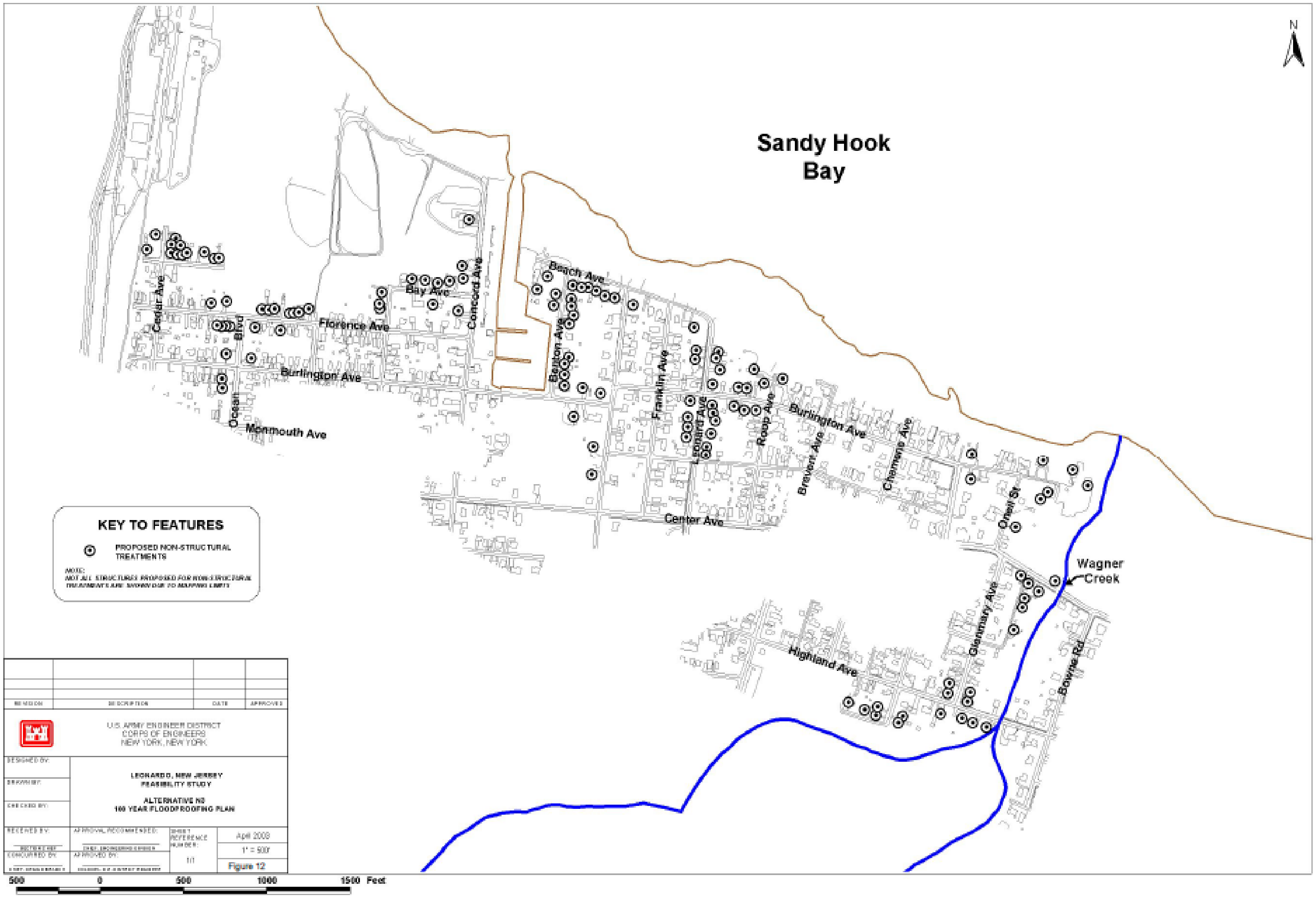

Figure 14: Alternative N3 – 161 Structures in the one percent floodplain

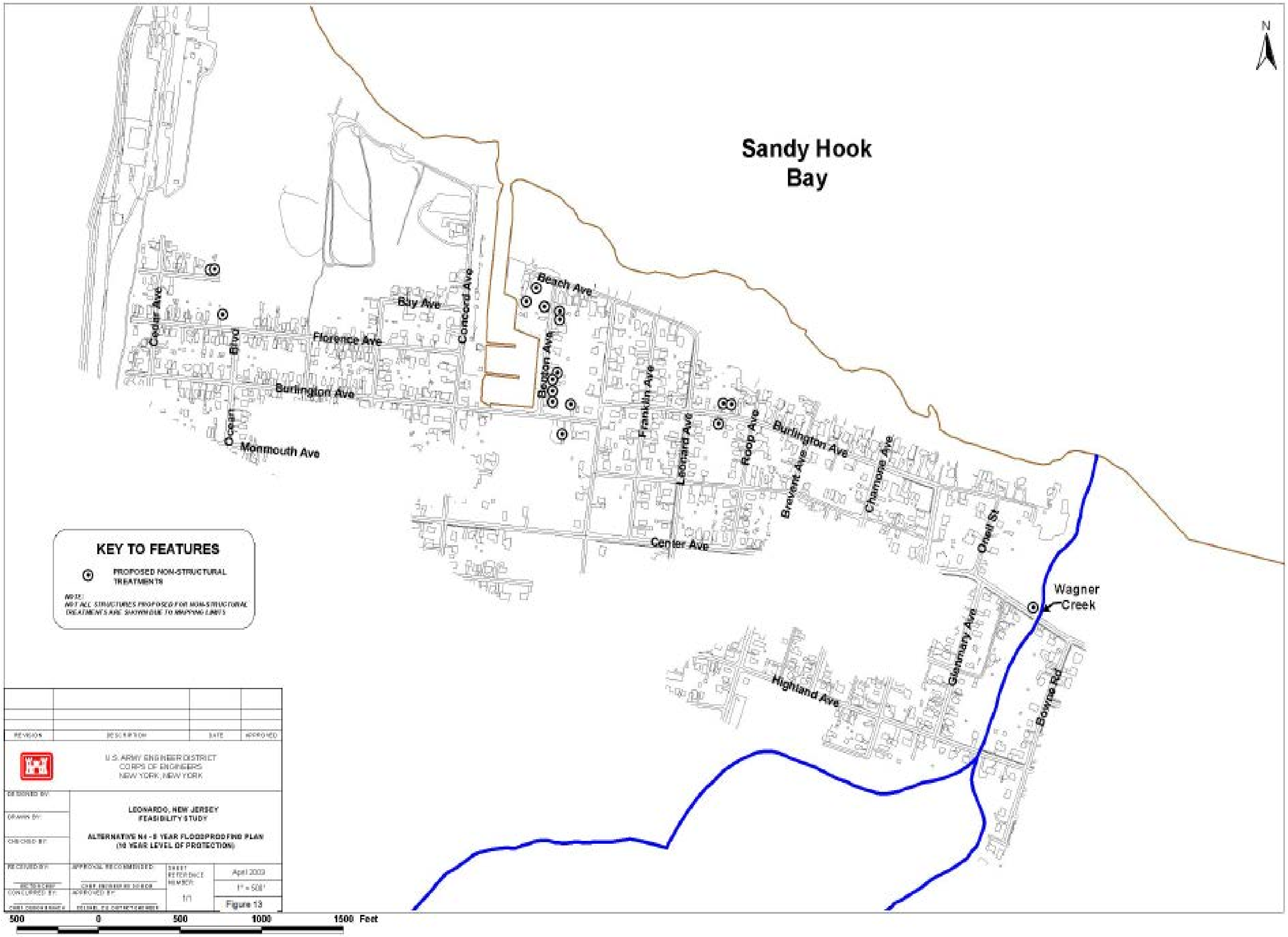

Figure 15: Alternative N4 – 18 Structures in the 20 percent floodplain elevated to 10 percent flood

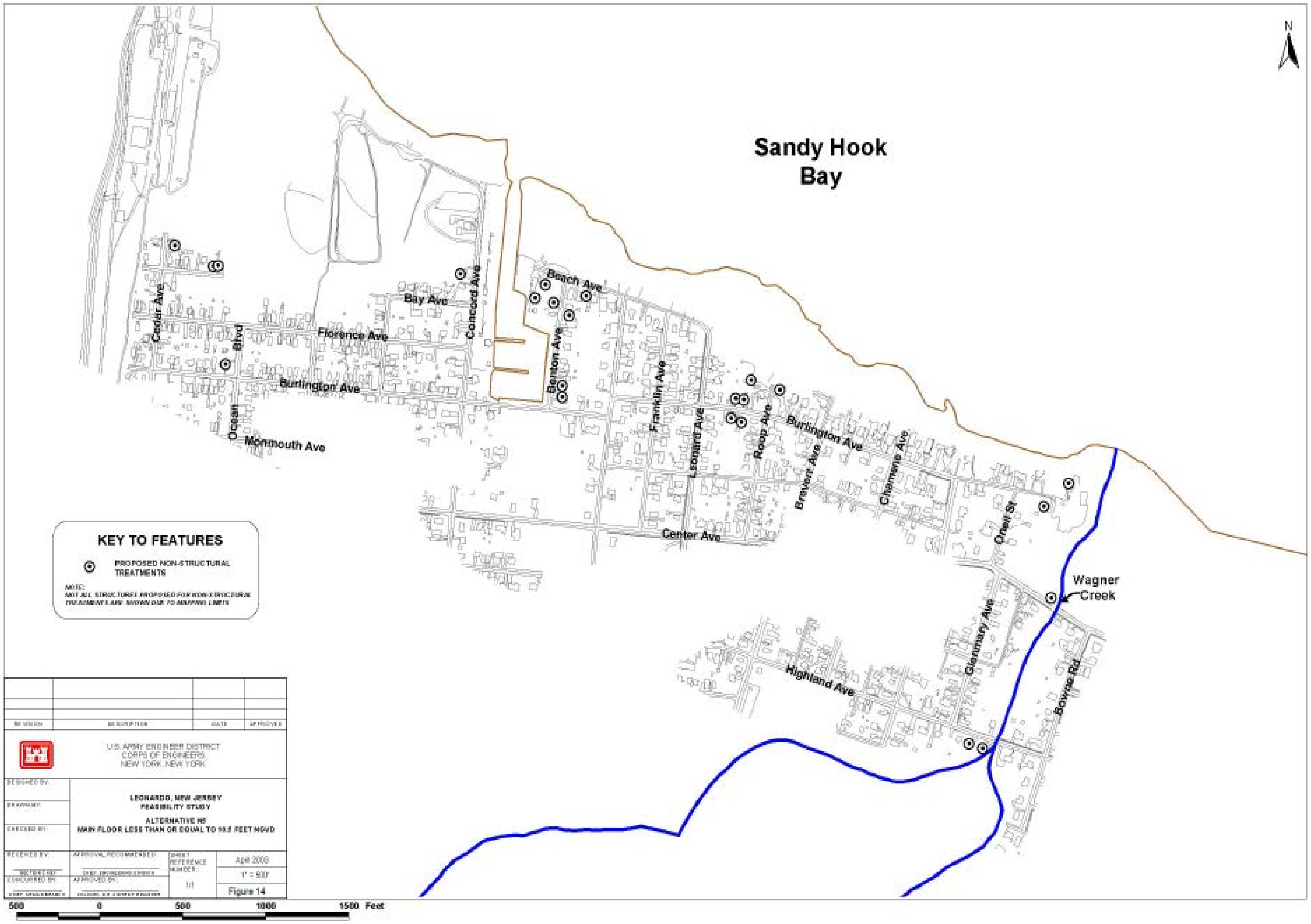

Figure 16: Alternative N5 – 25 Structures with a main floor at or below +9.4 feet NAVD88, ground elevation below +7.9 feet NAVD88

Table 3: First Cost and Annual Cost Summary for Leonardo Alternatives

(October 2008 price level – Discount Rate of 4.375%)[15]

	Alternative #S1	Alternative #S2	Alternative #S3	Alternative #S4	Alternative #S5	Alternative #S6	Alternative #N1	Alternative #N2	Alternative #N3	Alternative #N4	Alternative #N5
Total First Cost	$30,097,000	$31,508,000	$31,191,000	$23,554,000	$14,334,000	$499,000	$2,379,000	$11,026,000	$16,202,000	$1,571,000	$2,772,000
Interest During Construction	$1,167,000	$1,221,000	$1,121,000	$916,000	$556,000	$0	$21,000	$97,000	$149,000	$14,000	$24,000
Total Investment Cost	$31,264,000	$32,729,000	$32,312,000	$24,470,000	$14,890,000	$499,000	$2,400,000	$11,123,000	$16,351,000	$1,585,000	$2,796,000
Annualized Total Investment Cost	$1,500,000	$1,580,000	$1,557,000	$1,177,000	$715,000	$25,500	$118,000	$547,000	$803,000	$78,000	$137,000
Annualized Periodic Nourishment Cost	$0	$202,000	$57,000	$57,000	$57,000	$0	$0	$0	$0	$0	$0
Annualized Maintenance Cost	$195,000	$227,000	$181,000	$155,000	$45,000	$2,500	$0	$0	$0	$0	$0
Total Annual Cost	**$1,695,000**	**$2,009,000**	**$1,795,000**	**$1,389,000**	**$817,000**	**$28,000**	**$118,000**	**$547,000**	**$803,000**	**$78,000**	**$137,000**

Alternative Descriptions

Alternative S1 – Seawall with gate across the marina.
Alternative S2 – Beach Fill with gate across the marina.
Alternative S3 – Combination Beach Fill and Seawall with gate across the marina.
Alternative S4 – Combination Beach Fill and Seawall with gate across the marina, coastal storm risk management provided only west of Brevent Avenue.
Alternative S5 – Limited structural plan with no gate across the marina.
Alternative S6 – Road Raising.[16]
Alternative N1 – 23 Structures in the 20 percent floodplain.
Alternative N2 – 99 Structures in the four percent floodplain.
Alternative N3 – 161 Structures in the one percent floodplain.
Alternative N4 – 18 Structures in the 20 percent floodplain, elevated to 10 percent flood.
Alternative N5 – 25 Structures with a main floor at or below +9.4 ft NAVD88, ground elevation below +7.9 ft NAVD88.

[15] Through a sensitivity analysis, it was determined that the update to existing conditions would not affect the results of the plan formulation. Consequently, costs and benefits are presented in 2008 price level to reflect when these numbers were derived. The estimated construction period is 24 months.
[16] Post-Hurricane Sandy, it was determined that the problem to be addressed by road raising in S6 was related to interior drainage, not storm surge induced flooding. Consequently, S6 was dropped from consideration.

3.10 Final Array of Alternative Plans

The 1983 Principles and Guidelines (P&G) require that plans are formulated in consideration of four criteria: **completeness**, **effectiveness**, **efficiency**, and **acceptability**.

a. **Completeness** is the extent to which the alternative plans provide and account for all necessary investments or other actions to ensure the realization of the planning objectives, including actions by other Federal and non-Federal entities. *For the Leonardo CSRM study, any structural alternative had to provide risk management along the entire length of the alignment (6,500 ft) to be considered complete. Any "holes in the fence" would threaten the success of the entire project.*

b. **Effectiveness** is the extent to which the alternative plans contribute to achieve the planning objectives. *Effectiveness of the alternatives was measured by the reduced damages in the with-project condition against a one percent flood design elevation. Alternatives that have a benefit-to-cost ratio under 1 will be eliminated from consideration.*

c. **Efficiency** is the extent to which an alternative plan is the most cost effective means of achieving the objectives. *Efficiency will be measured through a comparison of benefit-to-cost ratios (BCRs) and reduced damages. Plans that provide the same level of performance, but at higher cost, will be eliminated from consideration.*

d. **Acceptability** is the extent to which the alternative plans are acceptable in terms of applicable laws, regulations, and public policies. *The alternatives were formulated to be in accord with applicable laws and regulations. Public acceptance of the plan is one criterion to consider, as the homeowners are concerned about maintaining their access to the water.*

The most expeditious way to evaluate the alternatives against the P&G criteria is through the second criterion of effectiveness. Accordingly, the annual costs are considered against the annual benefits for the alternatives in Table 4.

Table 4: Leonardo Alternatives Annual Costs and Benefits

Net Benefit and Benefit-to-Cost Ratio (2008 P.L.)				
Alternative	**Annual Cost**	**Annual Equivalent Benefit**	**Net Benefit**	**B/C ratio**
S1	$1,695,000	$901,000	-$793,000	0.53
S2	$2,009,000	$1,041,000	-$968,000	0.52
S3	$1,795,000	$948,000	-$847,000	0.53
S4	$1,389,000	$604,000	-$785,000	0.43
S5	$817,000	$397,000	-$420,000	0.49
S6	$28,500	$21,000	-$7,000	0.75
N1	**$118,000**	**$150,000**	**$32,000**	**1.27**
N2	$547,000	$334,000	-$213,000	0.61
N3	$803,000	$376,000	-$427,000	0.47
N4	$78,000	$64,000	-$14,000	0.82
N5	**$137,000**	**$186,000**	**$49,000**	**1.36**

Only Alternatives N1 and N5 had BCRs above one. To reiterate, these plans involve:

- Alternative N1 – Structures in the 20 percent floodplain (23 structures).
- Alternative N5 – Structures with a main floor at or below +9.4 ft NAVD88, ground elevation below +7.9 ft NAVD88 (25 structures).

Considered against the remaining P&G criteria, both Alternatives N1 and N5 meet the criteria of completeness, efficiency, and acceptability. Based on having the greater net benefits, Alternative N5 (25 structures), would appear to be the Tentatively Selected Plan (TSP). However, structures within the study area are at different levels of risk for storm damage. Some are at higher ground elevations, while others may be at lower ground elevations but constructed in such a way that the main floor is at an elevation above expected flood levels. For example, a building within the 20 percent floodplain could have a main floor above the one percent flood design elevation.

Accordingly, the study team decided to refine the identification of structures to maximize the net benefits, through a two-step optimization process that would incorporate both main floor elevation and floodplain elevation.

First, the study team expanded the subset of N5 to include the structures in N1 (the 20 percent floodplain) and went back into the field to capture neighboring structures for a more cohesive approach, resulting in a subset of 61 structures. Of these 61 structures, more detailed data on ground and main floor elevations were collected, and reevaluated in light of their purpose (residential or commercial). Field survey data were also used to check structures for the technical feasibility of the proposed nonstructural treatments. Finally, an economic analysis was conducted, focusing on the criteria of ground elevation and main floor elevation.

The optimization method of nonstructural plans is a project-by-project decision. Alternatives development may take into consideration ground elevation or first-floor elevation as the primary grouping criterion, depending on the specific circumstances of the study area, and should maintain a focus on completeness of plans. Furthermore, main floor elevation and floodplain elevation should not be considered as mutually exclusive. Structures grouped by floodplain elevation would get a second evaluation to determine whether they should remain in the damages based on their main floor elevation, or if additional structures could be considered based upon first floor elevation; while structures grouped by main floor elevation, their immediate neighbors would be assessed for inclusion into a recommendation based on a holistic look at the immediate topography and damages experienced.

Based upon the physical nature of the floodplain in Leonardo, development of plans based upon the floodplain does not contribute to plans that are more cohesive or comprehensive in nature. Based upon the evaluation done to date, the recommendation for Leonardo is to formulate alternatives based upon first floor elevation *and* floodplain evaluation. Using only main floor elevations may potentially give the impression of ‘cherry picking’ the most vulnerable structures for inclusion into a recommendation, however, evaluating the plans based upon ground elevation alone would result in a similar impression, due to the highly irregular nature of the floodplains in the study area.

Before Hurricane Sandy, the results of the optimization process indicated that structure selection should be limited to those structures within the 20 percent floodplain whose main floors are below elevation +11.0 ft NAVD88 – slightly less than the flood elevation from a .02 percent flood. The 19 structures are identified in Figure 17 and are listed in Table 5. The first cost of the optimized plan was $3,144,000 (2009 price level). The average annual costs of the Pre-Hurricane Sandy recommended plan were $164,000, and the average annual benefits were $221,000, resulting in net benefits of $57,000, with a benefit-to-cost ratio of 1.3.

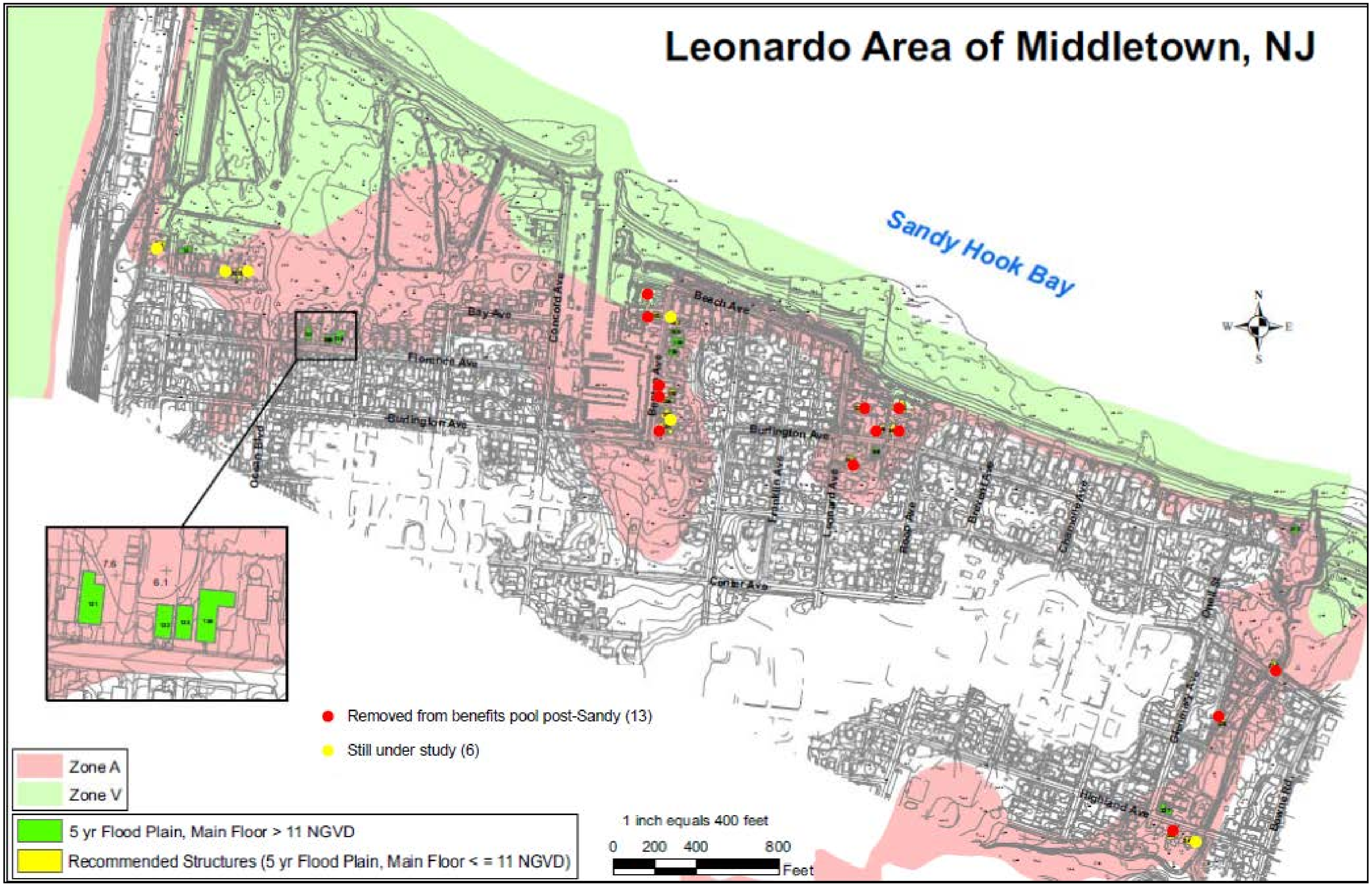

Figure 17: Tentatively Selected Plan for Leonardo Prior to Hurricane Sandy

Table 5: Selected Plan Structures Prior to Hurricane Sandy

Structure ID	Ground Elevation (+ft NAVD88)	Main Floor Elevation (+ft NAVD88)	Non-structural Measure	Status After Hurricane Sandy
4	5.6	9.6	ELEVATION	Under study
22	6.4	9.8	ELEVATION	Under study
23	4.8	9.4	ELEVATION	Under study
181	*4.5*	*7.9*	*ELEVATION*	*Removed*
182	4.8	6.9	ELEVATION	Under study
184	*4.7*	*9.8*	*ELEVATION*	*Removed*
185	5.0	6.0	ELEVATION	Under study
191	5.8	9.3	ELEVATION	Under study
193	*5.0*	*8.4*	*ELEVATION*	*Removed*
199	*6.4*	*9.6*	*ELEVATION*	*Removed*
237	*5.7*	*7.7*	*ELEVATION*	*Removed*
240	*4.6*	*7.9*	*ELEVATION*	*Removed*
241	*5.0*	*7.4*	*ELEVATION*	*Removed*
243	*5.1*	*7.7*	*ELEVATION*	*Removed*
245	*6.9*	*9.7*	*ELEVATION*	*Removed*
318	*4.2*	*7.5*	*REBUILD*	*Removed*
328	*5.6*	*8.9*	*ELEVATION*	*Removed*
343	6.8	9.7	ELEVATION	Under study
344	*6.5*	*9.3*	*ELEVATION*	*Removed*

After Hurricane Sandy it was determined by the Township of Middletown that 12 out of the 19 structures were substantially damaged, to the point that they were removed from the potential damages. The term “removed” means either that the owner is elevating the structure to comply with current requirements, or the structure physically no longer exists.

3.11 Trade-Off Analysis

The structural alternatives captured the annual benefits within the one percent floodplain, which worked out to approximately $1,000,000 prior to Hurricane Sandy. Non-structural alternatives address only structures and their contents, which provided $345,000 in annual benefits for all of the eligible structures within the one percent floodplain (see Table 4). Damages to roads, utilities, automobiles, and the Leonardo marina are not addressed by the nonstructural alternatives. Also unaddressed are the bulkhead/seawall replacement costs, emergency and clean up costs, evacuation and relocation costs, and Flood Insurance Administrative costs incurred. These residual annual damages constitute the approximately $650,000 in difference between the benefits of the structural alternatives and the nonstructural alternatives.

Of the nonstructural alternatives, only the smaller scaled plans, consisting of around 25 structures and covering less than 10% of the overall benefits, were economically justified. If the larger nonstructural alternatives or the structural alternatives had benefit-to-cost ratios (BCRs) above one, the team could recommend investigation of these larger alternatives as potential locally preferred plans (LPP) to address concerns about residual risk. However, a basic sensitivity analysis has shown that even smaller versions of the structural alternatives are still not economically viable.

3.12 Selection of the Final Plan

In the post-Hurricane Sandy assessment, the study team determined that the TSP would be a variant of a small scale nonstructural solution. The District conducted a sensitivity analysis on the viability of smaller structural plans post-Hurricane Sandy. Prior to Hurricane Sandy, the structural alternatives had all been developed to the one percent flood design elevation to facilitate comparisons among alternatives. All of the structural alternatives had negative net benefits, with BCRs well below one.

Post-Hurricane Sandy, the team considered smaller versions of the structural alternatives, at the four percent flood. Based on the stage frequency curves, a reduction from the one percent flood to the four percent flood corresponded to a two foot drop in water surface elevation. To estimate the reduction in cost, the team consulted the alternatives developed for the nearby Shrewsbury River, NJ CSRM study. The Shrewsbury River alternatives included seawall alignments at varying heights. Two of those alternatives had the same features but at differing heights, +9.5 ft NAVD88 and +11.5 ft NAVD88. The +9.5 ft NAVD88 alternative had a cost that was 90% of that for the +11.5 ft NAVD88 alternative. To complete the sensitivity analysis, the team reduced the costs of the structural alternatives by 10% and held the benefits constant for a best case scenario. Even under the best case scenario, the net benefits were still negative for all of the structural alternatives. Consequently, the team decided to focus on the nonstructural alternatives post-Hurricane Sandy. Furthermore, out of the nonstructural alternatives, the updated TSP would most likely be identified using the criteria behind the development of N1 and N5, as the BCRs for the remaining nonstructural alternatives were well below one as well.

In the update of existing conditions, the economics team updated the structure inventory, which covered 162 structures in Leonardo (see Table 6). Structures that were in the process of being elevated, or which were now gone, were noted in the survey. The information collected in the update of the structure inventory was screened through the criteria behind N1 and N5, and through the updated stage-frequency curves. Of the 162 structures surveyed, there were 47 structures that passed through the preliminary economic screening.

The 47 structures identified in the post-Hurricane Sandy screening were surveyed by project engineers for better details on ground elevation and main floor elevations, and to confirm the suitability of individual structures for treatments (*i.e.*, some structures may appear fine on the surface, but could be too damaged to elevate). After the update of the engineering surveys, 22 structures were removed from consideration due to poor structure condition, structure elevation already in progress, or lack of key information to identify a proposed treatment, leaving 25 out of the 47 structures in the subset for further consideration.

Table 6: Comparison of Structure Analysis Before and After Hurricane Sandy

Step	Pre-Hurricane Sandy (# of eligible structures)	Post-Hurricane Sandy (# of eligible structures)
Structure Inventory*	162	162
Structures Considered for Damages	61	47
Post-Hurricane Sandy Ground Truthing	N/A	25 (TSP)
Optimization	19	TBD

* Post-Hurricane Sandy analysis began with Pre-Hurricane Sandy data set that included structures in the 2 percent floodplain and structures with first floor elevation below +10.9 ft NAVD88.

In the post-Hurricane Sandy condition, buy-outs of structures were revisited as a nonstructural option for the subset of candidate structures. Based on the structure attributes (foundation type, main floor elevation, building type, *etc.*), it was determined that elevation or floodproofing were more cost effective than buyouts for all of the candidate structures. Preliminary estimates for buy-outs were obtained from realty websites, which provided projected sale estimate figures for the 25 structures in the subset. On average, the cost to buy out a structure was about two times the amount to elevate it. Buy-outs will be revisited during the optimization phase, when the team can focus on greater level of detail in its analyses and have input from the public and from reviews.

Accordingly, the remaining 25 structures constitute the subset of structures for the TSP (shown in Figure 18).

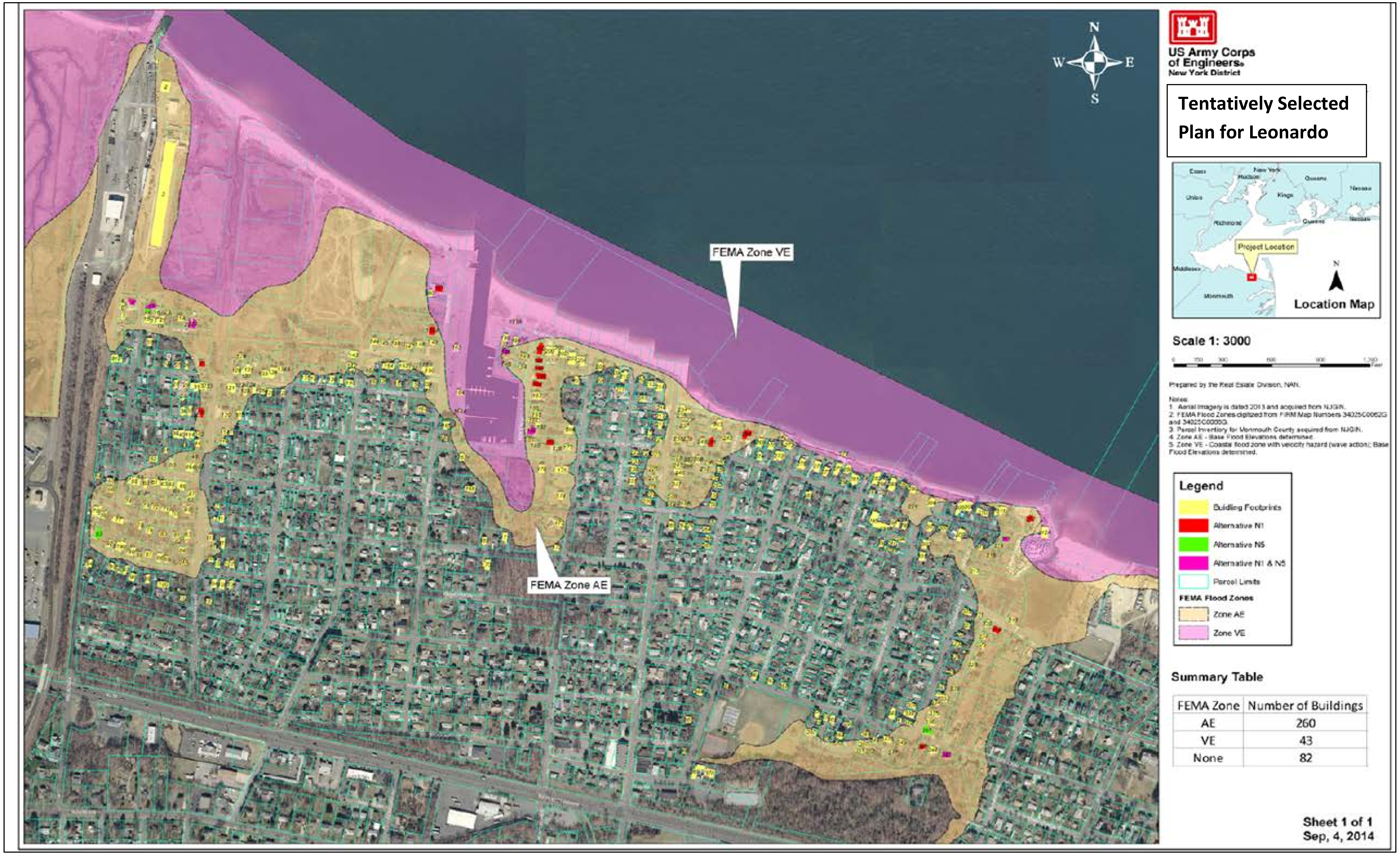

Figure 18: Tentatively Selected Plan for Leonardo

Chapter 4: Tentatively Selected Plan

4.1 Plan Components

The Tentatively Selected Plan (TSP) provides for nonstructural treatment of up to 25 structures within the community of Leonardo to manage risks from coastal storms. This number will undergo further refinement during plan optimization, which will result in between 10 to 25 structures to be recommended for treatment. The USACE effort is complementary to ongoing Hurricane Sandy recovery efforts, and will not include structures that are already receiving treatment or assistance through other means.

The recommended nonstructural treatment for the 25 structures is structure elevation to a level of the one percent flood still water elevation (+11.9 feet NAVD88) plus historic sea level rise (0.7 feet) plus wave contribution (varies for each structure) plus 1 feet or 3 feet of freeboard for structures in the AE and VE zones, respectively. After treatment, the final main floor elevation of elevated structures will range between +15.2 ft NAVD88 to +18.4 ft NAVD88, depending on the specific location of each structure (Table 7). To achieve this height, structures will be elevated anywhere between 1.8 ft to 10.6 ft from their existing heights, dependent upon their current, individual main floor elevations.

The construction technique varies depending on the foundation type, which in Leonardo includes crawl space, slab on grade, and sub-grade basement. Existing basements would be filled in and compacted as part of the elevation of the structure and associated utilities. Slab on grade or crawl space structures would have their foundations extended into the ground for stability as part of elevation; the space between the elevated structure and ground surface may be enclosed or left open. Diagrams illustrating the construction technique for each foundation type can be found in the Engineering Appendix.

Due to the highly irregular nature of the floodplain in Leonardo, the selected structures are scattered throughout the study area. Although the study team considered comprehensive structural and nonstructural alternatives, they were not cost effective and were screened from further consideration. It is acknowledged that with the implementation of this TSP, there may still be public and private properties that are vulnerable to coastal storm damages. Assistance and aid for these other properties may come from other Federal agencies, such as FEMA and the US Department of Housing and Urban Development (HUD), or from other programs run by the non-Federal partner, NJDEP.

Table 7: Components of the Leonardo TSP

Structure ID no.	Foundation Type	# of Stories	First Floor Area (sq ft)	FEMA Zone	FEMA Base Flood Elevation (+ft NAVD88)	Ground Elevation (+ft NAVD88)	First Floor Elevation (+ft NAVD88)	Increase to Structure Height (ft)	First Floor Elevation of Elevated Structure** (+ft NAVD88)	Included in Pre-Hurricane Sandy Plan
4	Crawl Space	1	1,500	AE	13	6.9	8.9	6.9	15.8	Yes
13	Crawl Space	2.5	1,200*	AE	13	6.8	6.8	9.0	15.8	No
14	Crawl Space	1	600	AE	12	8.9	8.9	6.9	15.8	No
22	Crawl Space	2	600	AE	13	5.4	8.3	7.5	15.8	Yes
23	Crawl Space	1	600	AE	13	4.9	8.3	8.1	16.4	Yes
27	Slab on Grade	2	1,125	AE	13	5.9	11.3	4.5	15.8	No
38	Crawl Space	1	1,200	AE	12	6.9	12.7	3.1	15.8	No
93	Slab on Grade	1	1,500	AE	12	8.4	8.9	6.3	15.2	No
149A	Crawl Space	2	1,800	AE	13	6.9	9.9	6.5	16.4	No
161***	Subgrade Basement	1.5	1,600	VE	14	6.9	10.3	8.1	18.4	No
179	Slab on Grade	2	900	AE	12	6.4	10.4	4.8	15.2	No
182	Slab on Grade	2.5	1,600	VE	13	4.9	6.6	10.6	17.2	Yes
185	Slab on Grade	2	900	AE	13	5.4	10.1	5.1	15.2	Yes
188	Subgrade Basement	1	1,000	AE	13	4.9	10.6	4.7	15.2	No
189	Subgrade Basement	1	2,025	AE	13	4.9	10.4	4.9	15.2	No
190	Subgrade Basement	1.5	800	AE	13	4.9	9.6	5.6	15.2	No
191	Subgrade Basement	1.5	1,000	AE	13	5.9	9.8	6.0	15.8	Yes
192	Subgrade Basement	1	1,800	VE	13	5.9	12.3	5.5	17.8	No
196	Crawl Space	2	1,200	VE	13	4.9	9.2	8.6	17.8	No
268	Crawl Space	1	2,500	VE	12	6.9	10.6	7.2	17.8	No
313	Subgrade Basement	1.5	750	AE	13	6.9	8.9	7.3	16.2	No
319	Subgrade Basement	1	1,250	AE	12	6.9	14.0	1.8	15.8	No
337	Subgrade Basement	1	2,400	AE	11	8.9	8.9	6.3	15.3	No
343	Crawl Space	1	1,200	AE	11	4.9	6.9	8.8	15.8	Yes
345	Subgrade Basement	2	900	AE	11	6.9	13.6	2.2	15.8	No

Notes:
**** - First Floor Area estimated (not recorded by survey)***
***** - This is equivalent to the one percent flood design elevation, which includes the one percent flood still water level, plus sea level change, plus wave component (which varies by structure) and freeboard. See Table 12 in the Engineering Appendix for more information.***
****** - All structures in the table are residential except #161, which is commercial***

4.2 Operation, Maintenance, Repair, Replacement, and Rehabilitation Considerations

Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R) responsibilities are not anticipated for the non-Federal partner, and there will be no additional operations and maintenance expenses for the individual property owners as a result of project implementation. Accordingly, no OMRR&R costs are anticipated for the Leonardo project.

4.3 Cost Estimate

A summary of the costs of the Leonardo TSP is presented in Table 8.

Table 8: Total First Costs & Annual Costs for Leonardo (Oct. 2014 P.L.)

Initial Project Cost (FY14 price level)	$5,463,000
Annualized Initial Cost*	$227,000
Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R) Costs**	$0
Total Annual Cost*	$227,000

*Discounted at 3.375% over a 50-yr period

** OMRR&R costs will be nominal, as nonstructural treatments will not result in OMRR&R responsibilities for the non-Federal cost share partner.

The initial project cost is $5,463,000 and the fully funded cost is $5,703,000. These costs include construction, lands and damages, design, supervision and associated administration costs. The material costs were based on a combination of MII database, RSMeans, quotes, and some historical information. Equipment rates were obtained from region 1, and Davis Bacon Wage Rates for Monmouth County, NJ were utilized for labor costs. The contingencies were developed using Abbreviated Risk Analysis program (ARA). The summary of the results of this risk analysis, and more detail on the cost estimate, can be viewed in the Cost Appendix.

4.4 Project Economics

The benefits of implementing nonstructural coastal storm risk management measures represent flood damages avoided by the project. Benefits were calculated as the difference in damages before and after project implementation. Benefits were then amortized over a 50-year period to identify equivalent annual benefits using October 2014 price levels and an interest rate of 3.375%.

Table 9 provides a summary of the costs and benefits of the plan. All 25 structures have the same treatment – elevation. The final number of structures will be determined in optimization following the TSP and release of the draft report, but will number no more than 25 structures.

Table 9: Performance of Leonardo Tentatively Selected Plan (Oct. 2014 P.L.)

Total First Cost	$5,463,000
Equivalent Annual Cost	$227,000
Equivalent Annual Benefits	$287,000
Annual Net Benefit	**$59,000**
Benefit-to-Cost Ratio	**1.3**

* All of the dollar amounts in this table have been rounded to the nearest thousand for display purposes, resulting in minor discrepancies between the expected totals and the displayed totals. Please see the Economics Appendix for the unrounded amounts.

4.5 Risk and Uncertainty Analysis

The Leonardo TSP does not contribute to risk in an overall sense, as it does not encourage development in the floodplain. In this sense, the plan is compliant with Executive Order 11988 (1977), which requires Federal agencies to minimize and prevent encouragement of development in the floodplain in their planning and project implementation. It should be noted, however, that Leonardo is fully developed and there is no room for additional development within the community, regardless of which alternative is under consideration.

In comparison to the larger and more comprehensive alternatives evaluated at earlier stages of this study, the TSP carries relatively high residual risk, as less than 10% of the structures within the one percent floodplain are included. Other properties within the one percent floodplain could receive assistance or funding for nonstructural treatments through other sources, but there would still be residual risks even if every structure within the floodplain were treated. The fundamental risk associated with a nonstructural plan is that access routes would become inaccessible due to flooding from coastal storm events, stranding individuals who choose not to evacuate when told to during future coastal storms.

As discussed in Section 3.11 of this report, none of the structural alternatives could be investigated by USACE as a potential locally preferred plan, because they all had benefit-to-cost ratios below one. There is no way to mitigate the risk through a more comprehensive plan; the only option in this situation is to communicate the residual risk.

Key uncertainties for this study were described in Section 3.8 of this report, of which the most important were the projected rates of relative sea level change and the likelihood of structures being elevated or demolished, which mean that benefits for those structures could not be included in this analysis. The question of sea level change will be addressed during plan optimization, which will investigate the performance of the TSP under accelerated rates of sea level rise.

The second key uncertainty relates to implementation of the TSP as well. Participation in nonstructural projects is voluntary for property owners. Theoretically, it is possible for the project to have a benefit-to-cost ratio above one for the purposes of authorization, but below one in implementation if some of the property owners elect not to participate. Based on coordination with non-Federal and local interests to date, lack of participation is not anticipated for this project. Plan optimization will investigate the potential combinations and subsets of the subset of 25 structures to minimize this possibility, and may result in a final recommendation for fewer than 25 structures for inclusion.

4.6 Economic, Environmental, and Other Social Effects

Four accounts have been established to facilitate evaluation and display of effects of alternative plans:

a. National Economic Development (NED) – changes in the economic value of the national output of goods and services
b. Environmental Quality (EQ) – non-monetary effects on significant natural and cultural resources
c. Regional Economic Development (RED) – changes in the distribution of regional economic activity that result from each alternative plan
d. Other Social Effects (OSE) – effects from perspectives that are relevant to the planning process, but are not reflected in the other three accounts.

In reducing damages from future storm and flood events, the Leonardo TSP contributes to National Economic Development. Regarding the other accounts, a small nonstructural project neither contributes to nor detracts from the EQ and RED accounts. As identified in the Environmental Assessment, there would be minimal environmental impacts to implementation of the TSP. No wetlands will be affected nor will any other habitat be destroyed, because the project footprint is limited to structure elevation, which utilizes the existing footprint and floodwaters will essentially be allowed to flow as they would under the no action alternative. For the same reason, and because no historic buildings are included in the project, there will be no impact to cultural resources. Any other impacts, including the environmental impacts associated with building elevation, will be minor and temporary (e.g., temporary relocation of residents during construction).

As for the OSE account, this project does not detract from the community's water views or water access. However, the fact that it includes only a small subset of the community means that some property owners who experience flood damages and need help may not receive it from this project. Information regarding other sources of Federal and non-Federal assistance for affected property owners will be an important aspect of public communication.

Chapter 5: Plan Implementation

As non-Federal partner, the NJDEP must sign a Project Partnership Agreement (PPA) that will carry the project through the Preconstruction Engineering and Design (PED) phase to project construction. This process is described in more detail in Section 5.5 below. A Project Management Plan (PMP) will be prepared to identify tasks, responsibilities, and financial requirements of the Federal Government and the non-Federal partner during PED and construction. A project schedule has been estimated to serve as the basis of the cost estimate based on reasonable assumptions for the detailed design and construction schedules. It will be refined as more data are available in subsequent phases of the project.

5.1 Institutional Requirements/Local Cooperation

NJDEP has indicated its intent to implement this project through a strong record of involvement and coordination in the feasibility study, and a letter of support (Pertinent Correspondence Appendix).

A fully coordinated PPA package, which will include the non-Federal partner's financing plan, will be prepared subsequent to the approval of the feasibility phase to initiate design and construction. It will be based on the recommendations of the Feasibility Study. NJDEP has agreed to comply with all applicable Federal laws and policies and other requirements that include, but are not limited to:

a. Provide all lands, easements, rights-of-way, and relocations and disposal/borrow areas (LERRD) uncontaminated with hazardous and toxic wastes.

b. Provide an additional cash contribution if the value of LERRD contributions toward total project costs is less than 35 percent, so that the total share equals 35 percent.

c. Provide all improvements required on lands, easements, and rights-of-way to enable the proper disposal of dredged or excavated material associated with the construction, operation, and maintenance of the project. Such improvements may include, but are not necessarily limited to, retaining dikes, waste-weirs, bulkheads, embankments, monitoring features, stilling basins, and dewatering pumps and pipes.

d. For so long as the project remains authorized, operate, maintain, repair, replace, and rehabilitate the completed project, or functional portion of the project, including mitigation features, at no cost to the Government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State laws and any specific directions prescribed by the Government in the OMRR&R manual and any subsequent amendments thereto.

e. Provide of the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal project partner, now or hereafter, owns or controls for access to the Project for the purpose of inspection, and, if necessary after failure to perform by the non-Federal project partner, for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating the Project. No completion, operation, maintenance, repair, replacement, or rehabilitation by the Federal Government shall operate to relieve the non-Federal project partner of responsibility to meet the non-Federal project partner's obligations, or to preclude the Federal Government from pursuing any other remedy at law or equity to ensure faithful performance.

f. Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, replacement, and rehabilitation of the Project and any Project-related betterments, except for damages due to the fault or negligence of the United States or its contractors.

g. Keep, and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the Project in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 Codes of Federal regulations (CFR) Section 33.20.

h. Perform, or cause to be performed, any investigations for hazardous substances as are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Public Law (P.L.) 96-510, as amended, 42 U.S.C. 9601-9675, that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for the construction, operation, and maintenance of the Project. However, for lands that the Federal Government determines to be subject to the navigational servitude, only the Federal Government shall perform such investigations unless the Federal Government; provides the non-Federal project partner with prior specific written direction, in which case the non-Federal project partner shall perform such investigations in accordance with such written direction.

i. Assume complete financial responsibility, as between the Federal Government and the non-Federal project partner for all necessary cleanup and response costs of any CERCLA regulated materials located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be necessary for the construction, operation, or maintenance of the Project.

j. As between the Federal Government and the non-Federal project partner, the non-Federal project partner shall be considered the operator of the project for the purpose of CERCLA liability. To the maximum extent practicable, operate, maintain, repair, replace and rehabilitate the Project in a manner that will not cause liability to arise under CERCLA.

k. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1790, Public Law 91-646, as amended by Title IV of the Surface Transportation and Unifom1 Relocation Assistance Act of 1987 (Public Law 100-17),and the Unifom1 Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way, required for the construction, operation, and maintenance of the Project, including those necessary for relocations, borrow materials, and dredged or excavated material disposal, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act.

l. Comply with all applicable Federal and State laws and regulations, including, but not limited to, Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d), and Department of Defense directive 5500.11 issued pursuant thereto, as well as Army regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army."

m. Provide the non-Federal share of that portion of the costs of mitigation and data recovery activities associated with historic preservation, that are in excess of 1 percent of the total amount authorized to be appropriated for the project, in accordance with the cost sharing provisions of the agreement.

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

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

p. Publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in preventing unwise future development in the flood plain and in adopting such regulations as may be necessary to prevent unwise future development and to ensure compatibility with the coastal storm risk management provided by the project.

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

r. Provide, during construction, any additional funds needed to cover the non-Federal share of PED costs.

s. Grant the Government a right to enter, at reasonable times and in a reasonable manner, upon land which the non-Federal project partner owns or controls for access to the project for the purpose of inspection and, if necessary, for the purpose of completing, operating, maintaining, repairing, replacing or rehabilitating the project.

t. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, and Section 103 of the Water Resources Development Act of 1986, Public Law 99-662, as amended, which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the non-Federal project partner has entered into a written agreement to furnish its required cooperation for the project or separable element.

u. Prevent obstructions of or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) which might reduce the ecosystem restoration, hinder its operation and maintenance, or interfere with its proper function, such as any new development on project lands or the addition of facilities which would degrade the benefits of the project.

v. Perform, or cause to be performed, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 USC 9601-9675, that may exist in, on, or under lands, easements or rights-of-way necessary for the construction, operation, and maintenance of the project; except that the non-Federal partner shall not perform such investigations on lands, easements, or rights-of-way that the Government determines to be subject to the navigation servitude without prior specific written direction by the Government.

w. Participate in and comply with applicable Federal floodplain management and flood insurance programs.

x. Do not use Federal funds to meet the non-Federal partner's share of total project costs unless the Federal granting agency verifies in writing that the expenditure of such funds is authorized.

In an effort to keep the non-Federal project partner involved and the local government informed, meetings were held throughout the feasibility phase. Coordination efforts will continue, including coordination of this study with other State and Federal agencies. It is currently anticipated that a public meeting will be held upon release of the draft feasibility report for public review and approval of this feasibility study.

5.2 Real Estate Requirements

The project will require up to twenty five individual Rights of Entry for Construction, for the entire subset of the properties identified for nonstructural flood proofing through elevation. The project requires Rights of Entry for Construction affecting a total of 5.29 acres of land. In addition to Rights of Entry for Construction, Temporary Work Area Easements may be required. The need for such easements will be determined following the publication of this report and prior to construction of the project. More detail can be found in the Real Estate Plan (REP) in the Real Estate Appendix.

A summary of estimated real estate costs for the Leonardo project is presented in Table 10.

Table 10: Real Estate Requirements for Leonardo (Oct. 2014 P.L.)

Real Estate Cost Category	*Federal Share*	*Non-Federal Share*	Total
Incidental Costs	$18,000	$85,000	$103,000
Acquisition Costs (Temporary Relocations)	$0	$443,000	$443,000
Subtotal*	**$18,000**	**$528,000**	**$545,000**
Contingency (20%)	$4,000	$106,000	$110,000
Total Lands & Damages*	**$21,000**	**$633,000**	**$654,000**

*All of the dollar amounts in this table have been rounded to the nearest thousand for display purposes, resulting in minor discrepancies between the expected totals and the displayed totals. Please see the Real Estate Plan for the unrounded amounts.

5.3 Relocations

For persons temporarily displaced by the project, two basic types of financial relocation assistance payments are provided to residential occupants: 1) a comparable housing payment; and 2) a moving expense payment. These costs are intended to compensate a displaced person for the additional costs he/she will incur in securing comparable replacement housing. The Leonardo REP estimates persons affected by the project will be displaced for up to two months.

Comparable Housing Payment: This includes the sum of the amounts by which the cost of a temporary comparable dwelling exceeds the out of pocket cost of the displacement dwelling (commonly referred to as price differential payments), per diem and laundry service as temporary accommodations generally do not include required facilities, and the reasonable expenses incidental to the temporary comparable dwelling (commonly referred to as incidental expenses). Comparable housing payment was determined by assuming a displaced person has owned and occupied his/her dwelling for at least 180 days prior to initiation of negotiations (i.e. the date a written offer was made to acquire the property). Currently, by Federal law the sum of total of payments are not to exceed $22,500, unless under housing of last resort.

Comparable replacement dwellings are expected to be available in Monmouth County and surrounding areas, therefore, housing of last resort is not anticipated. Based on an average New Jersey household size of 2.68 persons from the 2010 United States Census, comparable housing payments are estimated at approximately $17,000 per household (Oct. 2014 P.L.).

Moving Expense Payment: The 2012 Fixed Residential Moving Cost Schedule approved by the Federal Highway Administration does not apply to this Project as the relocations are temporary not permanent. An estimated figure of $1,000 (Oct. 2014 P.L.) is used to account for the displaced person(s)' move into and out of a temporary comparable dwelling.

The total estimated relocation assistance benefits paid in support of the Project is approximately **$443,000** (Oct. 2014 P.L.).

5.4 Financial Analysis

For purposes of executing the PPA, NJDEP has a source of funding for coastal storm risk management projects and has indicated its intent to enter into a PPA at the conclusion of the study. The Letter of Support from NJDEP is included in the Pertinent Correspondence Appendix.

5.5 Preconstruction Engineering and Design

Because Leonardo has been included as a project under study as part of the P.L. 113-2 response to Hurricane Sandy, Preconstruction Engineering and Design (PED) could be cost shared under a Project Partnership Agreement (PPA) (which typically only covers construction), if there are sufficient P.L. 113-2 funds to complete initial construction of the project.[17,18] Initial construction does not include subsequent periodic nourishment of beach elements, if applicable, to the project. A separate Design Agreement (DA) for PED is not required unless P.L. 113-2 funds are insufficient to complete initial construction of a project. Given the modest scale of this project and that it is a nonstructural project with no beach element that will require future periodic nourishment, it is anticipated that completion of the Leonardo feasibility study will be followed by PPA execution, once the Assistant Secretary to the Army (Civil Works) (ASA (CW)) provides notification to the Committee on Appropriations of the U.S. House of Representatives and the Senate.

[17] 09 December 2013 CECW-ZA guidance, "Disaster Relief Appropriations Act of 2013, Policy Guidance Memorandum Construction Account."

[18] 07 July 2013 CECW-ZA guidance, "Disaster Relief Appropriations Act of 2013, Policy Guidance Memorandum Expenses and Investigations Accounts."

For the Leonardo project, PED costs are estimated at $750,000 (Oct. 2014 P.L.), to be cost-shared 65% Federal and 35% non-Federal. The approximate duration for PED is six (6) months.

5.6 Construction Schedule

The project assumes a start date of October 2016 because of the lack of technical complexity and small scale of the project. In addition to the start date, the construction schedule assumes that five homes would be worked on at once by one contractor with multiple crews working five days a week. A single home will take approximately eight weeks to accomplish with one group of five over lapping with the next group by one week. The construction schedule is included as Figure 19 to illustrate the sequencing of nonstructural treatments. Assuming work will not be done the months of December, January, and February because of weather and the potential for disconnected plumbing to freeze, the overall duration will be ten (10) months with a completion date in July 2017.

5.7 Cost Sharing and Non-Federal Partner Responsibilities

The details behind the total first cost of implementing the TSP are shown in Table 11. The Federal share of the project's total first cost is 65 percent of the total. The Federal Government will design the project, prepare detailed plans/specifications and construct the project, exclusive of those items specifically required of non-Federal interests. The non-Federal share of the estimated total first cost of the proposed project is 35 percent of the total. The non-Federal share consists of a number of components including LERRDs (of which the Non-Federal portion is deducted from the Non-Federal cash contribution) and cost-sharing for PED and construction.

Table 11: Cost Apportionment (Oct. 2014 P.L.)

	Cost Category	*Federal Share*	*Non-Federal Share*	**Total**
Coastal Storm Risk Management-Nonstructural Treatments	Initial Project Costs	$3,551,000	$1,912,000	$5,463,000
	Real Estate Costs LERRDS)	$21,000**	$633,000	$633,000
	Cash Contribution	$3,551,000	$1,279,000	$4,830,000
	OMRR&R Costs		$0*	$0
Total		$3,551,000	$1,912,000	$5,463,000

*OMRR&R costs are not anticipated, as nonstructural treatments will not result in OMRR&R responsibilities for the non-Federal cost share partner.
**The Federal share of Real Estate costs does not reduce the Federal cash contribution and is shown for information purposes only.

Task Name	Duration	Start	Finish
Leonardo, NJ Non Structural Cons	**258 days**	**Mon 10/3/16**	**Mon 7/31/17**
Structure ID No. 4	**48 days**	**Mon 10/3/16**	**Mon 11/28/16**
Preconstruction Activities	4 days	Mon 10/3/16	Fri 10/7/16
Disconnect Utilities	2 days	Fri 10/7/16	Mon 10/10/16
Mobilization	2 days	Mon 10/10/16	Wed 10/12/16
Demo	5 days	Wed 10/12/16	Tue 10/18/16
New Foundation	15 days	Tue 10/18/16	Fri 11/4/16
Reconnect Utilities	2 days	Fri 11/4/16	Mon 11/7/16
Interior Work	5 days	Mon 11/7/16	Sat 11/12/16
Exterior Work	10 days	Sat 11/12/16	Thu 11/24/16
Demobilization	3 days	Thu 11/24/16	Mon 11/28/16
Structure ID No. 13	**48 days**	**Mon 10/3/16**	**Mon 11/28/16**
Structure ID No. 14	**48 days**	**Mon 10/3/16**	**Mon 11/28/16**
Structure ID No. 22	**48 days**	**Mon 10/3/16**	**Mon 11/28/16**
Structure ID No. 23	**48 days**	**Mon 10/3/16**	**Mon 11/28/16**
Structure ID No. 27	**48 days**	**Mon 3/6/17**	**Mon 5/1/17**
Structure ID No. 38	**48 days**	**Mon 3/6/17**	**Mon 5/1/17**
Structure ID No. 93	**48 days**	**Mon 3/6/17**	**Mon 5/1/17**
Structure ID No. 149.1	**48 days**	**Mon 3/6/17**	**Mon 5/1/17**
Structure ID No. 161	**48 days**	**Mon 3/6/17**	**Mon 5/1/17**
Structure ID No. 179	**48 days**	**Mon 4/3/17**	**Mon 5/29/17**
Structure ID No. 182	**48 days**	**Mon 4/3/17**	**Mon 5/29/17**
Structure ID No. 185	**48 days**	**Mon 4/3/17**	**Mon 5/29/17**
Structure ID No. 188	**48 days**	**Mon 4/3/17**	**Mon 5/29/17**
Structure ID No. 189	**48 days**	**Mon 4/3/17**	**Mon 5/29/17**
Structure ID No. 190	**48 days**	**Mon 5/1/17**	**Mon 6/26/17**
Structure ID No. 191	**48 days**	**Mon 5/1/17**	**Mon 6/26/17**
Structure ID No. 192	**48 days**	**Mon 5/1/17**	**Mon 6/26/17**
Structure ID No. 196	**48 days**	**Mon 5/1/17**	**Mon 6/26/17**
Structure ID No. 268	**48 days**	**Mon 5/1/17**	**Mon 6/26/17**
Structure ID No. 313	**48 days**	**Mon 6/5/17**	**Mon 7/31/17**
Structure ID No. 319	**48 days**	**Mon 6/5/17**	**Mon 7/31/17**
Structure ID No. 337	**48 days**	**Mon 6/5/17**	**Mon 7/31/17**
Structure ID No. 343	**48 days**	**Mon 6/5/17**	**Mon 7/31/17**
Structure ID No. 345	**48 days**	**Mon 6/5/17**	**Mon 7/31/17**

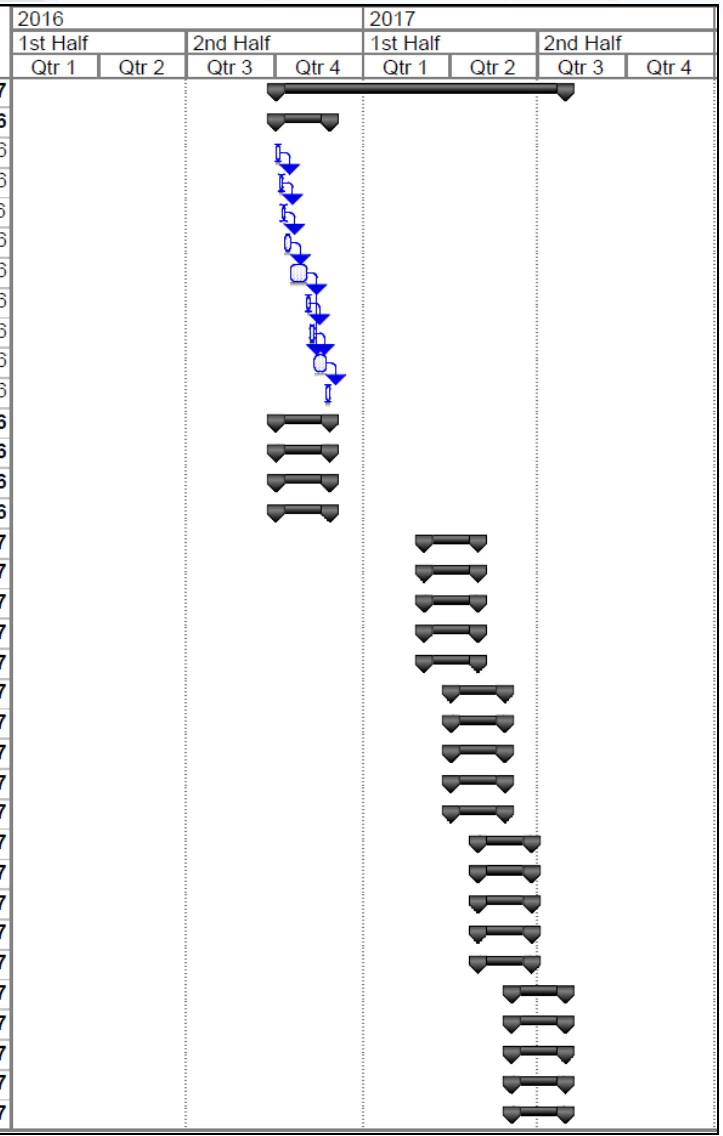

Figure 19: Construction Schedule for the Leonardo, NJ Project

5.8 Views of the Non-Federal Partner and Other Agencies

The tentatively selected plan has received strong support from the non-Federal project partner, NJDEP and the affected local governments, Middletown Township. This support is expressed through the Letter of Support (Pertinent Correspondence Appendix). Through project planning and National Environmental Policy Act (NEPA) scoping, a variety of other Federal agencies have been involved in this investigation and support the project goals.

Details on coordination with the U.S. Fish and Wildlife Service (USFWS), the NJ Historic Preservation Office, and the Delaware Nation and the Delaware Tribe, can be found in the Environmental Assessment. Assuming that this project does not expand beyond the scope of the properties identified for nonstructural treatment during coordination, the project is in compliance with NEPA.

5.9 Summary of Public Coordination

A public notice announcing the upcoming availability of the Environmental Assessment for public review was placed on the New York District's website on March 2015. Comments from the public on the draft feasibility report will be incorporated into plan optimization.

Chapter 6: Major Findings and Conclusions

This investigation has determined that periodic hurricanes and coastal storms pose a severe threat to life and property in Leonardo, NJ. There is significant potential to manage coastal storm risks in Leonardo. In response to these problems and opportunities, plan formulation activities considered a range of structural and nonstructural measures. Through an iterative plan formulation process, potential coastal storm risk management measures were identified, evaluated, and compared.

Alternative coastal storm risk management plans that survived the initial screening of alternatives included only small-scale nonstructural solutions, due to the heterogeneity of the study area topography. Prior to Hurricane Sandy, 19 structures were identified for nonstructural treatment and coordinated with non-Federal partners. After Hurricane Sandy it was determined by the Township of Middletown that 12 out of the 19 structures were substantially damaged. In an assessment of the post-Hurricane Sandy landscape, it was found that despite changes to the floodplain, stage frequency curves, and economics analyses, the fundamental conditions underlying the plan formulation still pointed to a small nonstructural solution. Using most recent information, up to 25 structures have been identified for potential inclusion in the Tentatively Selected Plan (TSP) for Leonardo.

These structures will undergo further refinement during plan optimization, which will result in between 10 to 25 structures to be recommended for treatment. The recommended nonstructural treatment for the 25 structures is structure elevation to a level of the one percent flood still water elevation (+11.9 feet NAVD88) plus historic sea level rise (0.7 feet) plus wave contribution (varies for each structure) plus 1 feet or 3 feet of freeboard for structures in the AE and VE zones, respectively. After treatment, the final main floor elevation of elevated structures will range between +15.2 ft NAVD88 to +18.4 ft NAVD88, depending on the specific location of each structure. To achieve this height, structures will be raised anywhere between 1.8 ft to 10.6 ft from their existing elevations, dependent upon their current, individual main floor elevations. The estimated total first cost for project implementation is $5,463,000 (Oct. 2014 P.L.), to be cost shared 65% Federal and 35% non-Federal. Annual net benefits are in the amount of $59,000 and the benefit-to-cost ratio is 1.3.

The non-Federal project partner, NJDEP, has indicated its support for the TSP and is willing to enter into a Project Partnership Agreement with the Federal Government for the implementation of the plan.

Chapter 7: Recommendations

In making the following recommendations, I have given consideration to all significant aspects in the overall public interest, including environmental, social and economic effects, engineering feasibility and compatibility of the project with the policies, desires and capabilities of the State of Jersey and other non-Federal interests.

I recommend that the selected plan for coastal storm risk management at Leonardo, Raritan Bay and Sandy Hook Bay, New Jersey (Leonardo), as fully detailed in this draft feasibility report and environmental assessment, be authorized for construction as a Federal project, subject to such modifications as may be prescribed by the Chief of Engineers.

I recommend authorization of the coastal storm risk management project for Leonardo, NJ, with such modifications thereof as in the discretion of the Commander, HQUSACE, as may be advisable. These recommendations are made with the provisions that local interests will:

a. Provide to the United States all necessary lands, easements, rights-of-way, relocations, and suitable borrow and/or disposal areas deemed necessary by the United States for initial construction and subsequent maintenance of the project.

b. Hold and save the United States free from claims for damages that may result from construction and subsequent maintenance, operation, and public use of the project, except damages due to the fault or negligence of the United States or its contractors.

c. Maintain continued public ownership and public use of the shorefront areas upon which the amount of Federal participation is based during the economic life of the project.

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

e. Contribute the local share of non-Federal costs for initial construction and operation and maintenance over the economic life of the project, as required to serve the intended purposes. **This plan consists of nonstructural treatments of up to 25 properties within Leonardo at a total first cost of $5,463,000 and a fully funded cost of $5,703,000 (Oct. 2014 P.L.). Under current guidelines, the project will be cost shared on a 65% Federal and 35% non-Federal basis.**

f. Upon completion of each project feature, acquire, rehabilitate, repair, replace, operate and maintain easements for public access to areas created or enhanced by the project.

The cost of the operation and maintenance of these easements will be the responsibility of the non-Federal partner.

The recommendations contained herein reflect the information available at this time and current departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program nor the perspective of highest review levels within the Executive Branch. Consequently, the recommendations may be modified (by the Chief of Engineers) before they are transmitted to the Congress as proposals for authorization and implementing funding. However, prior to transmittal to Congress, the partner, the State, interested Federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

Paul E. Owen
Colonel, U.S. Army
District Engineer

Chapter 8: References

Federal Emergency Management Agency. 2014. Preliminary Flood Insurance Rate Map. Accessed at http://apps.femadata.com/preliminaryviewer/

Federal Emergency Management Agency. 2013. Google spreadsheet on Hurricane Sandy damage claims in New Jersey. Accessed at: https://docs.google.com/spreadsheet/pub?key=0Ajo5KVzgSHJ5dEdoLS1OR2piUXcwQVFSeGgtWkZqVWc&output=html

Intergovernmental Panel for Climate Change (IPCC). 2007. *Climate Change 2007: The Physical Science Basis.* Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA (IPCC, 2007)

Monmouth County Planning Board. 1995. *Growth Management Guide*.

Monmouth County Planning Board. 1987. *Bayshore Waterfront Access Plan*.

National Research Council. 1987*. Responding to Changes in Sea Level: Engineering Implications*. Washington, D.C., National Academy Press.

New Jersey Coastal Zone Management Program. Accessed December 2014 at http://www.state.nj.us/dep/cmp/.

U.S. Army Corps of Engineers. 2013. Engineering and Construction Bulletin No. 2013-33: Application of Flood Risk Reduction Standard for Sandy Rebuilding Projects. Accessed at: http://wbdg.org/ccb/ARMYCOE/COEECB/ecb_2013_33.pdf

U.S. Army Corps of Engineers. 2013. Engineering Regulation 1100-2-8162 (31 Dec 2013): *Incorporating Sea Level Change in Civil Works Programs.*

U.S. Army Corps of Engineers. 2003. *Raritan Bay and Sandy Hook Bay, Leonardo, NJ: Preliminary Alternatives Screening (P7) Report.* New York District.

U.S. Army Corps of Engineers. 1999. *Raritan Bay and Sandy Hook Bay, Leonardo, New Jersey, Pre-Feasibility Report for Hurricane Storm Damage Reduction and Erosion Control.* New York District.

U.S. Army Corps of Engineers. 1993. *Raritan Bay and Sandy Hook Bay, New Jersey, Reconnaissance Report for Hurricane Storm Damage Reduction and Shore Protection.* New York District.

U.S. Army Corps of Engineers. 1960. *Survey Report*. New York District.

U.S. Army Corps of Engineers. 1946. *Preliminary Examination of Navy Breakwater.* New York District.

U.S. Census Bureau. American Community Survey (2008-2012) for Monmouth County, NJ. Accessed at: http://www.census.gov/acs/www/

U.S. Water Resources Council. 1983. *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies.*

Leonardo, Raritan Bay and Sandy Hook Bay, New Jersey Coastal Storm Risk Management Feasibility Study

Appendix A
Environmental Assessment
And Supporting Documentation

March 2015

Leonardo, Raritan Bay and Sandy Hook Bay, New Jersey Coastal Storm Risk Management Feasibility Study

Appendix B
Economics

March 2015

Leonardo, Raritan Bay and Sandy Hook Bay, New Jersey Coastal Storm Risk Management Feasibility Study

Appendix C
Engineering

March 2015

Leonardo, Raritan Bay and Sandy Hook Bay, New Jersey Coastal Storm Risk Management Feasibility Study

Appendix D
Cost Engineering

March 2015

Leonardo, Raritan Bay and Sandy Hook Bay, New Jersey Coastal Storm Risk Management Feasibility Study

Appendix E
Real Estate Plan

March 2015

Leonardo, Raritan Bay and Sandy Hook Bay, New Jersey Coastal Storm Risk Management Feasibility Study

Appendix F
Pertinent Correspondence

March 2015