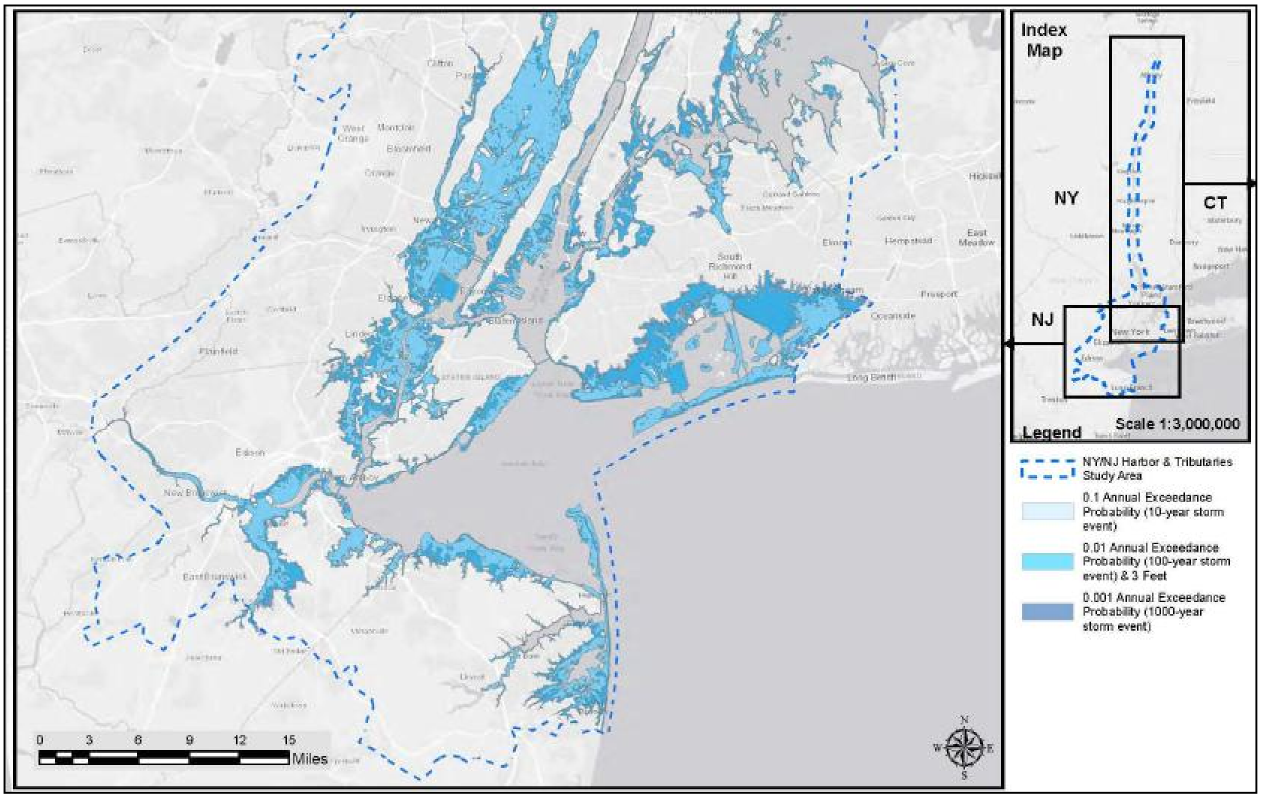
NEW YORK-NEW JERSEY
HARBOR AND TRIBUTARIES
COASTAL STORM RISK MANAGEMENT

INTERIM REPORT



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US Army Corps of Engineers

NEW YORK STATE Department of Environmental Conservation

Mayor's Office of Recovery & Resiliency

US Army Corps
of Engineers®
New York District

New York – New Jersey Harbor and Tributaries Coastal Storm Risk Management Feasibility Study

Interim Report

February 2019

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1 INTRODUCTION

Historical storms have severely impacted the New York- New Jersey Harbor region, including Hurricane Sandy most recently, causing loss of life and extensive economic damages. In response, the U.S. Army Corps of Engineers (USACE) is investigating measures to manage future flood risk in ways that support the long-term resilience and sustainability of the coastal ecosystem and surrounding communities, and reduce the economic costs and risks associated with flood and storm events for the New York-New Jersey Harbor and Tributaries (NYNJHAT) study area. The alternative concepts proposed would help the region manage flood risk that is expected to be exacerbated by relative sea level rise (RSLC). The study team has prepared this Interim Report to document existing information and assumptions about the future, and to identify gaps in our knowledge that warrant further investigation because of their potential to affect plan selection. It presents an opportunity for public participation in the study process. Public and agency feedback on the Interim Report will inform the investigations and modeling for the next planning decision, the Tentatively Selected Plan (TSP) to be presented in the upcoming Draft Feasibility Report and Tier 1 Environmental Impact Statement (EIS).

This report describes alternative concepts at preliminary stages of development. A key consideration for the ongoing development of these concepts is the range of future RSLC projections and the need for adaptability, to ensure long-term resiliency in the face of uncertain future conditions. For each alternative concept, there is a need for measures of various scales, which are often complementary, in order to investigate the feasibility of managing frequent flooding which will worsen as sea levels rise, as well as managing the risk for larger more catastrophic storms, like hurricanes and nor'easters which can bring dangerous and damaging storm surge. This Interim Report will identify key investigations needed to identify the optimal combination of such measures for coastal storm risk management (CSRM) in the NYNJHAT study area.

1.1 Project Background

In 2012, Hurricane Sandy caused considerable loss of life, extensive damage to property, and massive disruption to the North Atlantic Coast. The effects of this storm were particularly severe because of its tremendous size and the timing of its landfall during high tide. Twenty-six states were impacted by Hurricane Sandy, and disaster declarations were issued in 13 states. New York and New Jersey were the most severely impacted states, with the greatest damage and most fatalities in the New York Metropolitan Area. For example, a storm surge of 12.65 feet and 9.4 feet above normal high tide was reported at Kings Point on the western end of Long Island Sound and the Battery at the southern tip of Manhattan, respectively. Flood depths due to the storm tide were as much as nine feet in Manhattan, Staten Island, and other low-lying areas within the New York Metropolitan Area. The storm exposed vulnerabilities associated with inadequate CSRM measures and lack of defense to critical transportation and energy infrastructure.

Devastation in the wake of Hurricane Sandy revealed a need to address the vulnerability of populations, infrastructure, and resources at risk throughout the entire North Atlantic coastal region. At the time of the publication of this report, Hurricane Sandy is the second costliest hurricane in the nation's history and the largest storm of its kind to hit the U.S. East Coast.

1.1.1 Purpose

The purpose of this Interim Report is to describe study work done to date, and to identify factors that warrant further investigation because of their potential to improve plan selection. This report will not make any conclusions regarding a preferred alternative, instead focusing on an unbiased presentation of the facts as they stand based on analysis conducted by USACE to date. It is important to note that some portions of the study area experience riverine flooding and damages in addition to coastal storm damages. In these areas, this study focuses on ways to manage coastal storm damages.[1]

The impacts from Hurricane Sandy highlighted the national need for a comprehensive and collaborative evaluation to reduce risk to vulnerable populations within the North Atlantic region. In January 2015, USACE completed the North Atlantic Coast Comprehensive Study (NACCS), which identified high-risk areas on the Atlantic Coast for warranting further investigation of flood risk management solutions. The NYNJHAT focus area was one of the three focus areas, along with the Nassau County Back Bays and the New Jersey Back Bays studies, identified to investigate coastal flood risk within the New York-New Jersey Harbor region. (Figure 1).

1.1.2 Location

This study area encompasses the New York Metropolitan Area, including the most populous and densely populated city in the United States, and the six largest cities in New Jersey. The shorelines of some of the NYNJHAT study area is characterized by low elevation areas, developed with residential and commercial infrastructure, and is subject to tidal flooding during storms. The study area covers more than 2,150 square miles and comprises parts of 25 counties in New Jersey and New York, including Bergen, Passaic, Morris, Essex, Hudson, Union, Somerset, Middlesex, and Monmouth Counties in New Jersey; and Rensselaer, Albany, Columbia, Greene, Dutchess, Ulster, Putnam, Orange, Westchester, Rockland, Bronx, New York, Queens, Kings, Richmond, and Nassau Counties in New York. For the purposes of this

[1] When the hydrology of flooding and potential solutions are separate, such as with riverine versus coastal flooding, the USACE uses separate authorities and studies to investigate the feasibility of managing the various flood risks. Those affected by riverine flood damages can request state and local officials to initiate a study with USACE for their flood risk problems under a separate study.

study, the Capital District region extends from Kingston, NY upstream to the location of the Federal Lock and Dam in Troy, NY (Figure 2).

Congressional interest in the study area lies with New Jersey Senators Robert Menendez and Cory Booker and New York Senators Kirsten Gillibrand and Charles Schumer. The study area contains all or portions of the following Congressional Districts: NJ-5, NJ-6, NJ-7, NJ-8, NJ-10, NJ-11, NJ-12, NY-3, NY-4, NY-5, NY-6, NY-7, NY-8, NY-9, NY-10, NY-11, NY-12, NY-13, NY-14, NY-15, NY-16, NY-17, NY-18, NY-19, and NY-20.

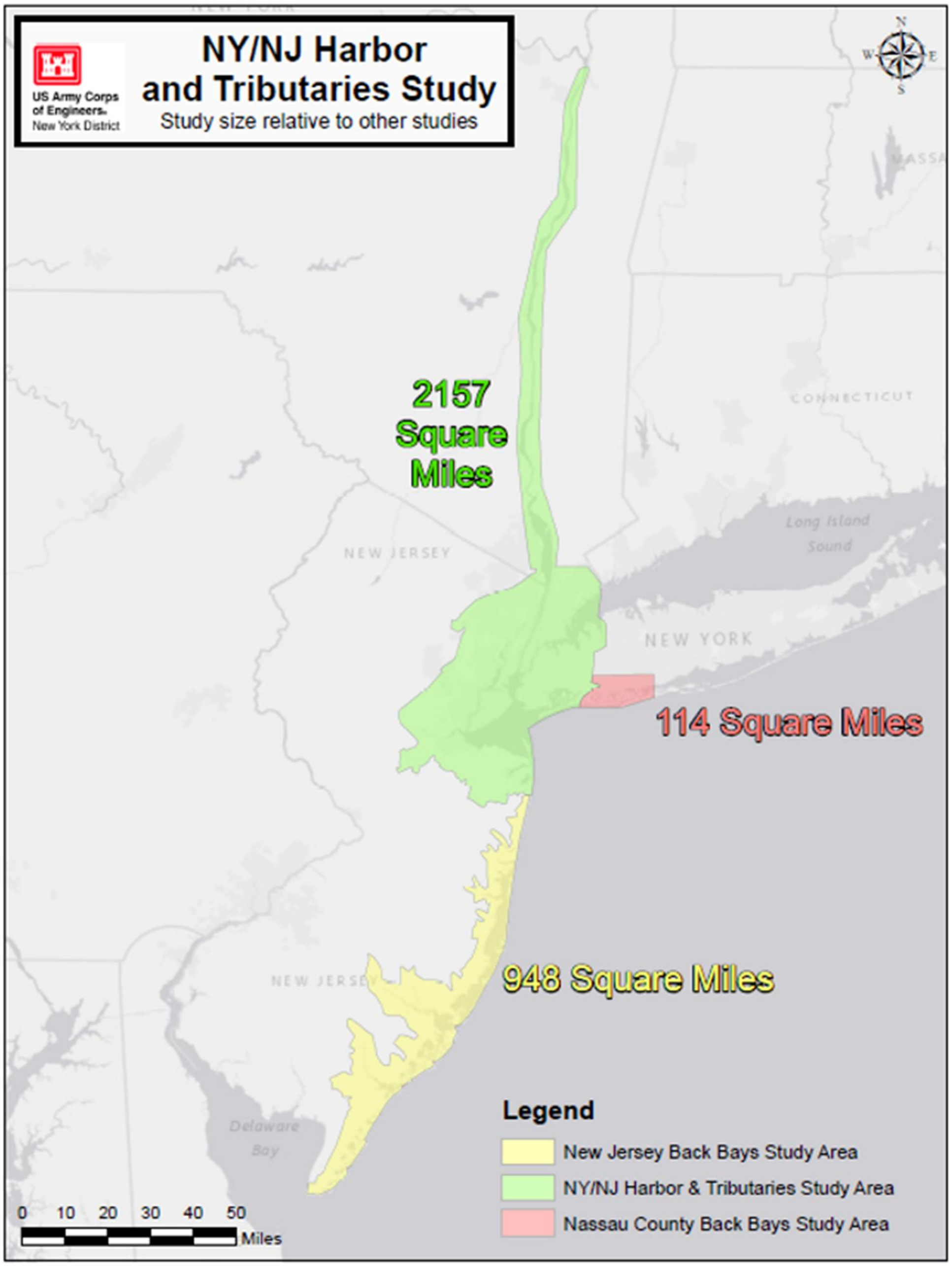

Figure 1. New York-New Jersey Harbor and Tributaries Study Area

1.1.3 Scope

This Interim Report documents the following:

a. Identification of the CSRM problems;
b. Relationship of CSRM problems to the environmental and socioeconomic needs and desires of the people living and working in the study area;
c. Preliminary estimates of the costs and benefits associated with implementing potential CSRM measures as well as the environmental, social and economic impacts; and
d. Identification of investigation needs to be able to identify a TSP for the future Draft Feasibility Report.

Proposed CSRM alternatives should either minimize exacerbating riverine/fluvial flooding, covered under the Flood Risk Management (FRM) mission of USACE, or include measures to alleviate any induced flooding. Should significant FRM problems be identified within the study area, a separate investigation could be initiated to address them with the most appropriate authorities and feasibility cost sharing arrangements.

1.1.4 Tiered NEPA Process

The National Environmental Policy Act (NEPA) of 1969 requires federal agencies, including the USACE, to consider the potential environmental impacts of their proposed actions and any reasonable alternatives before undertaking a major federal action, as defined by 40 CFR 1508.18. To evaluate potential environmental impacts, USACE is currently preparing an Environmental Impact Statement (EIS). An EIS is a supporting document that is the most thorough and comprehensive level of NEPA documentation used to assist in making a decision. The EIS will be conducted in two stages or tiers. Tiering, which is defined in 40 CFR 1508.28, is a means of making the environmental review process more efficient by allowing parties to "eliminate repetitive discussions of the same issues and to focus on the actual issues suitable for decision at each level of environmental review" (40 CFR 1502.20).

Tier 1 is a broad-level review, and Tier 2 consists of subsequent specific detailed reviews.[2] The broad-level review identifies and evaluates the issues that can be fully addressed and resolved, notwithstanding possible limited knowledge of the project. In addition, it establishes the standards, constraints, and processes to be followed in the specific detailed reviews. As proposed alternatives are developed and refined, incorporating a higher level of detail, the specific detailed reviews evaluate the remaining issues based on the policies established in the broad-level review. Together, the broad-level review and all specific detailed reviews will collectively comprise a complete environmental review addressing all required elements. Tiering the EIS resolves the "big-picture" issues so that subsequent studies can focus on project-specific impacts and issues.

[2] Note on terminology: Many use different names to refer to tiering. For example, broad-level and specific detailed reviews referred to as "Tier 1" or "area-wide" and "Tier 2" reviews, respectively. These terms can be used interchangeably.

Tiering also allows environmental analyses for each Tier 2 project to be conducted closer in time to the actual construction phase, or as funds become available for construction.

A Tier I and Tier 2 EIS consistent with USACE guidance and policy will be performed for this study. A public comment period and public engagement will be conducted for both the Tier I and Tier II EIS. The Tier I EIS is currently being prepared and is anticipated to be released for public review in March 2020.

This Interim Report precedes the Tier 1 EIS which is being developed. The Interim Report lays out the existing conditions in the study area and initiates but does not complete impact discussions.

1.2 Federal Interest

Recurring impacts from coastal flooding has resulted in significant economic, environmental, and community impacts in the NYNJHAT study area. Millions of people live in communities located in low lying, densely developed urban and suburban neighborhoods. Many households in these communities are low income, elderly, live in public housing/use public housing assistance, and do not have access to cars. Approximately 51 percent of New Yorkers speak only English at home, with Spanish, Chinese, French/French Creole, Russian, Yiddish, Hebrew, and Indic languages being the native language of millions of New Yorkers (USACE 2015). Flood impacts vary from street closures due to high tides, to massive destruction from hurricane surge inundation.

Hurricane Sandy in 2012 greatly impacted the study area. The storm caused 60 deaths in the study area; flooded homes, businesses, and critical infrastructure (police, fire, hospitals, power stations, etc.); rendered major highways, tunnels, rail and subway stations, and infrastructure unusable; and caused blackouts, school and businesses closures, and gas shortages. New York City alone incurred an estimated $19 billion in damages due to the storm. Many communities are still recovering from the storm’s effects while incurring damages from more recent nor’easters and other tropical storms. In response to the destruction laid forth by Hurricane Sandy in 2012, the U.S. Congress passed and the President signed into law the Disaster Relief Appropriations Act of 2013 (Public Law 113-2). The legislation appropriated over $50 billion to address damages caused by the hurricane, and to reduce future flood risk in ways that will support the long-term resilience of vulnerable coastal communities. Almost half of this appropriated funding supports the ongoing recovery and resilience of communities within the study area. In New York City alone, $17 billion has been committed to provide funding for projects and programs administered by the federal, state, and local governments (NYC Recovery, 2019). Developing a project that will reduce the frequency and severity of coastal storm damage supports one of the primary missions of USACE. As with all USACE feasibility studies, potential water resource solutions will be formulated to support the Federal Objective to contribute to National Economic Development (NED) consistent with protecting the Nation's environment, in accordance with National environmental statutes, applicable executive orders, and other federal planning requirements, including the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (US Water Resources Council, 1983).

1.3 Study Authority

On January 29, 2013, President Obama signed into law the Disaster Relief Appropriations Act of 2013 (Public Law [P.L.] 113-2), to assist in the recovery in the aftermath of Hurricane Sandy. The North Atlantic Division was authorized by P.L. 113-2 to commence the NACCS to investigate CSRM strategies for areas impacted by the storm. Under the direction of Public Law 113-2, Chapter 4, USACE completed a Focus Area Analysis (FAA) for the New York-New Jersey Harbor and Tributaries (NYNJHAT) as part of the NACCS in response to the portion of P.L. 113-2 that states, "… as a part of the study, the Secretary shall identify those activities warranting additional analysis by [USACE]." The January 2015 NACCS final report identifies nine high-risk focus areas of the North Atlantic Coast that warrant additional analyses by USACE to address coastal flood risk. One of these areas is the New York-New Jersey Harbor and Tributaries area. The NYNJHAT FAA, completed in 2014, identified CSRM opportunities warranting additional analysis. However, authority to complete the additional analysis required to achieve a Chief of Engineers' Report for the focus areas is not provided for under P.L. 113-2.

Authorization for this effort is provided by P.L. 84-71, approved June 15, 1955, which calls for:

> "…an examination and survey to be made of the eastern and southern seaboard of the United States with respect to hurricanes, with particular reference to areas where severe damages have occurred.
>
> "Sec. 2. Such survey, to be made under the direction of the Chief of Engineers, shall include the securing of data on the behavior and frequency of hurricanes, and the determination of methods of forecasting their paths and improving warning services, and of possible means of preventing loss of human lives and damages to property, with due consideration of the economics of proposed breakwaters, seawalls, dikes, dams, and other structures, warning services, or other measures which might be required."

1.4 Non-Federal Sponsors and Partners

The non-federal sponsors are the New Jersey Department of Environmental Protection (NJDEP) and New York State Department of Environmental Conservation (NYSDEC), in partnership with the New York City Office of Recovery and Resiliency (NYCORR). A Feasibility Cost Sharing Agreement (FCSA) was executed on July 15, 2016.

1.5 Summary of Agency and Public Coordination

Public outreach and discussion have been priorities for this study and as such, USACE will seek to build off past engagement with deeper and more robust stakeholder engagement as the study progresses (see Public Engagement Appendix for description of outreach efforts to date). Given the scale and scope of this study, meetings cannot feasibly be held in every town or community with an interest in the study. The study team will therefore seek to reach as broad an audience as possible by locating meetings in transit-accessible locations, advertising meetings as early as possible, and opening up opportunities for stakeholders to join meetings remotely through webinar capabilities. Primary outreach efforts include agency workshop meetings held in 2017, and NEPA scoping meetings held in 2018.

1.5.1 Agency Workshops

Agency workshop meetings were held in January-February 2017. Over 100 local government and agency representatives participated (see Public Engagement Appendix). Common themes from the workshops include:

- There is a need for a systems-level, regional analysis and approach to determine appropriate CSRM measures and future initiatives. For this to occur successfully, coordination and collaboration across agencies and levels of government is required. Localized efforts are only pieces to the larger regional puzzle.
- Proper evaluation of a potential or a series of potential storm surge barriers is needed and must encompass flood risk management benefits and costs. They must consider all potential impacts to people, property, local economies, and the environment. Some agencies are opposed to the hard solutions such as barriers and floodwalls, whereas others are supportive. Multi-benefit solutions with natural or nature-based features are preferred.
- The public and many critical assets continue to be at risk as exemplified by the effects of Hurricane Sandy. Communication of these risks, continued public outreach, education, and engagement is essential for future efforts.
- Impacts to critical assets, for example transportation infrastructure and evacuation routes, power generation and supply, and wastewater infrastructure, were echoed throughout the various methods of feedback. Managing risk to the public and to critical infrastructure is vital to the CSRM Feasibility Study.
- Agencies identified two technical topics in which uncertainty should be addressed. While there is uncertainty in many technical topics, these two topics were identified as great importance to the agencies. First, there is uncertainty related to appropriately defining the design condition and thus, the selection and incorporation of a sea level change scenario. Clarity and a transparent decision-making process will allow for agencies and communities to maintain engagement in the design process. Secondly, there is

uncertainty associated with the occurrence and timing of fluvial (i.e., stormwater runoff) flooding with coastal flooding. There is a concern that regional storm surge barriers will exacerbate fluvial flooding.

- Structural measures that may cause negative impacts to the environment, especially to the Hudson River and its estuaries, are a major concern.
- Funding, time, legislation and bureaucracy hinder the progress of coastal resiliency in many communities within the study area. There is an urgency to identify CSRM measure(s) prior to another storm or with a changing sea level condition. If a cost-effective, publicly acceptable, and feasible project cannot be identified within a reasonable timeframe, the agencies are willing to consider supporting less-than-ideal solutions that can be implemented.

1.5.2 Scoping Process and Public Comments

USACE announced the preparation of an integrated Feasibility Report/Tiered EIS for the proposed NYNJHAT feasibility study in the February 13, 2018 Federal Register, pursuant to the requirements of section 102(2)(C) of NEPA. Scoping is the process used to identify issues, concerns and opportunities for enhancement or mitigation associated with the proposed action. The purpose of the scoping process is to:

- Invite the participation of local, county, state, and federal resource agencies, Indian Tribes, non-government organizations (NGOs), and the public to identify significant environmental and socioeconomic issues related to the study;
- Determine the depth of analysis and significance of issues to be addressed in the Integrated Feasibility Report/EIS;
- Identify how the proposed alternatives would or would not contribute to cumulative effects in the study area. This includes the identification of any local, county, state, and federal resource plans and future project proposals in the study area, implementation schedules, and any data that would help to describe past and present actions and effects of the project and other development activities on environmental and socioeconomic resources;
- Gather information, quantitative data or professional opinions that may help define the scope of the analysis related to both site-specific and cumulative effects and that helps identify significant environmental issues;
- Solicit, from local, county, state and federal agencies and the public available information on the resources at issues, including existing information and study needs; and,
- Identify any information sources that might be available to characterize the existing environmental conditions and analyze and evaluate impacts.

1.5.2.1 Description of the Scoping Period

The NEPA scoping period for the NYNJHAT study originally spanned 45 days from July 6th - August 20, 2018, but because of numerous requests from the public, was extended for an additional 77 days for a total scoping period of 122 days. The extended period was open until November 5, 2018.

During the NEPA scoping public comment period, comments were submitted to NYNJHarbor.TribStudy@usace.army.mil, mailed by hard copy, or provided in person at one or more of the Scoping Meetings that were held during the scoping period. Questions, comments, and information received after this date were and will continue to be compiled and considered as the study progresses and included in the draft report and will be part of the administrative record.

Originally, there were five NEPA scoping meetings scheduled for this study. Pursuant to the request of congressional representatives, USACE held four additional meetings. Meeting locations were chosen to be easily accessible by transit, able to accommodate large groups, and dispersed throughout the large study area, such that interested stakeholders could reasonably travel to at least one meeting. The dates, locations, and numbers of participants for each meeting are listed in Table 1. There were a total of nine meetings in six locations that reached 705 participants,[3] though some participants stayed for both meetings where there were two sessions in one day and some participants came to subsequent meetings throughout the region.

Table 1. NYNJHAT Scoping Meeting Locations, Dates, and Number of Participants

Date	Location	Number of Participants
July 9, 2018, 3 PM	Lower Manhattan, New York County	139
July 9, 2018, 6 PM	Lower Manhattan, New York County	115
July 10, 2018, 3 PM	Newark, Essex County	19
July 10, 2018, 6 PM	Newark, Essex County	8
July 11, 2018	Poughkeepsie, Dutchess County	158
September 20, 2018	Coney Island, King County	78
October 3, 2018, 3 PM	White Plains, Westchester County	74
October 3, 2018, 6 PM	White Plains, Westchester County	51
October 23, 2018	Nassau County	63
Nine meetings total	**Six locations**	**705 meeting participants total**

Information was provided to the public through a combination of PowerPoint presentations, poster sessions, and a structured question and answer session at the meetings. A poster session, hosted by the study team, was held at the conclusion of the formal presentation

[3] This is the number of individual entries on the sign-in sheets at the meetings. There were individuals who opted not to sign in.

1.5.2.2 Total Number of Comments of Received

During the comment period USACE received 4,250 submissions of comments. Fourteen different form letters were received, totaling 3,295 of the submittals. A total of 234 comment cards were submitted from attendees at the NEPA scoping meetings. Of the 234 comment cards, 30 submissions came from municipalities (Table 2), 14 of which generated resolutions expressing positions on the study from a municipal or community board perspective (Table 3). Additionally, 21 submissions were received from 26 elected officials (Table 4). Two submissions were received from other federal agencies: the US Fish and Wildlife Service and Housing and Urban Development. The remaining 668 submissions were received by email, mail, and fax from organizations and individual citizens.

Table 2. Municipalities Commenting on NYNJHAT Study

Municipalities Comments Were Received From		
Town of Ossining - Village of Ossining, NY	City of Beacon, NY	County of Ulster Environmental Management Council, NY
Town of Stony Point, NY	City of Yonkers - Office of the Mayor , NY	Village of Rhinebeck, NY
Village of Hastings-on-Hudson, NY	NYC Councilman Costa Constantinides - 22nd District, Queens	Village of Sands Point, NY
Westchester County Executive, NY	Members of the Ulster County Legislature, NY	Town of North Hempstead, NY
Village of Croton-on-Hudson, NY	Village of Irvington, NY	Village of Roslyn Harbor, NY
Tarrytown Environmental Council, NY	Town of Poughkeepsie, NY	Village of Piermont, NY
Hudson River Drinking Water Intermunicipal Council	Village of Roslyn, NY	Village of Sea Cliff, NY
Putnam County Legislature, NY	Town of Oyster Bay, NY	Village of Flower Hill, NY
Village of Dobbs Ferry, NY	Town of Greenwich, CT	Town of Cortland, NY
Community Board #1 - Manhattan, NY	Common Council of Kingston, NY	Community Board 13 - Brooklyn, NY

Table 3. Municipalities Generating Resolutions

Municipalities Generating Resolutions		
City of Beacon	Village of Croton on Hudson	Town of Cortlandt
Village of Hastings-on-Hudson	Village of Irvington	City of Kingston
City of New York, Community Board 1	Town of Ossining	Village of Ossining
Village of Piermont	Town of Poughkeepsie	Putnam County Legislature
Village of Rhinebeck	Town of Stony Point	

Table 4. Elected Officials Who Submitted Comments

Elected Officials Who Submitted Comments		
Affiliation	**Name**	**Representing**
US House of Representatives	Joe Courtney Jim Himes Nita M. Lowey Sean Patrick Maloney Rosa DeLauro	Connecticut Connecticut 17th District, New York 18th District, New York Connecticut
US Senate	Richard Blumenthal Christopher S. Murphy	Connecticut Connecticut
The Senate of the State of New York	David Carlucci Shelley B. Mayer Terrence P. Murphy Sue Serino Elaine Phillips	38th District 37th District 40th District 41st District 7th District
The Assembly of the State of New York	Didi Barnett William A. Colton Sandy Galef Deborah Glick Ellen C. Jaffe Yuh-Line Niou Steven Otis Kenneth P. Zebrowski	106th District 47th District 95th District 66th District 97th District 65th District 91st District 96th District
Dutchess County	Joel Tyner	Dutchess County Legislator, 11th District
Westchester County	George Latimer	Westchester County Executive
NYC Council	Costa Constantinides Mark Treyger	NYC Council Member, 22nd District NYC Council Member, 47th District
Community Board	Joann Weiss	Community Board 13
Yonkers	Mike Spano	Mayor of Yonkers

1.5.3 General Comment Trends

The comments received fell into seven themes, which are outlined below. A brief synopsis of each comment theme and a summary of the District's response is presented below. From the 4,250 submissions, 393 unique comments were identified by the USACE study team. These unique questions and their responses are provided in the Comment Response Document.

1.5.3.1 Scoping Process

Throughout the scoping period, commenters requested additional time for the scoping period, additional meetings throughout the larger study area as well as additional comprehensive, detailed information about all of the alternatives being considered, to include the environmental impacts. Eighty-eight percent of all submissions expressed that there was not sufficient information available to the public for them to make an informed decision.

Response: In response to these comments, four additional meetings were added by request and the public comment period extended to run through 120 days. The purpose of a scoping meeting is to get input at an early point in the study. Details on the impacts of particular alternatives were not available at this time because the goal of the scoping process is to initiate public engagement early-on, before large amounts of resources have been invested into the study, so that the public can help to 'scope' the study.

Starting public engagement early allows the rest of the study to be shaped by the input received from the public. The scoping process helps to define what questions the study team should be asking, based on local knowledge, and can identify valuable data and information that local stakeholders share through the scoping process. More detailed information and analysis, including environmental impacts, will be released to the public when it is available, based on the level of design detail, in either the Draft Tier 1 EIS or the Draft Tier 2 EIS. Due to the large scale and scope of this study and the largely conceptual nature of the alternatives early on, the Tiered NEPA process will be used so that the analysis can be performed using the available concepts for the initial evaluation (Tier 1), followed by design detail in the more advanced evaluation (Tier 2). There will be multiple opportunities for public input throughout the study and design phase, as the study and project progresses.

1.5.3.2 Storm Surge Vs Sea Level Rise

Many commenters stated that they did not think storm surge should be addressed without first addressing RSLC. Concerns about RSLC were voiced in 84% of all the submissions. This is important because, for many communities, sea level rise poses a risk of chronic, daily flooding in this century. Many of these commenters expressed the opinion that the only alternative that is acceptable is Alternative 5, given that it is the only alternative that has shoreline based measures that will protect communities from both storm surge and RSLC, without impacting the harbor, river and its tributaries with surge barriers.

Response: This study is a bi-state long-term planning study focused on regional resiliency in the face of growing coastal flood risk which is expected to be greatly exacerbated by sea level change in this region. The congressional authorization for the New York-New Jersey Harbor and Tributary study is to address the threat of storm surge from coastal storms in the study area. Where shoreline-based measures (SBM's) are proposed, such as in Alternative 5, the threat of RSLC is also addressed by those measures. Where storm surge barriers are proposed (Alternatives 2, 3A, 3B, and 4), complementary measures to manage the risk of frequent flooding are also proposed, which would provide an integrated solution. In most cases, solutions for these high-recurrence events do not differ greatly from solutions tailored specifically for sea level rise alone, though further analysis under a separate study would be needed to understand the daily impacts of high-tide inundation due to sea level rise to the region.

1.5.3.3 Environmental Impacts

Concerns about environmental impacts were the most ubiquitous of all the comment themes, being present in 91% of all submissions. Commenters felt that the alternatives that include surge barriers (2, 3A, 3B and 4) would have the most profound adverse environmental impacts. Concerns about impacts to tidal flow and circulation were mentioned in 68% of the submissions, contamination with Polychlorinated Biphenyls (PCBs) or combined sewer overflows (CSOs) were in 67%, wildlife and ecology (from the inability or restriction to migrate up/down river or to Long Island Sound) were in 76%, sedimentation rates were in 66%, and water quality (salinity, temperature, circulation, dissolved oxygen, nutrient concentrations, algal blooms) were in 71%.

Response: The study team recognizes the potential for the proposed concept alternatives to result in some or all of the above cited serious environmental impacts. As part of the risk-informed planning process, both a Tier 1 and Tier 2 EIS will be completed on the *tentatively selected plan* (TSP) once it is selected to analyze the potential impacts. If the environmental impacts of the TSP are unacceptable, the plan will not move forward. Any plan that is ultimately recommended from this study must avoid, minimize and mitigate for environmental impacts. There will be opportunities for public input on each report (Interim Report, Tier 1 EIS, and Tier 2 EIS). A Tier 2 EIS will be prepared because not all of the site-specific design information will be available during the Feasibility Study to fully address all of the specific impact analysis. Where detail is available, full analysis will be performed in the Tier 1 EIS, and where the alternative remains more conceptual, broad analysis will be performed. The Tier 2 EIS will have the full detailed analysis for every aspect of the proposed plan, once identified, and no plan can be implemented without the preparation and coordination of a Tier 2 EIS.

1.5.3.4 Navigation Impacts

Commenters were concerned that the alternatives that include surge barriers could have adverse impacts to the movement of vessels in New York Harbor. This was a concern brought up in 66% of the submissions. This includes activity related to commercial shipping as well as recreational boating. There are concerns that surge barriers would restrict the movement of vessels into and out of the harbor, disrupting the current traffic flow. Additionally, commenters feared that the surge barriers would increase sedimentation of channels, which in turn would necessitate more frequent dredging of existing navigation channels.

Response: If the TSP includes surge barriers, they will be carefully engineered to reduce their impact on vessel traffic. Any surge barrier across a navigable waterway will include a gate large enough to allow vessels to pass through. A navigational traffic analysis would be required to be completed if a surge barrier is recommended. Any potential navigational impact would be evaluated in the Tiered EIS to understand how to minimize, avoid or mitigate impacts to transportation.

1.5.3.5 Cost and Construction

Many commenters asked questions about the cost of the project and how the construction would take place. Some common questions that were in 77% of the submissions included: how much would this project cost; how long will it take to build; and, who will pay for it? Along this theme, many commenters asked what would happen if a non-federal sponsor decides not to participate in the project; or, what would happen if the states of New York or New Jersey decided not to participate?

<u>Response</u>: The cost and construction duration are determined by what measures will be selected for the TSP. An explanation on how the preliminary cost estimates have been developed is available in the Cost Appendix to the Interim Report. Please note that the costs and benefits in the Interim Report are parametric and would require follow-up, site-specific investigations for refinement before any recommendation could be made. They are presented in the Interim Report only for the purposes of comparing alternative concepts.

The study is cost-shared with 50% being paid by the federal government and 50% being paid by the non-federal sponsors, the States of New York and New Jersey who split their cost-share equally. If implemented, the project would also be cost-shared between the federal government and non-federal sponsor(s) and a new Project Partnership Agreement would be executed. USACE cannot implement projects without the support and participation of non-federal sponsor(s) and authorization and funding provided by Congress. If the study sponsor(s) opt not to participate in project implementation, the project would not proceed until an eligible party steps forward to act as the cost-sharing partner for implementation.

1.5.3.6 Overall Study Process

Many of the commenters asked about how the six alternatives were selected, or how the plans were formulated, and how the existing conditions projects being used in the study, which RSLC projection are being used and why, and how many years the study will take to complete. These types of questions were present in 74% of the submissions.

<u>Response</u>: The six alternative concepts presented at the NEPA scoping meetings represent scales of solutions: system-wide, or basin-wide, or site-specific CSRM solutions. A system-wide solution has the potential to reduce the need for localized studies and projects, resulting in considerable economies of scale. However, it may not leverage the benefits of existing and planned coastal storm risk management projects, resulting in what may be unnecessary expenditures. For this reason, agreement on the list of assumed projects is critical to the calculation of potential benefits. The existing projects that were used in the economic analysis were coastal flood risk management projects that are already built, or will have funding, completed construction documents, and permits by July 2020. USACE reached out to the lead agencies and project managers to verify information on these projects. The full list of projects included can be found in the Plan Formulation Appendix of the Interim Report. At this point, the alternative concepts include assumptions of the type of measures to be included for cost estimating purposes. However, the actual type of barrier, gates, and SBM's (floodwall vs levee, nonstructural, or natural and nature-based features) have not yet been confirmed, nor their exact locations in the Interim Report. These refinements are anticipated for the draft report to be released in 2020.

In regards to RSLC, the study team is using one sea level scenario (out of three used by USACE: low, intermediate, high) for estimating potential benefits in the Interim Report. As probability values have not yet been determined for each USACE scenario, it cannot be stated with certainty which scenario is the most likely at this time. Accordingly, the study chose an intermediate curve for the Interim Report as a rough way to approximate the median value between the low and high scenarios. A more detailed consideration project performance in light of the low, intermediate, and high rates of RSLC will be conducted for the draft report in 2020, when the more clearly defined locations and measures can be evaluated.

Due to the vast scale and complexity of this project, the study team was granted permission to exceed the normal three year study limit imposed on USACE studies and is authorized to take up to six years to complete the study by July 2022. This Interim Report was released in February 2019 for public comment. Subsequent public meetings will be held throughout the study area to solicit input on the Interim Report which will be incorporated into additional analyses that can be used to screen the alternatives. The TSP Milestone is targeted for January 2020 when the study team, including the states of New York and New Jersey, will convene with USACE Headquarters to identify a TSP based on the analysis. The Draft Feasibility Report and Tier 1 EIS will be released within 60 days of the TSP Milestone for public and agency comment. Comments will be incorporated into the Final Feasibility Report and Tier 1 EIS.

1.5.3.7 Induced Flooding

Many commenters voiced their concerns about induced flooding from surge barriers. Induced flooding could potentially come from two directions when the gates are closed; from behind the gates as freshwater from local streams accumulated behind the barrier, and from outside the gates as the storm surge reflects off the barrier and is forced into the areas adjacent to the barrier. Induced flooding was brought up in 72% of all submissions.

Response: The proposed alternatives will be analyzed during the feasibility study, including modelling to assess possible induced flooding from changes in hydrology from storm surge barriers under evaluation. If any of the alternatives are shown to induce flooding, these damages would need to be mitigated as part of the permitting requirements for the project, and that additional cost would factor into the benefit to cost ratio. For example, if analysis showed that freshwater would accumulate behind the barriers and cause flooding, pumps could be added to the recommended plan to remove this water and reduce damages. If flooding is induced outside of the barrier, nonstructural solutions or floodwalls could be included to reduce these damages. If it is not technically possible to mitigate for the induced flood damages caused by a storm surge barrier, or if the cost to mitigate renders a plan economically unviable such that the costs exceed the benefits, then these measures would be screened out.

2 EXISTING INFORMATION AND MODELS

This section summarizes the available information and models that were gathered from within USACE, as well as other federal, state, and local agencies, and peer-reviewed articles in academic journals. For the sake of readability, and due to its immense size, the available information and models have been separated into the following nine regions (Figure 2):

- Upper Bay/Arthur Kill Region
- Lower Bay Region
- Jamaica Bay Region
- Hackensack/Passaic Region
- Raritan Region
- Long Island Sound Region
- Lower Hudson/East River Region
- Mid-Hudson Region
- Capital District Region

These regions are based on hydrologic unit codes (HUCs) from the Watershed Boundary Dataset of the United States Geological Survey (USGS). HUCs are divisions and subdivisions of the United States, based on the area drained by one or more waterbodies, or section thereof, depending on the hierarchical level of the unit. These units range from the largest two-digit unit down to the smallest 12-digit unit (with portions of the United States being further divided into 14- and 16-digit units) (USGS, 2013).

The percentage of block groups in each region that qualify as environmental justice communities is presented by region in sections 2.1 through 2.9. For Environmental Justice analysis, a census block group was considered to be an Environmental Justice community (containing a disproportionately high percentage minority or low-income population) if it exceeded 50% of the population within that block group, or if the percentage was meaningfully greater (e.g., 20 percentage points) than the associated county.

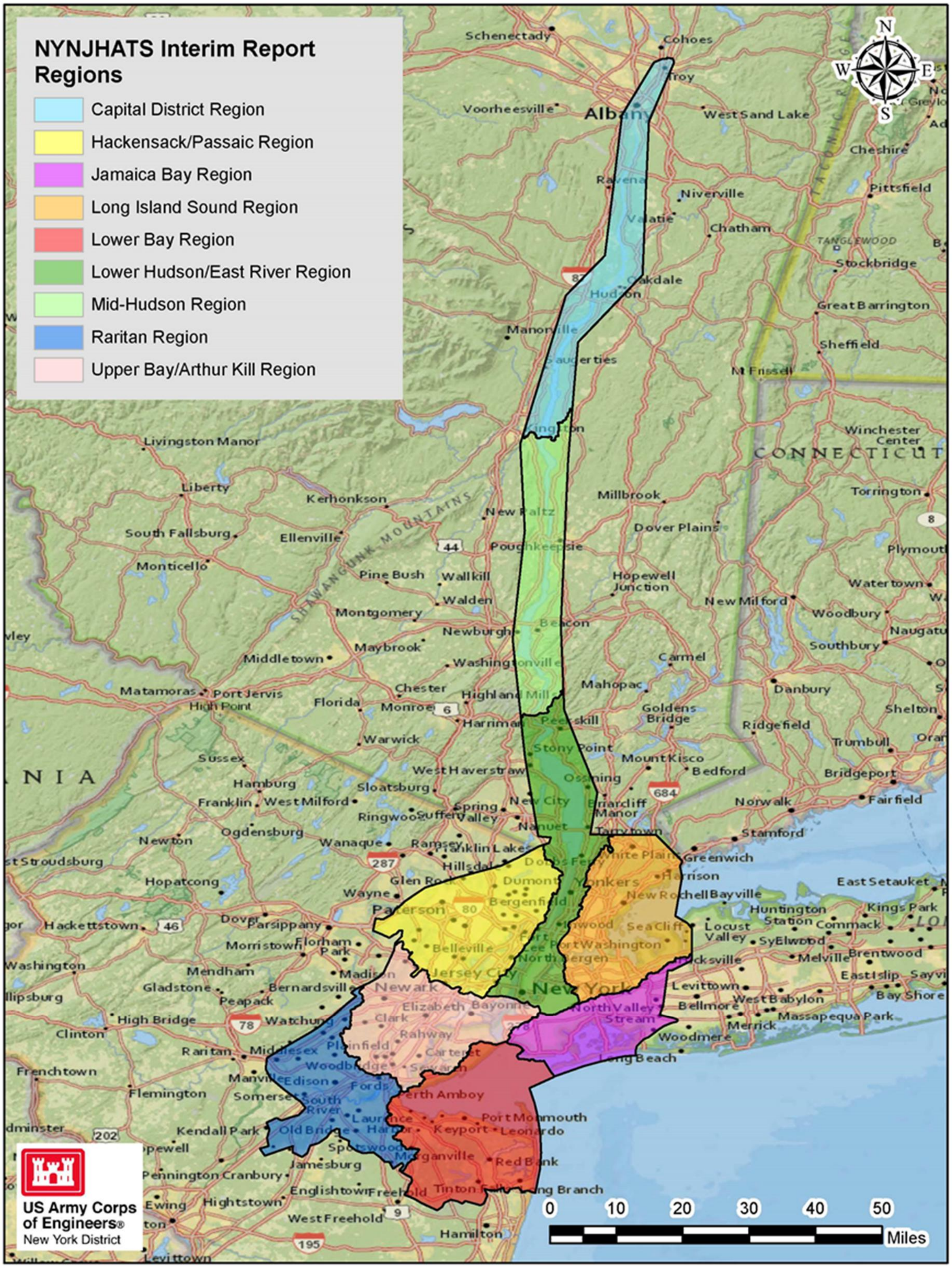

Figure 2. NYNJHAT Region Index

2.1 Upper Bay/Arthur Kill Region

The Upper Bay/Arthur Kill Region (Figure 3) is based on the 10-digit HUCs for the Arthur Kill-Upper Bay watershed and the Rahway River watershed, from the Watershed Boundary Dataset (USGS, 2018). This region lies between the mouth of the Hudson River and the Lower Raritan River, and includes portions of Richmond and Kings counties in New York, as well as Governors Island, New York County. This region also includes portions of Hudson, Essex, Union, and Middlesex counties in New Jersey. The population in this region is approximately 1,970,000.

Figure 3. Upper Bay/Arthur Kill Region

Fifty-two percent of the census block groups in the Upper Bay/Arthur Kill Region qualify as environmental justice communities. This includes communities in Perth Amboy, Carteret, Edison, Woodbridge, Plainfield, Summit, Westfield, Rahway, Linden, Roselle, Roselle Park, Kenilworth, Elizabeth, Springfield, Union, Hillside, Orange, East Orange, South Orange Village, West Orange, Irvington, Maplewood, Millburn, Newark, Bayonne, and Jersey City. This region also includes New York City environmental justice communities in Kings County (neighborhoods of Red Hook and Sunset Park) and Richmond County (Charleston, Arden Heights, Heartland Village, New Springville, Manor Heights, Bulls Head, Todd Hill, Castleton Corners, Arlington, Mariners Harbor, Elm Park, Port Richmond, Randall Manor, and West Brighton) (USCB 2016a, USCB 2016b).

The Arthur Kill is a tidal strait that connects to Upper Bay via the Kill Van Kull (another tidal strait) and mixes waters with Newark Bay. The Arthur Kill also connects Newark Bay with Raritan Bay. Important tributaries to the Arthur Kill include the Rahway and Elizabeth Rivers, Old Place Creek, Woodbridge Creek, and Fresh Kills Creek (USACE, 2004a). The Upper Bay/Arthur Kill Region has a dynamic hydrology due to the variation in tidal velocity, amount of freshwater flow, and bathymetry among the connecting bays (USACE, 1999).

These waterways exist within a heavily industrialized and developed corridor. The New Jersey side of the Arthur Kill is industrialized; large areas of wetlands are intermingled with industrial facilities on the New York side. The Arthur Kill and Kill Van Kull have deepwater navigation channels that allow transport of cargo into and out of the Ports of New York and New Jersey. While the Arthur Kill is highly industrialized, approximately 55% of the shoreline is natural mudflats and marshes.

The extensive tributary system of the Arthur Kill supports a mosaic of tidal and freshwater wetlands, mudflats, and riparian forest. Deeper, open-water habitats in this region support over 60 migratory and resident fish species including species of commercial or recreational importance such as winter flounder (*Pseudoplueronectes americanus*) and black sea bass (*Centropristis striata*) (RPA, 2003; USACE, 2004a). Northwest Staten Island and the islands along the Arthur Kill and Kill Van Kull were designated as a Special Natural Waterfront Area (SNWA) by NYC due to the diverse landscape of habitats (NYCDCP, 2011). Arlington Marsh and Graniteville Swamp are examples of important habitats within this region.

Large breeding populations of herons, egrets, and ibises have used uninhabited islands in the region as nesting sites, and the nearby marshlands and mudflats as foraging areas. From the late 1970s through the early 1990s, the islands supported the largest heron rookery in New York State. It was estimated that the entire rookery in the study area accounted for almost 25 percent of the wading birds that nested in coastal waters within New York, New Jersey, and Connecticut (USFWS, 1997). Although none of the islands in this region currently support active wading bird rookeries, these islands provide habitat for other bird species and may be recolonized by wading birds in the future (NYC Audubon, 2017). The water of the Upper Bay/Arthur Kill Region also support migratory marine mammals, such as humpback whales (*Megaptera noveangliae*) (NYSDEC, 2019).

South of the Newark Bay Bridge, Richard A. Rutkowski Park provides a contrast to the industrial development with preserved wetlands and a bird sanctuary along the eastern shoreline of Newark Bay (City of Bayonne, 2012).

The Gowanus Canal is a prominent site within the Upper Bay Planning Region. The canal is a 100-foot wide, 1.8-mile long canal in a highly developed section of Brooklyn, NY, that has become one of the most contaminated water bodies in the country. Contaminants found in high levels include polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), mercury, lead, and copper. In 2010, this site was added to the USEPA Superfund List. A plan has been put in place to dredge the contaminated soil and then cap the area. In addition, retention tanks for the combined sewer overflows are planned to be built in order to not compromise the cleanup. Both of these tasks are currently underway (USEPA, 2018).

Shoreline habitat can be found in the form of wetlands on the west side of Liberty Island. Remnant mudflats are located along the New Jersey coastline (USACE, 2000; USACE, 1999). Sandy shallows within the Bay Ridge Flats that have been significantly reduced in size over time by dredging are located along the eastern edge of the bay. These flats provide some habitat to many species of young fishes. The Upper Bay is still a critical component of the study area because it serves as a migratory pathway for many fish species, providing access to important feeding, overwintering, and nursery areas (USACE, 2004a).

2.2 Lower Bay Region

The Lower Bay Region (Figure 4) is based on the 10-digit HUCs for the Raritan Bay-Lower Bay watershed and the Navesink River-Shrewsbury River watershed, and well as the 8-digit HUC for the Mullica-Toms subbasin, from the Watershed Boundary Dataset (USGS, 2018). This includes a portion of Richmond County in New York, and portions of Middlesex and Monmouth counties in New Jersey. The population in this region is approximately 565,000.

Eleven percent of the census block groups in the Lower Bay Region qualify as environmental justice communities. This includes communities in Aberdeen, Keyport, Keansburg, Holmdel, Middletown, Red Bank, Long Branch, Eatontown, Shrewsbury, Old Bridge, Sayreville, and the Staten Island borough of New York City (neighborhoods of Arrochar, Midland Beach, and New Dorp Beach) (USCB 2016a, USCB 2016b).

Major waterbodies in this area provide a combination of marine and estuarine habitats that support diverse ecological communities (USACE, 2004a) and are hydrologically connected to the Upper Bay and Hudson River, Jamaica Bay, and the Atlantic Ocean. There are major estuarine wetland systems throughout the region. The Sandy Hook peninsula makes up one unit of the National Park Service (NPS)'s Gateway National Recreation Area (GNRA). The Staten

Island Unit of GNRA consists of Great Kills Park, Miller Field, and Fort Wadsworth (NPS, 2018). GNRA features important sections of estuarine wetland habitat and freshwater forested/shrub wetland habitat (USFWS, 2018). Sandy Hook is a nine-mile narrow sand spit that has a fairly extensive vegetated dune system and two distinct maritime forest communities that encompass 285 acres (RPA, 2003).

The uplands along the shoreline of the Lower Bay are important as migratory and wintering stopover habitat for migratory perching birds and raptors, as well as an important staging area for many species of waterfowl on the Atlantic Flyway (USACE, 2016; USACE, 2017). Beach habitat provides foraging areas for waterfowl and shorebirds (RPA, 2003). The Sandy Hook Unit of GNRA provides habitat for roughly 60 percent of the New Jersey piping plover (federally threatened, New York State- and New Jersey State-endangered) population. This region also contains valuable fish and shellfish habitat (RPA, 2003). The waters of the Lower Bay Region also support migratory marine mammals, such as humpback whales (*Megaptera noveangliae*) (NYSDEC, 2019).

This region is heavily utilized for recreation. There are many maintained beaches with public access on the New Jersey and Staten Island shorelines. Point Comfort beach, located in Keansburg, New Jersey, includes an amusement park/waterpark with a walkway along the beach. Many areas, both on- and off-shore, are designated for fishing. Recreational species include weakfish, bluefish, winter flounder, summer flounder, and striped bass.

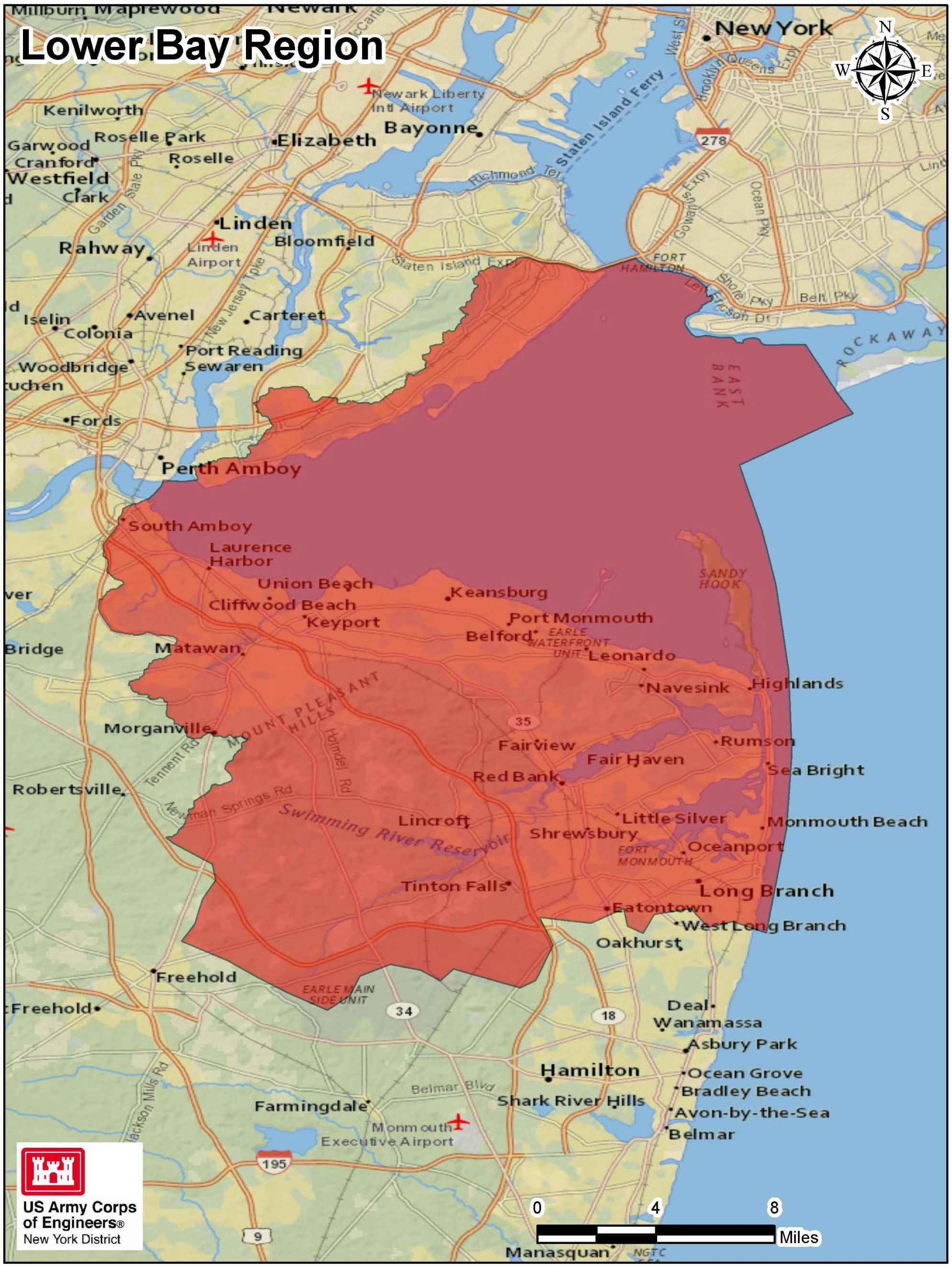

Figure 4. Lower Bay Region

2.3 Jamaica Bay Region

The Jamaica Bay Region (Figure 5) is based on the 8-digit HUCs for the Southern Long Island subbasin from the Watershed Boundary Dataset (USGS, 2018). This includes a portion of Kings, Nassau, and Queens Counties in New York, as well as the John F. Kennedy International Airport. The population in this region is approximately 2,957,000.

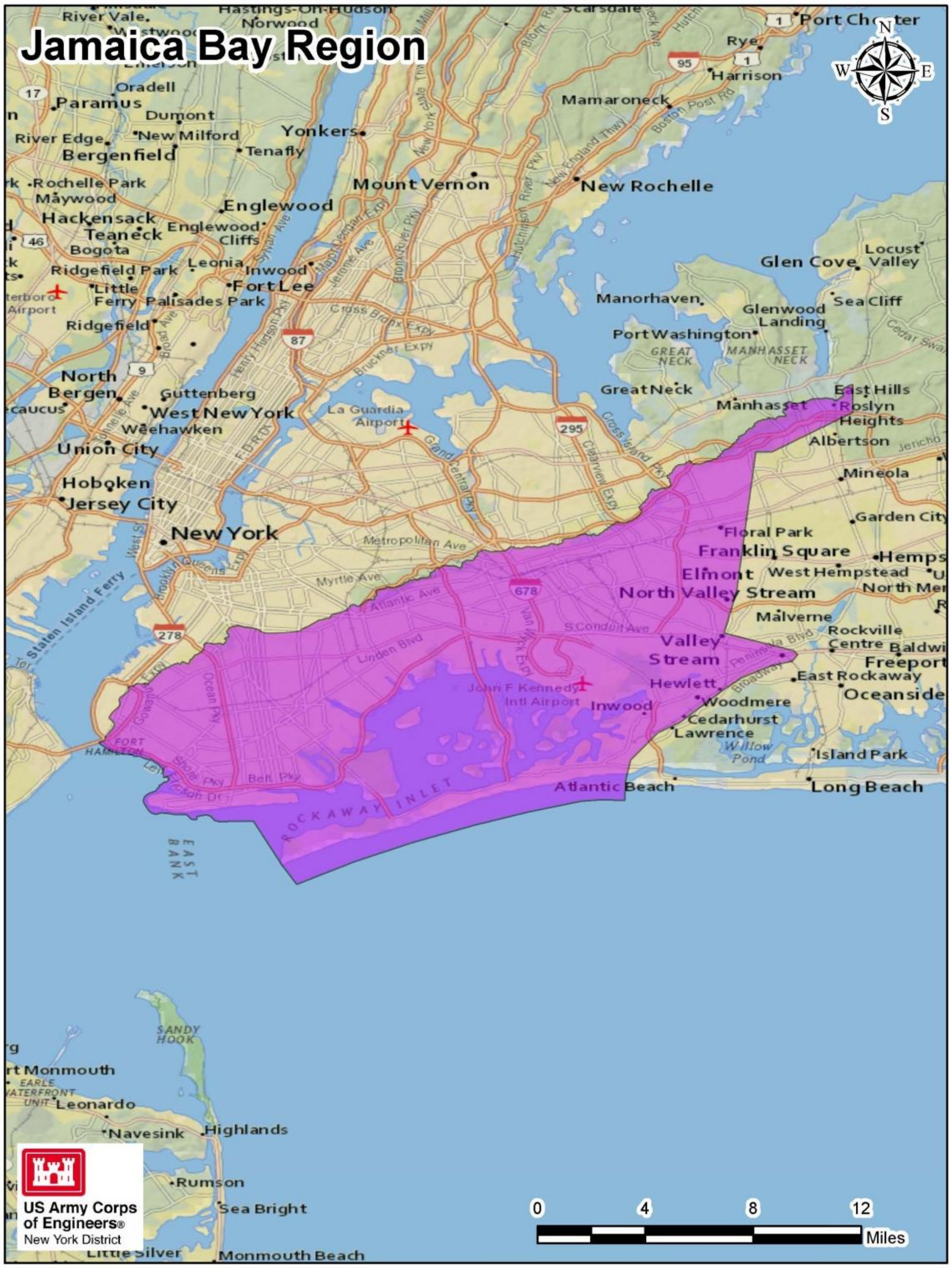

Figure 5. Jamaica Bay Region

Sixty-seven percent of the census block groups in the Jamaica Bay Region qualify as environmental justice communities. This includes communities in:

- Nassau County (Hempstead, North Hempstead, Lake Success, New Hyde Park, South Floral Park, and Valley Stream);
- Kings County (neighborhoods of Coney Island, Brighton Beach, Gravesend, Sheepshead Bay, Bath Beach, Bensonhurst, Borough Park, Kensington, Flatbush, East Flatbush, Prospect Lefferts Gardens, Crown Heights, Flatlands, Canarsie, East New York, Brownsville, and Cypress Hills);
- Queens County (neighborhoods of Glen Oaks, Bellaire, Queens Village, Hollis, Holliswood, Jamaica, Jamaica Estates, Jamaica Hills, Briarwood, Kew Gardens, Richmond Hill, Woodhaven, Ozone Park, South Ozone Park, Rochdale, Cambria Heights, Laurelton, Springfield Gardens, Rosedale, Far Rockaway, Edgemere, Somerville, Arverne, Seaside, and Rockaway Park) (USCB 2016a, USCB 2016b). In addition, the eastern end of Jacob Riis Park (part of Gateway National Recreation Area) in Queens has a history as a gay beach going back to the 1940s (NYC LGBT Historic Sites Project, 2017).

Jamaica Bay is a saline to brackish, nutrient-rich estuary covering almost 40 square miles. The bay has a mean depth of 13 feet, a tidal range averaging five feet, and a residence time of about 33 days (USFWS, 1997). The bay opens into Lower Bay and the Atlantic Ocean via the Rockaway Inlet. Rockaway Inlet is a high current area that is 0.63 miles wide at its narrowest point, with an average depth of 23 feet (USFWS, 1997). Jamaica Bay is an estuary with diverse habitats, including open water, coastal shoals, bars, mudflats, intertidal zones (low and high marshes), and upland areas (Hartig et al., 2002). Upland communities are predominantly grasslands, scrub-shrub, developing woodland, and beachgrass dune. The Jamaica Bay Unit of NPS's GNRA is made up of Floyd Bennett Field, Jamaica Bay Wildlife Refuge, Canarsie Pier, Breezy Point, Fort Tilden, and Jacob Riis Park (NPS, 2018). There are major estuarine wetland systems in Coney Island, Gerritsen Creek, Four Sparrow Marsh, Spring Creek, Hawtree Basin, Jamaica Bay Wildlife Refuge, Head of Bay, Dubos Point Wildlife Sanctuary, as well as the marsh islands of Jamaica Bay and the shoreline of the Rockaway Peninsula (USFWS, 2018).

Jamaica Bay continues to be a significant nursery ground for commercially and recreationally important fish, such as the winter flounder (*Pseudopleuronectes americanus*) and striped bass (USACE, 2017). Under the Magnuson-Stevens Fishery Conservation and Management Act (16 United States Code 1801 et seq.), Jamaica Bay has been designated by the National Marine Fisheries Service (NMFS) as essential fish habitat (EFH) for numerous species and life stages of commercially or ecologically important fish. Widely recognized as a uniquely valuable habitat complex within the Study Area, New York City designated Jamaica Bay as a SNWA in response to recommendations in the 1992 Comprehensive Waterfront Plan (NYCDCP, 2011). The waters of the Jamaica Bay Region also support marine mammals such as Harbor Seals (*Phoca vitulina*) and Harbor Porpoises (*Phocoena phocoena*) (NPCA, 2019).

Areas of existing salt marsh in the region provide reproductive habitat for invertebrates such as mussels and crabs. Each spring, horseshoe crabs congregate on the mudflats of this region to breed. Migratory shorebirds that winter in temperate or tropic locales and breed in the Arctic stop during their migration to rest and replenish their fat reserves by feeding on the horseshoe crab eggs. Species such as ruddy turnstones (*Arenaria interpres*) and red knots (*Calidris canutus*) rely on the horseshoe crabs for their survival. Favorable habitat is generally limited to small, isolated patches on the beaches of Jamaica Bay (USACE, 2017).

This region is heavily utilized for recreation. There are many maintained beaches with public access along the Rockaway Peninsula through Fort Tilden and Jacob Riis Parks (NYC Parks, 2018). Beach attendance data provided by the Department of Parks and Recreation (DPR), City of New York, indicates that approximately 7.7 million beach visits per year occur on the Rockaway Peninsula at Rockaway Beach (USACE, 2018). Jamaica Bay is a popular destination for recreational boaters, kayakers, kite surfers, hikers, and birders. Coney Island, on the south shore of Long Island in Brooklyn, includes an amusement park with a boardwalk along the beach. Many areas, both on- and off-shore, are designated for fishing. Recreational species include bluefish, tautog, weakfish, black sea bass, winter flounder, summer flounder, and striped bass (USACE, 2017).

2.4 Hackensack/Passaic Region

The Hackensack/Passaic River Region (Figure 6) is based on the 8-digit HUCs for the Hackensack-Passaic subbasin from the Watershed Boundary Dataset (USGS, 2018). This includes portions of Bergen, Passaic, Essex, and Hudson counties in New Jersey, as well as a small part of Rockland County in New York. The population in this region is approximately 2,067,000.

Fifty-three percent of the census block groups in the Hackensack/Passaic Region qualify as environmental justice communities. This includes communities in Belleville, Bloomfield, Orange, East Orange, West Orange, Montclair, Newark, East Newark, Nutley, Union City, Kearny, West New York, Secaucus, North Bergen, Harrison, Jersey City, North Arlington, Lyndhurst, Fairview, Rutherford, East Rutherford, Ridgefield, Ridgefield Park, Moonachie, Palisades Park, Little Ferry, Fort Lee, Hackensack, South Hackensack, Hasbrouck Heights, Leonia, Bogota, Garfield, Lodi, Englewood, Englewood Cliffs, Teaneck, Maywood, Saddle Brook, Elmwood Park, Tenafly, Bergenfield, River Edge, New Milford, Fair Lawn, Cresskill, Dumont, Demarest, Oradell, Paramus, Closter, Westwood, Ridgewood, Teterboro, Clifton, Passaic, Woodland Park, Paterson, Prospect Park (New Jersey), Hawthorne, Haledon, and Wayne (USCB 2016a, USCB 2016b).

This watershed is indirectly connected to Upper Bay and Lower Bay through Kill Van Kull and Arthur Kill, respectively. An important and ecologically valuable habitat complex in this region is the New Jersey Hackensack Meadowlands, which includes the largest remaining brackish wetland complex in the study area, measuring approximately 8,400 acres (USACE, 2004b). Originally a large, 21,000-acre marshland complex, the Meadowlands have diverse habitat types and over 100 species of nesting birds, fish and shellfish, many of which are state- or federally-protected (RPA, 2003). Although degraded, the Meadowlands and surrounding areas in this region represent significant open spaces that continue to provide ecosystem functions, including flood storage and fish/wildlife habitat, and offer a variety of potential restoration opportunities (USFWS, 1997).

Lower reaches of the Passaic and Hackensack Rivers provide habitat for marine and estuarine fish and invertebrates, while farther upstream, the rivers support a mix of estuarine and freshwater species (USACE 2004b). Newark Bay's open water is used by many fish as nursery habitat. The bay supports nearly 50 species of finfish including bay anchovy, Atlantic menhaden, striped bass, Atlantic herring, Atlantic tomcod, and white perch (Wilk et al., 1997). The Hackensack Meadowlands provide important habitat for thousands of shorebirds, both in spring and fall migrations, and for wintering and summering waterfowl (USFWS, 1997). Bald eagles also forage and roost in the Hackensack Meadowlands.

There is much public access to the water in this region, the majority of which are found along the Hackensack and Passaic River and in the Hackensack Meadowlands overlooking the wetlands. There are a few public access points scattered around the east waterfront of Newark Bay in Bayonne and Jersey City (USACE, 2017).

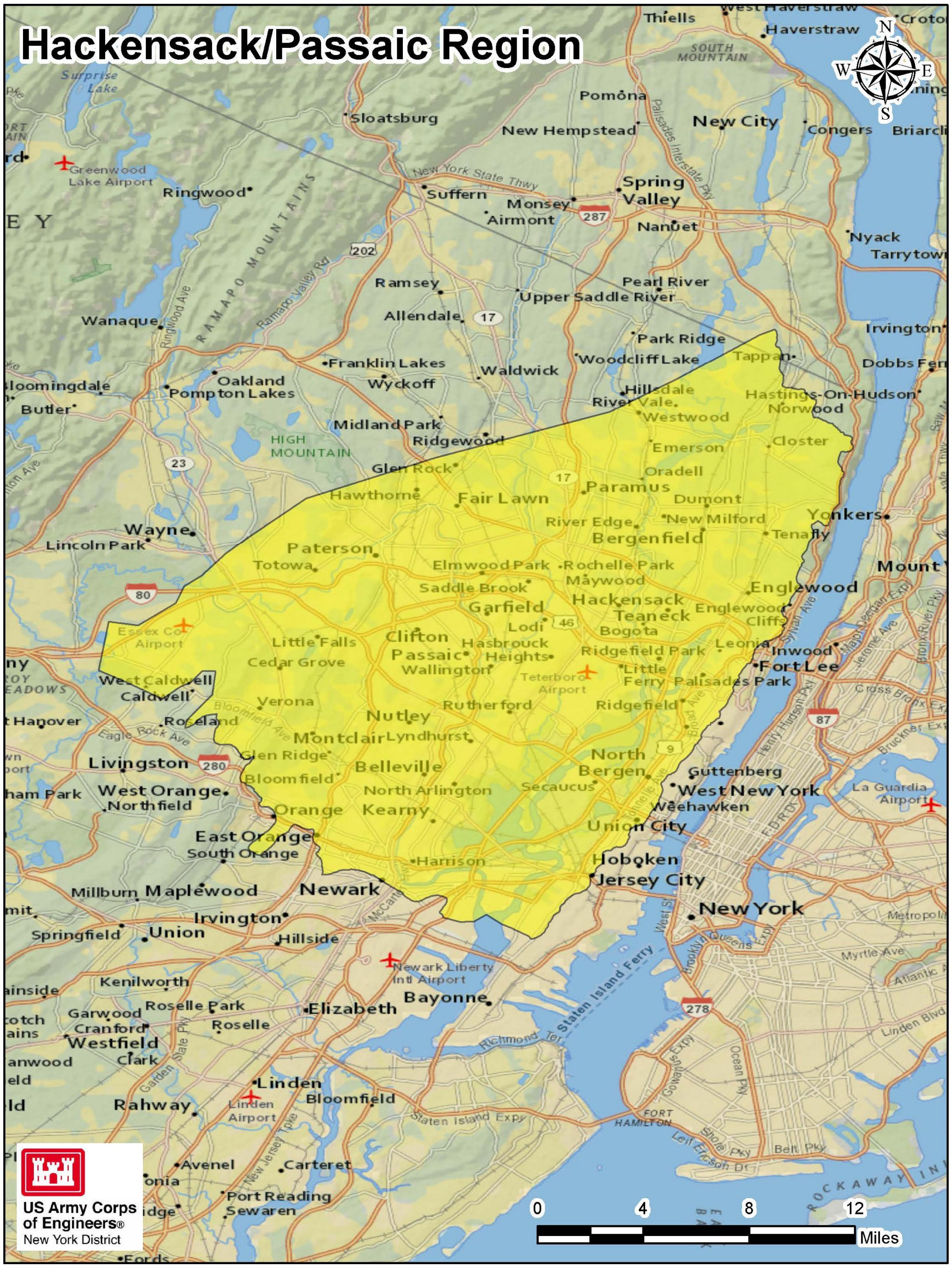

Figure 6. Hackensack/Passaic Region

2.5 Raritan Region

The Raritan River Region (Figure 7) is based on the 8-digit HUCs for the Raritan subbasin in the Watershed Boundary Dataset (USGS, 2018). This includes portions of Middlesex, Monmouth, Somerset, and Union counties in New Jersey, and is the westernmost region in the study area. The population in this region is approximately 955,000.

Forty-six percent of the census block groups in the Raritan Region qualify as environmental justice communities. This includes communities in Marlboro, Old Bridge, New Brunswick, East Brunswick, North Brunswick, South Brunswick, South River, Spotswood, Highland Park, Edison, Piscataway, Middlesex, Dunellen, South Plainfield, North Plainfield, Perth Amboy, Woodbridge, Plainfield, Scotch Plains, Franklin, Bound Brook, South Bound Brook, and Bridgewater (USCB 2016a, USCB 2016b).

This region contains the lower six miles of the Raritan River before its confluence with Raritan Bay (USACE, 2004a). The shoreline of the Lower Raritan River is flanked with residential or industrial development. Land use is predominantly industrial development with bulk-headed shorelines and piers at the river's mouth, and changes to a mix of industrial, commercial, and residential development farther upstream (USACE, 2004a; USACE, 1999). Agricultural lands are located along the upstream boundary of the region (USACE, 2004a). Isolated pockets of tidal wetlands occur along the shore (USACE, 2004a; USACE, 1999). An unremediated landfill, the former Raritan Arsenal, and the Sayreville and Werner generating stations are also located along the shoreline.

This tidally influenced river features some regionally important floral and faunal assemblages (RPA, 2003; USACE, 2004a). A large wetland complex of 1,000 acres, located in Edison Township, provides habitat for waterfowl, wading birds, mammals, and fish (USACE, 2004a). Saltwater intrusion occurs throughout the length of the Lower Raritan River, with sensitive estuarine resources such as tidal wetlands, submerged aquatic vegetation, and intertidal mud flats occurring in shallow, nearshore areas (USACE, 1999). Some fallow or abandoned agricultural lands afford open spaces for upland wildlife (USACE, 2004a). However, these habitats are isolated and somewhat degraded due to the industrial land uses in the region.

Although there are no public bathing areas in the region, waterbodies are used for recreational navigation and secondary contact recreation including water/jet skiing and fishing (USACE, 2004a).

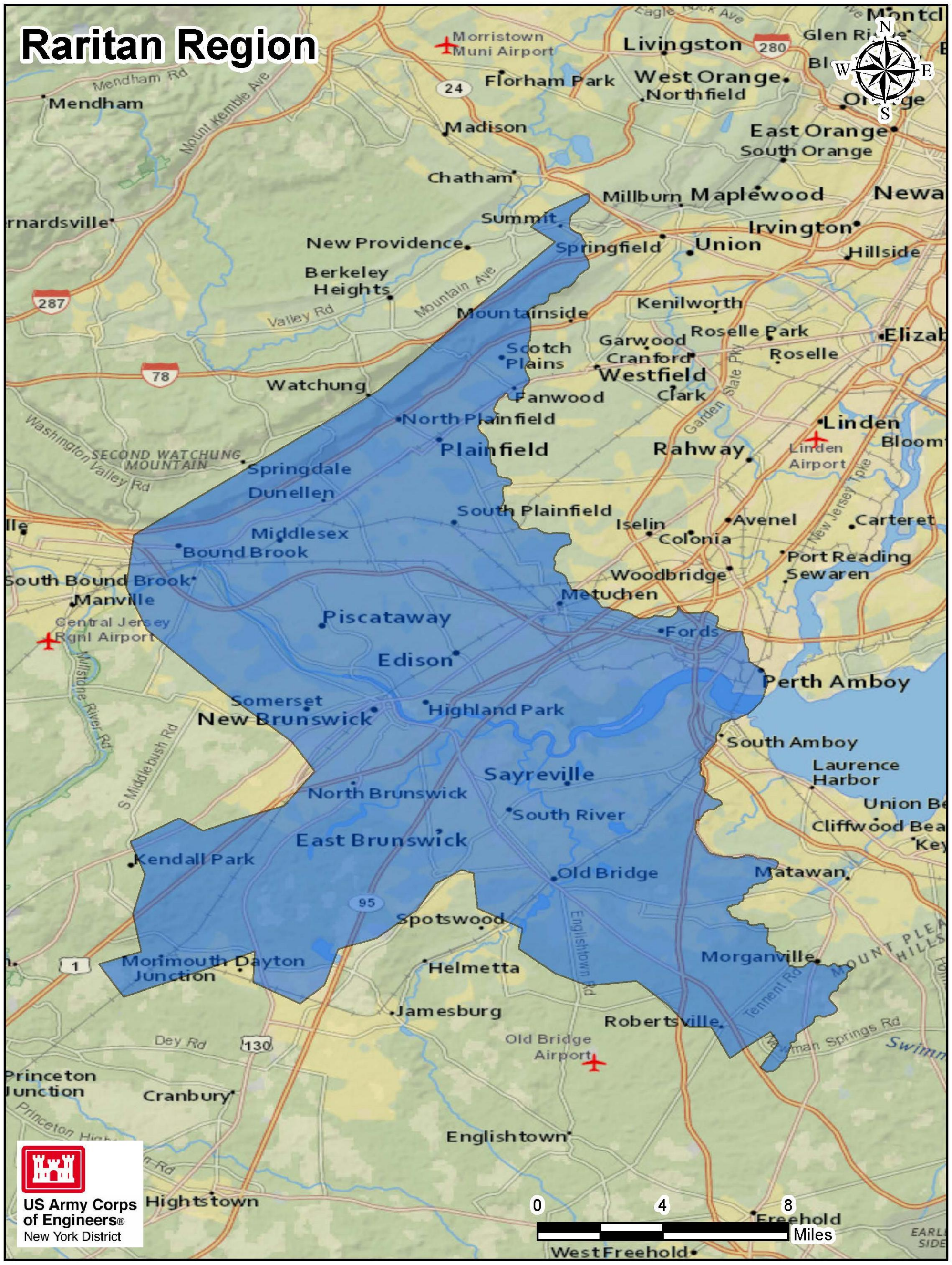

Figure 7. Raritan Region

2.6 Long Island Sound Region

The Long Island Sound Region (Figure 8) is based on the 8-digit HUCs for the Bronx, Saugatuck, Long Island Sound, and Northern Long Island subbasins from the Watershed Boundary Dataset (USGS, 2018). This region contains sections of Bronx County and Queens County, as well as portions of Westchester and Nassau Counties. The population in this region is approximately 3,032,000.

Figure 8. Long Island Sound Region

Sixty-eight percent of the census block groups in the Long Island Sound Region qualify as environmental justice communities. This includes communities in New Rochelle, Mount Vernon, White Plains, Greenburgh, Pelham, Yonkers, Mamaroneck, Tuckahoe, Elmsford, Port Chester, North Hempstead, Glen Cove, Great Neck, Lake Success, and Manor Haven. This region also includes New York City environmental justice communities in Queens County (neighborhoods of Elmhurst, East Elmhurst, Jackson Heights, Corona, North Corona, Woodside, Rego Park, LeFrak City, College Point, Flushing, Murray Hill, Auburndale, Bayside, Oakland Gardens, Kew Gardens Hills, Pomonk, Utopia, Hillcrest, Fresh Meadows, Little Neck, and Douglaston) and all of the associated neighborhoods of Bronx County (except Country Club and Woodlawn Heights) (USCB 2016a, USCB 2016b).

The Long Island Sound is connected to the Upper Bay via the East River, a tidal strait. Tributaries of the Sound in this region include the Bronx River, Flushing Creek, Westchester Creek, Hutchinson River, Mamaroneck River, and Byram River. There are major estuarine wetland systems in Little Neck Bay, sections of the coast line in Sands Point on Long Island, Hen Island and Milton Harbor, Mamaroneck River and its tributaries, and Pelham Bay Park (USFWS, 2018). The 437-acre Thomas Pell Wildlife Refuge is also within Pelham Bay Park, on the Bronx River. A portion of this region has been designated as the Upper East River-Long Island Sound SNWA by New York City due to the extensive marsh systems in the area, such as those in Alley Pond Park, and islands that support significant populations of nesting shorebirds (NYCDCP, 2011).

This region is a significant route for migratory fish, and the bays are also productive nurseries and feeding areas for marine finfish and shellfish, including clams, striped bass, scup, bluefish, Atlantic silverside, Atlantic menhaden, winter flounder, and blackfish (USFWS, 1997). Several islands in this region support large populations of wading birds, most notably the 12-acre South Brother Island. Little Neck Bay, Manhasset Bay, and Hempstead Harbor contain significant waterfowl wintering areas (USACE, 2000; USACE, 2004a).

This region is heavily utilized for recreation. Orchard Beach, a part of Pelham Bay Park in The Bronx, is a popular beach destination. There are also a number of maintained beaches with public access in Nassau and Westchester counties. Rye Playland Beach in Westchester County includes an amusement park with a boardwalk along the beach. Fishing also occurs from vessels and the shorelines of this area. In Western Long Island, bays such as Little Neck, Flushing, Manhasset, and Hempstead bays are important recreational fishing areas (USACE, 2000). Species sought include striped bass, bluefish, weakfish, scup, black sea bass, tautog, summer flounder and winter flounder.

2.7 Lower Hudson/East River Region

The Lower Hudson River/East River Region (Figure 9) is based on the 8-digit HUCs for the Lower Hudson subbasin in the Watershed Boundary Dataset (USGS, 2018). This region extends from the Upper Bay to the Bear Mountain Bridge (also known as the Purple Heart Veterans Memorial Bridge), and includes all of New York County, as well as portions of Kings, Queens, and Bronx Counties. In addition, this region includes portions of Bergen and Hudson Counties in New Jersey, and of Rockland and Westchester Counties in New York. The population in this region is approximately 4,138,000.

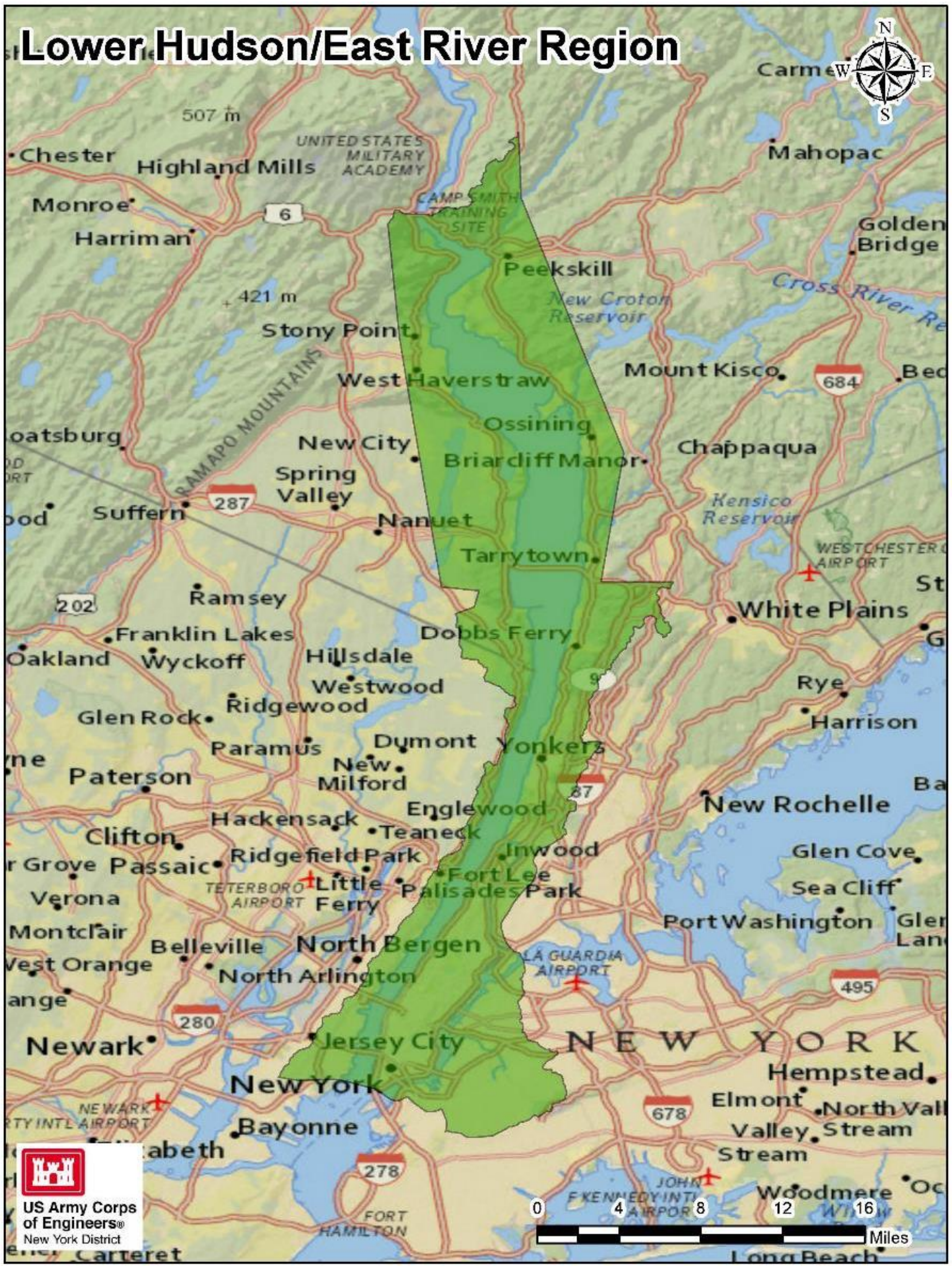

Figure 9. Lower Hudson/East River Region

Fifty-five percent of the census block groups in the Lower Hudson/East River Region qualify as environmental justice communities. This includes communities in Hoboken, Weehawken, Union City, West New York, Guttenberg, North Bergen, Jersey City, Fairview, Cliffside Park, Edgewater, Fort Lee, Englewood Cliffs, Stony Point, Haverstraw, West Haverstraw, Clarkstown, Orangetown, Nyack, South Nyack, Piermont, Peekskill, Greenburgh, Yonkers, Ossining, Croton-on-Hudson, Sleepy Hollow, Tarrytown, and Elmsford. This region also includes New York City environmental justice communities in New York County (neighborhoods of Lower East Side, Roosevelt Island, and the majority of Manhattan north of 98th Street), Kings County (neighborhoods of Williamsburg, Bushwick, Bedford-Stuyvesant, Crown Heights, Prospect Heights, Clinton Hill, Fort Greene, and Downtown Brooklyn), Queens County (neighborhoods of Astoria, Sunnyside, Maspeth, Ridgewood, and Glendale), and all of the associated neighborhoods of Bronx County (USCB 2016a, USCB 2016b).

This region is home to several Superfund sites, including Quanta Resources (Edgewater, NJ), Diamond Alkali Co. (Newark, NJ), Chemical Control (Elizabeth, NJ), and Newtown Creek (New York, NY) (USEPA, 2018).

Strong semi-diurnal tides make the Hudson River one of the few major tidal rivers of the North Atlantic coast (USFWS, 1997). The water level of the Hudson River rises and falls, accompanied by changes in flow direction, based on the ocean’s tide from the Upper Bay to Troy, NY. In addition, salt water from the ocean remains in the mix between the Governor Mario M. Cuomo Bridge (formerly known as the Tappan Zee Bridge) and Poughkeepsie, depending on the time of year and drought conditions (NYSDEC, 2014). There are estuarine wetland systems on the northern tip of Manhattan at Sherman Creek, Muscota Marsh, and Inwood Hill Park (USFWS, 2018). Along the Hudson River there are additional major wetland systems at Croton Bay and River, Stony Point Bay and State Park, Cedar Pond Brook, Furnace Brook, Dickey Brook, and the Piermont Marsh and Iona Island components of the Hudson River National Estuarine Research Reserve (HRNERR) (NYSDEC, 2009; USFWS, 2018).

The Lower Hudson River includes a wide range of riverine and estuarine habitats that function as overwintering habitat and significant nursery areas for many fish and invertebrate species (USACE, 2004a; USFWS, 1997; USACE, 2000). The Lower Hudson River is the primary nursery and overwintering area for striped bass (*Morone saxatilis*) in the Hudson River estuary. Two federally listed endangered species, shortnose sturgeon (*Acipenser brevirostrum*) and Atlantic sturgeon (*A. oxyrhynchus*), also spawn in the Lower Hudson. The Hudson River also provides important winter feeding and roosting areas for bald eagles.

Recreational and commercial boating is prevalent in the Lower Hudson River. There is a public beach at Croton Point Park.

2.8 Mid-Hudson Region

The Mid-Hudson Region (Figure 10) is based on the 8-digit HUCs for the Hudson-Wappinger subbasin and the Rondout subbasin in the Watershed Boundary Dataset (USGS, 2018). This region includes portions of Orange, Putnam, Ulster, and Dutchess counties in New York. The population in this region is approximately 247,000. Thirty-two percent of the census block groups in the Mid-Hudson Region qualify as environmental justice communities (Figure 12). This includes communities in Beacon, Fishkill, Kingston, Newburgh, New Windsor, Poughkeepsie, and Wappingers Falls (USCB 2016a, USCB 2016b).

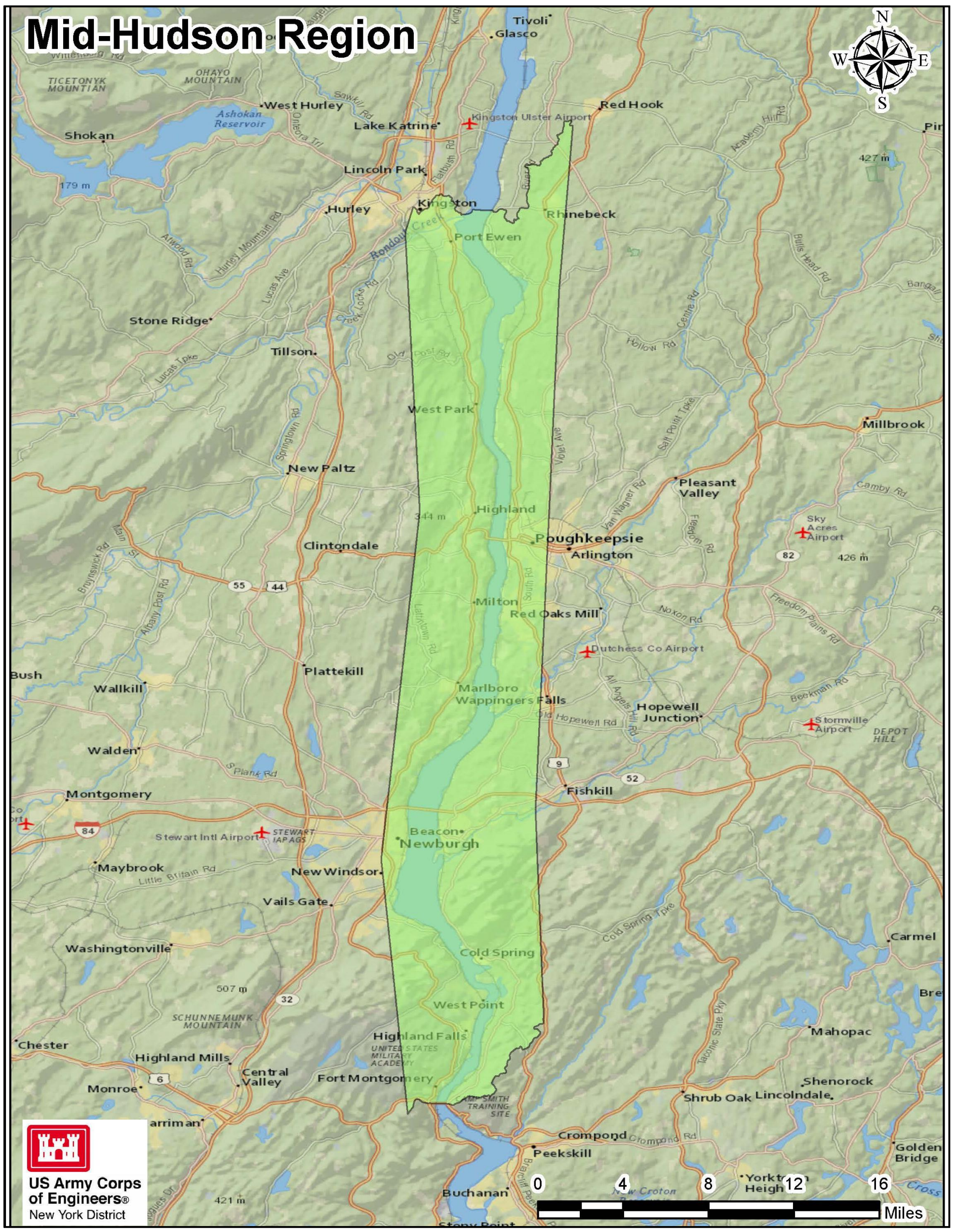

Figure 10. Mid-Hudson Region

There are major wetland systems at Constitution Marsh, Moodna Creek, Fishkill Creek, and Sleightsburgh Park at the mouth of Rondout Creek (USFWS, 2018). The Mid-Hudson Region contains migratory fish runs for many species, including alewife, American eel, American shad, Atlantic tomcod, blueback herring, sea lamprey, striped bass, and shortnose sturgeon. The Hudson River also provides important winter feeding and roosting areas for bald eagles.

2.9 Capital District Region

The Capital District (Figure 11) is the northern most portion of the study area and is based on the 8-digit HUCs for the Middle Hudson, Mohawk, and Hudson-Hoosic subbasins in the Watershed Boundary Dataset (USGS, 2018). This region includes portions of Ulster, Dutchess, Greene, Columbia, Albany, and Rensselaer counties in New York. The population in this region is approximately 219,000.

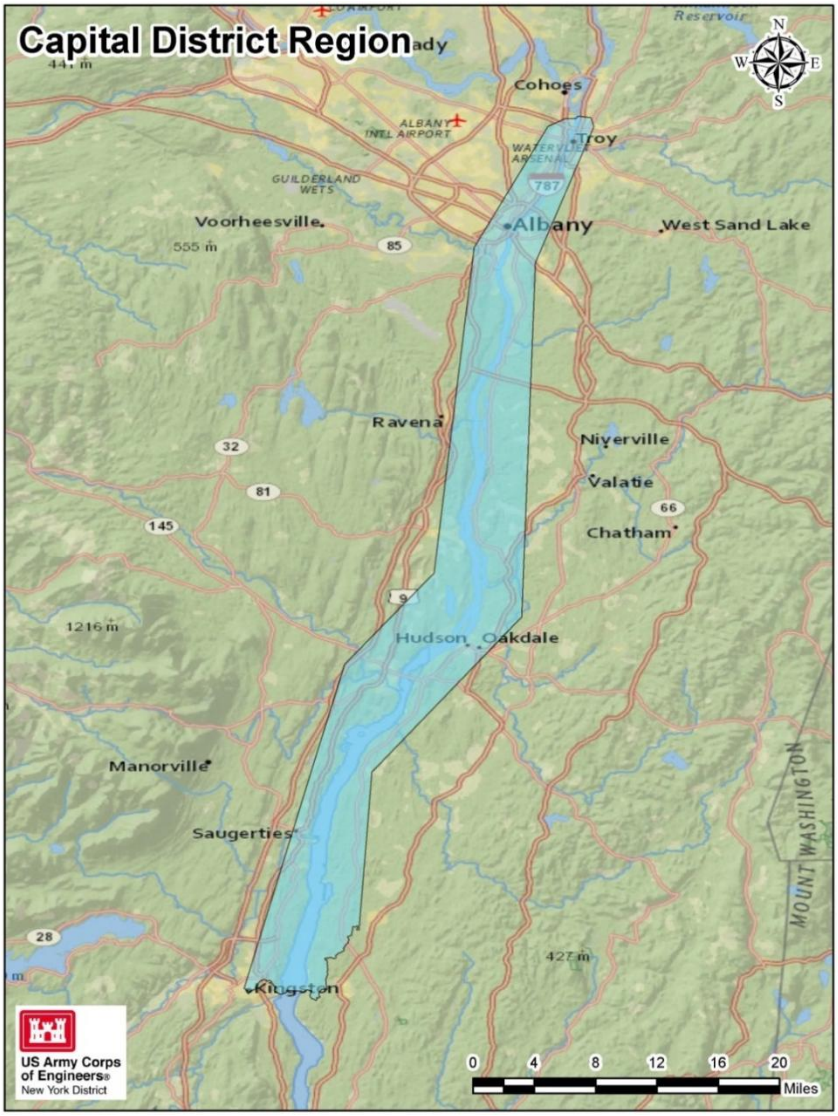

Figure 11. Capital District Region

38% of the census block groups in the Capital District Region qualify as environmental justice communities. This includes communities in Watervliet, Albany, Troy, Rensselaer, Menands, Hudson, Greenport, Kingston, and Catskill. (USCB 2016a, USCB 2016b). This region is also home to the Wappinger Creek superfund site (USEPA, 2018).

There are major wetland systems at Kingston Point, Duck Cove, Inbocht Bay, Burget Creek, Ramshorn Creek, Catskill Creek, Mill Creek, Hannacrois Creek, Rogers Island, North Bay, Moordener Kill, the south side of Normans Kill, Vosburgh Swamp, Coxsackie Island, Rattlesnake Island, Bronck Island, Mull Island, Houghtaling Island, Schodack Island and across Schodack Creek in Columbia County, the peninsula now made up of Shad and Schermerhorn Islands, the flats near Esopus Creek, and the Tivoli Bays and Stockport Flats components of the HRNERR NYSDEC, 2009; USFWS, 2018). There are also significant wetlands south of the City of Hudson, landward of the train tracks, as well as on the eastern bank of the Hudson River south of the Village of Athens, south of the Town of Stuyvesant between the Hudson River and the train tracks, south of the Town of Coeymans, and along the shoreline of Albany. The Hudson River also provides important winter feeding and roosting areas for bald eagles.

The northernmost portion of this region contains the Troy Lock and Dam and is dredged to a maintenance depth of approximately 14 feet deep. The Federal Dam at Troy is the limit of the Hudson River's tidal influence (approximately 1.5 meters or 4.92 feet). Recreational and commercial boating is prevalent in the Capital Region. There are public beaches at Kingston Point Beach and Sojourner Truth/Ulster Landing Park.

2.10 Summary

Within the nine regions of the study area described in the preceding sections, we have identified over 100 major sensitive and important ecological areas.

This study area contains six major superfund sites. However, there are many more New York State-level superfund sites, and New Jersey Known Contaminated Sites, that will need to be considered as we move forward.

Fifty-seven percent of the census block groups of the study area as a whole qualify as environmental justice communities (Figure 12).

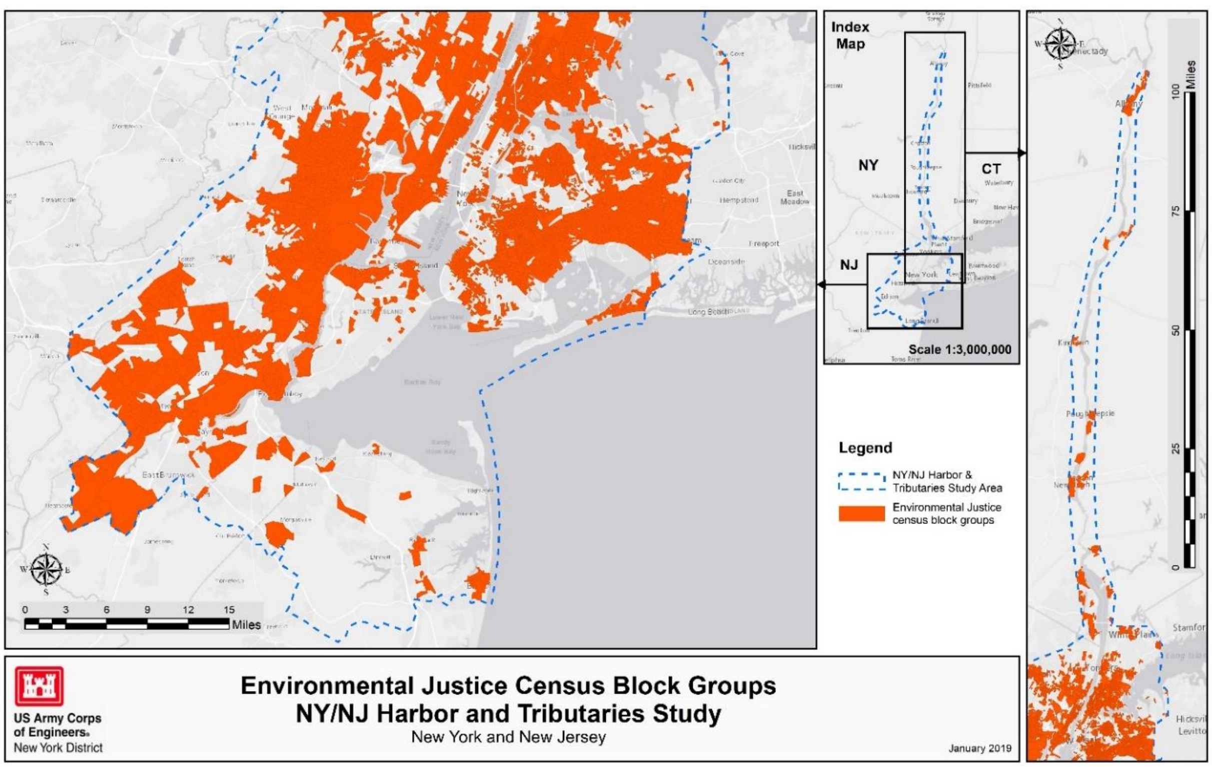

Figure 12. Environmental Justice Communities in the NYNJHAT Study Area

There are 97 identified protected fauna species (Table 5) within the study area, and hundreds of protected flora species.

Table 5. Federal and State Listed Threatened and Endangered Species of the New York-New Jersey Harbor and Tributaries

Common Name	Scientific Name	Federal Status	NY Status	NJ Status
Mollusks				
Dwarf wedgemussel	*Alasmidonta heterodon*	E	E	E
Eastern pond mussel	*Podarcis sicula*	-	-	T
Green floater	*Lasmigona subviridis*	-	T	E
Pink mucket	*Lampsilis abrupta*	-	E	-
Triangle floater	*Alasmidonta undulata*	-	-	T
Insects				
Arogos skipper	*Atrytone arogos arogos*	-	E	E
Barrens buckmoth	*Hemileuca maia*	-	SC	-
Bog buckmoth	*Hemileuca sp.*	-	E	-
Checkered white	*Pontia protodice*	-	SC	T
Frosted elfin	*Callophrys irus*	-	-	T
Gray petaltail	*Tachopteryx thoreyi*	-	SC	-
Henry's elfin	*Callophrys henrici*	-	SC	
Hessel's hairstreak	*Callophrys hesseli*	-	E	-
Karner blue butterfly	*Lycaeides melissa samuelis*	E	E	-
Mottled duskywing	*Erynnis martialis*	-	SC	-
Northeastern beach tiger beetle	*Cicindela dorsalis dorsalis*	T	T	E
Persius duskywing	*Erynnis persius*	-	E	-
Robust baskettail	*Epitheca spinosa*	-	-	T
Silver-bordered fritillary	*Boloria selene myrina*	-	-	T
Fishes				
Atlantic sturgeon	*Acipenser oxyrinchus*	E, CH	-	E
Banded sunfish	*Enneacanthus obesus*	-	T	-
Mud sunfish	*Acantharchus pomotis*	-	T	-
Shortnose sturgeon	*Acipenser brevirostrum*	E	E	E
Reptiles and Amphibians				
Atlantic Ridley sea turtle	*Lepidochelys kempii*	E	E	E
Blue-spotted salamander	*Ambystoma laterale*	-	SC	E
Bog turtle	*Clemmys muhlenbergii*	T	E	E
Eastern box turtle	*Terrapene carolina*	-	SC	-
Eastern hog-nose snake	*Heterodon platirhinos*	-	SC	-

Common Name	Scientific Name	Federal Status	NY Status	NJ Status
Fence lizard	*Sceloporus undulatus*	-	T	-
Green sea turtle (non-breeding range)	*Chelonia mydas*	T	T	T
Hawksbill sea turtle	*Eretmochelys imbricata*	E	E	E
Jefferson salamander	*Ambystoma jeffersonianum*	-	SC	-
Leatherback sea turtle	*Dermochelys coriacea*	E	E	E
Loggerhead sea turtle	*Caretta caretta*	T	T	E
Long-tailed salamander	*Eurycea longicauda*	-	-	T
Marbled salamander	*Ambystoma opacum*	-	SC	-
Mud turtle	*Kinosternon subrubrum*	-	E	-
Northern cricket frog	*Acris crepitans*	-	E	-
Southern gray treefrog	*Hyla chrysocelis*	-	-	E
Spotted turtle	*Clemmys guttata*	-	SC	-
Southern leopard frog	*Rana sphenocephala utricularius*	-	SC	-
Timber rattlesnake	*Crotalus horridus*	-	-	E
Wood turtle	*Clemmys insculpta*	-	SC	T
Worm snake	*Carphophis amoenus*	-	SC	-
Birds				
American bittern	*Botaurus lentiginosos*	-	SC	E/SC
American kestrel	*Falco sparverius*	-	-	T/T
Bald eagle	*Haliaeetus leucocephalus*	-	T	E/T
Barred owl	*Strix varia*	-	-	T/T
Black rail	*Laterallus jamaicensis*	-	E	T
Black skimmer	*Rynchops niger*	-	SC	E/E
Black tern	*Chlidonias niger*	-	E	-
Black-crowned night-heron	*Nycticorax nycticorax*	-	-	T/SC
Bobolink	*Dolichonyx oryzivorus*	-	-	T/SC
Cattle egret	*Bubulcus ibis*	-	-	T/SC
Common nighthawk	*Chordeiles minor*	-	SC	-
Common tern	*Sterna hirundo*	-	T	SC/-
Cooper's hawk	*Accipiter cooperii*	-	SC	SC/-
Grasshopper sparrow	*Ammodramus savannarum*	-	SC	T/SC
Henslow's sparrow	*Ammodramus henslowii*	-	T	E/E
King rail	*Rallus elegans*	-	T	-
Least bittern	*Ixobrychus exilis*	-	T	SC/SC
Least tern	*Sterna antillarum*	-	T	E/E
Loggerhead shrike	*Lanius ludovicianus*	-	E	E
Long-eared owl	*Asio otus*	-	-	T/T

Common Name	Scientific Name	Federal Status	NY Status	NJ Status
Northern goshawk	*Accipiter gentilis*	-	SC	E/SC
Northern harrier	*Circus cyaneus*	-	T	E/SC
Osprey	*Pandion haliaetus*	-	SC	T/-
Peregrine falcon	*Falco peregrinus*	-	E	E/SC
Pied-billed grebe	*Podilymbus podiceps*	-	T	E/SC
Piping plover	*Charadrius melodus*	T	E	E/E
Red knot	*Calidris canutus*	T	-	-/T
Red-headed woodpecker	*Melanerpes erythrocephalus*	-	-	T/T
Red-shouldered hawk	*Buteo lineatus*	-	SC	E/SC
Roseate tern	*Sterna dougallii dougallii*	E	E	E/E
Savannah sparrow	*Passerculus sandwichensis*	-	SC	T/-
Seaside sparrow	*Ammodramus maritimus*	-	SC	-
Sedge wren	*Cistothorus platensis*	-	T	E/E
Sharp-shinned hawk	*Accipiter striatus*	-	SC	-
Short-eared owl	*Asio flammeus*	-	E	E/SC
Upland sandpiper	*Bartramia longicauda*	-	T	E/E
Vesper sparrow	*Pooecetes gramineus*	-	SC	E/SC
Yellow-breasted chat	*Icteria virens*	-	SC	-
Yellow-crowned night-heron	*Nyctanassa violaceus*	-	-	T/T
Mammals				
Allegheny woodrat	*Neotoma magister*	-	E	E
Blue whale*	*Balaenoptera musculus*	E	E	E
Eastern small-footed bat	*Myotis leibii*	-	SC	-
Fin whale*	*Balaenoptera physalus*	E	E	E
Humpback whale**	*Megaptera novaeangliae*		E	E
Harbor porpoise*	*Phocoena phocoena*		SC	
Indiana bat	*Myotis sodalis*	E	E	E
New England cottontail	*Sylvilagus transitionalis*	-	SC	-
Northern long-eared bat	*Myotis septentrionalis*	T	T	-
North Atlantic right whale*	*Eubalaena glacialis*	E	E	E
Sei whale*	*Balaenoptera borealis*	E	E	E
Small-footed bat	*Myotis leibii*	-	SC	-
Sperm whale*	*Physeter macrocephalus*	E	E	E

*Federally protected under the Marine Mammal Protection Act

**Under the U.S. Endangered Species Act humpback whales are broken into 14 distinct population segments (DPS). The NYNJHAT study area is within the range of the West Indies DPS, which is not listed as endangered or threatened. This species is protected under the Marine Mammal Protection Act

E=Endangered, T=Threatened, CH = Critical Habitat, SC=Special Concern, M = Marine Mammal Protection Act

For NJ bird Conservation Status, the first designation is for breeding populations and the second designation is for non-breeding populations (e.g. T/SC signifies that the breeding population is threatened and the non-breeding population is of special concern).

In short, the study area is vast and diverse, with many significant ecological resources and important habitat within. The impact analysis which is under development for the proposed concept alternatives will consider impacts to threatened and endangered species, critical habitat, tidal range and water elevations, as well as environmental justice communities and hazardous sites. Conceptual impacts will be analyzed broadly where design detail is not yet available and detailed analysis will be prepared as design detail is developed.

2.11 Reaches

As the study progressed the coastline was subdivided into 64 reaches overall to facilitate a more refined analysis of the limits of flood risk management projects being constructed under both the Future Without Project Condition (FWOPC) and the alternative plans (Figure 13). The 64 study reaches served as the basis for measures refinement and preliminary benefits calculations.

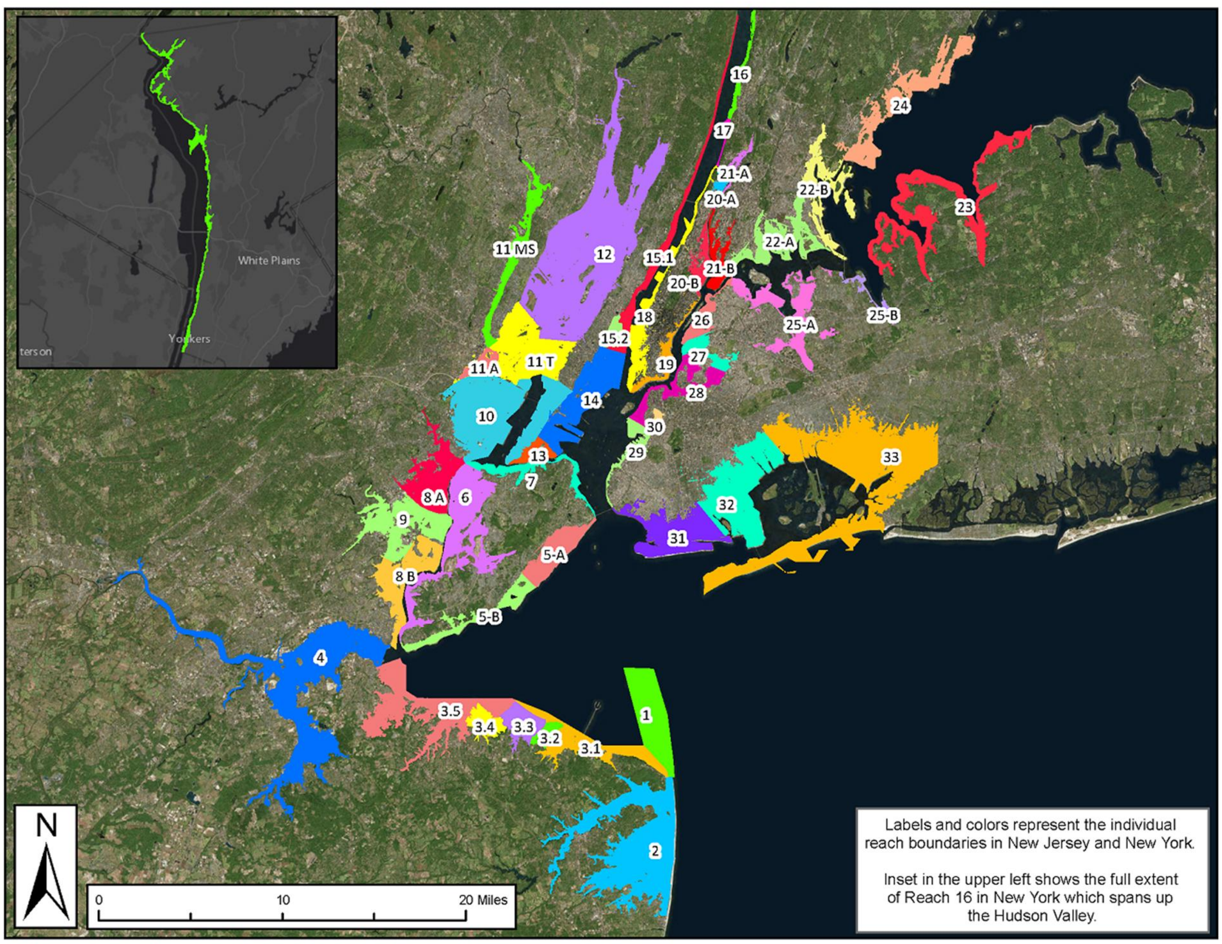

Figure 13. NYNJHAT Study Reaches

3 PLANNING PROCESS, PROBLEM IDENTIFICATION, AND BASELINES

An important step in the USACE planning process is identifying the water resources problem to be solved, and what will happen if USACE does not take action, in what is known as the No Action Alternative. The No Action alternative serves as the baseline for evaluating the performance of other alternatives. This evaluation happens in an iterative, risk-informed planning process described in this section.

3.1 Iterative Formulation Process

For the initial round of alternatives screening, the focus is on the feasibility of implementing system-wide, or basin-wide, or site-specific CSRM solutions. In other words, the primary question is the optimal scale of a solution. A system-wide solution has the potential to reduce the number of localized studies and projects, resulting in considerable economies of scale. However, it may not leverage the benefits of existing and planned CSRM projects, resulting in what may be unnecessary expenditures. For this reason, the Future Without Project Condition is critical to the calculation of potential benefits. At this first stage of screening, benefits and costs are calculated on a parametric basis, and the goal is to identify system-wide, basin-wide, and site-specific scales of solutions in order of maximum return. At this point, there are assumptions of the type of measures to be included for cost estimating purposes. However, the specific type of barrier, gates, and SBM's (floodwall vs levee, nonstructural, or natural and nature-based features) have not yet been confirmed, nor their exact locations. Documentation from this first round of screening will include assumptions made, major uncertainties, and the analyses recommended to address the uncertainties.

In the second round of formulation, the optimal scale of solution (whether system-wide, basin-wide, and site-specific) is further developed through the recommended analyses from the first round to arrive at the best combination of measures (barriers, floodwalls, levees, pumps, nonstructural, and natural and nature-based features) and the anticipated footprint of the overall alternative, known as the TSP. Documentation from the second round of screening in the draft Feasibility Report/Tier 1 EIS will include explanations behind the selection of the specific measures, their siting, and descriptions of implementation requirements for the proposed alternative.

In the final round of formulation, comments from review of the draft report are addressed and different dimensions of the measures from the TSP will be considered for the purpose of maximizing net benefits. The footprint of the alternative is not expected to change, but the height could be lower or higher, and the study could consider more cost-effective ways to achieve the target level of risk reduction. This final round, through which the TSP becomes the Recommended Plan, will be documented in the Final Report/Tier 1 EIS.

3.2 Risk Informed Planning

For risk informed planning, the project delivery team must continually ask critical questions about the appropriate level of detail necessary to make decisions. Throughout the study process, the team makes continuous choices about what data is necessary to make planning decisions and the appropriate level of detail for the phase of the study.

The study team progressively and deliberately determines the level of detail they need to make the next planning decision. The study team must balance its choice for additional detail with the funds and time available against the risk and uncertainty of decision outcome. Using these tools in conjunction with clear communication of decisions and understanding of the risks helps achieve the integration with all members of the study team, as well as project reviewers from USACE North Atlantic Division and USACE Headquarters.

The first step in any planning study is to identify the problem to be solved.

3.3 Problem Identification

The study area is vulnerable to damage from storm surge, wave attack, erosion, and intense rainfall events that can also cause riverine or inland flooding. These forces constitute a threat to human life and increase the risk of flood damages to public and private property and infrastructure. The study area encompasses the New York Metropolitan Area, including the most populous and densely populated city in the United States and the six largest cities in New Jersey. This region is the hub of financial centers and international trade, qualifying it as one of the most important economic regions in the world. The City of New York alone had a Gross Metropolitan Product (GMP) of $1.6 trillion in 2016. The study area is highly urbanized, and with existing geography, topography, and proximity to tidally influenced areas, is highly vulnerable to coastal storm damage. Projections of climate change and sea level change effectively increase the risk/vulnerability of this area to future flooding events and coastal storm damage.

Coastal storms have played important roles in shaping the present-day shoreline through erosion and movement of sand. Development of housing and waterfront properties along the coastline has placed many property owners in areas of high vulnerability due to the lack of shoreline stabilization, erosion of supportive and protective landforms, and surge during coastal storms. Historic sea level change has exacerbated flooding over the past century, and potential sea level change in the future will only increase the magnitude, frequency, and extent of the problem. Since 1900, relative sea level has risen by more than a foot within the study area due to global climate change and local land subsidence (NPCC2, 2013). According to the NYS 2100 Commission Report (2013), experts project sea level to rise in New York City and Long Island by as many as six feet under certain scenarios within the next 90 years. As sea levels continue to rise, coastal storms will cause flooding over a larger area and at increased heights than they otherwise would have in the past.

The States of New Jersey and New York, in their respective state hazard mitigation plans, have documented the numerous, historic instances of flooding, Presidential disaster declarations, and damage estimates. Coastal storms have and will continue to cause flooding and severe impacts to the NYNJHT study area. It is projected that the frequency and intensity of these coastal storms will increase (NPCC2, 2013). Between 1996 and 2013, 22 major coastal flooding events were recorded for the study area (NOAA NCDC, 2013).

Most recently, Hurricane Sandy damaged or destroyed at least 650,000 houses and left approximately 8.5 million customers without power during the storm and its aftermath. Preliminary estimates from the event exceed $50 billion in damages (NOAA, 2013), with 24 states impacted by the storm. Hurricane Sandy caused devastation in the study area, damaging property and disrupting millions of lives. As a result of the storm, 48 people lost their lives in NY and 12 people lost their lives in NJ.

Some of the highest storm surges and greatest inundation, which reached record levels, occurred in New York and New Jersey. Storm surge caused flooding at 10 feet above ground level in some locations. The storm exposed vulnerabilities associated with inadequate CSRM measures and lack of defense to critical transportation and energy infrastructure. Environmental impacts to the study area were also significant. Storm surge inundated regional wastewater plants and with additional loss of power to key electrical and operational components, billions of gallons of untreated and partially-treated wastewater were discharged into receiving water bodies. Hazardous waste sites, such as those identified through the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), otherwise referred to as Superfund sites, brownfields, petrochemical plants, and fuel refineries were also inundated and spills reported. Hurricane Sandy's size, path, and timing caused unprecedented damages within the study area. Collateral losses also include disruption of commerce, unemployment due to inundated workplaces and transportation systems, expenses for disaster relief and cleanup, and other related costs.

In support of a comprehensive and systematic characterization of the problem, a GIS inventory of vulnerable resources and their risk from coastal storms was compiled for the NACCS and the NYNJHAT FAA, in what is known as the composite risk index (see GIS Appendix). This product can be used to determine which areas are considered high risk. For the current study effort, the composite risk index was updated through the following tasks:

- USACE or local projects have modified the shoreline in the NYNJHAT study area. Best available ground surface elevation data can be obtained to represent current conditions. The Future Without Project Condition (FWOPC) can be developed to take into account planned and in-progress resiliency projects so vulnerability and risk are reduced in areas that will be protected by these soon to be constructed projects. With projects implemented along the shoreline of the NYNJHAT area, residual risk will always remain. Residual risk is the flood risk to people and assets after all implementation efforts to reduce risk are completed. It is important to identify residual risk to account for extreme flood extents associated with a catastrophic event. Often, flood risk management measures do not reduce risk associated with an extreme event. As observed with the incorporation of projects into the vulnerability index for the FWOPC, few projects manage risk to a catastrophic event.

- ADCIRC storm surge modeling, completed as part of NACCS, is now available to determine inundation extents for typical and extreme flooding events (Figure 14).
- Available exposure data has since been updated. Nationwide, regional, and local datasets are updated and incorporated.
- Since the NACCS covered such a broad area, city or area-specific exposure datasets were not incorporated due to lack of consistent coverage across regions and states. Because this study is focused entirely on the NYNJHAT area, additional refinement to specific data (airports and train stations) where detailed data was available allowed for factoring in passenger volume and ridership on a location-by-location basis into the development of weights within those data layers.
- Additional datasets, not included in NACCS, are incorporated to enhance the study output, notably building replacement value and employment data.
- In coordination with USACE and local sponsors, modifications to weighting and datasets preferences were incorporated. The weights as defined in NACCS were rigid for consistency across the NACCS study area. Flexibility of on-the-fly factoring of datasets allows for a comparison of different preferences.
- In NACCS, exposure indices were a function of the three broad exposure categories: 1) Population Density and Infrastructure, 2) Social Vulnerability, and 3) Environmental and Cultural Resources. Each of these exposure categories were comprised of subcategories (e.g., population density and infrastructure were combined as one index; environmental and cultural resources index was comprised of environmental data layers, habitat, and cultural resources). For the update, each exposure index is assigned its own weight (Table 6).

Table 6. Update to Exposure Index Weights from NACCS for NYNJYHAT Study

NACCS CATEGORY	NACCS WEIGHT	NYNJHAT CATEGORY	NYNJHAT WEIGHT
Population Density Infrastructure	80%	Population Density	25%
		Infrastructure	30%
		Building Value	20%
Social Vulnerability	10%	Social Vulnerability	10%
		Employment	10%
Cultural and Environmental Resources	10%	Cultural	5%
		Environmental	0%
		Habitat	0%
Total	**100%**	**Total**	**100%**

This simplifies the risk equation, allows for expansion with additional categories and clarifies the impact of weighting on the final risk product (Figure 15).

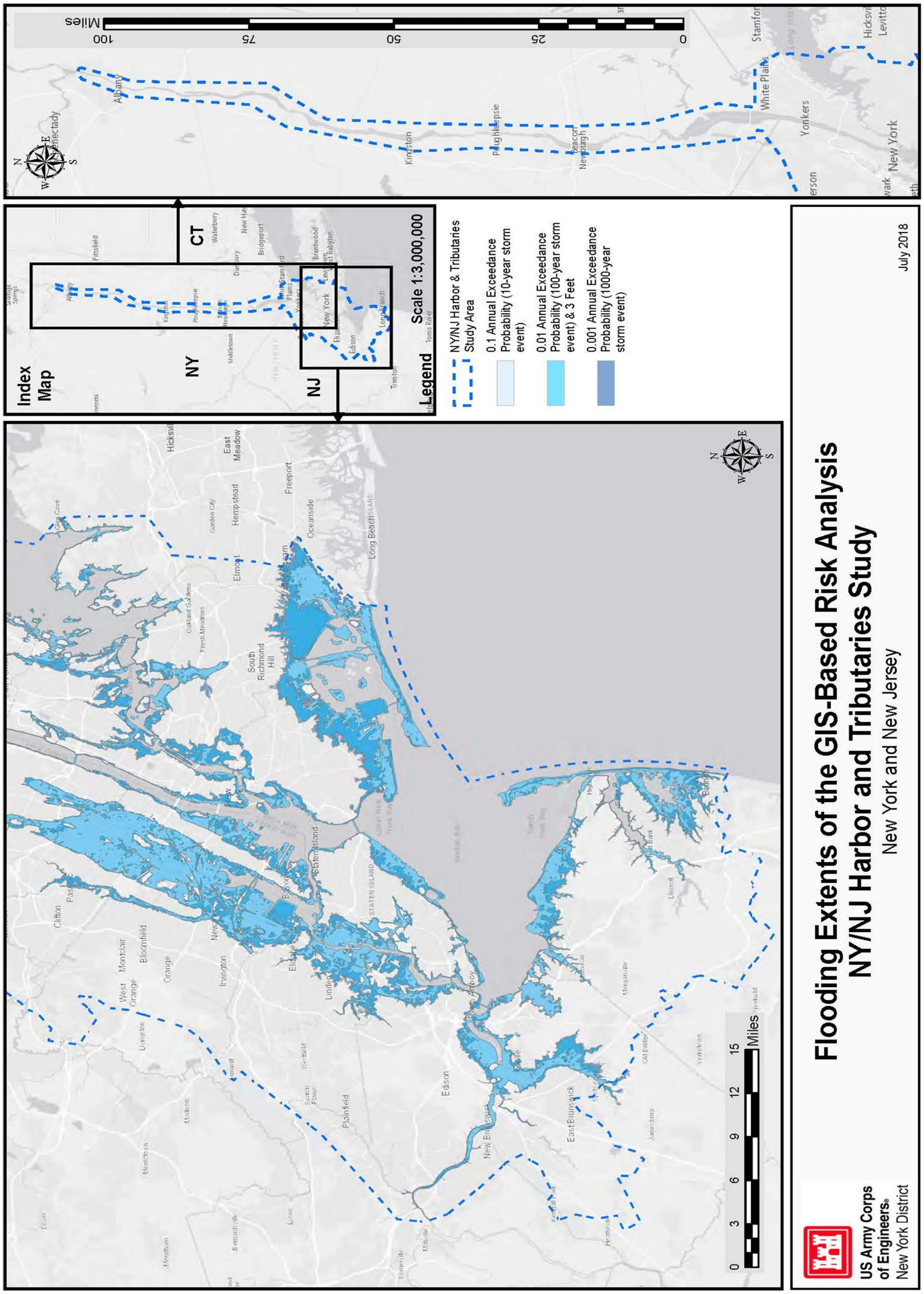

Figure 14. Flooding Extents of GIS-Based Risk Analysis

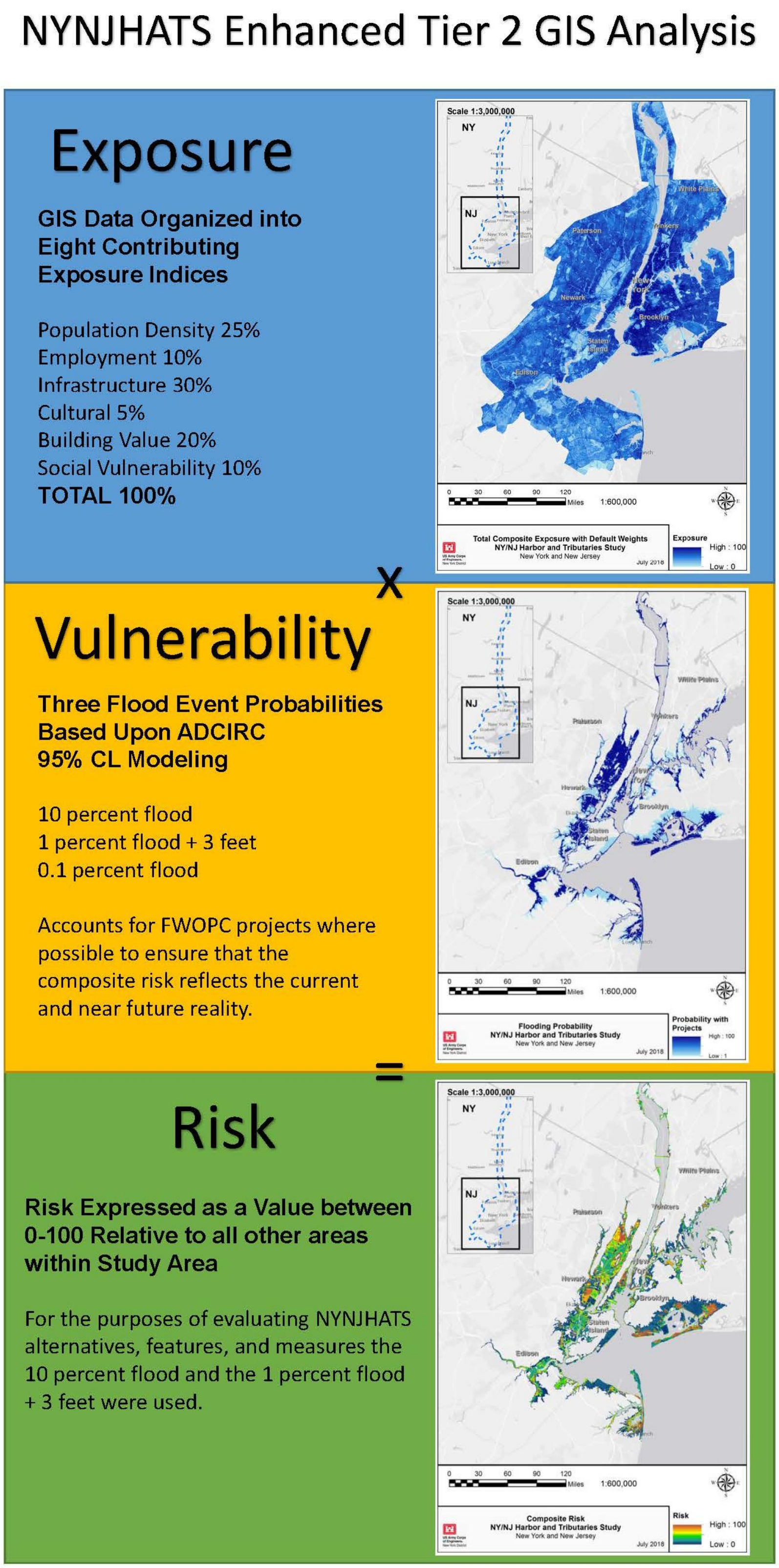

Figure 15. Risk Calculation

3.4 Future Without Project Conditions

In the Future Without Project Condition, it is anticipated that the study area will continue to experience damages from coastal storms, and that the damages may increase as a result of more intense storm events. For this initial round of plan formulation, the decision was made to compare the alternatives using a present worth analysis (due to the complexities of comparing features with a wide range of implementation timeframes). Effectively, the base year has not yet been established. Without project damages from 2030 to 2100 have been calculated at this time, with the period of analysis (over 50 years, starting when the last feature of the initial construction elements of recommended plan become operational) to be identified for the upcoming draft report The planning horizon, which is a 100-year period to account for the effects of relative sea level change, has been identified as 2022-2122 (starting from the conclusion of this study).

Another consideration for the FWOPC is the numerous recovery efforts and resiliency improvements to address CSRM in the study area. As part of a federal agency collaborative effort, these efforts are tracked in a database detailing the action and its current stage of development (e.g., conceptual to construction). While some efforts are relatively certain as they are near or in construction, others are largely conceptual with uncertainty in scope or funding. Also, some efforts will have very localized and site specific effects, and may not substantially change the broader CSRM planning for the study area.

This section presents prior USACE studies, existing reports, existing USACE water projects, and existing projects by other agencies, and then identifies which projects are included in the FWOPC. Some will affect economic justification of alternatives and need to be included in the modeling of potential benefits. Other projects included in the FWOPC may have unquantified, indirect or relatively localized/minor benefits to CSRM. In that case, they will be included in the assessment of cumulative impacts for the upcoming NEPA document. More details are in the Plan Formulation Appendix.

3.4.1 Prior USACE Studies, Reports, and Existing Water Projects

The USACE has played a major role in water resource planning and project execution in the New York and New Jersey Harbor Estuary, Hudson River, Passaic River, Long Island Sound, and related waterways for more than 200 years. The following is a summary of major existing, planned, and ongoing USACE water resource projects, studies, and reports.

3.4.1.1 Coastal Storm Risk Management

USACE has constructed or completed studies for over a dozen major CSRM projects and erosion control projects in the study area. Major constructed projects include the ocean-side portion of the East Rockaway Inlet to Rockaway Inlet (Rockaway Beach) and Jamaica Bay project, and the Atlantic Coast of New York City, Rockaway Inlet to Norton Point (Coney Island) project.

In response to Hurricane Sandy in 2012, USACE completed near-term coastal restoration work at previously completed coastal storm risk reduction projects in the study area, which involved the placement of hundreds of thousands of cubic yards of sand along beaches on the New Jersey and New York shorelines impacted by the storm. In addition, twelve authorized but unconstructed CSRM projects and twelve CSRM studies received funding for completion by P.L. 113-2 as part of the USACE's post-Hurricane Sandy response mission. Most of these studies are completed or are near completion, and the ones that are most likely to have funding and permitting by July 2020 are included in the economics modeling for the Future Without Project Condition assumptions.

There are ongoing CSRM studies adjacent to the NYNJHAT study area: New Jersey Back Bays feasibility study on the Jersey shore and the Nassau County Back Bays feasibility study and the Fire Island to Montauk Point General Reevaluation study on the south shore of Long Island, which taken together with the NYNJHAT study, provide for contiguous assessments of coastal storm risk on the Atlantic shorelines of New Jersey and New York.

3.4.1.2 Flood Risk Management

USACE has constructed or completed studies for almost two dozen major FRM projects and streambank stabilization projects in the study area. Constructed projects include major portions of the Green Brook project along the Raritan River in New Jersey, and streambank stabilization projects in Westchester County, New York. Major ongoing or completed studies include those for the Rahway River, South River, Lower Saddle River, Ramapo River, Peckman River, Saw Mill River, Green Brook River, and the Mamaroneck River, Byram River and Westchester County streams in New York and Connecticut.

3.4.1.3 Navigation

USACE has dredged and/or maintains over two dozen federal navigation channels in the study area that support nationally-important trade and recreation. Significantly, the USACE recently deepened major harbor navigation channels of the New York and New Jersey Harbor to 50 feet at a cost of $2.1 billion, in support of regional and national economic growth. The Port of New York and New Jersey is the largest port on the east coast of North America, the third largest in the nation, and one of the most productive high-volume port operations globally. The Port of New York and New Jersey must be dredged to maintain navigation and commerce estimated to generate about $20 billion annually in direct and indirect benefits. The port has premier access to rail, road, and inland waterway routes to transport goods to 23 million local consumers and up to 100 million customers within 36 hours at markets all over the U.S. and Canada. Most federal navigation channels under the purview of the New York District in the study area are within the Port's jurisdiction.

At the northern extent of the study area is the Troy Lock and Dam on mile 153 of the Hudson River, which the USACE operates and maintains. The lock provides significant economic and recreational support to the region, and serves as a gateway to the New York State Canal System.

3.4.1.4 Ecosystem Restoration

The New York and New Jersey Harbor Estuary, designated as an "Estuary of National Significance" by the U.S. Environmental Protection Agency, has suffered hundreds of years of urban development and extensive loss and degradation of natural habitats. These impacts have reduced the diversity, abundance, function and integrity of the multiple ecosystems in the Estuary. In support of the USACE ecosystem restoration mission, the USACE New York District completed the Hudson-Raritan Estuary Comprehensive Restoration Plan in 2009. It provides a framework for the estuary's restoration, the feasibility of which is currently being investigated as part of the Hudson-Raritan Estuary Ecosystem Restoration Study and the Hudson River Habitat Restoration Study.

USACE has beneficially used hundreds of thousands of cubic yards of dredged material from channel dredging to restore habitat in the study area. A number of marsh island habitats have been restored in Jamaica Bay, New York via the beneficial use of dredged material program.

3.4.1.5 Water Supply

USACE has executed over 40 projects that support and enhance the water supply system for the City of New York, which provides water for 8 million residents in New York City and 1 million residents in neighboring suburbs.

3.4.2 Existing Water Studies and Projects by Other Agencies

Information on existing water studies and projects by other agencies comes from the Sandy Recovery Infrastructure Resilience Coordination (SRIRC) Group, which compiled a tracking sheet of over 400 efforts in the region. The time period over which these various studies and projects may be performed or implemented varies and is oftentimes uncertain. Given the uncertainty, for purposes of evaluating these projects for the FWOPC for the study, the date of the USACE Agency Decision Milestone for the study (i.e., July 2020) has been used as a cut-off date to screen which efforts are anticipated to be fully permitted, funded and into construction by that date. Following the criteria and cut-off date of July 2020, out of over 400 projects tracked in the federal database, approximately 160 projects have been identified for inclusion in the cumulative impacts assessment for the study (Plan Formulation Appendix). Highlights of these 160 projects are presented in Table 7.

Table 7. Existing Water Studies and Projects by Other Agencies

Main Agency	Types of Actions
DOI	- Provide community protection while strengthening ecosystem resiliency from floods and run-off impacts. - Restore ecosystem function and habitat. - Improve water quality and resilience through stream daylighting. - Develop a self-sustaining oyster population. - Restore 11 acres of salt marsh and 16 acres of coastal upland in Queens, New York. - Restore five acres of wetland and seven acres of upland habitat in Queens, New York. - Construct a 6,400 foot coastal dune and restore 17 acres of marsh in Monmouth Beach, NJ. - Strengthen Coney Island's resilience through installation of 14 green streets in Brooklyn, New York. - Incorporate natural and nature-based infrastructure into Block 12's redesign in Hoboken, New Jersey. - Perform 54 municipality assessments and impervious cover reduction action plans for the Raritan River Basin in New Jersey. - Restore Newark Bay's wetlands in New Jersey. - Create and improve Liberty State Park's 40 acres of salt marsh and 100 acres of upland habitat in Jersey City, New Jersey.
FEMA	- Repair, rehabilitation, and stabilization of a 7,750-foot seawall in the City of Troy, NY. - construct a floodwall around the West Field Lighting Vault Building at LaGuardia Airport. - Elevation and extension of the Klein Avenue Levee in Clarkstown, NY. - A double dune system n Breezy Point, Queens. - Restore over 150 acres of valuable maritime habitats including 86.6 acres of upland buffer (dunes and maritime forest), 49 acres of low marsh, 10 acres of high marsh, and 6 acres of tidal creek. - Elevate flood prone private residential structures at or above the base flood elevation. - Acquire and demolish properties in the flood-prone communities in Middlesex County, NJ. - Upgrade and enhance resiliency of 104 scour-critical and flood prone bridges across the State of New York.
HUD	- Experimental flood protection levee to keep the peninsula (Hunts Point, Bronx) dry while providing waterfront greenway for the everyday use. - System of breakwaters that buffer against wave damage, flooding, and erosion and are also designed to sustain habitat. - Comprehensive urban water strategy that deploys programmed hard infrastructure and soft landscape for coastal defense. - Protective system around Manhattan from West 57th Street south to The Battery and to East 42th Street. - Intricate system of berms and marshes to protect against storm surges, collect rainfall, and reduce sewer overflows in adjacent towns (Meadowlands, NJ).
NOAA	- Contract topometric-bathymetric light detection and ranging (LiDAR) data collection of the shoreline in the highest impact areas from Hurricane Sandy. - Refine datum models to support hydro and shoreline surveys from Rhode Island to New Jersey (CO-OPS). - Establish global positioning system observations for determining geodetic to ellipsoid relationships at historic tidal gauge sites (NGS).
USDA/NRCS	- Provide $7.5 million to restore urban wetland. The project includes creating wetland pools that will reduce the speed of water flow and hold flood and storm water. - Floodplain Easement Program (EWP-FPE) acquires an easement in lieu of recovery measures is the more economical and prudent approach to reducing a threat to life or property.
USDOT/NJ TRANSIT	- Reduce the risk of flooding to Hoboken rail yard and the city by filling a deteriorated inlet inside the rail yard (Long Slip). - Replace the aged and deteriorated Raritan River Drawbridge that was damaged by Hurricane Sandy. - Raise and protect vulnerable train signal, communication, and switch systems located within the 100-year flood zone for multiple rail lines.
USDOT/ PANYNJ	- Floodproof major above ground PATH facilities and equipment to prevent flooding of underground assets. - Construct an automated flood barrier at the Harrison Car Maintenance Facility. - Construct a concrete seawall to protect PATH tracks near the Passaic River.
USDOT/ NYCDOT	- Acquire new ferry vessels for the Staten Island Ferry that are capable of side boarding; upgrade ferry landings to accommodate such vessels; and flood proof existing terminals to improve response to disasters.

Main Agency	Types of Actions
USDOT/MTA	- Construct multiple forms of flood protections at four rail yards that are vulnerable to flooding. - Make flood protections for substations throughout system, and acquire four mobile substations for use in emergency response. - Reduce the risk of floodwaters entering and traversing underground infrastructure through sealing at vulnerable locations. - Make flood protections for three NYCT support facilities: The Tiffany Central Warehouse, Zerega Central Maintenance and Training, and Revenue Control Facility. - Install flood protections at street-level openings (stairs, vents, etc.) at locations throughout the system that are between the 100- and 500-year flood hazard areas and beyond. - Make flood protections for the Metro-North Railroad Hudson River Line, Long Island Rail Road, Amtrak subway, police stations, bus depots and critical underground infrastructure. - Flood proofing of communications and signal rooms at 20 key subway stations within the flood hazard area. - Upgrade pumping capacity by improving existing equipment, purchasing mobile equipment and creating two new pump trains.
NJDEP	- Union Beach Beachfill. - Sea Bright Seawall. - Bayshore Flood Gate facility management. - Build ecological solutions to coastal community hazards. - Study conducted by Rutgers University: a) determined the causes of flooding in the Cities of Elizabeth, Linden and Rahway, and Woodbridge Township; b) determined current measures and measures envisioned by officials; and c) offered recommendations to mitigate flood risks (Rutgers, 2014d). - Assessment of the flood pathways in Hudson County. - Identified regional and municipal flood risk reduction strategies for both the Hackensack River and the Hudson River waterfront including the municipalities of Hoboken and Jersey City. - Investigation of alternative measures for flood mitigation in the Hackensack/Moonachie/Little Ferry area (NJIT, 2014a).
NY Rising	- Evaluate cost and feasibility of various stormwater capture and retention approaches, wetland creation, constructing berms and deployable floodwalls, develop flood protection strategies, and performing a feasibility study and conceptual design for multipurpose flood barriers using a raised greenway, berms, and deployable flood walls on the east and west sides of Lower Manhattan. - Develop flood prevention strategies, implement stormwater management measures. - Repair, rehabilitate, upgrade, and fortify critical infrastructure (transportation, wastewater facilities, interceptors, and sewer lines). - Enhance dune walkways; develop coastal protection projects in Breezy Point, Rockaway Point, and Roxbury. - Restore the Sunset Cove ecosystem and integrate it into a larger restoration project by the NYC DPR. - Use natural and nature-based infrastructure for stormwater collection and treatment. - Leverage existing coastal protection initiatives, including those by USACE, planting and stabilizing temporary dunes and to fill in the gaps of dunes, construction of a dune system. Additional projects include installing Best Management Practices to capture stormwater, alleviate flooding, and improve water quality in the Staten Island Bluebelt, along New Creek and Hylan Boulevard. Property acquisition and buyouts are another proposed project in South Beach.
NYC EDC/ NYC ORR	- Construction of a new, more resilient boardwalk that features various coastal protection structures such as a sand retaining wall, a dune “betterment” which will increase the overall height of the USACE dune, sand infill underneath the new boardwalk, dune plantings, and other sand retention measures. - Elevated, steel-reinforced concrete and multiple layers of protection, including approximately six miles of retaining walls and planted dunes, the design is being rethought to make it sturdier and better able to withstand future hurricanes. - Understand the extent of shorelines exposed to RSLC, reinforce the shoreline to prevent erosion, and address risk of RSLC by increasing the height of coastal edges. - Investigate hydrological management strategies that would prevent and mitigate upland flooding, improve waterfront open space, strengthen neighborhood connections, enhance infrastructure, and provide opportunity for economic development.

3.4.3 Assumed Projects

Of the 160 projects identified, there are approximately 47 assumed projects that could affect economic justification of alternatives and were factored into the economics modeling of benefits (Figure 16 and Plan Formulation Appendix, Fact Sheets). This list of assumed projects will be updated at key milestone points, up to submission of the final report to USACE Headquarters.

List of Fact Sheets Included

- NTA NYCT Flood Mitigation in Rail Yards – Coney Island Rail Yard
- MTA LIRR West Side Yard and East River Tunnel Portal Flood Mitigation
- MTA NYCT Protection of Transit Street Level Openings
- NYC Comprehensive Ferry Transit Resilience Project
- NYS Staten Island Residential Buyout Program
- NYC Rockaway Line Resiliency
- NJ Transit Train Controls, Signals, Power & Communication Resiliency
- NYC Transit Flood Resiliency for Critical Bus Depots
- NYC Transit Tunnel Portals and Internal Tunnels
- Metro-North Power and Signal Resiliency
- PANYNJ Exchange Place, Newport Station & Grove Street Station Head House Protection
- PANYNJ LaGuardia Airport Mitigation
- NYC Transit Internal Station Hardening
- PANYNJ Extension of PATH Rail Yards
- LIRR Long Island City Yard Resiliency
- NYC Transit Right-of-Way Equipment Hardening
- NYC Raised Shorelines
- PVSC Passaic Valley Sewerage Commission Repairs and Mitigation
- New York NYU Langone Medical Center
- New York Coney Island Hospital Repairs and Mitigation
- New York Bellevue Hospital
- New York Flood Mitigation in Rail Yards – 207th Street
- New York New York Harbor Healthcare System
- New Jersey Hoboken Long Slip Flood Protection
- New York Amtrak Hudson Yards Concrete Casing
- New York Flood Mitigation in Rail Yards – 148th Street
- LEONJ Leonardo Costal Storm Risk Reduction Project, NJ
- JGMNJ Joseph G. Minish Park Coastal Erosion Project, NJ
- PRTPA Passaic River Tidal Protection Area, Newark, NJ
- PMNJ Port Monmouth Coastal Strom Risk Management Project, NJ

- SSSI South Shore of Satan Island Coastal Strom Risk Management Project, NY
- UBNJ Union Beach Storm Risk Management Project, NJ
- NJ State Edison Pump Station Mitigation
- NJ Hoboken Wet Weather Pump Station H5
- NYC Lower Manhattan Coastal Resiliency Project
- NJ North Hudson Sewerage Authority Mitigation
- NJDEP Old Bridge MUA Laurence Harbor Floodwall
- PANYNJ Concrete Sea Wall and Flood Barrier at PATH Harrison Car Maintenance Facility
- FRA Penn-Moynihan Station Complex-Train-Shed Hardening Project
- USACE Coney Island Coastal Storm Risk Reduction Project
- NYC East Side Coastal Resiliency
- NJDEP Middletown Township Sewer Authority TOMSA Mitigation
- NJDEP Rebuild by Design – Hudson River
- USACE Oakwood Beach Wastewater Plant Mitigation
- NJ State Sayreville Pump Station Mitigation

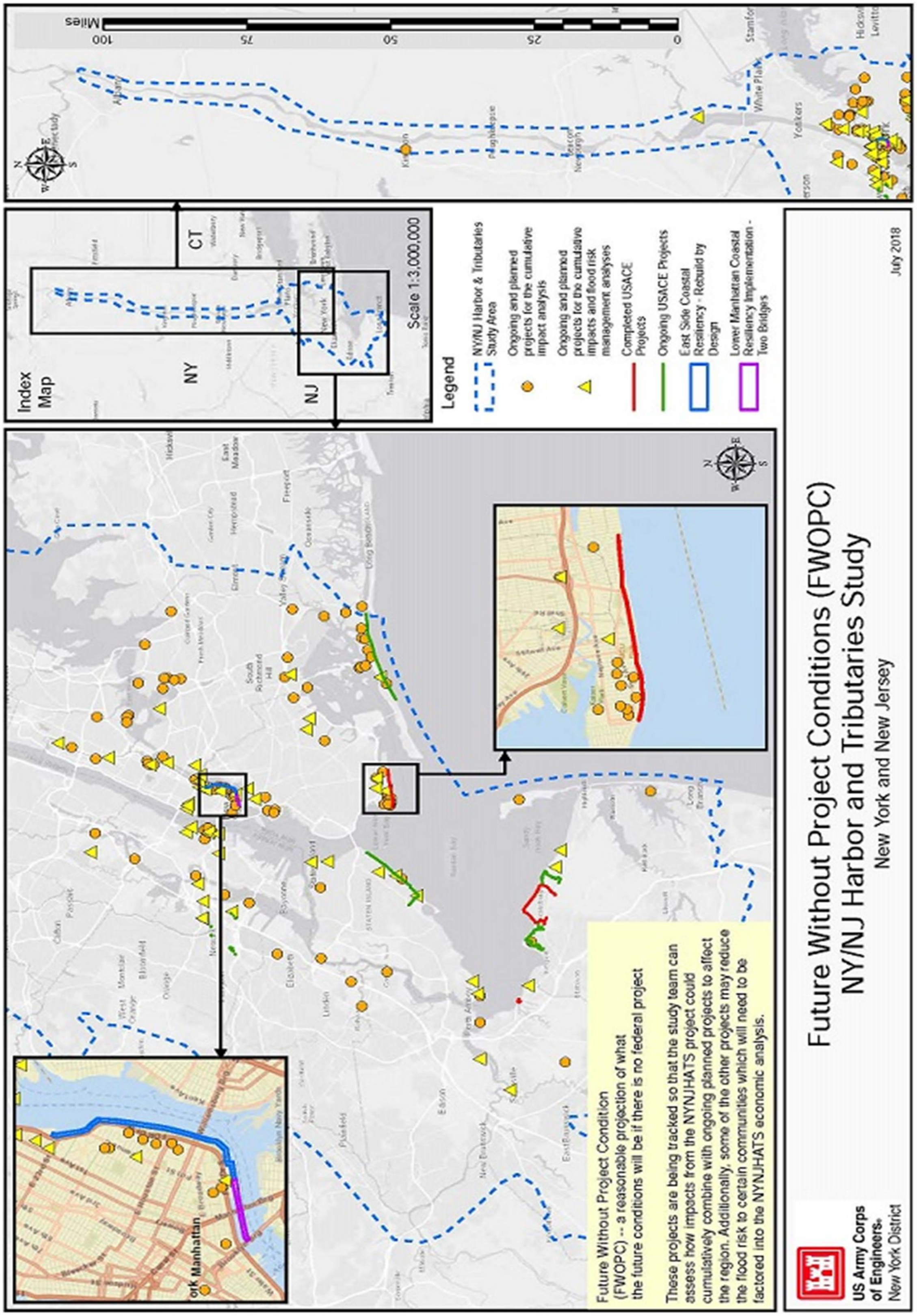

Figure 16. Projects Assumed for the Future Without Project Condition

3.4.4 Relative Sea Level Change

Sea level change (SLC) is a change in the mean level of the ocean. Relative or "local" sea level change (RSLC) is the locally observed change in sea level relative to a fixed point. 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 or subsidence of the Earth's crust in locations previously covered by glaciers, the compaction of sedimentary strata and the withdrawal of subsurface fluids. USACE projects must consider sea level change when planning and designing projects, per Engineering Regulation (ER) 1100-2-8162 (December 31, 2013).[4]

ER 1100-2-8162 requires that future RSLC projections must be incorporated into the planning, engineering design, construction and operation of all civil works projects. The study team should evaluate the proposed alternatives in consideration of the "low," "intermediate," and "high" potential rates of future RSLC for both "with" and "without project" conditions. This range of potential rates of RSLC 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 RSLC is determined directly from gauge data gathered in the vicinity of the study area.

Because of the spatial extent of the study area, there are multiple relative sea level change (RSLC) curves for the area, and the sensitivity of plan formulation to RSLC varies greatly. USACE projections for the Battery, NY are shown in Figure 17, and range from an increase of +0.7 feet for the low scenario up to five feet for the high scenario through 2100. For purposes of considering the potential impacts of RSLC during initial plan formulation, the study team used the intermediate rate of relative sea level change (an increase of +1.8 feet through 2100) as a rough approximate for the median, to decrease the amount of adjustment needed later for future rounds of formulation, when the low and high rates will be evaluated as well. Based on a desktop inventory of structures compiled for the Hydrologic Engineering Center – Flood Damages Analysis (HEC-FDA) model, the expected average annual damages in the FWOPC are $5.1 billion in 2030 and expected to increase to approximately $13.7 billion by 2100, based on the intermediate rate of RSLC.

[4] An overview of how USACE considers RSLC can be found at: https://planning.erdc.dren.mil/toolbox/library/LessonsLearned/Quick%20Reference%20-%20Climate%20Considerations%20Oct2018.pdf

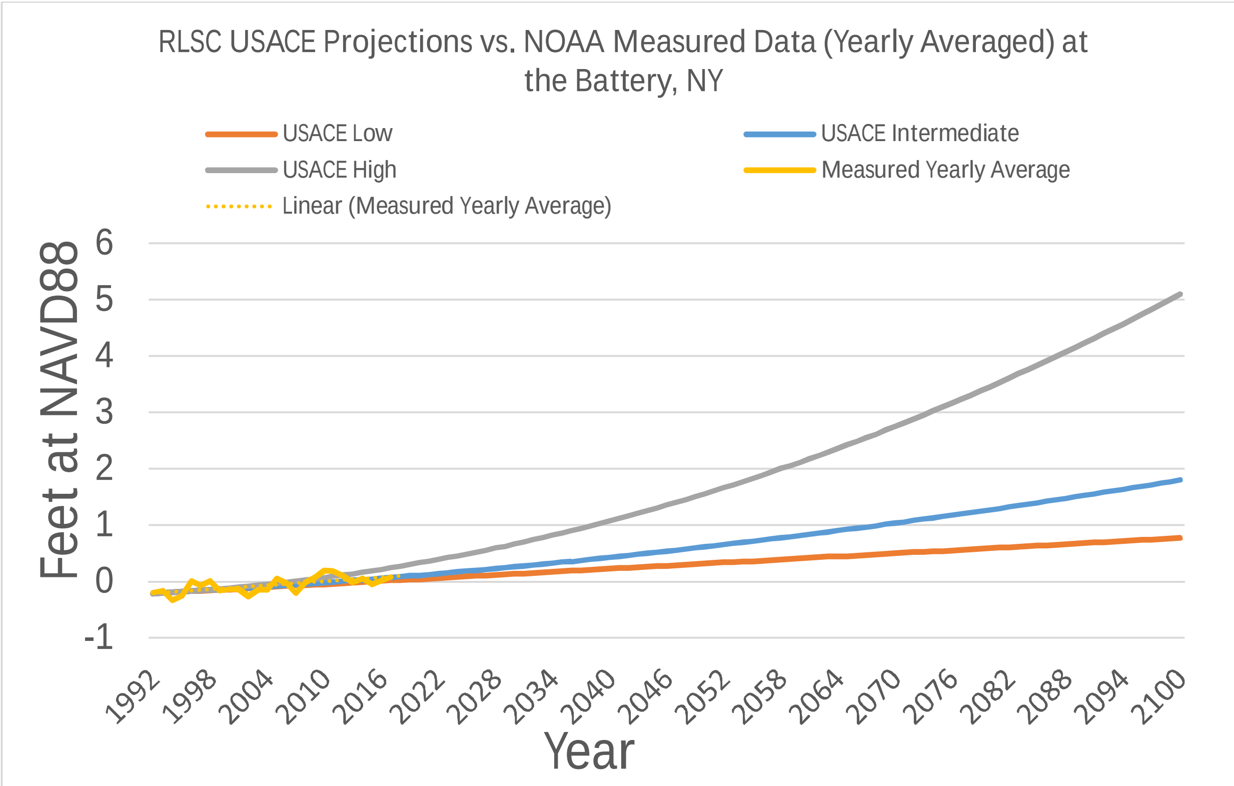

Figure 17. Sea Level Rise Projections

3.5 Planning Opportunities and Objectives

Project opportunities were developed to comply with the project authority and to respond to study area problems. The primary goal of the current study is to manage the coastal flood risk from repetitive flooding. The primary opportunity presented is the potential to reduce future damages to property and to decrease risks to life safety. Damages from such storm events present a significant risk to public health and life-safety. Opportunities to solve problems in the study area include:

- Manage coastal storm flood risk
- Better communicate coastal storm risk to communities
- Restore natural systems in ways that may provide CSRM benefits
- Contribute to community rebuilding and resilience
- Improve port resilience and navigation maintenance requirements

Planning objectives were identified based on the needs and opportunities, as well as existing physical and environmental conditions in the project area:

- Reduce the risk of coastal storm damage to communities, public infrastructure, important societal resources, and the environment

- Improve the community's ability to recover from damages caused by storm surges by reducing the duration of interruption in services provided by man-made and natural systems.
- Enhance human health and safety by improving the performance of critical infrastructure and natural features during and after storm surge events. (Areas that had USACE projects in place during Hurricane Sandy had fewer flood damages – for instance, faster and smaller scale clean-up of roads, which meant less impact to emergency response times.)
- Restore natural coastal features that have ability to reduce coastal storm risk for communities and ecosystems

3.6 Planning Constraints and Considerations

Unlike planning objectives that represent desired positive changes, planning constraints represent restrictions that limit what could be done and are recognized as constraints because they should not be violated in the planning process. The planning constraints identified in this study are as follows:

- Minimize impacts to ongoing recovery, ecosystem restoration, and risk management efforts by others;
  - There are multiple agencies, which are planning and constructing infrastructure, ecosystem, and risk management improvements within the project area. Some of this work is in response to Hurricane Sandy; other efforts are part of other ongoing programs (see Plan Formulation Appendix).
- CSRM plans that fall within the boundaries of or impact the resources of the Gateway National Recreation Area must be mutually acceptable to the Department of the Interior and the Department of the Army5;
- Minimize impacts to access for federal navigation channels;
  - The federal navigation channels within this study area serve navigation interests including commercial cargo transport, charter fishing fleets, and recreational boaters;
- Minimize induced flooding in areas not currently vulnerable to flooding and minimize induced additional flooding in flood-prone areas;
- Minimize impacts to community access and egress during emergencies;

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[5] The authorizing legislation (P.L. 92-592, 1972) for GNRA recognized the potential need for water resource development projects within the Corps mission to be undertaken within its boundaries by establishing that that there must be agreement between the two agencies.

The authorizing language states that "The authority of the Secretary of the Army to undertake or contribute to water resource developments, including shore erosion control, beach protection, and navigation improvements (including the deepening of the shipping channel from the Atlantic Ocean to the New York harbor) on land and/or waters within the recreation area shall be exercised in accordance with plans which are mutually acceptable to the Secretary of the Interior and the Secretary of the Army."

- Island and peninsular communities within the study area currently have limited access, egress, and emergency evacuation routes;

- Minimize impacts to operations at International Airports.
- Minimize negative effects to plants, animals, or critical habitat of species that are listed under the Federal Endangered Species Act or a New York State Endangered Species Act.

In addition to planning constraints, which may be used to screen alternatives out if mitigation is infeasible, planning considerations also inform the planning process and may be used to help differentiate among alternatives.

- Local sensitivity to certain measures (e.g., acquisition, unintended adverse impacts to communities and/or the environment).
- Enhancing sustainability by incorporating resilient features
- Complement other post-Hurricane Sandy resilience projects and planning efforts (avoid duplication of effort)

4 CONCEPTUAL MEASURES AND ALTERNATIVES

Having established the baseline and parameters for this planning study, this report now turns to potential solutions, in the form of CSRM measures that may be combined to form alternatives for evaluation. Please note that the measures and alternatives in this report are preliminary and conceptual, subject to modifications (including being dropped from consideration or added if not currently in the descriptions) once more site-specific data are collected.

4.1 Management Measures

For initial planning purposes, the study area was divided into 64 reaches based on water body and county limits (Figure 18). For each reach, a suite of structural (Table 8), nonstructural (Table 9), and natural and nature based features (Table 10) from the NACCS report were considered. In the first round of assessment for USACE participation, measures that were a non-federal responsibility were removed (and are shaded with grey in the table).

The remaining measures were screened by dominant shoreline type of each reach. Offshore barriers, nonstructural actions, and natural and nature-based features (NNBF) apply to the entire study area. Beach fill solutions were limited to Raritan Bay and Sandy Hook Bay, Lower Bay, Jamaica Bay, and Atlantic coast line. From this step, alternatives were developed based on systems approach, starting with alternatives that would maximize spatial coverage of the study area and progressing to more localized, perimeter-based scale solutions.

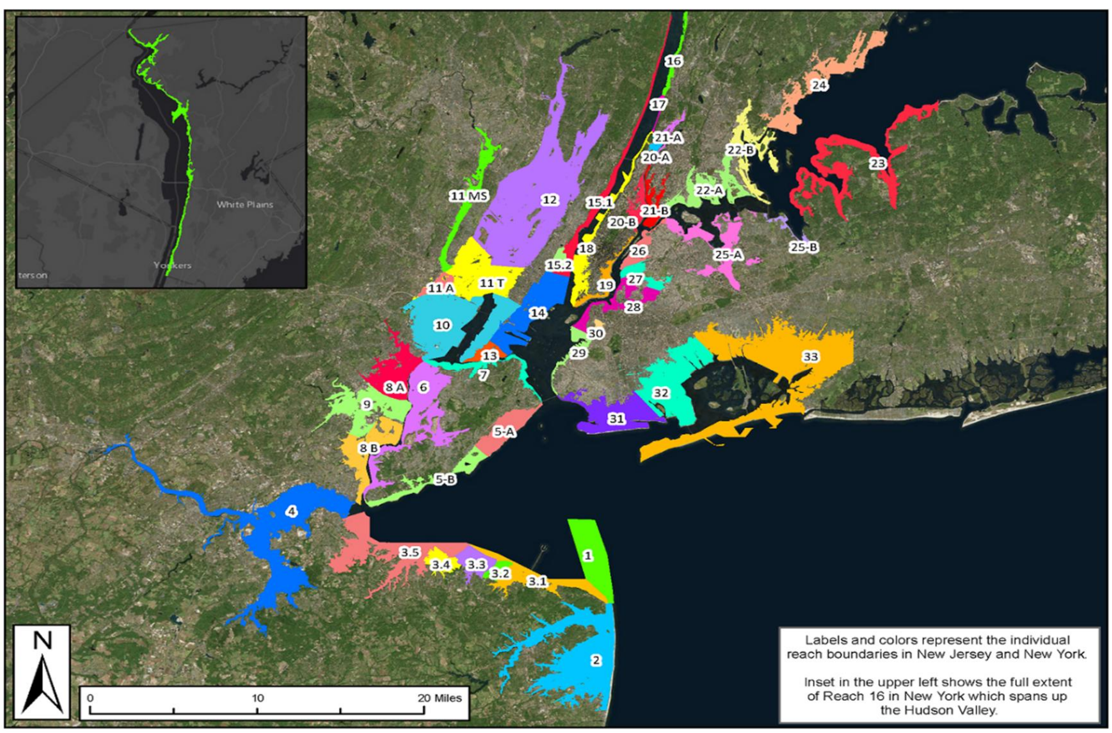

Figure 18. NYNJHAT Planning Reaches

4.1.1 Structural

Table 8. Structural Measures

Seawall/revetment	Groins	Detached breakwaters
Berms/levees	Multipurpose berms/levees	Floodwalls/bulkheads
Tide gate	Deployable floodwall	Deployable berms/cofferdams
Surge barrier	Road or rail raisings	Beach and dune restoration
Bridge trash racks	Stormwater system improvements	

* Measures that are a non-federal responsibility are shaded with grey in table

4.1.2 Nonstructural

Table 9. Nonstructural Measures

Acquisition/buyouts	Early warning systems	Elevating structures
Floodproofing	Increase storage	Public engagement
Preservation	Resilience standards	Emergency response systems
Stormwater management	Building codes/zoning	Strategic Acquisition
Hazard mitigation plans	Retreat	Wetland migration
Relocating utilities and critical infrastructure	Modify/remove channel structures	Design/redesign and location of services and utilities
Coastal zone management	Regional sediment management	

* Measures that are a non-federal responsibility are shaded with grey in table

4.1.3 Natural and Nature Based Features

Table 10. Natural and Nature Based Features (NNBFs)

Freshwater wetlands	Vegetated dunes/beaches	Salt marshes
Maritime forests/shrubs	Oyster reefs	Barrier island restoration
Submerged aquatic veg.	Green stormwater management	

* Measures that are a non-federal responsibility are shaded with grey in table

4.2 Key Assumptions and Possible Sensitivities

Important assumptions used during plan formulation and evaluation include:

- Planned CSRM and resilience project that are funded for construction will be constructed according to schedule.
- RSLC projections will remain accurate. At present, none of the projections have assigned probabilities, so it is not possible to predict which scenario is the most likely. However, the working assumption is that rates of RSLC will not be slower than the historic/low rate or faster than the currently projected high rate.
- Readily available desktop information is a reasonable representation of field conditions regarding demography, zoning, natural and cultural resources, or shoreline conditions, etc.

- Existing rule of law continues, that is, major laws and statutes will continue in their current form through the period of analysis.

4.3 Array of Alternative Concepts

4.3.1 Conceptual Nature

This is the first round of formulation. Although this report shows alignments on study area maps, their locations are based only readily available desktop information and do not yet have the benefit of site specific data, recent modeling, or specific field data collection that would be required to answer questions about the full effects of these concepts. The concepts presented in this report serve to convey cost and time, construction specifics are not conceptualized as part of the initial array of the study. The actual type of barrier, gates, and SBM's (floodwall vs levee, nonstructural, or natural and nature-based features) have not yet been confirmed, nor their exact locations.

It is possible that the barriers, gates, and SBMs shown in this report could be removed from consideration as more site specific investigations indicate that the certain measures may not be technically feasible, or economically justified, or environmentally acceptable - measures must meet all three criteria to proceed. Furthermore, the study team expects to modify or add measures that are currently not shown in this report, as part of the public and agency feedback on this report. USACE encourages communities at coastal flood risk to provide feedback on these preliminary concepts especially if coastal storm risk measures are not shown for them.

The alternative concepts span the spectrum of predominantly off-shore, in-water structures (barriers) that provide CSRM for most of the study area (Alternative 2), to solely land-based measures, also known as shoreline based measures (SBM) consisting of floodwalls and levees at localized areas of high risk (Alternative 5). In between are the regional hybrid combinations of smaller barriers and land-based measures (3A to 4). The continuum of in-water to land-based measures is illustrated in Figure 19.

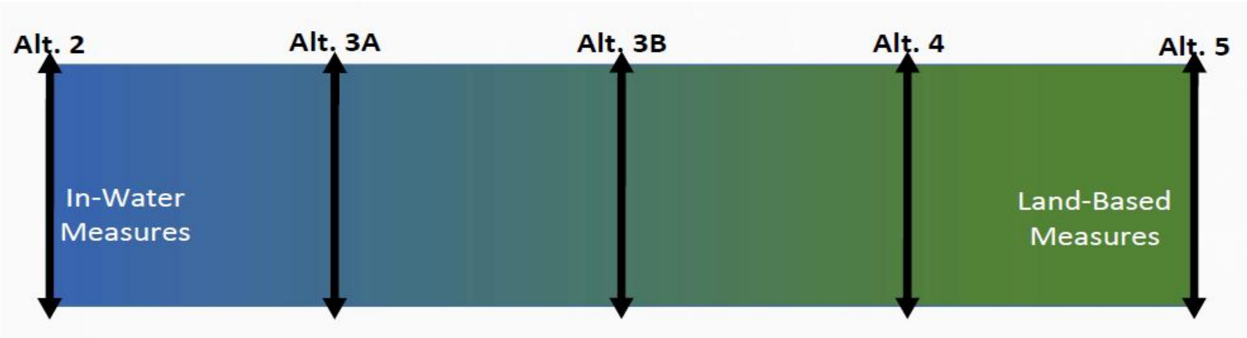

Figure 19. Gradient of in-water measures and land-based measures of alternatives 2 thru 5

The goal here is to identify specific scales of solutions in order of maximum return. In following risk informed planning USACE must determine what additional information is needed to come to a planning decision. The study teams will consider critical questions throughout each phase of the study.

4.3.2 Assessment of Major Cost and Benefit Drivers

The areas benefitting from each proposed barrier location are the major drivers at this point in this study, as the most expeditious way to study potential scales of solutions. In turn, barriers were assumed at this stage to simplify the process of developing a preliminary cost estimate. It should be noted that although a barrier may be identified to proceed forward for investigation at this point, it is possible that implementation considerations may prompt consideration of alternate, land-based measures (structural or nonstructural) to achieve coastal storm risk management, depending on each circumstance. The goal of this report is to identify which types of future studies would be beneficial in making future decisions.

4.3.3 Complementary Features for High Frequency Flooding

It is assumed for screening purposes that barriers will be operated at the 50 percent flood (see Box A for definition) event. However, as investigations are refined, the trigger event for some barriers may the 10 percent flood to lessen impacts to navigation and the environment. In either case, the barriers will not be operated for all events or nuisance flooding, which is expected to increase over the period of analysis due to RSLC. Accordingly, complementary measures for high frequency events ("high frequency measures"), including nonstructural measures and natural and nature-based features (wetlands, living shorelines, etc.) are assumed for surge barrier measures. NYNJHAT will draw from the analysis for high frequency measures from the East Rockaway to Rockaway Inlet General Reevaluation Report (Rockaway GRR) for siting high frequency measures in future rounds of formulation. The Rockaway GRR identified the following criteria:

- Clusters of high frequency flooding. Figure 20 shows the 10% floodplain, which would be key in identifying these high frequency features.
- Existing bathymetry and lateral space—if there is enough space and appropriate underwater bathymetry offshore to fit an NNBF.
- Site suitability—consideration was also given to whether the site conditions will support the appropriate NNBF type being able to persist. An example is that docks and piers are not suitable because they typically have heavy traffic.
- Ability to provide wave attenuation and erosion control.

Box A: TERMS USED TO DESCRIBE THE CHANCE OF A COASTAL OR RIVERINE FLOOD

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.

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 the following table.

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."

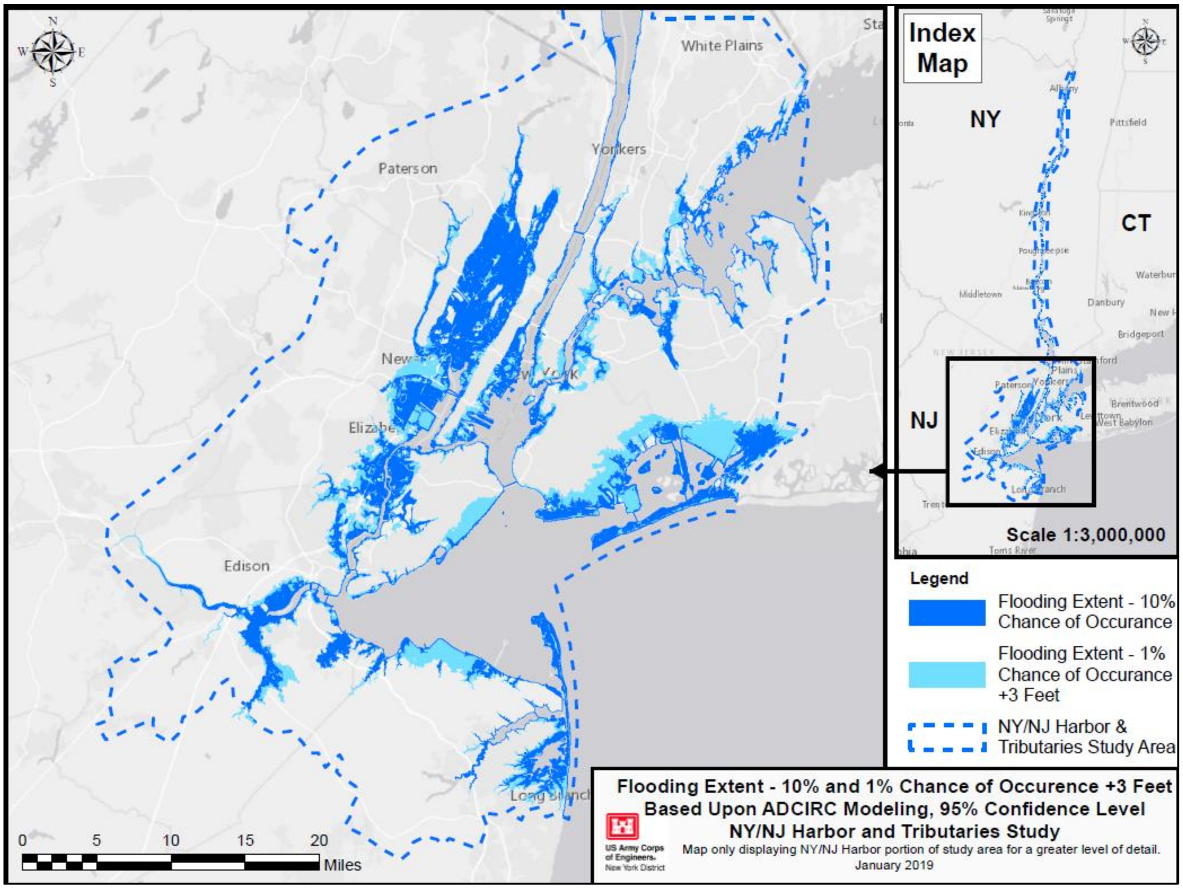

Figure 20. Flooding extents at the 10% and 1% + 3 feet levels

4.3.4 Engineering Considerations for Concept Development

The locations within alternative concepts were based on known areas of coastal flood damages from past storms. Engineering studies to support the development of the concepts include:

- Conceptual designs for structural CSRM measures, SBM's, and storm surge barriers. Renderings developed to inform and illustrate the assumptions made can be found in the Engineering Appendix.
- Numerical Modeling, including Adaptive Hydraulics (AdH) and the Coastal Storm Modeling System (CSTORM-MS).

Conceptual Designs: General plan view layouts and typical sections for each component of the line of coastal flood risk management was developed. Layouts were prepared in GIS format with bathymetry and/or topography contours from readily available digital sources top elevations for the flood risk reduction alignment were calculated and the type of measure (levee, floodwall, etc.) in each reach were assigned. As part of the study typical cross-sections and were developed for each type of protection measure. Typical sections were developed based on representative ground elevations, approximate top elevations, and typical design concepts for similar structures in previous USACE projects and studies. Coastal, structural, civil, or geotechnical engineering analyses were only minimally performed when existing databases/tools allowed for it.

The storm surge barriers are at the concept level to provide a preliminary engineering basis to support the evaluation and development of conceptual designs for the storm surge barriers, specifically the minimum practical dimensions of the barrier openings and preliminarily selection of gate types. The barrier openings consist of a navigable passage and auxiliary flow openings. The objective at this stage of the study is to provide a description and first conceptual design which outline the basis for key geometric characteristics (e.g. height, width, and depth of openings) for each storm surge barrier.

Design criteria and dimensions are based on qualitative data, quantitative data when readily available and desktop analyses to a level of detail commensurate with a feasibility study. In instances where limited data was available, assumptions were made based on engineering judgment, previous experience and/or the partial data that has been collected over the course of the feasibility study phase. The implications of such assumptions along with recommendations for further data collection and refined analyses to support the design were documented.

The preliminary assessment of navigable passage widths and storm surge barrier configuration shall not be construed as recommendations or requirements for actual design for implementation. Significant additional study is required to substantiate the conceptual design of the storm surge barriers. Additional study is required to study the width, location, and configuration of the navigable passages and auxiliary flow gates, including a full evaluation of navigation, environmental, ecological, and cost considerations, amongst others.

<u>Numerical Modeling</u>:

AdH: The AdH model was applied to the study region in order to quantify changes in tide characteristics, water levels, current velocities and salinity associated with barrier open conditions. Year-long AdH three dimensional simulations were performed for two sets of the four conceptualized alternatives that include in-water structures, and a “without project” condition. For all alternatives, the barriers had similar broader flowfield changes, a localized increase in current velocities surrounding the structures, and a slight reduction in tidal prism. Reduced tidal mixing resulted in more local and regional stratification depending on the alternative.

CSTORM-MS: This modeling task was designed to assess the potential increase in storm surge outside of the barriers along with the corresponding changes in water level within the protected basin due to freshwater ponding and wind setup during an event in which the barriers are closed. Twenty-one storm events selected from the NACCS model simulation database were used to evaluate “without project” to “with-project” conditions.

Building upon these engineering tasks, five scales of initial alternative concepts, in addition to No Action, were developed:

1. No Action/FWOPC (baseline)
2. Outer Harbor Barrier system (Sandy Hook to Breezy Point)
3. Multiple Barriers, Floodwalls, and Levee systems
    a. Three Barrier Plan
    b. Two Barrier Plan
4. Single water body barriers, Floodwalls, and Levees
5. Perimeter only

4.3.5 Overview of Alternative Concepts

The New York and New Jersey Harbor and Tributaries study area encompasses one of the most hydrodynamically complex estuaries in the nation. The tidally affected shoreline is approximately over 900 miles in length, with dozens of tributary rivers, most notably the Hudson, Passaic, Raritan and Hackensack Rivers. Numerous inhabited and uninhabited islands, several tidal straits (e.g., East River, Harlem River, Kill Van Kull, Arthur Kill). Addressing coastal storm risk from relatively minor frequent storm events (e.g., nor'easters) to more infrequent and severe events (e.g., Hurricane Sandy) with climate change and possibly accelerating RSLC pose significant challenges for the study. Combined with these environmental and geographic conditions, the study encompasses New York City, the most populated city in the nation, and the most densely populated region of New Jersey, the most densely populated state in the nation. While the next severe event will likely have the different characteristics, Hurricane Sandy demonstrated the vulnerabilities of this study area to coastal storm risks.

As relatively rare, severe coastal storm events can cause such dramatic damage and fatalities in the study area, the initial formulation and screening of conceptual "with project" alternatives is using, for common comparison purposes, the mean 1 percent flood with USACE intermediate relative sea level change projection for the identification and evaluation of measures that may be combined to form alternatives for the study area. Conceptually, this selected percent flood condition limits the types of measures that may be employed.

As noted in the description of Alternative 1 (No Action/Future Without Project Condition (FWOPC)), SBM's have been employed and are assumed throughout a number of locations within the study area. Generally speaking, other things being equal, the benefits and costs associated with SBM's tend to be proportional to each other, with the exception being the terminus ends where SBM's must then tie-in to higher ground. In other words, as the distance of measure (e.g., beach nourishment, levee, floodwall, etc.) is extended, the costs for implementing, operating and maintaining the measure generally increase as well as the potential damages avoided to the structures (e.g., homes, businesses, etc.) that are located behind the measures and would otherwise be at risk. Also, SBM's generally address coastal storm risks from both frequent and infrequent events. A common primary challenge to SBM's in the study area are space constraints for siting and constructing such measures as well as the extensive real estate acquisitions necessary to implement such measures.

Under older and more recent studies by USACE or other agencies, in–water measures, notably surge gate type measures, have been evaluated and identified as possibly feasible approaches for select bays, rivers and creeks within the study area (e.g., Hackensack River, Gowanus Creek, Newtown Creek, and Jamaica Bay). As relatively short distance surge gate structures (with associated land-based features for tie-in to high ground) may address long distances of shoreline that otherwise may have coastal risk exposure, the benefits and costs of these measures can be quite disproportionate (in other words, a relatively short distance of surge gate measures with associated shoreline-based measure tie-ins can address long distances of shoreline that otherwise would have exposure to extreme coastal storm events).

Surge gate structures have been employed in the past in a number of other areas in the northeast (e.g., Stamford, CT, and Providence, RI, etc.) and internationally (e.g., St. Petersburg, Rotterdam, etc.) as well as more recently in other areas of the nation (e.g., New Orleans) and internationally (Venice), but the areas where they have been utilized is limited. Whereas shore-line based measures as may be conceptualized in the study area have largely been employed at many other locations in region, nation and internationally, although SBM's in areas as heavily urbanized as this study area are also limited. In the study area, a limited number of in-water surge gate structures constructed at narrow locations on major waterways may be uniquely suited to address large areas of upstream and tributary coastal storm risk, given the high density of tributaries and associated vulnerable urbanized areas.

As surge gate structures involve the operation of the gate to address coastal storm risks for an impending storm, they do not address ambient coastal flooding risks (e.g., due to RSLC), or flood risk from the more frequent events that may not trigger the surge gate closure. However, the low lying areas which are vulnerable to more frequent flooding or from future RSLC are more limited spatially and the types of land-based measures that may be employed to address the coastal storm risks in these areas are broader (e.g., NNBF) and the height of the measures needed to solely address RSLC and frequent storm events (i.e., relative height) is generally far lower than that which is needed to address severe coastal storms. The locations where additional measures that may address more frequent flooding and ambient RSLC (when surge gates are open), are to be determined during future stages of this study. Also, future refinements in this study of potential benefits and costs may identify additional measures (i.e., structural, non-structural and NNBF) that may be warranted and developed for locations that do not have measures presently identified.

The impending storm condition which may trigger surge gate closure versus remaining open involves numerous factors including, but not limited to, the time and cost of enacting surge gate closure, as well as the cost impacts to other associated waterway uses (e.g., navigation) and the potential environmental impacts associated with gate closure (see the Engineering Appendix for more details). As RSLC occurs in the study area, surge gate closure may also become more frequent. For purposes of the initial evaluation of conceptual alternatives in this study, USACE assumed that all surge gates measures in all alternatives that have surge gates would close, once built, for the 50 percent flood but would increase over time as RSLC increases, using the USACE intermediate projection.

Many combinations of shoreline-based and in-water measures can be conceptualized in the vast study area to address coastal storm risks posed by the selected percent flood. Given that in-water measures, notably surge gate structures, as well as SBM's in such a largely urbanized area can have costs of billions, if not tens of billions of dollars, the initial evaluation is largely predicated on broad conceptual alternatives spanning the spectrum from largely in-water measures to measures composed of only shoreline-based features, building upon past related studies by USACE and others. Should any of these conceptual alternatives show possible economic justification, then further study and refinement of those alternatives may be advanced in this study. The first alternative to be discussed is No Action, which serves as the baseline for evaluating the projected performance of the other alternatives.

4.3.5.1 No Action Alternative

This alternative, a requirement of NEPA analysis and a key USACE requirement for formulating plans, is defined by the present and future conditions in the study area that are reasonably anticipated to exist should there be no action as an outcome of the study, also known as the future without project condition (FWOPC) (Attachment 1). While it is predicated on no tangible outcomes from the NYNJHAT study, it does *not* mean that no further action is taken to improve resilience or reduce coastal flood risks in the study area. Indeed, the USACE and many other federal, state and local agencies have a multitude of ongoing and planned actions in this area, and are included in the economics modeling if they are CSRM projects of large enough scale to be captured by the modeling, and if they will have funding and permits in place by July 2020 (Figure 21).[6]

Given the uncertainty involved in project implementation or design changes, along with varying forecast for climate/sea level change, the study is planning to perform sensitivity analysis to see how these uncertainties and variables may affect the plan formulation. Examples of projects that are under development and included within the No Action Alternative fall primarily as planned structural measures along defined areas of shoreline or non-structural measures (e.g., floodproofing) focused on improved coastal risk management and/or resilience at specifically defined buildings or locations in the study area, typically of notable importance within the study area (e.g., hospital, train terminal, etc.).

[6] July 2020 is the anticipated date for this study's Agency Decision Milestone. The study team will update the FWOPC at each successive milestone to account for the latest conditions until the Final Report.

The structural projects in the FWOPC include the USACE Rockaway peninsula Atlantic-side beach nourishment, the NYC's East Side Resiliency project (a U.S. Housing & Urban Development (HUD) funded Rebuild By Design project), and the HUD funded Rebuild by Design Hudson River project located primarily in Hoboken, New Jersey.

This alternative also considers future changes that are anticipated to occur to the study environment over the foreseeable planning horizon. The most notable example of this is relative sea level change (RSLC). While RSLC in some areas in the United States can decrease, in all of the NYNJHAT study area, sea level is projected to increase over time as it has throughout the Holocene Epoch. Given uncertainties, notably due in large part to climate change, USACE has established three RSLC projections: low, intermediate and high. Low is based upon historical long-term measured rates, which can vary by location, with intermediate and high projections being 1.5 and 2 times the historical rate, respectively. In the NYNJHAT study area, RSLC projections are available at three locations: Sandy Hook, New Jersey, the Battery (located at the southern tip of Manhattan, New York), and Kings Point, Queens, New York.

Given that RSLC in the NYNJHAT study area is projected to increase, by approximately 5-6 feet in the USACE high projection at year 2122 from the sea level measured in 1992, RSLC will cause a substantial increase in the coastal storm risk profile over time throughout the entire NYNJHAT study coastline. The HEC-FDA economic analysis prepared for the NYNJHAT study and included within this Interim Report reflects this changing profile. The analysis, which assumes the intermediate RSLC projection, indicates that the selected comparison event (i.e., 1 percent flood) would cause approximately over 2.6 times more economic damage in the NYNJHAT study area at year 2100 than the same event would cause in year 2030.

Other environmental changes are also anticipated with the increased sea level over time in the NYNJHAT study area. Notably, these include changes to tidal ecosystems as well as increase salinity intrusion into the estuary. While the former is difficult to describe unless on a site-by-site basis, the latter was preliminarily simulated utilizing USACE AdH model.

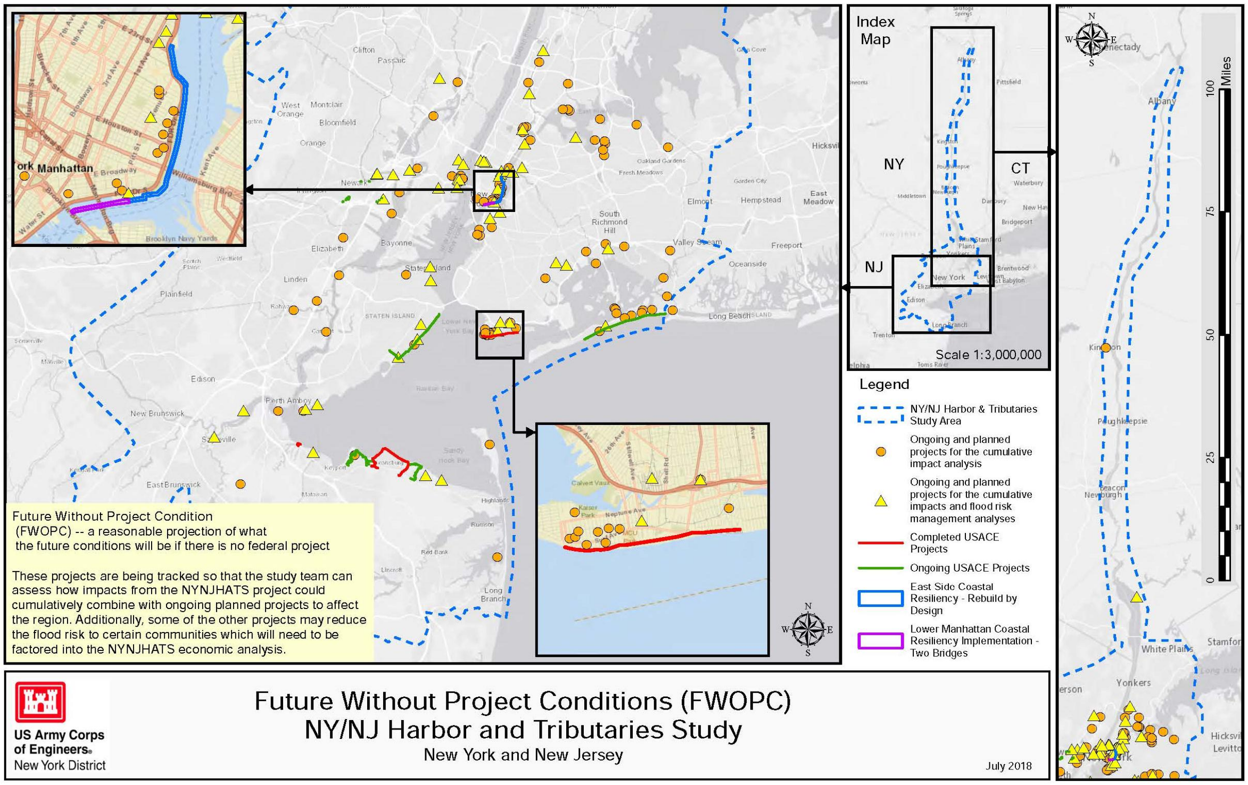

Figure 21. Future without project conditions

4.3.5.2 Alternative 2 - NY-NJ Harbor-Wide Surge Gates/Beach Restoration

Features: This conceptual alternative includes two features. The first is primarily conceptualized given the geography of the study region which indicates that a combination levee, berm and surge gate/barrier system connecting to Sandy Hook, New Jersey, across the transect to Breezy Point of Rockaway peninsula (SH-BP) and similar surge barrier enclosure along the East River just west of the Throgs Neck (TN) could conceptually broadly address coastal storm surge and wave attack from either the New York Bight or Long Island Sound to the vast majority of the study area (Figure 22). Numerous navigational surge gates and auxiliary gates of approximately 31,480 feet length with approximately 1,050 feet of static barrier connectors comprise the in-water measures in the SH-BP surge gate structure in alternative feature. At the Throgs Neck between the Bronx and Queens, the surge gate structure is estimated to involve approximately 4,510 feet of navigational and auxiliary surge gates. At the land connection points, approximately 139,636 feet of associated SBM's including floodwalls, levees, operable flood gates and buried seawalls/dunes would connect the surge gate measures to high ground.

The second feature of this conceptual alternative involves one relatively small embayment next to Pelham Bay Park in the Bronx along western Long Island Sound, which is outside of the SH-BP and TN surge gates. The Pelham Bay feature involves approximately 850 feet. of navigable and auxiliary surge gates with approximately 8,300 feet. of associated SBM's including floodwalls and levees are included to make connection to high ground.

The Engineering Appendix contains more details of the layout and preliminary numerical modeling analysis during both ambient and closed gate conditions for the primary SH-BP feature.

Percentage of Study Area CSRM: Using GIS estimates for the selected 1 percent flood with 95% confidence level plus 3 feet (for common comparison between conceptual alternatives), the Alternative 2 features address approximately 94.7% of the land area which would otherwise be directly impacted by the selected comparison event (Figure 23), with SH-BP and TN features combining to address approximately 94% and the PB features addressing approximately 0.7%

As noted above, an additional aspect of this alternative will include as feasible nonstructural (e.g., acquisition, relocation, and building retrofits) as well as structural measures (e.g., levee and floodwall) within the study area behind the surge gates to address residual coastal flooding impacts under ambient conditions due to increasing sea level and during more frequent, less severe coastal storms when the surge gates would not be closed. A placeholder has been assumed for such nonstructural, NNBF, and local structural measures to address locations susceptible to this high frequency flooding. If this alternative is carried into further evaluation, these placeholder measures will be refined to address residual or future coastal storm risks (e.g., from RSLC) or to improve the environmental aspects of other measures.

This alternative would be slightly redundant with many existing and planned USACE as well as other federal, state and local government funded CSRM projects in the study area and described in the FWOPC. USACE has analyzed this alternative such that these redundancies with planned and existing projects are not counted toward towards the preliminary benefits calculations for this alternative concept.

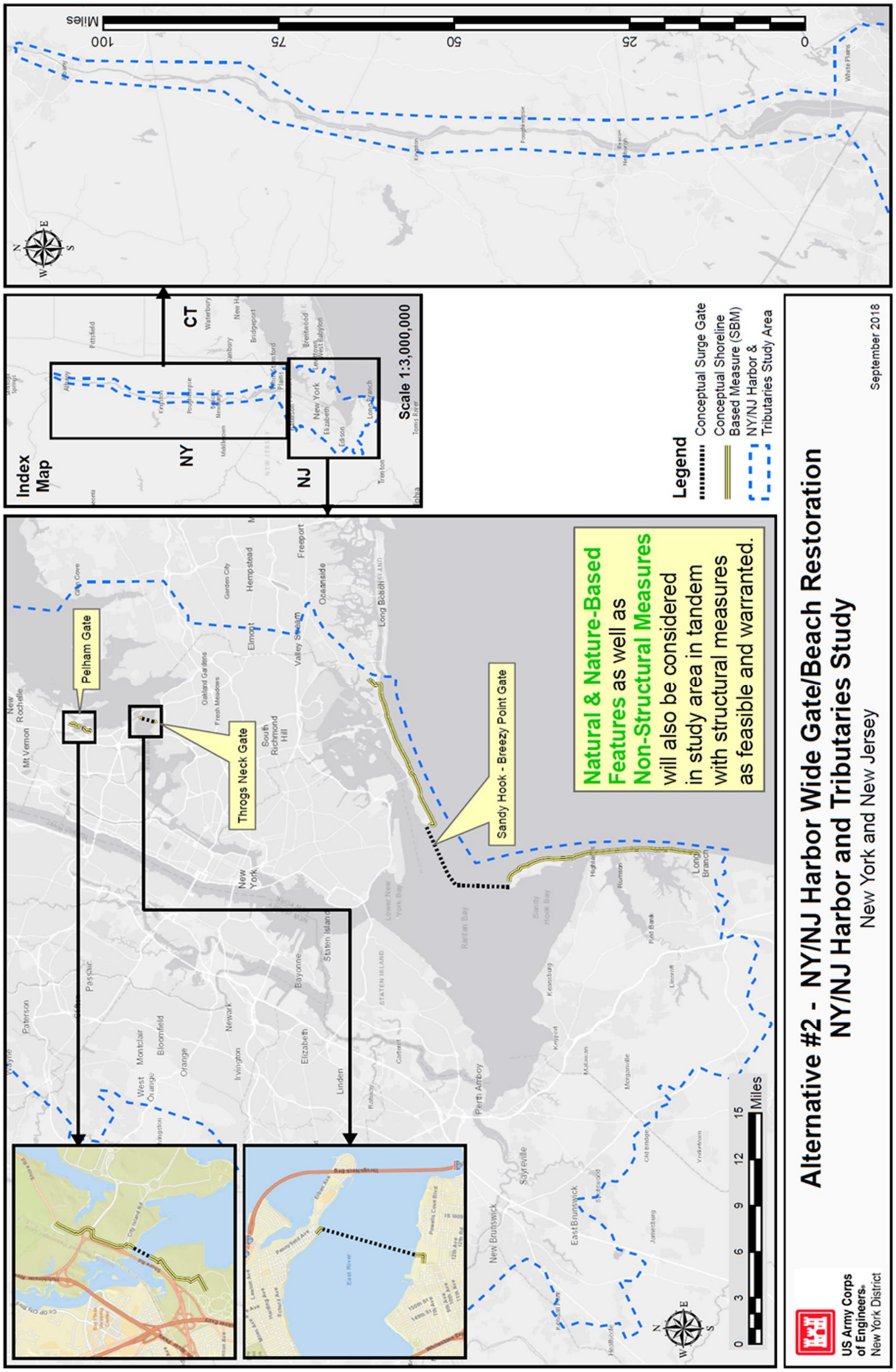

Figure 22. Alternative 2

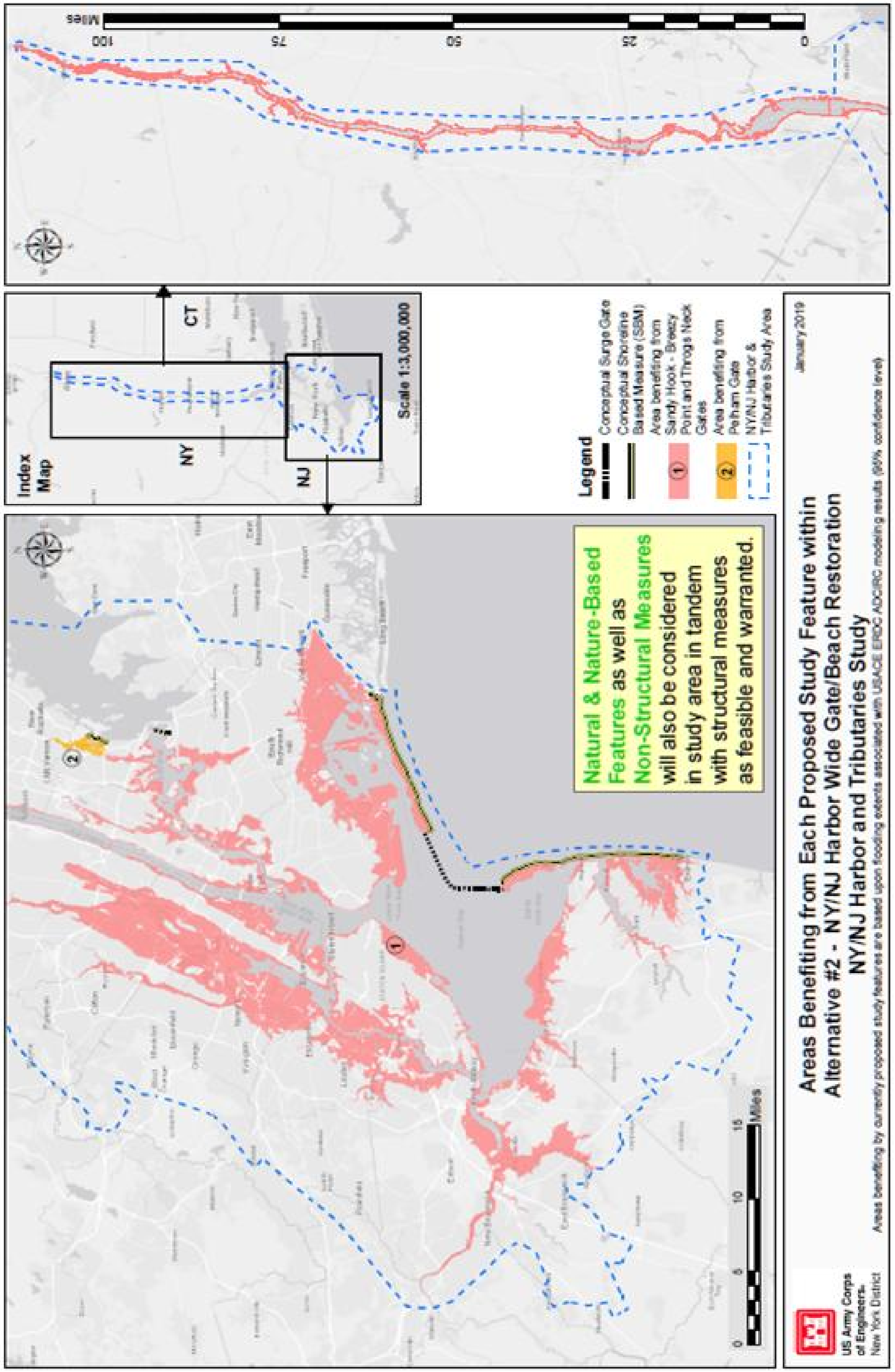

Figure 23. Areas directly benefiting from reduction in flood damages by measures proposed in Alternative 2

4.3.5.3 Alternative 3A - Upper Bay-Newark Bay Surge Gate and Jamaica Bay Surge Gate Plan

Features: This conceptual alternative involves three separate features. The first feature is defined by the next geographic location inside from the Lower Bay transect where surge gate measures may be conceptualized. It involves surge gate measures at the southern mouth of the Arthur Kill, the Verrazano Narrows, and at the Throgs Neck (see Figure 24). The navigational and auxiliary surge gate measures located at the southern mouth of the Arthur Kill between Woodbridge, NJ and Staten Island, are approximately 1,760 feet in length with an additional 200 feet of seawall to connect to land. The surge gate structure at the Verrazano Narrows between Brooklyn and Staten Island involves approximately 6,420 feet of navigational and auxiliary surge gates with approximately 630 feet of seawalls to connect the gates to land. At the Throgs Neck between the Bronx and Queens, the surge gate structure is estimated to involve approximately 4,510 feet of navigational and auxiliary surge gates. These three surge gate structures require approximately 9,800 feet of floodwalls, levees and operable flood gates on land to tie-in to high ground.

The second feature in this conceptual alternative involves a combination of SBM's along with multiple surge gate structures in the southern Brooklyn to the mouth of Jamaica Bay and then to Rockaway Peninsula. In the years following Hurricane Sandy, USACE identified and developed this feature under the separate Rockaway/Jamaica Bay Reformulation Study. This feature includes navigational and auxiliary surge gates at the entrance to Jamaica Bay with separate surge gate and SBM's connecting to Coney Island and Coney Island Creek. These surge gate structures at the mouth of Jamaica Bay, Gerritsen Creek, Sheepshead Bay, and Coney Island Creek are estimated to involve navigational and auxiliary gates with associated static barriers of approximately 3,980 ft/, 300 ft., 825 ft., and 400 ft., respectively, to connect to adjacent land. On land, this feature involves approximately 118,029 feet of floodwall, levees, seawalls, operable flood gates, elevated promenades, buried seawall/dunes, and tide gates to connect the surge gate structures and to tie-in to high ground at the feature terminuses.

The third feature of this conceptual alternative involved one relatively small embayment next to Pelham Bay Park in the Bronx along western Long Island Sound, which is outside of the SH-BP and TN surge gates. The Pelham Bay feature involves approximately 850 feet of navigable and auxiliary surge gates with approximately 8,300 feet of associated SBM's including floodwalls and levees are included to make connection to high ground.

The Engineering Appendix contains more details of the layout and preliminary numerical modeling analysis during both ambient and closed gate conditions for the applicable features of this conceptual alternative.

Percentage of Study Area CSRM: Using GIS estimates for the selected 1 percent flood with 95% confidence level plus 3 feet (for common comparison between conceptual alternatives), the first, second and third feature of this conceptual alternative address approximately 58%, 16%, and 0.7%, respectively, of the land area which would otherwise be directly impacted by the selected comparison event (Figure 25). Combined, this conceptual alternative addresses approximately 74% of the land area which would otherwise be directly impacted by the selected comparison event.

As noted above, an additional aspect of this alternative will include as feasible nonstructural (e.g., acquisition, relocation, and building retrofits) as well as structural measures (e.g., levee and floodwall) within the study area behind the surge gates to address residual coastal flooding impacts under ambient conditions due to increasing sea level and during more frequent, less severe coastal storms when the surge gates would not be closed. A placeholder has been assumed for such nonstructural, NNBF, and local structural measures to address locations susceptible to this high frequency flooding. If this alternative is carried into further evaluation, these placeholder measures will be refined to address residual or future coastal storm risks (e.g., from RSLC) or to improve the environmental aspects of other measures.

This alternative would be slightly redundant with some of the other existing and planned CSRM projects in the study area and described in the FWOPC. USACE has analyzed this alternative such that these redundancies with planned and existing projects are not counted toward towards the preliminary benefits calculations for this alternative concept.

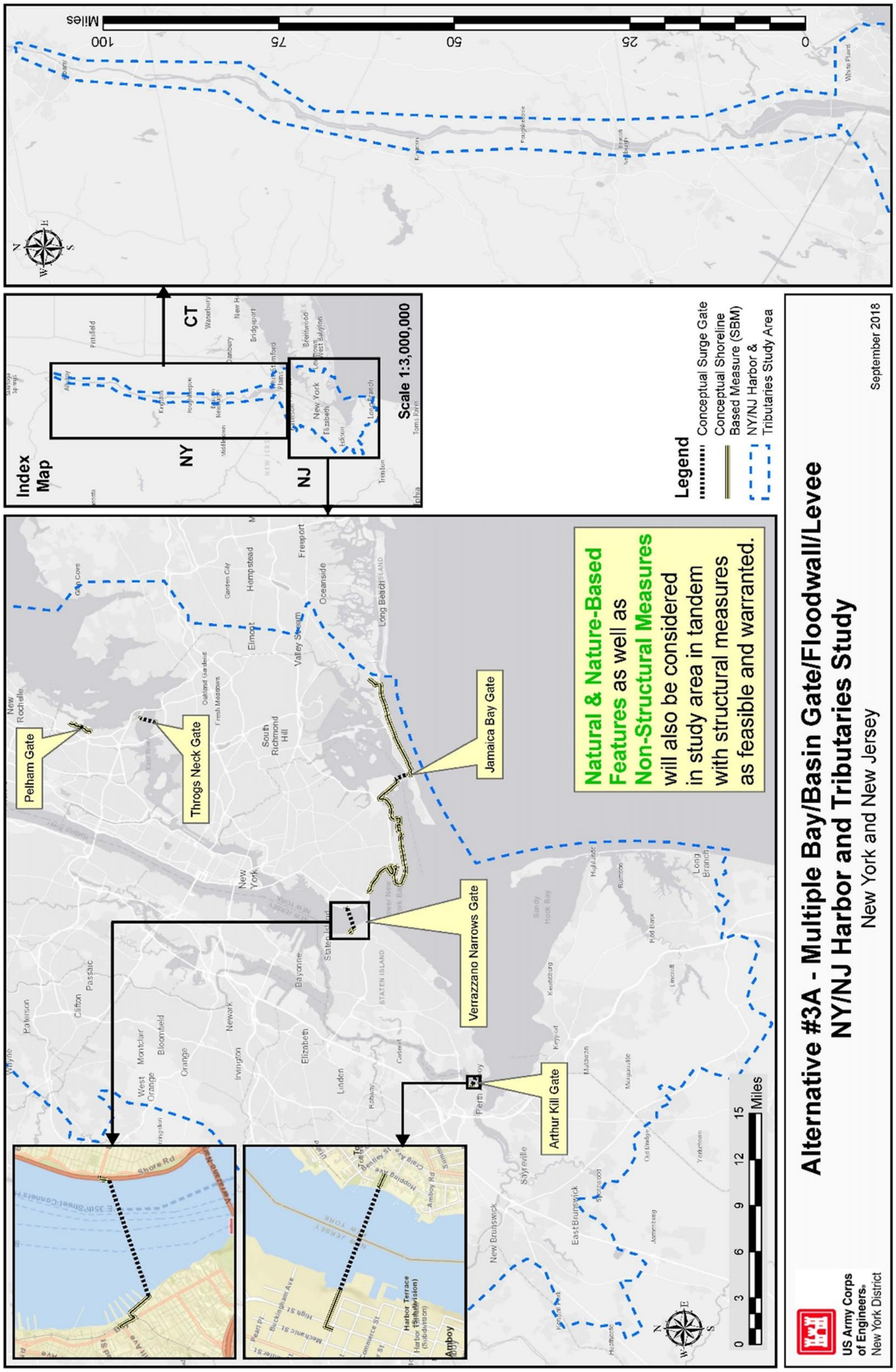

Figure 24. Alternative 3A

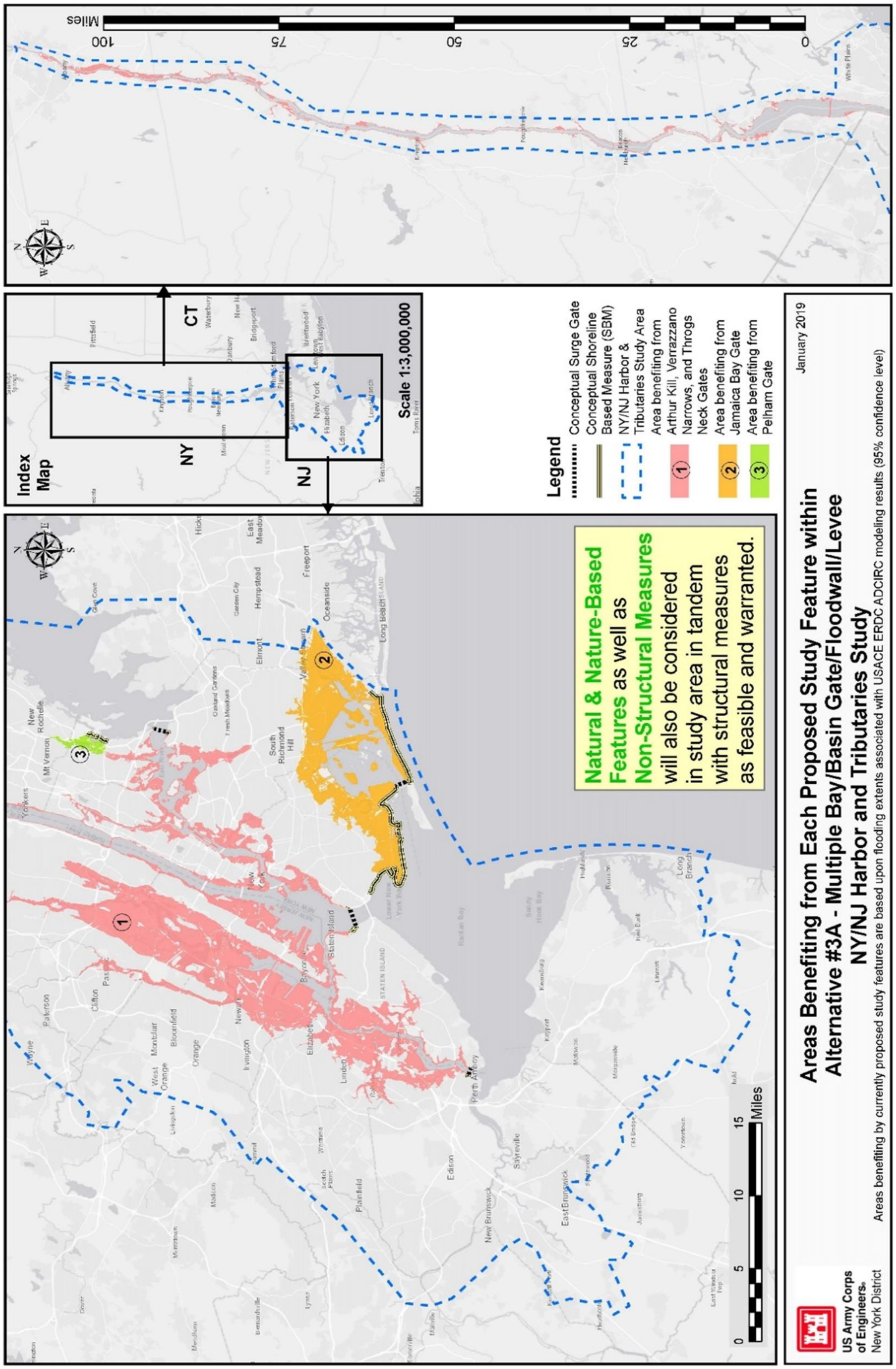

Figure 25. Areas directly benefiting from reduction in flood damages by the measures in Alternative 3A

4.3.5.4 Alternative 3B - Newark Bay, Jamaica Bay, Newtown Creek, Gowanus Creek, Flushing Creek, Bronx River, Westchester Creek Surge Gates and Multiple SBM's (i.e., East Harlem, Astoria, Long Island City, Jersey City and Lower West Side, and multiple Hudson River towns)

Features: This conceptual alternative includes 18 separate features covering multiple bays, rivers, creeks, and numerous shoreline areas. The largest single feature in this conceptual alternative is a dual surge gate system at the southern mouth of the Arthur Kill (the same as in conceptual alternative 3A), and the eastern mouth of the Kill Van Kull between Bayonne, NJ and Staten Island, NY (Figure 26). The navigational and auxiliary surge gate structures at these locations are estimated to have a total length of 4,080 feet, with an associated 10,055 feet of SBMs comprising floodwalls and operable flood gates to tie-in to high ground.

The second feature in this conceptual alternative involves a combination of SBM's and multiple surge gate structures in the southern Brooklyn to the mouth of Jamaica Bay and then to Rockaway Peninsula (the same feature as in conceptual alternative 3A). In the years following Hurricane Sandy, USACE identified and developed this feature under the separate Rockaway/Jamaica Bay Reformulation Study. This feature includes navigational and auxiliary surge gates at the entrance to Jamaica Bay with separate surge gate and SBM's connecting to Coney Island and Coney Island Creek. These surge gate structures at the mouth of Jamaica Bay, Gerritsen Creek, Sheepshead Bay, and Coney Island Creek are estimated to involve navigational and auxiliary gates with associated static barriers of approximately 3,980 ft., 300 ft., 825 ft., and 400 ft., respectively, to connect to adjacent land. On land, this feature involves approximately 118,029 ft. of floodwall, levees, seawalls, operable flood gates, elevated promenades, buried seawall/dunes, and tide gates to connect the surge gate structures and to tie-in to high ground at the feature terminuses.

Five other features are located solely within New York City involve surge gate structures on various tributaries located within the city in predominantly low lying areas with adjacent SBM's to tie-in to high ground. These five features are located at the southern Bronx shoreline (including the Bronx River and Westchester creek), Pelham Bay (the same as in conceptual alternatives 2 and 3A), Flushing Creek (Queens), Newtown Creek (boarder of Brooklyn and Queens) and the Gowanus Canal (Brooklyn). The estimated lengths of the surge gate structures for these five conceptual features are 300 ft., 340 ft., 850 ft., 260 ft., 250 ft. and 130 ft., respectively. The SBM associated with these surge gate structures in these five features have an estimated length of 25,774 ft., 8,293 ft., 14,183 ft., 17,554 ft., and 4,019 ft., respectively, including floodwalls, levees, seawalls, operable flood gates, and elevated promenades.

The remaining 11 features in this conceptual alternative involve only SBM's. Five are located in the lower Hudson River estuary and along the East and Harlem Rivers. They cover the following shorelines: 1) New Jersey shoreline along the Hudson River (primarily located in Jersey City and connecting to planned FWOPC), 2) lower West Side of Manhattan (connecting to planned FWOPC), 3) East Harlem in Manhattan along the East and Harlem Rivers, and 4) Long Island City and 5) Astoria in Queens. Respectively, they involve approximately 46,590 ft., 32,282 ft., 24,881 ft., 17,153 ft., and 21,205 feet of SBM's including floodwalls, levees, seawalls, operable flood gates, and elevated promenades.

Six shoreline-based features are initially proposed at various low-lying communities (two in Yonkers, one in Tarrytown, one in Ossining, and two in Stony Point) along the Hudson River. These six features combined involve approximately 56,327 feet of shoreline-based floodwall measures. These six features are preliminary and subject to modification or removal if site-specific investigations reveal that some of them are not technically feasible, economically justified, or environmentally acceptable. Some communities that are at high risk of coastal flooding (such as Piermont, NY) were not identified in this stage of preliminary modeling, however, if this alternative is selected as the TSP, all areas of shoreline will be studied in further detail to appraise the cost-feasibility of shoreline-based features. Due to the size and scale of this study, it was not feasible to review the feasibility of such shoreline-based features across 100% of at-risk shoreline at this phase.

The Engineering Appendix contains more details of the layout and preliminary numerical modeling analysis during both ambient and closed gate conditions for the applicable features of this conceptual alternative.

Percentage of Study Area CSRM: Using GIS estimates for the selected 1 percent flood with 95% confidence level plus 3 feet (for common comparison between conceptual alternatives), the 18 features of this conceptual alternative address approximately 54% of the land area which would otherwise be directly impacted by the selected comparison event (Figure 27).

As noted above, an additional aspect of this alternative will include as feasible nonstructural (e.g., acquisition, relocation, and building retrofits) as well as structural measures (e.g., levee and floodwall) within the study area behind the surge gates to address residual coastal flooding impacts under ambient conditions due to increasing sea level and during more frequent, less severe coastal storms when the surge gates would not be closed. A placeholder has been assumed for such nonstructural, NNBF, and local structural measures to address locations susceptible to this high frequency flooding. If this alternative is carried into further evaluation, these placeholder measures will be refined to address residual or future coastal storm risks (e.g., from RSLC) or to improve the environmental aspects of other measures.

This alternative would be slightly redundant with the other planned CSRM projects in the Hackensack river portion of the study area and as described in the FWOPC. USACE has analyzed this alternative such that these redundancies with planned and existing projects are not counted toward towards the preliminary benefits calculations for this alternative concept.

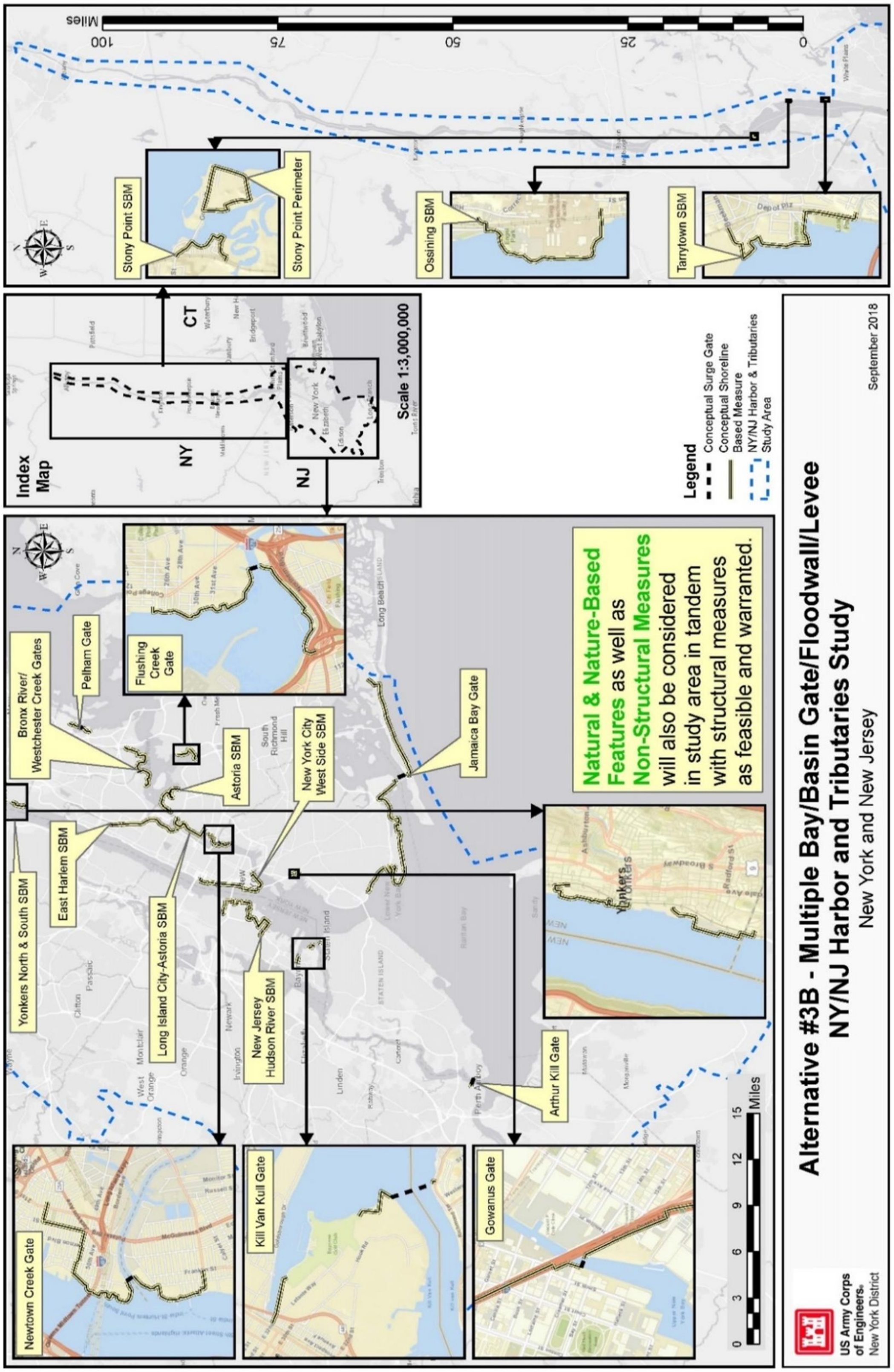

Figure 26. Alternative 3B

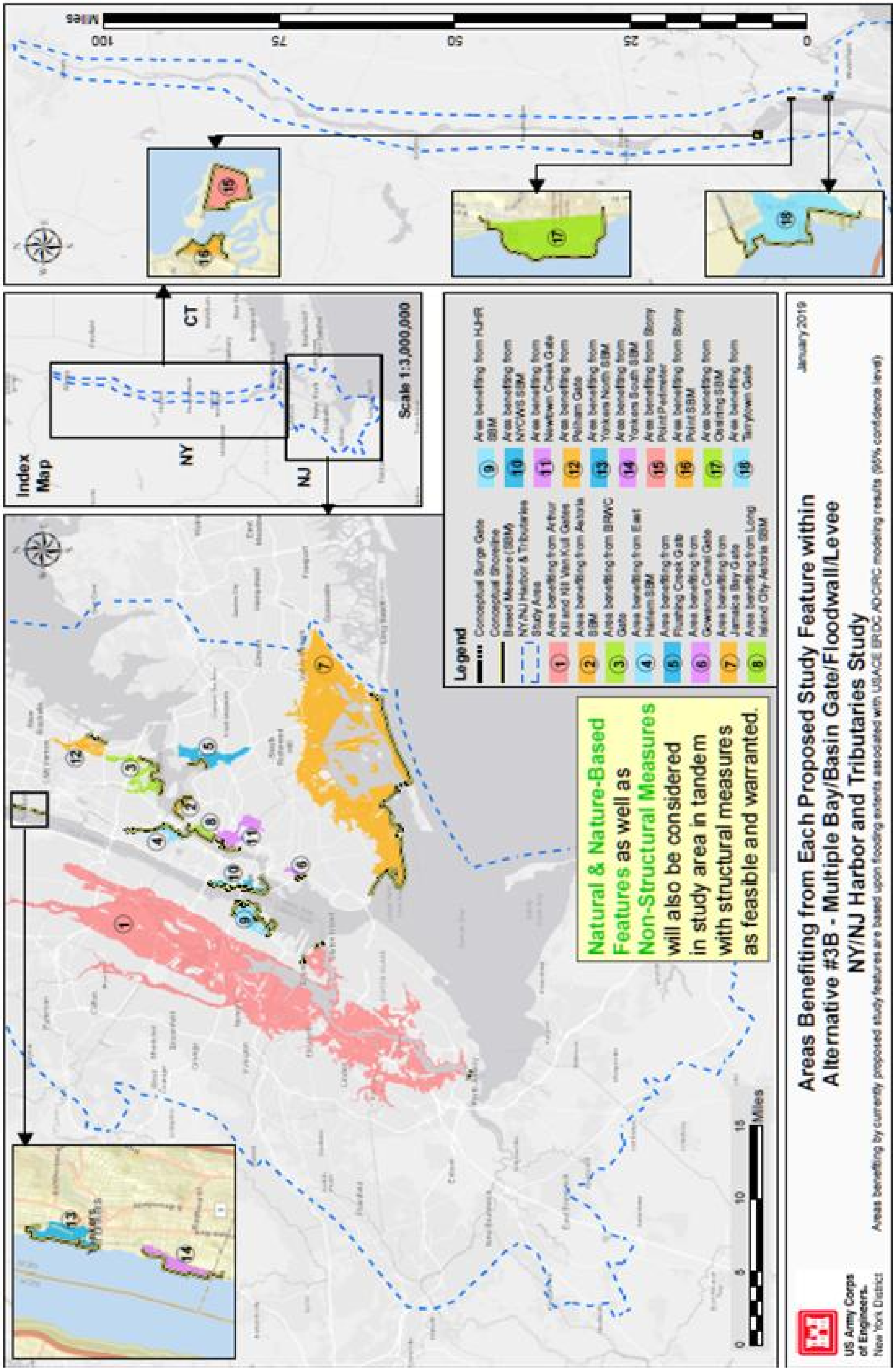

Figure 27. Areas benefiting from reduction in flood damages by the measures in Alternative 3B

4.3.5.5 Alternative 4 - Single Water Body Barriers/Floodwalls/Levees: Jamaica Bay, Hackensack River, Newtown Creek, Gowanus Creek, Flushing Creek, Bronx River, Westchester Creek Surge Gates and Multiple SBM's (i.e., East Harlem, Astoria, Long Island City, Jersey City and Lower West Side, and multiple Hudson River towns)

Features: This conceptual alternative includes 18 separate features covering multiple bays, rivers, creeks, and numerous shoreline areas (Figure 28).

The largest single feature in this conceptual alternative involves a combination of SBM's and multiple surge gate structures in the southern Brooklyn to the mouth of Jamaica Bay and then to Rockaway Peninsula (the same feature as in conceptual alternative 3A and 3B). In the years following Hurricane Sandy, USACE identified and developed this feature under the separate Rockaway/Jamaica Bay Reformulation Study. This feature includes navigational and auxiliary surge gates at the entrance to Jamaica Bay with separate surge gate and SBM's connecting to Coney Island and Coney Island Creek. These surge gate structures at the mouth of Jamaica Bay, Gerritsen Creek, Sheepshead Bay, and Coney Island Creek are estimated to involve navigational and auxiliary gates with associated static barriers of approximately 3,980 ft., 300 ft., 825 ft., and 400 ft., respectively, to connect to adjacent land. On land, this feature involves approximately 118,029 feet of floodwall, levees, seawalls, operable flood gates, elevated promenades, buried seawall/dunes, and tide gates to connect the surge gate structures and to tie-in to high ground at the feature terminuses.

The second feature in this conceptual alternative is a surge gate system at the southern mouth of the Hackensack River, NJ. The navigational and auxiliary surge gate structures at this location is estimated to have a total length of 1,460 feet with an associated 30,369 feet of SBM's comprising floodwalls, levees, operable flood gates and tide gates to tie-in to high ground.

Five other features (the same as in conceptual alternative 3B) are located solely within New York City involve surge gate structures on various tributaries located within the city in predominantly low lying areas with adjacent SBM's to tie-in to high ground. These five features are located at the southern Bronx shoreline (including the Bronx River and Westchester creek), Pelham Bay (the same as in conceptual alternatives 2 and 3A), Flushing Creek (Queens), Newtown Creek (boarder of Brooklyn and Queens) and the Gowanus Canal (Brooklyn). The surge gate structures in these six tributaries in these five features, respectively, are estimated approximately to involve 300 ft., 340 ft., 850 ft., 260 ft., 250 ft. and 130 ft. of in-water surge gates. The SBM associated with these surge gate structures in these five features have an estimated length of 25,774 ft., 8,293 ft., 14,183 ft., 17,554 ft., and 4,019 ft., respectively, including floodwalls, levees, seawalls, operable flood gates, and elevated promenades.

The remaining 11 features in this conceptual alternative (the same as in conceptual alternative 3B) involve predominantly only SBM's. Five are located in the lower Hudson River estuary and along the East and Harlem Rivers. They cover the following shorelines: 1) New Jersey shoreline along the Hudson River (primarily located in Jersey City and connecting to planned FWOPC), 2) lower West Side of Manhattan (connecting to planned FWOPC), 3) East Harlem in Manhattan along the East and Harlem Rivers, and 4) Long Island City and 5) Astoria in Queens. Respectively, they involve approximately 46,590 ft., 32,282 ft., 24,881 ft., 17,153 ft., and 21,205 ft. of SBM's including floodwalls, levees, seawalls, operable flood gates, and elevated promenades.

Six shoreline-based features are initially proposed at various low-lying communities (two in Yonkers, one in Tarrytown, one in Ossining, and two in Stony Point) along the Hudson River. These six features combined involve approximately 56,327 feet of shoreline-based floodwall measures. These six features are preliminary and subject to modification or removal if site-specific investigations reveal that some of them are not technically feasible, economically justified, or environmentally acceptable. Some communities that are at high risk of coastal flooding (such as Piermont, NY) were not identified in this stage of preliminary modeling, however, if this alternative is selected as the TSP, all areas of shoreline will be studied in further detail to appraise the cost-feasibility of shoreline-based features. Due to the size and scale of this study, it was not feasible to review the feasibility of such shoreline-based features across 100% of at-risk shoreline at this phase.

The Engineering Appendix contains more details of the layout and preliminary numerical modeling analysis during both ambient and closed gate conditions for the applicable features of this conceptual alternative.

Percentage of Study Area CSRM: Using GIS estimates for the selected 1 percent flood with 95% confidence level plus 3 feet (for common comparison between conceptual alternatives), the 18 features of this conceptual alternative address approximately 34.45% of the land area which would otherwise be directly impacted by the selected comparison event (Figure 29).

As noted above, an additional aspect of this alternative will include as feasible nonstructural (*e.g.*, acquisition, relocation, and building retrofits) as well as structural measures (*e.g.*, levee and floodwall) within the study area behind the surge gates to address residual coastal flooding impacts under ambient conditions due to increasing sea level and during more frequent, less severe coastal storms when the surge gates would not be closed. A placeholder has been assumed for such nonstructural, NNBF, and local structural measures to address locations susceptible to this high frequency flooding. If this alternative is carried into further evaluation, these placeholder measures will be refined to address residual or future coastal storm risks (e.g., from RSLC) or to improve the environmental aspects of other measures.

This alternative would be slightly redundant with the other planned CSRM projects in the Hackensack river portion of the study area and as described in the FWOPC. USACE has analyzed this alternative such that these redundancies with planned and existing projects are not counted toward towards the preliminary benefits calculations for this alternative concept.

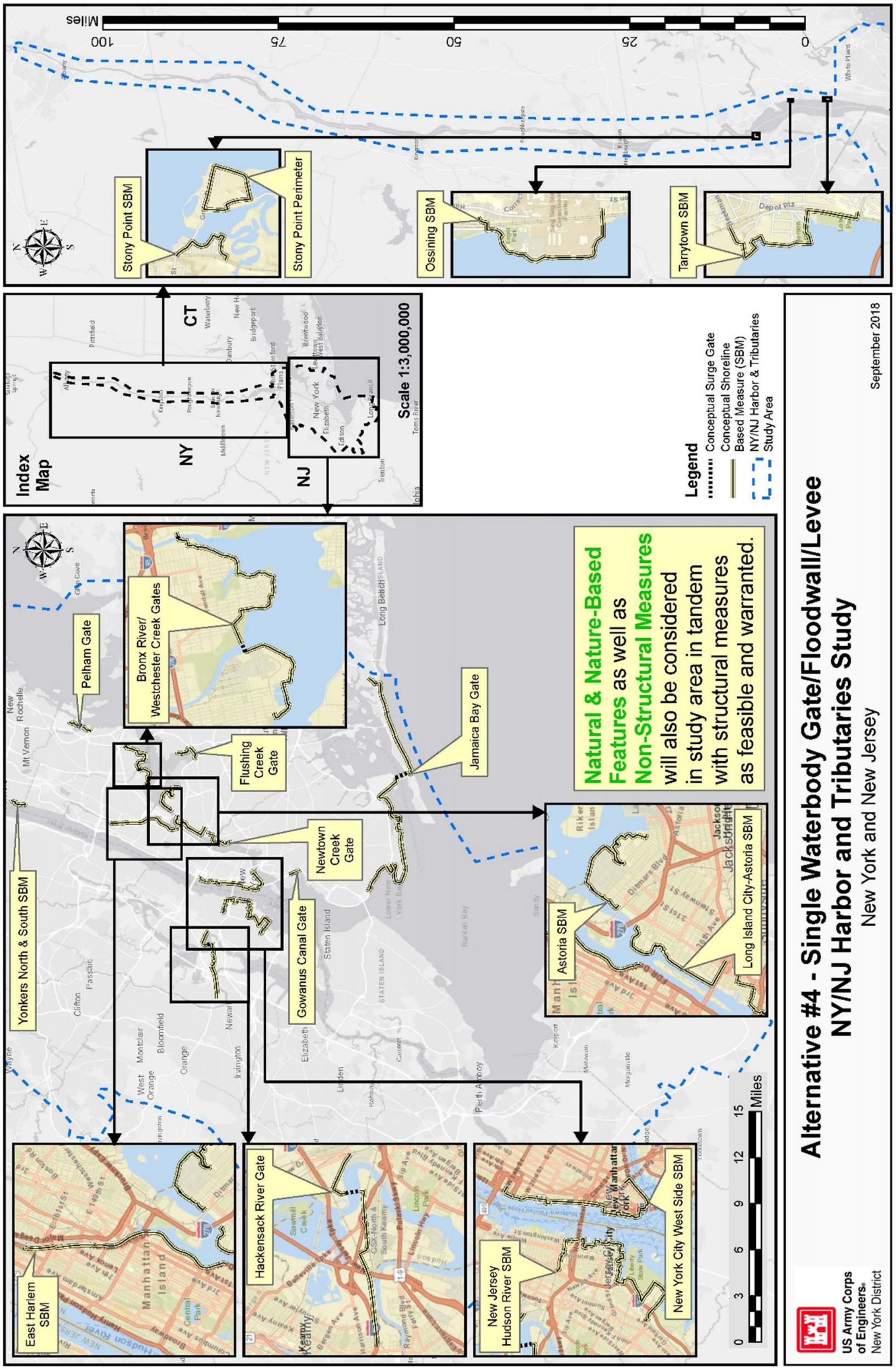

Figure 28. Alternative 4

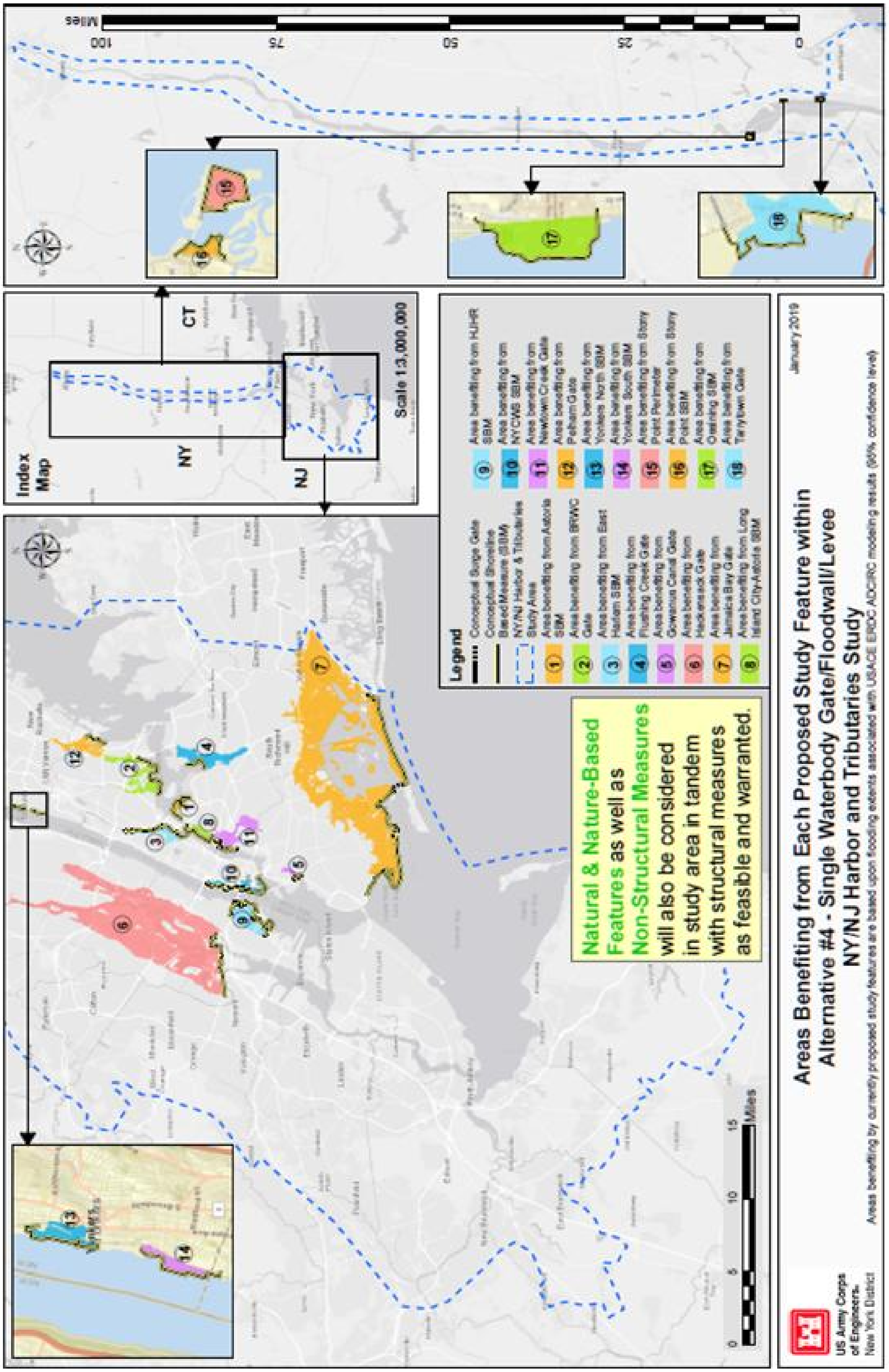

Figure 29. Areas directly benefiting from reduction in flood damages by measures in Alternative 4

4.3.5.6 Alternative 5 - Perimeter Only Solutions

Features: This conceptual alternative categorically excludes any large in-water structures as a requirement to bracket the spectrum range of conceptual alternatives. Consequently, many areas addressed under prior with-project conceptual alternatives are absent from this alternative as shoreline-based only measures are cost prohibitive for those areas based on prior USACE and other agencies analyses. For example, the separate USACE Rockaway/Jamaica Bay Reformulation Study conducted after Hurricane Sandy evaluated a perimeter based approach to Jamaica Bay which determined it to pose considerable challenges with managing interior drainage, particularly around the number of inlets and creeks discharging into Jamaica Bay, at roughly twice the cost than that which could be achieved through the use of surge gate features as described in conceptual alternatives 3A-4 above.[7] For this reason, to again consider perimeter based solutions in areas where they have been previously found infeasible by USACE or other agencies would require explicit request from the study non-federal sponsors as well as concurrence by USACE higher authority offices. This conceptual alternative includes 14 features (Figure 30).

Eight features are located in the lower Hudson River estuary, the Hackensack Meadowlands, and along the East and Harlem Rivers. They cover the following shorelines: three features are perimeter shoreline based measures in the Hackensack Meadowlands (based on a prior USACE reconnaissance study), New Jersey shoreline along the Hudson River (primarily located in Jersey City and connecting to planned FWOPC), lower West Side of Manhattan (connecting to planned FWOPC), East Harlem in Manhattan along the East and Harlem Rivers, and Long Island City and Astoria in Queens. Respectively, they involve approximately 39,714 ft., 9,719 ft., 11,525 ft., 46,590 ft., 32,282 ft., 24,881 ft., 17,153 ft., and 21,205 ft. of SBM's including floodwalls, levees, seawalls, operable flood gates, and elevated promenades.

Six shoreline-based features are initially proposed at various low-lying communities (two in Yonkers, one in Tarrytown, one in Ossining, and two in Stony Point) along the Hudson River. These six features combined involve approximately 56,327 feet of shoreline-based floodwall measures. These six features are preliminary and subject to modification or removal if site-specific investigations reveal that some of them are not technically feasible, economically justified, or environmentally acceptable. Some communities that are at high risk of coastal flooding (such as Piermont, NY) were not identified in this stage of preliminary modeling, however, if this alternative is selected as the TSP, all areas of shoreline will be studied in further detail to appraise the cost-feasibility of shoreline-based features. Due to the size and scale of this study, it was not feasible to review the feasibility of such shoreline-based features across 100% of at-risk shoreline at this phase.

[7] The report can be found at https://www.nan.usace.army.mil/Missions/Civil-Works/Projects-in-New-York/East-Rockaway-Inlet-to-Rockaway-inlet-Rockaway-Beach/

The Engineering Appendix contains more details of the layout for the features of this conceptual alternative.

<u>Percentage of Study Area CSRM</u>: Using GIS estimates for the selected 1 percent flood with 95% confidence level plus 3 feet (for common comparison between conceptual alternatives), the 13 features of this conceptual alternative address approximately 3.2% of the land area which would otherwise be directly impacted by the selected comparison event (Figure 31).

As noted above, an additional aspect of this alternative will include as feasible nonstructural (e.g., acquisition, relocation, and building retrofits) as well as structural measures (e.g., levee and floodwall) within the study area behind the surge gates to address residual coastal flooding impacts under ambient conditions due to increasing sea level and during more frequent, less severe coastal storms when the surge gates would not be closed. A placeholder has been assumed for such nonstructural, NNBF, and local structural measures to address locations susceptible to this high frequency flooding. If this alternative is carried into further evaluation, these placeholder measures will be refined to address residual or future coastal storm risks (e.g., from RSLC) or to improve the environmental aspects of other measures.

This conceptual alternative is not redundant with any of the other existing and planned USACE as well as other federal, state and local government funded CSRM projects in the study area and described in the FWOPC.

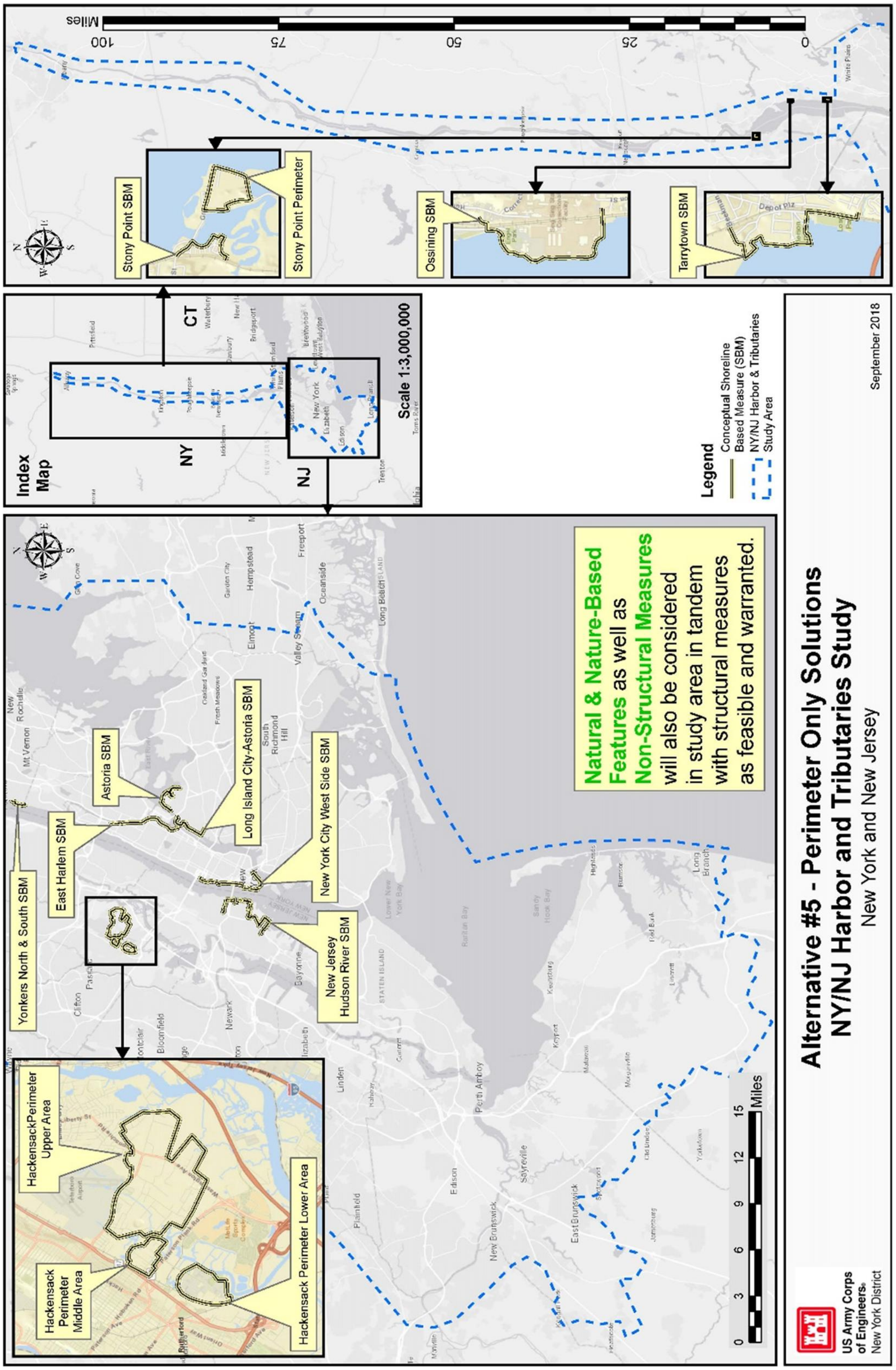

Figure 30. Alternative 5

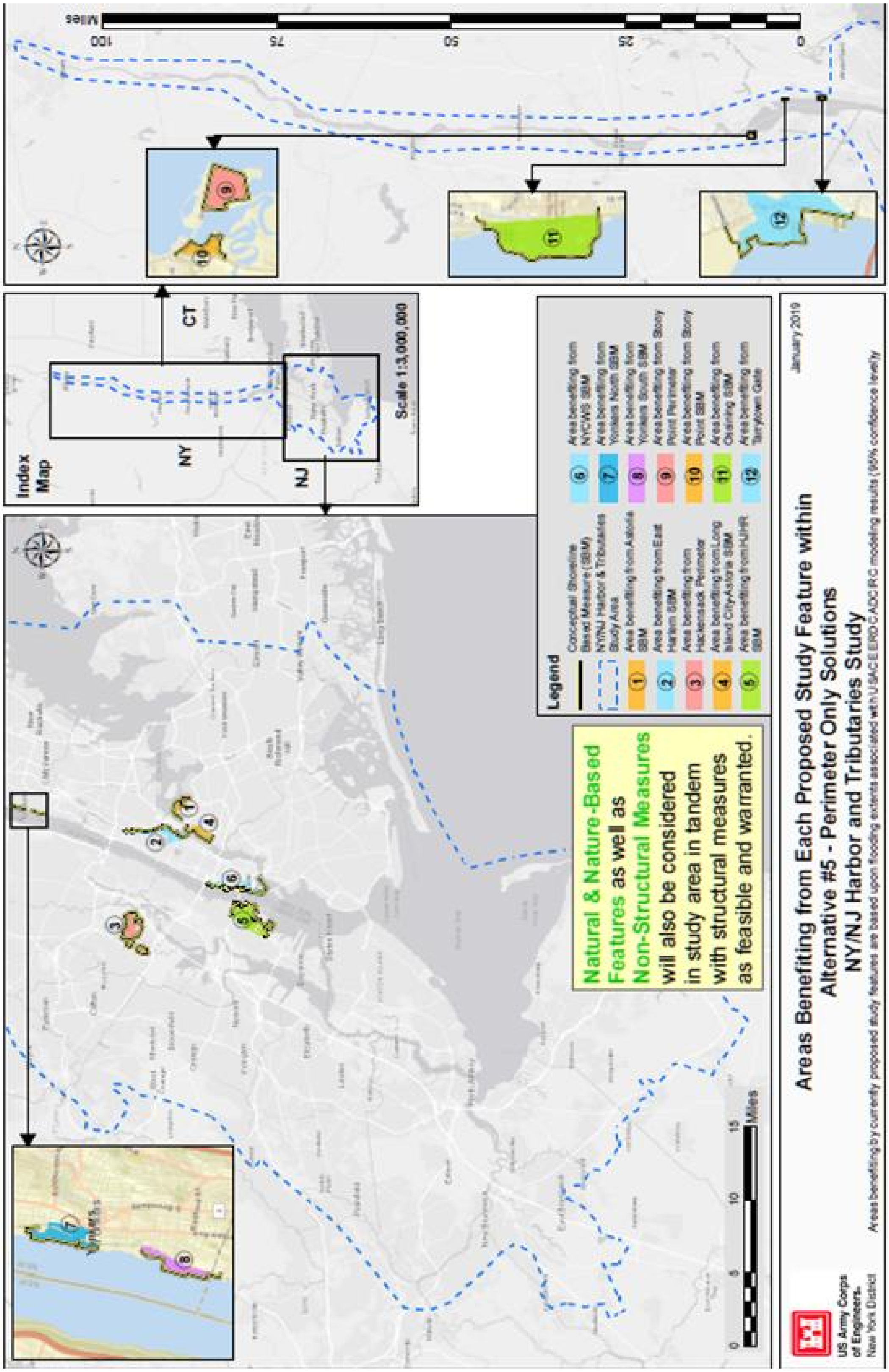

Figure 31. Areas directly benefiting from reduction in flood damages by measures in Alternative 5

As noted throughout this section of the report, other non-structural and NNBF measures will be evaluated and included within the formulation for all shoreline communities potentially affected by coastal storm risk into the future (with RSLC). This includes possible improvements to existing flood warning and evacuation planning, land use planning/zoning (as recommended/regulated by coastal zone management agencies), flood insurance, acquisition/relocations, building retrofits, etc. Public outreach and education will also play a pivotal piece of this nonstructural baseline strategy common to all alternatives and plans to ensure future societal resiliency to the infrequent but severe adverse effects of coastal storms. Given the broad geographic area for the study and in coordination with the non-federal sponsors, an alternative of only nonstructural or only natural and nature based features is not conceptualized as part of the initial array of the study. However, with non-federal sponsor support and pending further evaluation in the study, alternatives of solely non-structural or solely of natural and nature based features may be developed as warranted.

Given the large amount of uncertainty and the long planning horizon for the study, many features of the various conceptual alternatives may not be recommended for immediate construction (i.e., included in the short-term plan) but may be phased for construction later (i.e., long-term plan) if and as other existing factors, such as RSLC, progress. By having a short-term and long-term plan, FWOPC factors with high uncertainty (e.g., RSLC) may best be incorporated into a practical and pragmatic solution that addresses current needs and the method for addressing future possible CSRM needs that encompasses all reasonable potential future planning scenarios. Table 11 shows a matrix of which measures are within each alternative:

Table 11. Matrix of Features within Alternatives 2 – 5

Feature	Alt. 2	Alt. 3A	Alt. 3B	Alt. 4	Alt. 5
Sandy Hook – Breezy Point & Throgs Neck Barriers	Yes	No	No	No	No
Arthur Kill & Verrazano & Throgs Neck Barriers	No	Yes	No	No	No
Arthur Kill & Kill Van Kull Barriers	No	No	Yes	No	No
Hackensack River Barrier	No	No	No	Yes	No
Jamaica Bay Barrier	No	Yes	Yes	Yes	No
New Jersey along Hudson River SBM	No	No	Yes	Yes	Yes
Flushing Creek Barrier	No	No	Yes	Yes	No
Hackensack Perimeter Upper Area	No	No	No	No	Yes
Newtown Creek Barrier	No	No	Yes	Yes	No
Bronx River & Westchester Creek Barriers	No	No	Yes	Yes	No
New York City West Side SBM	No	No	Yes	Yes	Yes
East Harlem SBM	No	No	Yes	Yes	Yes
Pelham Barrier	Yes	Yes	Yes	Yes	No

Feature	Alt. 2	Alt. 3A	Alt. 3B	Alt. 4	Alt. 5
Hackensack Perimeter Lower Area	No	No	No	No	Yes
Long Island City Astoria SBM	No	No	Yes	Yes	Yes
Gowanus Canal Barrier	No	No	Yes	Yes	No
Hackensack Perimeter Middle Area	No	No	No	No	Yes
Astoria SBM	No	No	Yes	Yes	Yes
Tarrytown SBM	No	No	Yes	Yes	Yes
Yonkers North SBM	No	No	Yes	Yes	Yes
Yonkers South SBM	No	No	Yes	Yes	Yes
Stony Point Perimeter	No	No	Yes	Yes	Yes
Stony Point SBM	No	No	Yes	Yes	Yes
Ossining SBM	No	No	Yes	Yes	Yes
NNBF (locations TBD)	Yes	Yes	Yes	Yes	Yes
Nonstructural (locations TBD)	Yes	Yes	Yes	Yes	Yes
Total Percentage of Study Area CSRM	94.79%	74.36%	54.11%	35.45%	3.2%
Percentage of Study Area with Future Unaddressed CSRM	5.21%	25.64%	45.89%	64.55%	96.8%

4.3.5.7 Preliminary Benefits Estimation

USACE considers the four accounts established in the Principles & Guidelines (P&G 1983) in the evaluation of alternatives: NED, Environmental Quality (EQ), Other Social Effects (OSE), and Regional Economic Development (RED) benefits. Typically, USACE CSRM feasibility studies acknowledge all four accounts but focus on the NED account. This analytical limitation has been acknowledged in the NACCS (USACE 2015), and attempts to capture the remaining three accounts made some progress through the use of GIS data sets in the NACCS. However, no benefits quantification method for all four accounts has been approved for use in USACE studies to date.

The NYNJHAT study team has been refining the GIS analysis that was completed for the NACCS and subsequent Focus Area Report for NYNJHAT (see section 3.1: Problem Identification). The intent of the refinement is to improve the analysis by incorporating new data (ex: FEMA HAZUS and ADCIRC modeling), updating existing data, and ensuring that our Non-Federal sponsors' priorities are captured in the weighting of resources [population (especially socially vulnerable populations), property, critical infrastructure, environmental and cultural resources, etc.] that are at risk from coastal storm impacts (see GIS appendix). This, in turn, feeds into the characterization of high risk areas that merit greatest consideration of CSRM measures. The characterization of areas and resources at coastal storm risk is also our best chance at addressing the four P&G accounts.

Our current milestone requirements include benefits developed through an approved or certified model for the TSP. For CSRM studies, the models that have been approved are for NED benefits. Accordingly, for the upcoming milestone, the study team will identify, on the broadest terms, the NED benefits for NYNJHATS alternatives to meet this requirement, while acknowledging that such an analysis still needs the remaining three accounts to be complete.

For each alternative, the concentration of NED benefits by location will be compared to the GIS characterization of areas and resources at risk to assess how the results correlate, and what refinements are needed to best meet our requirements. Potential outcomes could include refinements to HEC-FDA if the correlations are strong, or adding more rigor and resources to the GIS method to support an application for model certification.

HEC-FDA

The first level of screening used HEC-FDA to leverage as much of the existing investigation reports on CSRM studies and projects in the USACE New York District (NYD) area (see Economics Appendix). Due to the large size of the study area, the structure inventory was largely desktop based. Average annual damages were evaluated for all 64 reaches and the average annual damage results tabulated by reach, analysis year, and damage category. The total present worth and equivalent annual inundation damages were calculated using a spreadsheet format that provided flexibility to compare with and without project damages for plans with different completion dates. The economic analysis is spreadsheet-based however the development of measures and alternatives require geospatial data defining the flooding extent of the equivalent flooding event modeled within the spreadsheet based economic analysis. The flooding extent was based upon ADCIRC modeling results.

For this first screening of alternatives in the study (due to the complexities of comparison between the initial focused array of alternatives), the decision was made to compare the alternatives using a present worth analysis with the period of analysis of 50 years for various measures each starting when each measure in each alternative is considered to become operable/functional. Effectively, the base year has not yet been established. Without project damages from 2030 to 2100 have been calculated to support the identification of the period of analysis in the next round of formulation, with the base year set to when the last feature of the initial construction elements of recommended plan become operational.

Other assumptions for the preliminary HEC-FDA benefits are that all measures would be designed to provide CSRM up to the 1% plus three (3) foot water surface elevation, and that barriers would be operated for the 50% flood event (the actual trigger event will be identified for each barrier in successive phases of the study).

The expected average annual damages in the FWOPC are $5.1 billion in 2030 and expected to increase to approximately $13.7 billion by 2100, based on the intermediate rate of RSLC, resulting in $7.2 billion average annual without project damages over the period under consideration. The preliminary results are presented in Table 12.

Table 12. Preliminary HEC-FDA Benefits

Alternative	Average Annual With Project Damages	Average Annual Benefits	Risk Reduction from No Action
1- No Action	--	--	0%
2 – SH-BP barrier	$618,186,000	$6,486,293,000	92%
3A-Three Barriers	$764,084,000	$6,338,586,000	89%
3B –Two Barriers	$1,208,850,000	$5,955,380,000	83%
4 –Single waterbody Barriers	$1,607,201,000	$5,503,796,000	78%
5- Perimeter only	$5,345,800,000	$1,801,476,000	25%

GIS

The updated GIS composite risk index was used to generate unit values of resources for which the risk is managed by each scale of alternative as a comparison to the HEC-FDA values. It is worth noting again that HEC-FDA is designed to measure NED benefits – more specifically, the subset of NED benefits that consists of damages prevented to structures and their contents. HEC-FDA does not capture damages prevented to critical infrastructure, or secondary and tertiary effects (lost productivity, etc.). The GIS values were generated as an attempt to capture the four Principles and Guidelines accounts (NED, RED, EQ, and OSE). The values per alternative were generated by superimposing polygons over the areas that would be landward of the potential alignments, and tabulating the values within the polygons according to the exposure weights set for this study. The preliminary GIS results are presented for comparison to the HEC-FDA results in Table 13.

Table 13. Comparison of GIS Outputs and HEC-FDA Results

Alternative	GIS values	Risk Reduction from No Action	HEC-FDA Average Annual Benefits	Risk Reduction from No Action
1- No Action	(151,100,926)	0%	--	0%
2 – SH-BP barrier	143,471,207	95%	$6,486,293,000	92%
3A-Three Barriers	116,350,849	77%	$6,338,586,000	89%
3B –Two Barriers	88,312,497	58%	$5,955,380,000	83%
4 –Single waterbody Barriers	61,015,129	40%	$5,503,796,000	78%
5- Perimeter only	6,017,650	4%	$1,801,476,000	25%

The preliminary results show similar trajectories in the HEC-FDA and GIS output results, although the distribution is considerably wider in the GIS outputs. As USACE is required to present benefits calculated through a certified model, the benefits generated through HEC-FDA factor into the net benefit calculations. GIS based values are presented for comparison purposes and to identify potential analyses needed. Per USACE guidance and regulations, benefits should be considered in conjunction with the costs, and so this summary will now describe the assumptions behind the parametric costs development.

4.3.5.8 Parametric Costs

The alternative concepts range from large transect storm surge barriers (SSB's) paired with the necessary on-land tie-in features (alternative 2) to an entirely on-land, perimeter solution of (SBM's throughout the study area (alternative 5) with additional alternatives with different combinations of intermediate SSB's and the corresponding SBM's for shoreline left exposed outside of the protection of the SSB's (alternatives 3A, 3B & 4).

For a project with such a sprawling geographic area under consideration, at this early phase of the feasibility study, parametric cost estimates are required for plan selection/elimination. Parametric cost engineering involves a "top-down" process for estimating construction costs of measures as a function of their dominant characteristics based on available reference data from comparable projects. This process is distinct from cost engineering practices informed by designs, contracting and market condition assumptions and typical contractor markups among other direct cost assumptions such as quantity takeoffs, labor rates, material prices and more. Given the absence of designs beyond the identified parameters, the use of such a reference-based methodology comes with greater risks than are involved with more traditional bottom-up estimating methods. The value of the parametric approach is that it can identify the order of magnitude and relative size of costs among alternatives considered with little to no design.

Details of the parametric approach to cost engineering are detailed in Cost Appendix, but to summarize: All proposed measures for the four alternatives under consideration fall within the two categories of Storm Surge Barriers (SSB's) and SBM's. Each measure is assigned a unit cost based on type while design dimensions are estimated based on preliminary layout informed by available topography/bathymetry and development data (see Engineering Appendix).

SSB's include a range of features (mostly dynamic such as navigable gates and auxiliary flow openings) constructed to transect existing bodies of water. Their design is meant to permit the maximum flow of / minimum interruption to existing fluvial and tidal flow while retaining the capacity to close and block the advance of a high surge associated with a large coastal storm.

SBM's include a range of features (mostly static ones like levees and floodwalls) constructed along the coast to impede rising waters associated with fluvial or storm surge flood events. Their design is meant to integrate as smoothly as possible with current coastal land use while providing elevated mitigation against flood risk.

For this study, the large size of—and the design uncertainties associated with—the SSB's under consideration drive the cost engineering approach. The proportional weight of these measures upon the ultimate construction costs and durations of whichever alternative is selected has meant that the bulk of the cost engineering effort thus far has focused on development of a cost model which is both sufficiently sensitive to the limited design decisions available at this phase and well-grounded in the limited reference data available.[8]

Our greater experience with SBM's, paired with research into estimates compiled by study partners with experience in higher density applications, informs the unit costs applied for perimeter features. For both SSB's and SBM's the unit costs published in the NACCS were taken as a starting point and refined based on the need for greater site-specific design dependency and improved modeling based on additional available information.

Storm Surge Barriers (SSB)

Within the NYNJHAT study area, sixteen storm surge barriers were identified for investigation. The length and crest elevation of each barrier is presented in Figure 32 for comparison purposes. They were sited based on the considerations described in the NACCS:

- Embayments characterized by relatively high development (such are needed to provide benefits to offset the relatively high costs of the barriers)
- Embayments with reasonably narrow entrances and therefore lower relative costs
- Some preference was also given to existing harbors featuring navigation channels

Lengths of the barriers range from 130 linear feet (lf) on the Gowanus Creek in Brooklyn, NY, to 32,500 lf for the Outer Harbor barrier from Sandy Hook to Breezy Point. The crest elevations of the barriers range from +16.5 feet NAVD88 for the barrier at Newtown Creek to +46 feet NAVD88 for the Outer Harbor barrier. The crest elevation was based on the 1% flood water surface elevation (from NACCS modeling) plus intermediate RSLC through 2080 plus freeboard. The height of freeboard was calculated to limit the overtopping flow rate to prevent damage to the gate itself and to limit the volume of water accumulated on the exterior side of the barrier. Of note is the extremely high design crest elevation for the Sandy Hook to Breezy Point Barrier (+46 feet NAVD88). This is the effect of adjacent land funneling the storm surge, elevating the water surface. This effect combines with the vertical orientation of the gate face and the 16 feet wave heights anticipated by the models to inform the +46 feet NAVD88 crest elevation for this location.

The update of parametric costs for barriers included limited use of previously developed Engineering Research Development Center (ERDC) models of the study area. The ADH model,previously developed as part of the NY/NJ Harbor Deepening Project, simulates five separate selected years of flows of physical parameters. and the ADCIRC modeling is for tropical and extratropical storm events. These models were used to evaluate the effect of conceptualized initial surge gate structures on localized and far-field flows under ambient conditions, as well as under select storm conditions to evaluate the potential for induced impacts from surge gate structures in alternatives 2, 3A, and 3B on areas outside of the barriers. This

[8] Fewer than twenty SSB's of comparable size to those considered on this project have been constructed around the world.

modeling information was used to determine the range for the number of gates and open span for the barriers under consideration as well as other initial design and environmental considerations (e.g., navigation near and through the gate structures, potential effect on tide range, induced flooding impacts, etc.).

As the Port of New York-New Jersey is the most active port on the East Coast, maintaining navigation access is key to the nation's economy. Additionally, an initial potentially feasible size of navigation surge gates was identified. Also, an analysis of the ambient tidal flows informed the number of auxilliary surge gates necessary in these alternatives which are needed to minimize impacts to tidal exchange and environmental resources. Figure 33 shows the in-water cross section area of the alternatives (compared to the number of gates within each alternative). The number of gates does not correlate to the cross section area, but is rather driven by the hydrologic modeling results and presence of navigation channels.

The length and crest elevation for the barriers alone are not enough for parametric cost estimates. Unlike shoreline flood mitigation features such as levees and floodwalls, length alone is not a sufficient independent parameter upon which to estimate construction costs for storm surge barriers. Statistical regression analysis of the reference set of existing storm surge barriers demonstrates that the unit cost of the dynamic[9] span should be estimated to be at least one order of magnitude greater than that of static span. Given the structural and functional complexities associated with dynamic features relative to static ones, this difference is consistent with engineering judgment.

[9] Length or area of "dynamic" span of storm surge barriers refers to those portions of a barrier system which can be opened either to allow for navigation or auxiliary flow. The values include both the width/area of the openings and the structures associated with operation and housing of such features. By contrast, length and area of "static" span refers to that of the closed off wall or dam portions of barrier systems.

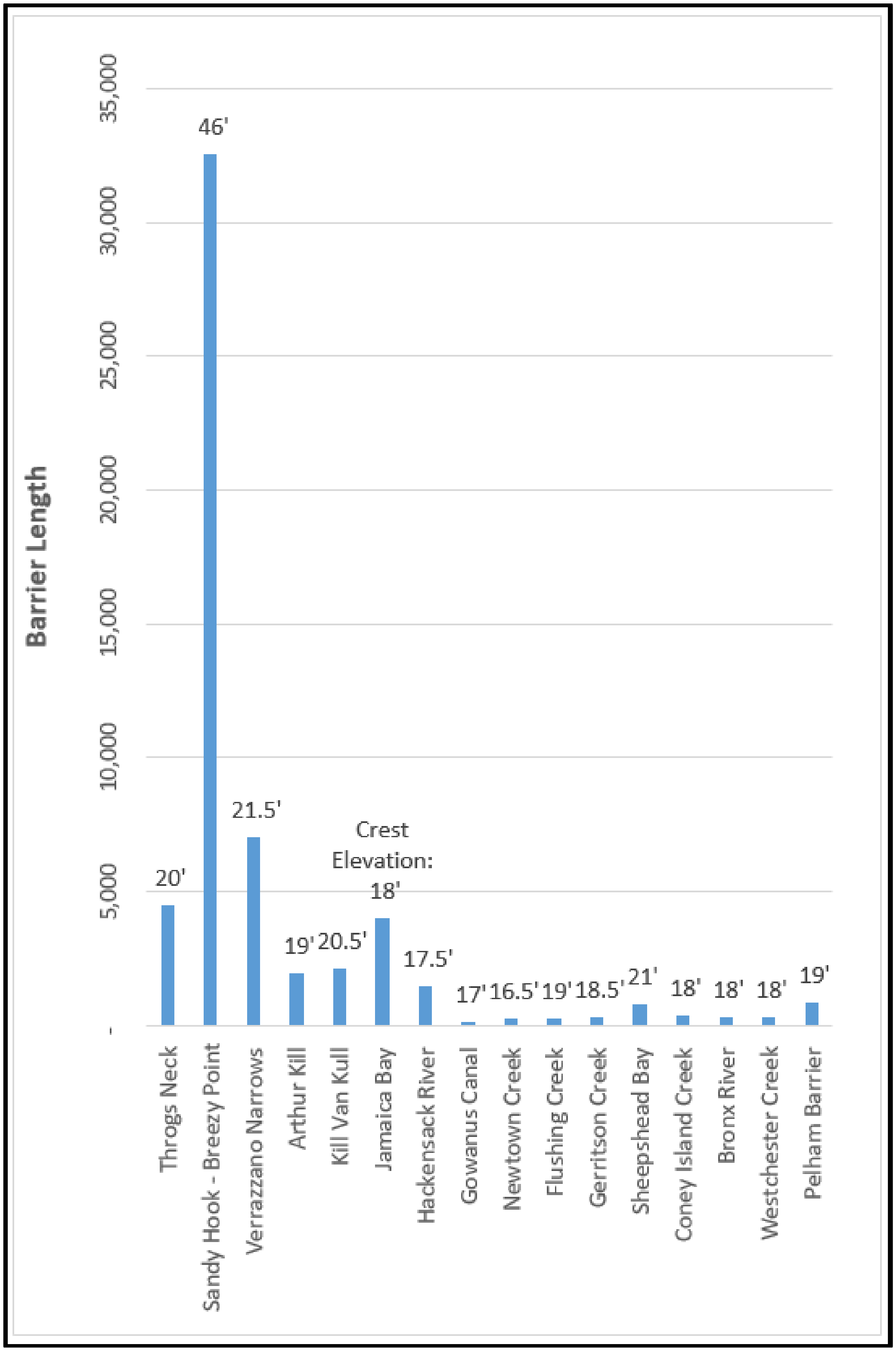

Figure 32. Lengths and crest elevations of barriers in alternative 2-4

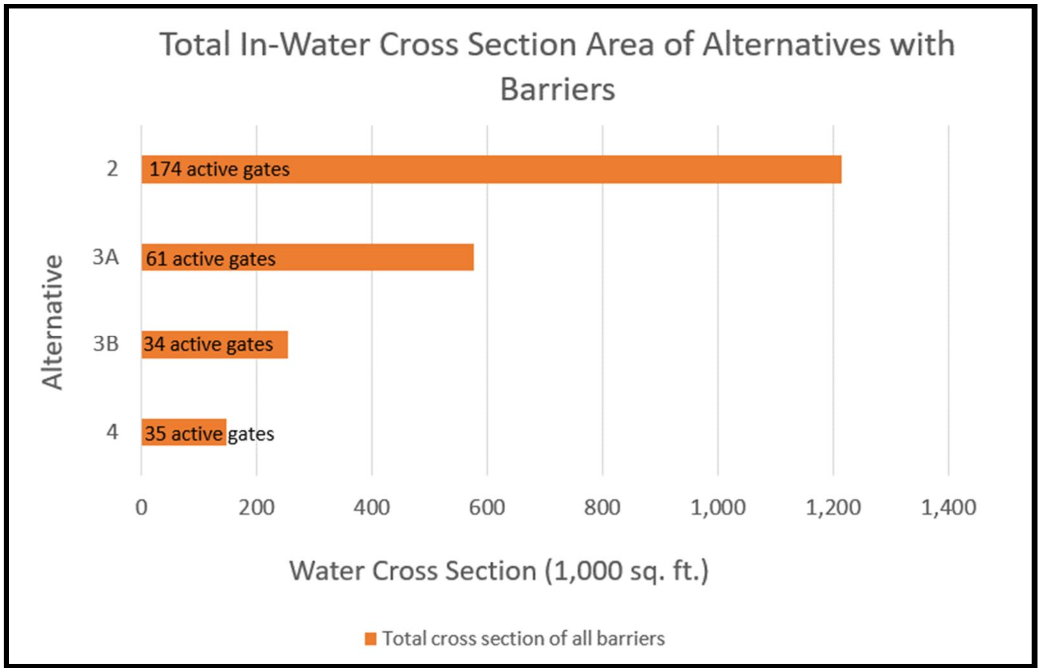

Figure 33. Total In-Water Cross Section Area of Alternatives with Barriers

Through application of autocorrelation tests and regression analysis, this study built upon the NACCS model for estimating the costs of SSB's. There is a very high correlation between cost and number of gates and low correlation between Total Height (TH) and Head Differential (H). For construction cost and duration of SSBs, the following model is recommended:

Cost = (*$19,000 x Navigable Area*) + (*$14,000 x Auxiliary Area*) + (*$3,000 x Dam Area*)

Where, all areas are measured in Square Feet and Cost, in 2019 American Dollars.

The same methodology is also used to develop a model for estimating construction duration, resulting in the following formula:

Duration = (4 *months / 100FT of Navigable Span*) +
(*7 weeks/ 100FT of Auxiliary Flow Span*) + (*5 Days / 100FT of Dam*)

The costs and durations shown in Table 14 do not reflect any additional contingencies (an extra percentage over the base cost estimate assumed to cover uncertainty in the design and construction process). Various combinations of these proposed barriers figure into each of the alternatives, with none of the barriers appearing in the SBM-only alternative (Alternative 5).

It should be noted at this point while construction durations have been parametrically estimated for the barriers and inform the parametric cost estimate, these construction durations have not been factored into the calculations of benefits. The flows of benefits and costs through time will be reconciled for the upcoming Draft Feasibility Report.

Table 14. Proposed Storm Surge Barrier Cost and Duration (without contingencies)

Proposed Storm Surge Barrier	Estimated Initial Cost of Construction by Model (w/o Contingency) [$, 2019Q1]	Estimated Duration of Construction [Years]
Throgs Neck	$ 3,640,000,000	10
Sandy Hook - Breezy Point	$ 36,455,000,000	25*
Verrazzano Narrows	$ 8,469,000,000	18
Arthur Kill	$ 1,671,000,000	7
Kill Van Kull	$ 3,574,000,000	8
Jamaica Bay	$ 2,378,000,000	9
Hackensack River	$ 719,000,000	4
Gowanus Canal	$ 85,000,000	2
Newtown Creek	$ 170,000,000	3
Flushing Creek	$ 200,000,000	3
Gerritson Creek	$ 98,000,000	2
Sheepshead Bay	$ 343,000,000	3
Coney Island Creek	$ 187,000,000	3
Bronx River	$ 150,000,000	3
Westchester Creek	$ 170,000,000	3
Pelham Barrier	$ 318,000,000	4

Model developed with regression analysis on a three parameters: the areas of navigable, auxiliary flow and dam features. Cost = $19000 x 'Navigable Area' + $14000 x 'Auxiliary Flow Area' + $3000 x 'Dam Area'

*SH-BP Barrier construction duration is estimated with the same reference-based parametric duration model as the others, but assumes that the total span will be constructed in 3 parts, concurrently.

Operations, Maintenance, Repair, Rehabilitation, and Replacement

Estimated operations and maintenance costs for storm surge barriers are grounded in reference data available from a small, local NY/NJ harbor reference (Keansburg, NJ) and that from the much larger Thames Barrier in the United Kingdom. The proximity of the O&M costs identified for these two, very different barriers provides some confidence that these estimates are within the correct order of magnitude and can be applied, preliminarily, to the full range of barriers under consideration. A bottom-up estimate for such costs would require additional engineering and design.

Based on these references, the per operation cost for storm surge barriers considered in this study are calculated as 0.3% of the initial construction cost. The number of operations per year is assumed as a 50% chance of operation within a given year at the start of the period of analysis, with the frequency estimated to triple after 50 years. These costs are comparable to the assumptions outlined in the NACCS study which identified annual maintenance costs as 0.5% of the initial construction cost. The NACCS did not identify less frequent scheduled maintenance, repair or rehabilitation costs.

In this study maintenance, repair and rehabilitation costs are assumed to match similar, large-scale coastal flood mitigation projects but warrant feature-specific refinement. Such costs are calculated the same across all alternatives. Maintenance costs are calculated at 0.3% of construction cost annually and 0.6% of construction cost every five years. Scheduled repair costs are calculated at 6% of construction cost every ten years. And major rehabilitation costs are calculated at 27.5% of construction cost every 25 years.

It should be noted that at this level of screening, the annual operations and maintenances costs for barriers have been assumed at 2% of the first cost of construction because of the high number of gates. Subsequent rounds of formulation will include operations, maintenance, repair, rehabilitation, and replacement costs (OMRR&R) based on the required tasks. Another key assumption is the 50% flood event as the trigger event for operating all of the barriers in each alternative.

In subsequent rounds of formulation, the trigger event for closure would likely be optimized per barrier based on the tradeoff of potential impacts minimized compared to the costs (navigation, environmental, etc.) from enacting the closure. Ultimately the trigger will be tied to the water surface elevation(s) that would impact most or all critical infrastructure. The frequency of occurrence for this water surface elevation will be calculated, as it may change over time due to climate change and relative sea level change (RSLC), and used to refine cost estimation and environmental impact analysis.

Shoreline Based Measures

As discussed above, the corresponding methodology for developing unit costs for Shoreline Based Measures (SBM's) depends on local experience and cost engineering judgment rather than statistical analysis. The SBM's currently proposed for at least one alternative on this study include floodwalls, levees, seawalls, operable floodgates, elevated promenades, dunes/buried seawalls and tide gates. Each type has a unit cost (per linear foot) which corresponds with three categories of anticipated accessibility: very limited, limited and unlimited.

Accessibility stands in as a catch-all categorization tool for various anticipated cost drivers which include local geotechnical factors as well as development density and site access conditions. The unit costs for each as currently used[10] are summarized in Table 15, below:

[10] January, 2019: for the Interim Report (pre-TSP)

Table 15. Unit Costs per linear foot by Shoreline Based Measure

SHORELINE BASED MEASURE UNIT COST TABLE			
FEATURES \ ACCESS	Very Limited	Limited	Unlimited
Floodwall	$ 37,500	$ 11,250	$ 6,000
Levee	$ 9,000	$ 3,750	$ 2,000
Seawall	$ 11,500	$ 4,500	$ 3,000
Operable Flood Gate	$ 75,000	$ 30,000	$ 16,500
Elevated Promenade	$ 45,000	$ 15,000	$ 7,500
Buried Seawall/Dune	$ 15,000	$ 6,000	$ 3,000
Tide Gate	$ 75,000	$ 30,000	$ 16,500

Determination of feature and access limitations by segment of shoreline is preliminary but reflects reasonable engineering judgment given the overall scope of the project area and length of shoreline studied.

4.3.6 Other Cost Considerations

Preliminary real estate, environmental mitigation, and cultural mitigation estimates have been developed on a rough order of magnitude basis based on desktop exercises and are presented in Table 16.

Table 16. Preliminary Estimates for Other Cost Considerations (FY 19 P.L.)

Alternative	Real Estate	Environmental and Cultural Resources Mitigation
2	$30,000,000	$270,000,000
3A	$110,000,000	$240,000,000
3B	$270,000,000	$1,270,000,000
4	$270,000,000	$1,270,000,000
5	$150,000,000	$1,380,000,000

Real estate estimates may seem surprisingly low; this rough order of magnitude estimate is based on the location of measures near roads and other public infrastructure and are already in public ownership. As the footprint of each measure is refined, the real estate costs for each alternative could change significantly.

Environmental and cultural mitigation estimates are based on potential impacts on land and within water from the footprint of each measure. To establish rough mitigation costs using existing information, the study team looked at what estimates USACE-NYD had developed in the region recently for similar measures. The East Rockaway Inlet to Rockaway Inlet and Jamaica Bay Hurricane Sandy Reformulation Study (Rockaway Reformulation) is an ongoing study in the region, scheduled to conclude in 2019, with overlap in the Jamaica Bay Region of this study. Among the measures analyzed in the Rockaway Reformulation, are a storm surge barrier (the further evaluation of which will now be conducted in this study), and shore-based measures (SBMs), such as floodwalls and natural and nature-based features, to manage the risk of coastal flooding. The impact cost for gates (roughly, $700 per linear foot) is based on the cost outlined in the Draft Hurricane Sandy General Reevaluation Report and EIS for the Atlantic Coast of New York, Rockaway Reformulation (Rockaway DHSGRR) (USACE, 2016b). SBMs are assumed to have an impact width of 135 feet (the assumed average width of a medium levee). The impact cost of the SBMs is also based on the Rockaway DHSGRR, and estimated to be roughly $500,000 per acre.

In order to account for monitoring costs and air mitigation costs not considered in the costs from the Rockaway DHSGRR, the monitoring and air mitigation costs from the Draft General Reevaluation Report for Fire Island to Montauk Point were scaled to the size of the measures in our study (USACE, 2016c). Given the scope of some of the possible measures, air mitigation costs were doubled for the in-water sections of barriers, and tripled for the in-water section of the Sandy Hook to Rockaway Peninsula barrier since the estimated construction duration for the Sandy Hook to Rockaway Peninsula barrier is so much greater than the estimated construction duration for the other barriers (25 years versus anywhere between 2 and 18 years). An additional 40% contingency was added for Alternatives 2 to 5. Contingency is based on risk and uncertainty of the cost estimates. Since storm surge barriers are relatively rare infrastructure in the U.S.—there are three in New Orleans and two small ones in New England—there is less data and impact analysis associated with them. The Texas Coastal Protection and Restoration Feasibility Study recently released an Integrated Draft Feasibility Report and EIS analyzing the potential impacts of storm surge gates on the coast of Texas which are being considered and two other USACE studies along the North Atlantic Coast, namely the Nassau County Back Bay Study and the New Jersey Back Bay Study are both also considering storm surge barriers in their array of alternatives under consideration. USACE is coordinating internally to share data, findings, and best practices given the relative nascency of storm surge gate measure implementation in the U.S. when compared to more widely utilized CSRM features like floodwalls and levees. Alternative 2, if constructed, would be the largest storm surge barrier in the world, which adds to the risk and uncertainty for environmental impacts associated with it, hence the high contingency of 40%. Moving forward, these estimates will be further refined, and adjusted to account for additional impacts, based on additional modelling and existing information.

In addition to Real Estate, Environmental Mitigation, and Cultural Mitigation, additional considerations include Operation and Maintenance costs, the estimates of which range from 2% of the initial construction costs annually for dynamic in-water measures, (i.e., navigation gates) to 0.5% of initial construction costs annually for static upland measures (i.e., levees and floodwalls). Interest during construction at 2.875% was applied based on the construction duration of the measures within each alternative, and PED and S&A were calculated based on the scale and complexity of each measure under consideration. Feature-specific contingencies are not included and will be developed in the next round of formulation. The preliminary totals are presented in Table 17.

Table 17. Costs of Alternatives 2-5, FY 19 P.L., Interest Rate 2.875% ($$ Billions)

Alternative	Construction Cost (w/ contingency)	Environmental and Cultural Mitigation	Real Estate	IDC, PED, S&A	OMRR	Total	Duration
2	$57.9	$0.27	$0.03	$49.0	$11.6	$118.8	25 Years
3a	$25.6	$0.24	$0.11	$14.3	$6.9	$47.1	18 Years
3b	$23.9	$1.27	$0.27	$9.7	$7.9	$43.0	9 Years
4	$17.6	$1.27	$0.27	$6.9	$6.0	$32.0	9 Years
5	$8.0	$1.38	$0.15	$2.7	$2.7	$14.8	9 Years

4.4 Benefits and Costs of Alternative Concepts

HEC-FDA outputs were converted from average annual benefits to present value using the present value function in Excel (50 year period, discount rate of 2.875%) for comparison with the first costs (Table 18), and the net benefits of the alternatives are presented in Table 19.

Table 18. HEC-FDA Average Annual Benefits in Present Value

Alternative	HEC-FDA Average Annual Benefits	Project Benefits in Present Value	Benefits rounded to $$ billions
1- No Action	--	--	
2 – SH-BP barrier	$6,486,293,000	$175,111,554,000	$175.1
3A- Regional barriers	$6,338,586,000	$171,123,883,000	$171.1
3B – Mid size barriers	$5,955,380,000	$160,778,406,000	$160.8
4 – Small Barriers	$5,503,796,000	$148,586,916,000	$148.6
5- Perimeter only	$1,801,476,000	$48,634,753,000	$48.6

Table 19. Net Benefits for Alternatives 2-5 (in billions)

Alternative	Project Benefits in Present Value	Alternative Costs	Net Benefits
1- No Action	--	--	--
2 – SH-BP barrier	$175.1	$118.8	$57.0
3A- Regional barriers	$171.1	$47.1	$124.0
3B – Mid size barriers	$160.8	$43.0	$117.8
4 – Small Barriers	$148.6	$32.0	$116.6
5- Perimeter only	$48.6	$14.8	$33.8

The preliminary results suggest that Alternative 3A has the greatest net benefits at $125.7 billion, with Alternatives 4 and 3B as close runners-up. The net benefits for these three alternatives are an order of magnitude greater than those for Alternatives 2 and 5, although they all have net benefits and could be pursued for further investigation in the next round of formulation.

4.4.1 Factors Affecting Plan Selection

The identification of the plan with the highest net benefits is contingent, however, upon investigation of the assumptions made throughout this study to date, and analyses needed to confirm or corroborate the assumptions. Any of the factors listed below has the potential to change the net benefits on a substantive scale.

1. **Hydrodynamic Modeling.** Early ADCIRC modeling suggests that Alternatives 2 and 3A may induce flooding outside of the study area, along the coastlines of New York and New Jersey. The induced flooding evident in the preliminary analysis may result in the alternative being deemed unacceptable. If the alternative warrants further consideration based on economic reasons, additional engineering analyses will be needed to identify means that may address or mitigate the induced flooding, which could negatively affect the economic justification for these alternatives. The initial ADH modeling indicates the potential for some navigation gate structure to accelerate ambient flows. Based on these results, it may be necessarily model the impacts to navigation in the vicinity of the conceptual surge gates, using ship simulation studies. Also, the initial ADH modeling indicates that the initial conceptual gate structures in alternative 3A, and to a lesser degree other alternatives, may have the potential to affect the tide range in other areas of the estuary. For this reason, further engineering analysis of the surge gate structures in alternatives that may be carried forward in the study are warranted.

   Recommendation: additional hydrodynamic modeling along with engineering gate structure designs for both navigation as well as environmental effects.

2. **Relative Sea Level Change (RSLC).** Benefits were developed on the intermediate rate of RSLC. It has been observed that use of the low or historic rate of RSLC will favor perimeter measures in plan selection, while the use of the high rate of sea level change favors larger barriers. All of the alternatives include a placeholder for complementary high frequency measures (NNBF, nonstructural, & localized perimeter measures targeted at clusters of high frequency flooding or areas that may be underwater under any RSLC scenario). The placeholders will be refined with respect to actual location, action, footprint in the next round of formulation.

   Recommendation: the next round of formulation will also include a detailed investigation how the alternatives perform under each of the RSLC scenarios.

3. **Period of Analysis.** Similar to the Relative Sea Level Change, a period of analysis that is closer in time to the study favors perimeter measures in plan selection. We are limited to a 50 year period of analysis that could begin either: 1) when the first separable element of any alternative is completed and begins to produce benefits, or when 2) construction of the longest lead time measure is complete. Under the first scenario, USACE will begin counting benefits from perimeter measures that could be built while barriers are still under

construction (meaning that the cost of the barriers is counted in the net benefit calculation, but very little of the benefit). Under the second scenario, all of the benefits from all of the measures can be compared against each other if it is assumed that smaller projects will be operated and maintained at their design level beyond the first 50 years.

Options: 1) agreement among USACE and the Non-Federal sponsors on which 50 years to use, or 2) go to a 100 year period of analysis, or 3) have separate 50 year periods of analysis per alternative.

4. **<u>Operations and Maintenance Assumptions</u>.** Plan selection is sensitive to when the gates will be operated. Currently the analysis assumes that the 50 percent flood is the trigger event for all of the gates under consideration. The next round of formulation will consider the optimal trigger event per gate – is it the 50 percent flood, the 20 percent flood, 10 percent flood, or some other event? Or should it be linked to the water surface elevation (WSEL) at which a critical mass of the region's critical infrastructure is affected? Figures 34 and 35 shows the distribution of critical infrastructure in two ft increments. From this broad view, it appears that the critical mass is reached somewhere between 6 feet NAVD88 and 8 feet NAVD88. This decision requires direct input from the Non-Federal sponsors, who would be responsible for the operations and maintenance, and should be made in conjunction with the siting and determination of the high frequency measures, which could reduce the need to operate the gates as frequently.

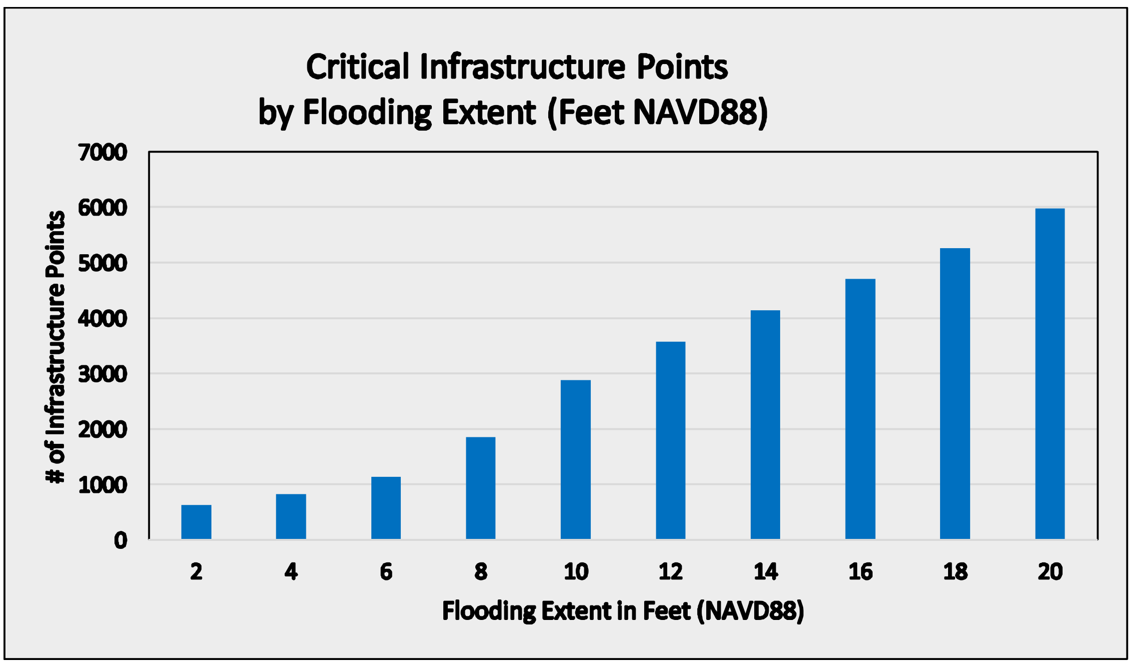

Figure 34. Number of critical infrastructure points inundated at different flooding extents

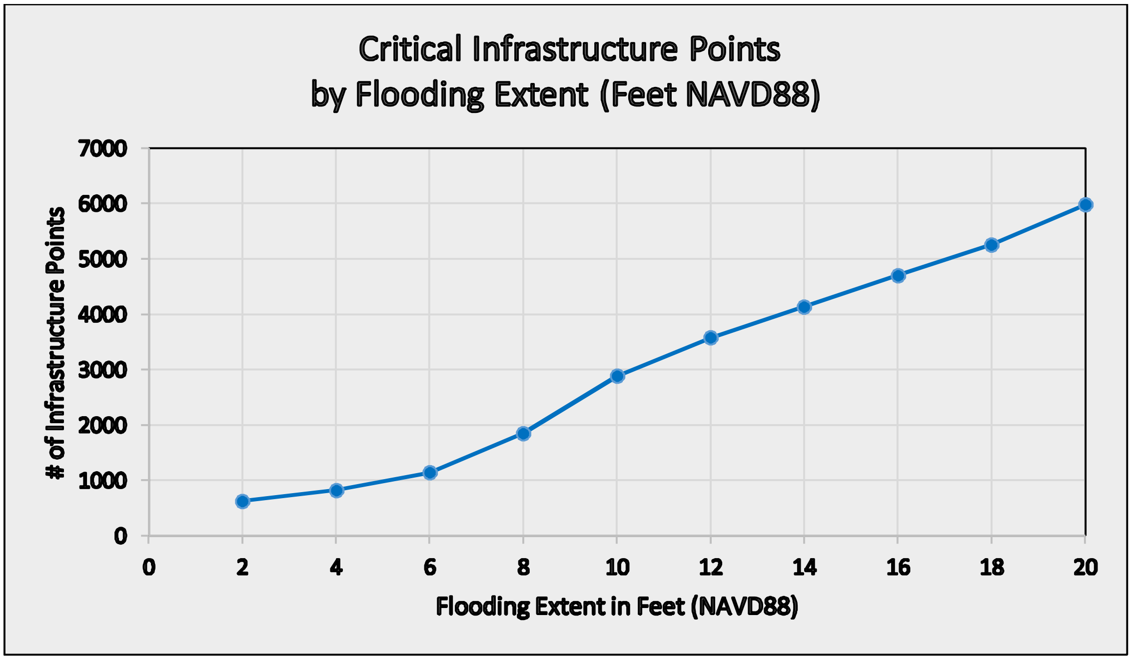

Figure 35. Number of critical infrastructure points inundated at different flooding extents

5. **Benefits Model.** HEC-FDA is best used for structures and their contents, and does not adequately capture critical infrastructure, let alone benefits from the other three P&G accounts (EQ, OSE, and RED). The GIS analysis produced a wider distribution of potential benefits, but is not a certified model, does not produce outputs in monetary units, and would require a time function to be able to estimate benefits over the period of analysis (Table 20).

   Options: 1) Continue to use HEC-FDA, as it adjusts to account for wave action and can be adjusted over time to accommodate RSLC assumptions; 2) Adapt HEC-FDA based on expert advice to capture more types of benefits; or 3) Develop GIS outputs and pursue model certification.

Table 20. Comparison on HEC-FDA Net Benefits and GIS Scores
($ in billions, FY19 P.L., IDC 2.875%)

Alternative	Alternative Costs	HEC-FDA		GIS	
		Project Benefits in Present Value	Net Benefits	Outputs	Score (Output/ Cost)
1- No Action	--	--	--	--	--
2 – SH-BP barrier	$118.1	$175.1	$57.0	143,471,207	904
3A- Three Barriers	$47.1	$171.1	$124.0	116,350,849	2151
3B –Two barriers	$43.0	$160.8	$117.8	88,312,497	1829
4 – Single Water Body Barriers	$32.0	$148.6	$116.6	61,015,129	1636
5- Perimeter only	$14.9	$48.6	$33.8	6,017,650	363

6. **Real Estate.** Real estate costs were provided on a rough order of magnitude based on existing information. Once more fully developed in an area with some of the most expensive real estate in the nation, it is possible that plan selection could be affected.

7. **Environmental and Cultural Resources Mitigation.** The environmental and cultural resources mitigation estimates were based on existing information from other completed studies and construction projects. More site-specific investigation may yield additional potential environmental and cultural resources impacts for resources that are: 1) currently unknown; 2) not known to be in either the study area or within areas affected by induced flooding from the various measures; and/or 3) so significant that they cannot be addressed through mitigation and may be declared environmentally unacceptable. (See Resource and Impact Discussion)

8. **Cost Refinements.** The current cost estimates are parametric and do not include contingencies developed through an Abbreviated Risk Analysis (ARA). The ARA factors the risk of unknown factors into the contingency. It is anticipated that the construction of barriers/gate, for which there is no existing example of this scale within the study area, may have very high contingencies compared to levees and floodwalls, with which USACE-NYD is familiar.

9. **Interior Drainage.** Interior drainage requirements have not been developed for this round of formulation. It is typically analyzed during the detailed feasibility level of analysis.

10. **Navigation Considerations.** The Port of New York and New Jersey is the busiest on the East Coast. As the formulation is refined, port operations requirements may affect the operations and maintenance assumptions, which in turn may affect plan selection.

11. **Scale.** This round of formulation relies upon existing information to develop scales of alternatives. As the investigations become more site specific, field investigations for economics, environmental, engineering purposes (geotechnical and bathymetric) could yield data of an unexpected nature.

4.4.2 Resource and Impact Discussion

The impact analysis for each of the proposed concept alternatives is in its nascent stage, incomplete and still under development. No new data gathering or modeling was prepared to inform a full impact analysis yet. The impact discussion herein lays out the project known impacts at this time based on the analysis to date of existing information (Table 21).

Table 21. Summary Table of Alternatives

Alt	Areas Benefited by Alternative	Areas Not Benefitting from Alternative	Main Environmental Concerns	Notes
1	None	Entire study area	Entire study area remains as vulnerable as it will be with the currently ongoing efforts to coastal flooding impacts.	Assumes all ongoing studies/projects by USACE and funded efforts by others (e.g., RBD) are implemented to extent currently considered feasible/actionable.
2	Nearly all of the study area	Part of the eastern shorelines Bronx & Westchester Counties.	Tidal exchange in Hudson River Estuary, migration of estuary resources through Bight and Long Island Sound, cultural resources impacts	Fewest number of alternative features (see Table 11).
3.a	Much of the study area	Shorelines around Raritan, Sandy Hook, and Lower Bay	Tidal exchange in Hudson River Estuary, migration of estuary resources to Bight and LIS.	Addresses severe coastal storm risk in nearly all of NYC, inner NJ, and Hudson River. Relatively few alternative features.
3.b	Inland NJ areas (incl. port, oil terminals and Newark airport) and backside of SI by barrier, high risk areas of NJ & upstate NY along HR & NYC	Segments of NY (incl. NYC) and NJ (along HR) that initially appear to not have high risk/exposure.	Tidal exchange in Kills/Newark Bay, migration of estuary resources to Newark Bay, impacts to CERCLA-listed sites, impacts to cultural and social resources from perimeter measures in NJ along HR and NYC.	Only relatively higher risk areas in NY (incl. NYC) and NJ (along HR) have alternative features (Table 11).
4	Only relatively higher risk sections of shoreline or smaller tributary basins in study area.	Relatively moderate and low risk areas.	Tidal exchange in Hackensack River, Gowanus Canal, and Newtown Creek; CERCLA-listed sites; impacts to cultural and social resources from perimeter measures in NJ along HR and NYC.	Only relatively higher risk areas in NY (incl. NYC) and NJ have features. Major port facilities (incl. oil terminals, etc.), Newark and LaGuardia airports remain at risk. Many alternative features (Table 11).
5	Only relatively higher risk sections of shoreline or smaller tributary basins in study area.	Relatively moderate and low risk areas.	Coastal zone and wetland impacts and impacts to cultural and social resources from perimeter measures in NJ, upstate Hudson in NY, and NYC.	Only relatively higher risk areas in NY (incl. NYC) and NJ have features when feasible without in-water measures. Major port facilities (incl. oil terminals, etc.), Newark and LaGuardia airports remain at risk. Several alternative features (Table 11).

4.4.2.1 No Action Alternative

Alternative 1: No Action Alternative would involve no action as a result of this study. Due to the synergistic effects of a combination of factors, including land subsidence, eustatic and RSLC[11], and an increase in the frequency and strength of storms, the risk from coastal inundation will rise in the coming years for this study area. As a result of climate change, global temperatures and sea level are expected to rise in the foreseeable future. Predicted climate change impacts, such as increased ocean temperatures, ocean acidification, RSLC, and changes in currents, upwelling, and weather patterns, have the potential to affect the nature and character of the estuarine and coastal ecosystem in the study area. As RSLCs over time, the natural morphological processes of erosion and siltation would occur. Under the no action alternative, erosion, subsidence, and flooding in the study area are anticipated to continue to occur.

In sediment-starved wetland areas where accretion cannot keep pace with RSLC or where there is not sufficient undeveloped upland habitat upland from wetlands for wetlands to migrate to, wetland losses can be expected as wetlands convert to open water habitat. Loss of wetland habitat, which is highly productive habitat that sustains many bird, fish, and insect species, will have cascading negative impacts on the species that rely on this habitat. Similarly, wetlands perform ecosystem services such as water filtration, by absorbing chemicals, filtering pollutants, helping turbid sediments to settle out of the water column and filtering phosphorous, heavy metals and toxins from sediments, and breaking down suspended solids and bacteria. Wetlands capture and store carbon, sequestering it from the atmosphere.

RSLC will bring with it increased water volume in the study area. Beyond this, the hydrology, hydraulics, and bathymetry of the study area are not likely to be affected. Beaches would continue to be renourished in Coney Island, Brooklyn, Queens[12], and Port Monmouth, New Jersey.

4.4.2.2 Alternative 2

Alternative 2 contains the Sandy Hook-Breezy Point storm surge barrier, which is the largest under consideration with a potential length of over 30 miles (including shore-based measures tying into high ground). The construction of the storm surge barrier, which would have multiple gates that remain open in non-storm conditions to allow for navigation and tidal exchange would permanently impact the benthic community in the construction footprint by replacing the open bottom habitat with a hard structure and temporarily impact the benthic community during construction and maintenance of the structure. In addition there would be permanent impacts to

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[11] Sea level changes can be driven by either variations in the masses or volume of the oceans, or by changes of the land with respect to the sea surface. In the first case, a sea level change is defined ‘eustatic’; otherwise, it is defined ‘relative’ (Rovere, et al, 2016).

[12] Additional renourishment beyond the existing authorized project for Rockaway Beach on the Atlantic Shorefront of Queens in the Rockaways from Beach 9th Street to Beach 149th Street are currently under consideration by USACE Headquarters, as discussed in the Revised Draft General Reevaluation Report and Environmental Impact Statement which was released to the public in August 2018.

the water column (e.g., loss of area due to construction of structure, changes in water flows) and temporary impacts to the water column (disturbance during construction and maintenance).

Alternative 2 is likely to produce minor impacts to geology and soils from the implementation of in-water gates and SBM's, and is predicted to have no adverse impacts to geology and soils beyond the footprints of these measures. Based on the preliminary Adaptive Hydraulics (AdH) modelling results, tidal ranges would decrease slightly with Alternative 2 (Emerin and McAlpin, 2018).

There would be direct permanent impacts to estuarine wetlands on the Sandy Hook and Rockaway peninsulas where the storm surge barrier would tie-in to land or the gate structures are placed, depending on the design. There may also be direct permanent or temporary impacts to estuarine wetlands on the Throgs Neck peninsula, and estuarine and freshwater forested/shrub wetlands in Pelham Bay Park. There is submerged aquatic vegetation (SAV) mapped on the bay side of Sandy Hook (NJDEP, 2018); however, this alternative would have no direct impacts to SAV because it is outside of the construction footprint for the barrier. Indirect impacts to SAV could include changes to flow velocities, scour, sedimentation patterns, and water quality.

Alternative 2 may directly impact three recognized Important Bird Areas: Jamaica Bay, Pelham Bay Park, and Sandy Hook/Gateway National Recreation Area (Audubon, 2007). This alternative has the potential to affect the following federal- or state-listed birds: piping plover, red knot, roseate tern, peregrine falcon, black tern, short-eared owl, pied-billed grebe, least bittern, bald eagle, northern harrier, common tern, least tern, common loon, American bittern, osprey, sharp-shinned hawk, cooper's hawk, northern goshawk, red-shouldered hawk, black skimmer, common nighthawk, red-headed woodpecker, horned lark, yellow-breasted chat, vesper sparrow, grasshopper sparrow, seaside sparrow, bobolink, American kestrel, black-crowned night heron, yellow-crowned night heron, barred owl, and savannah sparrow.

Regarding historical and cultural resources, the area of potential effect (APE) for this alternative consists of the physical footprint of the individual measures and the viewsheds of the properties listed in Table 22. This alternative would also have adverse effects from construction to the Fort Hancock and Sandy Hook Proving Ground District National Historic Landmark as well as other historic properties within the Gateway National Recreation Area. Section 306107 of the National Historic Preservation Act, as amended (54 USC 306107) requires an agency, in this case USACE, to "the maximum extent possible", to "undertake such planning and actions as may be necessary to minimize harm to any National Historic Landmark that may be directly and adversely affected by an undertaking" (36 CFR 800.10(a)). Adverse effect refers to the alteration to the characteristics or features of a historic property that qualify it for the National Register and, more importantly as a National Historic Landmark. National Historic Landmarks are those nationally significant historic places designated by the Secretary of the Interior because they possess exceptional value or quality in the interpretation of the heritage of the United States. The decision to cause an adverse effect to a National Historic Landmark must be made in coordination with the New York State Office of Parks, Recreation and Historic Preservation, the Department of the Interior and the Advisory Council on Historic Preservation. This alternative would require coordination with the entities for its further consideration.

Table 22. Known Historic Properties within Alternative 2 Area of Potential Effect.

Measure	Potentially Affected Resources
Sandy Hook to Breezy Point Gate	Gateway National Recreation Area including Fort Hancock and Sandy Hook Proving Ground Historic District National Historic Landmark, Breezy Point, Silver Gull Beach Club, Fort Tilden, and Jacob Riis Park Historic Districts; Far Rockaway Beach Bungalow Historic District; moderate to high archaeological sensitivity
Throgs Neck Gate	Fort Schuyler, US Merchant Marine Academy Historic District, Fort Totten and the Throgs Neck Bridge; moderate to high archaeological sensitivity
Pelham Gate	Pelham Bay Park Historic District, Hutchinson River Parkway; moderate to high archaeological sensitivity

Any construction on National Park Service lands by other entities, including other federal agencies, would require National Park Service agreement and acceptability. Other historic properties might also have adverse effects to their historic viewsheds. Alternative 2 is likely to have aesthetic impacts associated with a changed viewscape and some coastal views may be impacted, diminished or lost due to the construction of this alternative.

4.4.2.3 Alternative 3a

Alternative 3a includes five storm surge barriers with potential lengths of 3,200 feet (Arthur Kill), 6,000 feet (Throgs Neck), 10,000 feet (Pelham Bay), 11,000 feet (Verrazano-Narrows), and 125,000 feet (Jamaica Bay) respectively (including shore-based measures tying into high ground). The construction of the storm surge barrier, which would have multiple gates that remain open in non-storm conditions to allow for navigation and tidal exchange would permanently impact the benthic community in the construction footprint by replacing the open bottom habitat with a hard structure and temporarily impact the benthic community during construction and maintenance of the structure. In addition there would be permanent impacts to the water column (e.g., loss of area due to construction of structure, changes in water flows) and temporary impacts to the water column (disturbance during construction and maintenance).

Alternative 3a is likely to produce minor impacts to geology and soils from the implementation of in-water gates and SBM's, and is predicted to have no adverse impacts to geology and soils beyond the footprints of these measures. Based on AdH modelling results, tidal ranges would decrease slightly with Alternative 3a (Emerin and McAlpin, 2018).

There would be direct permanent impacts to estuarine wetlands on the Rockaway peninsula and around Gerritsen Creek. There may also be direct permanent or temporary impacts to estuarine wetlands on the Throgs Neck peninsula, and estuarine and freshwater forested/shrub wetlands in Pelham Bay Park.

Alternative 3a may directly impact three recognized Important Bird Areas: Arthur Kill Complex and Tributaries, Jamaica Bay, and Pelham Bay Park (Audubon, 2007). This alternative has the potential to affect the following federal- or state-listed birds: piping plover, red knot, roseate tern, peregrine falcon, black tern, short-eared owl, pied-billed grebe, bald eagle, northern harrier, common tern, least tern, common loon, osprey, sharp-shinned hawk, cooper's hawk, northern goshawk, red-shouldered hawk, black skimmer, common nighthawk, red-headed woodpecker, horned lark, yellow-breasted chat, vesper sparrow, seaside sparrow, American bittern, bobolink, cattle egret, black-crowned night heron, yellow-crowned night heron, barred owl, and least bittern.

The area of potential effect for this alternative includes the physical footprint of each measure as well as the viewsheds of the historic properties listed in Table 23. This alternative has the potential for adverse effects to the Alice Austen House National Historic Landmark, historic properties within the Gateway National Recreation Area, the Pelham Bay Park Historic District and other historic properties, including archaeological sites. The decision to cause an adverse effect to a National Historic Landmark must be made in coordination with the New York State Office of Parks, Recreation and Historic Preservation, the Department of the Interior and the Advisory Council on Historic Preservation. This alternative would require coordination with the entities for its further consideration.

Table 23. Known Historic Properties within Alternative 3A Area of Potential Effect

Measure	Potentially Affected Resources
Verrazano Narrows Gate	Alice Austen House National Historic Landmark, McFarlane-Bredt House, St. Mary's Roman Catholic Church, Rectory and School, US Coast Guard Rosebank Station and Family Housing, Fort Wadsworth, Fort Hamilton, and Bay Ridge Historic District; moderate archaeological sensitivity
Jamaica Bay Gate	Gateway National Recreation Area including Breezy Point, Silver Gull Beach Club, Fort Tilden, Jacob Riis Park and Floyd Bennett Field; Far Rockaway Beach Bungalow Historic District; Coney Island Historic District; moderate archaeological sensitivity
Throgs Neck Gate	Fort Schuyler, US Merchant Marine Academy Historic District, Fort Totten and the Throgs Neck Bridge; moderate to high archaeological sensitivity
Pelham Gate	Pelham Bay Park Historic District, Hutchinson River Parkway; moderate to high archaeological sensitivity
Arthur Kill Gate	Vessel hulks (canal boats, barges, car floats, etc.) along Perth Amboy and Tottenville shorelines; Moderate archaeological sensitivity

Any construction on National Park Service lands by other entities, including other federal agencies, would require National Park Service agreement and acceptability. Other historic properties might also have adverse effects to their historic viewsheds. Alternative 3a is likely to have aesthetic impacts associated with a changed viewscape and some coastal views may be impacted, diminished or lost due to the construction of this alternative.

4.4.2.4 Alternative 3b

Alternative 3b includes eight storm surge barriers with potential lengths of 3,200 feet (Arthur Kill), 5,000 feet (Gowanus), 8,000 feet (Kill Van Kull), 10,000 feet (Pelham Bay), and 15,000 feet (Flushing Bay). 18,000 feet (Newtown Creek), 27,000 feet (Westchester Creek/Bronx River), 125,000 feet (Jamaica Bay) respectively (including shore-based measures tying into high ground). The construction of the storm surge barrier, which would have multiple gates that remain open in non-storm conditions to allow for navigation and tidal exchange would permanently impact the benthic community in the construction footprint by replacing the open bottom habitat with a hard structure and temporarily impact the benthic community during construction and maintenance of the structure. In addition, there would be permanent impacts to the water column (e.g., loss of area due to construction of structure, changes in water flows) and temporary impacts to the water column (disturbance during construction and maintenance).

Alternative 3b is likely to produce minor impacts to geology and soils from the implementation of in-water gates and SBM's, and is predicted to have no adverse impacts to geology and soils beyond the footprints of these measures. Based on AdH modelling results, Alternative 3b would have negligible effects on water surface elevations (Emerin and McAlpin, 2018).

There would be direct permanent impacts to estuarine wetlands on the Rockaway peninsula and around Gerritsen Creek, and a small riverine section in Pierson Park, in Tarrytown, NY. There would also be possible direct permanent or temporary impacts to freshwater emergent wetlands in Jersey City, freshwater forested/shrub wetlands in Pelham Bay Park, estuarine wetlands along Flushing Bay, in Pelham Bay Park, in Stony Point, New York, and several freshwater ponds in Stony Point, New York.

Alternative 3b has the potential to directly impact, by constructing within the bounds of their habitat, four recognized Important Bird Areas: Arthur Kill Complex and Tributaries, Jamaica Bay, Lower Hudson River, and Pelham Bay Park (Audubon, 2007). This alternative has the potential to affect the following federal- or state-listed birds: piping plover, red knot, roseate tern, peregrine falcon, black tern, short-eared owl, pied-billed grebe, bald eagle, northern harrier, common tern, least tern, common loon, osprey, sharp-shinned hawk, cooper's hawk, northern goshawk, red-shouldered hawk, black skimmer, common nighthawk, red-headed woodpecker, horned lark, yellow-breasted chat, vesper sparrow, seaside sparrow, American bittern, bobolink, cattle egret, American kestrel, black-crowned night heron, yellow-crowned night heron, barred owl, least bittern, savannah sparrow, and grasshopper sparrow.

The area of potential effect for this alternative includes the footprint of each measure as well as potential viewshed effects for the properties listed in Table 24. This alternative has the potential for adverse effects to historic properties within the Gateway National Recreation Area, the

Pelham Bay Park Historic District, the Greenpoint Historic District, the Gowanus Canal Historic District and other historic properties, including archaeological sites. Several measures are within the Hudson River Valley National Heritage Area, consisting of heritage sites along the Hudson River in partnership with the National Park Service to interpret and preserve cultural and natural resources along the Hudson River Valley.

Table 24. Known Historic Properties within Alternative 3B Area of Potential Effect

Measure	Potentially Affected Resources
Jamaica Bay Gate	Gateway National Recreation Area including Breezy Point, Silver Gull Beach Club, Fort Tilden, Jacob Riis Park and Floyd Bennett Field; Far Rockaway Beach Bungalow Historic District; Coney Island Historic District; moderate archaeological sensitivity
Pelham Gate	Pelham Bay Park Historic District, Hutchinson River Parkway; moderate to high archaeological sensitivity
Arthur Kill Gate	Vessel hulks (canal boats, barges, car floats, etc.) along Perth Amboy and Tottenville shorelines; Moderate archaeological sensitivity
Flushing Creek Gate	No known historic properties; moderate archaeological sensitivity
Bronx River/Westchester Creek Gates	No known historic properties; moderate archaeological sensitivity
Newtown Creek Gate	Greenpoint Historic District, individual structures north of Newtown Creek
Gowanus Canal Gate	Gowanus Canal Historic District; moderate to high archaeological sensitivity
New Jersey-Hudson Shoreline Based Measures	Morris Canal Basin, Central Railroad of NJ Terminal, bulkheads/piers, Holland Tunnel National Historic Landmark, Lackawanna Train Station; moderate to high archaeological sensitivity
Kill Van Kull Gate	No known historic properties; moderate archaeological sensitivity
Long Island City Shoreline based Measures	Sohmer Piano Factory, Queensboro Bridge, Queensboro Bridge Houses North and South; moderate archaeological sensitivity
East Harlem Shoreline Based Measures	369th Regiment Armory, Harlem River Houses, Metro-North Harlem River Lift Bridge, the Madison Avenue Bridge; low archaeological sensitivity
Astoria Shoreline Based Measures	Astoria Play Center, Hell Gate Bridge, the Bowery Waste Water Treatment Plant
Yonkers South and North Shoreline Based Measures	South: low archaeological sensitivity; North: moderate archaeological sensitivity
Tarrytown Shoreline Based Measures	No known historic properties; low to moderate archaeological sensitivity
Ossining Shoreline Based Measures	Sing Sing Correctional Facility and contributing structures; moderate archaeological sensitivity
Stony Point Shoreline Based Measures	No known historic properties; low to moderate archaeological sensitivity

Any construction on National Park Service lands by other entities, including other federal agencies, would require National Park Service agreement and acceptability. Other historic properties might also have adverse effects to their historic viewsheds.

The Gowanus Barrier has the potential to impact the ongoing Superfund cleanup of hazardous and toxic materials in the substrate sediments of the Gowanus Canal. The EPA is a Cooperating Agency on this study and USACE will coordinate closely with the EPA to identify opportunities to adjust the proposed design to avoid impacting the Superfund cleanup and minimize the risk to breaching the cap of toxic materials. This risk will need to be further evaluated and analyzed as the study progresses, in coordination with the EPA.

There is an ongoing Feasibility Study by the EPA on potential cleanup alternatives for the Newtown Creek Superfund site. The potential to impact and/or synergistically complement federal efforts between the NYNJHAT study and the Newtown Creek Superfund study will be investigated as this study progresses. Prior to implementing any project feature within Newtown Creek, remediation of the hazardous and toxic substances must be completed. The USACE will coordinate closely with the EPA on this matter.

Alternative 3b is likely to have aesthetic impacts associated with a changed viewscape and some coastal views may be impacted, diminished or lost due to the construction of this alternative.

4.4.2.5 Alternative 4

Alternative 4 includes seven storm surge barriers with potential lengths of 5,000 feet (Gowanus), 10,000 feet (Pelham Bay), 15,000 feet (Flushing Bay), 18,000 feet (Newtown Creek), 27,000 feet (Westchester Creek/Bronx River), 32,000 feet (Hackensack) and 125,000 feet (Jamaica Bay) respectively (including shore-based measures tying into high ground).

The construction of the storm surge barrier, which would have multiple gates that remain open in non-storm conditions to allow for navigation and tidal exchange would permanently impact the benthic community in the construction footprint by replacing the open bottom habitat with a hard structure and temporarily impact the benthic community during construction and maintenance of the structure. In addition there would be permanent impacts to the water column (e.g., loss of area due to construction of structure, changes in water flows) and temporary impacts to the water column (disturbance during construction and maintenance).

Alternative 4 is likely to produce minor impacts to geology and soils from the implementation of in-water gates and SBM’s, and is predicted to have no adverse impacts to geology and soils beyond the footprints of these measures. Based on AdH modelling results, Alternative 4 would have negligible effects on water surface elevations (Emerin and McAlpin, 2018).

There would be direct permanent impacts to estuarine wetlands on the Rockaway peninsula and around Gerritsen Creek, and a small riverine section in Pierson Park in Tarrytown, NY. There may also be direct permanent or temporary impacts to freshwater emergent wetlands in Jersey City and near the Hackensack River in Kearny (NJ), freshwater forested/shrub wetlands in Pelham Bay Park (NY), estuarine wetlands in Pelham Bay Park (NY), Stony Point (NY), along Flushing Bay (NY), and along the Hackensack River in Secaucus (NJ) and Kearny (NJ), and several freshwater ponds in Stony Point (NY) and Secaucus (NJ).

Alternative 4 may directly impact four recognized Important Bird Areas: Jamaica Bay, Lower Hudson River, Meadowlands District and Pelham Bay Park (Audubon, 2007). This alternative has the potential to affect the following federal- or state-listed birds: piping plover, red knot, roseate tern, peregrine falcon, black tern, short-eared owl, pied-billed grebe, bald eagle, northern harrier, common tern, least tern, common loon, osprey, sharp-shinned hawk, cooper's hawk, northern goshawk, red-shouldered hawk, black skimmer, common nighthawk, red-headed woodpecker, horned lark, yellow-breasted chat, vesper sparrow, seaside sparrow, American kestrel, black-crowned night heron, savannah sparrow, grasshopper sparrow, upland sandpiper, bobolink, American kestrel, black-crowned night heron, yellow-crowned night heron, savannah sparrow, and least bittern.

The area of potential effect for this alternative includes the footprint of each measure, as well as the viewsheds of the properties identified in Table 25. This alternative has the potential for adverse effects to historic properties within the Gateway National Recreation Area, the Pelham Bay Park Historic District, the Greenpoint Historic District, the Gowanus Canal Historic District and other historic properties, including archaeological sites. Several measures are within the Hudson River Valley National Heritage Area, consisting of heritage sites along the Hudson River in partnership with the National Park Service to interpret and preserve cultural and natural resources along the Hudson River Valley.

Table 25. Known Historic Properties within Alternative 4 Area of Potential Effect

Measure	Potentially Affected Resources
Jamaica Bay Gate	Gateway National Recreation Area including Breezy Point, Silver Gull Beach Club, Fort Tilden, Jacob Riis Park and Floyd Bennett Field; Far Rockaway Beach Bungalow Historic District; Coney Island Historic District; moderate archaeological sensitivity
Pelham Gate	Pelham Bay Park Historic District, Hutchinson River Parkway; moderate to high archaeological sensitivity
Flushing Creek Gate	No known historic properties; moderate archaeological sensitivity
Bronx River/Westchester Creek Gates	No known historic properties; moderate to high archaeological sensitivity
Newtown Creek Gate	Greenpoint Historic District, individual structures north of Newtown Creek;
Gowanus Canal Gate	Gowanus Canal Historic District; moderate to high archaeological sensitivity
Hackensack River Gate	No known historic properties; low archaeological sensitivity
New Jersey-Hudson Shoreline Based Measures	Morris Canal Basin, Central Railroad of NJ Terminal, bulkheads/piers, Holland Tunnel National Historic Landmark, Lackawanna Train Station; moderate to high archaeological sensitivity
Kill Van Kull Gate	No known historic properties; moderate archaeological sensitivity
Long Island City Shoreline based Measures	Sohmer Piano Factory, Queensboro Bridge, Queensboro Bridge Houses North and South; moderate archaeological sensitivity
East Harlem Shoreline Based Measures	369th Regiment Armory, Harlem River Houses, Metro-North Harlem River Lift Bridge, the Madison Avenue Bridge; low archaeological sensitivity
Astoria Shoreline Based Measures	Astoria Play Center, Hell Gate Bridge, the Bowery Waste Water Treatment Plant
Yonkers South and North Shoreline Based Measures	South: No known historic properties; low archaeological sensitivity; North: No known historic properties; moderate archaeological sensitivity

Measure	Potentially Affected Resources
Tarrytown Shoreline Based Measures	No known historic properties; low to moderate archaeological sensitivity
New York City West Side Shoreline Based Measures	South Street Seaport, Municipal Ferry Pier, Pier A, Castle Clinton National Monument, Tribeca North Historic District, Holland Tunnel National Historic Landmark, US Lilac – lighthouse tender, Hudson River Bulkhead, Gansevoort Historic District, Pier 57, Piers 59-62, West Chelsea Historic District, Frying Pan Shoals Lightship, John J. Harvey fireboat, Highline Freight Railroad, Lincoln Tunnel, moderate to high archaeological sensitivity – extant and buried piers and bulkheads, historic fill
Ossining Shoreline Based Measures	Sing Sing Correctional Facility and contributing structure; moderate archaeological sensitivity
Stony Point Shoreline Based Measures	No known historic properties; low to moderate archaeological sensitivity

Any construction on National Park Service lands by other entities, including other federal agencies, would require National Park Service agreement and acceptability. Other historic properties might also have adverse effects to their historic viewsheds.

The Gowanus Barrier has the potential to impact the ongoing Superfund cleanup of hazardous and toxic materials in the substrate sediments of the Gowanus Canal. The EPA is a Cooperating Agency on this study and USACE will coordinate closely with the EPA to identify opportunities to adjust the proposed design to avoid impacting the Superfund cleanup and minimize the risk to breaching the cap of toxic materials. This risk will need to be further evaluated and analyzed as the study progresses, in coordination with the EPA.

There is an ongoing Feasibility Study by the EPA on potential cleanup alternatives for the Newtown Creek Superfund site. The potential to impact and/or synergistically complement federal efforts between the NYNJHAT study and the Newtown Creek Superfund study will be investigated as this study progresses. Prior to implementing any project feature within Newtown Creek, remediation of the hazardous and toxic substances must be completed. The USACE will coordinate closely with the EPA on this matter.

Alternative 4 is likely to have aesthetic impacts associated with a changed viewscape and some coastal views may be impacted, diminished or lost due to the construction of this alternative.

4.4.2.6 Alternative 5

Alternative 5 is likely to produce minor impacts to geology and soils from the implementation of SBM's, and is predicted to have no adverse impacts to geology and soils beyond the footprints of these measures. Because Alternative 5 contains only SBM's, no effects on water elevations are expected. There may be direct permanent or temporary impacts to freshwater emergent wetlands in Jersey City, as well as estuarine wetlands and several freshwater ponds in Stony Point. Within in the Hackensack Meadowlands there may be direct permanent or temporary impacts to estuarine wetlands, freshwater emergent wetlands, freshwater forested/shrub wetlands, and riverine areas.

Alternative 5 includes floodwalls along the coast to manage the risk of storm surge as well as frequent flooding. Thus, Alternative 5 could have significant adverse impacts to aesthetics, particularly viewscape. Aesthetic impacts may also impact real estate values for coastal properties where existing views would be diminished or lost.

Alternative 5 may directly impact two recognized Important Bird Areas: Lower Hudson River and Meadowlands District (Audubon, 2007). This alternative has the potential to affect the following federal- or state-listed birds: peregrine falcon, American kestrel, black-crowned night heron, savannah sparrow, common tern, common loon, cooper's hawk, black skimmer, short-eared owl, pied-billed grebe, northern harrier, least tern, osprey, grasshopper sparrow, upland sandpiper, bobolink, yellow-crowned night heron, bald eagle, and vesper sparrow.

The area of potential effect for this alternative includes the physical footprint of each measure as well as the viewsheds of the historic properties listed in Table 26. This alternative has the potential for adverse effects to the Holland Tunnel National Historic Landmark, Castle Clinton National Monument, the Hudson River bulkhead, and other historic properties, including archaeological sites. The decision to cause an adverse effect to a National Historic Landmark must be made in coordination with the New York State Office of Parks, Recreation and Historic Preservation, the Department of the Interior and the Advisory Council on Historic Preservation. This alternative would require coordination with the entities for its further consideration.

Table 26. Known Historic Properties within Alternative 5 Area of Potential Effect

Measures	Potentially Affected Resources
New Jersey Hudson River Shoreline Based Measures	Holland Tunnel National Historic Landmark, Morris Canal Basin, Central Railroad of NJ Terminal, bulkheads/piers; moderate to high archaeological sensitivity
New York City West Side Shoreline Based Measures	South Street Seaport, Municipal Ferry Pier, Pier A, Castle Clinton National Monument, Tribeca North Historic District, Holland Tunnel National Historic Landmark, US *Lilac* – lighthouse tender, Hudson River Bulkhead, Gansevoort Historic District, Pier 57, Piers 59-62, West Chelsea Historic District, Frying Pan Shoals Lightship, *John J. Harvey* fireboat, Highline Freight Railroad, Lincoln Tunnel, moderate to high archaeological sensitivity – extant and buried piers and bulkheads, historic fill
Long Island City – Astoria Shoreline Based Measures	Sohmer Piano Factory, Queensboro Bridge, Queensboro Bridge Houses North and South; moderate archaeological sensitivity
Astoria Shoreline Based Measures	Astoria Play Center, Hell Gate Bridge, the Bowery Waste Water Treatment Plant
East Harlem Shoreline Based Measures	369th Regiment Armory, Harlem River Houses, Metro-North Harlem River Lift Bridge, the Madison Avenue Bridge; low archaeological sensitivity
Hackensack Perimeter Lower Area	No known historic properties; moderate archaeological sensitivity
Hackensack Perimeter Middle Area	No known historic properties; moderate archaeological sensitivity
Hackensack Perimeter Upper Area	No known historic properties; moderate archaeological sensitivity
Tarrytown Shoreline Based Measures	No known historic properties; low to moderate archaeological sensitivity

Measures	Potentially Affected Resources
Ossining Shoreline Based Measures	Sing Sing Correctional Facility and contributing structure; moderate archaeological sensitivity
Stony Point Shoreline Based Measures	No known historic properties; low to moderate archaeological sensitivity

Any construction on National Park Service lands by other entities, including other federal agencies, would require National Park Service agreement and acceptability. Other historic properties might also have adverse effects to their historic viewsheds. Alternative 5 is likely to have aesthetic impacts associated with a changed viewscape and some coastal views may be impacted, diminished or lost due to the construction of this alternative.

5 NEXT STEPS

As the study moves forward toward the milestone of screening the array of alternatives down to a TSP, there will be public engagement as part of the comment period on this Interim Report, as well as agency coordination, in particular with the Cooperating Agencies on this study. The study team will hold a Risk-Informed Workshop with the Non-Federal Sponsors, Partners, and other key parties to discuss the appropriate level of detail for investigating each factor that may influence plan selection. These outreach activities will help to inform the development of site specific measures.

5.1 Recommendations to Refine Analysis

In order to analyze the potential impacts of the proposed alternatives and evaluate them, including how designs may need to be adjusted to avoid impacts and the associated costs, the study team will model the possible physical changes to flow, tidal range and water elevations (in storm and non-storm conditions), and sediment budget. Once the potential physical changes have been modeled and evaluated, site-specific analyses pertaining to potential water quality and migration patterns and other ecosystem impacts can be targeted. The physical modeling will help to identify what species are vulnerable to adverse impacts during gate closures and what width and number of gate openings could result in negligible impacts during normal "open" conditions, or if this is possible.

As for the AdH and CSTORM-MS modeling, these modeling tasks indicate the use of fixed, in-water infrastructure will modify tide propagation, water levels, current velocities and salinity locally and regionally within the study area. The geographic extent of change for each of these characteristics is directly influenced by the size of the barrier alternative. The greater the structure footprint (i.e. alternative 2) the larger geographic influence. During barrier open conditions, each alternative experienced a reduction in tidal prism and an increase in local fluid velocities. The reduced water exchange between ocean and estuary results in increased stratification and a change in salt distribution. The closure of the barriers appears to enhance ocean storm surge for most of the simulated events "outside" of the closed barrier. With storage capacities on the order of several days, flooding potential associated with wind setup and ponding within the enclosed basins is expected to be minimal. Potential for induced flooding outside of the closed barriers needs to be further analyzed in subsequent modeling efforts to better understand any induced impacts, as well as the potential to avoid and mitigate for those impacts. More detailed modeling will be required to refine barrier designs and to determine sediment transport patterns, changes to tidal range and flows, scour around the proposed structures, as well as environmental impacts.

5.2 Consultation and Compliance

In preparation of future NEPA documents, and in the implementation of a recommended plan, USACE will comply with all applicable environmental law and policy including, but not limited to:

- Clean Air Act
- Clean Water Act
- Endangered Species Act
- Rivers and Harbors Act
- Comprehensive Environmental Response, Compensation, and Liability Act, known also as Superfund
- Magnuson-Stevens Fishery Conservation and Management Act
- Coastal Zone Management Act
- Fish and Wildlife Coordination Act
- Marine Mammal Protection Act
- National Historic Preservation Act
- Federal Water Project Recreation Act
- Executive Order 11988, Floodplain Management
- Executive Order 11990, Protection of Wetlands
- Coastal Barrier Improvement Act
- Executive Order 12898, Environmental Justice
- Migratory Bird Treaty Act/Executive Order 13186, Responsibilities of Federal Agencies to Protect Migratory Birds
- Wild and Scenic Rivers Act
- Executive Order 13045, Protection of Children from Environmental and Safety Risks

Upon release of the report, a meeting with Study's Cooperating Agency will occur.

5.3 Future Opportunities for Public Engagement

With the release of this Interim Report, the public is invited to provide comments and feedback. Eight public meetings will be held during this comment period throughout the study area where interested stakeholders can ask questions and provide feedback in person. Given the large study area that spans two states, 25 counties, and includes 322 municipalities, it is not feasible to hold meetings in every location where there are interested stakeholders. The meetings, which will all cover the same subject matter, will be spread out throughout the study area and held in locations that are transit accessible, so that interested stakeholders can reasonably travel to at least one meeting. Virtual web-based meetings will also be held to provide further opportunity for engagement that does not require travel. Meeting location and information will be posted to the study website and a press release will be issued to inform the public. The study team will also notify the stakeholder email list. Additionally, the study team will accept and consider all comments sent on the study, whether by email, mail, or in-person. The input received on the Interim Report will be considered as the study team further analyzes the concept alternatives. Comments are welcome throughout the entire study process, however, comments received by two weeks after the last public meeting (date to be determined) will have the most effectiveness in helping to inform further evaluations and comparison of alternatives to arrive at a TSP in January 2020.

The Draft Feasibility Report and Draft Tier 1 EIS is targeted to be released for public comment in March 2020. A third round of public meetings will be held in conjunction with the public comment period on the Draft Report. Once comments have been incorporated into study, the team will finalize the report and submit a recommendation to USACE Headquarters.

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