FINAL

Feasibility Study
For the Rebuild by Design Meadowlands Flood Protection Project

June 2021





Boroughs of Little Ferry, Moonachie, Carlstadt, and Teterboro and the Township of South Hackensack, Bergen County, New Jersey

REBUILD BY DESIGN
MEADOWLANDS

Prepared by AECOM for the State of New Jersey Department of Environmental Protection

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Appendix G - Real Estate

Acronyms and Abbreviations

AADT	Average Annual Daily Traffic
ADCIRC	Advanced Circulation Model
AF	Aviation Facilities Zone Designation
ASD	Acceptable Separation Distance
AST	Aboveground Storage Tank
BCA	Benefit-Cost Analysis
BCR	Benefit/Cost Ratio
BCUA	Bergen County Utility Authority
BCSA	Berry's Creek Study Area
CADD	Computer Assisted Desktop Design
CDBG–DR	Community Development Block Grant Disaster Recovery
COPC	Chemical of potential concern
CEA	Classification Exception Area
cfs	Cubic feet per second
CP	Commercial Park Zone Designation
CREC	Controlled Recognized Environmental Condition
CSA	Carlstadt Sewerage Authority
DEM	Digital Elevation Model
DLUR	Division of Land Use Regulation
DPW	Department of Public Works
EC	Environmental Conservation Zone Designation
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
EJ	Environmental Justice
EMS	Emergency Medical Services
ESA	Endangered Species Act
FEMA	Federal Emergency Management Agency
FR	Federal Register
ft	Feet
ft/sec	Feet per second
GHG	Greenhouse gas
GIS	Geographic Information System
gpm	gallons per minute
HC	Highway Commercial Zone Designation
HEC-FDA	Hydrologic Engineering Center Flood Damage Reduction Analysis
HREC	Historical recognized Environmental Condition
HUD	US Department of Housing and Urban Development
IPaC	Information for Planning and Conservation

IPCC	Intergovernmental Panel on Climate Change
ISRA	Industrial Site Recovery Act
KCS	Known Contaminated Site
lbs	Pounds
lb/ft^2	Pounds per square foot
lb/ft^3	Pounds per cubic foot
LDR	Low Density Residential Zone Designation
LF	Linear feet
LFWPCF	Little Ferry Water Pollution Control Facility
LI	Light Industrial Zone Designation
LiDAR	Light Detection and Ranging
LMI	Low-and moderate-income
LOP	Line of Protection
MERI	Meadowlands Environmental Research Institute
MRI	Marsh Resources, Inc.
N/A	Not Applicable
NAVD 88	North American Vertical Datum of 1988
NC	Neighborhood Commercial Zone Designation
NEPA	National Environmental Policy Act
NFA	No Further Action
NFIP	National Flood Insurance Program
NJDCA	New Jersey Department of Community Affairs
NJDEP	New Jersey Department of Environmental Protection
NJDOT	New Jersey Department of Transportation
NJIT	New Jersey Institute of Technology
NJMC	New Jersey Meadowlands Commission
NJSEA	New Jersey Sports and Exposition Authority
NHPA	National Historic Preservation Act
NOAA	National Oceanic and Atmospheric Administration
NPCC	New York City Panel on Climate Change
NPL	National Priorities List
NWI	National Wetlands Inventory
O&M	Operations and Maintenance
ONJSC	Office of the New Jersey State Climatologist
OU	Operable Unit
PA	Parks and Recreation Zone Designation
PAH	Polycyclic aromatic hydrocarbon
PANYNJ	Port Authority of New York and New Jersey
PCB	Polychlorinated biphenyl

PCDD	Polychlorinated dibenzo-p-dioxin
PCDF	Polychlorinated dibenzofuran
PR	Planned Residential Zone Designation
PSE&G	Public Service Electric and Gas
PU	Public Utilities Zone Designation
RA	Redevelopment Area Zone Designation
RAO	Response Action Outcomes
RBD	Rebuild by Design
RBDM	Rebuild by Design Meadowlands
RC	Regional Commercial Zone Designation
REC	Recognized Environmental Condition
RIMS II	Regional Input-Output Modeling System
ROD	Record of Decision
SCC	Social Cost of Carbon
SCP	Scientific Chemical Processing
SF	Square feet
SLR	Sea Level Rise
SME	Subject Matter Expert
SPT	Standard Penetration Test
SVOC	Semi-Volatile Organic Compound
UOP	Universal Oil Products
US	United States
USACE	US Army Corps of Engineers
USEIA	US Energy Administration
USEPA	US Environmental Protection Agency
USFWS	US Fish and Wildlife Service
USGS	US Geological Survey
UST	Underground Storage Tank
VOC	Volatile Organic Compound
VSL	Value of a Statistical Life
WR	Waterfront Recreation Zone Designation
WSEL	Water Surface Elevation

Executive Summary

ES.1 Introduction

To restore and enhance resilience in the Hurricane Sandy-affected regions, the United States (US) Department of Housing and Urban Design (HUD) launched the Rebuild by Design (RBD) competition in 2013 to promote innovations in recovery and preparedness through development of locally contextual, but regionally scalable solutions.

On June 2, 2014, HUD announced the selection of a design concept for the New Jersey Meadowlands as one of seven successful RBD competition submittals. The award-winning concept employed a multi-faceted approach to addressing systemic risk from major storm surges, high tides, and heavy rainfall events. The concept consisted of three integrated but separable components: Protect, Connect, and Grow.

Following selection, HUD allocated $150 million in Community Development Block Grant Disaster Recovery (CDBG–DR) funds to the State of New Jersey for planning, design, and implementation of the RBD Meadowlands (RBDM) Flood Protection Project (the Proposed Project) to reduce flooding risks and enhance resiliency in the area identified by the competition as Pilot Area 1, (the Project Area). On behalf of the State of New Jersey through its Department of Community Affairs (NJDCA), the recipient of HUD grant funds, the New Jersey Department of Environmental Protection (NJDEP) is the "Responsible Entity," as defined by HUD regulations at 24 Code of Federal Regulations (CFR) § 58.2(a)(7)(i), for the Proposed Project. In accordance with criteria in 40 CFR § 1501.5(c), NJDCA has designated NJDEP as the Lead Agency to prepare an Environmental Impact Statement (EIS) and a Feasibility Study (this report) for the Proposed Project.

The Project Area (**Figure ES-1.1-1**) includes the Boroughs of Little Ferry, Moonachie, Carlstadt, and Teterboro, and the Township of South Hackensack, in Bergen County, New Jersey. The Project Area is bounded by the Hackensack River to the east; Paterson Plank Road (State Route 120) and the southern boundary of the Borough of Carlstadt to the south; State Route 17 to the west; and Interstate 80 (I-80) and the northern boundary of the Borough of Little Ferry to the north. In total, the Project Area encompasses approximately 5,405 acres; most all of which is located within the Meadowlands District.

Based on the nature of challenges experienced in the Project Area, feedback from local leaders and community members, and the amount of CDBG-DR funding awarded, the "Protect" component was determined to be of highest priority and the ultimate focus of the Proposed Project. This component focused on flood risk reduction through natural and human-made systems acting together to reduce the duration of exposure to extreme high tide, rainfall, and/or storm surge events. Following implementation of the critical "Protect" function, the remaining components ("Connect" and "Grow") could be logical and reasonable outcomes provided favorable conditions in the future.

ES.2 Project Purpose, Need, and Objectives

The purpose of the Proposed Project is to reduce flood risk and increase the resiliency of the communities and ecosystems within the Project Area, thereby protecting critical infrastructure and facilities, residences, businesses, and ecological resources from frequent and intense flood events anticipated in the future.

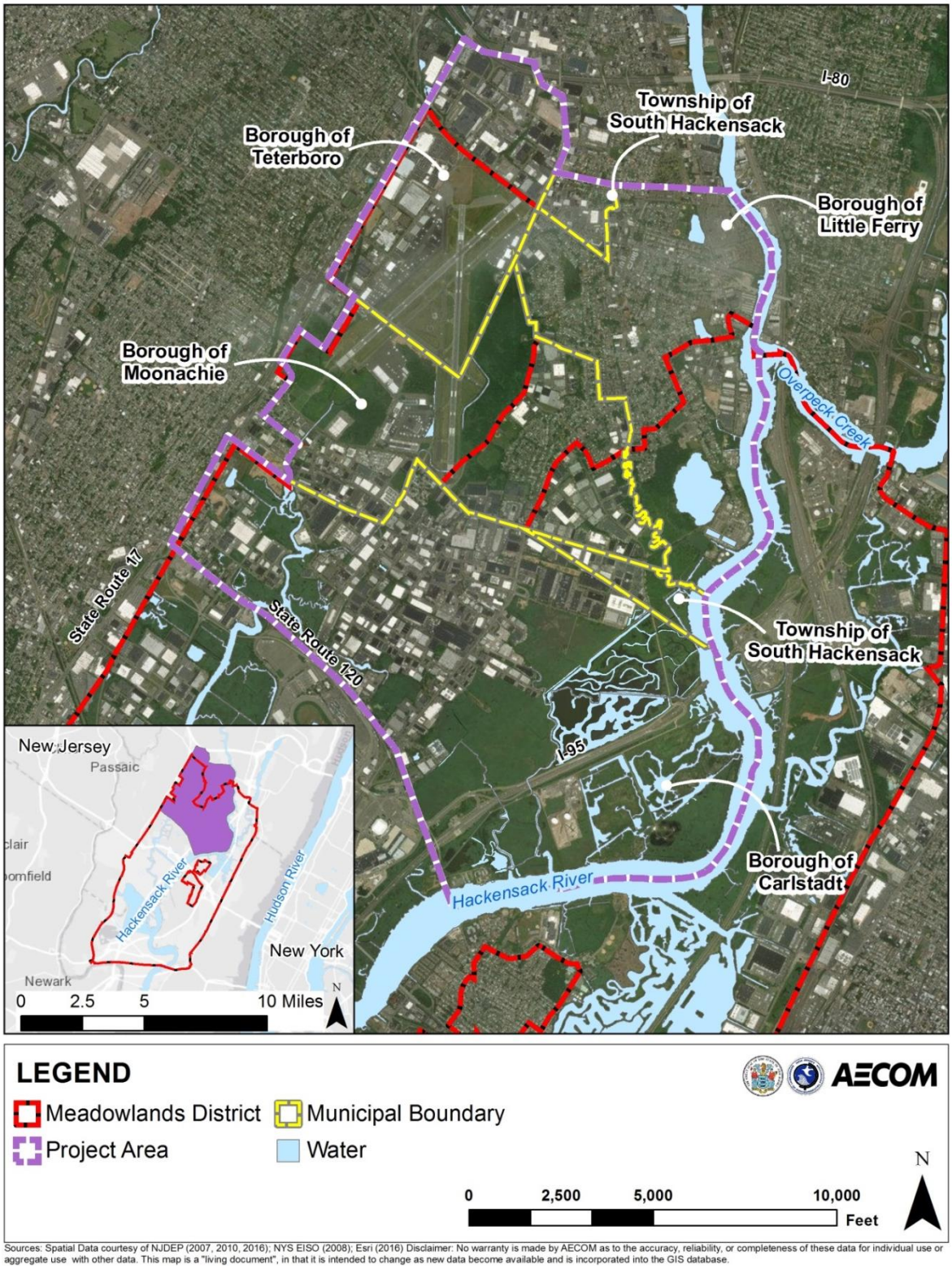


Figure ES-1.1-1: Rebuild by Design Meadowlands Flood Protection Project Area

To meet this purpose, the Proposed Project is measured in terms of ability to meet the following goals and objectives for a 50-year design horizon:

- Contribute to Community Resiliency;
- Reduce Risks to Public Health;
- Contribute to On-going Community Efforts to Reduce Federal Emergency Management Agency (FEMA) Flood Insurance Rates;
- Deliver Co-Benefits (e.g., active and passive recreational uses, multi-use facilities, etc.);
- Enhance and Improve Use of Public Space;
- Consider Impacts from Sea Level Change;
- Protect Ecological Resources; and
- Improve Water Quality.

The interrelationship between storm surges, high tides, and rainfall events contributes to the recurring flooding conditions throughout the Project Area. Each of these conditions represents a risk and therefore a need to develop a comprehensive risk-reduction strategy. As such, the Proposed Project is needed to address: (1) systemic inland flooding from high-intensity rainfall/runoff events; and/or (2) coastal flooding from storm surges.

Given these combined risks, the Proposed Project is needed to directly protect life, public health, and property by increasing community resiliency, including protecting accessibility to, and on-going operations of, critical health care services, emergency services, and transportation and utility infrastructure. In addition to reducing flood risk and improving community resiliency, the integrated approach of the Proposed Project would provide co-benefits, such as protection of ecological resources (enhancement of water quality, regional biodiversity, and ecosystem resiliency) and improvement of civic, cultural, and recreational opportunities in the Project Area.

ES.3 Flooding in the Project Area

Inland flooding in the Project Area is often the result of several types of rain events, including hurricanes moving up the coast, large frontal storms from the west and south (i.e., “nor’easters”), and local thunderstorms. The Meadowlands District, which includes the Project Area, is situated in a valley whose high ridges run parallel in a southwest to northeast direction. Comprised of mostly flat terrain, elevations within the Meadowlands District, including the Project Area, generally do not exceed 10 feet (North American Vertical Datum of 1988 (NAVD 88)), with most areas less than 6 to 7 feet (NAVD 88) (MERI 2014). Historically, the Meadowlands District was comprised primarily of wetlands and upland transitional area, however; the last two centuries have seen the area reclaimed for development through filling and draining wetlands. As a result, development in present day Meadowlands District often abuts the remaining tidally influenced wetland, and sit only a few feet above sea level. For comparison, the Hackensack River and Berry’s Creek, which are tidal, have mean high water spring elevations of 2.7 feet and 3.0 feet (NAVD 88), respectively (NJSEA 2005). The majority of the Project Area lies within the FEMA 100-year floodplain, including 49 critical facilities and other infrastructure (Bergen County Office of Emergency Management 2015).

Given the relative lack of topographical variation in the Meadowlands District, communities located in the Project Area are challenged to drain stormwater, as their stormwater infrastructure is typically powered by gravity (NJDEP 2015a). Further, much of the Meadowlands District has become impervious due to the high

degree of development. This, in conjunction with the significant changes made to the natural hydrology of the Project Area, has severely limited the ability of the land to absorb and store stormwater and discharge it over time. Consequently, much of the rainfall becomes runoff and immediately enters the stormwater drainage infrastructure (Rutgers University 2007). Taken together, the existing drainage infrastructure has become overburdened by stormwater during and after severe storms, as inconsistent system sizing and maintenance regimes combine with higher runoff volumes and the low elevation gradient. With the potential increase in frequency and intensity of stormwater-related flooding events over time, the existing stormwater infrastructure may become increasingly insufficient to address the flooding challenges in the Project Area.

The impacts of inland flooding generally manifest in localized areas, such as individual roads or properties. Generally, flooding in these locations was characterized by several inches to over a foot of standing water encompassing an area of hundreds or thousands of square feet (SF) (NJSEA 2005). Chronic localized flooding of roads and properties has severe impacts on local commerce, transportation, and residents by rendering roads impassable, disrupting normal activities, and causing significant commercial and residential property damage (Guo, et al. 2014, Rutgers University 2007).

The other major source of flooding in the Project Area is coastal flooding from storm surges. Coastal flooding occurs less frequently than inland flooding, and often accompanies tropical storms. During these events, the tidally influenced Hackensack River surges over its banks and inundates the coastal floodplain. A series of old berms along the Hackensack River offers some protection against coastal inundation. However, these berms are not entirely effective because they are neither continuous nor uniform in height (US Department of Homeland Security 2014). One recent study reported that they are breached approximately every 5 years. Due to the low elevation of the entire Project Area, these breaches can lead to widespread damage (NJIT 2014). Storm surges can be particularly severe if they occur in tandem with extreme high tides, since they can be substantially higher than normal high tides (NJSEA 2005, Rutgers University 2007).

The Project Area has been severely impacted by three major hurricanes since 1999: Hurricanes Floyd, Irene, and Sandy. The most recent of these, Hurricane Sandy, also most visibly revealed the vulnerability of the Project Area to coastal flooding. Although it was not a major rainfall event, its storm surge reached 9.5 feet (NAVD 88) in the Project Area (NJIT 2014). This massive surge is estimated to have been 20 percent larger as a result of the full moon amplifying the high tide (US Department of Homeland Security 2014). Gauges in the Project Area recorded the surge to be 7 feet (NAVD 88) or higher for a duration of 6 hours (NJIT 2014). This elevation and duration were sufficient for the Hackensack River to inundate nearly the entire Project Area. Reports suggest that the Borough of Moonachie was completely inundated and the Borough of Little Ferry was approximately 80 percent flooded (NJIT 2014, Petrecca 2012). Following the storm, the floodwaters were slow to drain because they were being retained by the old berms surrounding the communities (Borough of Little Ferry 2014).

Hurricane Sandy had enormous health and safety, critical infrastructure, and financial impacts on the Project Area. The National Guard, along with local and regional rescue teams, evacuated approximately 3,500 residents after the storm had passed (Akin and O'Brien 2012, Makely 2012). Numerous fires and gas leaks were reported as the electricity returned to homes that were still flooded and emergency and government services were hampered. In the Borough of Moonachie, the police station and municipal buildings sustained major damage and were forced to relocate their operations (Akin and O'Brien 2012). Schools were closed for two weeks in the Borough of Little Ferry following the storm, and only one school building was able to operate for the remainder of the year (Krulish 2013).

Electric and natural gas services were unavailable for nearly a week following Hurricane Sandy. The lack of electricity further prolonged the flooding event, as the pump stations needed to drain the communities all lost power. As a result, some neighborhoods were flooded with 5 to 6 feet of water for up to 5 days or more following the storm. Additionally, according to FEMA, approximately 1,700 homeowners sustained damage from the storm. The total assessed value of damage to homeowners in the five boroughs was over $21.4M. Most of this damage was concentrated in the Boroughs of Little Ferry and Moonachie, where the average damage per homeowner was approximately $12,000 (FEMA 2015a). Furthermore, upon review of the aggregate effects of residential, commercial, and municipal damages, as well as other factors, one study determined that the Borough of Moonachie was one of the two towns hit hardest in the State (Halpin 2013).

It is clear that the Project Area has a devastating history of inland and coastal storm surge flooding. With the anticipated effects of climate change and sea level change, flooding may become more common in the future. As such, the Proposed Project is needed to deliver a comprehensive flood reduction strategy that will protect life, public health, and property within the Project Area, as well as improve overall community resiliency.

ES.4 Overview of Proposed Project

Three alternatives were proposed to reduce the flood risk within the Project Area. The alternatives vary by the type of infrastructure that is proposed. Alternative 1 includes various infrastructure-based solutions intended to provide protection against coastal storm surges. Alternative 2 includes various grey and green infrastructure-based solutions, as well as new parks and improved open spaces, intended to improve stormwater management in key locations throughout the Project Area. Alternative 3 would consist of a hybrid of coastal flood protection and stormwater drainage improvements. .

- **Alternative 1**, the **Structural Flood Reduction Alternative**, to the extent practical, would evaluate a Federal Emergency Management Agency (FEMA) certifiable level of flood protection to a portion of the Project Area. Under Alternative 1, a LOP would be constructed using of a range of grey infrastructure, including floodwalls, levees, berms, a tide gate and eight closure gates, and a surge barrier and pump station, designed to provide flood protection up to an elevation of 7.0 feet (North American Vertical Datum of 1988 (NAVD 88)). In addition to flood reduction infrastructure, this alternative would integrate open space features and green infrastructure into the design.
- **Alternative 2**, the **Storm Water Drainage Improvement Alternative**, would improve stormwater management through the installation of 41 green infrastructure systems (bioswales, storage/tree trenches, and rain gardens) along roadways, five new parks, improvements to five existing open spaces/public amenities, three new pump stations, two new force mains, and dredging of the lower reach of East Riser Ditch.
- **Alternative 3**, the **Hybrid Alternative**, would combine components of Alternatives 1 and 2 to provide an integrated, hybrid solution that employs a combination of appropriate levees, berms, drainage structures, pump stations, and/or floodgates, coupled with local drainage improvement projects, to achieve the maximum amount of flood protection within the boundaries of the Project Area. However, due to funding and construction constraints associated with a project of this magnitude, the Alternative 3 features would be separated into two stages: a *Build Plan*, which includes all features to be constructed as part of the Proposed Project, and a *Future Plan*, which includes the remaining features that could be constructed over time by others as funding sources become available and construction feasibility permits. The Alternative 3 *Build Plan* would consist of all of the Alternative 2 components, with the exceptions of two new parks and a pump station

and force main in Losen Slote. Additionally, the proposed improvements proposed for one of the parks under Alternative 2 would be altered under the Alternative 3 *Build Plan.* The Alternative 3 *Future Plan* would consist of all of the remaining features from Alternative 2, as well as all features from Alternative 1.

ES.5 Alternatives Development and Screening Process

The Alternatives Development process involved the identification of flooding sources, locations of flooding, and the crafting of potential flood risk reduction alternatives. Each of the three alternatives (see **Section ES.4**) seeks to reduce the flood risk within the Project Area.

The key to the Alternatives Development and Screening process is an evaluation of the alternatives through a screening matrix in a community workshop setting. The screening matrix was developed with input from stakeholder groups, including the Citizen Advisory Group (CAG) informed by RBDM project team Subject Matter Experts (SMEs), and was used to evaluate each alternative on its potential impacts to the many resources within the Project Area based on the below general criteria categories. This process allowed for the elimination of alternatives that least satisfy the Proposed Project's Purpose and Need, which consist primarily of the following:

- Flood Risk Reduction,
- Built Environment / Human Environment,
- Constructability / Operations and Maintenance (O&M),
- Natural Environment, and
- Costs and Benefits.

Criteria in the screening matrix were utilized to reflect and address the Proposed Project's Purpose and Need, Project Goals and Objectives, its potential impacts to the natural environment and the community, and the Proposed Project's overall feasibility. Metrics that are measurable, either qualitatively or quantitatively, were developed for each criterion.

After the establishment of the metrics, a matrix was developed to evaluate each alternative. The completed matrix allowed for a comparison of each alternative. The three alternatives that were considered to best meet the Project Purpose and Need were advanced as the Proposed Project's Build Alternatives, and analyzed further in the EIS.

Each alternative was evaluated through the engineering Feasibility Study and application of preliminary screening criteria. The Feasibility Study was to help determine the feasible designs and strategies that best address the impacts from the two types of flooding (coastal and systemic inland flooding). The alternatives were further evaluated based on the screening criteria, and defined and modified as the EIS and Feasibility Study were developed.

Figure ES-1.1-2 shows the steps followed to identify Alternative 1 (which provides protection from storm surges), Alternative 2 (which provides protection from localized storms by improving stormwater drainage), and Alternative 3 (which provides protection from both storm surges and heavy rainfalls).

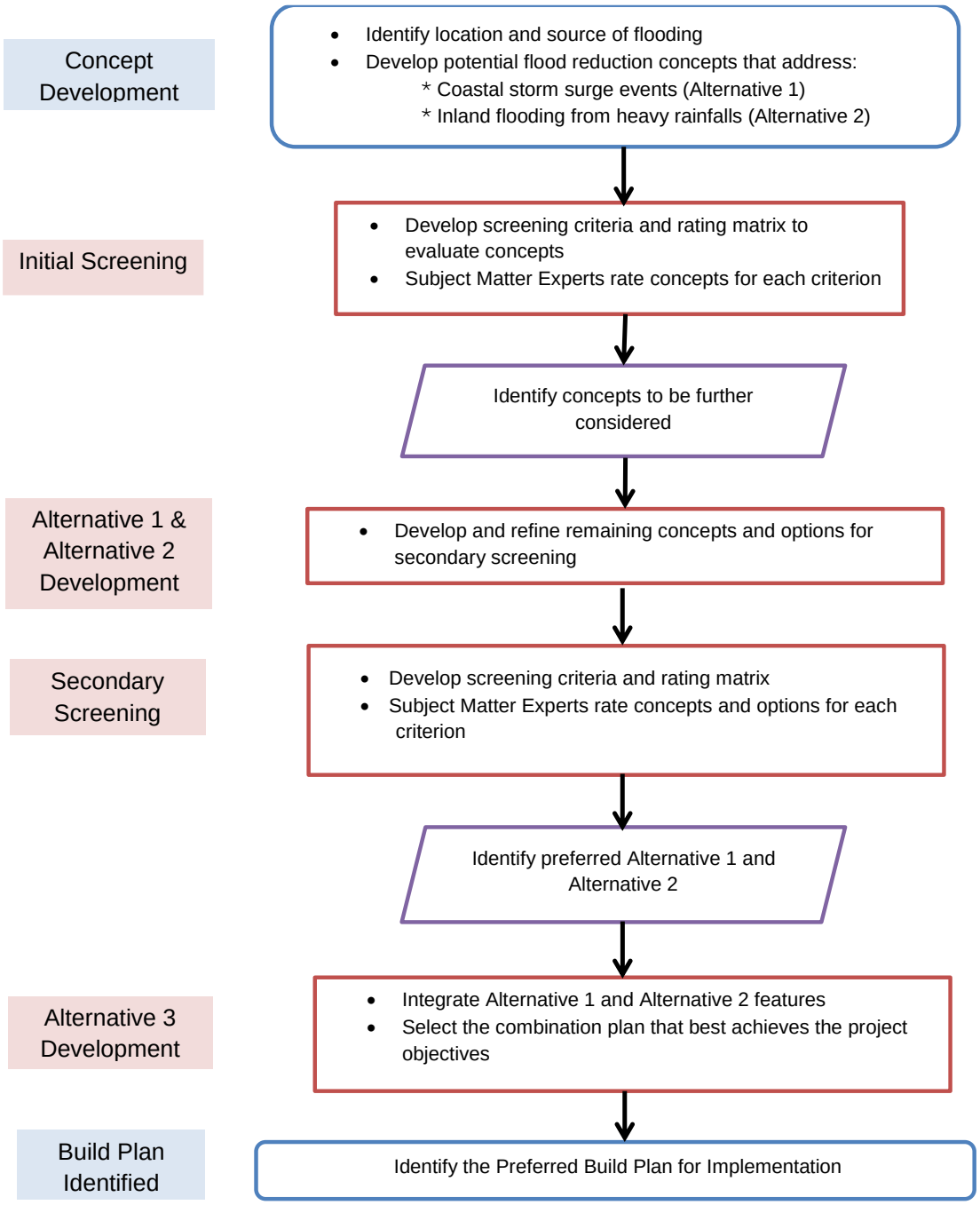


Figure ES-1.1-2: Alternatives Development and Screening Process

ES.6 Alternatives Evaluated in Feasibility Study

Through intensive screening and evaluation, the NJDEP identified three Build Alternatives (described below) that meet the purpose of and need for the Proposed Project, including the majority of the Proposed Project's established goals and objectives. Although the No Action Alternative would not meet the purpose of and need for the Proposed Project, it was analyzed to provide a comparative baseline against which to analyze the effects of the Proposed Project.

No Action Alternative

With the selection of the No Action Alternative, the Proposed Project would not be implemented and current conditions and operations would generally continue in the Project Area. Flood protection measures in the Project Area under this alternative would generally be limited to the O&M of existing infrastructure. Under the No Action Alternative, projected future conditions without implementation of the Proposed Project include:

- Continued coastal flooding from extreme high tides and tidal storm surges during severe coastal storm events;
- Continued inland flooding during heavy rainfall events due to local stormwater drainage issues; and
- Increased exposure to the effects of climate change and sea level change, including increased frequency of intense rainfall events and anticipated rise in regional sea level.

Worsening flood conditions over time would produce commensurately increased adverse impacts to residents, property, and the quality of the human and natural environment of the Project Area. Failure to provide the Project Area with additional protection from coastal storm surges and/or inland flooding would likely lead to increased and more frequent damage to local infrastructure and property, direct harm to economic activity, and increased potential for human health effects, including loss of life.

Alternative 1: Structural Flood Reduction

During the Concept Development and Initial Screening process for Alternative 1, the NJDEP evaluated several preliminary concepts intended to address coastal storm surge and/or inland flooding. Preliminary concepts to address coastal storm surge flooding (i.e., structural flood reduction measures for Alternative 1) included a Hackensack River surge barrier and numerous potential alignments and heights for a line of protection (LOP; i.e., floodwalls, levees, etc.) around the Project Area. It was determined that the available funding for the Proposed Project was not sufficient to construct a Hackensack River surge barrier or provide a FEMA-accredited level of protection against the 100-year flood (i.e., an LOP at elevation of 12.6 feet NAVD 88). The NJDEP also considered LOPs that would provide a lower level of flood protection (i.e., above 7 feet but lower than 12.6 feet NAVD 88), but determined that the higher elevation of these structures would have an unsafe threat of overtopping. The LOP at elevation 7 feet was carried forward for further development. Different alignment options for each of the four segments of the LOP (i.e. northern, central and southern segment) along the Hackensack River, and the Berry's Creek segment, were developed and screened. After the Secondary Screening, one alignment option for each of the four segments was identified to form the Alternative 1 carried forward for further development and evaluation (**Figure ES-1.1-3**).

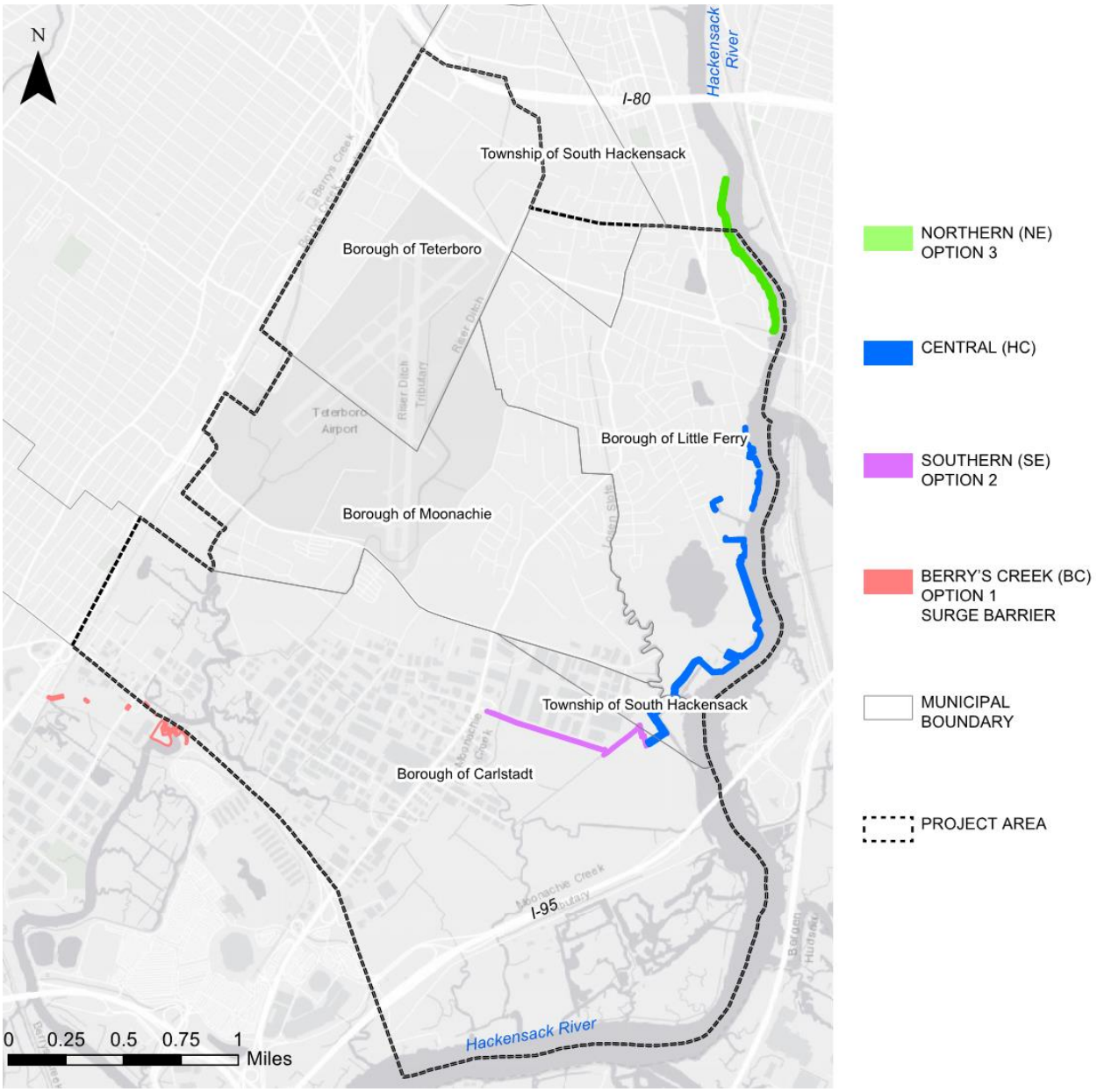


Figure ES-1.1-3: Alignment of Alternative 1 Line of Protection

Under Alternative 1, a LOP would be constructed to connect high ground along the Hackensack River and Berry's Creek using a range of grey infrastructure. Such grey infrastructure include floodwalls, tide gates, closure gates, and a storm surge barrier with a 1,000 cubic feet per second (cfs) pump station in Berry's Creek to provide flood protection up to an elevation of 7 feet (NAVD 88). A LOP at this height would be sufficient to reduce flanking and widespread overtopping during approximately the present-day 50-year storm surge (i.e., there would be an approximately 2 percent chance each year that the LOP would not be effective), and during approximately the 10-year storm surge (i.e., 10 percent annual chance of overtopping) in 50 years based on the intermediate-low sea level rise (SLR) projection. Operation of the LOP features such as road closure gates and the surge barrier are expected only during large flood events, such as when a Coastal Flood Warning is issued by the National Weather Service.

The Alternative 1 LOP (**Figure ES-1.1-3**) would extend from the Hackensack Riverwalk (located at the Riverfront shopping center in the City of Hackensack south along the river and existing wetlands) to high ground near the intersection of Commerce Boulevard and Washington Avenue in the Borough of Carlstadt. This high ground would extend to the Berry's Creek watershed, where a new surge barrier at the Paterson Plank Road Bridge and several other small LOP components would extend the LOP west to existing high ground near the Rutherford Commons shopping center in the Borough of East Rutherford. Additionally, open space, a cantilever riverwalk, walkways, and various green infrastructure elements would be integrated into the proposed LOP. These features would provide various co-benefits to the Project Area, thereby meeting the Proposed Project's established goals and objectives.

A 3-year construction phasing program is anticipated under Alternative 1, with construction peaking in 2021. In total, approximately 26.6 acres of permanent easements and 8.3 acres of temporary easements would be required; impacting approximately 69 parcels.

Alternative 2: Storm Water Drainage Improvements

During the Concept Development for Alternative 2, the NJDEP developed 30 preliminary fluvial flood reduction concepts to address inland flooding. Preliminary concepts included a wide assortment of potential upgrades to existing stormwater drainage networks, including, but not limited to, dredging channels, installing new pump stations, and establishing and/or improving open spaces. These concepts were refined or eliminated based on potentially significant impacts to the Project Area (i.e., impacts to large wetland complexes or contaminated sites) or their inability to meet the basic feasibility requirements (i.e., cost, schedule, or provision of enough benefits). The Initial Screening process identified seven concepts for further development and evaluation in the Secondary Screening, which resulted in six individual concepts of Alternative 2 passing into the Feasibility Study evaluation. In some cases, these individual concepts were distinct and separate; in others, meaningful system-based combinations were possible. Through the development, evaluation, and screening processes described, key components emerged within many individual concepts. These components were combined into a single plan for Alternative 2 that was carried forward for further development and evaluation.

Alternative 2 (**Figure ES-1.1-4**) would implement various grey and green infrastructure-based solutions, in addition to improved open spaces and new parks, to improve stormwater management in important locations throughout the Project Area. This includes the installation of three new pump stations, two new force mains, channel improvement in the lower reach of the East Riser Ditch, 41 green infrastructure features along roads (i.e., bioswales, storage/tree trenches, and rain gardens), improvements to five existing open spaces, and the acquisition and preservation of open space that would provide for five new parks. This alternative would reduce chronic inland flooding from heavy or frequent precipitation events. However, coastal flooding would continue to adversely affect the Project Area.



Figure ES-1.1-4: Components of the Alternative 2 Plan

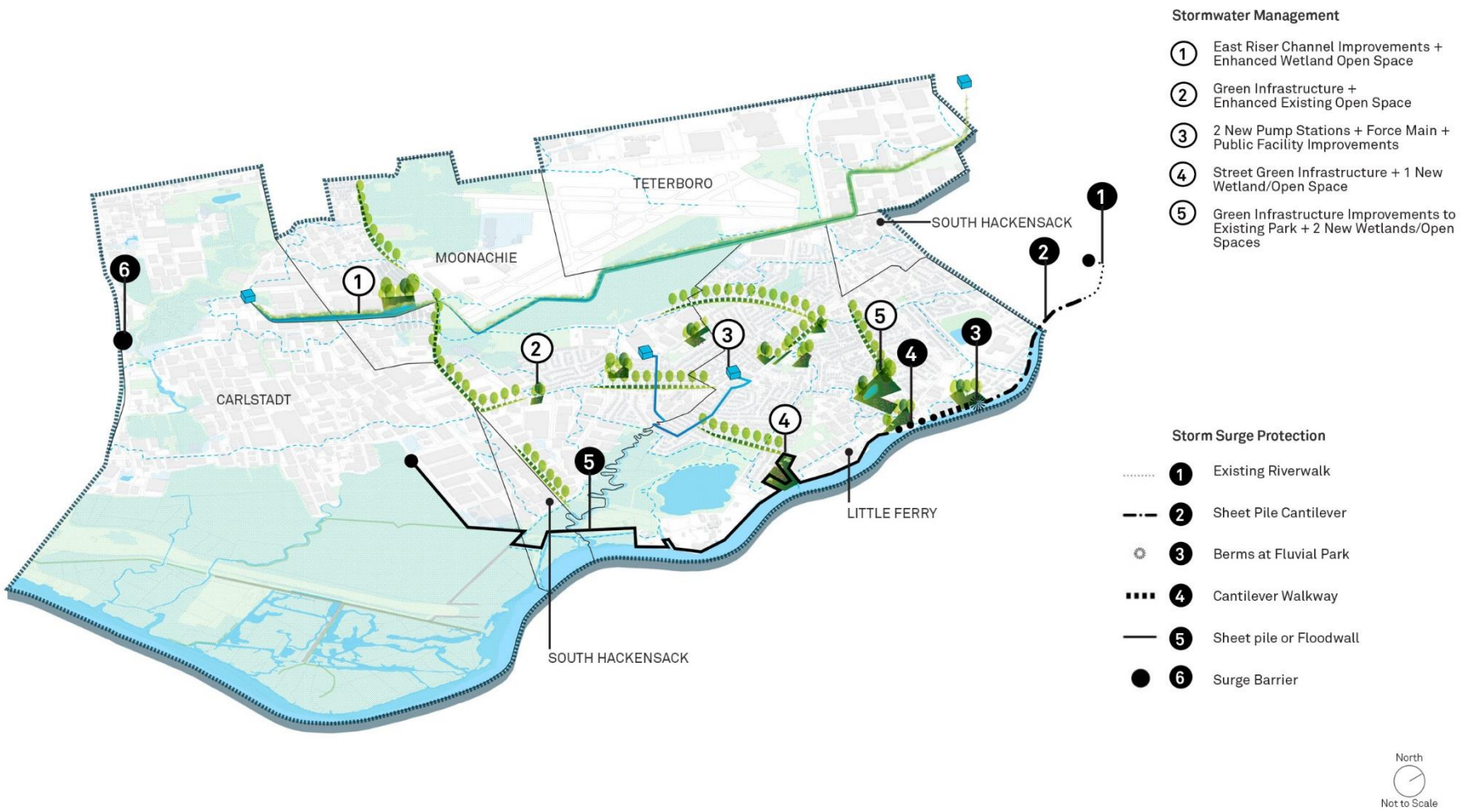


Figure ES-1.1-5: Components of the Preferred Alternative 3 Plan

Flood reduction under Alternative 2 would primarily be achieved through grey infrastructure improvements. They would be mainly channel improvements between the existing East Riser Ditch tide gate and Moonachie Avenue, and a new pump station at the tide gate that would increase the flow reaching the tide gate and discharge the flow past the tide gate, even with elevated tides or minor to moderate storm surges. Losen Slote Creek flood levels would also be reduced through the installation of two new pump stations, which would each use a force main to bypass the channel and pipe network where the capacity is limited. These improvements would reduce both the depths and extent of flooding in these channels for storms ranging in frequency from 2 years to 100 years. On East Riser Ditch, the area around Armor Avenue and West Commercial Avenue would see reductions in water surface elevation between 2 - 3 feet for all frequencies up to the 100-year. The area around Anderson Avenue to the intersection of Moonachie and Redneck Avenues would see reductions of 1 - 2 feet for the same frequencies. On Losen Slote Creek, water surface elevation reductions of 0.5 - 1 foot are expected for the higher frequency events in the Washington Avenue – Union Avenue area.

In addition to the grey infrastructure improvements, green infrastructure systems and new and improved open spaces would provide localized flood reduction. The green infrastructure systems would be designed to accommodate the NJDEP Water Quality Design Storm; open spaces and associated parks would be designed to store and treat stormwater through the use of additional green infrastructure, new or enhanced wetlands, native vegetation, and permeable pavement. Alternative 2 would reduce impervious surfaces in the Project Area by approximately 3.4 acres. By implementing these features, Alternative 2 would increase the rate and capacity of stormwater infiltration and treatment in the Project Area, thereby potentially decreasing stormwater runoff and flooding in the vicinity of Alternative 2's footprint during low intensity rainfall events, while also improving water quality and providing new recreational opportunities for the local communities.

Construction of Alternative 2 would occur in three phases over the approximately 3-year construction period, with construction peaking in 2020. In total, approximately 41.1 acres of permanent easements and 4.1 acres of temporary easements would be required, and approximately 64 parcels would be impacted.

Alternative 3: Hybrid Alternative

Alternative 3 would be a hybrid of coastal flood protection and stormwater drainage improvements (see **Figure ES-1.1-5**). The NJDEP developed five concepts for Alternative 3 by combining various components of Alternative 1 and Alternative 2. These concepts were evaluated based on the following criteria: the ability to provide storm surge protection; the ability to provide fluvial risk reduction; coverage of protection in low and moderate income residential areas; and the provision of public parks, open spaces, and other public realm amenities. Four concepts were eliminated because they would either fail to provide sufficient benefits, and/or would not fully meet the Purpose and Need of the Proposed Project. The remaining concept was carried forward for further development and evaluation.

For Alternative 3, the majority of both Alternatives 1 and 2 would be implemented. However, due to funding and construction constraints associated with a project of this magnitude, the Alternative 3 features would be separated into two stages: a *Build Plan* and a *Future Plan*. The *Build Plan* would include all the features to be constructed as part of the Proposed Project, and the *Future Plan* would include the remaining features that could be constructed over time by others as funding and construction feasibility permit. The Alternative 3 *Build Plan* would consist of all of the Alternative 2 components identified above, with the exception of one of the pump stations (and associated force main) along Losen Slote Creek and two of the proposed parks. Additionally, one of the proposed parks would be reconfigured from the Alternative 2 design. The Alternative 3 *Future Plan* would include the entire LOP from Alternative 1

(including three new open spaces, the cantilever riverwalk, and other features), the second pump station/force main along Losen Slote Creek from Alternative 2, and improvements (i.e., channel improvement and culvert replacements) to the remainder of East Riser Ditch from Moonachie Avenue north to Wesley Street. In total, approximately 27.8 acres of permanent easements and 4.1 acres of temporary easements would be required, and approximately 56 parcels would be impacted.

By implementing a hybrid solution of both coastal and inland flooding reduction, Alternative 3 would constitute the most holistic flood reduction strategy for the Project Area and provide numerous co-benefits including new recreational opportunities, water quality improvements, new and enhanced habitats, and aesthetic benefits, and adhere to the feasibility constraints of the Proposed Project, **Table ES-1.1-1** provides a summary and comparison of the three alternatives on meeting the project objectives, costs, and Benefit to Cost Ratio (BCR).

Table ES-1.1-1: Comparison of the Three Alternatives

Project Objectives, Costs & BCR Ratio	Alternative 1	Alternative 2	Alternative 3
Contribute to Community Resiliency	Provides flood protection from flooding from storm surge, but not from fluvial/rain events.	Provides flood protection from fluvial/rain events but not from storm surges.	Provides flood protection from both fluvial/rain events, and storm surge flooding.
Reduce Risks to Public Health	Provides risk reduction to public health by reducing the frequency of storm surge flooding events.	Provides risk reduction to public health by reducing the frequency of flooding from fluvial/rain events.	Provides greatest risk reduction to public health since it reduces the frequency of both storm surge and fluvial/rain events.
Deliver Co-Benefits	Provides about $2.4 million in annual benefits through economic revitalization, and enhanced social, recreational, aesthetic and environmental values.	Provides about $2.2 million in annual benefits through economic revitalization, and enhanced social, recreational, aesthetic and environmental values.	Provides about $3.5 million in annual benefits through economic revitalization, and enhanced social, recreational, aesthetic and environmental values.
Enhance and Improve Use of Public Space	Provides about 14.2 acres of new and improved parks and recreation space.	Provides about 30.8 acres of new and improved parks and recreation space.	Provides about 32.2 acres of new and improved parks and recreation space.
Consider Impacts from Sea Level Change	Provides resiliency benefits from coastal storm surges that will increase over time due to SLR, although overall level of protection will decrease.	Provides increased drainage reliability in response to SLR.	Provides both increased resiliency from coastal storm surges and increased drainage reliability in response to SLR.
Protect Ecological Resources	Provides about 2.5 acres of new and/or enhanced habitat.	Provides about 15.7 acres of new and/or enhanced habitat.	Provides about 15.7 acres of new and/or enhanced habitat.
Improve Water Quality	Provides about 1 acre of green infrastructure (tree trenches, bioswales, rain gardens) that will reduce storm water runoff and enhance water quality.	Provides about 4 acre of green infrastructure (tree trenches, bioswales, rain gardens) that will reduce storm water runoff and enhance water quality.	Provides about 4 acre of green infrastructure (tree trenches, bioswales, rain gardens) that will reduce storm water runoff and enhance water quality.
Project Cost	Total Cost: $162,134,000 Annual O&M: $1,350,000	Total Cost: $164,916,000 Annual O&M: $1,500,000	Total Cost: $358,105,000 Annual O&M: $2,400,000
Benefit to Cost Ratio	5.99	1.14	3.33

The NJDEP has identified Alternative 3 as the Preferred Alternative for implementation of the Proposed Project, as it provides the most comprehensive flood reduction to the Project Area, including both storm surge protection and stormwater drainage improvements. Although Alternative 3 is the Preferred Alternative, the *Build Plan* was recommended for implementation due to existing funding and construction feasibility constraints.

In the near-term, the Alternative 3 *Build Plan* would reduce flooding in the East Riser Ditch and Losen Slote Creek watersheds, and remain within both the budget and schedule associated with the RBD funding. Beyond 2022, as future funding becomes available, implementation of the *Future Plan* would incorporate additional inland flood reduction in the Losen Slote Creek and East Riser Ditch watersheds, and coastal flood protection during storm surges and extreme high tides.

ES.7 Description and Implementation of the Build Plan

The *Build Plan* (**Figure ES-1.1-6**) would be an integrated plan that would primarily address the systemic inland flooding that results from heavy or frequent precipitation in the Project Area. The *Build Plan* would include both grey and green stormwater management infrastructure features. The grey stormwater management infrastructure features would be designed to reduce flooding damages by capturing and more rapidly evacuating stormwater in the Project Area. The green stormwater management infrastructure features would be designed to capture stormwater runoff from streets and sidewalks to reduce local flooding, improve water quality, and enhance the streetscapes via the implementation of additional system storage through permanent vegetation or new porous paving. The *Build Plan* would also incorporate community co-benefits through the enhancement and improvement of public spaces in the Project Area.

Alternative 3 *Build Plan* Grey Stormwater Management Infrastructure

East Riser Ditch Components: A new 500 cfs pump station would be installed upstream of the existing East Riser Ditch tide gate and Starke Road. It is anticipated that the station would include a screened intake bay, Archimedean screw pumps (or other pumps as to be determined in design), a discharge channel, a modified forebay inlet to the existing tide gate, and an energy dissipation structure on the downstream side of the tide gate. The pump station would have a backup pump and a backup generator installed in case of pump malfunction or electricity outages. Flow discharged from the pump station would be conveyed through the existing culverts under Starke Road. An access road, facility access, and parking area would be provided for facility access and egress from the building, maintenance and operation, and parking.

The East Riser Ditch channel would be dredged from the tide gate location to Moonachie Avenue in order to increase flow conveyance capacity. Sediments would be removed from the ditch and disposed of off-site at a facility licensed to receive the dredged material. Channel boundaries and adjacent areas falling within the riparian zone would be re-vegetated with native plant species consistent with that habitat type in the Project Area.

To improve water conveyance in East Riser Ditch, three existing culvert and bridge structures would be removed and replaced with appropriately sized replacement culverts or bridges. The removed structures would be disposed of off-site at a facility licensed to receive the material.

Losen Slote Creek Components: In the Losen Slote Creek drainage basin, a new stormwater pump station (i.e., Losen Slote Creek pump station A) and associated force main are proposed. Pump station A would be located in the vicinity of 15 Liberty Street in the Borough of Little Ferry, immediately east of the Liberty Bell Village. This pump station would have one 50 cfs or similar sized pump, and would discharge stormwater through a force main in the vicinity of the Lorena Street, Liberty Street, Eckel Road, and Birch Street rights-of-way. This force main would be approximately 3,300 feet long, and would consist of a ductile iron pipe with manholes installed along the pipe for maintenance. It would discharge into Losen Slote Creek at the western terminus of Birch Street. Additionally, a remnant concrete headwall, once part

of a tide gate in the Losen Slote Creek channel in the vicinity of Joseph Street, would be removed to improve natural channel flow.

The Losen Slote Creek pump station A would have a backup pump and a backup generator installed in case of pump malfunction or electricity outages. Energy dissipation structures would be constructed as needed at the discharge point of the force main to reduce erosion of the Losen Slote Creek channel.

Alternative 3 *Build Plan* Green Stormwater Management Infrastructure and Open Space

The green infrastructure features associated with the Alternative 3 *Build Plan* would include bioswales, rain gardens, storage trenches/ tree trenches, permeable pavement, wetland improvements, parks/open spaces, and other associated structures and easements. The locations associated with green infrastructure features in the *Build Plan* would be:

- the DePeyster Creek right-of-way,
- the Carol Place right-of-way,
- the West Riser Ditch right-of-way,
- the Park Street right-of-way, and
- the Main Street area.

The *Build Plan* would also include additional flood management measures that are integrated with new parks and improved existing open space, and would also provide water quality benefits. These are proposed to be:

- Riverside Park,
- Caesar Place Park,
- Avanti Park,
- Willow Lake Park,
- Little Ferry Municipal Improvements,
- improvements at Little Ferry Public Schools,
- improvements at Robert Craig Elementary School, and
- Joseph Street Park.

Once the Alternative 3 *Build Plan* is completed, there would be annual O&M costs associated with the new pump stations and the other grey and green construction features. The annual cost of O&M would be approximately $1,250,000. **Table ES-1.1-2** shows a summary of the anticipated Alternative 3 *Build Plan* cost.

The benefits of the Alternative 3 *Build Plan* would be expected to exceed its costs by a factor of 1.14 to 1 (see **Section 10.6**).

Based on the Proposed Project's schedule constraints (i.e., construction must be completed and functional by September 2022), the *Build Plan* would be separated into six contracts for design and construction. Design of these six contracts could be carried out concurrently. Obtaining permits in the Meadowlands is challenging and could directly impact the feasibility of the *Build Plan* implementation. Therefore, permits would be submitted for approval as soon as they are ready for submission.

The recommended six contracts of the *Build Plan* design and construction are:

1. Green Infrastructure Improvements: Carol Place, West Riser Ditch, DePeyster Creek, Park Street, and Main Street;
2. Open Space Improvements: Riverside Park, Willow Lake Park, Little Ferry Municipal Improvements, improvements at Little Ferry Public Schools, and improvements at Robert Craig Elementary School;
3. Open Space Improvements: Joseph Street Park and Avanti Park;
4. Open Space Improvements: Caesar Place Park;
5. East Riser Ditch Improvements: Pump Station, Channel Improvements, Culvert and Bridge Remove and Replace; and
6. Losen Slote Creek Pump Station A and associated force main.



Figure ES-1.1-6: Components of the Alternative 3 Build Plan

Table ES-1.1-2: Construction Cost Summary for Alternative 3 Build Plan

Project Features	ESTIMATED COST BEFORE CONTINGENCY & ESCALATION (2017$)	CONTINGENCY	ESCALATION @3.5%/Yr	ESTIMATED TOTAL WITH CONTINGENCY & ESCALATION (2017$)
CONSTRUCTION				
Grey Infrastructure Features	$ 45,422,000	$ 11,355,000	$ 8,376,000	**$ 65,153,000**
Green Infrastructure Features and Open Space	$ 10,029,000	$ 2,507,000	$ 1,849,000	**$ 14,385,000**
Allowances (see Note 5)	$ 5,010,000	$ -	$ 739,000	**$ 5,749,000**
General Requirements	$ 3,930,000	$ 982,000	$ 725,000	**$ 5,637,000**
TOTAL CONSTRUCTION COSTS	**$ 64,391,000**	**$ 14,844,000**	**$ 11,689,000**	**$ 90,923,000**
Real Estate	$ 10,300,000		$ -	**$ 10,300,000**
Engineering and Design	$ 7,727,000	$ 927,000	$ 616,000	**$ 9,270,000**
Construction Administration	$ 2,791,000	$ 700,000	$ 515,000	**$ 4,006,000**
TOTAL PROJECT COSTS	**$ 85,209,000**	**$ 16,471,000**	**$ 12,820,000**	**$ 114,500,000**
Feasibilty Study/EIS	$ 20,500,000			**$ 20,500,000**
NJDEP Program Administration	$ 15,000,000			**$ 15,000,000**
TOTAL PROGRAM COSTS	**$ 120,710,000**	**$ 16,471,000**	**$ 12,820,000**	**$ 150,000,000**

NOTES:

1	Estimate includes 25% contingency for construction features and 12% for Engineering and Design.
2	Estimate includes escalation to assumed construction mid-point of 2021, at 3.5% per year compounded.
3	Estimate assumes all excess soils generated by construction will be classified as non-hazardous ID27 solid waste that would be transported/disposed from the site at a cost of $85 per ton. The weight of the excavated material was conseratively estimated to be 2 tons per cubic yard.
4	Estimate assumes that "hot spots" of Hazardous, Toxic, Radioactive Waste (HTRW) encountered can be addressed either through the project contingency or by implementing measures to reduce the volume. If significant "hot spots" are encountered, design modifications would be made to minimize the need to remove HTRW material.
5	Allowances provide for utility relocations/protection and for construction of wetlands to mitigate unavoidable impacts to existing wetlands that will not be offset by project features.
6	Estimate assumes deep foundation support will be needed for force mains, stormwater piping & box culverts.
7	GENERAL REQUIREMENTS - includes 6.5% of construction cost to cover contractor PM and Supervision (3%), Mob/Demob (1%), Traffic Maintenance (2 %), and Erosion-sedimentation controls (0.5%).

1.0 Introduction

The Hurricane Sandy Rebuilding Task Force created the Rebuild by Design (RBD) competition in the summer of 2013 to develop ideas to improve the physical, ecological, and economic resilience of regions affected by Hurricane Sandy. The competition had two goals: (1) to promote innovation by developing flexible solutions that would increase regional resilience; and (2) to implement proposals with both public and private funding dedicated to the RBD effort. To realize the RBD initiative, the United Sates (US) Department of Housing and Urban Development (HUD) set aside Community Development Block Grant – Disaster Recovery (CDBG-DR) funds allocated through the Federal Sandy Supplemental legislation to develop and incentivize implementation of RBD projects.

HUD engaged multi-disciplinary teams composed of architects, designers, planners, and engineers. HUD charged these teams with proposing regional- and community-based projects that would promote resilience in various Hurricane Sandy-affected areas. The teams included experts from around the world. The teams' proposals, developed with and by the communities where the projects were focused, were submitted to HUD. HUD ultimately selected six "winning" projects. Two of those projects were in New Jersey: one focused on the Hudson River region (RBD Hudson) and the other focused on the Meadowlands District (RBD Meadowlands, or RBDM). The winning project for the Meadowlands District included three Pilot Areas (**Figure 1.1-1**).

On October 16, 2014, HUD issued *Federal Register* Notice FR-5696-N-11 (effective October 21, 2014). This Notice allocated $881,909,000 of third round CDBG-DR funds to New Jersey. Of that total, HUD designated $380 million for the two RBD projects in New Jersey: $230 million to RBD Hudson and $150 million to RBDM, Phase 1 Pilot Area.

The State of New Jersey Department of Environmental Protection (NJDEP), on behalf of the State of New Jersey through its Department of Community Affairs (NJDCA), as the recipient of HUD grant funds and as the "Responsible Entity," is responsible for preparing an Environmental Impact Statement (EIS) and Feasibility Study for the RBDM Flood Protection Project (the Proposed Project).

This Feasibility Study evaluates the alternatives for implementing the Proposed Project in the Phase 1 Pilot Area. There are currently no plans to advance the Phase 2 and Phase 3 Pilot Areas of RBDM. The RBD award-winning concept takes a multi-faceted approach to address flooding from coastal storm surges and heavy rainfall events.

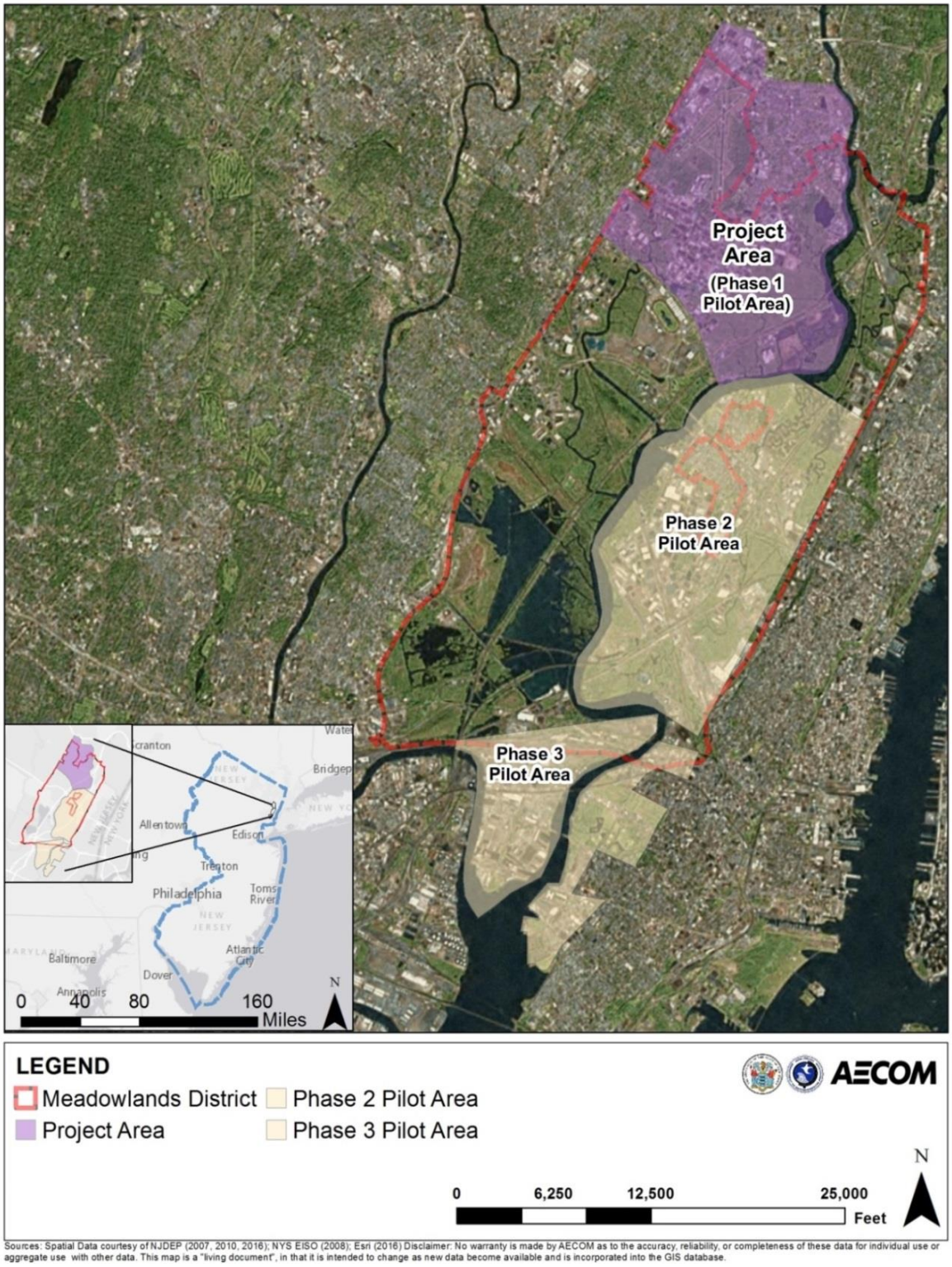


Figure 1.1-1: Meadowlands Program Area

1.1 Description of the Project Area

The $150 million in CDBG-DR funding awarded to the State of New Jersey was specifically designated for the "Phase 1 Pilot Area," now referred to as the Project Area (**Figure 1.1-1**). The Project Area, a part of both the larger New York metropolitan area and the New Jersey Meadowlands District, includes the Boroughs of Little Ferry, Moonachie, Carlstadt, and Teterboro, as well as the Township of South Hackensack, all located in Bergen County, NJ. The 5,405-acre Project Area has the following approximate boundaries: the Hackensack River to the east; Paterson Plank Road (State Route 120) and the southern boundary of the Borough of Carlstadt to the south; State Route 17 to the west; and Interstate 80 (I-80) and the northern boundary of the Borough of Little Ferry to the north.

The Proposed Project is located within the Meadowlands District. The Meadowlands District is situated in a valley with ridges on its sides that run parallel in a southwest to northeast direction. The area is prone to chronic flooding because of the nature of the landscape, the low elevation, the complexity of tidal influence, and inadequate stormwater management systems (NJSEA 2004). Comprised of mostly flat terrain, elevations within the Meadowlands District, including the Project Area, generally do not exceed 10 feet (North American Vertical Datum of 1988 (NAVD 88)), with most areas less than 6 to 7 feet (NAVD 88) (MERI 2014). The Hackensack River, which borders the Project Area, and Berry's Creek, which runs through the Project Area, are both tidal. They have mean high water spring elevations of 2.7 feet and 3.0 feet (NAVD 88), respectively (NJSEA 2005). A spring high tide occurs during full and new moons, and represents the highest tide in the lunar cycle. Spring high tides have a significant impact on fluvial drainage.

The lack of elevation difference in the Meadowlands District puts a strain on the ability of the communities to drain stormwater, as stormwater infrastructure is typically powered by gravity (NJDEP 2015a). Further, much of the Meadowlands District has become impervious due to the high degree of development. This, in conjunction with the significant changes made to the natural hydrology of the Project Area, has severely limited the ability of the land to absorb and store stormwater and discharge it over time. Consequently, much of the rainfall becomes runoff and immediately enters the stormwater drainage infrastructure (Rutgers University 2007).

The Project Area comprises both relatively dense suburban development and large areas of wetlands. Residential areas are clustered mostly in the northeastern portion of the Project Area in the Borough of Little Ferry, eastern Borough of Moonachie, and the Township of South Hackensack. Approximately 22,400 people reside in the five municipalities that compose the Project Area. The largest economic sector employing these residents includes educational services, healthcare, and social assistance services. Industrial and commercial land uses are concentrated primarily in the southern portion of the Project Area in the Boroughs of Carlstadt and Moonachie, and in the Township of South Hackensack. Teterboro Airport and additional, primarily airport-related, industrial and commercial areas encompass much of the northwestern portion of the Project Area. Given its proximity to New York City, the Project Area hosts a variety of businesses and warehouses that support the supply chain to New York City, located approximately 10 miles to the east.

The population of the Project Area is generally middle class with employment rates resembling those of Bergen County and New Jersey. **Section 3.3** further describes the socioeconomic conditions of the Project Area.

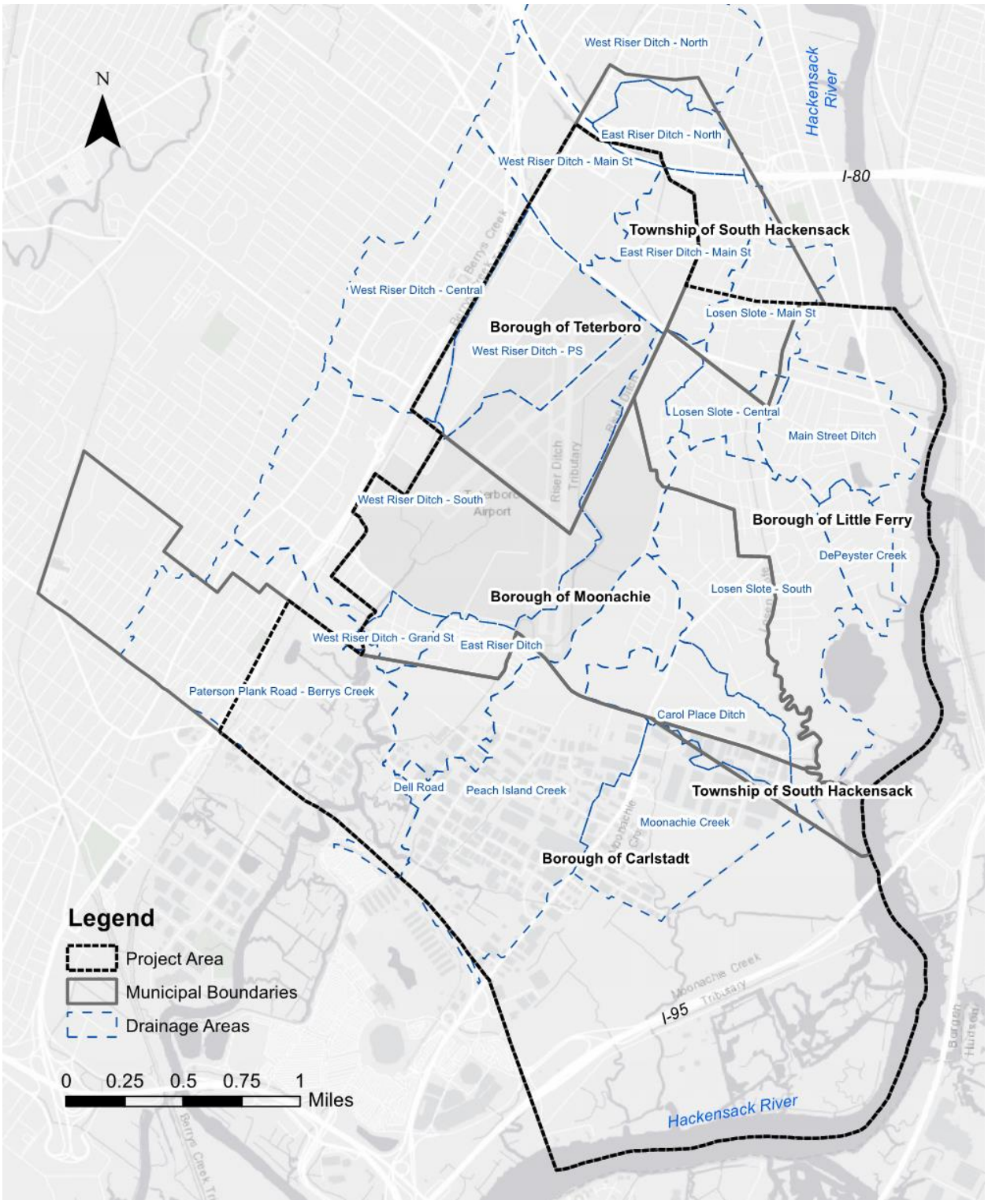


Figure 1.1-1: Municipal Boundaries and Drainage Areas in the Project Area

The southern and eastern portions of the Project Area, including portions of the Borough of Carlstadt, the Township of South Hackensack, and the Borough of Little Ferry, are largely dominated by wetlands associated with the Hackensack River, including the Marsh Resources, Inc. (MRI) Wetland Mitigation Bank and the Richard P. Kane Natural Areas and Wetland Mitigation Bank. These wetland-dominated areas encompass approximately 1,200 acres (approximately 20 percent) of the Project Area.

The Meadowlands District is an essential component of the New York / New Jersey Harbor Estuary and is a part of the largest wetland ecosystem in northern New Jersey (USACE 2017). The Meadowlands District area historically contained approximately 17,000 acres of waters and pristine wetlands. However, only an estimated 8,400 acres remain as a result of decades of extensive destruction and disturbance from activities including development, dredging, draining, and landfilling (USEPA 1996, NJSEA 2004). In addition, historical construction of dikes and tide gates, in an attempt to control and reduce flooding events, has affected the integrity and spatial configuration of the Meadowlands District and altered its biodiversity (NJSEA 2004). Despite its developed nature, the Meadowlands District provides an oasis of diverse habitats for plants and wildlife in the urban New York / New Jersey metropolitan region (USFWS 1997, NJSEA 2004).

Approximately 8,600 acres of the original 17,000 acres of wetlands have been developed and altered by human activity, including extensive land use and land cover changes, and the creation of large areas of impervious surfaces. As a result of these manmade changes throughout the Meadowlands District, development within the Project Area is vulnerable to both inland and coastal flooding.

1.2 Project Purpose, Need, and Objectives

The purpose of the Proposed Project is to reduce flood risk and increase the resiliency of the communities and ecosystems within the Project Area, thereby protecting critical infrastructure and facilities, residences, businesses, and ecological resources from frequent and intense flood events anticipated in the future. The ability of the Proposed Project to meet this purpose is measured in terms of the following goals and objectives:

- ***Contribute to Community Resiliency*.** The Proposed Project would integrate a flood hazard risk reduction strategy with existing and proposed land uses and assets. The Proposed Project would reduce flood risks within the Project Area, leading to improved resiliency and the protection of accessibility and on-going operations of services (including protecting critical infrastructure and facilities such as hospitals, fire stations, and police department buildings; and roadways and transit resources). This would allow these key assets to support emergency preparedness and community resiliency during and after flood events.
- ***Reduce Risks to Public Health*.** In addition to providing protection to critical healthcare infrastructure (such as local hospitals and emergency services), the flood risk reduction strategy would reduce the adverse health impacts associated with these types of flood events, such as the spread of infectious diseases, compromised personal hygiene, and contaminated water sources.
- ***Contribute to On-going Community Efforts to Reduce Federal Emergency Management Agency (FEMA) Flood Insurance Rates*.** The National Flood Insurance Program's (NFIP) Community Rating System allows municipalities to reduce their flood insurance rates through implementation of comprehensive floodplain management. The Proposed Project would include concepts and alternatives that are consistent with the local municipalities' overall effort to reduce FEMA flood insurance rates.

- ***Deliver Co-Benefits.*** Where possible, the Proposed Project would integrate the flood hazard risk reduction strategy with civic, cultural, ecological, economic, and recreational values. The Proposed Project would strive to incorporate active and passive recreational uses, multi-use facilities, and other design elements that integrate the Proposed Project into the fabric of the community. In this way, the Proposed Project would be independent of but complement local strategies for future growth to the extent possible.
- ***Enhance and Improve Use of Public Space.*** The Proposed Project would strive to include flood reduction design elements that improve public and recreational spaces, thereby enhancing quality of life for the community.
- ***Consider Impacts from Sea Level Change.*** The Proposed Project would consider the projected impacts from sea level change and its impacts on the frequency and degree of flooding.
- ***Protect Ecological Resources.*** The Proposed Project would strive to protect and enhance ecological resources by protecting wetlands and other habitats that contribute to local and regional biodiversity and ecosystem resiliency.
- ***Improve Water Quality.*** The Proposed Project may incorporate green infrastructure solutions into the design and construction of proposed flood risk reduction measures to manage stormwater runoff, reduce stormwater pollution, and improve water quality.

The Proposed Project is needed to address: (1) systemic inland flooding from high-intensity rainfall/runoff events; and/or (2) coastal flooding from storm surges. In addition to reducing flooding in the Project Area, the Proposed Project is needed to protect life, public health, and property in the Project Area. The Proposed Project seeks to reduce flood insurance claims from future events and potentially restore property values to the extent possible. The Proposed Project is further needed to increase community resilience, including protecting accessibility to, and on-going operations of, critical health care services, emergency services, and transportation and utility infrastructure. In addition to reducing flood risk and improving community resiliency, the Proposed Project could provide ancillary benefits, such as protection of ecological resources (enhancement of water quality, regional biodiversity, and ecosystem resiliency) and improvement of civic, cultural, and recreational values in the Project Area.

1.3 Report Organization

This report comprises 11 sections. **Section 1.0** through **Section 4.0** provide introduction and background information for the Project Area:

- **1.0 – Introduction**. This section provides general information regarding the Hurricane Sandy Rebuilding Task Force, the Proposed Project authorization, and funding mechanisms.
- **2.0 – Background**. This section provides information about conception of the Proposed Project through the RBD competition. It explains the award-winning concept's multi-faceted approach intended to address flooding from both coastal storm surges and heavy rainfall events, with several potential ancillary benefits.
- **3.0 – Existing Conditions**. This section provides a detailed characterization of the components of the environment, or technical resource areas, that could potentially be affected by the Proposed Project. The information in this section provides the basis for the assessment of impacts from the Proposed Project's three Build Alternatives and No Action Alternative.

- **4.0 – Future Conditions with No Action Alternative**. This section evaluates the No Action Alternative, under which no project would be implemented and current conditions and operations would continue in the Project Area. The No Action Alternative is evaluated under current and projected future SLR scenarios.

The remaining sections provide information on plan development, alternatives, feasibility, and plan implementation:

- **5.0 – Plan Development Approach**
- **6.0 – Alternative 1 – Plan Development**
- **7.0 – Alternative 2 – Plan Development**
- **8.0 – Alternative 3 – Plan Development**
- **9.0 – Comparison of Alternatives – Selection of Build Plan**
- **10.0 – Alternative 3 Build Plan Description**
- **11.0 – Build Plan Implementation**

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2.0 Background

The NJDEP is undertaking Preliminary Planning and Design for the Proposed Project, which includes the Boroughs of Little Ferry, Moonachie, Carlstadt, and Teterboro, and the Township of South Hackensack, Bergen County, NJ (i.e., the Project Area).

The RBD award-winning concept took a multi-faceted approach intended to address flooding from both major storm surges and heavy rainfall events, with several potential ancillary benefits. The concept's comprehensive approach to resilience consists of three integrated components: *Protect*, *Connect*, and *Grow* (as shown in **Figure 2.0-1**).

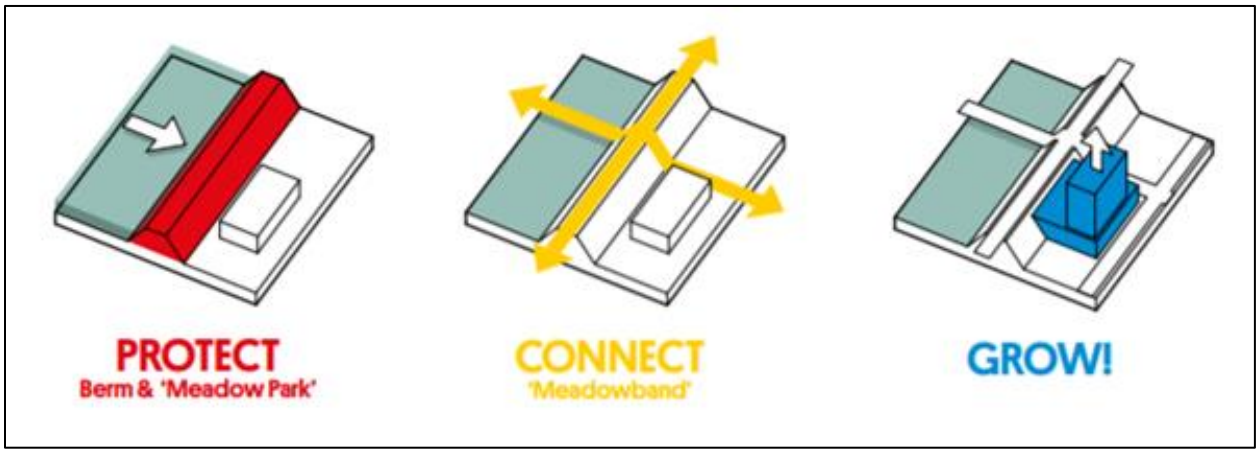


Figure 2.0-1: Conceptual Diagram of Components from the Winning Concept of RBD Competition

1. **Protect.** Provide flood protection through a combination of hard infrastructure (such as bulkheads or floodwalls) and soft landscaping features (such as berms and/or levees) that act as barriers during exceptionally high tide and/or storm surge events. Flood control structures would be complemented with freshwater basins and expanded Meadowlands wetlands to increase flood storage capacity. A proposed Meadowpark, envisioned as a natural reserve and expansion of the existing marsh, would offer additional flood protection and connection of surrounding developments to the Meadowlands through its views and recreational offerings.
2. **Connect.** Increase connectivity among Meadowlands District towns with a "Meadowband" (multi-use levee) that would include a new local street, recreational facilities and access, and a Bus Rapid Transit line that would provide improved connectivity and access within the Project Area, much in the same way 5th Avenue and 8th Avenue frame Central Park in New York City.
3. **Grow.** Through improved flood control, an ancillary benefit of re-zoning and up-zoning newly protected areas could become a reality. Through re-zoning, the local development pattern could transform from lower density, suburban-type development to a denser, better planned, multi-functional, and multi-level mixed use of offices, warehousing, retail, and residential development.

The winning design from the RBD competition proposed 9 miles of flood protection features. FEMA-certifiable levees were estimated to cost $35 million per mile. The proposal of the winning project was estimated to cost approximately $850 million dollars before real estate acquisition. However, the Proposed Project allocation of $150 million could only provide 3 miles of protection. The reality of these costs required reconsideration of the proposal and a thorough review for strategies and elements capable of meeting the implementation deadline within the available funding.

A bridging analysis was prepared to move from the original, regional concept to a more focused concept. The team evaluated and built upon the original RBD winning concept to determine the ideal, and most cost effective, way to implement comprehensive flood protection. Based on the amount of CDBG-DR funding (i.e., $150 million) provided by HUD for the "Phase 1 Pilot Area" (i.e., the Project Area), NJDEP has determined that the Proposed Project, in application, will focus primarily on reducing flood risk within the Project Area (i.e., the "Protect" component of the "Protect, Connect, Grow" concept)[1]. The AECOM team continued to investigate protection from inland flooding, tidal storm surge flooding, and stormwater flooding in the Project Area and proposed three protection approaches: (1) Alternative 1 or the Structural Flood Reduction Alternative, (2) Alternative 2 or the Stormwater Drainage Improvement Alternative, and (3) Alternative 3 or the Hybrid Alternative. Due to budget constraints, the Meadowband concept is not included in the Proposed Project design, but improving evacuation and access remains one of the main design goals of the Proposed Project, along with the strategy of utilizing design elements to co-benefit the community for growth rather than re-zoning the areas. This bridging effort served as the foundation and initial steps for the Feasibility Study, Environmental Impact Statement (EIS), design, and construction administration for the Proposed Project.

2.1 History of Flooding in the Project Area

The Project Area is vulnerable to both coastal flooding from storm surges and systemic inland flooding from large rainfall events. The interrelationship between coastal flooding and rainfall events contributes to the recurring flooding conditions throughout the Project Area. Each component represents challenges and needs to be addressed within the context of an overall flood reduction strategy for the Project Area.

In the Project Area, the 2-year storm is classified as 3.3 inches of rainfall in a 24-hour period (see **Appendix B**). In the Boroughs of Little Ferry and Moonachie, most of that rainfall becomes runoff (Guo, et al. 2014). The runoff issues are compounded when the river experiences an extreme high tide, as the Hackensack River is the destination for the stormwater. If the river is not at a lower elevation than the stormwater outfalls, they back up until the tide recedes, unless the infrastructure has been specifically designed to mitigate this situation. A number of tide gates, pumps, and other water control structures have been installed in the Project Area to assist in the drainage process (Rutgers University 2007).

Inland flooding is often the result of several types of rain events, including hurricanes moving up the coast, large frontal storms from the west and south (i.e., "nor'easters"), and local thunderstorms. The Meadowlands District experiences chronic flooding during frequent rain events. The area sits at a low elevation relative to sea level; its pipes, infrastructure, and flood protection structures are undersized; and its historical wetlands were filled, which reduced natural drainage capacity. As shown in **Figure 2.1-1**, the 100-year floodplain encompasses the majority of the Project Area, including 49 critical facilities and other infrastructure (Bergen County Office of Emergency Management 2015).

According to the National Climatic Data Center's storm events database, 97 heavy rain and flood events were reported in Bergen County between 1995 and 2015 (NOAA 2016). The State of New Jersey reports that there have been 16 nor'easters (or similar storms) statewide since 1991. FEMA disasters were declared in Bergen County for three of these nor'easters (in 1992, 2007, and 2011), as well as for six other flooding events during the same period (New Jersey Office of Emergency Management 2014).

[1] Potential ancillary "Connect" and "Grow" components of the winning concept, while not funded specifically, could be further investigated by other parties following implementation of the critical "Protect" function should future conditions become favorable.

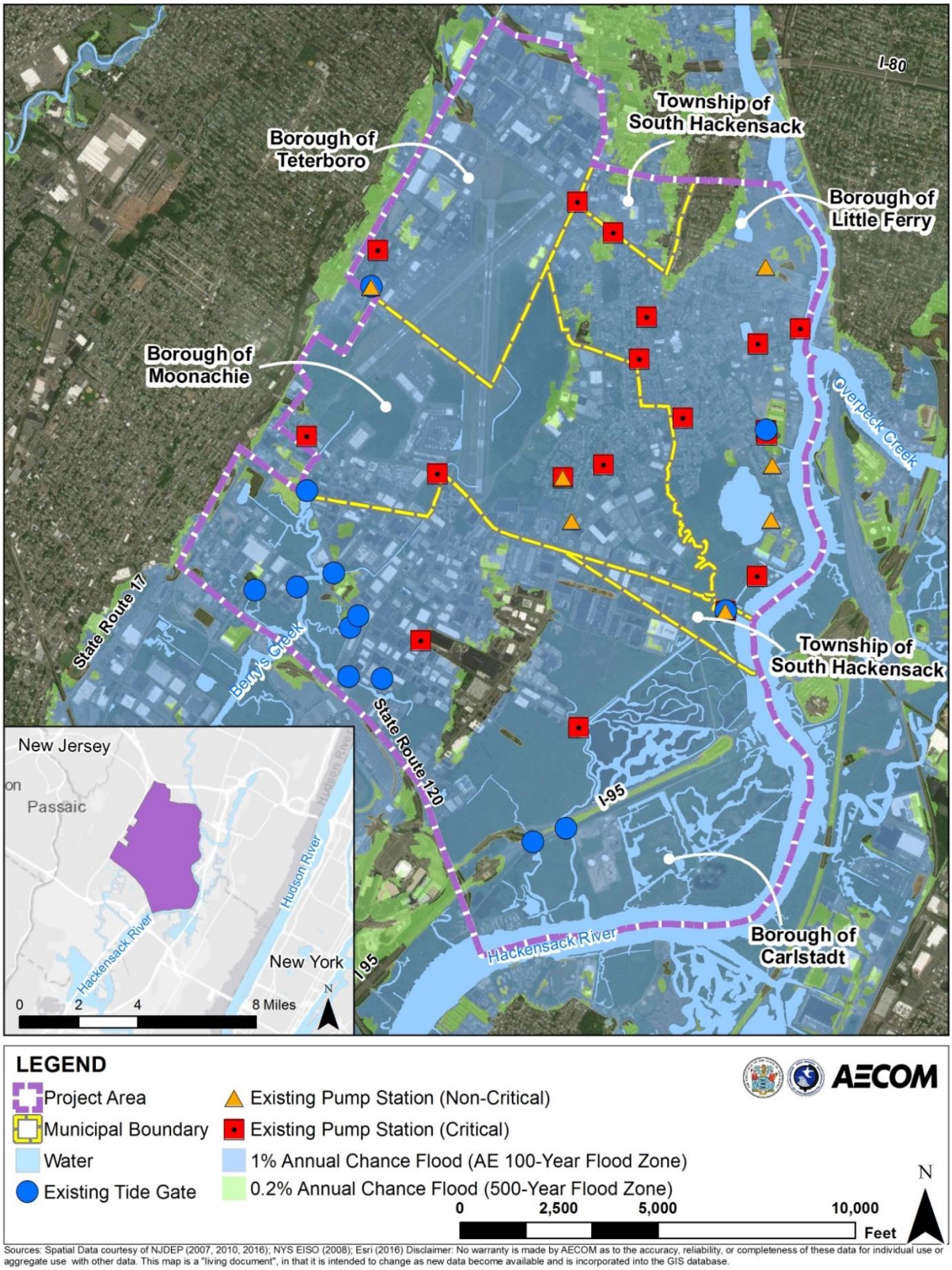


Figure 2.1-1: FEMA's Digital Flood Insurance Rate Mapping Within the Project Area

The impacts of inland flooding generally manifest in localized areas, such as individual roads or properties. In 2005, the New Jersey Meadowlands Commission (NJMC; which has since become the New Jersey Sports and Exposition Authority [NJSEA]) produced the Hackensack Meadowlands Floodplain Management Plan. Although the details of the information may be dated, the plan provides insight into the nature of the local flooding challenges. In the plan, the NJMC highlighted 16 flood hazard areas in the Meadowlands District, eight of which are located in the Project Area (NJSEA 2005). Chronic localized flooding of roads and properties has severe impacts on local commerce, transportation, and residents by rendering roads impassable, disrupting normal activities, and causing significant commercial and residential property damage (Guo, et al. 2014, Rutgers University 2007). In 2016, NJSEA updated the 2005 NJMC Plan and identified ten specific activities undertaken since Hurricane Sandy to reduce the impact of flooding in the region (NJSEA 2016).

The other major source of flooding in the Project Area is coastal flooding from storm surges. Coastal flooding occurs less frequently than inland flooding, and often accompanies storms of tropical origin. During these events, the tidally influenced Hackensack River overtops its banks and inundates the coastal floodplain. A series of old berms along the Hackensack River offers some protection against coastal inundation. However, these berms are not entirely effective because they are neither continuous nor uniform in height (US Department of Homeland Security 2014). One recent study reported that they are breached approximately every 5 years. Due to the low elevation of the entire Project Area, these breaches can lead to widespread damage (NJIT 2014). Storm surges can be particularly severe if they occur in tandem with spring high tides, since they can be substantially higher than normal high tides (NJSEA 2005, Rutgers University 2007).

2.2 Recent Flooding

The Project Area has been severely impacted by three major storms since 1999: Hurricanes Floyd, Irene, and Sandy. The most recent of these, Hurricane Sandy, also most visibly revealed the vulnerability of the Project Area to coastal flooding. Although it was not a major rainfall event, its storm surge reached 9.5 feet (NAVD 88) in the Project Area (NJIT 2014). This massive surge is estimated to have been 20 percent larger because of the full moon amplifying the high tide (US Department of Homeland Security 2014). Gauges in the Project Area recorded the surge to be 7 feet (NAVD 88) or higher for a duration of 6 hours (NJIT 2014). This elevation and duration were sufficient for the Hackensack River to inundate nearly the entire Project Area (**Figure 2.2-1**). Reports suggest that the Borough of Moonachie was completely inundated and the Borough of Little Ferry was approximately 80 percent flooded (NJIT 2014, Petrecca 2012). Following the storm, the floodwaters were slow to drain because they were being retained by the old berms surrounding the communities (Borough of Little Ferry 2014).

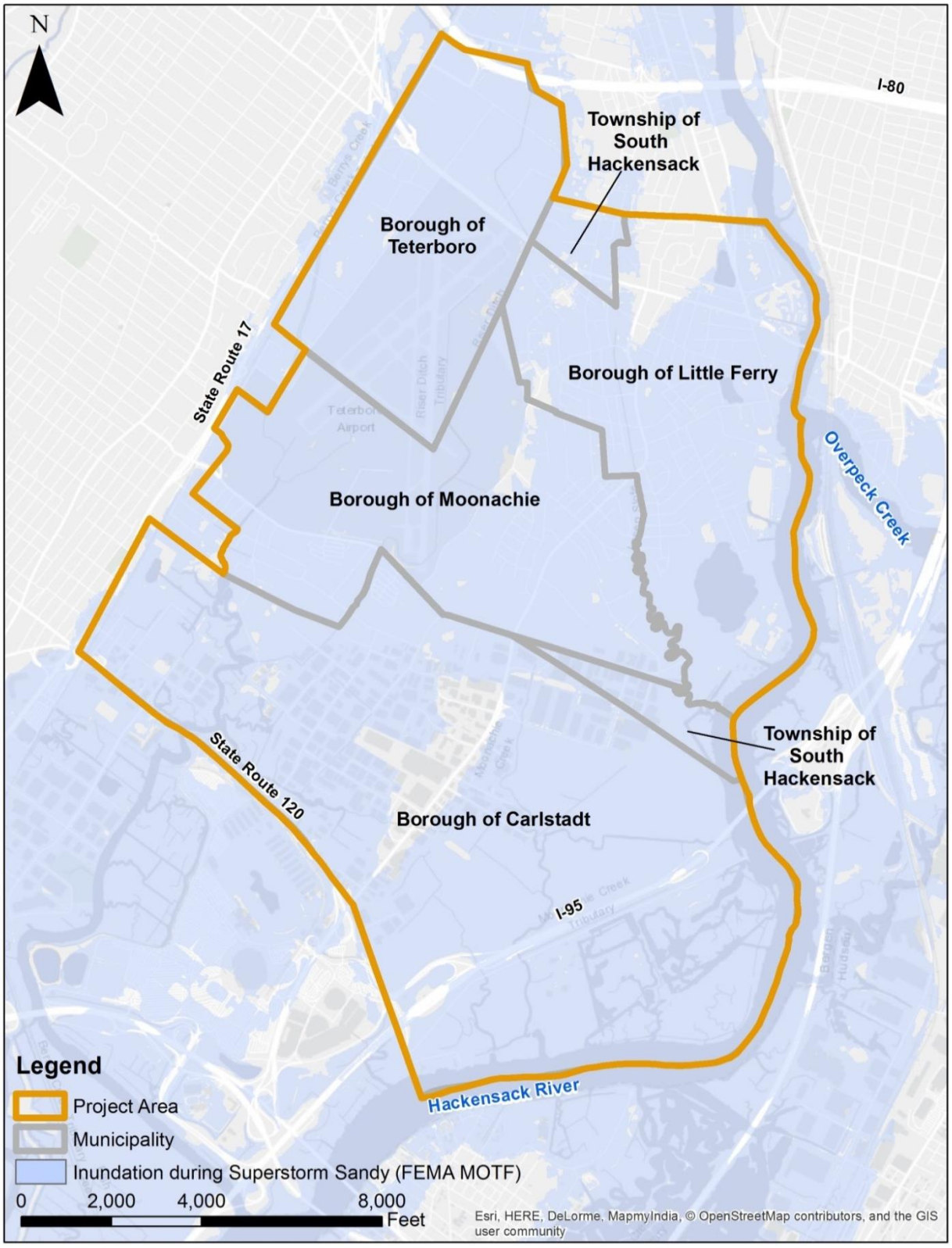


Figure 2.2-1: Extent of Flooding during Hurricane Sandy

Hurricane Sandy had enormous health and safety, critical infrastructure, and financial impacts on the Project Area. The National Guard, along with local and regional rescue teams, evacuated approximately 3,500 residents after the storm had passed (Akin and O'Brien 2012, Makely 2012). The storm also caused minor injuries to residents of the Project Area, and one man from the Township of South Hackensack was killed in the City of Hackensack, just north of the Project Area, as a result of the flooding (Keller 2012). Numerous fires and gas leaks were reported as the electricity returned to homes that were still flooded and emergency and government services were hampered. In the Borough of Moonachie, the police station and municipal buildings sustained major damage and were forced to relocate their operations (Akin and O'Brien 2012). Schools were closed for 2 weeks in the Borough of Little Ferry following the storm, and only one school building was able to operate for the remainder of the year (Krulish 2013).

Electric and natural gas service were unavailable for nearly a week following Hurricane Sandy. The lack of electricity further prolonged the flooding event, as the pump stations needed to drain the communities lost power. As a result, some neighborhoods were flooded with 5 to 6 feet of water for up to 5 days or more following the storm (NJIT 2014). Over 1,100 residents reported having at least 1 foot of water in the first floor of their home, and several hundred reported over 4 feet of water (HUD n.d.).

The financial impact of Hurricane Sandy on the Project Area was also devastating. According to FEMA, approximately 1,700 homeowners sustained damage from the storm. The total assessed value of damage to homeowners in the five boroughs was over $21.4 million. Most of this damage was concentrated in the Boroughs of Little Ferry and Moonachie, where the average damage per homeowner was approximately $12,000 (FEMA 2015a). FEMA delivered over $15.5 million in assistance to homeowners and renters in the area following Hurricane Sandy (FEMA 2015b). Structural damage to homes and businesses in the Project Area totaled approximately $110 million. **Table 2.2-1** provides a breakdown of these damages by municipality. Property values were affected as well. Between 2012 and 2013, the Borough of Little Ferry experienced a decrease in value of 1.8 percent, according to the assessed value in land. This was approximately three times the rate of depreciation the borough had been experiencing in the years prior to Hurricane Sandy (Borough of Little Ferry 2014).

Table 2.2-1: Structural Damage Incurred During Hurricane Sandy, by Municipality

Municipality	Damage Amount (Million)	Quantity		
		Residences	Commercial	Industrial
Little Ferry	$63	609	427	488
Moonachie	$29	331	221	378
Carlstadt	$12	1	0	807
South Hackensack	$6	24	0	379
Teterboro	0	0	0	0
TOTAL	**$110**	**965**	**648**	**2,052**

It is estimated that over 1,700 businesses in the Project Area were impacted by Hurricane Sandy from physical damage and operational losses (NJIT 2014, State of New Jersey n.d.). Over 4,000 commercial private insurance claims were filed in Bergen County, which was the most out of any county in New Jersey (State of New Jersey n.d., Halpin 2013). The Borough of Moonachie was awarded the highest

average commercial claim per parcel at over $20,000. Furthermore, upon review of the aggregate effects of residential, commercial, and municipal damages, as well as other factors, one study determined that the Borough of Moonachie was one of the two towns hit hardest in the State (Halpin 2013).

Evidence of repetitive flooding in the Project Area can also be found in the NFIP data. As of February 2016, the average annual premium for an NFIP policy was $1,935 in the Borough of Little Ferry, $2,342 in the Borough of Moonachie, $4,323 in the Borough of Carlstadt, $2,710 in the Borough of Teterboro, and $2,270 in the Township of South Hackensack. There are 1,440 NFIP policies in force in these five municipalities, which combine for $3 million in written premiums and $350 million of insurance (FEMA 2016a). Additionally, there have been 1,761 recorded losses in these municipalities, totaling nearly $60 million in NFIP payouts (FEMA 2016b). A large portion of those losses has been the nearly 300 repetitive loss and severe repetitive loss properties, of which 255 are located in the Borough of Little Ferry, and which have combined for over 750 losses and $30.8 million in payouts (Bergen County Office of Emergency Management 2015). The NJSEA is registered as an NFIP community as well, and overlaps the Project Area in part. It is unclear whether any residents of the Project Area have insurance through the NJSEA NFIP community.

2.3 Project Need

The Project Area has a devastating history of inland and coastal storm surge flooding. With the anticipated effects of climate change and sea level change, flooding may become more common in the future (see **Section 4.0**). Hurricane Sandy exposed the vulnerabilities within the Project Area to coastal storms and made visible the severity of an increasing risk, causing significant hardship and damage to residents and industry in the Meadowlands District. The majority of the area is already in the 100-year floodplain and experiences rainfall-induced flooding, which is more common and happens more frequently than coastal storm surge flooding, as well. The Project Area's past history of flooding during heavy rainfall events indicates that if Hurricane Sandy had been a substantial rainfall event as well as a storm surge event, the storm could have resulted in increased flood levels and property damages. The Proposed Project is needed to deliver a comprehensive flood reduction strategy that will protect life, public health, and property within the Project Area, as well as improve overall community resiliency. The Proposed Project could also deliver co-benefits through the protection of ecological resources and enhancement of water quality, which in turn could benefit regional biodiversity and ecosystem resiliency. In addition, to the extent practicable with the available funding, the Proposed Project could potentially integrate the flood hazard risk reduction strategy with civic, cultural, and recreational values to incorporate active and passive recreational uses, multi-use facilities, public spaces, and other design elements that integrate the Proposed Project into the fabric of the community.

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3.0 Existing Conditions

This section provides a detailed characterization of the components of the environment, or technical resource areas, that could potentially be affected by the Proposed Project. The information in this section provides the basis for the assessment of impacts from the Proposed Project's three Build Alternatives and No Action Alternative. Subsections present existing physical, environmental, social and economic, and flood risk conditions.

3.1 Physical Conditions

The following sections will describe the Project Area's physical conditions including topography, tidal datums, soils, storms, drainage systems, utilities, and waterfront structures.

3.1.1 Topography

Within approximately 95 percent of the Meadowlands District, elevations range from approximately 0 to 10 feet (NAVD 88), as shown in **Figure 3.1-1**. The majority of the area is at elevation 6 to 7 feet (NAVD 88) and below, with a few areas in the north and south with elevations above 10 feet (MERI 2014). The waterfront area along the Hackensack River is mostly below 6 feet (NAVD 88) (MERI 2014). The area is prone to chronic flooding because of the nature of the landscape, the low elevation, the complexity of tidal influence, and inadequate stormwater management systems (NJSEA 2004). The Project Area is delineated into 27 drainage areas (**Figure 3.1-1**).

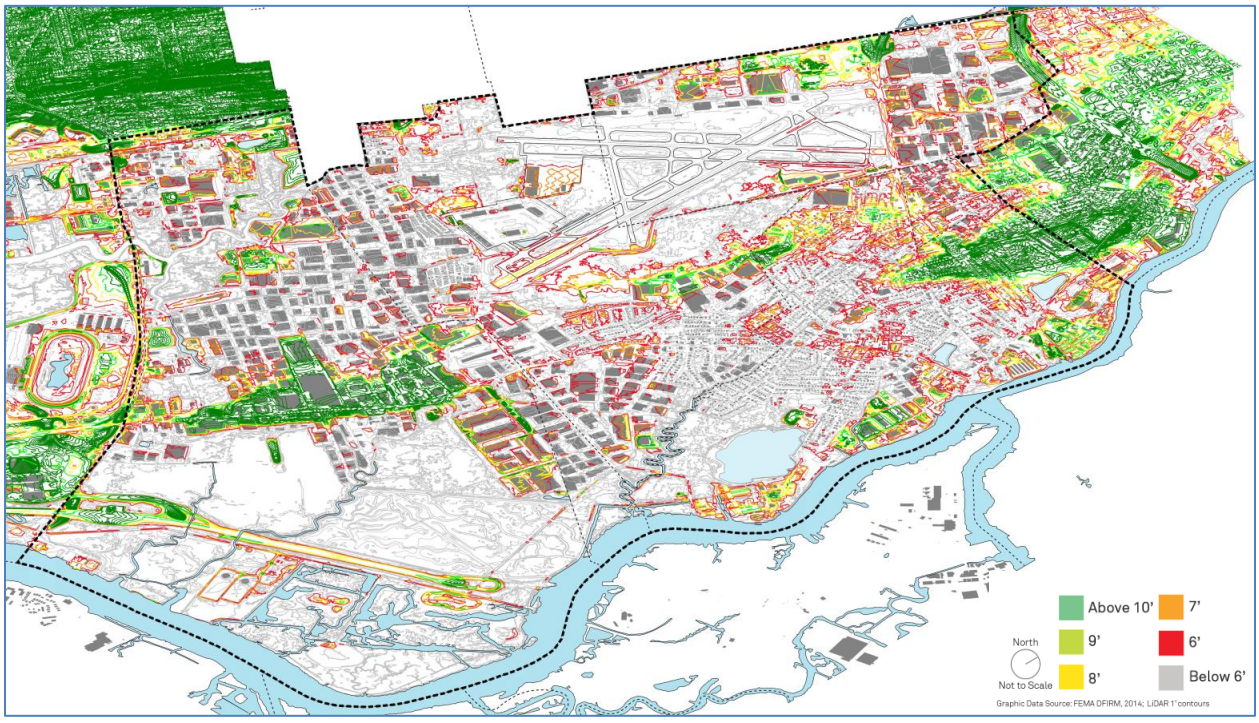


Figure 3.1-1: Project Area Topography (NAVD 88)

3.1.2 Tidal Datums

The nearest National Oceanic and Atmospheric Administration (NOAA) tide station to the Project Area that reports tidal datums relative to NAVD 88 is station 8530278-Hackensack, Hackensack River. The

tidal datum analysis period for this gauge is August 1, 1994 to October 31, 1994. In 2007, The Woods Hole Group also performed an analysis of tidal datums for several NJSEA gauges.

For comparison, **Table 3.1-1** shows the tidal datums for the Hackensack tide station alongside other nearby tide stations. Stations are listed in order of proximity to the Project Area with NJSEA Station 10 being the closest and the Battery station in Lower Manhattan, New York being the farthest (see **Figure 3** in **Appendix B2** for gauge locations). Tidal ranges can vary with distance as a result of tidal amplification and other hydrodynamic effects from the bathymetry and topography. The peak spring tides can be up to an elevation in the order of 3.1 feet (NAVD88). It should be noted that the data shown in **Table 3.1-1** is based on past measurements and does not take into account future sea level change. Sea level change is discussed in **Section 4.1.1**.

Table 3.1-1: Comparison of Tidal Datums

Station	NJSEA Station 10 – Berry's Creek (Woods Hole Group)	8530278-Hackensack, Hackensack River (NOAA)	8530772-Kearny Point, Hackensack River (NOAA)	8519483-Bergen Point West Reach, NY (NOAA)	8518750-The Battery, NY (NOAA)
Mean Higher High Water	3.1	3.1	2.7	2.6	2.3
Mean High Water	2.8	2.8	2.4	2.3	2.0
Mean Sea Level	0.4	<0.1	-0.1	-0.2	-0.2
Mean Low Water	-2.1	-3.3	-2.8	-2.7	-2.6
Mean Lower Low Water	-2.3	-3.6	-3.1	-2.9	-2.8

Datum elevations are in feet (NAVD 88).
Mean Higher High Water is the average of the higher high water height of each tidal day observed over the National Tidal Datum Epoch.
Mean High Water is the average of all the high water heights observed over the National Tidal Datum Epoch.
Mean Sea Level is the arithmetic mean of hourly heights observed over the National Tidal Datum Epoch.
Mean Low Water is the average of all the low water heights observed over the National Tidal Datum Epoch.
Mean Lower Low Water is the average of the lower low water height of each tidal day observed over the National Tidal Datum Epoch.
More information on tidal datums are provided in the Coastal Flood Risk Model Report in **Appendix B**.

3.1.3 Soils and Bedrock

Figure 3.1-2 presents the location of existing soil borings and the contours of bedrock elevation below sea level within the Project Area. The existing soil borings include borings with Standard Penetration Test (SPT) N-values from the New Jersey Department of Transportation Soil Borings Database (NJDOT 2015a), and borings without SPT N-values that are from the US Army Corps of Engineers (USACE) (Joseph S. Ward, Inc. 1962), Stanford D. Scott (Scott 1993), and USACE (The Louis Berger Group, Inc. 2010). The bedrock elevation contours are from USACE (Joseph S. Ward, Inc. 1962).

Based on the subsurface conditions and the bedrock elevations, the Project Area was divided into seven soil areas so that proper structural design of the flood protection facilities could be proposed. To characterize the subsurface conditions at each soil area, soil profiles were prepared using the boring logs and results of geophysical investigations from Earthworks LLC (Earthworks, LLC 2007). All boring logs used in this study are attached as **Appendix C1**. Ground surface elevations were estimated from the ground elevation (NAVD 88) contour maps where no data were available from the boring logs. Likewise, bedrock elevations were estimated from the bedrock elevation contours where no data were available from the boring logs.

The soil profiles were used to prepare the representative stratification and recommended material properties for each of the soil areas. The material properties were carefully selected based on engineering judgement, material descriptions, the limited SPT N-values available from the existing boring logs, and results of laboratory tests performed on similar soils from a nearby project site. Details of the soil areas map and soil profiles and properties are provided in **Appendix C1**. **Table 3.1-2** and **Figure 3.1-3**, which represent Soil Area 1, are included here as examples to show the representative soil stratification and recommended material properties, as well as the soil profile, for this soil area.

Table 3.1-2: Representative Stratification and Recommended Material Properties for Soil Area 1

Stratum No.	Top Elevation (feet NAVD 88)	Bottom Elevation (feet NAVD 88)	Material	Unit Weight, γ (lb/ft^3)	Friction Angle, ϕ (degree)		Cohesion, c (lb/ft^2)	Hydraulic Conductivity, k (ft/sec)
1	Ground Surface Elevation	0	Fill	110	32		0	3.3×10^{-5} to 3.3×10^{-6}
2	0	-40	Clay and silt	110	Short term	0	1,000	6.6×10^{-6} to 6.6×10^{-7}
					Long term	25	100	
3	-40	-55	Glacial till	130	36		0	1.65×10^{-5} to 1.65×10^{-6}
4	-40 to -60	-	Bedrock	-	-	-	-	-

lb/ft^3 = pounds per cubic foot
lb/ft^2 = pounds per square foot
ft/sec = feet per second

This Feasibility Study Report is based on limited subsurface soil information from borings near the Project Area. It was found that Soil Areas 1 through 3 have no organic soil layer while Soil Areas 4 through 7 have an organic clay or peat layer of varying depth, which would require stronger foundation support for the flood protection facilities falling within these soil areas when compared to Soil Areas 1 through 3. Final design of the Preferred Alternative would likely require additional borings, including SPT blow count data, field permeability tests, cone penetration tests, laboratory testing, sieve analyses, Atterberg limits, consolidation and triaxial tests, and seepage analyses.

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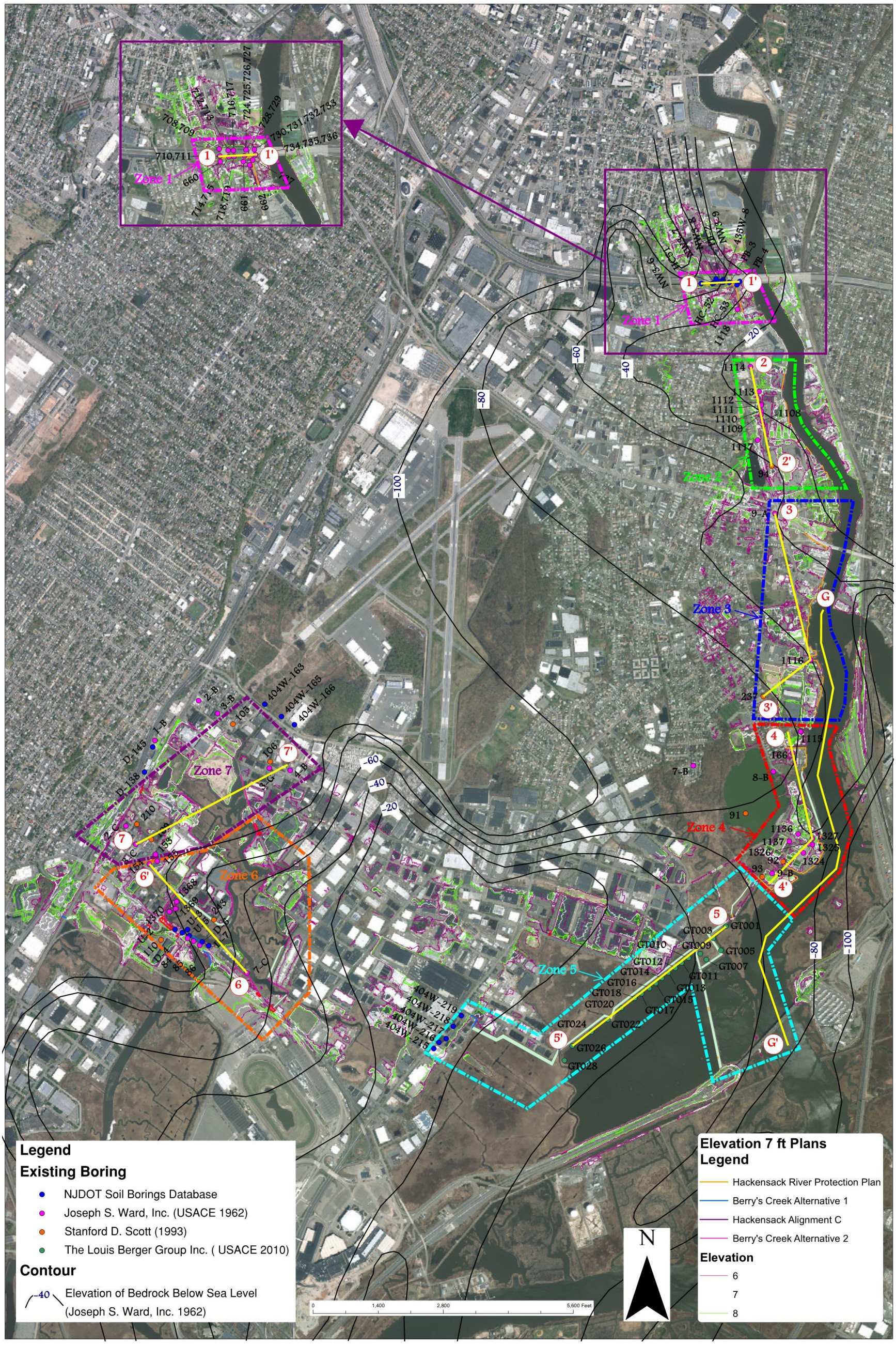


Figure 3.1-2: Existing Boring Locations and Bedrock Contours

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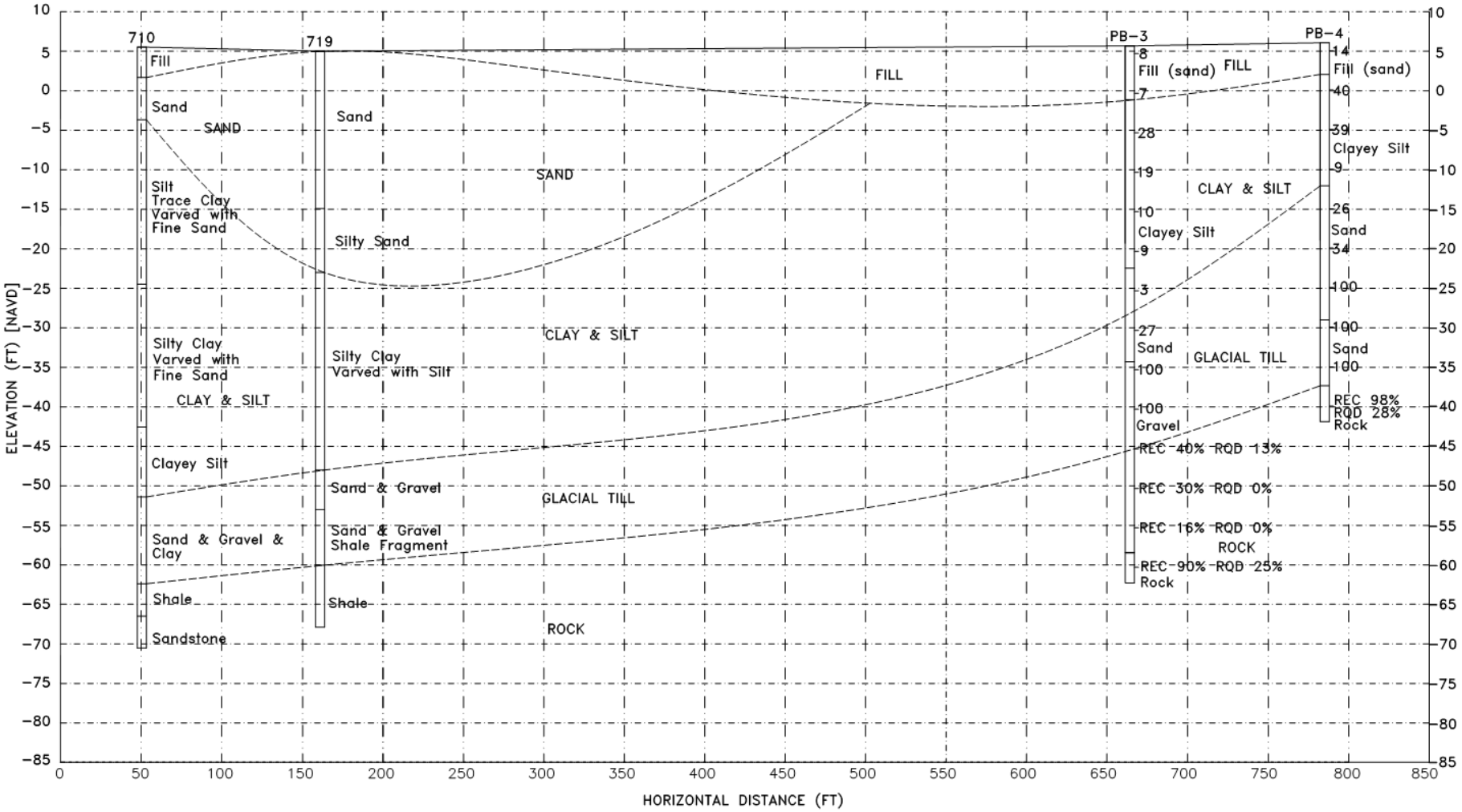


Figure 3.1-3: Soil Profile Cross Section 1-1' for Soil Area 1

3.1.4 Precipitation and Storm Events

Annual rainfall in the Project Area averages approximately 47 inches and annual snowfall averages 40 to 50 inches. During the summer, thunderstorms are responsible for most of the rainfall. Cyclones and frontal passages are less frequent. Thunderstorms spawned in Pennsylvania and New York often move into the Project Area, where they usually reach maximum development in the evening (ONJSC 2014).

The Project Area is also subject to impacts from coastal storms, often characterized as “nor'easters,” which are most frequent between October and April. These storms track over the coastal plain or up to several hundred miles offshore, bringing strong winds and heavy rains. Typically, at least one significant coastal storm occurs each winter; some years, the Project Area experiences as many as 5 to 10 such storms. Tropical storms and hurricanes are also a special concern along the coast. In some years, they contribute a significant amount to the precipitation totals of the region. Flood damage during high tide can be severe when tropical storms or nor'easters affect the region (ONJSC 2014).

Flooding in the Project Area can occur during any season of the year since New Jersey lies within the major storm tracks of North America. The worst storms have occurred in late summer or early fall when tropical disturbances (i.e., hurricanes) are most prevalent. Recent events include Hurricane Floyd in 1999, Hurricane Irene in 2011, and Hurricane Sandy in 2012 (FEMA 2014).

3.1.5 Drainage Systems

The Meadowlands District has had substantial historical challenges with stormwater management because of its low elevation and high degree of development. In the Project Area, stormwater infrastructure includes a combination of stormwater sewers, drainage ditches, levees, tide gates, pump stations, vegetated channels, and detention basins that convey stormwater to the Hackensack River. To facilitate drainage during high tides, numerous tide gates have been installed within the Project Area (Rutgers University 2007). Tide gates block tidal surges, and release stormwater during low tide.

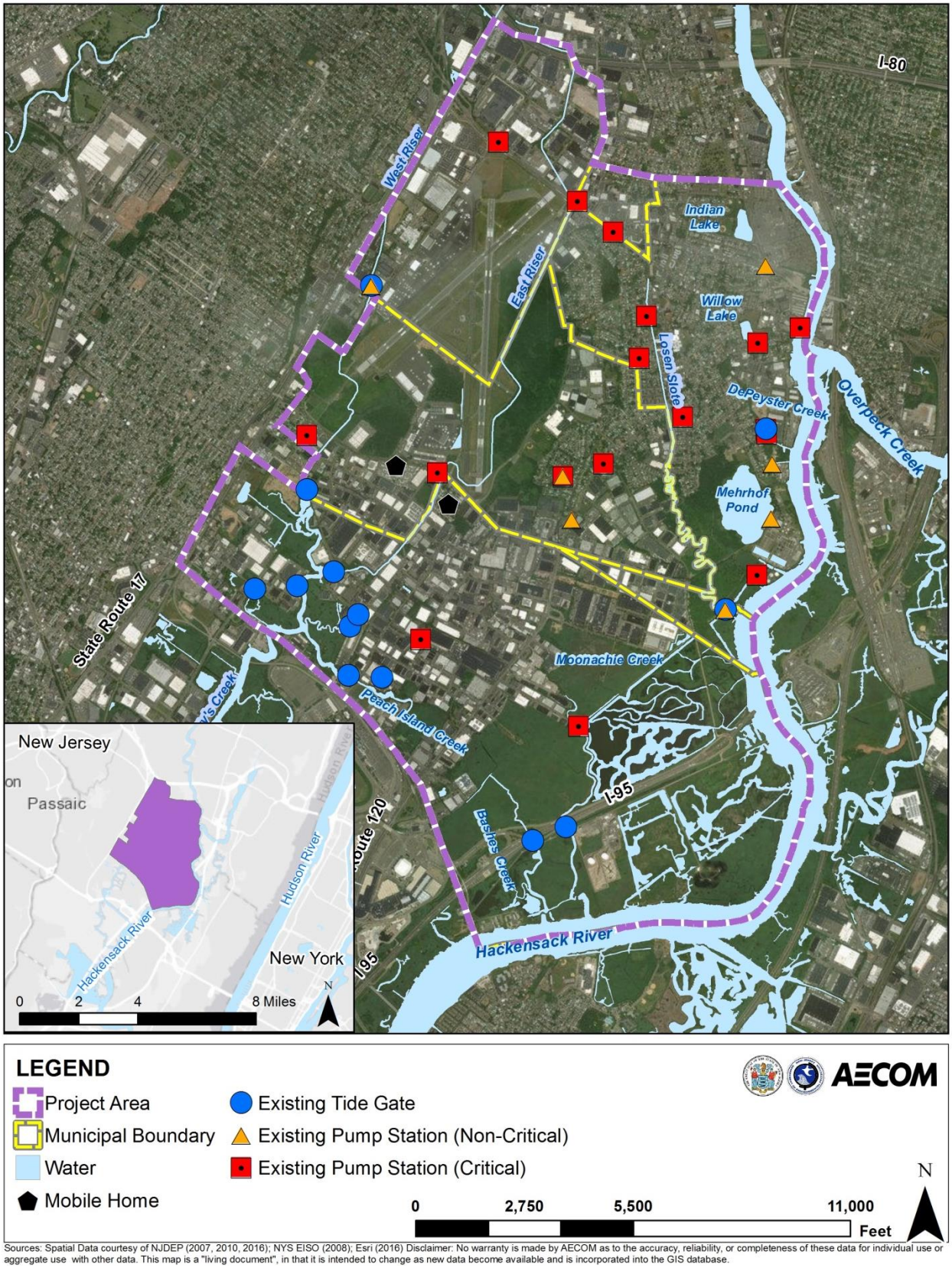
Recent reports note maintenance and upgrade needs for the stormwater management system in the Project Area, as well as the inadequacies of some structures to handle even a 25-year storm (Guo, et al. 2014, NJIT 2014). However, some improvements have been completed, such as the replacement of the West Riser Tide Gate in 2014 (NJDCA 2014). **Table 3.1-3** identifies the stormwater infrastructure present within the Project Area (see also **Figure 3.1-4**).

Table 3.1-3: Stormwater Infrastructure Located Within Project Area

Municipality	Infrastructure
Detention Ponds	
Little Ferry	Indian Lake
	Willow Lake
Tide Gates	
Little Ferry	DePeyster Creek Tide Gate
Moonachie	West Riser Tide Gate
Carlstadt	Broad and 20th Street Tide Gate
	Waitex Tide Gate
	East Riser Tide Gate
	Yellow Freight Tide Gate
	Dell Road Tide Gate
	Peach Island Creek Tide Gate
	Palmer Terrace Tide Gate
	Bashes Creek Tide Gate
	Moonachie Creek Tide Gates Upper
Teterboro	Teterboro Tide Gate
South Hackensack	Losen Slote Creek Tide Gate
Pump Stations	
Little Ferry	Main Street Storm Drainage Pump Station
	Willow Lake Pump Station
	DePeyster Creek Tide Gate Pump Station
	Losen Slote Drain Station
	Eckel Rd Pump Station
	Union Ave Pump Station
	Williams St. Drainage Station
	Main & Franklin Pump Station
	Maiden Lane Pump Station
	Pump Bay Stormwater Pump Station
	Unknown Name near Mehrhof Pond
Moonachie	Lincoln Place Pump Station
	Concord St. Pump Station
	Moonachie Ave Pump Station
	Moonachie Rd. Pump Station
	Burger King Pump Station

Municipality	Infrastructure
Teterboro	Teterboro Tide Gate Pump Station
	Vincent Place Pump Station
	Huyler Street Pump Station
South Hackensack	Losen Slote Creek Tide Gate Pump Station
Ditches	
Multiple Municipalities	Commercial Ditch System
	East Riser Ditch System
	Industrial Avenue Ditch
	West Riser Ditch System
Moonachie	Grand Street Ditch
	Caesar Place Ditch
	Jackson Place Ditch
	Lincoln Place Pump Station Ditch
	Ryder Ditch
	Sova Place Ditch
Carlstadt	Eastern Avenue Ditch
	Gotham Parkway Ditch
	Bashes Creek Ditch System
	Moonachie Creek Ditch System
	Unnamed by Paterson Plank Road
	Veterans Ditch

Sources: (Borough of Little Ferry 2005, MERI 2016, NJDEP 2016b, Bergen County Office of Emergency Management 2015)



Sources: Spatial Data courtesy of NJDEP (2007, 2010, 2016); NYS EISO (2008); Esri (2016) Disclaimer: No warranty is made by AECOM as to the accuracy, reliability, or completeness of these data for individual use or aggregate use with other data. This map is a "living document", in that it is intended to change as new data become available and is incorporated into the GIS database.

Figure 3.1-4: Stormwater Infrastructure in the Project Area

3.1.6 Utilities

Utility systems in the Project Area that would cause potential conflicts with the Proposed Project include sanitary wastewater collection and treatment, water supply and distribution, electricity, natural gas, stormwater management, and communication systems (i.e., landline telephone, cable television, and internet).

3.1.6.1 Sanitary Wastewater Collection and Treatment

Within the Project Area, sanitary wastewater is separate from stormwater at all times. There are no combined sewers in the Project Area. However, there are several combined sewers in other nearby municipalities that do convey wastewater through the common sewer mains (BCUA 2016a).

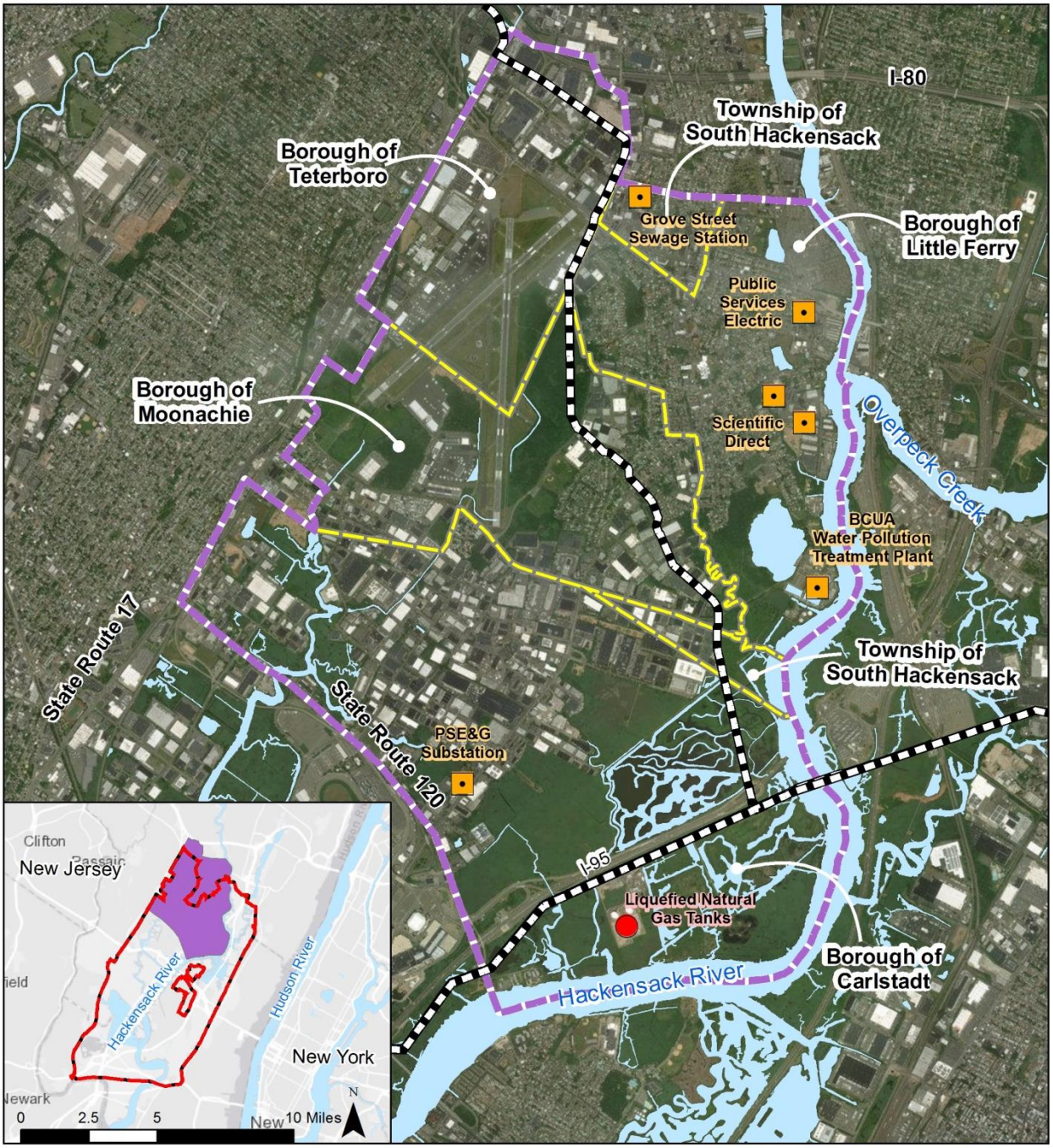
The Bergen County Utilities Authority (BCUA) is responsible for treating 83 million gallons per day of sanitary wastewater for over half a million residents across 47 municipalities in eastern Bergen County, including those that compose the Project Area (BCUA 2016b). The Little Ferry Water Pollution Control Facility (LFWPCF), the primary wastewater treatment plant for the BCUA and a critical facility in the Borough of Little Ferry (Bergen County Office of Emergency Management 2015), serves the Project Area, and is located at the southern end of Mehrhof Road in the Borough of Little Ferry, immediately adjacent to the Hackensack River. **Figure 3.1-5** shows critical and non-critical facilities and natural gas transmission pipelines.

The BCUA owns 108 miles of sewer lines, including both gravity and force mains, which convey wastewater from the municipal collection systems to the treatment facility. There are also nine automatic pumping stations, which are predominately located on the outskirts of the service area, and 166 metering chambers (BCUA 2016a).

Three primary trunk systems, constructed between 1951 and 1972, convey wastewater to the LFWPCF (BCUA 2016a). The Overpeck Trunk Sewer, a 60-inch sewer, enters the facility from across the Hackensack River to the east, where it extends to Tenafly and serves the Overpeck Valley (BCUA 2016a). The Hackensack Valley Trunk Sewer, a 96-inch sewer, extends north toward Westwood, paralleling the western bank of the Hackensack River (BCUA 2016a). The Southwest Trunk Sewer, a 48-inch sewer, runs along Moonachie Avenue to about NJ-17 before turning northeast and extending into Hasbrouck Heights (BCUA 2014, BCUA 2016a). These trunk sewers may conflict with the Proposed Project components at some locations and are evaluated in the alternatives development sections. **Table 3.1-4** identifies the sanitary sewage pump and drain stations that are located within the Project Area.

Collected wastewater is treated at the Little Ferry Water Pollution Control Facility. Treated effluent is either provided to the Public Service Electric and Gas (PSE&G) Ridgefield Power Plant to be beneficially reused for cooling purposes, or is discharged into the Hackensack River (BCUA 2016a). Biosolids removed from the sanitary wastewater are stored in tanks and transported to the Passaic Valley Sewage Commission's Yantacaw Treatment Plant in Newark, New Jersey, via truck or barge. Following further treatment, they are transferred to either the NJMC landfill in the Township of Lyndhurst or Amelia Landfill in Virginia (BCUA 2016c).

In addition to the BCUA, the Carlstadt Sewerage Authority (CSA) services the industrial portion of the Borough of Carlstadt bounded between Berry's Creek and Washington Avenue. CSA owns 13 miles of gravity sewers, two miles of force mains, and two pump stations, which deliver the wastewater to the LFWPCF (CSA 2016).



LEGEND

- Meadowlands District
- Project Area
- Municipal Boundary
- Water
- Natural Gas Pipeline
- Critical Facility
- Non-Critical Facility

AECOM

0 2,500 5,000 10,000 Feet

N

Sources: Spatial Data courtesy of NJDEP (2007, 2010, 2016); NYS EISO (2008); Esri (2016) Disclaimer: No warranty is made by AECOM as to the accuracy, reliability, or completeness of these data for individual use or aggregate use with other data. This map is a "living document", in that it is intended to change as new data become available and is incorporated into the GIS database.

Figure 3.1-5: Utility Facilities Present in the Project Area

Table 3.1-4: Pump and Drain Stations Located Within Project Area

Municipality	Infrastructure	Critical Facility?
Little Ferry	Eckel Road Pump Station	Yes
	Main and Franklin Street Pump Station	Yes
	Maiden Lane Drain Station	Yes
	Union Avenue Pump Station	Yes
	Williams Street Drainage Station	Yes
Moonachie	Concord Street Pump Station	Yes
	Moonachie Avenue Pump Station	Yes
	Moonachie Road Pump Station	Yes
Carlstadt	Carlstadt Pump Station (Barrell Avenue)	Yes
	Pumping Station 1 (Jony Drive)	Yes
Teterboro	Sewer and Stormwater Pumping Station	Yes
South Hackensack	Grove Street Sewage Station	Yes
	Huyler Street Pumping Station	Yes

Source: (Bergen County Office of Emergency Management 2015)

During Hurricane Sandy, extensive flooding from the Hackensack River flooded more than 15 structures and component locations at the BCUA LFWPCF. With a High Water level of 7.43 feet NAVD 88 during Hurricane Sandy, the recurrence interval was estimated to be 65 years or a 1.6-percent-annual-chance event at the LFWPCF facility.

3.1.6.2 Water Supply and Distribution

SUEZ Water New Jersey, Inc., a large international conglomerate, is responsible for water supply and distribution in the Project Area (SUEZ 2016a). In New Jersey, SUEZ services about 850,000 residents in Bergen, Hudson, Passaic, Sussex, and Hunterdon Counties (SUEZ 2016a). SUEZ New Jersey collects water from four primary sources: the Oradell Reservoir (located in New Jersey), Woodcliff Lake Reservoir (located in New Jersey), Lake Tappan Reservoir (located in New Jersey), and Lake DeForest (located in New York). On occasion, the water supply may be supplemented by the Boonton, Wanaque, and Monksville Reservoirs (SUEZ 2016a). Following collection, the water is transported to Haworth Water Treatment Plant, where it undergoes a complex treatment process, including the addition of safe drinking water chemicals and ozone, filtration, and additions of chlorine and ammonia (SUEZ 2016b). The water is then distributed through a network of pipes to individual consumers.

The full water distribution network includes reservoir pumping stations, transmission mains (16 inches or larger in diameter), distribution mains, service pipes, and connecting pipes (at least 0.75 inch in diameter). SUEZ New Jersey owns the network down to and including the service pipes. Connecting pipes, which transport water from service pipes to individual properties, are owned by the customers (SUEZ 2016c).

During Hurricane Sandy, impacts to the water supply were minimal. There were no reports of damage or disruption of service by SUEZ New Jersey.

3.1.6.3 Electricity

PSE&G, a subsidiary of Public Service Enterprise Group, provides electricity to the Project Area. PSE&G is the State's largest public utility, and one of the largest combined gas and electric companies in the nation. **Table 3.1-5** lists the substations and switching stations located within and near the Project Area.

Table 3.1-5: Substations and Switching Stations Located Within and Near the Project Area

Municipality	PSE&G Facility	Critical Facility?
Little Ferry	Substation on Poplar Ave at Bergen Turnpike	Yes
Carlstadt	Substation on Industrial Ave north of Nam Knights Way	Yes
Hasbrouck Heights	Substation on Williams Ave at Teterboro border	Yes (outside of Project Area)
Hackensack	Substation on South River St at Water St	Yes (outside of Project Area)
East Rutherford	Substation on Van Winkle St north of Union Ave	Yes (outside of Project Area)
East Rutherford	Switching Station on Willow St at Central Ave	Yes (outside of Project Area)

During Hurricane Sandy, extensive power outages in the Project Area were associated with the extensive power outages that affected approximately 8.5 million customers across 20 States and the District of Columbia. As a result of damages suffered by Hurricanes Irene and Sandy, PSE&G is undergoing a $1.22 billion renovation program called the Energy Strong Program. As part of this program, PSE&G is protecting, raising, and/or relocating 28 switching and substations in flood-prone areas (PSE&G 2016b, PSE&G 2016a). The substation in the Borough of Little Ferry is one of those that received improvements (i.e., raising), which were completed in 2016 (PSE&G 2016a).

3.1.6.4 Natural Gas

Natural gas in the Project Area is imported through a network of pipelines, depicted in **Figure 3.1-5**, owned by Williams and operated as the Transcontinental Gas Pipeline Corporation (Transco) (NJSEA 2004). The Transco system runs from south Texas to the New York City area (USEIA 2016). Two Transco pipelines traverse the Project Area. One runs in a southwest-northeast orientation through the Project Area along the I-95 corridor. The other runs northwest-southeast from I-80 in Teterboro, to the southwestern side of the BCUA lagoon in the Borough of Little Ferry, to where it meets with the first pipeline in the Borough of Ridgefield at the Vince Lombardi Service Area directly across the Hackensack River from the Project Area (Williams 2016). These pipelines supply a liquid gas storage facility in the Borough of Carlstadt along the Hackensack River (NJSEA 2004). The Transco gas pipeline may pose potential conflicts with the Proposed Project components along the Williams Transco Gas Pipeline Road.

PSE&G is responsible for distributing natural gas within the Project Area (NJSEA 2004). There were no reports of natural gas service disruption within the Project Area during Hurricanes Irene and Sandy, nor did PSE&G identify any damage to facilities on properties that they own within the Project Area.

3.1.6.5 Solid Waste

The Project Area is within two solid waste districts: BCUA and the NJSEA. BCUA is responsible for solid waste management for all 70 Bergen County municipalities and maintains the Bergen County District Solid Waste Management Plan (BCUA 2016b). NJSEA is responsible for the 14 municipalities within the Meadowlands District and also maintains a Solid Waste Management Plan. Both plans were most recently updated in 2006, following an update to the State Solid Waste Management Plan in 2005 (BCUA 2006, NJSEA 2006a).

Municipalities in the Project Area generally collect solid waste using either their public works departments or a contracted company (NJSEA 2004). Bergen County has adopted an open market strategy, meaning their solid waste may be disposed of at any legal landfill, regardless of location. Prior to the last update to the Bergen County Solid Waste Management Plan, a waste quantification study found that total solid waste in Bergen County was estimated to increase at a rate of approximately 0.7 percent per year, from 943,783 pounds (lbs) in 2006, to an estimated 1,004,194 lbs in 2015 (BCUA 2006).

Recycling and source reduction is encouraged as the best way to manage solid waste in Bergen County (BCUA 2016e). The municipalities within the Project Area generally either bring recycling material straight to market, or hold it at their Department of Public Works (DPW) yard before bringing it to market (NJSEA 2006a). All municipalities in Bergen County have a curbside residential recycling program. BCUA provides additional assistance to the municipalities regarding recycling, such as being a liaison to NJDEP, providing educational materials, and facilitating specialized programs to recycle non-traditional materials like tires and batteries (BCUA 2016d).

3.1.6.6 Communication Systems

The three primary providers of communication systems that have associated hard infrastructure within the Project Area are Verizon, Time Warner Cable, and Optimum. During Hurricane Sandy, telecommunication outages followed the pattern of utility power outages and flooding. When there was utility power outages, cable and Internet services in homes and businesses went out immediately. These power-driven telecommunications outages affected the greatest number of customers and were generally short-term. Cell service outages were also largely caused by loss of power, loss of back haul service, and/or physical damage to antennas. In addition, lack of power created challenges to recharging electronic equipment.

None of the telecommunication companies reported flood damage from Hurricane Sandy to critical facilities or properties that they own within the Project Area.

3.1.7 Waterfront Structures

A visual survey of the waterfront structures was conducted by Matrix New World Engineering, Inc. in February 2016 for the waterfront assessment (Matrix New World Engineering, Inc. 2016). For this visual survey, 86 locations with waterfront structures were inspected. They were spread out in the Project Area as shown in **Figure 3.1-6**. **Figure 3.1-7** shows a sample inspection report. The inspection report documents the waterfront structure location and condition rating with pictures included. Details of the waterfront structure inspection are provided in **Appendix A**.

The general condition assessment ratings for the waterfront structures are based on a six-point assessment scale developed by the American Society of Civil Engineers (Waterfront Inspection Task Committee 2015):

- 1 – Critical: Very advanced deterioration, overstressing, or breakage has resulted in localized failure(s) of primary structural components. More widespread failures are possible or likely to occur, and load restrictions should be implemented as necessary.
- 2 – Serious: Advanced deterioration, overstressing, or breakage may have significantly affected the structural or load-bearing capacity of primary components. Local failures are possible and loading restrictions may be necessary.
- 3 – Poor: Advanced deterioration or overstressing is observed on widespread portions of the structure but does not significantly reduce the load-bearing capacity of the structure.
- 4 – Fair: All primary structural elements are sound, but minor to moderate defects or deterioration are observed. Localized areas of moderate to advanced deterioration may be present but do not significantly reduce the overall structural capacity.
- 5 – Satisfactory: Limited minor to moderate defects or deterioration levels are observed, but no overstressing is observed.
- 6 – Good: No visible damage or only minor damage is noted. Structural elements may show minor deterioration, but no overstressing is observed.

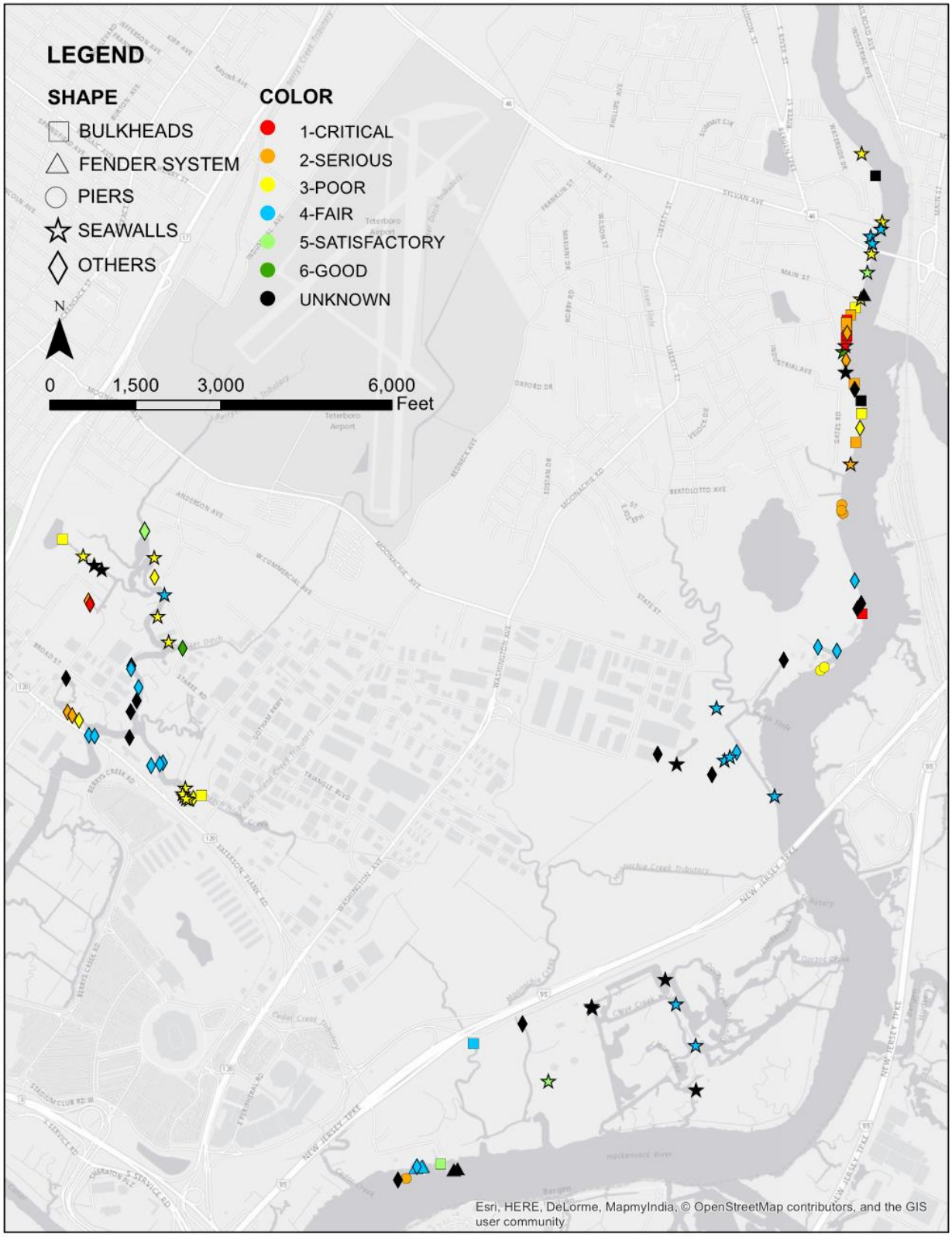
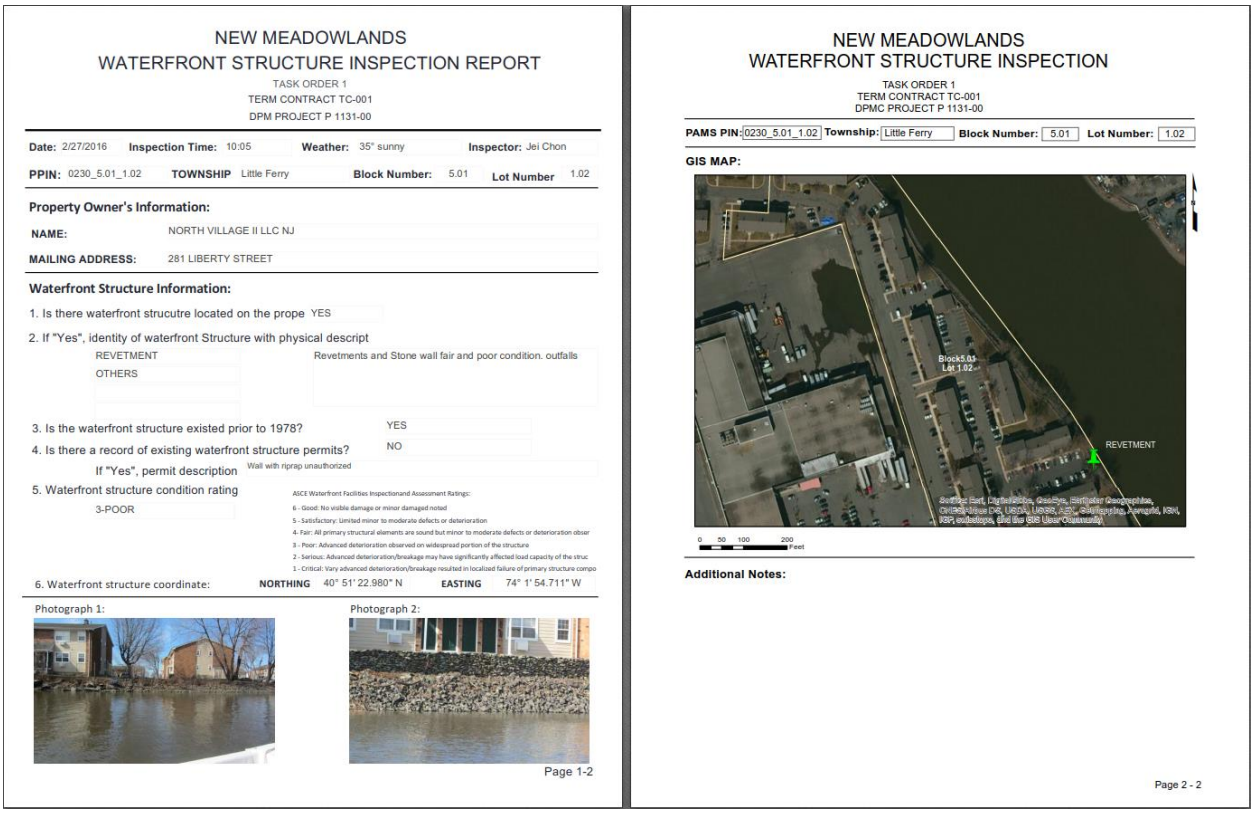


Figure 3.1-6: Map of Inspected Waterfront Structures



NEW MEADOWLANDS
WATERFRONT STRUCTURE INSPECTION REPORT

TASK ORDER 1
TERM CONTRACT TC-001
DPM PROJECT P 1131-00

Date: 2/27/2016 Inspection Time: 10:05 Weather: 35° sunny Inspector: Jei Chon

PPIN: 0230_5.01_1.02 TOWNSHIP Little Ferry Block Number: 5.01 Lot Number 1.02

Property Owner's Information:

NAME: NORTH VILLAGE II LLC NJ

MAILING ADDRESS: 281 LIBERTY STREET

Waterfront Structure Information:

1. Is there waterfront strucutre located on the prope YES

2. If "Yes", identity of waterfront Structure with physical descript

REVETMENT Revetments and Stone wall fair and poor condition. outfalls

OTHERS

3. Is the waterfront structure existed prior to 1978? YES

4. Is there a record of existing waterfront structure permits? NO

If "Yes", permit description Wall with riprap unauthorized

5. Waterfront structure condition rating

3-POOR

ASCE Waterfront Facilities Inspectionand Assessment Ratings:
6 - Good: No visible damage or minor damaged noted
5 - Satisfactory: Limited minor to moderate defects or deterioration
4- Fair: All primary structural elements are sound but minor to moderate defects or deterioration obser
3 - Poor: Advanced deterioration observed on widespread portion of the structure
2 - Serious: Advanced deterioration/breakage may have significantly affected load capacity of the struc
1 - Critical: Vary advanced deterioration/breakage resulted in localized failure of primary structure compo

6. Waterfront structure coordinate: NORTHING 40° 51' 22.980" N EASTING 74° 1' 54.711" W

Photograph 1:

Photograph 2:

Page 1-2

NEW MEADOWLANDS
WATERFRONT STRUCTURE INSPECTION

TASK ORDER 1
TERM CONTRACT TC-001
DPMC PROJECT P 1131-00

PAMS PIN: 0230_5.01_1.02 Township: Little Ferry Block Number: 5.01 Lot Number: 1.02

GIS MAP:

Block5.03
Lot 1.02

REVETMENT

0 50 100 200 Feet

Additional Notes:

Page 2 - 2

Figure 3.1-7: A Sample Waterfront Structure Inspection Report

Table 3.1-6 shows a summary of the waterfront structures. Approximately 48 percent of the structures are in critical to poor condition. In other words, the majority of the existing waterfront structures would require significant reinforcement or reconstruction in order to support new coastal protection structures.

Table 3.1-6: Summary of Waterfront Structure Inspections

Condition Rating	No. of Structures	Percent (%) of All Structures Inspected
1 - Critical	6	7%
2 - Serious	13	15%
3 - Poor	22	26%
4 - Fair	23	27%
5 - Satisfactory	4	5%
6 - Good	1	1%
7 - Unknown	15	17%
8 - Null	2	2%
Total	**86**	**100%**

3.2 Environmental Conditions

The Meadowlands District, within the Eastern Broadleaf Forest Province, is among the largest remaining coastal wetland ecosystems in the Hudson-Raritan Estuary system. Approximately 5,800 acres of estuarine wetlands are within the Meadowlands' 8,400-acre complex of wetlands and waterways (USFWS 2007). Major habitat types of the Meadowlands District within the Project Area include the mainstem of the Hackensack River; a variety of brackish tidal creeks, canals, and ditches; salt marshes; impounded

brackish and freshwater marshes; non-tidal wetlands and hardwood swamps; woodlands and meadows; and industrial, commercial, and residential areas that include roads, dikes, and berms.

Prior to European settlement in the 17th century, the Meadowlands District was largely a tidal freshwater system consisting of large expanses of freshwater emergent wetlands and Atlantic white cedar swamp. Colonial-era settlers converted many of these wetlands to farmland. The flows of the Hackensack and Passaic Rivers were altered by the construction of dams for millponds, construction of the Morris Canal, and other municipal water supply projects. As freshwater flows decreased, the waters in the area became more saline, and brackish tidal marshes formed. Further, over the past 100 years, expanses of the Meadowlands District have been drained and/or filled in attempts to control mosquitoes, for industrial and commercial uses, and for the creation of landfills (Kiviat and MacDonald 2002).

The following sections summarize the habitats and wildlife characteristics of the Meadowlands District, including the Project Area. This discussion focuses on both terrestrial and aquatic environments, as well as species of concern that are protected at the Federal or State level. In addition, field surveys were conducted for various resources (i.e., plants, birds, mammals, reptiles/amphibians, fish, and benthic invertebrates) in the Project Area beginning in late summer/early fall 2016 to supplement the existing information (see **Appendix A**). Data from these field surveys are incorporated into this discussion, as and where appropriate. **Figure 3.2-1** identifies habitats and biological survey/sampling locations in the Project Area that are further discussed in **Appendix A**.

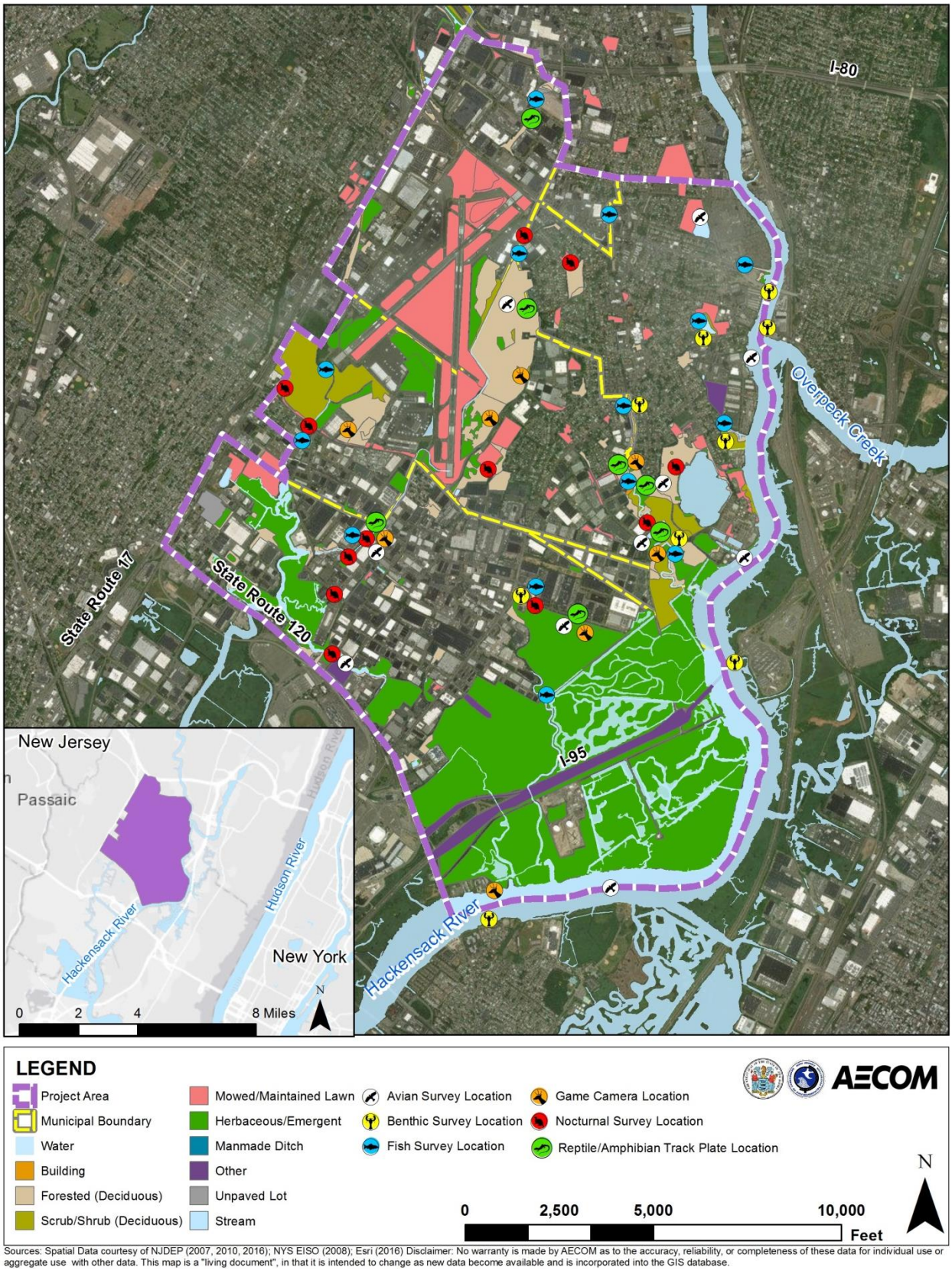


Figure 3.2-1: Habitat Area Coverage Type and Biological Sampling Locations in the Project Area

3.2.1 Water Resources and Water Quality

Water resources in the Project Area include portions of the Hackensack River and its tributaries, including Losen Slote Creek, Moonachie Creek, Bashes Creek, Peach Island Creek, West Riser Ditch, East Riser Ditch, DePeyster Creek, and Berry's Creek; ponds; and several large wetland complexes (see **Figure 3.2-2**).

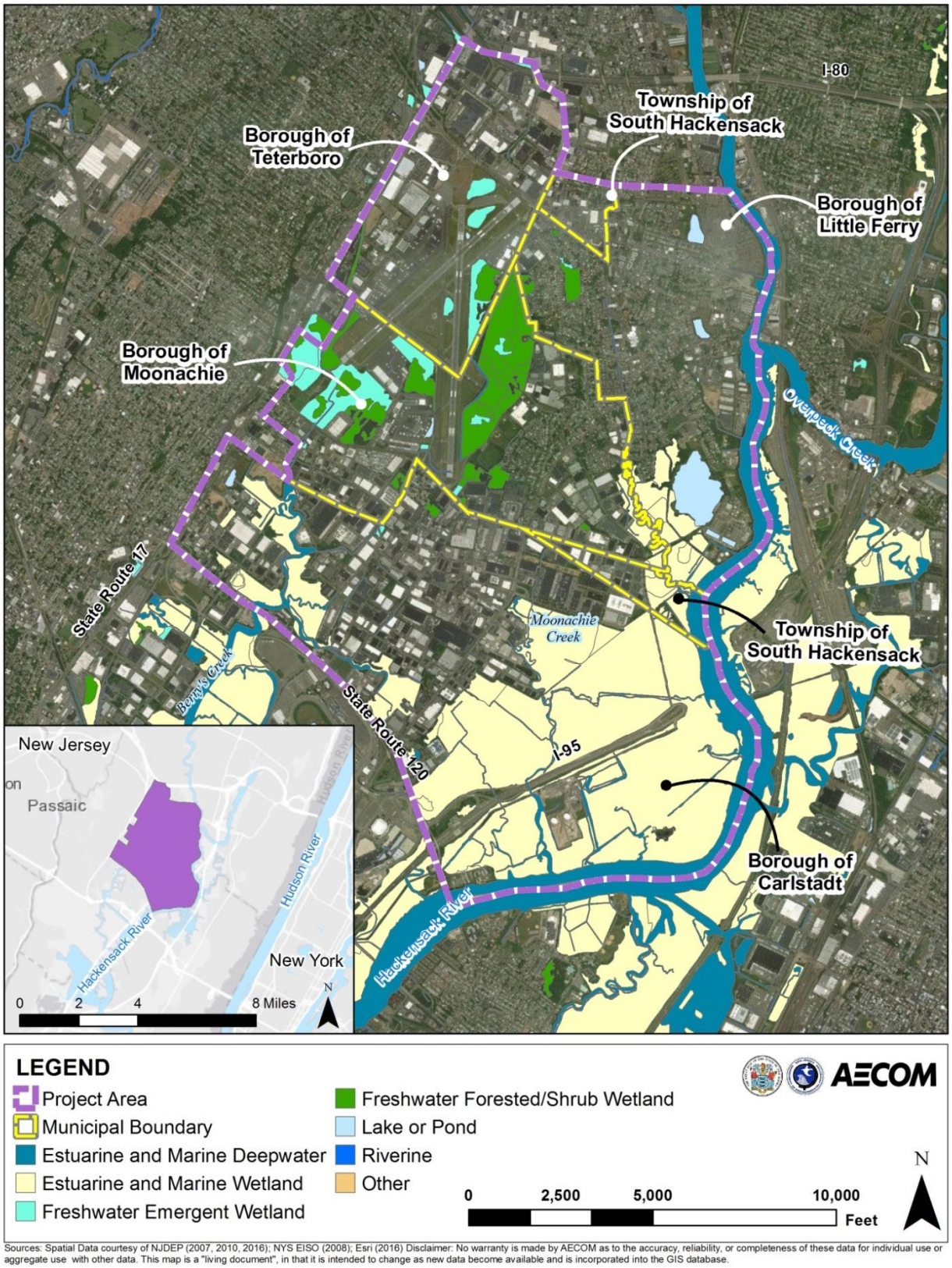
The Project Area is an urbanized watershed that was, and continues to be, impacted by ongoing residential, commercial, and industrial development. Much of this development has taken place in areas within the FEMA-designated 100-year floodplain and along tributaries to the Hackensack River, which has increased the amount of pollutants entering these water resources.

The surface water resources of the Meadowlands District are dominated by one of the largest tidal wetland complexes within the Hudson-Raritan Estuary, encompassing approximately 5,800 acres of estuarine wetlands (USFWS 2007). Major open waters and wetland types within the Project Area include estuarine shallow and deep water; estuarine emergent wetlands (i.e., saline or salt marsh, brackish marsh); riverine waters; pond/lakes; freshwater emergent wetlands; and freshwater forested/shrub wetlands, as shown in the US Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI) map (**Figure 3.2-2**) and the NJDEP Wetlands map (**Figure 3.2-3**).

Draining the central and west sides of the Project Area are the West Riser Ditch, East Riser Ditch, Peach Island Creek, and other tributaries that flow to Berry's Creek and Berry's Creek Canal, conveying drainage to the Hackensack River. Losen Slote Creek, Moonachie Creek, and Bashes Creek discharge directly to the Hackensack River. These tributaries also convey waters to and from the adjacent wetland areas, as shown in **Figure 3.2-3**. A number of the creeks and drainages in the Project Area have control structures and pump houses in place to control the tidal influences and associated flooding from the Hackensack River.

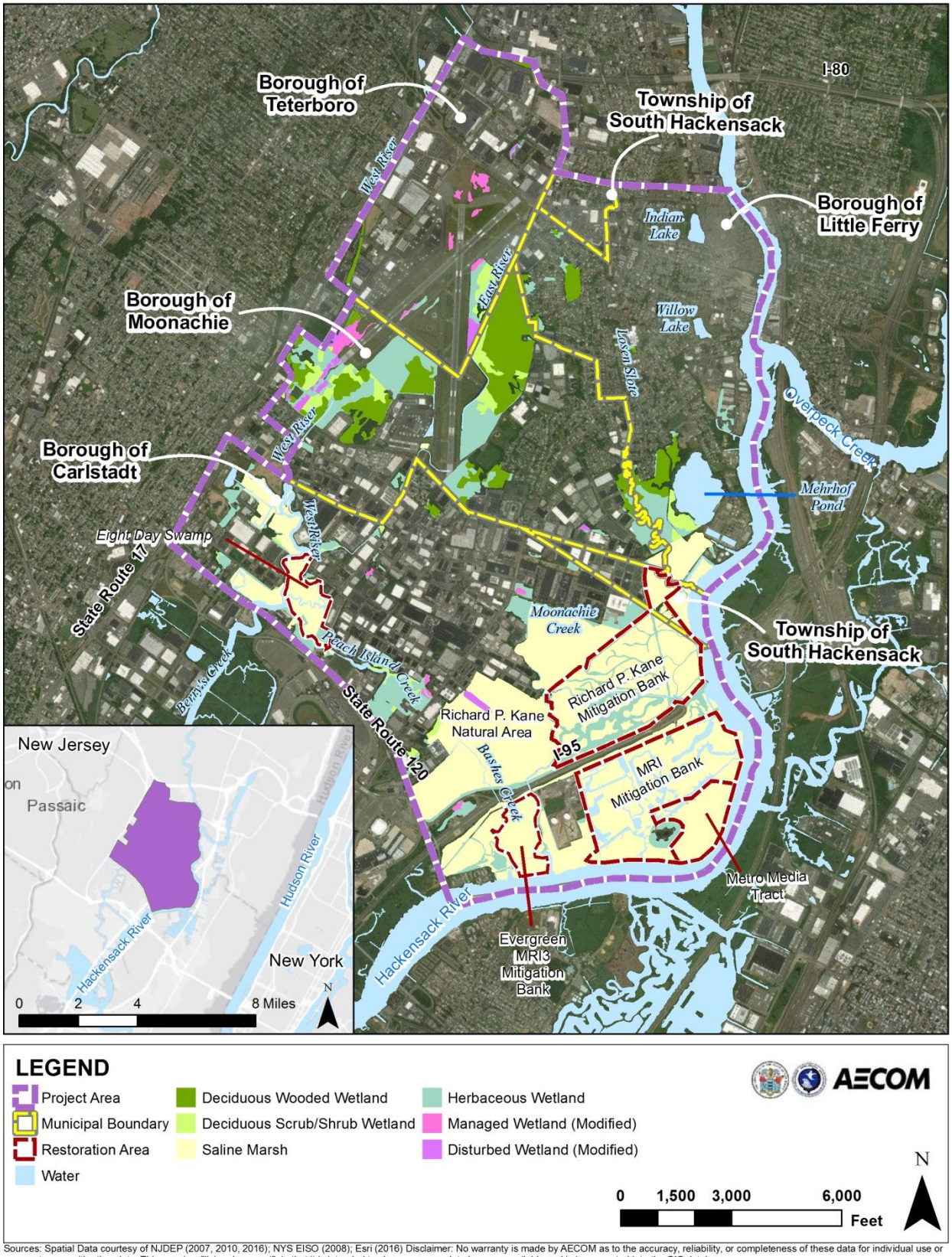
The hydrology of the Project Area, as well as the entire Meadowlands District, is characterized by extensive human-made changes to tidally influenced drainages resulting from the historical construction of dikes, tide gates, dams, berms, and roadways, and the subsequent failure of water control structures along the Hackensack River (Kiviat and MacDonald 2004). The Oradell Dam, constructed in 1922, along with water supply withdrawals from the Oradell Reservoir, curtails freshwater inputs into the lower Hackensack River, increasing tidal effects and facilitating the movement of saline waters further upriver. As many as 30 flood control structures, including tide gates and culverts, are located along the Hackensack River and its tributaries near the Project Area. **Figure 3.1-4** shows the tidal control structures within the Project Area. Remnants of former or non-functioning tide gates are visible in several other tributaries (i.e., Mill Creek, Penhorn Creek) (USFWS 2007). A distinctive physical feature of tidal wetlands within the Meadowlands District is the lack of typical tidal creek drainage patterns due to human-made ditching and draining. Over time, landowners have filled and developed many ditched wetland areas, diminishing flood storage capacity and shoreline stabilization functions (Kiviat and MacDonald 2002).

Further detail regarding water resources and water quality in the Project Area is provided in **Section 3.16** of the EIS.



Sources: Spatial Data courtesy of NJDEP (2007, 2010, 2016); NYS EISO (2008); Esri (2016) Disclaimer: No warranty is made by AECOM as to the accuracy, reliability, or completeness of these data for individual use or aggregate use with other data. This map is a "living document", in that it is intended to change as new data become available and is incorporated into the GIS database.

Figure 3.2-2: US Fish and Wildlife Service National Wetlands Inventory Map



Sources: Spatial Data courtesy of NJDEP (2007, 2010, 2016); NYS EISO (2008); Esri (2016) Disclaimer: No warranty is made by AECOM as to the accuracy, reliability, or completeness of these data for individual use or aggregate use with other data. This map is a "living document", in that it is intended to change as new data become available and is incorporated into the GIS database.

Figure 3.2-3: NJDEP Wetlands and Open Waters

3.2.2 Sediment Quality

Many of the creeks in the Project Area contain contaminated sediments. For example, sediments in Peach Island Creek and Berry's Creek, both within a US Environmental Protection Agency (USEPA)-designated Superfund Site, contain elevated levels of mercury, polychlorinated biphenyls (PCBs), metals, and other constituents that exceed New Jersey Ecological Screening Criteria in both freshwater and saltwater reaches. Mercury and PCBs have been identified as primary chemicals of potential concern (COPCs) in the context of the Berry's Creek Remedial Investigation and are, therefore, of particular interest. A review of data for West and East Riser Ditches, downstream of their respective tide gates, indicates that these remedial investigation results are in general agreement with nearby data from the Berry's Creek Study Area (BCSA).

Within the Project Area, recent sediment data are available for the Berry's Creek COPCs for two other tributaries (DePeyster Creek and Losen Slote Creek) that flow directly to the Hackensack River. In the case of DePeyster Creek, sediment concentrations of total mercury and total PCBs are similar to the average concentrations found within Peach Island Creek and Berry's Creek. Average sediment concentrations in Losen Slote Creek are somewhat higher than in DePeyster Creek, but still at the low end of the range for the Berry's Creek sub-reaches (Berry's Creek Study Area Cooperating PRP Group 2016).

Other COPCs in the above-referenced study, but considered to be of secondary importance because of their limited contribution to human and ecological health risk, include chromium, copper, lead, and nickel. While these metals frequently exceed New Jersey Surface Water Quality Criteria, a refined bioavailability-based methodology (i.e., a methodology that considers whether these metals can be absorbed by an organism) has been used to analyze their toxicity (USEPA 2005). The analysis indicated that these metals are not expected to cause toxicity.

Many other organic chemicals have been measured in sediments in the Project Area, including polycyclic aromatic hydrocarbons, PCBs, dioxins/furans, semi-volatile organic compounds (SVOCs), and volatile organic compounds (VOCs). Several of these chemicals exceed New Jersey sediment severe effects levels for freshwater or New Jersey sediment effects range medium levels for marine sediments and, as a result, they are a potential cause for concern. More information on contamination in the Project Area is provided in **Section 3.20** of the EIS.

3.2.3 Groundwater Conditions

Groundwater conditions are critical to the selection, construction, and functioning of the Proposed Project components, because high groundwater levels will affect the construction and performance of the flood protection facilities. The Meadowlands District has relatively flat topography; as a rough estimate, groundwater elevation in the land areas within the Meadowlands District is approximately 2 feet NAVD 88, based on the following calculations. The Hackensack Pascack Watershed Management Area US Geological Survey (USGS) 7.5-minute Digital Elevation Model (DEM) is available via the NJDEP Geographic Information Network. This DEM provides elevation in feet with a vertical resolution of 7.7 inches, given at horizontal intervals of 10mx10m, using NAVD 88. For reference, the Hackensack River to the east of the Project Area flows from approximately 2 feet in elevation at the northern edge of the Project Area to 0 feet in elevation at the southern portion of the Project Area. Based on these estimates, groundwater depths generally range from 1 to 8 feet below ground surface in the Project Area.

To estimate groundwater depth, 2 feet was subtracted uniformly across the DEM elevations. In actuality, depth to groundwater will vary with elevation and the tide, among other factors, so this representation is a rough estimate. Groundwater levels are also affected by tidal influences in this area, which have not been considered in this assessment. Furthermore, local development or new pumping wells in the area of a feature could affect the water table significantly, so that the current water table in the area of green infrastructure features could be very different than during the sampling events.

The Project Area has 40 groundwater Classification Exception Areas (CEAs). NJDEP defines CEAs as sites with identified groundwater contamination in accordance with NJAC 7:9C-1.6 and 1.9(b). CEAs are geographically defined areas within which specific contaminants have exceeded New Jersey Groundwater Quality Standards, and for which institutional controls, or administrative and legal controls, have been established. Additional details on groundwater CEAs and contamination can be found in **Section 3.2.10.3** of this Feasibility Study.

3.2.4 Terrestrial Resources

Terrestrial communities within the Project Area provide habitat for a number of wildlife species, including migratory birds. These habitats also provide important ecosystem services to the surrounding area, such as providing aquifer recharge and supporting nutrient cycling. Many terrestrial communities or habitat types within the Project Area juxtapose natural settings and the “built environment,” and are characterized by floristic and faunal assemblages adapted to urban landscapes. Both vegetated (e.g., forests, shrublands, herbaceous uplands) and non-vegetated (e.g., buildings, levees, human-made ditches, transportation infrastructure) areas occur within the terrestrial landscape mosaic of the Project Area (see **Figure 3.2-1**).

The Project Area offers a wide variety of habitats for migrant and resident bird species to utilize for breeding, nesting, and foraging. Recent studies and Project Area-specific surveys have documented over 220 bird species in and around the Project Area.

In general, mammal species observed in the Project Area were small mammal species common to suburban and/or disturbed environments. Some of these mammals are important prey species for other mammals, raptors, and some reptiles. In addition, bats were observed throughout the Project Area. Habitats near Losen Slote Creek and the woods near Teterboro Airport likely support both resident and migratory bats.

Few amphibians have been documented in the Meadowlands District and the Project Area, in part because few studies have been conducted and also because the Meadowlands District does not provide a wide range of habitats with appropriate size and diversity to support various amphibian species. The scarcity of natural upland soils and high-quality, fresh surface waters also likely contributes to the low species richness of amphibians. Previous studies in the Meadowlands District have documented a total of 18 reptile species. Reptile species have been observed in open water habitats, freshwater wetland habitat, and at the Teterboro Airport.

The findings of several butterfly, dragonfly/damselfly, and moth surveys completed in the Meadowlands District indicate that a number of species have been documented. A study completed by Kiviat and Barbour (2007) indicated that 49 different species were identified in the Meadowlands District, with additional species listed by the NJSEA. No additional terrestrial invertebrate surveys were conducted in support of this analysis.

A full list of terrestrial species identified in or near the Project Area during the RBDM project team's biological resources data collection in 2016 and 2017 can be found in **Appendix J** of the EIS. **Appendix J** also provides a detailed discussion regarding the research, locations, and survey methodologies used.

3.2.5 Aquatic Resources

Aquatic habitats include shallow and open-water estuarine areas, such as open waters and the intertidal mudflats associated with the Hackensack River and its tributaries. Aquatic habitats in the Project Area also include brackish and freshwater tidal and non-tidal freshwater wetlands and marshes. Aquatic wildlife includes the characteristic organisms that occupy these habitats on either a permanent or nearly permanent basis, depending on their individual life history requirements. The aquatic wildlife primarily includes fish, marine mammals, and benthic invertebrates.

Aquatic communities or habitat types within the Project Area represent a gradient, or continuum, of flooded conditions, ranging from the permanently inundated open waters of the Hackensack River to the intertidal mudflats and regularly flooded tidal wetlands along tributaries and the intermittently flooded high marsh areas. Also included within aquatic habitats in the Project Area are human-made open-water ponds and impoundments. Many of these habitats have been disturbed or fragmented.

The tidal Hackensack River and its tributaries support a relatively diverse assemblage of fish representing marine, estuarine, freshwater, and coastal migratory species. Most of the small streams in the Project Area have been channelized and/or are affected by human-caused disturbances, and the fish survey data suggest a prevalence of disturbance-tolerant species (Anselmini 1974a, 1974b, Ichthyological Associates, Inc. 1979, Bragin, et al. 1989, 2005). Some fish collected in the Berry's Creek drainage were observed to have tumors or lesions on their bodies.

Marine mammal sightings are uncommon in the Hackensack River and its tributaries, as the river's degraded water quality and low salinity levels are not preferred conditions for these species, although anecdotal sightings have occurred.

The benthic community consists of a wide variety of small aquatic invertebrates, which live burrowed into or in contact with the substrate. Sediment grain size, chemistry, and physical properties determine benthic community composition. The majority of benthic invertebrate taxa present within the Meadowlands District are considered tolerant of a wide range of environmental conditions, including polluted substrates and surface waters (Weis and Weis 2003).

A full list of aquatic species identified in or near the Project Area during the RBDM project team's biological resources data collection in 2016 and 2017 can be found in **Appendix J** of the EIS. **Appendix J** also provides a detailed discussion regarding the research, locations, and survey methodologies used.

3.2.6 Essential Fish Habitat

Essential Fish Habitat (EFH) is defined under the Magnuson-Stevens Fishery Conservation and Management Act, as amended, as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." EFH designations emphasize the importance of habitat protection to healthy fisheries and serve to protect and conserve the habitat of marine, estuarine, and anadromous finfish, mollusks, and crustaceans. EFH includes both the water column (including its physical, chemical, and biological growth properties) and the underlying substrate (including sediment, hard bottom, and other submerged structures). Under the EFH definition, necessary habitat is that which is required to

support a sustainable fishery and the managed species' contribution to a healthy ecosystem. EFH is designated for a species' complete lifecycle, including spawning, feeding, and growth to maturity, and may be specific for each life stage (i.e., eggs, larvae, adult). EFH designations have been defined for specific life stages based on their occurrence in tidal freshwater, estuarine, and marine waters.

Certain EFH-managed species designated within the Hudson-Raritan Estuary would not be expected to occur in the Project Area (i.e., the upper portion of the tidal Hackensack River) because they occur only in the seawater salinity zone (i.e., an area with greater than or equal to 25 parts per thousand). Species with a designated EFH in the lower Hackensack River but with an unspecified salinity zone are unlikely to occur in the Project Area given their affinity for warmer high-salinity waters. Three species with designated EFH within the Hudson-Raritan Estuary have been reported in fish surveys of the tidal Hackensack River (Bragin, et al. 2005).

Atlantic and shortnose sturgeon are both State and federally endangered species with principal spawning grounds are located in the brackish and freshwater tidal portions of the Hudson River (Bain 1997). While the Hackensack River and its tributaries have not been identified as spawning habitat for either sturgeon species, it is possible that adults of either species could traverse the tidal portion of the Hackensack River during migration. Early life stages (i.e., eggs, larvae, juveniles) would not be present in the Project Area and it is highly unlikely that either species would use the Project Area as spawning habitat, as both species typically spawn in large aggregations (Bain 1997).

Additional details on EFH in or near the Project Area can be found in **Section 3.14.3.2** of the EIS and in the EFH Assessment Report in **Appendix Q** of the EIS.

3.2.7 Existing Threats to Aquatic and Terrestrial Habitats

Habitat degradation, habitat loss, species invasions, habitat fragmentation, contaminant uptake and sequestration, and loss of biodiversity are the primary threats to aquatic and terrestrial habitats and resources in the Meadowlands District. Unused dams and inoperable tide gates degrade habitat and impair passage for anadromous species into upper reaches of the watershed (Durkas 1992). Invasive plants are an important concern in the Project Area, where common reed (*Phragmites australis*) dominates thousands of acres. Invasive plants are often effective colonizers in disturbed habitats, out-competing native flora under stressed conditions. This threat is potentially exacerbated within the Project Area by extensive hydrologic alterations and habitat fragmentation and loss associated with residential, commercial, and industrial development, and transportation infrastructure.

In addition to invasive common reed, several other non-native plant species represent a potential threat to wetland habitats in the Meadowlands District. Identification of and details on these other non-native plant species can be found in **Section 3.14.3.3** of the EIS.

Contamination of upland and wetland soils, as well as vegetation and biota, is a substantial concern throughout the Meadowlands District as a result of decades of industrial activity. Of specific concern is mercury contamination within Berry's Creek. Over several decades, the production of mercury compounds at the former Ventron/Velsicol site resulted in the disbursement of mercury into the natural environment. Mercury can mobilize through erosion, groundwater transport, volatilization, and transformation, and through uptake by plants and biota. Natural attenuation of mercury occurs through uptake by saltmarsh vegetation and sediment accumulation.

In addition to mercury, biotic uptake of other metals, such as chromium, polychlorinated dibenzo-p-dioxins (dioxins or PCDDs), polychlorinated dibenzofurans (furans or PCDFs), and PCBs, remains a concern to aquatic resources in the Project Area.

3.2.8 Federal and State Endangered Species and Species of Concern

Based on a review of the Information for Planning and Conservation (IPaC) Report obtained for the Proposed Project from the USFWS website, no Federal-listed threatened or endangered species are known to inhabit the Project Area. In addition, the National Marine Fisheries Service responded that no listed species under its jurisdiction are present in the Hackensack River or its tributaries.

The USFWS (2007) listed the Appalachian grizzled skipper (*Pyrgus wyandot*), an endangered butterfly, as present in the Hackensack River watershed. This indicates that this species could be present in the Project Area. This species is an Appalachian Mountain specialist found in open, sparsely grassed and barren areas that are close to oak or pine forests (NJDEP 2016a). This habitat is not present in the Project Area and the USFWS did not identify this species as present in the Project Area according to the IPaC Report.

Atlantic sturgeon and shortnose sturgeon are the only two Federal-listed fish species that could potentially be present within the Project Area. Both species are federally listed as endangered. While the Hackensack River and its tributaries have not been identified as spawning or foraging habitat for either sturgeon species, occasional, anecdotal reports of sturgeon in the river do occur.

The NJDEP's Endangered and Non-game Species Program defines state-listed endangered species as those species whose prospects for survival in New Jersey are in immediate danger because of a loss or change in habitat, over exploitation, predation, competition, disease, disturbance, or contamination. State-listed threatened species are defined as those species that may become endangered if conditions surrounding them begin to, or continue to, deteriorate. For birds, the State status may be different for breeding (nesting) versus non-breeding populations. Over the years, 31 State-listed endangered and threatened species have been documented in the Meadowlands District.

Federally and state-listed species documented in the Project Area can be found listed in **Table 3.14-6** of the EIS.

3.2.9 Wetlands and Wetland Restoration Projects in the Meadowlands District

Large, contiguous wetlands are an important landscape feature within the Meadowlands District and in the Project Area, especially in the most heavily developed areas where they perform vital ecosystem functions and represent important open space resources. Large wetland complexes provide a "critical mass" of habitat for native wildlife throughout the year, as well as for migratory species on a seasonal basis. Large wetland complexes are also more effective at intercepting and storing floodwaters and mediating wave energy along shorelines. Wetlands are valued for their aesthetic properties and provide active and passive recreational opportunities in urban settings.

Substantial wetland complexes within the Project Area include the Richard P. Kane Natural Area, which is owned by the Meadowlands Conservation Trust, as well as a network of extensive tidal marshes along Berry's Creek (Berry's Creek Marsh) and fringe wetlands associated with Mehrhof Pond (see **Figure 3.2-3**). The 587-acre Richard P. Kane Natural Area represents the second largest public landholding in the Meadowlands District (Kiviat and MacDonald 2002). The Richard P. Kane Tidal Wetland Mitigation Bank is located within the Richard P. Kane Natural Area in the Borough of Carlstadt on the north side of

the New Jersey Turnpike, as shown on **Figure 3.2-3**. Construction of this 217-acre mitigation bank was initiated in 2010 to provide mitigation for major transportation projects within the Meadowlands District (MERI 2015). Construction was substantially completed in 2012, but the activities resulted in more open water and mudflat habitat than originally planned and large areas within the site were subsequently replanted.

Along the upper portion of Berry's Creek, as shown in **Figure 3.2-3**, is a brackish tidal marsh named Eight-Day Swamp. Common reed dominates these wetlands; however, both high and low *Spartina* sp. marsh occurs in scattered areas (Kiviat and MacDonald 2002).

Large tracts of wetland in the Borough of Carlstadt have been restored through hydrological enhancements and the establishment of native salt marsh species. Restoration activities on about 273 acres of land south of the New Jersey Turnpike and adjacent to the Transco facilities and the Hackensack River were completed in several stages. Between 1999 and 2001, MRI restored 206 acres of wetlands during the development of Phases 1 and 2 of the MRI Meadowlands Mitigation Bank. Between 2011 and 2012, Evergreen Environmental, LLC restored the remaining 67 acres to develop the Evergreen MRI3 Wetland Mitigation Bank (51 acres) and a 16-acre mitigation project for the expansion of the Global Marine Terminal in Jersey City. See **Figure 3.2-3** for an approximate location of these wetland mitigation banks.

Also, along Losen Slote, a wetland complex consisting of forested, shrub/scrub and emergent wetlands is present north of the tide gate. This complex is bordered largely by vegetated wooded uplands and the BCUA pond. This complex and the large wooded tracts present on Teterboro Airport represent the largest freshwater wetland complexes within the Project Area.

3.2.10 Hazards and Hazardous Materials

The affected environment includes parcels of land and surface waterbodies within the communities of the Project Area having confirmed or suspected presence of hazardous materials, hazardous substances, or other contaminants. The Project Area is urban and densely developed with land uses ranging from heavy industry, transportation corridors, and residential use to open space, wetlands, and large areas set aside for recreation. For over 200 years, the Meadowlands District was subject to landfilling, dumping, and both intentional and unintentional releases of hazardous materials.

As described in the EIS, the properties identified during the review process as representing an environmental concern were classified according to the ASTM International's "Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process" Designation E 1527-13 terminology as follows:

- Recognized Environmental Condition (REC): "The presence or likely presence of any hazardous substance or petroleum products in, on, or at a property: (1) due to any release to the environment; (2) under conditions indicative of a release to the environment; or (3) under conditions that pose a material threat of a future release to the environment."
- Historical Recognized Environmental Condition (HREC): "A past release of any hazardous substance or petroleum products that has occurred in connection with the property and has been addressed to the satisfaction of the applicable regulatory authority or meeting unrestricted residential use criteria established by a regulatory authority, without subjecting the property to any

required controls (e.g., property use restrictions, Activity and Use Limitations [AULs], institutional controls, or engineering controls)."

- Controlled Recognized Environmental Condition (CREC): "A REC resulting from a release of hazardous substances or petroleum products that has been addressed to the satisfaction of the applicable regulatory authority (e.g., as evidenced by the issuance of a No Further Action [NFA] letter or equivalent, or meeting risk-based criteria established by regulatory authority), with hazardous substances or petroleum products allowed to remain in place subject to the implementation of required controls (e.g., property use restrictions, AULs, institutional controls, or engineering controls)."

In cases where the existing information indicated that contaminated sites may affect the Proposed Project through the migration of contaminated groundwater, additional information, including a site visit and/or NJDEP and municipal file reviews of the contaminated sites, was obtained to determine the location, type and extent of contamination within the Project Area. Based on this data gathering process, a summary of RECs, HRECs, and CRECs that could pose constraints on the Proposed Project was compiled. These include:

- USEPA Superfund sites on the National Priorities List (NPL);
- Known historical landfills;
- Groundwater CEAs;
- Known Contaminated Sites (KCSs); and
- Other potential RECs, including active underground storage tank (UST) remediation sites, automobile filling stations and service stations, and NJDEP-mapped historical fill.

3.2.10.1 USEPA Superfund Sites on NPL

Three USEPA Superfund sites are located within, or in close proximity to, the Project Area: Scientific Chemical Processing (SCP), Ventron/Velsicol, and Universal Oil Products (UOP). The Ventron/Velsicol site is a large, complex site on the NPL that has been broken down into Operable Units (OUs). OUs are smaller, more manageable portions of the site often defined by the type and location of the contamination relative to the original area of discovery (also known as the source area). The Ventron/Velsicol OU2 site is known as the BCSA; it encompasses a large part of the western portion of the Project Area along Berry's Creek, as well as all three of the Superfund sites identified herein (see **Figure 3.2-4**).

Scientific Chemical Processing

SCP is a former waste processing facility that operated prior to 1980 and accepted various wastes for recovery and disposal. SCP operated on a 6-acre parcel in the Borough of Carlstadt at 216 Paterson Plank Road. This property is located on the southern banks of Peach Island Creek, which is a tributary to Berry's Creek. During operations, SCP stored approximately 375,000 gallons of hazardous substances onsite in tanks, drums, and tank trailers. The facility closed in 1980 in response to a court order and was placed on the NPL in 1983. Investigations beginning in 1987 revealed potential contaminants of concern in soil and groundwater, including VOCs, SVOCs, PCBs, pesticides, inorganics, and metals (USEPA 2012). The site is currently vacant.

The 1990 USEPA Record of Decision (ROD) for OU1 of SCP defined it as "contaminated soils and groundwater above the clay layer" within the 6-acre SCP parcel. The primary objective of the ROD was to reduce the migration of hazardous substances into the groundwater and surface water of Peach Island

Creek until a permanent remedy for the site was selected. The fully implemented, interim remedy for OU1 included a containment wall, a barrier covering the property, a retaining wall along Peach Island Creek, a groundwater extraction system, groundwater sampling and monitoring, and a fence around the site's perimeter (Golder Associates Inc. 2009).

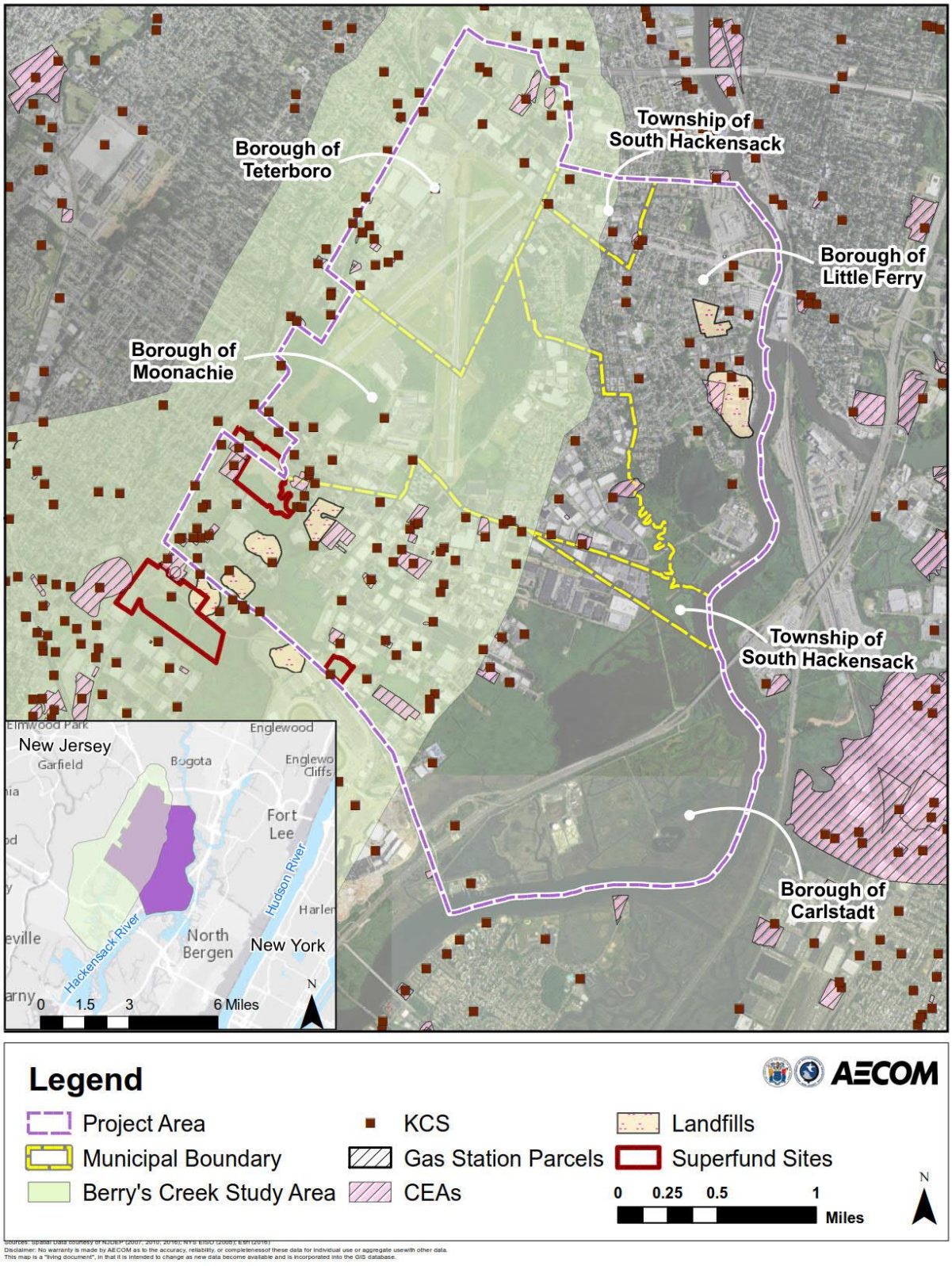


Figure 3.2-4: Locations of Superfund Sites, CEAs, KCSs, and Landfills within the Project Area

The August 2002 USEPA ROD for OU2 of SCP included soil, groundwater, and sludge (mud-like material resulting from industrial or refining processes) above the clay layer throughout much of the 6-acre parcel. The fully implemented, final remedy for OU2 included new groundwater treatment systems at the site, the installation of a cover system over the fill area, improvements to the existing groundwater extraction system implemented during OU1, the installation of additional groundwater monitoring wells, improvements to the retaining wall installed during OU1 along Peach Island Creek, and restrictions for future use of the property (USEPA 2012).

The September 2012 USEPA ROD for OU3 of SCP addressed off-property and deep groundwater contamination. Contamination of Peach Island Creek will be studied as part of the BCSA. The selected remedies that remain to be implemented are in-place groundwater treatment technologies, natural degradation of site contaminants over time, and further property use restrictions (USEPA 2012).

Ventron/Velsicol

The Ventron/Velsicol site is a former mercury processing and manufacturing plant that operated between 1927 and 1974 at a 38 acre property in the Boroughs of Carlstadt and Wood-Ridge. Ventron/Velsicol is located south of Ethel Boulevard and on the western bank of Berry's Creek. The western side of the West Riser Tide Gate touches the eastern boundary of the site. Disposal of approximately 160 tons of process wastes, including mercury, resulted in soil, sediment, groundwater, and surface water contamination of the site and Berry's Creek. Several investigations have been conducted since the initial involvement of NJDEP in the 1970s. Regulatory oversight was transferred to the USEPA when the site was placed on the NPL in 1984 (USEPA n.d.).

The Ventron/Velsicol site consists of two OUs. OU1 is designated as a 7 acre developed area and 19 acre undeveloped area. OU2 is designated as the Berry's Creek watershed, which represents the BCSA. Potential contaminants of concern in soil, sediments, and onsite groundwater in OU1 include metals, VOCs, and SVOCs (Exponent 2004). Air samples collected in the 1970s detected mercury in ambient air exceeding environmental guidelines (NJDEP 2015b); however, resampling in 1997 and 1998 determined gaseous mercury levels were below recommended exposure limits (Exponent 2004). The remediation of OU1 was completed in December 2010 (NJDEP 2015b).

Mercury contamination from the Ventron/Velsicol site impacted Berry's Creek, its tidally influenced tributaries, and the Hackensack River. Further, investigation and delineation of offsite contamination of Nevertouch Creek and Diamond Shamrock/Henkel Ditches is ongoing (NJDEP 2015b).

The BCSA boundary is the limit of the Berry's Creek Watershed within the Boroughs of Rutherford, East Rutherford, Carlstadt, Wood-Ridge, Moonachie, and Teterboro. Within the BCSA boundary are two Superfund sites, SCP and UOP, in addition to the BCSA designation as OU2 of the Ventron/Velsicol Superfund site (see **Figure 3.2-4**). Portions of the BCSA located in the Project Area include Upper Berry's Creek, East Riser Ditch, West Riser Ditch, and Upper Peach Island Creek (USEPA 2008).

Industrial discharges, sewage treatment plant discharges, and landfills resulted in contamination in the BCSA. Elevated concentrations of mercury and PCBs are present in waterway and marsh sediments within the Upper Peach Island Creek and Upper Berry's Creek areas. Ongoing sources of contamination to BCSA include upland groundwater and stormwater runoff, permitted and unpermitted surface water and groundwater discharges, atmospheric deposition, and contaminant flux from other sources within the Hackensack River estuary. Contamination is further dispersed by the tidal forces of the estuary, potentially resulting in impacts to sediment and soils in additional locations.

Universal Oil Products

The UOP site is a former chemical manufacturing facility that operated between 1932 and 1970. It encompasses approximately 74 acres. Operations ranged from use as an aroma chemical laboratory to handling of chemical wastes and solvent recovery. Approximately 4.5 million gallons of waste solvents and solid chemical wastes were discarded into two unlined lagoons during the facility's operation, resulting in soil, surface water, and groundwater contamination. UOP was placed onto the NPL in September 1983. NJDEP was the lead agency for the site between 1982 and 2008. USEPA assumed the role of lead agency in July 2008 (USEPA 2016a).

UOP includes two OUs. OU1 consists of the upland areas of the site, located in the western and northern portions of the parcel; OU1 is addressing soil and groundwater contamination. Contaminants of concern include VOC, polycyclic aromatic hydrocarbon (PAH), PCB, and lead in soil, and VOCs in leachate/shallow groundwater. The major components of the selected remedy included excavation of soil, on-site treatment by thermal desorption, thermally enhanced vapor extraction, soil cover/impermeable caps, deed restrictions, leachate collection, and discharge of treated effluent to groundwater. As of September 2016, remediation of OU1 was not complete. The final remedy for the OU1 portion of the site will be provided in the OU2 ROD (USEPA 2016a).

OU2 consists of the areas located in the southeastern portions of the parcel, and extends eastward to Berry's Creek. Some remedial actions, including groundwater collection, excavation, thermal treatment, and multimedia caps, have been performed in OU2 during remediation of OU1. However, no ROD has been finalized as of September 2016 (USEPA 2016a).

3.2.10.2 Historical Landfills

Seven historic landfills are located within 3,000 feet of the Build Alternative footprints and are considered RECs:

- Two Zurn Section G landfills located in the southwestern portion of the Project Area, north of Paterson Plank Road and west of Berry's Creek;
- Two Zurn Section H landfills located in the southeastern portion of the Project Area, between the New Jersey Turnpike (I-95) and the Hackensack River;
- Little Ferry Landfill, located near Gates Road along the Hackensack River;
- Willow Lake Park (i.e., Esposito Construction Company); and
- Morris Park Avenue Corporation.

Domestic waste, refuse, and demolition debris in these landfills contain many contaminants of concern, including VOCs, SVOCs, metals, PCBs, and pesticides. **Figure 3.2-4** provides the locations of known landfills within the Project Area.

Zurn Series G and H Landfills

The Series G and H historical landfills contained 10 feet of burned refuse, and 10 feet of semi-burned refuse, respectively (Zurn Environmental Engineers 1970). The Project Area contains two historical landfill locations for each series in the Borough of Carlstadt. The Series G historical landfills are north of Paterson Plank Road between 20th Street and Berry's Creek, adjacent to Berry's Creek and its connected tributaries. The Series H historical landfills are in the southeastern portion of the Project Area, between the New Jersey Turnpike (I-95) and the Hackensack River.

Little Ferry Landfill

The 35-acre Little Ferry landfill located in the Borough of Little Ferry, adjacent to the Hackensack River, south of Industrial Avenue, operated prior to 1968 and was closed in 1970. The site accepted approximately 700 tons of solid waste per week, consisting of approximately 5 percent domestic waste and 95 percent demolition waste (Zurn Environmental Engineers 1970).

Willow Lake Park

A brickyard occupied the present Willow Lake Park site until the 1930s in the Borough of Little Ferry. Between the 1930s and the 1970s, Willow Lake was approximately the size of the parcel defined by the current boundary of Willow Lake Park. In the early 1970s, the Borough of Little Ferry added fill material consisting of "approved earth and noncombustible demolition material" to reduce the size of the lake to its present area (Borough of Little Ferry 1971-1972). The NJDEP Division of Solid and Hazardous Waste identifies the site as "Esposito Const. Co." on the New Jersey Landfill List.

Morris Park Avenue Corporation

This landfill is located at the Meadowlands Distribution Center, 350 Starke Road, near the West Riser Tide Gate in the Borough of Carlstadt. NJDEP issued several solid waste violations to the Morris Park Avenue Corporation in the 2000s regarding permitting, emissions, and placement of fill without approval.

3.2.10.3 Groundwater Classification Exemption Areas

The Project Area has 40 groundwater CEAs. NJDEP defines CEAs as sites with identified groundwater contamination in accordance with NJAC 7:9C-1.6 and 1.9(b). CEAs are geographically defined areas within which specific contaminants have exceeded New Jersey Groundwater Quality Standards, and for which institutional controls, or administrative and legal controls, have been established.

CEAs are established to provide notice that the pollutant standards for a given aquifer, or body of permeable rock that can contain or transmit groundwater, are not, or will not be, met in a localized area due to natural water quality or anthropogenic influences. CEAs specify that designated aquifer uses are suspended in the affected area for the term of the CEA. CEAs are treated as Controlled Recognized Environmental Conditions (CRECs) in that they are institutional controls for groundwater contamination to remain in place for a specified period of time with approval from NJDEP. Contaminants resulting in the CEA designations within the Project Area primarily include VOCs, SVOCs, metals, and PCBs.

Tables in **Appendix N** of the EIS summarize the 40 CEAs in the Project Area, including site names, NJDEP Program Interest numbers, addresses, total sizes of the CEAs, the depths below ground surface of the CEAs, the year the CEAs were established, the duration of the CEAs in years, and the contaminants of concern. **Figure 3.2-4** provides the locations of the CEAs within the Project Area.

3.2.10.4 Known Contaminated Sites

The KCS list contains non-homeowner sites and properties within the State where contamination of soil and/or groundwater has been confirmed at levels equal to or greater than applicable standards. The list may include sites where remediation is either currently underway, required but not yet initiated, or where it has been completed. The KCS list contains most of the contaminated sites within the State, including identified Industrial Site Recovery Act (ISRA) facilities and sites where releases of hazardous substances are known to have occurred. ISRA sites are properties occupied by facilities with specific North American Industry Classification System (NAICS) codes listed in the ISRA regulation. These sites have mandatory remediation requirements when certain business and property transactions occur, which are not always

planned (e.g., a business owner dies and the business is sold). Non-ISRA sites where releases of hazardous substances have occurred are known as discharge sites. Discharges (NJAC 7:1E) are unplanned events where contamination has been released onto the lands or waters of the State (e.g., a drum containing chemicals is knocked over outdoors and gets into a stormwater basin).

KCSs where remediation has not yet been completed are treated as RECs. KCSs where Deed Notices and/or CEAs have been established are treated as CRECs, as engineering and/or institutional controls are in place to address contaminated soil and/or groundwater. In addition, KCSs that have been issued Restricted Use No Further Action (NFA) letters (previously issued by the NJDEP) or Limited Restricted Use or Restricted Use Response Action Outcomes (RAOs; issued under the current New Jersey Licensed Site Remediation Professionals program) are treated as remediated; however, they include engineering and/or institutional controls and are, therefore, considered CRECs. KCSs that have been issued Unrestricted Use NFA letters or Unrestricted Use RAOs are treated as remediated and, therefore, are considered HRECs. There are more than 100 sites on the KCS list in the Project Area. Tables in **Appendix N** of the EIS summarize the sites on the KCS list that were determined to have the greatest potential to be impacted by the Build Alternatives and No Action Alternative based on professional judgment of the available data for each site. **Figure 3.2-4** depicts the locations of the sites on the KCS list.

3.2.10.5 Other Potential RECs

Other potential RECs identified within the Project Area included UST Active Remediation sites, gasoline filling stations and automobile service stations, and areas containing historical fill material.

USTs are generally used to store petroleum products such as heating and motor fuel underground, but may also be used for the storage of other compounds. Corrosion, damage, and loose fittings may result in leaks that impact the subsurface. Surface spills result from overfilling. These releases of petroleum and other substances to the environment require remediation. The UST Active Remediation Sites list includes dozens of sites in the Project Area with leaking USTs where remediation has not yet been completed. These sites would be considered RECs in the Project Area because the remediation is still ongoing.

Several gasoline filling stations and automobile service stations are located within the Project Area. UST failures are common at gasoline filling station sites. Surface spills result from automobile fluid discharges and fueling overfills. The releases of petroleum products and metal fuel additives (e.g., lead) to the environment require remediation. These known gasoline filling station and automobile service station sites would be considered RECs in the Project Area due to the high likelihood of contamination.

The Project Area contains approximately 1,850 acres of NJDEP-mapped historical fill. According to NJDEP, “historical fill material means non-indigenous [non-native] material, deposited to raise the topographic elevation of the site, which was contaminated prior to emplacement, and is in no way connected with the operations at the location of emplacement and which includes, without limitation, construction debris, dredge spoils, incinerator residue, demolition debris, fly ash, or non-hazardous solid waste. Historical fill material does not include any material that is substantially chromate chemical production waste or any other chemical production waste or waste from processing of metal or mineral ores, residues, slag or tailings. In addition, historical fill material does not include a municipal solid waste landfill site” (NJAC 7:26E-1.8). Historical fill material commonly contains elevated concentrations of SVOCs and metals, and is treated as a REC unless it is capped/covered. A CREC designation may be appropriate for capped historical fill. Tables in **Appendix N** of the EIS summarize other potential RECs.

Figure 3.2-5 provides a map of UST Active Remediation sites, gasoline filling stations and automobile service stations, and historical fill as delineated by NJDEP (NJDEP 2004).

3.2.10.6 Aboveground Storage Tanks

While all existing hazards and hazardous materials were identified for their spatial relation to Proposed Project components, HUD policy requires an explosive and flammable operations evaluation of the Project Area for public threat (24 CFR Part 51C). Specifically, this requires the evaluation of the distance that existing aboveground storage tanks (ASTs) are from the Proposed Project features that would have a draw or increase in public use, such as a public park or recreational component. As such, this Acceptable Separation Distance (ASD) evaluation was performed in accordance with 24 CFR Part 51C and HUD's Acceptable Separation Distance Guidebook (HUD 2011). Using both aerial imagery and site reconnaissance, the presence, size, contents, and condition were determined for ASTs that could impact the Proposed Project.

A total of 41 potential AST sites were identified during the desktop review, of which a total of 19 facilities with ASTs were confirmed during the site visit. Field-assessed ASTs were photo-documented. The ASTs range in size from 1,000 gallons to 250,000 gallons. AST contents that are not under pressure include petroleum products (e.g., diesel, gasoline, heating oil, or waste oil), solvents (e.g., toluene, ethyl acetate, or normal butyl acetate), polyethylene resin, or chlorine. Pressurized AST contents include liquid oxygen, liquid nitrogen, or an unknown gas. The site investigation revealed that five of the facilities have ASTs with secondary containment (i.e., AST 1, 6, 11, 14, and 15) in the form of a fabricated containment wall.

The Preliminary ASD Technical Report for the Proposed Project is included in **Appendix O** of the EIS.

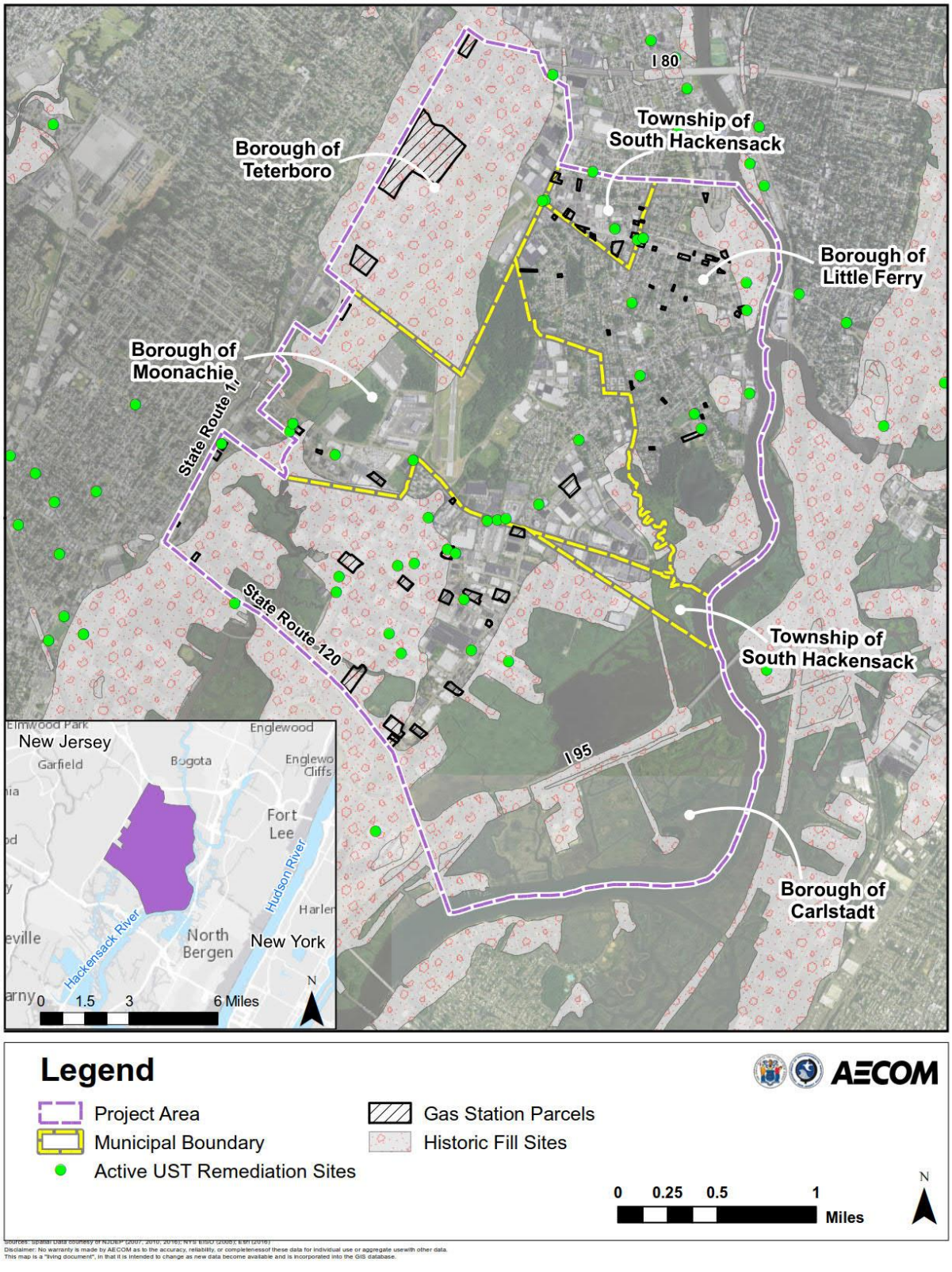


Figure 3.2-5: Historical Fill, Gas Stations, and UST Remediation Sites within the Project Area

3.3 Social and Economic Conditions

Approximately 22,400 people reside within the Project Area (US Census Bureau 2014). The five municipalities that compose the Project Area are located in Bergen County, which is the most densely populated county in the State (Bergen County Planning Board 2011). The following sections summarize the characteristics of the populations in the Project Area and the surrounding region, the characteristics of the surrounding land use that these populations work and/or reside in, and the social and economic conditions that are present.

3.3.1 Population and Demographics

In 1990, 7,730,188 persons resided in the State of New Jersey and 825,380 persons resided in Bergen County (Department of Labor and Workforce Development 2016). Between 1990 and 2014, the population of New Jersey increased by approximately 15 percent (1,144,186 residents) and the population of Bergen County increased by approximately 12 percent (95,076 residents). **Table 3.3-1** presents overall population trends from 1990 to 2014 at the municipal, county, and State levels.

In 2014, populations ranged between 10,773 and 56 individuals within the five municipalities in the Project Area. The Boroughs of Carlstadt and Little Ferry and the Township of South Hackensack all exhibited moderate population growth (8 to 26 percent), compared to the Borough of Teterboro, which grew by 155 percent. In contrast, the Borough of Moonachie had three percent fewer residents than it did in 1990(Department of Labor and Workforce Development 2016, US Census Bureau 2014).

Table 3.3-1: Demographic Trends from 1990 to 2014

Area	1990 Population	2014 Population	Percent Change (%)
New Jersey	7,730,188	8,874,374	15
Bergen County	825,380	920,456	12
Borough of Carlstadt*	5,570	6,189	11
Borough of Little Ferry	9,989	10,773	8
Borough of Moonachie	2,817	2,741	-3
Borough of Teterboro	22	56	155
Township of South Hackensack*	2,106	2,652	26

* Includes portions of municipalities outside of the Project Area
Source: (Department of Labor and Workforce Development 2016, US Census Bureau 2014)

The percent of the total population by race or ethnicity at the municipality, county, and State levels are presented in **Table 3.3-2** and **Table 3.3-3**. Whites composed the greatest percentage of the total population within the State of New Jersey, Bergen County, and the five municipalities within the Project Area, ranging from 59 percent in the Borough of Little Ferry to 89 percent in the Borough of Teterboro. With the exception of the Borough of Little Ferry (59 percent), White populations were higher in the municipalities in comparison to Bergen County (71 percent) and the State of New Jersey (69 percent).

Table 3.3-2: Distribution of Population by Race at the State, County, and Municipal Level in 2014

Race	New Jersey	Bergen County	Borough of Carlstadt	Borough of Little Ferry	Borough of Moonachie	Borough of Teterboro	Township of South Hackensack*
White Alone	68.7%	71.2%	79.4%	58.5%	84.0%	89.3%	68.7%
Black or African American Alone	13.5%	5.7%	0.4%	4.1%	0.7%	0.0%	6.9%
American Indian and Alaska Native Alone	0.2%	0.2%	0.4%	0.9%	0.0%	0.0%	0.0%
Asian Alone	8.8%	15.2%	10.7%	29.3%	7.9%	0.0%	4.0%
Native Hawaiian and Other Pacific Islander Alone	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Some other race Alone	6.3%	5.5%	7.5%	4.9%	5.8%	5.4%	15.2%
Two or more races	2.5%	2.2%	1.6%	2.2%	1.6%	5.4%	5.2%
Total Population Count	**8,874,374**	**920,456**	**6,189**	**10,773**	**2,741**	**56**	**2,652**

Values are percentages and for the entirety of each borough.
*Includes all three entities of the Township of South Hackensack
Source: (US Census Bureau 2014)

Table 3.3-3: Distribution of Population by Ethnicity at the State, County, and Municipal Level in 2014

Ethnicity	New Jersey	Bergen County	Borough of Carlstadt	Borough of Little Ferry	Borough of Moonachie	Borough of Teterboro	Township of South Hackensack*
Hispanic or Latino^	18.6%	17.4%	23.0%	22.3%	27.0%	39.3%	34.2%
Non-Hispanic or Latino	81.4%	82.6%	77.0%	77.7%	73.0%	60.7%	65.8%
Total Population Count	**8,874,374**	**920,456**	**6,189**	**10,773**	**2,741**	**56**	**2,652**

Values are percentages and for the entirety of each borough.
*Includes all three entities of the Township of South Hackensack
^Hispanic or Latino of any race, including Hispanic White, Hispanic Black, etc.
Source: (US Census Bureau 2014)

With the exception of the Borough of Teterboro, Asians were the second largest race. For example, Asians comprised 29 percent of the Borough of Little Ferry's population in 2014, compared to just 15 percent of the population in Bergen County. In contrast, the Borough of Teterboro had no reported Asian population in 2014. Blacks or African Americans were the third largest race in the Project Area. The Township of South Hackensack's population, consisting of 7 percent, had the largest population of Blacks or African Americans in 2014. However, the Boroughs of Carlstadt and Moonachie had Black or African American populations of less than 1 percent and the Borough of Teterboro had no reported Black or African American population in 2014 (US Census Bureau 2014).

The population of the Hispanic or Latino ethnicity in New Jersey and Bergen County was 19 and 17 percent in 2014, respectively. All of the Project Area municipalities had Hispanic and Latino populations greater than both the State of New Jersey and Bergen County, ranging from 22 percent in the Borough of Little Ferry to 39 percent in the Borough of Teterboro (US Census Bureau 2014).

3.3.2 Age Characteristics

As indicated in **Table 3.3-4**, the State of New Jersey, Bergen County, and the five municipalities in the Project Area all exhibited relatively comparable age cohort patterns in 2014. Approximately 45 percent of the total population within the Project Area municipalities was in the 35 to 64 years age group. The Borough of Teterboro and the Township of South Hackensack had 4 and 8 percent of their populations within the 15 to 24 years age group respectively, which was lower compared to the remainder of the Project Area municipalities and Bergen County (US Census Bureau 2014).

Table 3.3-4: Distribution of Population by Age at the State, County , and Municipal Level in 2014

Age (in years)	New Jersey	Bergen County	Borough of Carlstadt	Borough of Little Ferry	Borough of Moonachie	Borough of Teterboro	Township of South Hackensack*
Less than 5 years	6.0%	5.4%	2.9%	5.8%	4.9%	8.9%	5.3%
5 to 14 years	12.9%	13.0%	11.8%	9.5%	10.1%	8.9%	11.0%
15 to 24 years	12.9%	11.9%	15.3%	12.6%	9.6%	3.6%	8.2%
25 to 34 years	12.8%	11.7%	16.5%	12.7%	10.7%	16.1%	19.8%
35 to 64 years	41.4%	42.9%	40.6%	47.6%	47.5%	48.2%	40.6%
65 years and older	14.0%	15.5%	13.0%	11.8%	17.1%	14.3%	15.1%
Total Population Count	**8,874,374**	**920,456**	**6,189**	**10,773**	**2,741**	**56**	**2,652**

*Includes all three entities of the Township of South Hackensack
Percent totals are greater or less than 100% due to rounding.
Source: (US Census Bureau 2014)

In 2014, the population of children less than 5 years in the State of New Jersey and Bergen County were 6 and 5 percent, respectively. The highest percentage of children less than 5 years in age in the Project Area occurred in the Borough of Teterboro (9 percent) and was lowest in the Borough of Carlstadt (3 percent) (US Census Bureau 2014).

The population of seniors (individuals 65 years and older) in Bergen County and the State of New Jersey were 16 and 14 percent, respectively. Within the Project Area, only the Borough of Moonachie had a population of seniors greater than Bergen County at 17 percent. With the exception of the Borough of Moonachie, the population of seniors in the Project Area ranged from 12 percent in the Borough of Little Ferry to 15 percent in the Township of South Hackensack (US Census Bureau 2014).

3.3.3 Labor Force, Employment, and Business Characteristics within the Project Area

As indicated in **Table 3.3-5**, over half of the population of New Jersey, Bergen County, and the five municipalities in the Project Area were both in the labor force and employed in 2014. The total labor force

population includes individuals 16 years and over. The unemployment rate in Bergen County was 5 percent in 2014. The Borough of Little Ferry and the Township of South Hackensack had unemployment levels similar to Bergen County at 5 percent, while the remaining Boroughs had higher unemployment rates, ranging from 7 percent (Boroughs of Carlstadt and Moonachie) to 9 percent (Borough of Teterboro) (US Census Bureau 2014).

Table 3.3-5: Labor Status at the State, County, and Municipal Level in 2014

Labor Category	New Jersey	Bergen County	Borough of Carlstadt	Borough of Little Ferry	Borough of Moonachie	Borough of Teterboro	Township of South Hackensack*
In Labor Force	66.3%	65.6%	68.1%	71.1%	63.2%	69.6%	67.2%
Employed	59.8%	60.8%	61.5%	66.3%	56.1%	60.9%	62.5%
Unemployed	6.4%	4.8%	6.6%	4.8%	7.0%	8.7%	4.7%
Total Population Count (population 16 years of age and older)	**7,080,181**	**741,961**	**5,253**	**9,022**	**2,313**	**46**	**2,189**

*Includes all three entities of the Township of South Hackensack
Percent totals are greater or less than 100% due to rounding
Source: (US Census Bureau 2014)

In 2016, a total of 20,133 individuals were employed by businesses within the Project Area. The number of employees within the five municipalities from highest to lowest was as follows: Borough of Moonachie (6,527 employees), Borough of Teterboro (5,169 employees), Borough of Little Ferry (3,999 employees), Borough of Carlstadt (3,668 employees), and Township of South Hackensack (770 employees) (GIS Planning 2017).

The educational services, health care, and social assistance sector employed the largest percentage of the workforce across all areas, according to 2010 to 2014 American Community Survey data (US Census Bureau 2014). Of the major industry types, services, retail trade, and manufacturing businesses employed the largest percentage of individuals in the Project Area; in Bergen County, the top three industry types are the same. However, the distribution of these jobs is different in comparison to the Project Area, with more individuals employed in the service industry and fewer employed in the manufacturing industry (GIS Planning 2017). A summary of the percentage and number of individuals employed by businesses within the Project Area and Bergen County by major industry type (e.g., construction, manufacturing, retail trade, public administration, etc.) in 2016 is available in **Section 3.4.3.6** of the EIS. A summary of the employment percentage by industry at the State, county, and municipal level in 2014 is available in **Section 3.4.3.5** of the EIS.

Approximately 1,510 business establishments had employees in the Project Area in 2016, with one-third of them occurring in the Borough of Little Ferry. Of these business establishments, 84.7 percent of them employed fewer than 20 employees within the Project Area. Further, only 5 business establishments in the Project Area employed more than 250 individuals. Similarly, approximately 91.3 percent of the 52,777 business establishments in Bergen County employed fewer than 20 individuals and only 0.3 percent employed more than 250 individuals (GIS Planning 2017). Symrise Inc., a wholesaler company in the Borough of Teterboro, employed approximately 500 employees in 2016, and represents the largest employer in the Project Area (GIS Planning 2017). Additional details on business establishments in the Project Area can be found in **Section 3.4.3.6** of the EIS.

3.3.4 Income and Poverty

According to the 2010 to 2014 American Community Survey data, presented in **Table 3.3-6**, the median household income in the State of New Jersey ($72,062) was lower than Bergen County ($83,686). Median household incomes of municipalities in the Project Area were all lower than Bergen County with values ranging from $53,125 in the Borough of Teterboro to $71,847 in the Borough of Carlstadt. Per capita income exhibited similar patterns as illustrated for median household income. Per capita income was $36,359 in New Jersey and $43,194 in Bergen County; it ranged from $30,617 in the Township of South Hackensack to $33,534 in the Borough of Carlstadt (US Census Bureau 2014).

Table 3.3-6: Income and Poverty at the State, County, and Municipal Level in 2014

Income and Poverty	New Jersey	Bergen County	Borough of Carlstadt	Borough of Little Ferry	Borough of Moonachie	Borough of Teterboro	Township of South Hackensack*
Median household income in the last 12 months (in 2014 Inflation-adjusted)	$72,062	$83,686	$71,847	$63,810	$63,438	$53,125	$66,042
Per capita income	$36,359	$43,194	$33,534	$33,286	$30,837	$31,621	$30,617
Percent below poverty level	10.7%	7.5%	6.8%	8.0%	6.6%	16.1%	8.2%

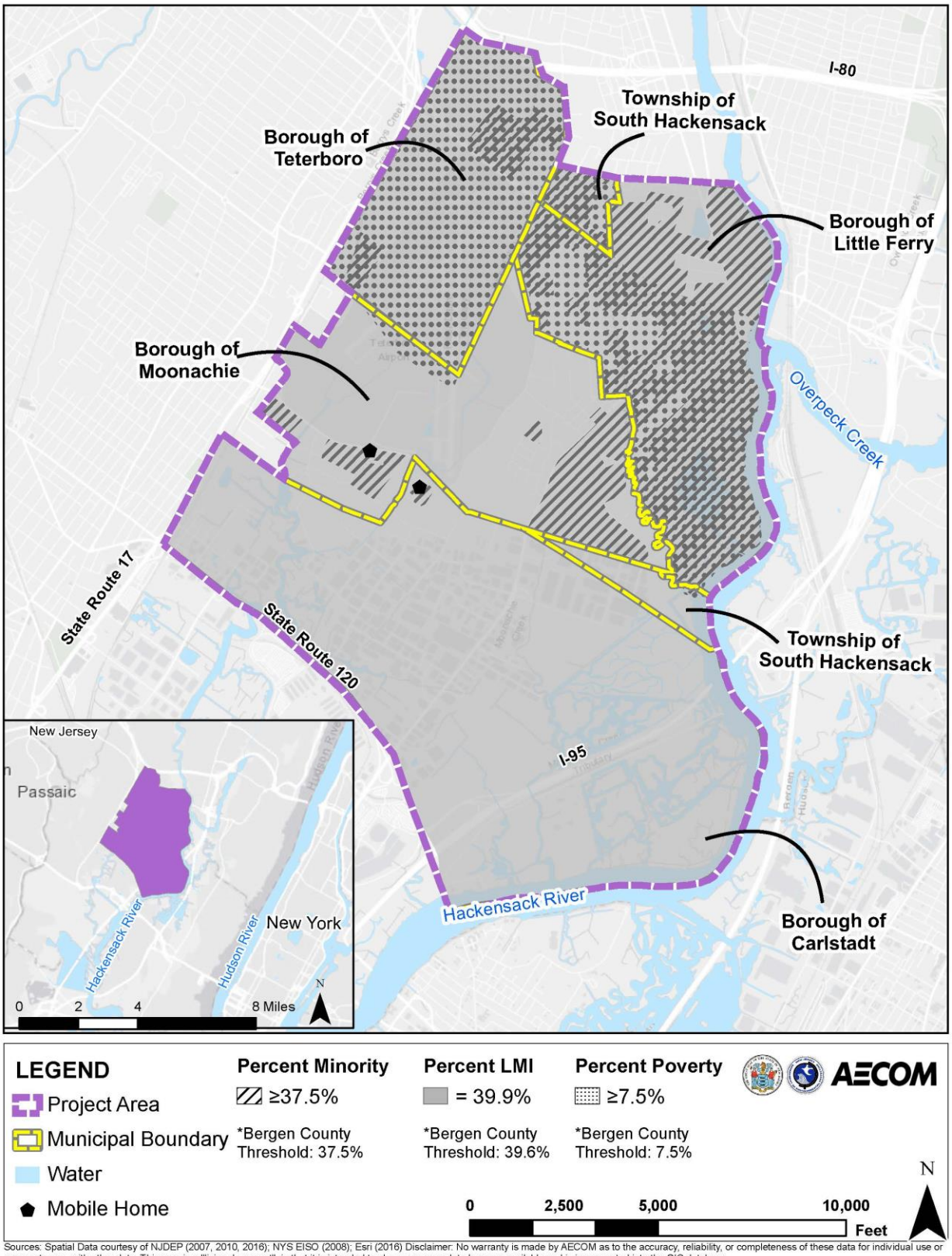
*Includes all three entities of the Township of South Hackensack
Source: (US Census Bureau 2014)

The percentage of persons living below the poverty level was 11 percent in the State of New Jersey and 8 percent in Bergen County in 2014. The majority of the municipalities in the Project Area had similar poverty levels as compared to Bergen County, except for the Borough of Teterboro, where 16 percent of the population was living below the poverty level.

3.3.5 Low- and Moderate-Income Populations

Environmental Justice (EJ) communities of concern include places that are home to high concentrations of minority and low-income populations that equal or exceed a given threshold. For the analysis conducted in the EIS, Bergen County data were used to establish a threshold for comparison to determine communities of concern within the Project Area. Based on this analysis, the entire Project Area is considered an EJ community of concern, given that the percentage of LMI persons in the Project Area is 39.9 percent and exceeds the Bergen County LMI exception threshold of 39.57 percent.

The highest concentration of minority populations occurs in the northeast portion of the Project Area, predominantly within the Boroughs of Moonachie and Little Ferry, and the Township of South Hackensack. All areas of the Project Area except the Borough of Teterboro and portions of the Borough of Little Ferry and the Township of South Hackensack have low-income and LMI populations. One location exceeds the Bergen County thresholds for all three EJ indicators: a portion of the Borough of Little Ferry that extends northward to Main Street, westward to Redneck Avenue, and along the municipal boundary of the Borough of Moonachie. Figure 3.3-1 illustrates the EJ communities of concern in the Project Area. Further description of LMI data in the Project Area is provided below.



Sources: Spatial Data courtesy of NJDEP (2007, 2010, 2016); NYS EISO (2008); Esri (2016) Disclaimer: No warranty is made by AECOM as to the accuracy, reliability, or completeness of these data for individual use or aggregate use with other data. This map is a "living document", in that it is intended to change as new data become available and is incorporated into the GIS database.

Figure 3.3-1: EJ Communities of Concern in the Project Area

Table 3.3-7 shows the number and percentage of LMI persons within the Project Area by municipality and for Bergen County overall.

Table 3.3-7: Low- and Moderate-Income Populations within the Project Area

Area	Number of LMI Persons	Percentage of LMI Persons
Borough of Carlstadt	2,185	36.10%
Borough of Little Ferry	4,550	42.90%
Borough of Moonachie	1,085	40.10%
Borough of Teterboro	4	4.20%
Township of South Hackensack*	655	29.00%
Bergen County	**247,910**	**28.00%**

*Includes all three entities of the Township of South Hackensack
Source: (HUD 2016)

The LMI exception threshold for area benefit activities is 39.57 percent (HUD 2017). Of the five municipalities, the Boroughs of Little Ferry and Moonachie would be characterized as EJ communities of concern for LMI populations because the percentage of LMI persons exceeds the exception threshold for Bergen County.

To better understand the distribution of EJ communities of concern within the Project Area, LMI data were examined and mapped at the block group level. A total of 15 block groups occur within the Project Area, and seven of them exceed the Bergen County LMI exception threshold of 39.57 percent, as shown in **Figure 3.3-2**. Further, as illustrated in **Figure 3.3-3**, the highest concentration of LMI persons occurs in the northeast portion of the Project Area, specifically within the Boroughs of Little Ferry and Moonachie, and the Township of South Hackensack. Two block groups in the Borough of Little Ferry have the highest concentration of LMI persons in the whole Project Area.

However, the 15 block groups that comprise the Project Area, when combined, have an overall LMI percentage of 39.9 percent, which exceeds the Bergen County threshold. As such, the entire Project Area meets the LMI exception threshold for area benefit activities (HUD 2017). For additional, more specific information regarding the percentage of LMI persons in each block group, please refer to **Appendix D** of the EIS.

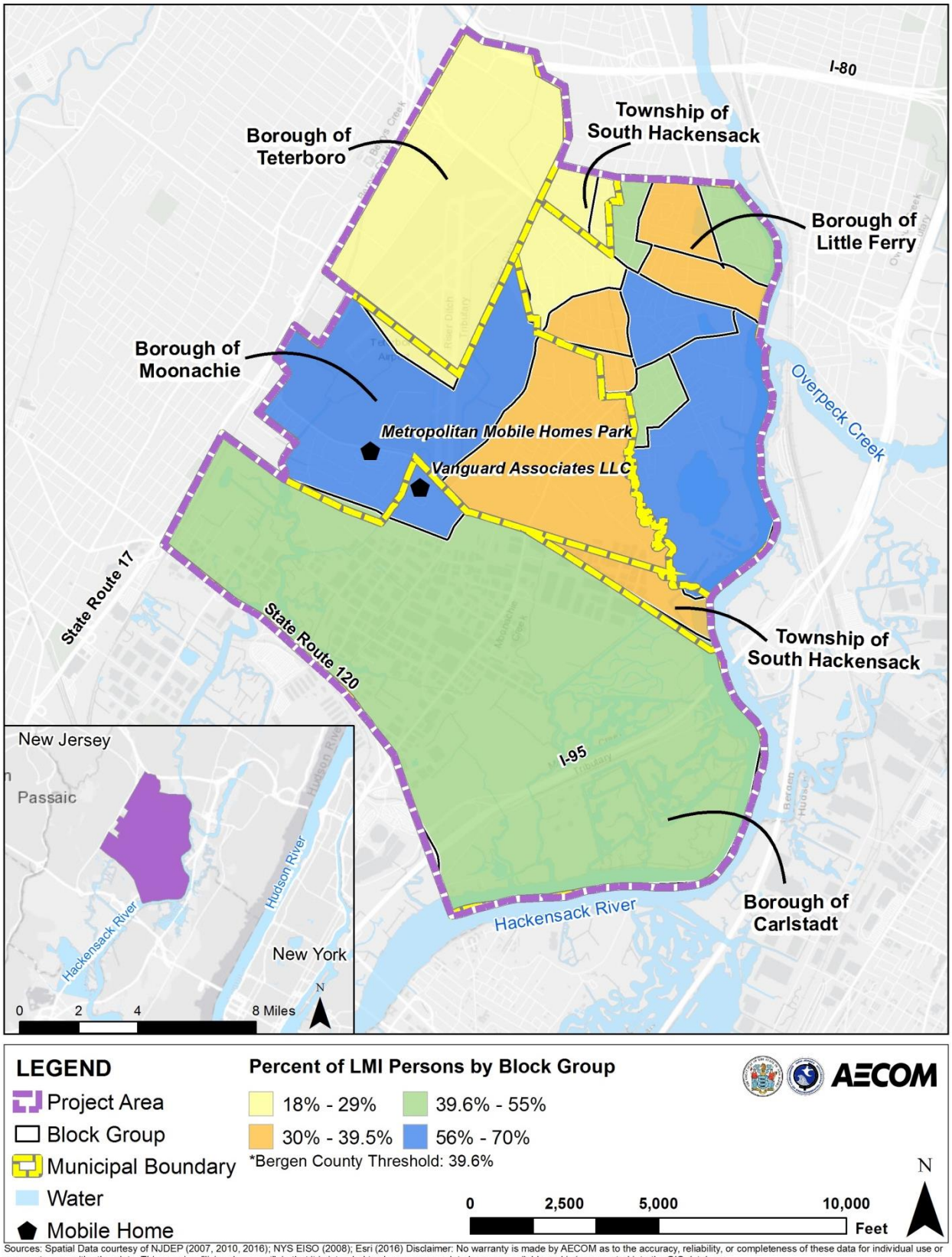
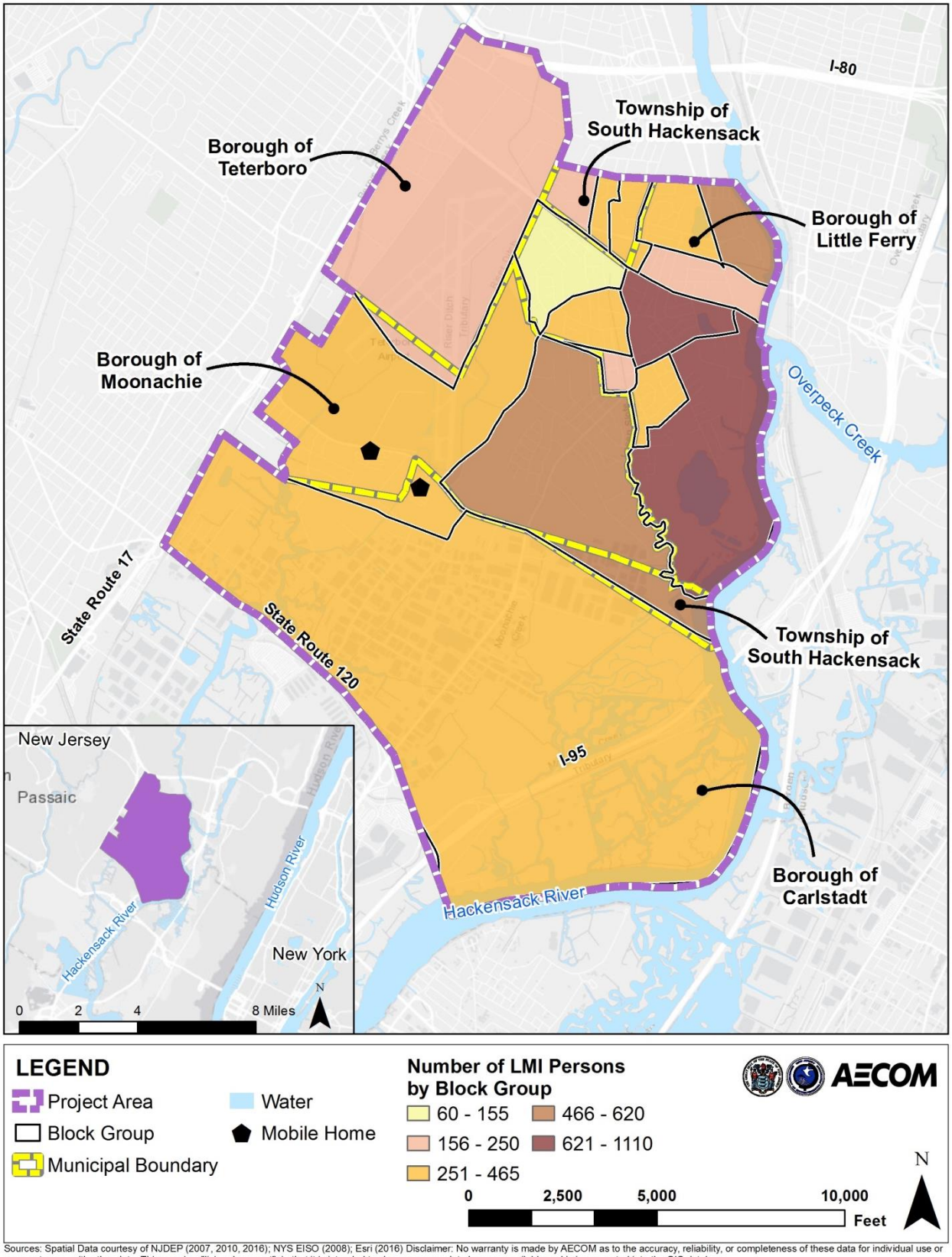


Figure 3.3-2: Percentage of LMI Persons by Block Group



Sources: Spatial Data courtesy of NJDEP (2007, 2010, 2016); NYS EISO (2008); Esri (2016) Disclaimer: No warranty is made by AECOM as to the accuracy, reliability, or completeness of these data for individual use or aggregate use with other data. This map is a "living document", in that it is intended to change as new data become available and is incorporated into the GIS database.

Figure 3.3-3: Number of LMI Persons by Block Group

3.3.6 Land Use, Zoning, and Development

Bergen County is part of the New York Metropolitan Area, and has been developed in conjunction with New York City. As a result, the county has very little developable land remaining; new development typically occurs as redevelopment or infill within existing developed areas that are either vacant or underutilized (Bergen County Planning Board 2011a).

Most of the Project Area is within the Meadowlands District, which is in the southwestern portion of Bergen County and characterized by large tracts of wetlands and other public/quasi-public uses. The Meadowlands District experienced extensive development in the 20th century. With the development of both a robust road and railroad network in the region, cheap, developable land nearby became desirable for the construction of warehouses and distribution industries; these land uses still occupy much of the Project Area. This commercial boom led to significant growth in population and employment. Most of the natural upland areas within the Meadowlands District, including within the five municipalities of the Project Area, are already developed; people also have made numerous attempts throughout history to convert the wetland areas into developable lands (i.e., reclamation).

In recent years, however, NJSEA initiated a number of redevelopment projects in the Meadowlands District that moved away from traditional patterns of urban sprawl and reclamation of wetland areas. The NJSEA Master Plan initiated a shift toward sustainability and smart growth. The plan includes redevelopment/infill for new development, an increased focus on mass transit to accommodate the dense population, and preservation of open space (particularly the remaining wetlands and other natural areas) (NJSEA 2004).

Under the Meadowlands District's zoning regulations (NJAC 19:4), there are 18 zoning designations and one Redevelopment Area classification within the Meadowlands District. Fourteen of those designations, described below, apply to lands within the Project Area.

- **Environmental Conservation.** The environmental conservation (EC) zone includes areas that are ecologically significant wetlands, open waters, and adjacent uplands. Permitted uses in the zone include restoration activities, water access features, and scientific equipment. These uses aim to encourage scientific and educational study regarding wetland ecology. Special exception uses, such as communication towers, marinas, or structures needed to conduct a restoration activity, are permitted, assuming the use does not impair the environmental quality of the zone.
- **Recreation.** Two recreation zone designations under the Meadowlands District's zoning regulations occur in the Project Area: (1) parks and recreation (PA) and (2) waterfront recreation (WR). The PA zone includes areas that provide public open space and recreational facilities. Allowable activities in the PA zone include parks and recreation facilities. The WR zone includes areas that accommodate marinas and other water-oriented commercial and recreational facilities, such as boat rental facilities or waterfront parks. Prohibited uses in the WR zone include any uses that exclude public access to the Hackensack River or adversely affect the visual aesthetics of the waterway.
- **Residential.** Two residential zone designations under the Meadowlands District's zoning regulations occur in the Project Area: (1) low density residential (LDR) and (2) planned residential (PR). The LDR zone includes single-family, two-family, and townhome dwellings. In an area zoned LDR, there may also be community residences and shelters, daycare facilities, and schools. The PR zone includes high-density neighborhoods and multi-family dwellings (i.e.,

apartment complexes and condominiums). In areas zoned PR, there may be offices, restaurants, and health care facilities.

- **Commercial.** Four commercial zone designations under the Meadowlands District's zoning regulations occur in the Project Area: (1) neighborhood commercial (NC), (2) commercial park (CP), regional commercial (RC), and highway commercial (HC). The NC zone allows for uses that serve the neighboring communities, such as banks, retail stores, and houses of worship. The CP zone allows for commercial services in pedestrian-friendly compact centers, such as shopping centers. The RC zone also allows for compact commercial services, but is generally located next to major roadways and accommodates a larger range of commercial uses, such as convention centers, movie theaters, and business/office parks. Finally, the HC zone allows for commercial uses related to highway operations, such as automobile repair facilities, gas stations, hotels and motels, and restaurants. Note that these example uses are not limited per zone, and commercial zones, through a special exception, may have uses that are not generally allowable.
- **Transportation.** Transportation zone designations under the Meadowlands District's zoning regulations that occur in the Project Area include any roads, highways, rails, or other rights-of-way. Aviation facilities (AF) is also a specific designation under the Meadowlands District's zoning regulations and includes any land used for an airport or in support of airport operations, such as car rental facilities, helistops, or taxi services.
- **Industrial.** Two industrial zone designations under the Meadowlands District's zoning regulations occur in the Project Area: (1) light industrial A (LI-A) and (2) light industrial B (LI-B). The LI-A zone allows for industrial and distribution uses congregated on a large lot, such as automobile sales, research and development facilities, and warehouses. The LI-B zone is similar to the LI-A zone, but the uses are not located on a large lot. Industrial and commercial zones often support similar uses and are often in close proximity to each other.
- **Public Utilities.** Public utility (PU) zones are areas that support public utilities and intermodal uses, such as electric power facilitates, intermodal facilities, railroad yards, and special exception recycling facilities.
- **Redevelopment Areas.** Redevelopment areas (RA) are zoned as areas that are "in need of redevelopment," such as in the case of a recreation (open space) area that becomes residential to provide additional housing for a growing community. These areas retain their existing zoning designation until such an area has an approved a redevelopment plan.

For land use, zoning, and development information that is specific to each municipality of the Project Area, refer to **Section 3.2.3.5** through **Section 3.2.3.9** of the EIS.

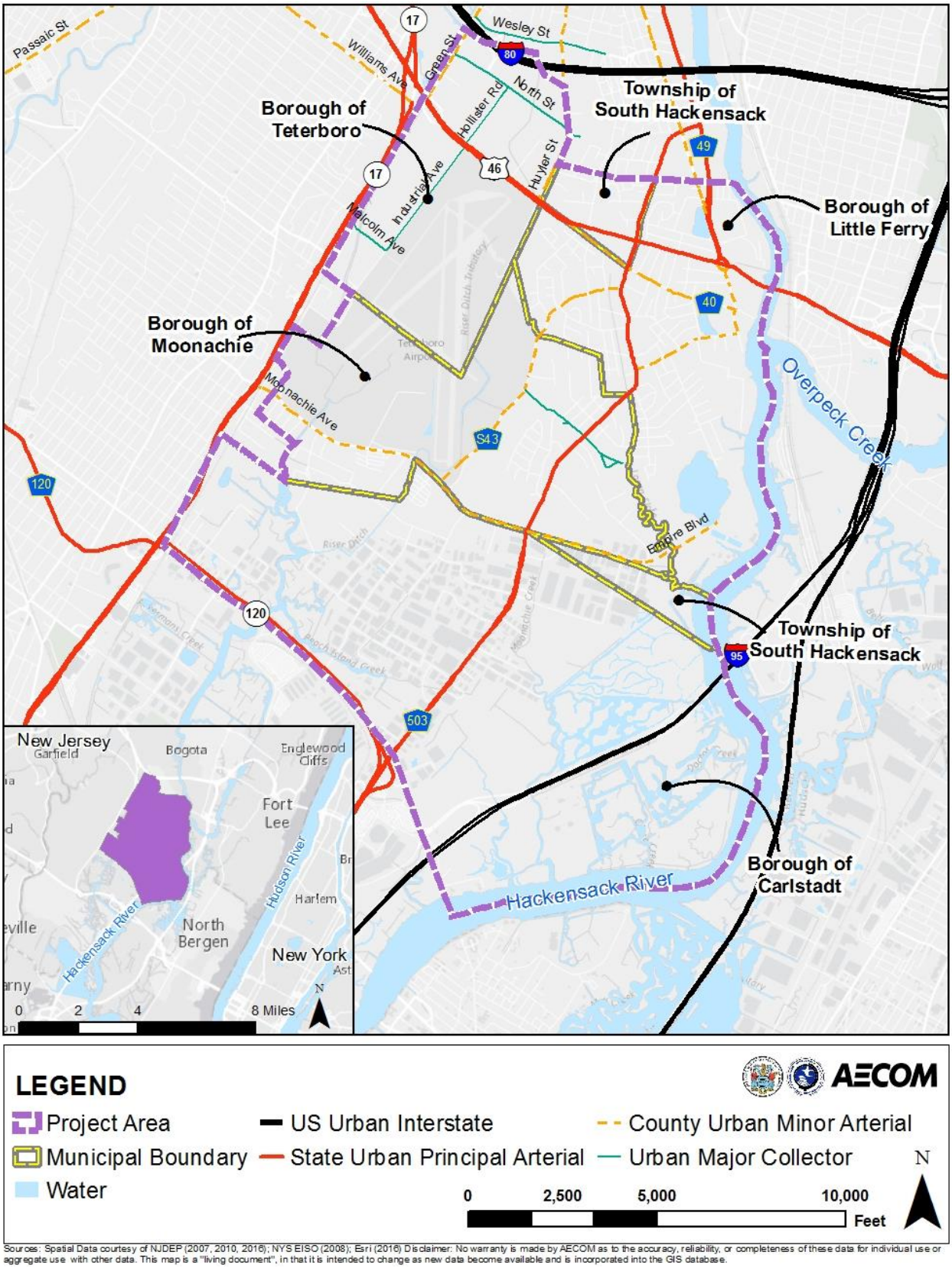
3.3.7 Transportation and Circulation

The Project Area is connected to the regional roadway network by two major interstate routes, two US routes, and several State routes, including Interstates 80, 95, and 280; US Route 1-9 and US Route 46; and State Routes 3, 7, 17, 120, and 495. Each of these roads is designated as a critical evacuation route (NJSEA 2005). Major roadways in the Project Area, including their roadway functional classification and Average Annual Daily Traffic (AADT), are listed in **Table 3.3-8** and shown in **Figure 3.3-4**. AADT is the daily average vehicular traffic measured on a specific roadway segment over a period of 365 days. AADT along major roadways in the Project Area ranges from 14,300 to 89,300 trips per day, with the highest traffic along State Route 17 (NJDOT 2015b).

Table 3.3-8: Major Roadway Functional Classifications and AADT

Roadway Name	Functional Class	AADT
State Route 17	Urban Principal Arterial	59,000–89,300 (2014)
State Route 120 (Paterson Plank Road)	Urban Principal Arterial	19,500–48,300 (2012)
US Route 46	Urban Principal Arterial	37,600–54,300 (2012)
Bergen County Route 40 (Main Street)	Urban Minor Arterial	7,400 (2015)
Bergen County Route S40 (Huyler Street)	Urban Minor Arterial	NA
Bergen County Route S43 (Redneck Avenue)	Urban Minor Arterial	7,400 (2012)
Bergen County Route 49 (South River Street)	Urban Principal Arterial	14,700 (2013)
Bergen County Route 120 (Paterson Avenue)	Urban Minor Arterial	18,800 (2012)
Bergen County Route 124 II (Bergen Turnpike)	Urban Principal Arterial	14,300 (2014)
Bergen County Route 503 (Washington Avenue / Moonachie Road / Liberty Street)	Urban Principal Arterial	17,500 (2010)
Bergen County Route 36 (Moonachie Avenue)	Urban Minor Arterial	6,521 (2012)
Washington Avenue, Little Ferry	Urban Minor Arterial	NA
Wesley Street, Hackensack	Urban Major Collector	NA
Green Street, Hackensack	Urban Minor Arterial	NA
Joseph Street, Moonachie	Urban Major Collector	NA

Source: (NJDOT 2015b), (NJDOT 2014b)



Sources: Spatial Data courtesy of NJDEP (2007, 2010, 2016); NYS EISO (2008); Esri (2016) Disclaimer: No warranty is made by AECOM as to the accuracy, reliability, or completeness of these data for individual use or aggregate use with other data. This map is a "living document", in that it is intended to change as new data become available and is incorporated into the GIS database.

Figure 3.3-4: Regional Roadway Network

Existing parking facilities in the Project Area include free and paid on-street parking and off-street parking in private and public lots. Private lots are limited to use by private businesses, business patrons, and local and commercial retail patrons. Public lots include park-and-ride facilities available for bus and rail passengers.

Existing pedestrian and bicycle facilities in the Project Area include sidewalks, pedestrian and bicycle pathways, and limited bike paths. Sidewalks in commercial and residential areas are typically continuous and well-maintained, while sidewalks in industrial and warehouse areas are limited. A 0.5-mile-long pedestrian and bicycle pathway is located in the Project Area, which runs through Losen Slote Creek Park in the Borough of Little Ferry, and is a segment of the 5.4-mile-long Meadows Path. Losen Slote Creek Park also includes hiking trails for pedestrians and bicyclists.

NJ TRANSIT is the primary public transportation agency that provides bus and passenger rail service within the Project Area. Transit facilities within the Project Area, including bus stops, rail stations, and park-and-ride facilities are shown in **Figure 3.3-5**. As listed in **Table 3.3-9**, seven NJ TRANSIT bus routes have designated stops near the Project Area. Private bus and shuttle companies, such as DeCamp Bus Company and EZ Ride, serve some of the boroughs around the Project Area; however, their routes and bus stops fall outside the Project Area.

Table 3.3-9: NJ TRANSIT Bus Routes in the Project Area

Bus Route	Service Area	Major Roads Traveled	Average Maximum Directional Weekday Peak Hour Headway
76 (Meadowlands)	Newark – Hackensack	Paterson Plank Road, Gotham Parkway, Moonachie Avenue, Industrial Avenue, Huyler Street	40 minutes
144	Elmwood Park – Hackensack – New York City	Paterson Plank Road, Gotham Parkway	9 minutes
151 (Express)	Paterson – New York City	Main Street	12 minutes
161	Paterson, Passaic – New York City	Washington Avenue, Moonachie Road	8 minutes
165	Westwood – New York City	Main Street	8 minutes
703	Haledon – Paterson – East Rutherford	Paterson Plank Road, Washington Avenue	10 minutes
772	New Milford – Hackensack – Meadowlands	Washington Avenue, Moonachie Road	30 minutes

Source: (NJ Transit 2016)

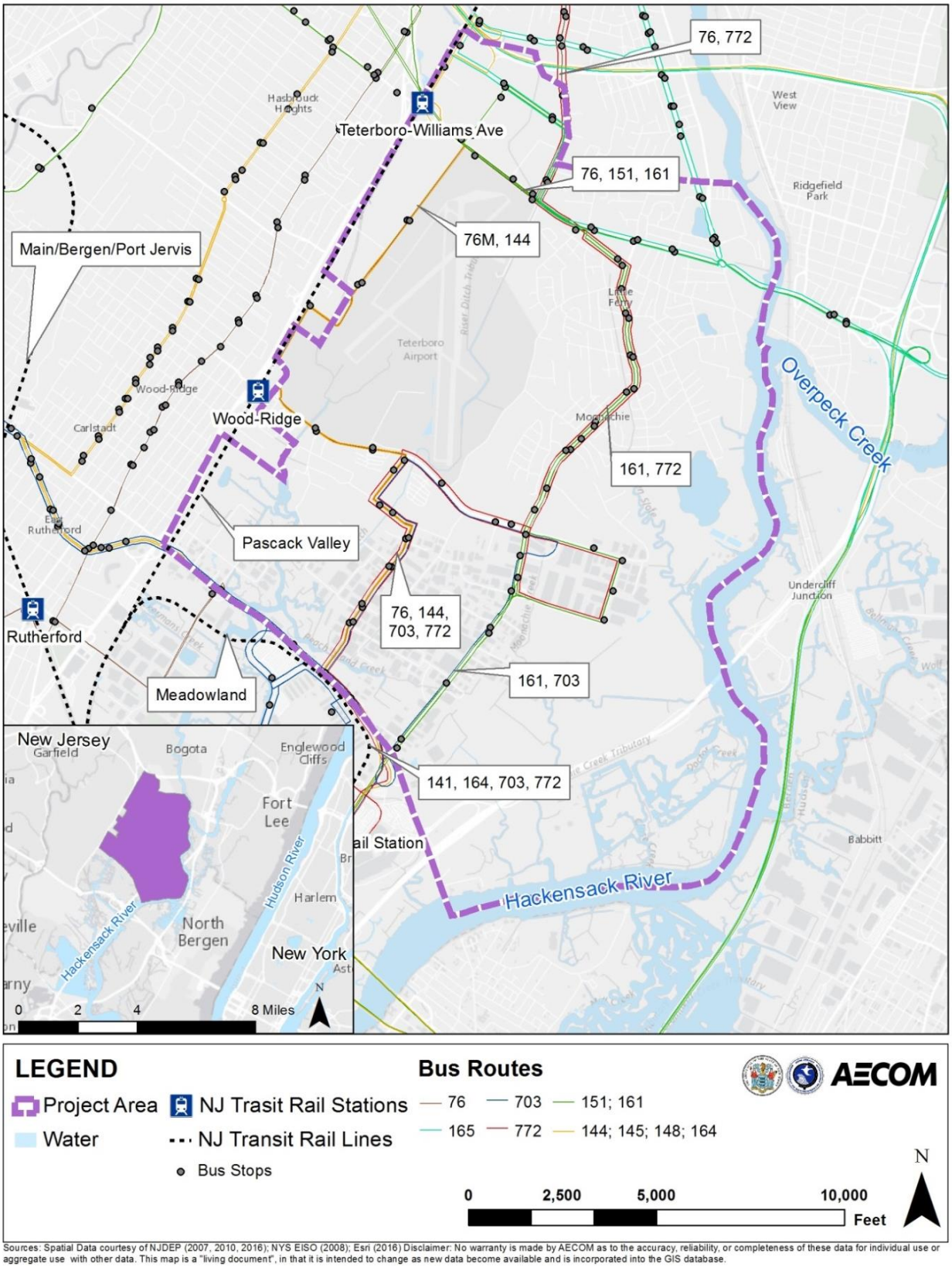


Figure 3.3-5: NJ TRANSIT Service

The NJ TRANSIT Pascack Valley Line services the Project Area, with the Wood-Ridge Station and Teterboro Stations providing service between Spring Valley, NY, and Hoboken, NJ. Rail service at these stations operates at a frequency of up to three trains per hour during weekday AM and PM peak hours. Passengers must transfer at Secaucus Junction for service to and from New York Penn Station in New York City. Secaucus Junction is a major transit hub near the Project Area that functions as a transfer point for several NJ TRANSIT rail lines for service to destinations in New Jersey, as well as New York Penn Station.

Two NJ TRANSIT park-and-ride facilities are located along State Route 17 near the Project Area. The NJ TRANSIT Wood-Ridge Station has one parking lot with 130 standard and six handicap-accessible spaces, located on Anderson Avenue and Park Place East in the Borough of Wood Ridge. The Teterboro Station has a 27-space parking lot located on Green Street in the Borough of Teterboro.

The Project Area lies within the nation's largest metropolitan market area, making it a prime location for trucking services and associated land uses. Based on existing land use maps, major freight generators within the Project Area include Teterboro Airport, and local commercial and industrial/manufacturing businesses. The roads within and around the Project Area provide a link between businesses and freight facilities, resulting in a high percentage of heavy vehicles traveling on roadways in the Project Area. The 2015 New Jersey Department of Transportation (NJDOT) Truck Map shows two types of designated truck routes within the Project Area: New Jersey access network routes and national network routes (NJDOT Bureau of TDD 2015).

I-80 is a national truck route. State Route 17, US Route 46, and State Route 120 are all New Jersey access network truck routes. Trucks are prohibited on Liberty Street within the Borough of Little Ferry. No rail yards lie within the Project Area. The nearest rail yard, the Little Ferry Rail Yard, is located east of the Hackensack River (NJDOT 2015c). Norfolk Southern Railroad shares the Pascack Valley Line tracks owned by NJ TRANSIT within the Project Area, and also owns and operates spur lines branching from the Pascack Valley Line between the Wood-Ridge and Teterboro-Williams Avenue stations (NJDOT 2015c).

Teterboro Airport is one of the oldest operating airports in the New York and New Jersey metropolitan area, and is owned and operated by the Port Authority of New York and New Jersey (PANYNJ). It borders the municipalities of Teterboro, Hasbrouck Heights, Little Ferry, Moonachie, and Wood-Ridge. The airport is a critical facility in the Borough of Teterboro (Bergen County Office of Emergency Management 2015) and is considered a general aviation "reliever" that helps remove smaller and slower aircraft from regional air traffic to avoid major congestions at other PANYNJ commercial airports. Teterboro Airport provides air transportation access for private aircraft owners and local freight companies. In 2015, Teterboro Airport had 172,866 aircraft operations, consisting mostly of private charter flights (GCR, Inc. 2016). Business services include charter flights, aircraft leasing, cargo, shipping, medically oriented flight activities, and international travel. Access to the airport is available by train, bus, taxi, or private automobile. Train and bus stops are approximately 1 mile from the airport. The NJ TRANSIT Pascack Valley Line station on Williams Avenue is the closest station to Teterboro Airport. Currently, the airport has no central parking facility; however, fixed-base operators such as Atlantic Aviation, Signature Flight Support, Jet Aviation, and Meridian Teterboro offer parking services.

3.3.8 Recreation

The Hackensack River is an important recreational resource to the Project Area and provides a wide variety of recreational and educational opportunities (Bergen County Department of Planning and Economic Development 2004). Approximately 1,519 total acres of active and passive parkland, wetlands

and mitigation banks, open spaces, recreational areas, and boating facilities occur within the Project Area. Several private boating facilities are also located in the Boroughs of Carlstadt and Little Ferry, offering boat storage, slips, repair facilities, and public launch areas (Bergen County Department of Planning and Economic Development 2004). **Table 3.3-10** displays the percentage of total land use that is currently recreational and open space within each municipality in the Project Area. **Table 3.3-11** shows the types of recreational land and open space use within each municipality in the Project Area.

Table 3.3-10: Percentage of Recreational and Open Space by Municipality

Municipality	Percentage of Total Land	Description
Little Ferry	4%	Woodlands, fields, parks
Moonachie	4%	Woodlands, fields, parks, playground
Carlstadt	2%	Woodlands, shrubland, fields, parks
Teterboro	2%	Woodlands, shrubland
South Hackensack	<1%	Fields

Table 3.3-11: Types of Recreational Land and Open Space within Project Area Municipalities

Type of Land	Acres in Project Area	Percent of Total Recreational Land and Open Space
Designated Parks and Recreational Fields/Facilities (includes school athletic fields)	147	10%
Marinas	11	1%
Wetlands and Mitigation Banks	1,155	76%
Other Open Spaces (includes cemeteries)	206	13%
Total	**1,519**	**100%**

3.3.9 Critical Facilities

A critical facility is a structure, service, or facility that is particularly vulnerable to flooding due to its potential to cause harm, damage, or disruption to community persons, properties, or activities if it is destroyed or impaired. Critical facility determinations in this document are in accordance with those in the Bergen County Multi-Jurisdictional All-Hazards Mitigation Plan (Bergen County Office of Emergency Management 2015). There are several critical facilities in the Project Area, as listed below by municipality:

- **Borough of Little Ferry**: five pump stations, four drain/drainage stations, one substation, two fire departments (Little Ferry Hose Company #1 and Little Ferry Hook & Ladder), one emergency medical service (EMS) unit (Little Ferry First Aid Corps), four schools (Little Ferry Nursery School, Early Learners Child Care, Memorial Middle School, and Washington Elementary School), two municipal buildings (Municipal Building and DPW), and two community facilities (Little Ferry Public Library and St. Margaret's of Cortana Church)

- **Borough of Moonachie**: four pump stations, one fire department (Moonachie Fire Department), one EMS unit (Moonachie First Aid and Rescue Squad), one school (Robert L. Craig School), and two municipal buildings (Borough Hall and DPW)
- **Borough of Carlstadt**: two pump stations, one substation, and one municipal building (DPW)
- **Borough of Teterboro**: one sewer and stormwater pump station, one school (Bergen County Technical High School), and four municipal buildings (Municipal Building, DPW, Bergen County Bergen's Place Youth Shelter, and Bergen County Animal Shelter)
- **Township of South Hackensack**: one pump station and one sewage station

Critical facilities in the Project Area that provide EMS were identified using the vulnerability ratings from the Bergen County Multi-Jurisdictional All-Hazards Mitigation Plan (Bergen County Office of Emergency Management 2015). **Table 3.3-12** displays the critical facilities in the Project Area that were analyzed and the respective flooding and storm-surge vulnerability ratings.

Table 3.3-12: Critical Facilities and Vulnerability Ratings

Critical Facility	Flooding Vulnerability Rating	Storm-surge Vulnerability Rating
Little Ferry Hose Co. #1 Fire Department	2	2
Little Ferry Hook and Ladder Fire Department	3	1
Moonachie Fire Department	3	1
Moonachie First Aid Squad	3	1

A flooding vulnerability rating of 1 indicates that the structure is in a floodplain/flood-prone area but has no previous history of flood damage; 2 indicates that the structure is in a floodplain/flood-prone area and has experienced some limited flood damage in the past; and 3 indicates that the structure is in a floodplain/flood-prone area and has experienced significant flood damage or is a NFIP repetitive loss property. A storm-surge vulnerability rating of 0 indicates that the structure is not located in a storm surge inundation area; 1 indicates that the structure is located in a storm-surge area for a category 4 or 5 hurricane, or is located at the edge of a designated tsunami risk zone; and 2 indicates that the structure is located in a storm-surge area for a category 3 hurricane, but has no previous damage.

3.4 Flood Risk

As stated previously, flood risk in the Project Area mainly comes from two types of events: (1) systemic inland flooding from high-intensity rainfall/runoff events; and (2) coastal flooding from storm surges (see **Section 1.1** and **Section 2.1**).

Intense rainfalls that cause overflow onto the floodplains of the rivers and streams cause fluvial floods. Normal tidal conditions present a high tailwater relative to the Project Area topography and retard drainage rates causing overbank flooding and surcharge flooding in piped systems. The communities and the county can normally handle such flood events, which usually do not have major consequences. However, in the recent past, because of drainage network deficiencies, fluvial flood frequency has increased in the Project Area, making it a recurrent or even chronic problem. Extreme fluvial floods due to heavy rainfalls also occur, though less frequently, but lead to more significant damage and impacts to the communities.

Extreme tidal events, such as spring tides or tidal surges associated with coastal storms, are infrequent but can have severe consequences. A tidal event combined with a high fluvial flow can produce even more severe events. Partial protection is currently provided by an incomplete and inadequate system of berms and tide gates, which is in need of extension, raising, and reinforcing, as it may not be able to withstand future tidal events, particularly in consideration of climate change and SLR.

A coastal storm surge event such as Hurricane Sandy is considered very infrequent. However, surge events can produce severe yet selective flooding as seen with Hurricane Sandy. Records show that the most important historical surges of interest in the Project Area occurred in 1821, 1938, 1944, 1954, 1955 (Connie), 1960 (Donna), 1971 (Doria), and 2012 (Sandy). **Table 3.4-1** presents important historical surges measured at the Battery, in nearby Lower Manhattan, NY, from 1926 to 2012. Hurricane Sandy significantly impacted the Project Area, highlighting deficiencies in the ability of the existing line of protection (LOP) to adequately protect vulnerable populations and critical infrastructure from flooding during major storm events. These impacts included extensive inland flooding due to major tidal surges with significant damage to residential and commercial properties; impacts to critical health care facilities; and the failure of critical power, transportation, and water and sewer infrastructure.

Table 3.4-1: Historical Hurricane Surges: Battery, NY

Date	Surge Height (feet NAVD 88)*
October 2012 (Sandy)	9.4
September 1960 (Donna)	5.3
September 1944**	5.0
August 1971 (Doria)	4.2
September 1938***	4.1
August 1954 (Carol)	3.1
August 1955 (Connie)	3.1

*Net surge, exclusive of predicted tide
**1944 Great Atlantic Hurricane
***New England Hurricane of 1938
Source: (NOAA 2017)

Extratropical cyclones, or nor'easters, are far more frequent in the area than hurricanes and may produce severe surges. Winds in the nor'easters blow in a direction that is conducive to surge generation along the 80 or 90 miles of continental shelf off New York Bight (FEMA 2014). **Table 3.4-2** presents important nor'easter surges nearby in Battery, NY, from 1926 to 1976.

Table 3.4-2: Historical Nor'easter Surges: Battery, NY

Date	Surge Height (feet NAVD 88)*
November 1950	8.5
November 1953	5.4
November 1932	5.3
December 1974	5.2
November 1968	5.0
February 1927	4.6
March 2010	4.4
December 1992	4.3

*Net surge, exclusive of predicted tide
Source: (NOAA 2017)

3.4.1 Existing Flood Protection System

Berms and Levees

Existing berms typically consist of raised ridges of earth that resulted from the historic excavation of drainage ditches as a mosquito control strategy to reduce the potential for standing water in low-lying areas. Earthen berms also reduce the potential for waters from high tides from reaching and ponding in the low-lying meadows. Between 1913 and the late 1970s, hundreds of miles of ditches were dug near the towns of Carlstadt, Little Ferry, and Moonachie.

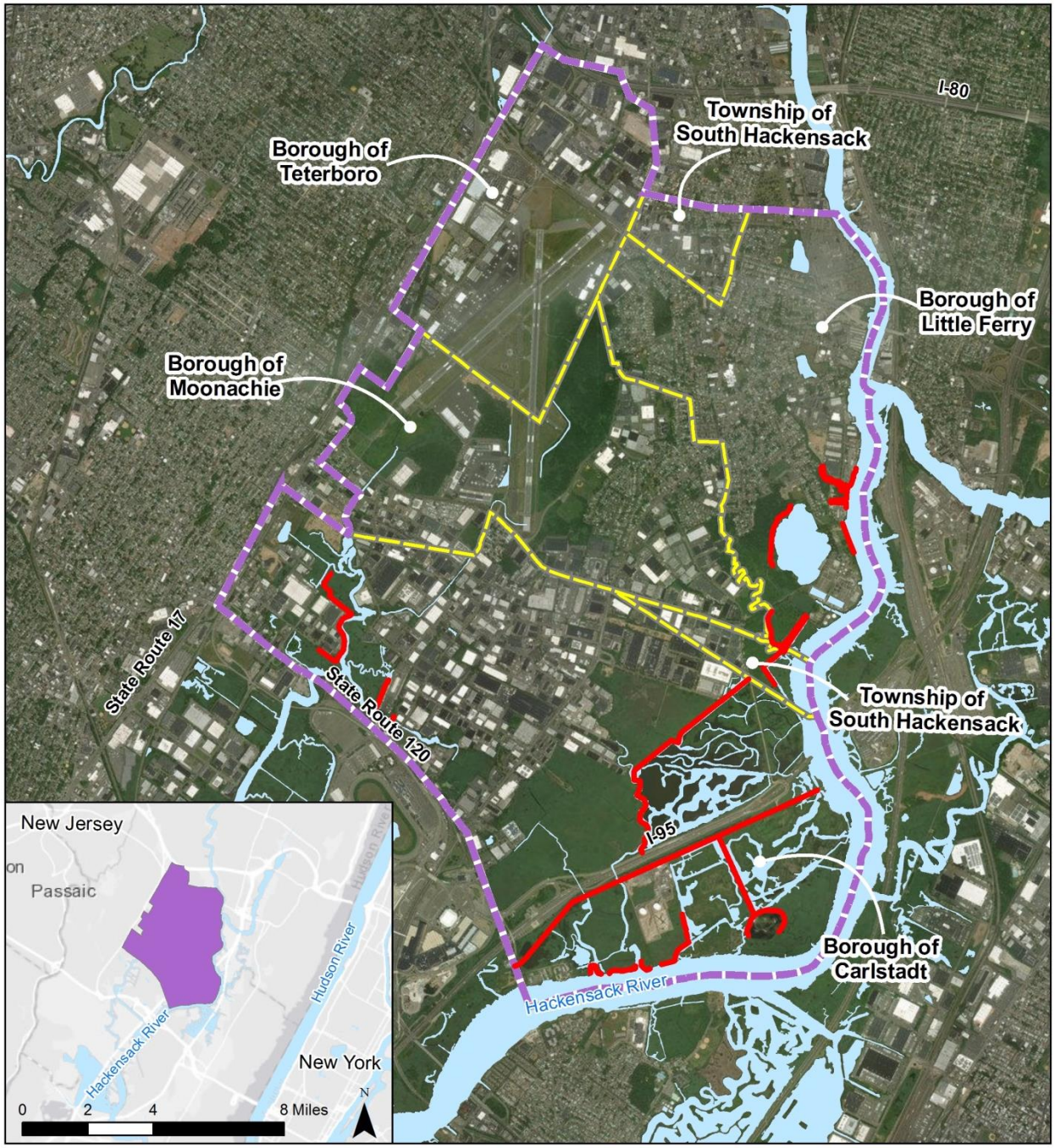
Many of the berms have settled or slumped, or were just constructed haphazardly. Until Hurricane Sandy, this berm system provided limited flood protection to the residential and industrial areas of these towns from the highest of the high tides, but offered only minor flood protection for larger events, typically less than a 10-year event. Hurricane Sandy's tidal surge measured 8.5 to 9.5 feet (NAVD 88) and overtopped all existing earthen berms in the Project Area (NJSEA 2013). **Figure 3.4-1** shows the existing berms and levees in the Project Area.

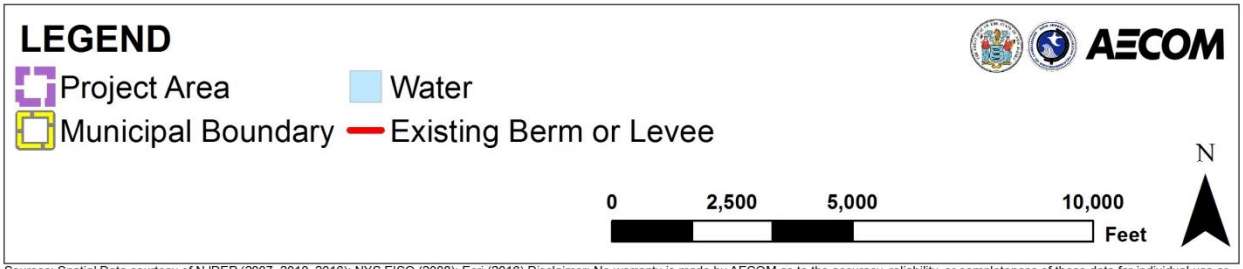
Pump Stations and Tide Gates

Existing flood protection features in the Boroughs of Teterboro, Little Ferry, Moonachie, and Carlstadt and the Township of South Hackensack include systems of tide gates, pump stations, and berms (see **Table 3.4-3**) (NJSEA 2006b). The berm adjacent to the Losen Slote pump station along the Hackensack River at the southern boundary of the Borough of Little Ferry is not of uniform height, nor is it continuous. This allows the tidal stages of the river to flood the characteristically low topographic areas of the borough (FEMA 2014). **Figure 3.1-4** shows the locations of existing flood protection pump stations and tide gates (Rutgers University 2007).

Table 3.4-3: Existing Pump Stations and Tide Gates in the Project Area

Municipality	Tide Gates & Top Elevation in feet (ft) (NAVD 88)	Pump Stations
Carlstadt	9 Tide Gates: East Riser (5.0 ft), Broad & 20th Street (not applicable (N/A)), Dell Road (3.11 ft), Waitex (5.33 ft), Peach Island Creek (3.05 ft), Yellow Freight (3.36 ft), Palmer Terrace (0.46 ft), Moonachie Creek (N/A), Bashes Creek (N/A)	None
Little Ferry	1 Tide Gate: DePeyster Creek (2.1-4.0 ft)	6 Pump Stations: Willow Lake (two 50 horsepower (hp) 5,500 gallons per minute (gpm) pumps in poor condition and in need of backup generator) DePeyster Creek (three 15 hp 1,100 gpm pumps in good working condition, but inadequate to handle a 25-year storm event), Main Street (two 8,000 gpm pumps) Losen Slote (three 150 hp 43,000 gpm pumps in excellent condition, but inadequate to handle a 25-year storm event) Pump Bay (details unavailable) Unnamed near Mehrhof Pond (details unavailable)
Moonachie	1 Tide Gate: West Riser (5.26 ft)	2 Pump Stations: Lincoln Place (two 6,000 gpm pumps in need of repairs, renovations, and backup generator) Burger King (details unavailable)
South Hackensack	1 Tide Gate: Losen Slote (9.6 ft)	None
Teterboro	1 Tide Gate: Teterboro (N/A)	2 Pump Stations: Teterboro (175 cfs total, four 6-feet diameter screw pumps in need of upgrade) Vincent Place (details unavailable)





Sources: Spatial Data courtesy of NJDEP (2007, 2010, 2016); NYS EISO (2008); Esri (2016) Disclaimer: No warranty is made by AECOM as to the accuracy, reliability, or completeness of these data for individual use or aggregate use with other data. This map is a "living document", in that it is intended to change as new data become available and is incorporated into the GIS database.

Figure 3.4-1: Existing Berms and Levees in the Project Area

Flooding from Tidal Surges

Figure 3.4-2 through **Figure 3.4-6** show the areas with the potential to flood because of storm surge in the Boroughs of Little Ferry, Teterboro, and Moonachie, the Township of South Hackensack, and the Borough of Carlstadt, respectively, when the storm surge elevation is 5 feet (NAVD 88). The NJSEA produced these maps in October 2013 factoring water control structures, such as tide gate, berms, dykes, and ditches, as well as hydraulic connectivity of sub-basins, into its analysis (NJSEA 2013a, NJSEA 2013b, NJSEA 2013c, NJSEA 2013d, NJSEA 2013e). These maps show the flooding that would occur if the surge persists long enough at the given elevation for the water to reach the predicted flood areas. Storm surge elevation of 5 feet (NAVD 88) is about a 8 to 9.5-year return period on the Hackensack River, depending on the river station (base year), and a 25-year recurrence for the Berry's Creek (base year).

Flood maps from the NJSEA showed potential flooding when the surge elevation is at 4 feet to 8 feet (NAVD 88) with 1-foot interval for the Borough of Carlstadt, the Borough of Moonachie, the Township of South Hackensack and the Borough of Teterboro. The Borough of Little Ferry's flood map was plotted at surge elevations 2 feet to 8 feet (NAVD 88). In general, flooding starts to occur in these areas when the surge elevation reaches about 5 feet (NAVD 88) even with the tide gates in place.

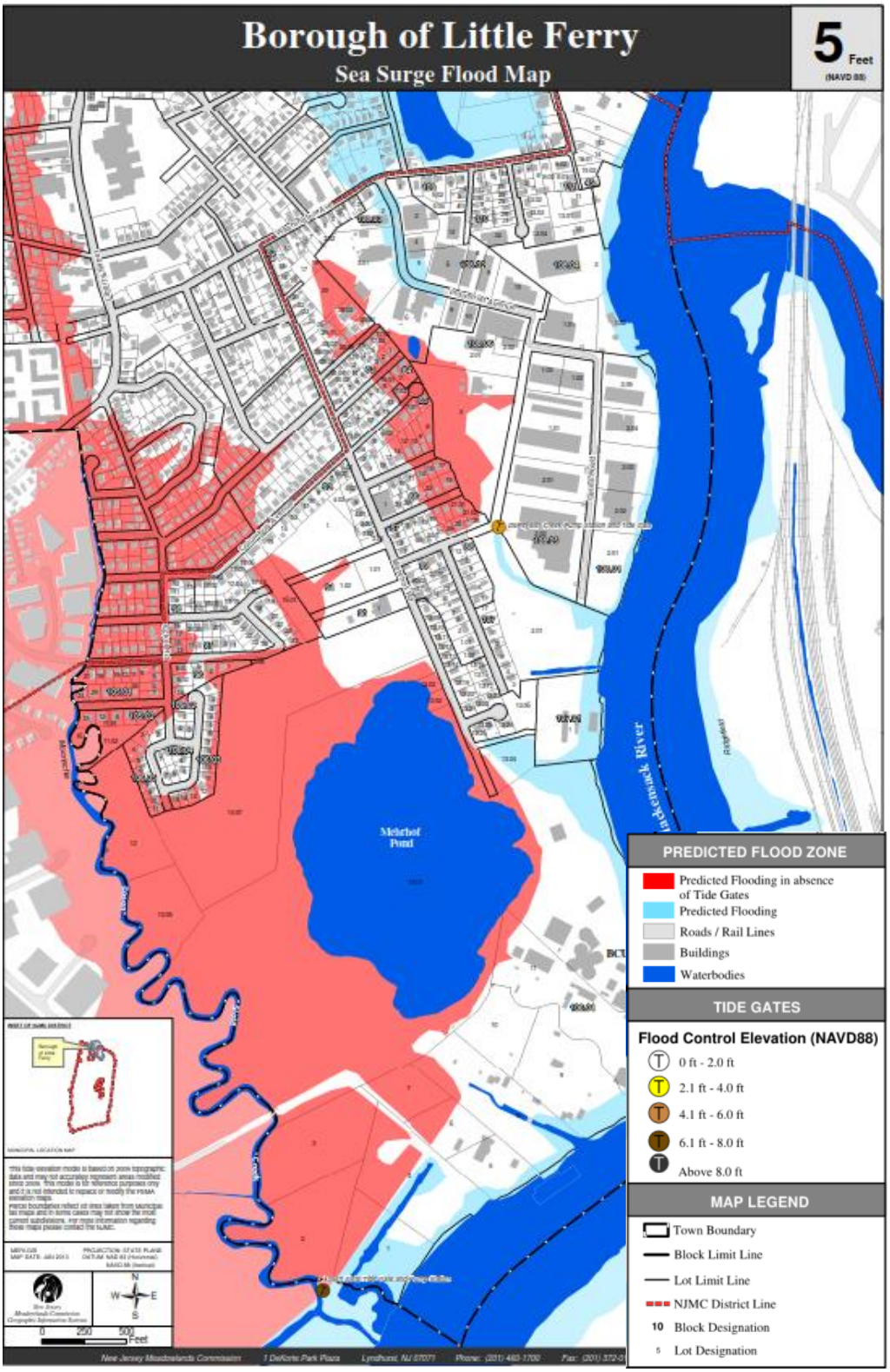


Figure 3.4-2: Predicted Storm Surge Flooding in the Borough of Little Ferry at 5 feet WSEL NAVD 88

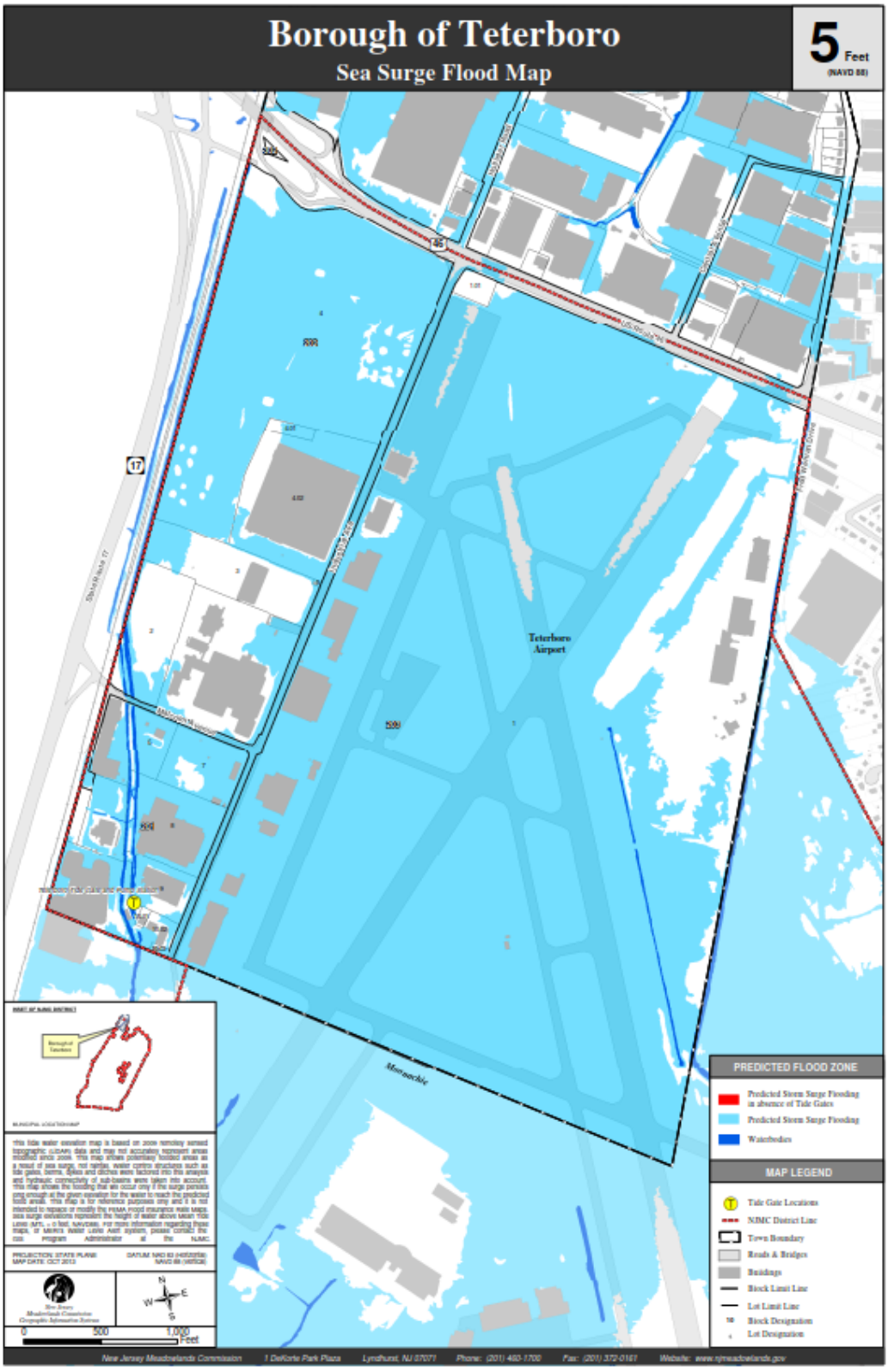


Figure 3.4-3: Predicted Storm Surge Flooding in the Borough of Teterboro at 5 feet WSEL NAVD 88

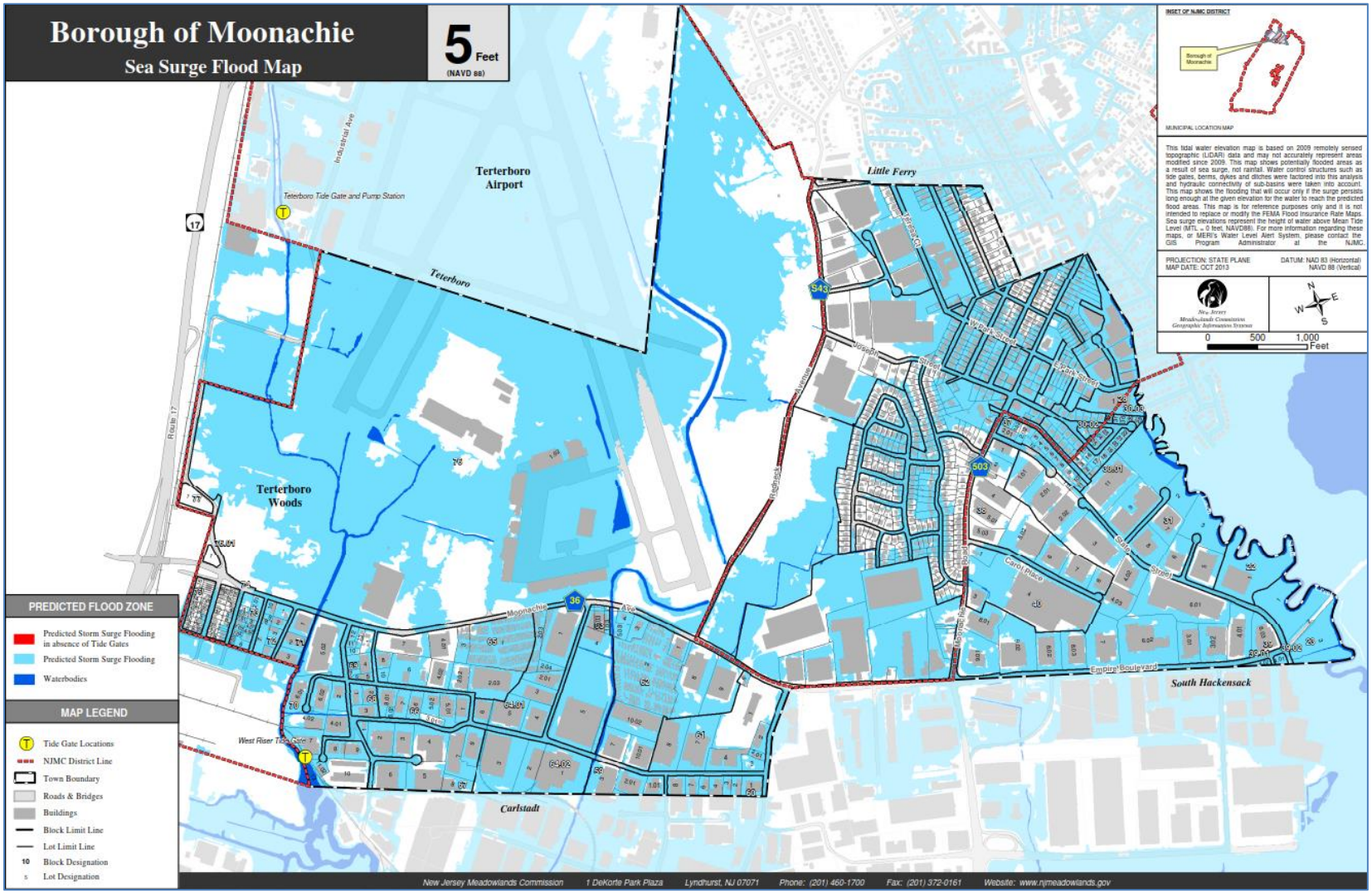


Figure 3.4-4: Predicted Storm Surge Flooding in the Borough of Moonachie at 5 feet WSEL NAVD 88

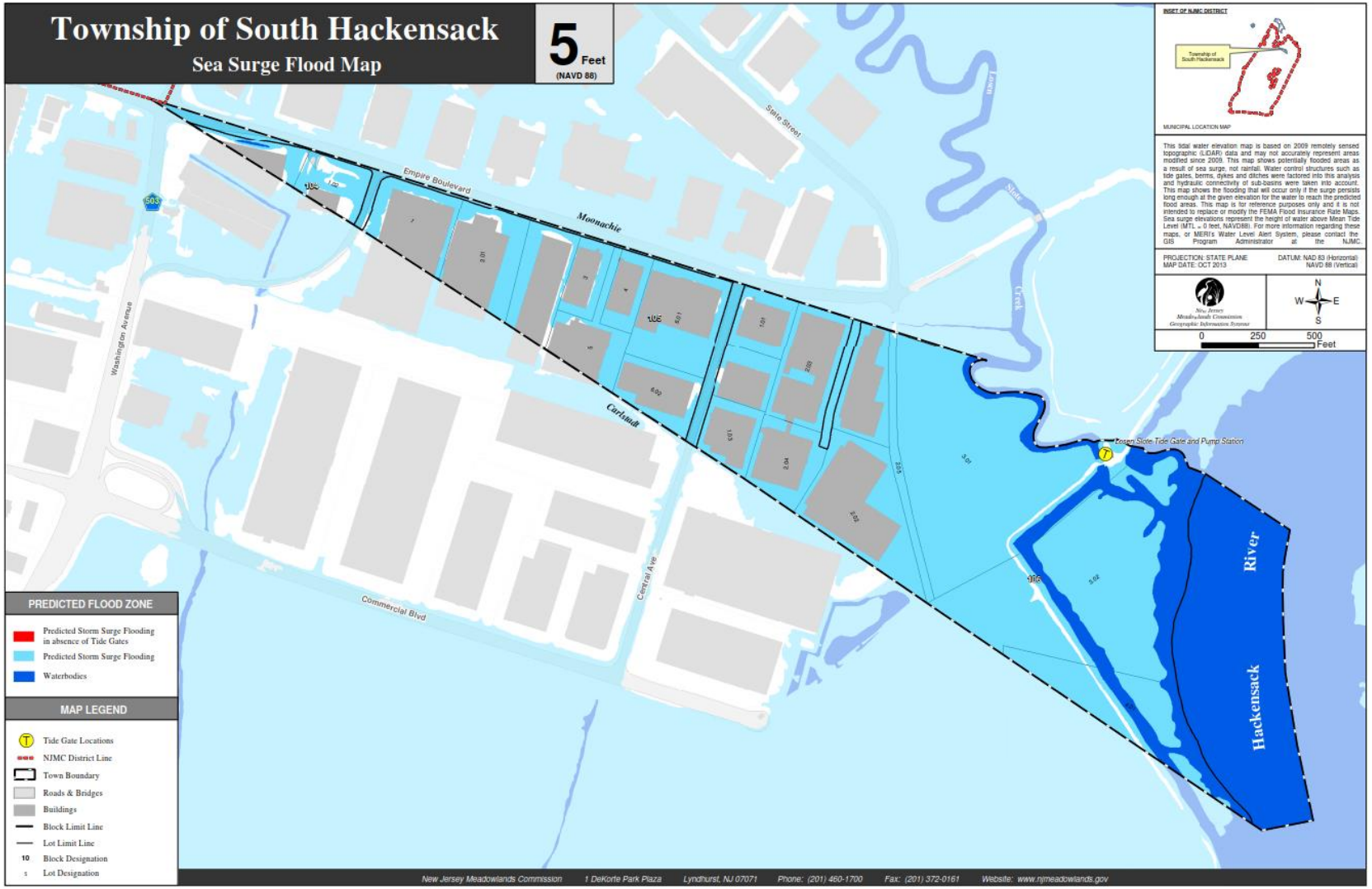


Figure 3.4-5: Predicted Storm Surge Flooding in the Township of South Hackensack at 5 feet WSEL NAVD 88

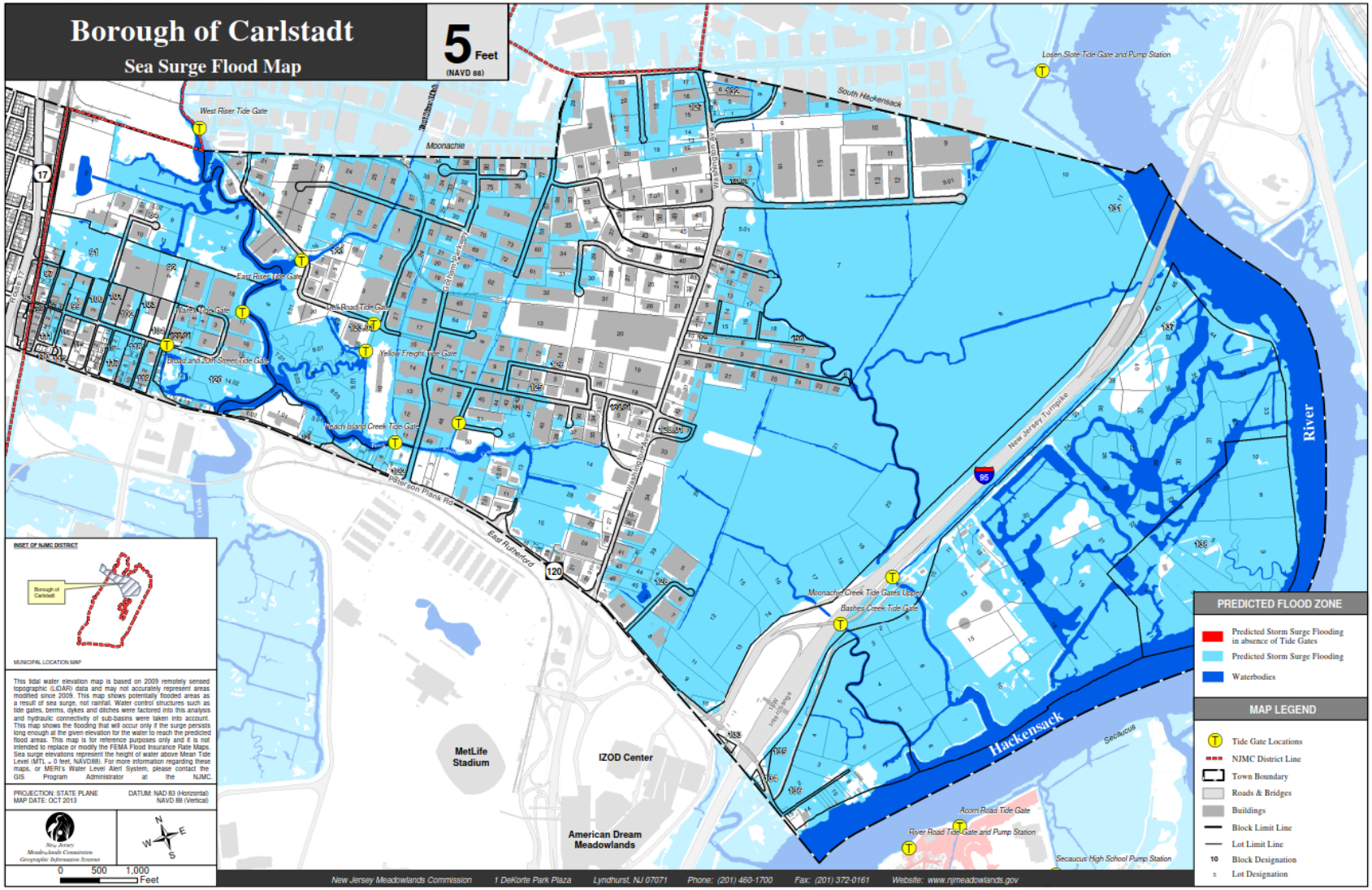


Figure 3.4-6: Predicted Storm Surge Flooding in the Borough of Carlstadt at 5 feet WSEL NAVD 88

3.4.2 Development and Assets at Risk from Coastal Storms

Table 3.4-4 compares FEMA's 2005 projected water surface elevations (WSELs) at different storm probabilities to FEMA's 2014 update. Using FEMA's 2014 update, a database of assets potentially at risk was developed by overlaying a GIS map delineating the FEMA 500-year floodplain (elevation 11 feet NAVD 88) and adding additional two feet to account for future sea level changes.[2] As shown in **Figure 3.4-7**, about 4,402 buildings were found to be below 13 feet NAVD 88. **Table 3.4-5** shows the number of buildings below various ground elevations and **Table 3.4-6** shows the number of buildings with WSELs above the ground and main floor under various events, based on the Hydrologic Engineering Center Flood Damage Reduction Analysis (HEC-FDA) model. "Ground" means the lowest grade adjacent to the structure and it is the first point at which rising floodwater would be expected to contact the exterior of the building. "Main floor" means the lowest level of finished interior space, which is at or above ground level. It is usually the primary living/working area. The main floor elevation is also the reference elevation for depth-damage relationships in the damage model.

Table 3.4-4: Existing Project Area Stage vs. Frequency

Annual Chance Event	FEMA Effective Water Surface Elevation (Feet NAVD 88; 2005)	FEMA Preliminary Water Surface Elevation (Feet NAVD 88; 2014)
10% (10-year)	5.6	5.0
2% (50-year)	7.0	7.0
1% (100-year)	7.7	8.1
0.2% (500-year)	8.1	11.0

Table 3.4-5: Number of Buildings in Each Municipality below Certain Ground Elevation

Municipality	Ground Elevation (Feet, NAVD 88)									
	< 6.00	6.00 - 6.99	7.00 - 7.99	8.00 - 8.99	9.00 - 9.99	10.00 - 10.99	11.00 - 11.99	12.00 - 12.99	>= 13.00	Total
Carlstadt	172	60	39	38	28	14	19	18	96	484
Hackensack	7	12	22	16	16	17	51	19	24	184
Little Ferry	1,122	407	246	138	84	32	32	15	58	2,134
Moonachie	932	214	68	6	3	3	1	0	0	1,227
South Hackensack	43	73	41	62	46	65	75	48	35	488
Teterboro	40	25	21	11	1	0	0	0	0	98
Total	**2,316**	**791**	**437**	**271**	**178**	**131**	**178**	**100**	**213**	**4,615**

[2] Note: As discussed in **Section 4.1.1**, the NOAA Intermediate Low curves predict 1.2 feet rise by the year 2075 and the NOAA Intermediate High curves predict 2.4 feet rise by the year 2075.

Table 3.4-6: Number of Buildings in Each Municipality with Water Surface above Ground and Main Floor

Municipality	Flood Impact	Frequency of Event							
		2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	250-Year	500-Year
Carlstadt	> Ground	26	67	95	124	229	269	313	338
	> Main Floor	22	59	85	113	211	247	286	308
Little Ferry	> Ground	68	144	571	1,257	1,571	1,796	1,977	2,034
	> Main Floor	7	17	67	190	345	524	879	1,283
Moonachie	> Ground	189	437	627	805	1,148	1,215	1,221	1,225
	> Main Floor	15	45	79	139	460	700	894	1,002
South Hackensack	> Ground	1	4	12	45	118	162	241	332
	> Main Floor	1	4	11	19	46	73	100	158
Teterboro	> Ground	1	10	17	18	62	82	97	98
	> Main Floor	1	9	13	14	47	65	80	89
Hackensack	> Ground	0	0	2	7	21	43	70	111
	> Main Floor	0	0	0	5	8	15	26	38

Figure 3.4-8 presents the 100-year floodplain (i.e., the area with a 1 percent chance of being inundated within any given year) and the 500-year floodplain (i.e., the area with a 0.2 percent chance of being inundated within any given year) boundaries for the Project Area. As shown on **Figure 3.4-8**, over 90 percent of the Project Area is within the 100-year floodplain created by coastal surge. Based on an examination of the Preliminary Flood Insurance Rate Maps for the Project Area, the 100-year flood elevation is 8 feet (NAVD 88) (FEMA 2014).

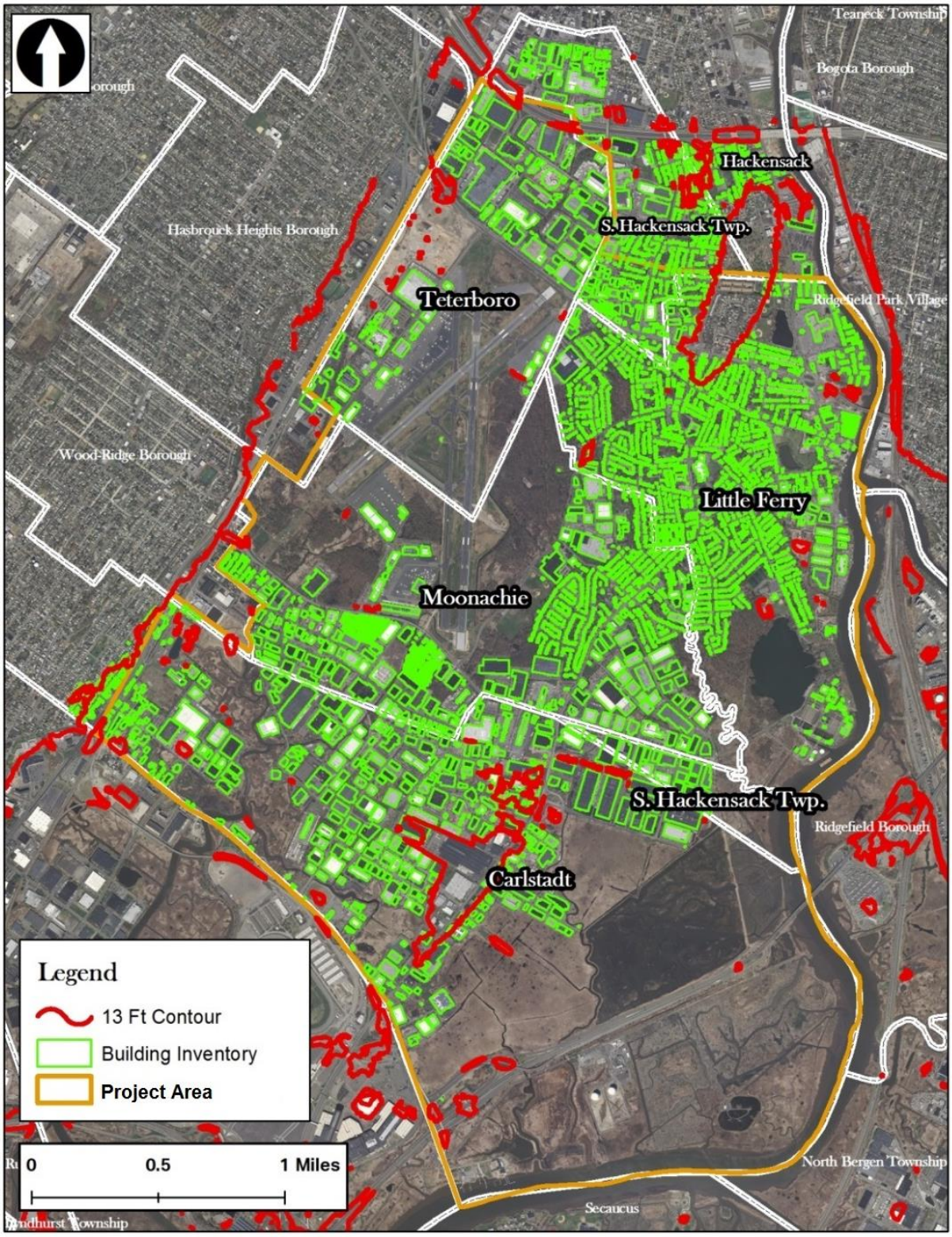
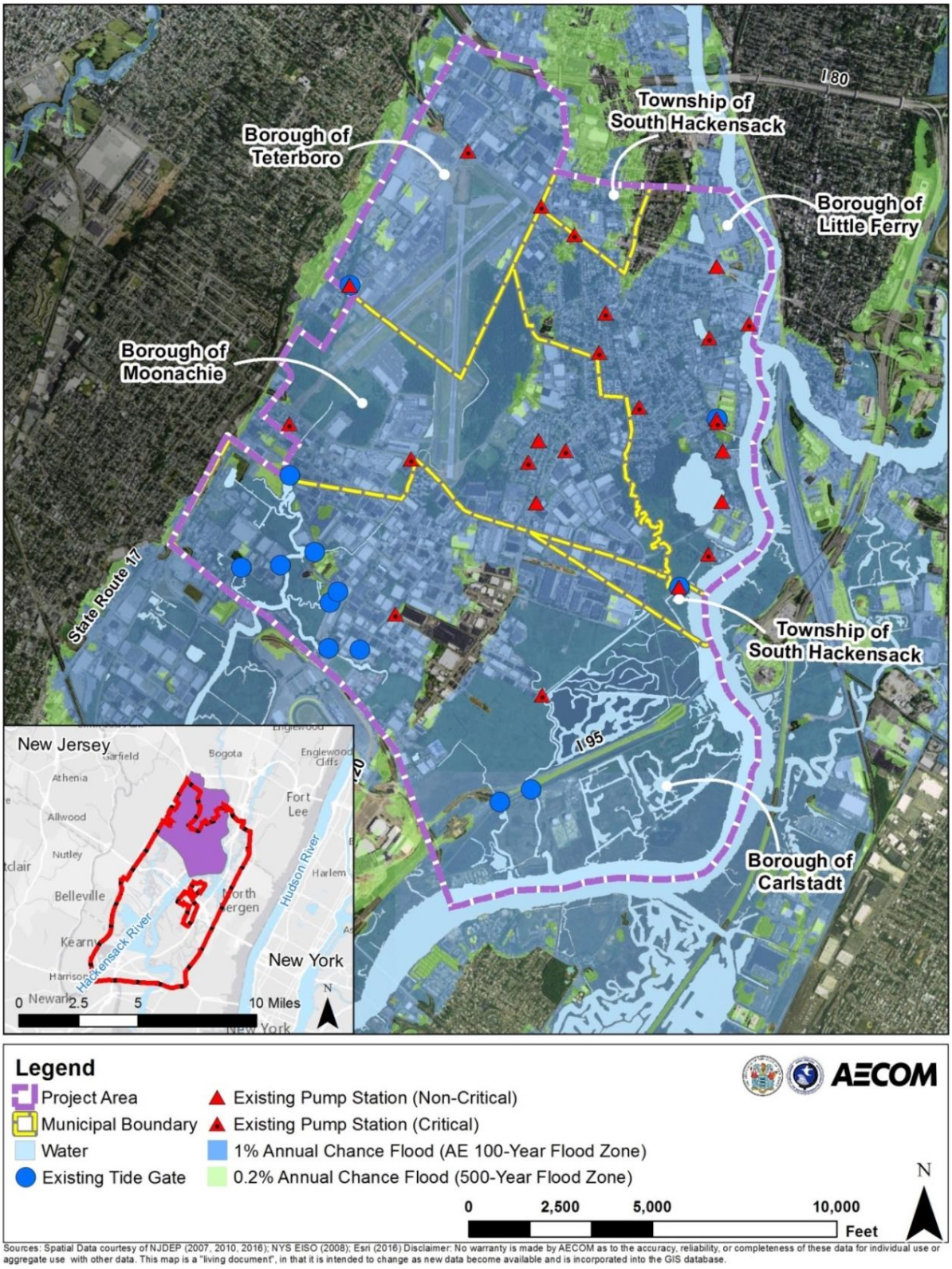


Figure 3.4-7: Inventory of Buildings below 13 feet NAVD 88 (500-year flood stage plus 2 feet)



Sources: Spatial Data courtesy of NJDEP (2007, 2010, 2016); NYS EISO (2008); Esri (2016) Disclaimer: No warranty is made by AECOM as to the accuracy, reliability, or completeness of these data for individual use or aggregate use with other data. This map is a "living document", in that it is intended to change as new data become available and is incorporated into the GIS database.

Figure 3.4-8: Floodplains in the Project Area

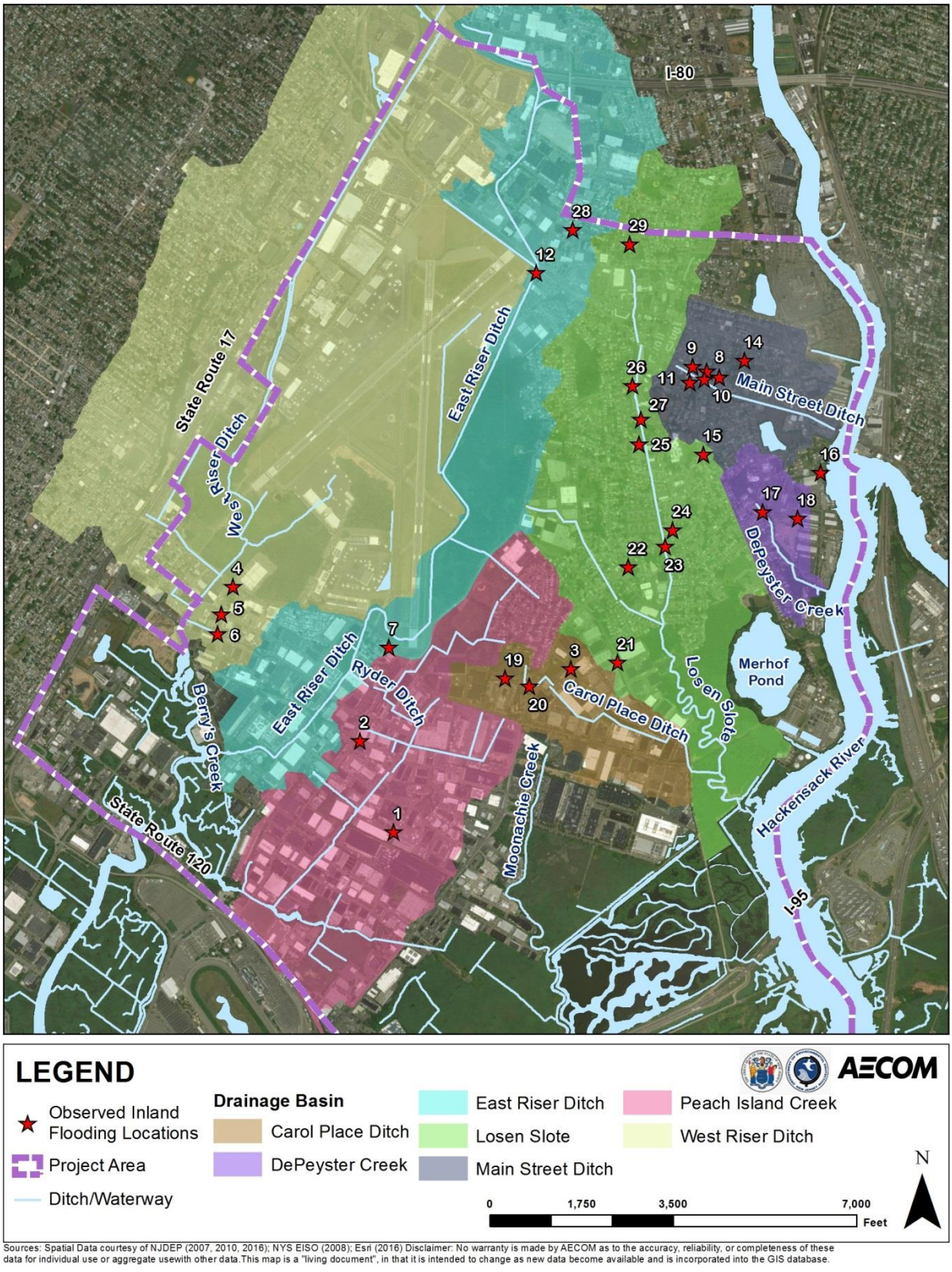
3.4.3 Hydrology and Fluvial Flooding

The relatively flat Project Area topography and low elevations relative to normal tidal conditions combine with a network of inadequate drainage systems to generate chronic fluvial flooding caused by frequent, low magnitude rainfall events (see **Section 1.1**, **Section 2.1**, and **Section 3.1.1**). **Figure 3.4-9** shows 29 locations spread over the Project Area where such flooding has been documented. Pictures of the flooding at a few example locations are shown in **Figure 3.4-10** through **Figure 3.4-14**. Rainfall characteristics for these events are shown in **Table 3.4-7**. Note that a number of rainfalls are very low magnitude events and most are less intense than the 5-year event. This information was used to validate the reasonableness of flooding elevations predicted by the fluvial models developed for the Proposed Project. Modeling results are provided in **Subappendix B6, B7, and B8**.

Reasons for flooding could vary from location to location, and could be a combination of problems. For example, flooding at locations #4 and #7 may be caused by the long duration heavy rainfall in conjunction with the high water level in the nearby West and East Riser Ditches, due to the high tide level. Flooding at locations #8 through #11 could be because of a clogged curb drainage inlet and a full stormwater sewer under Main Street. Flooding at location #19 may be because of the high water level in the nearby Carol Place Ditch due to high tide, and flooding at location #24 could be the result of long duration, high intensity rainfall overwhelming the drainage system in the area.

Table 3.4-7: Rainfall Characteristics for the Observed Flooding

Date	Storm Duration	Total Precipitation	Return Frequency	Maximum Intensity	Return Frequency	Peak Tide Level	Flooding Locations
	(hours)	(inches)	(years)	(inches/hour)	(years)	(feet NAVD 88)	
6/10/2005	24	1.08	<1	0.64	<1	2.52	#1
7/8/2005	3	1.42	<1	0.41	<1	3.12	#2
10/12/2005	24	3.83	2–5	0.55	<1	4.84	#3
10/14/2005	77	7.14	10–25	0.55	<1	4.84	#4–7
8/31/2014	6	0.77	<1	0.74	<1	2.55	#8–11
4/6/2017	13	0.83	<1	0.44	<1	4.28	#12–19
5/5/2017	24	3.36	2–5	1.22	1–2	0.88	#20–29



Sources: Spatial Data courtesy of NJDEP (2007, 2010, 2016); NYS EISO (2008); Esri (2016) Disclaimer: No warranty is made by AECOM as to the accuracy, reliability, or completeness of these data for individual use or aggregate usewith other data.This map is a "living document", in that it is intended to change as new data become available and is incorporated into the GIS database.

Figure 3.4-9: Map of Observed Flooding Locations in the Project Area for Calibration



Figure 3.4-10: Observed Flooding at the Intersection of Grand St and Moonachie Ave in Moonachie
(Location #4, 10/14/2005, Total Rain 7.14 inches, Max Intensity 0.55 inch/hour)



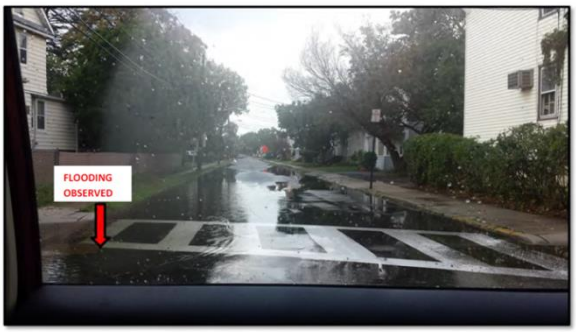
Figure 3.4-11: Observed Flooding near the Mobile Home Area Close to East Riser Ditch in Moonachie
(Location #7, 10/14/2005, Total Rain 7.14 inches, Max Intensity 0.55 inch/hour)



Observation #8 Figure 1: Flooding Observed on Brandt Street after Aug 31, 2014 Rainfall Event



Observation #9 Figure 2: Flooding Observed on Garden Street after Aug 31, 2014 Rainfall Event



Observation #10 Figure 2: Flooding Observed on Grand Street after Aug 31, 2014 Rainfall Event



Observation #11 Figure 3: Flooding Observed on John Street after Aug 31, 2014 Rainfall Event

Figure 3.4-12: Observed Flooding in Little Ferry
(Location #8-11, 8/31/2014 Total Rain 0.77 inches, Max Intensity 0.74 inch/hour)

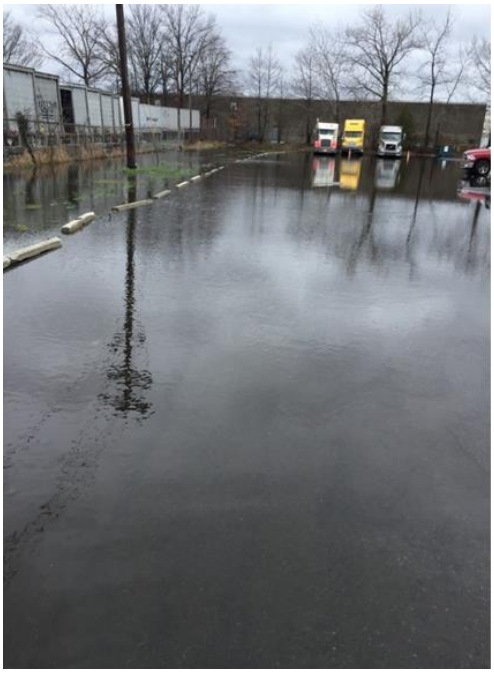




Figure 3.4-13: Observed Flooding in the Parking Lot off Washington Pl in Moonachie
(Location #19, 4/6/2017, Total Rain 0.83 inches, Max Intensity 0.44 inch/hour)



Figure 3.4-14: Observed Flooding on Eckel Rd in Little Ferry
(Location #24, 5/5/2017, Total Rain 3.36 inches, Max Intensity 1.22 inch/hour)

4.0 Future Conditions with No Action Alternative

The No Action Alternative assumes that the Proposed Project would not be implemented and current conditions and operations would generally continue in the Project Area. Under the No Action Alternative, the Purpose and Need for the Proposed Project would not be met. Flood protection measures under this alternative would generally be limited to the O&M of existing infrastructure. The No Action Alternative provides a comparative baseline analysis to compare the effectiveness of the alternatives for the Proposed Project within the Project Area under various coastal storm surge and rainfall events.

Anticipated future conditions within the Project Area without implementation of the Proposed Project include the following:

- Continued coastal flooding from tidal storm surges during severe coastal storm events;
- Continued inland flooding during heavy rainfall events due to local stormwater drainage problems; and
- Increased exposure to the effects of climate change and sea level change, with an anticipated 1.2- to 2.4-foot rise in relative sea level by the year 2075.[3]

4.1 Physical Conditions

4.1.1 Sea Level Change

Rising sea levels and climate change are expected to have a significant effect on the Project Area during the 50-year period of analysis. Impacts would likely include increased frequency and magnitude of storm-related flooding, temperature changes, and saltwater intrusion into the estuaries and aquifers (USEPA 2009). Relative sea level change would not only inundate larger coastal areas, but would also be a driver of changes in habitat and species distribution, as would other effects of climate changes, such as increased sea surface temperatures.

Global mean sea level change over the past several thousand years is a result of the inter-glacial warming period that followed the last ice age as is typical of previous glacial-interglacial cycles throughout the Earth's long history. Due to limited water level records it is not possible to know the exact historical rates of global sea level change; however, it is very likely that the rate of global SLR has accelerated dramatically over the 20th century. This acceleration period has caused the rate of global mean sea level change to increase from approximately +1.5 millimeters (0.0049 feet) per year from 1901 to 1990 to +2.8 mm (0.0092 ft) per year from 1993 to 2010 (IPCC 2007, IPCC 2013). The global mean sea level change rate is expected to accelerate further over the next century due to increases in ocean water temperatures (thermal expansion) and the rate of polar ice loss (IPCC 2014). Local/regional land uplift (rise) and subsidence (fall) can contribute to higher or lower local relative sea level change.

For the purposes of this Feasibility Study, gauge readings from a tide station in Battery, NY are used because it is the most proximate available data for the Project Area. Because the Project Area is located along an upstream section of a river and the Battery tide station is located directly along Upper New York Bay, the changes experienced in the Project Area could be somewhat less compared to the Battery tide

[3] NOAA Intermediate-Low / USACE Intermediate (Modified National Research Council Curve III) predicts 1.2 feet rise by the year 2075; NOAA Intermediate-High predicts 2.4 feet rise by the year 2075 for the Battery, NY tidal gauge.

station. The historical increase in sea level, based on Battery, NY gauge readings, has been about 0.013 feet per year. If sea level were to continue to rise at this rate, there would be a baseline increase of about 0.7 feet by 2075. However, NOAA, USACE, and others have identified the potential for accelerated SLR in the future. Projections are regularly updated to reflect improved estimates of land ice melt and other factors that contribute to global and local sea level change. For the purposes of this study, two sea level change scenarios have been identified for incorporation into the analyses (NOAA 2012)[4]:

- NOAA Intermediate-Low / USACE Intermediate (Modified National Research Council Curve III) predicts 1.2 feet rise by the year 2075; and
- NOAA Intermediate-High predicts 2.4 feet rise by the year 2075.

Under current sea level conditions, the existing protection features have an approximately 10 percent annual chance of being overtopped or flanked. If expressed as the "return period of the overtopping flood event in years," the level of protection is about 10 years. This risk would increase dramatically in response to future projected sea level change. In other words, the level of protection from the existing protection features would decrease over time as the sea level rises if no improvement is made to the existing flood protection system.

Future condition damages are based on 1.2 feet SLR at Battery, NY. The impact of SLR on coastal stage frequency relationships is presented in **Figure 4.1-1**. Storm surge simulations with and without SLR indicates that a 1.2-foot increase in sea level would result in approximately a 0.8-foot increase in peak storm surge elevations[5]. Similarly, a 2.4-foot SLR would result in approximately a 1.6-foot increase in peak storm surge elevations. In a low intermediate sea level change scenario of 1.2 feet rise at Battery Park over 50 years, the annual probability of exceeding the existing protection increases from approximately 10 percent or 10 years to approximately 25 percent, or 4 years as shown in **Figure 4.1-1**. Assuming an intermediate-high sea level change scenario of 2.4 feet rise at Battery over 50 years, the annual probability of exceeding the existing protection increases from approximately 10 percent or 10 years to approximately 100 percent, or 1 year.

It should be noted that only a limited number of storms were selected for simulation and those storms each represented a unique combination of storm surge and tide conditions. Actual future storms could present other combinations of storm surge and astronomic tides, which could result in different flood responses (e.g. a storm with an extremely long duration could result in higher flood elevations in the Project Area relative to Bergen Point than reflected in the current simulations).

[4] NOAA sea level change estimates were updated in 2017; however, the analyses for this project are based on the 2012 values that were available at the time when the project commenced.

[5] Hydrodynamic models of the area indicate that there is not a linear response in storm surge levels; rather, surges are dampened as water comes into the Meadowlands due to temporal and spatial effect. Dynamic modeling indicates that a 1.2-foot increase in sea level results in an increase of peak storm surge elevations at the Project Area on the order of 0.8 foot.

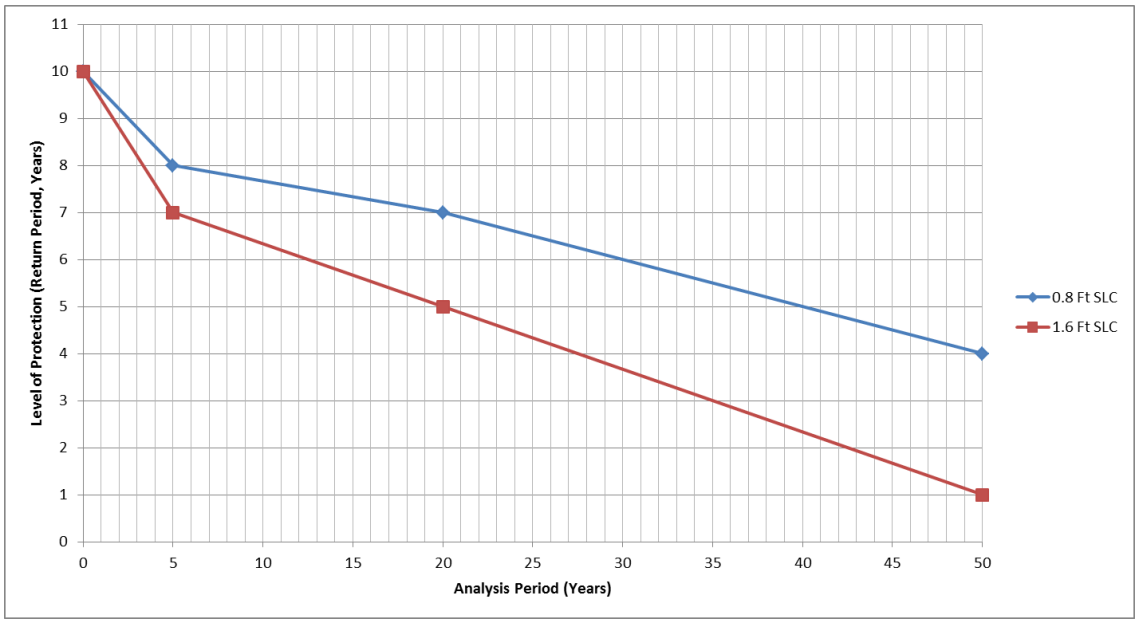


Figure 4.1-1: Change in Level of Protection over Time (No Action Alternative)

4.1.2 Precipitation and Storm Events

Historically, precipitation in the Project Area has averaged about 41 inches per year, with pronounced year-to-year variation. Because of climate change, precipitation and runoff are expected to increase in the northeast with increases in extreme events. However, there is considerable uncertainty with respect to magnitude of change from the baseline, as well as seasonality of the change. Since 1998, the State of New Jersey has experienced a string of extreme events, which include:

- Major floods in 1999, 2004, 2006, 2007, 2010, 2011, and 2012;
- The snowiest February (2010), January (2013), and October (2011) of record; and
- Eight of the 10 warmest summers since 1999.

Table 4.1-1 shows results from analyses completed by the New York City Panel on Climate Change (NPCC).

Table 4.1-1: NPCC Projected Seasonal Precipitation Changes

	Low Estimate (10th percentile)	Middle range (25th to 75th percentile)	High estimate (90th percentile)
2020s			
Winter	-3%	+1% to +12%	+20%
Spring	-3%	+1% to +9%	+15%
Summer	-5%	-1% to +11%	+15%
Fall	-5%	-2% to +7%	+10%
2050s			

Winter	+2%	+7% to +18%	+24%
Spring	-1%	+3% to +12%	+18%
Summer	-9%	-5% to +11%	+18%
Fall	-2%	+1% to +10%	+14%
2080s			
Winter	+4%	+10% to +25%	+33%
Spring	-1%	+4% to +15%	+21%
Summer	-10%	-5% to +18%	+23%
Fall	-7%	-1% to +11%	+18%

4.1.3 Topography, Soils, and Bedrock

Increased flooding within the Project Area could cause land subsidence. During excessive wetting of previously dry soils, soil can settle, resulting in land subsidence known as hydrocompaction. Land subsidence (in the form of hydrocompaction) leads to a decline in the structural stability of soils, which results in reduced soil strength and issues with foundation support. Additionally, as storm and flood events become more frequent, moderate to substantial soil erosion could be expected within the Project Area. Increased erosion could further lead to an increase in the amounts of sediments, nutrients, and contaminants within waterbodies or a change in topography.

4.1.4 Drainage Systems

Under the No Action Alternative, impacts to drainage systems would be expected to result from coastal storm surges and inland flooding from the Hackensack River, Berry's Creek, and associated ditches during substantial storm events. The existing inadequate stormwater drainage would result in inland flooding during instances of coastal storm surges. Drainage systems are also susceptible to damage or disruption during severe flood events. However, the magnitude of impacts would depend on the precise circumstances of each situation, including the location and severity of the stormwater drainage issues and the type and durability of the systems present in those locations.

4.1.5 Utilities

As described above in **Section 4.1.4**, the existing inadequate stormwater drainage would result in inland flooding, which could in turn lead to increased utility damages and disruptions. Flood events can damage and/or inhibit operations of both above-ground and underground infrastructure. Damaged infrastructure would result in increased repair costs for the utility providers, which would in turn be paid by consumers via their regular bills. Additionally, delivery of utility services would also be substantially disrupted both during and after large flood events.

4.1.5.1 BCUA LFWPCF

Under the No Action Alternative, future flood events could damage and/or inhibit operations of the BCUA LFWPCF. BCUA's LFWPCF is located in the Borough of Little Ferry and surrounded on all sides by flood risk. The entire facility exists below the 500-year flood elevation of 10.9 feet NAVD88 with much of the facility below the 100-year flood elevation of 7.9 feet NAVD88. The facility first experiences flood impacts below the 10-year recurrence interval; service loss is first experienced at the 25-year recurrence interval,

and every system on site would experience inundation at 10.25 feet, just below the 200-year recurrence interval. Under the NOAA Intermediate-High scenario, 2.4 feet of SLR would begin to encroach upon the LFWPCF property. For example, the plant was impacted during Hurricane Sandy. Within 24 hours of the storm making landfall, water from the Hackensack River and overflowing lagoon came into the plant and flooded more than 15 structures and component locations. In response, flood hazard mitigation plans that were considered by the plant included protecting critical facilities by installing flood resistant doors/ barricades and dry flood proofing walls, raising room access, replacing pumps, installing new electrical assets, and other related efforts. Flood hazard mitigation plans would be expected to be implemented in response to any future flood events.

4.1.6 Waterfront Structures

Under the No Action Alternative, future flood events could damage waterfront structures. As discussed in **Section 3.1.7**, approximately 48 percent of the existing structures are already in critical to poor condition. Damage from potential future flood events would be expected to increase the deterioration of waterfront structures, and consequently decrease their general condition assessment rating (as described in **Section 3.1.7**).

4.2 Environmental Conditions

This section analyzes the future environmental conditions within the Project Area under the No Action Alternative. As described in the previous section, without implementation of the Proposed Project, tidal storm surges during severe coastal storms, continued flooding during heavy rainfall events, and increased exposure to the effects of climate change and sea level change would continue to impact environmental conditions within the Project Area.

Future development and progress in the cleanup of the hazardous waste sites discussed in **Section 3.2** would also impact the future environmental conditions within the Project Area under the No Action Alternative.

4.2.1 Water and Sediment Quality

This section includes an analysis of the No Action Alternative impacts on surface water, sediments, and groundwater.

As a result of the No Action Alternative, surface water quantity would be expected to increase in the Project Area due to anticipated impacts of SLR on the tidal regime. Surface water flow would also change as watercourses in the Project Area would receive more tidal flows and increased stormwater runoff from expected higher intensity, more frequent precipitation events. Surface water quality would permanently change from the baseline condition as the tidal influence extends farther inland and salinity levels increase, which would reduce the quantity/availability of freshwater. Water quality would also be adversely impacted over the long-term by increased coastal and inland flooding. The expected increased frequency of coastal flooding would impact water quality during storm events by increasing pollutant loading, contaminant transport, and sediment transport. As described in **Section 3.2.2**, waterways (i.e., creeks) in the Project Area are characterized by high levels of contamination in the sediments. Under the No Action Alternative, sedimentation could lead to the release of contaminated sediment into the waterways and to downstream areas outside the Project Area.

Additionally, as a result of the No Action Alternative, groundwater flow, quantity, and quality would permanently change in parts of the Project Area that are exposed to increased tidal inundation as a result of SLR. Groundwater in these areas could become more saline as the tidal regime influences flow within the shallow groundwater aquifer.

4.2.2 Wetlands

As a result of the No Action Alternative, the projected increase in sea level could cause long-term changes to the areal extent and types of wetlands in the Project Area. As sea level rises and the tidal influence extends farther inland, existing tidal wetlands could be converted to unvegetated tidal flats and open water, and existing freshwater wetlands would be converted to tidal wetlands if existing berms are overtopped. These changes to wetland types would permanently alter the functions and services provided by these wetlands, including the quantity and quality of habitats. Additionally, as a result of the increased frequency and intensity of coastal and inland flooding, wetland resources would be permanently impacted from increased shoreline erosion. Increased shoreline erosion would lead to potentially significant impacts to water resources as sediment containing contaminants and nutrients could be mobilized to surface waters and reduce water quality.

Undeveloped uplands adjacent to tidal or freshwater wetlands could convert to wetland habitats, depending on topography. However, net acreage changes to tidal and freshwater wetlands would likely overall be negative, since, in developed urban areas, natural shorelines landward of coastal marshes are rare, and marshes are unable to retreat (Titus, et al. 2009). It is anticipated that the existing wetlands would continue to be protected and that the managed wetland banks would continue to be maintained under the No Action Alternative.

4.2.3 Biological Resources

This section includes an analysis of the No Action Alternative impacts on terrestrial and aquatic resources, including EFH and Federal and State engendered species and species of concern.

Under the No Action Alternative, flooding within the Project Area would be expected to continue to, and increasingly, have impacts on biological resources. Even without projected SLR, low-lying open space in the Project Area along Berry's Creek and the Hackensack River is expected to flood more often during more frequent and intense storm events. Open areas, including extensive salt marshes and wetlands that are ecologically important to the Meadowlands District, flood under current conditions and would continue to be flooded with deeper water under the projected SLR scenarios, exacerbating chronic, incremental shoreline erosion and flooding of terrestrial and aquatic environments located along shorelines and low-lying, flood-prone areas.

As the water levels rise, the marshes would not be able to retreat inland due to the existing hard shoreline infrastructure and would turn into open water habitat. Additionally, shoreline erosion would gradually reduce habitat for shoreline and edge-dwelling wildlife. Chronic erosion would increase turbidity in the Hackensack River and its tributaries, further degrading natural systems.

In the absence of effective flood protection structures, severe storm events in the region would continue to result in impacts to biological resources, such as loss of wetlands and other habitats that contribute to regional biodiversity and ecosystem resiliency. These impacts would vary in intensity over time as the sea level is anticipated to rise and the severity of coastal storms is anticipated to increase.

4.2.4 Hazards and Hazardous Materials

Under the No Action Alternative, a large portion of the BCSA would be inundated during a 50-year storm event under both NOAA SLR scenarios. Further, Superfund sites in the Project Area and numerous KCS sites would be inundated as well. Long-term or permanent inundation of contaminated sites could severely limit the feasibility of conducting remediation investigations and actions. Continued and increased flooding could lead to contaminants being carried off contaminated sites or new contaminants being introduced within existing sites. Flooding has the potential to increase the erosion of protective caps, damaging the remedy and transporting contaminants off-site. Further, shoreline erosion and sedimentation could lead to the release of contaminated sediment into the waterways and to downstream areas outside the Project Area.

4.3 Social and Economic Conditions

4.3.1 Socioeconomics and Community/Populations

This section includes an analysis of the No Action Alternative impacts on social and economic conditions, including population, demographics, labor force, employment, businesses, and income and poverty.

Under the No Action Alternative, increased flooding of the Project Area in the future could significantly damage residential and commercial properties, impact health care facilities, and disrupt critical power, transportation, water, and sewer infrastructure. These impacts have the potential to significantly adversely affect the community character and change the demographic, housing, and employment conditions of the Project Area and its residents. Increased future flooding in the area may lead to both temporary and permanent displacement and relocation of persons affected by the event. Some individuals could decide to permanently relocate outside the Project Area, potentially shifting the population numbers and demographic profiles of the communities affected. Closure of businesses during flooding events could lead to a loss of jobs and incomes, as well as increased levels of underemployment and unemployment. These, in turn, would affect the quality of life for persons in the Project Area. Finally, potentially reduced population levels and property values could subsequently reduce tax revenue for the municipalities, further impacting their ability to provide services to residents.

4.3.2 Low- and Moderate-Income Populations

Based on the locations of LMI persons within the Project Area at this point in time, a large portion of the area with LMI persons has the potential for increased flooding in the future under the No Action Alternative (see **Figure 3.3-2**).

Ongoing and increased flooding within the Project Area may increasingly affect properties either owned or rented by low-income and minority persons. Additionally, businesses that have low-income and minority persons as part of their workforce would also experience potentially adverse impacts that would affect the standard of living and quality of life of such persons in the Project Area. Therefore, any long-term damage to these assets has the potential to adversely affect the community character for minority, low-income, and LMI persons and adversely change their demographic, housing, and employment conditions.

Low-income individuals are more vulnerable to disruptions of their livelihoods, employment, and negative health effects associated with flooding; therefore, the No Action Alternative has the potential to adversely affect these populations significantly and disproportionately as compared to other sections of society.

4.3.3 Land Use, Zoning, and Development

Continued development is expected to occur in the floodplain, subject to Federal, State and District requirements with regard to floodplain storage. Small residences would continue to be displaced by larger new homes and townhouses, and vacant areas would come under increasing pressure to be developed as the local population continues to increase. Under the No Action Alternative, continued and increased flooding within the Project Area could lead to increased property damage, flood-related costs, or other hazards that could reduce the ability of property owners to use the land for its existing or intended purpose. Compounded with the continued development, this could lead to substantial changes in the existing land use types within the Project Area, and necessitate substantial changes in zoning and land use planning.

4.3.4 Development Plans

A number of development projects are planned in the Project Area. **Table 4.3-1** summarizes the types of projects planned by municipality. Descriptions of each project are provided in the following sections.

Table 4.3-1: Planned Project Types by Municipality

Project Type	Little Ferry	Moonachie	Carlstadt	Teterboro	South Hackensack
Improvements to Ditches, Tide Gates, and Pumping Stations	x	x			
Transportation Projects, involving Drainage Improvements		x	x		
Wetland Mitigation Projects			x	x	
Redevelopment and Rezoning Local to Project Area			x		x
Improvements to Utility Systems	x		x		
Teterboro Airport Improvements				x	
Industrial Building Construction			x		
Transportation Projects, without Specified Drainage Improvements	x		x		
Improvements to Recreational Facilities		x			

4.3.4.1 Improvements to Ditches, Tide Gates, and Pumping Stations

According to the 2016 Floodplain Management Plan by NJSEA, the following is a summary of activities implemented to mitigate flood impacts in the Meadowlands District. These initiatives and projects have been implemented in keeping with the District's goal of planning and managing to effectively reduce the impact of flooding in the region.

1. Collection and Assessment of Flooding Incidents

The NJSEA continues to actively collect, log, and assess flooding complaints on individual properties, including inspecting the Meadowlands District for flood impacts following severe storms. NJSEA staff

engineers are available to meet with property owners for on-site inspections and to discuss drainage options.

2. Drainage System Maintenance (Tide Gates, Pump Stations, Waterways)

The NJSEA evaluates the functionality of all tide gates and pump stations within the Meadowlands District. Since the Meadowlands District is tidally impacted, routine inspection of tide gates and pump stations is important to identify issues that could impact flood protection for upstream areas. The NJSEA inspects tide gates at various tide conditions in order to accurately identify problems or determine maintenance that may be required. Pump stations are inspected with the respective municipality's DPW to ensure the system is operating properly. Additionally, waterways and ditches are inspected throughout the District to ensure adequate stormwater conveyance capacity. The NJSEA coordinates with the DPW's to remove stream debris. These inspections and maintenance activities have helped to lessen the effect of several major storms.

3. Municipal Equipment Pool

The Meadowlands District recognizes that maintenance of storm sewer systems is critical to ensure adequate stormwater carrying capacity. The NJSEA provides and maintains equipment to assist municipalities in the Meadowlands District with maintenance issues that, if neglected, could create flooding issues. A jet vac-truck, root cutter, portable automatic self-priming pump systems, and trailer mounted light tower are available to municipalities free of charge to encourage maintenance of storm sewer systems.

4. Monitoring Water Levels in the District

The NJSEA continues to maintain, update, and upgrade equipment that monitors water levels. This ensures that timely warning can be provided to first-responders and residents when water levels rise during tidal events, heavy rains, or storms. The state-of-the art data collection instruments are stationed at tide gates, in the marshes, and in the Hackensack River. They relay information to the NJSEA via satellite. The information gathered is relayed to out-of-state servers to ensure that data is available to the public even during power outages in the Meadowlands District. The active monitoring of water levels allows the NJSEA to alert the municipalities and general public regarding potential flooding events. The NJSEA maintains twelve (12) water level sensors that can be accessed by the public in real time.

5. Flood Warning Systems

The general public can subscribe to receive email and text-based early warning flood alerts, which are available continuously. These alerts are provided when water levels reach 5.5 feet (NAVD 88) and continue to be relayed as the levels rise. The NJSEA also provides detailed flood maps for Meadowlands District municipalities, showing exactly which streets and properties would be flooded by a two-foot, four-foot, six-foot, or eight-foot tidal surge. The system includes an automated warning to all emergency responders in the Meadowlands District in the advent of a major, six-foot flood.

6. Palmer Terrace Tide Gate and Asia Place Ditch Cleanout (2007)

This flood control project included the restoration of several drainage systems in the Boroughs of Carlstadt and Moonachie between Washington Avenue and Gotham Parkway. NJSEA engineers designed the improvements, including a new tide gate on Palmer Terrace in the Borough of Carlstadt and

4,500 linear feet (LF) of ditch cleanout (Asia Place ditch system). This $340,000 project serves to better manage tidal impacts on industrial and commercial properties west of Washington Avenue.

7. Route 17 Project (2009- 2010)

This flood control project, which was undertaken to relieve flooding on Route 17 in the Boroughs of East Rutherford and Rutherford, was a joint effort involving the NJSEA, Bergen County, and the NJDOT. The first phase of the project included the installation of a dozen culverts, and the installation of new tide gates (Rutherford and East Rutherford tide gates) to improve flow control to and from the Hackensack River. The project also included the clearing of a drainage ditch that conveys runoff from Route 17 and adjacent properties to the new tide gates. Another phase of the project included the NJDOT installation of drainage pipes at the Route 17 low point and upgrading the existing roadway stormwater system. These collective improvements, at a cost of $5.5 million, help to reduce tidal flooding and storm surges from flowing upstream to the highway and from impacting commuters, businesses, and residents in the area.

8. Moonachie and Bashes Creek Tide Gates (2010)

This flood control project included the installation of two new tide gates in the Borough of Carlstadt near the Hackensack River at the Bashes Creek and Moonachie Creek culverts. These tide gates cross under the New Jersey Turnpike's Western Spur. These improvements, at a cost of $414,000, help to address tidal surges from impacting the industrial area located east of Washington Avenue. The tide gates were outfitted with solar-powered sensors that allow NJSEA scientists to remotely monitor the gates' operations.

9. West Riser Tide Gate (2014)

This flood control project, located along the West Riser Ditch on the border of the Boroughs of Moonachie and Wood-Ridge, included the installation of a new tide gate structure with a trash rack system to replace the original 1977 structure. The $1,249,800 project was partially funded by a $551,800 grant from the PANYNJ, with the NJSEA funding the remaining balance. This project helps to better protect residential, commercial, and industrial properties in the Boroughs of Moonachie, Carlstadt, Wood-Ridge and Teterboro, including the Teterboro Airport, from daily tidal flooding from the Hackensack River.

10. Wetland Acquisition

In order to maintain natural buffer areas between the Hackensack River and developed areas, the NJSEA continues to acquire critical tracts of wetlands. To date the agency has acquired 2,500 acres of wetlands to help dissipate storm events and tidal flows. The NJSEA has expended tens of millions of dollars to acquire and maintain these tracts.

11. Pump Station Improvements

The Borough of Moonachie plans to purchase and install a natural gas powered 135-kilowatt generator for the Lincoln Place Pumping Station, using a $75,000 grant from FEMA.

The Borough of Little Ferry plans to install a self-cleaning grate and associated site improvements at the Losen Slote Creek Pumping Station following an award of $652,970 by the NJDEP.

4.3.4.2 Transportation Projects involving Drainage Improvements

1. Borough of Carlstadt

Using a $3.4 million grant, the Borough of Carlstadt plans to reconstruct and improve Kero Road, Jomike Court, Barell Avenue, Eastern Way, and Starke Road, as well as their associated drainage inlets. The scope of the project will include the reconstruction of various outfalls, the installation of a backflow preventer/check valve, the purchase of equipment for ongoing maintenance, the purchase of rapid-deployment flood protection devices, and the repaving of roadway surfaces.

Additionally, with funds received through two separate CDBGs from Bergen County, and a $149,000 grant from the NJDOT, the Borough of Carlstadt plans to resurface Starke Road, Marsan Drive, and Broad Street. The Marsan Drive and Broad Street projects plan to incorporate drainage improvements. The Borough also plans to make some improvements to Monroe Street, Center Street, and Franklin Street.

2. Borough of Moonachie

The Borough of Moonachie plans to improve its West Commercial Avenue Extension using funds from the 2015 NJDOT Road Improvement Program and the 2015 Municipal Road Program. The project would extend from Grand Street to Anderson Avenue. West Commercial Avenue Extension and various streets located within the Borough would be milled and resurfaced. In addition, the Borough plans to repair curbs, sidewalks, driveways, detectable warning surfaces, NJDEP curb pieces, drainage pipes, and bicycle safety grates. West Park Street, in front of the Robert L. Craig Elementary School, may also be milled and resurfaced.

4.3.4.3 Wetland Mitigation Projects

1. Metro Media Wetland

The Comprehensive Restoration Plan for the Hudson-Raritan Estuary recommends the 74-acre Metro Media Wetland site in the Borough of Carlstadt for an initial restoration project. The effort would involve replacing invasive common reed with native vegetation and altering the existing hydrology to create low marsh, high marsh, scrub-shrub, and maritime upland habitats, as well as better functioning tidal channels. This project has not been funded for construction.

2. Teterboro Airport Tower

The Borough of Teterboro is developing an 11-acre wetland mitigation plan that would offset impacts caused by the construction of the Teterboro Airport Tower project, a new air traffic control tower. This plan is contingent upon approval and commencement of the Teterboro Airport Tower project.

4.3.4.4 Redevelopment and Rezoning Local to Project Area

1. Commercial Gateway Center

A Commercial Gateway Center is planned for development on acreage to the north and south of Paterson Plank Road in the Borough of Carlstadt. The goal is to create a gateway to the Paterson Plank Road Corridor and the NJSEA sports complex. The plan seeks to attract commercial, retail, and light industrial uses, including banks, cultural facilities, hotels, movie theaters, indoor commercial recreation, offices, studios, distribution facilities, houses of worship, and day care. The Borough of Carlstadt received 16

grants totaling $891,488 from the New Jersey Economic Development Authority for environmental reclamation associated with contaminated properties in this redevelopment zone.

2. South Hackensack Master Plan

The 2008 South Hackensack Master Plan was amended to include guidelines encouraging private capital to rehabilitate/revitalize streetscapes and facades along US Route 46, Huyler Street, and Garfield Park. New zoning recommendations were also included in the Master Plan.

4.3.4.5 Improvements to Utility Systems

1. BCUA LFWPCF

The BCUA plans to implement improvements to the LFWPCF, including establishing black starting and islanding capabilities, installing a 175,000-cubic-foot biogas storage tank, raising substations above FEMA base flood elevations, and relocating conduits and transformers. Islanding capabilities would allow the facility to continue functioning when the power grid fails, and black start capabilities would allow the facility to restart when disconnected from the grid. The project is currently under review by the NJDEP.

2. Jony Drive Pumping Station

Jony Drive Pumping Station in the Borough of Carlstadt plans to make numerous repairs and improvements to its facility, including the station's structure, piles, and foundations; the existing wet well (including the sewage grinder); the dry well (including the manlift structure, piping valves, and appurtenances); buildings and chambers; maintenance of facilities operations (including the bypass pumping); standby generator set; electrical instrumentation and controls; Supervisory Control and Data Acquisition system; and air release valve chamber.

4.3.4.6 Teterboro Airport Improvements

1. Hangers

First Aviation plans to build two new 40,000-square-foot airplane hangars with an adjoining apron, a parking lot, and 22,500 square feet (SF) of associated office space near the end of Lindbergh Drive at the Teterboro Airport. The NJDEP issued a permit in February 2017.

Signature Flight Support plans to build a new airplane hangar at the end of Fred Wehran Drive at Teterboro Airport. Permitting with the NJDEP is in process.

2. Air Traffic Control Tower

Teterboro Airport seeks to design and construct a new air traffic control tower. Construction is planned for 2020, barring unforeseen complications. As mentioned above, a wetland mitigation plan would be prepared to offset impacts caused by construction of the tower. However, according to airport representatives, construction of the air traffic control tower is not currently funded by the Federal Aviation Administration or PANYNJ. Additionally, new applications were received by NJDEP Land Use to construct two additional hangars (Application pending 0237-04-0002.1 FHA 170001, 170002).

3. Airport Rescue and Fire Fighting Building

Teterboro Airport plans to replace the Airport Rescue and Fire Fighting building with a larger structure to comply with Federal Aviation Administration Advisory Circular 5210-15A, *Aircraft Rescue and Firefighting Station Building Design*. The new building would house new airport rescue and fire fighting vehicles ordered by the PANYNJ in January 2017. It will also support a centralized Customs operation. Wetland mitigation efforts may be necessary.

4. Lighting Infrastructure

Teterboro Airport plans to replace airport lighting infrastructure damaged by Hurricane Sandy. Over 300,000 feet of lighting cable circuits and 3,000 splices would be replaced. Other components of the lighting infrastructure would be cleaned.

5. Drainage System

Teterboro Airport plans to rehabilitate the current drainage system and mitigate flooding/standing water issues.

4.3.4.7 Industrial Building Construction

1. Meadowlands Park

The Borough of Carlstadt plans to build 230,000 SF of flex/industrial space off State Route 17 North. The project, known as Meadowlands Park, has been delayed by litigation concerning the environmental clean-up of the 19-acre site.

4.3.4.8 Transportation Projects without Specified Drainage Improvements

1. Bergen County Public Works Department

The Bergen County Public Works Department was awarded $775,000 in Federal funding for safety improvements on Washington Avenue in the Borough of Carlstadt, focusing on the area between Paterson Plank Road and Empire Boulevard. The Department plans to repair sidewalks, enlarge waiting areas at bus stops, and install a crosswalk. This is Phase II of a project that began last year with an award of $1.9 million from the North Jersey Transportation Planning Authority. Phase I involved improvements to slow traffic, repairing pedestrian countdown signals, filling in gaps in concrete medians, and making improvements to crosswalks and pavement markings.

4.3.4.9 Recreational Facilities

1. Memorial Park North

The Borough of Moonachie is seeking a matching grant from the Bergen County Open Space Trust Fund to fund Memorial Park North. This proposed park would be located on the north side of the new Moonachie Municipal Building. It would incorporate a waterfall, flowers, trees, and a pergola. The park would serve to beautify the area, while emphasizing sustainability and green living.

4.3.5 Transportation and Circulation

Under the No Action Alternative, continued and increased flooding could lead to more frequent roadway and sidewalk inundation that reduces the capacity and safety of the affected roadway for vehicular, bicycle, and pedestrian modes of transportation. Long-term inundation of particular transportation routes

could result in the closure or inaccessibility of roadways, railroads, mass transit routes/services, sidewalks, bicycle paths, and on-street parking. This in turn could lead to the need for short-term or long-term detours, resulting in increased traffic and the deterioration of level of service within the Project Area and overall region. Ultimately, this could lead to unreliable access for local communities to major arterial roadways and interruptions or delays in mass transit and freight services within the Project Area.

4.3.6 Recreation

Under the No Action Alternative, increased flooding within the Project Area would continue to impact recreational resources; this would be expected to increase in frequency and duration over time. Impacts to recreational facilities, such as parks and marinas, would result primarily from flooding associated with coastal storms and their associated storm surges, as well as fluvial flooding during heavy rainfall events.

With projected climate change and SLR, marinas and the majority of the parks within the Project Area could be subject to regular, if not permanent, flooding. These flood events would be expected to disrupt the operation of recreational facilities in the Project Area by damaging recreational infrastructure (e.g. docks and park facilities) and flooding recreational areas. Flooded roads would also impact the access to/use of these facilities, thereby reducing visitation.

4.3.7 Critical Facilities

Under the No Action Alternative, future flooding could damage infrastructure and property associated with critical facilities within the Project Area. Flood damage to critical facilities would likely result in physical displacement and relocation of these facilities on at least a temporary, if not permanent, basis. Compromised critical facilities would result in disruptions to services, the duration and severity of which would depend on numerous circumstantial factors, such as tidal height at the time of landfall of a storm.

The response times of critical facilities that are fire departments and EMS is dependent on accessibility to businesses or residents requesting assistance. Flood events can damage or inhibit the use of infrastructure (e.g., road closures), causing increases in the response times of fire departments and EMS within the Project Area. Road closures would also have the potential to inhibit the ability of residents to access critical facilities during flooding events. In the case of fire and EMS facilities, any increase in response time or accessibility has the potential to result in loss of life.

Flooding of critical facilities could cause closures and force the relocation of critical facilities within (or outside of) the Project Area, resulting in a reduced supply of their associated services, or increased response times. For example, during Hurricane Sandy, tidal flooding forced the closure and relocation of two municipal buildings (both of which are critical facilities) and one police station in the Borough of Moonachie. Additionally, all four of the schools in Little Ferry are critical facilities and were forced to close, and students and faculty were displaced. Memorial Middle School, a critical facility, was closed for two weeks before reopening at the former Roman Catholic School in Lyndhurst (Smith 2012). At Robert Craig Elementary School, a critical facility, students were bused to the Borough of Wood-Ridge for approximately two months after the storm, before relocating into trailers for the remainder of the school year (Nicholaides and Cattafi 2017, Sullivan 2013). Generally, the school buildings were not fully renovated until the beginning of the 2013-2014 school year.

The demand for critical facilities, particularly those that have emergency services, temporarily, but substantially, increases during flooding events, as flooding results in an increase in call volumes from affected residents, businesses, or other users requesting emergency assistance. As the frequency and

severity of these events increase over time, the periodic increased demand on these emergency services would increase proportionately. An increased demand for emergency services during flood events could surpass the ability of the associated critical facility to effectively respond to calls. Furthermore, an increase in demand during flood events, in conjunction with a reduced supply of critical facilities due to flood-related displacements and road closures, could overwhelm the capacity of critical facilities to reliably provide services within the Project Area.

4.4 Flood Risk

Within the Project Area, coastal flooding is often a result of tropical storm surge events. During these events, the tidally influenced Hackensack River overtops its banks and inundates the coastal floodplain. Elevations within the Project Area generally do not exceed 10 feet (NAVD 88), with most areas less than 6 to 7 feet (NAVD 88) (see **Section 3.1.1**) (MERI 2014). As described in **Section 2.1**, a series of old berms within the Project Area was designed to help protect against coastal inundation, but these berms are neither continuous nor uniform in height, and thus provide only limited protection (US Department of Homeland Security 2014). On average, these berms are breached every 5 years (NJIT 2014). Storm surges can be particularly severe if they occur in tandem with extreme high tides, since they can be substantially higher than normal high tides (NJSEA 2005, Rutgers University 2007). During Hurricane Sandy, for example, the Project Area experienced a 9.5-foot storm surge (NAVD 88), which was sufficient to inundate virtually the entire Project Area (NJIT 2014). Coastal flooding is expected to worsen in the future with rising sea levels.

The Project Area is vulnerable to the effects of climate change and sea level change. Sea level in the northeast region of the United States has risen approximately 12 inches since 1900, which is 50 percent more than the global average (Horton, et al. 2014). In 2015, the NPCC released a report specific to the New York metropolitan region, including the Project Area, which came to a similar conclusion. This report cited a local rate of sea level rise of 1.2 inches per decade since 1900, which is approximately double the global rate of 0.5 to 0.7 inch per decade (Horton, et al. 2015b). Various agencies, including the USACE, NOAA, the NPCC, and Rutgers University, have published projections to analyze potential sea level change over the coming decades. Overall, the middle range of these projections indicates that sea level may rise another 1.2 to 2.4 feet by the year 2075, and 1.8 to 4.0 feet by the end of the century.

Existing studies and data suggest that flooding conditions in the Project Area will increase over time. **Figure 4.4-1** and **Figure 4.4-2** show a comparison of areas flooded under the existing and future No Action Alternative conditions (normal tide and 50-year storm surge) with SLR. Normal tide is 3.7 feet NAVD 88 under the existing condition, 4.7 feet NAVD 88 under the future condition assuming SLR of 1.2 feet, or 5.7 feet assuming SLR of 2.4 feet. **Figure 4.4-1** shows that normal tide in combination with 2.4 feet of SLR would inundate a very large area because the Project Area is flat and mostly below 6 to 7 feet (NAVD 88). **Figure 4.4-2** shows that under the 50-year storm surge condition, a 1.2-foot sea level rise would inundate roughly half of the Project Area, and 2.4 feet of sea level rise would inundate the majority of the Project Area.

These worsening flooding conditions would produce commensurately increased adverse impacts to residents, property, and the quality of the human and natural environment. Failure to provide the Project Area with additional protection from inland flooding and coastal storm surges may lead to increased and more frequent damage to local infrastructure and property, direct harm to economic activity, and increased potential for loss of life.

As described in **Section 4.3.1** and **Section 4.3.2**, property damage from flooding and the expenses of post-flood clean-up would be expected to continue to disrupt the lives of homeowners and renters in the Project Area. Under the No Action Alternative, low-income, elderly, and disabled populations would continue to be disproportionately impacted by flooding, including the concentrated LMI areas in the Boroughs of Teterboro and Little Ferry and in the Township of South Hackensack. As during Hurricane Sandy, when nearly 30 percent of the structures damaged within the Project Area were renter-occupied, challenges dealing with residents displaced by flooding would continue. Additionally, local businesses could experience temporary or permanent closures, and employees could be prevented from working because of flooding impacts.

As described in **Section 4.3.3**, continued development is expected to occur in the Project Area floodplain, subject to local floodplain management ordinances, which would displace small residences with larger new homes and townhouses. Development is also expected to encroach on, or increase use intensity of open spaces and recreational areas in the next 10 to 50 years. Municipalities may come under increasing pressure to develop these areas as the local population continues to increase (according to the State of New Jersey Department of Labor and Workforce Development, the total population of Bergen County is projected to increase from 933,600 in 2014 to 1,065,500 in 2034, or 114 percent). An increase in developed areas could lead to an increase in impervious surfaces and stormwater runoff, exacerbating the inadequacy of stormwater management/drainage systems in the Project Area. As shown in **Section 4.3.4**, examples of the types of development likely to occur in the Project Area in future years include transportation projects, redevelopment and rezoning projects, improvements to Teterboro Airport, and industrial building construction projects.

A set of models was developed to evaluate the extents of fluvial flooding in the Project Area and what improvement measures might reduce it. Hydrologic Engineering Center's HEC-HMS runoff model was applied to develop runoff estimates for the entire Project Area for rainfall events of varying magnitudes. Output from this model was applied in the HEC-RAS 2D model to estimate flooding extents resulting from these rainfall events in the West Riser and East Riser ditch drainage areas with the normal tidal boundary condition. **Figure 4.4-3**, **Figure 4.4-4**, and **Figure 4.4-5** show these extents for the 2-year, 25-year, and 100-year rainfall events. Results presented here assume that the subsurface pipe systems in these drainage areas are full of water by the time the peak rainfall occurs during each storm.

Flooding extents for these events in the Losen Slote Creek drainage area are shown in **Figure 4.4-6**, **Figure 4.4-7**, and **Figure 4.4-8**. These estimates were developed through application of the InfoWorks 2D model. These areas contain extensive subsurface pipe networks compared to the East Riser and West Riser drainage areas and the model's ability to simulate subsurface piping, open channel flow and overbank flow influence its selection for this task. These model results are examples of the 'baseline' conditions against which tested improvements were measured.

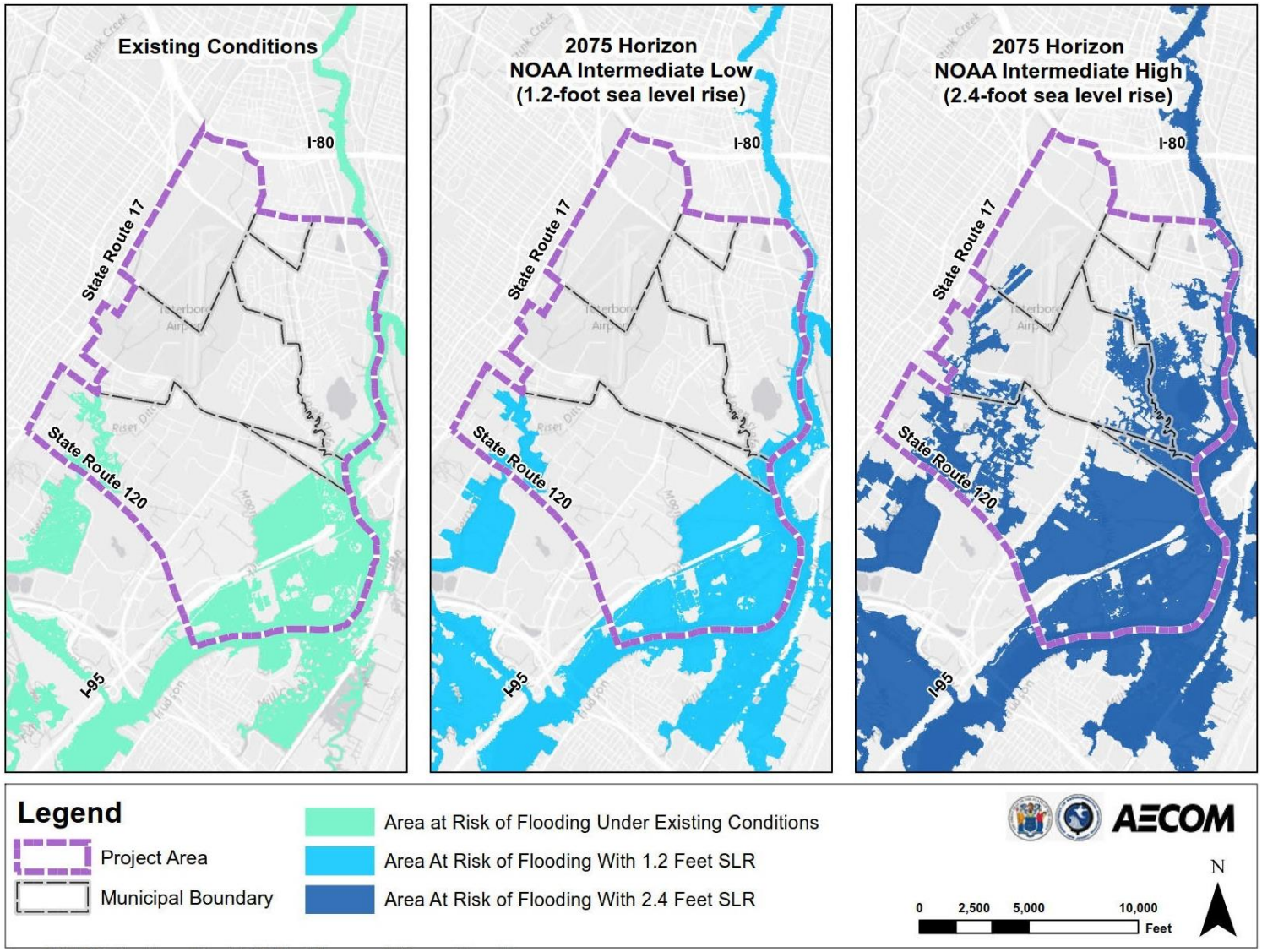


Figure 4.4-1: Area at Risk of Flooding During Normal Tide under the No Action Alternative

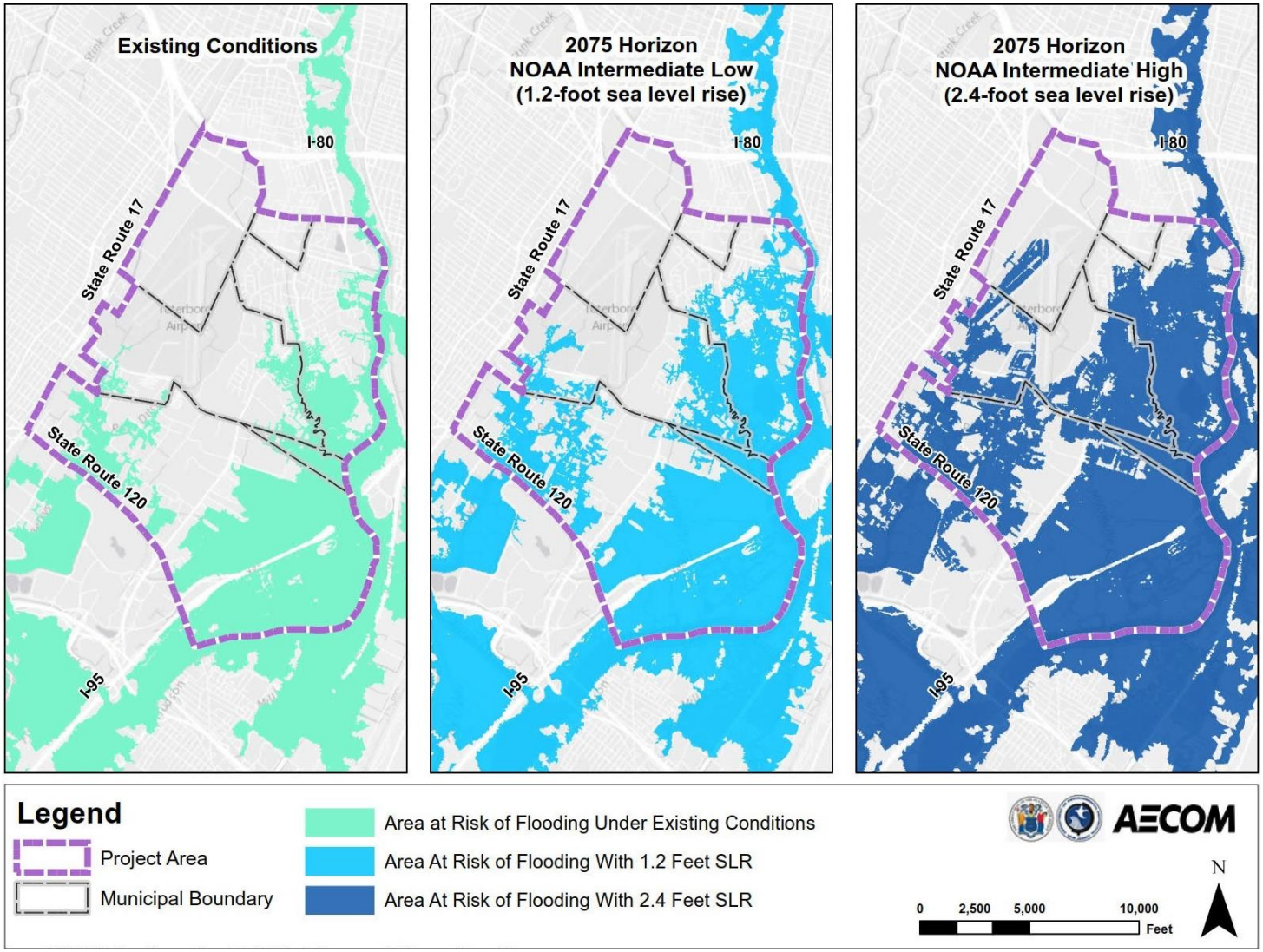


Figure 4.4-2: Area at Risk of Flooding During a 50-year Storm Surge under the No Action Alternative

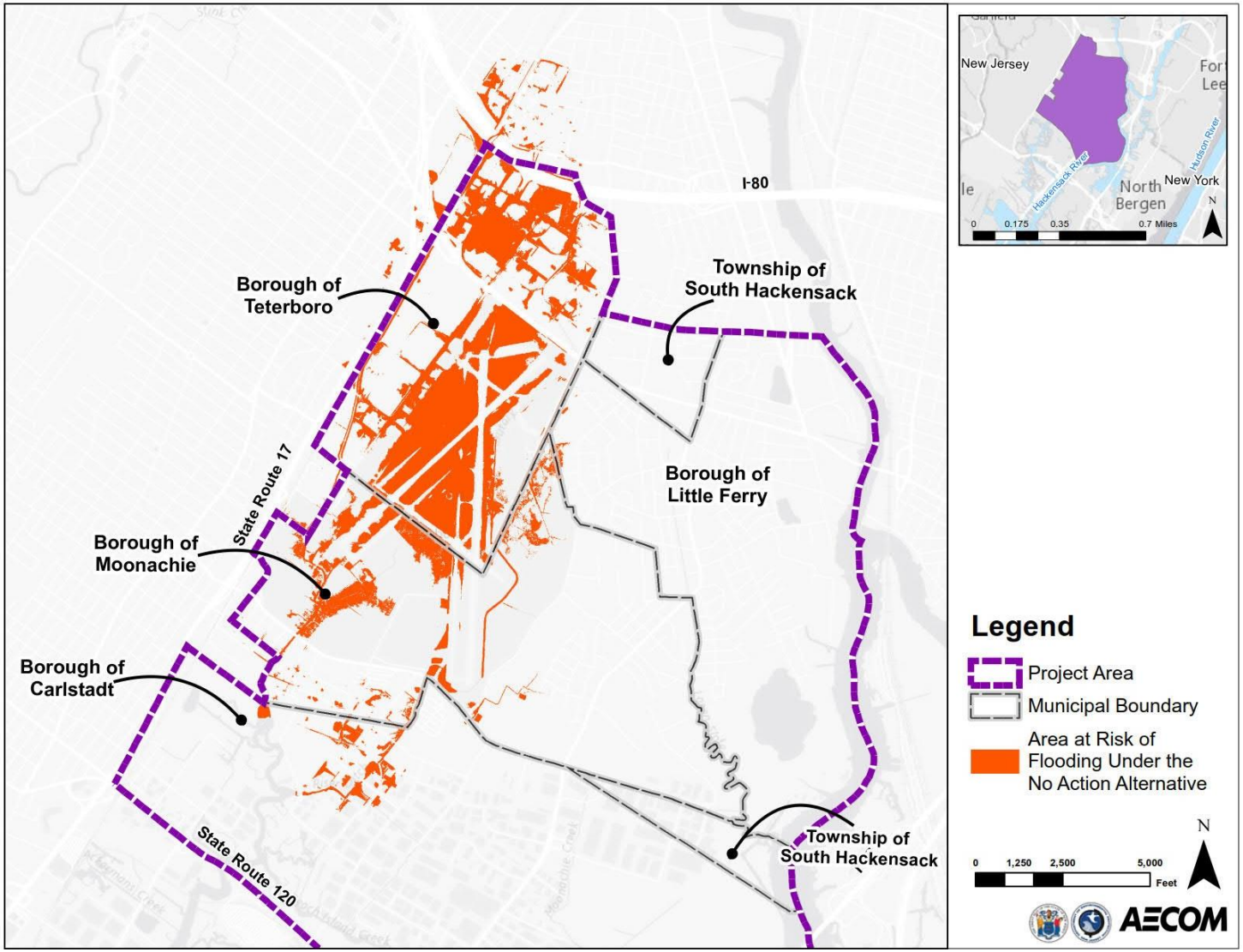


Figure 4.4-3: East and West Riser Ditch Area at Risk of Flooding During a 2-year Rainfall under the No Action Alternative

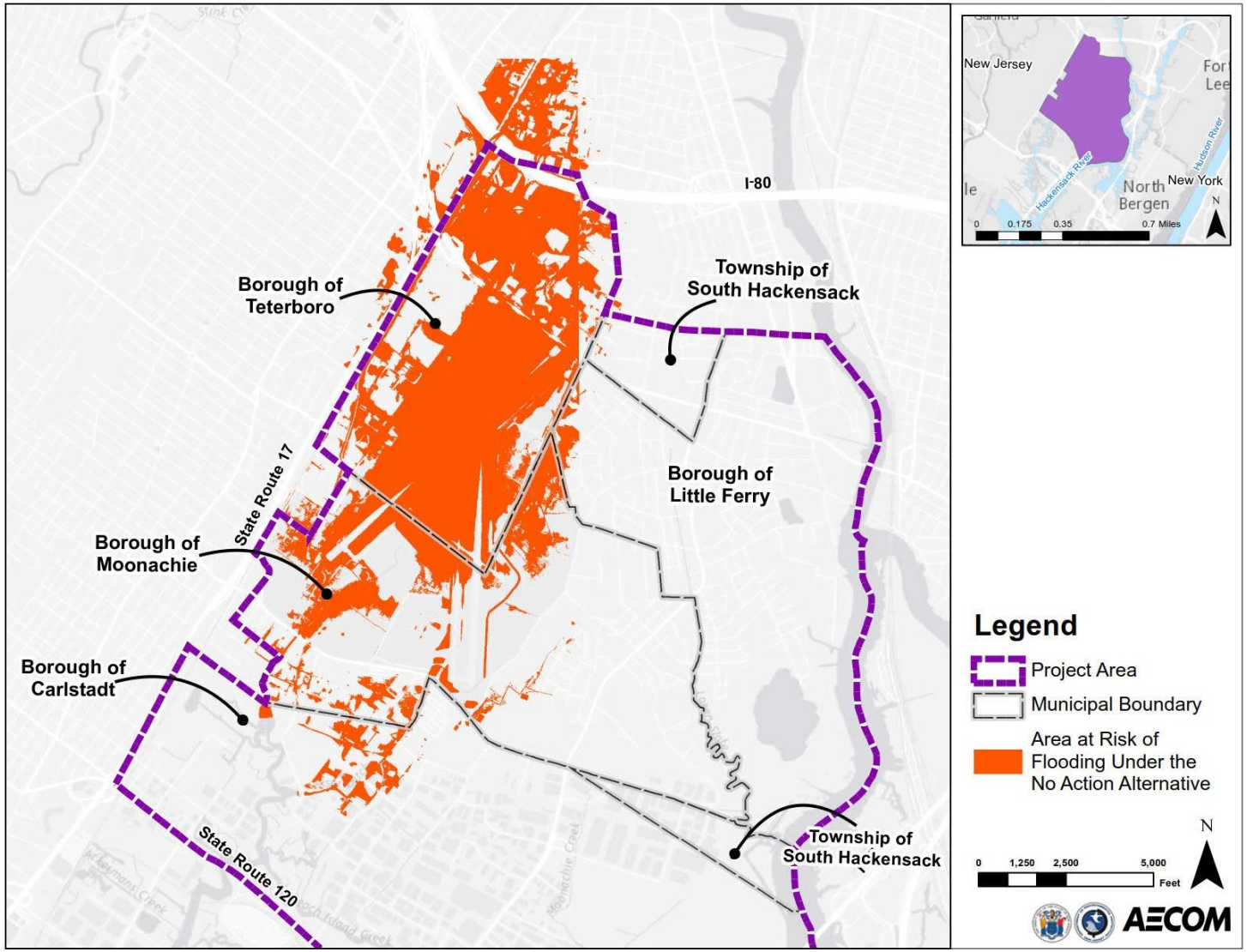


Figure 4.4-4: East and West Riser Ditch Area at Risk of Flooding During a 25-year Rainfall under the No Action Alternative

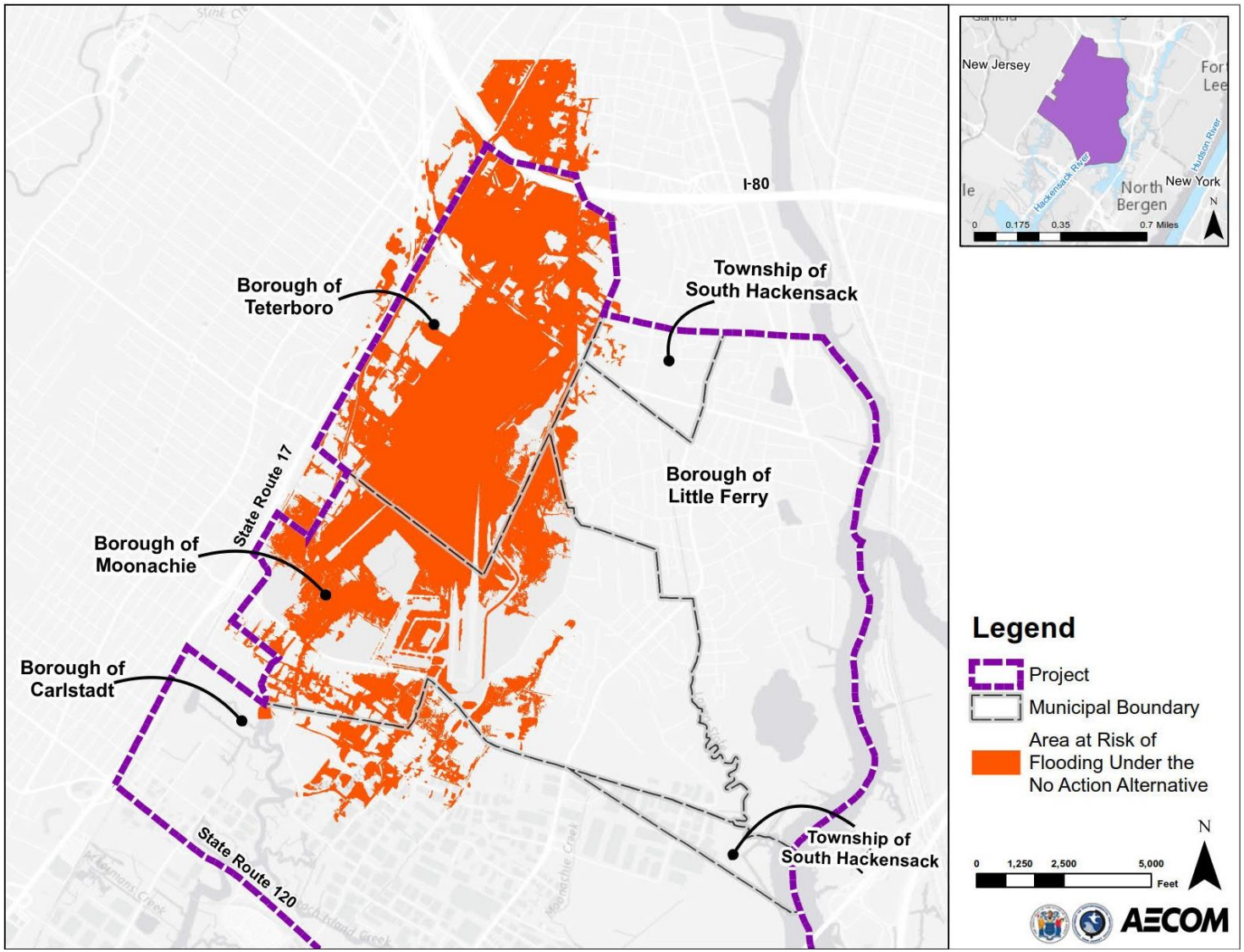


Figure 4.4-5: East and West Riser Ditch Area at Risk of Flooding During a 100-year Rainfall under the No Action Alternative

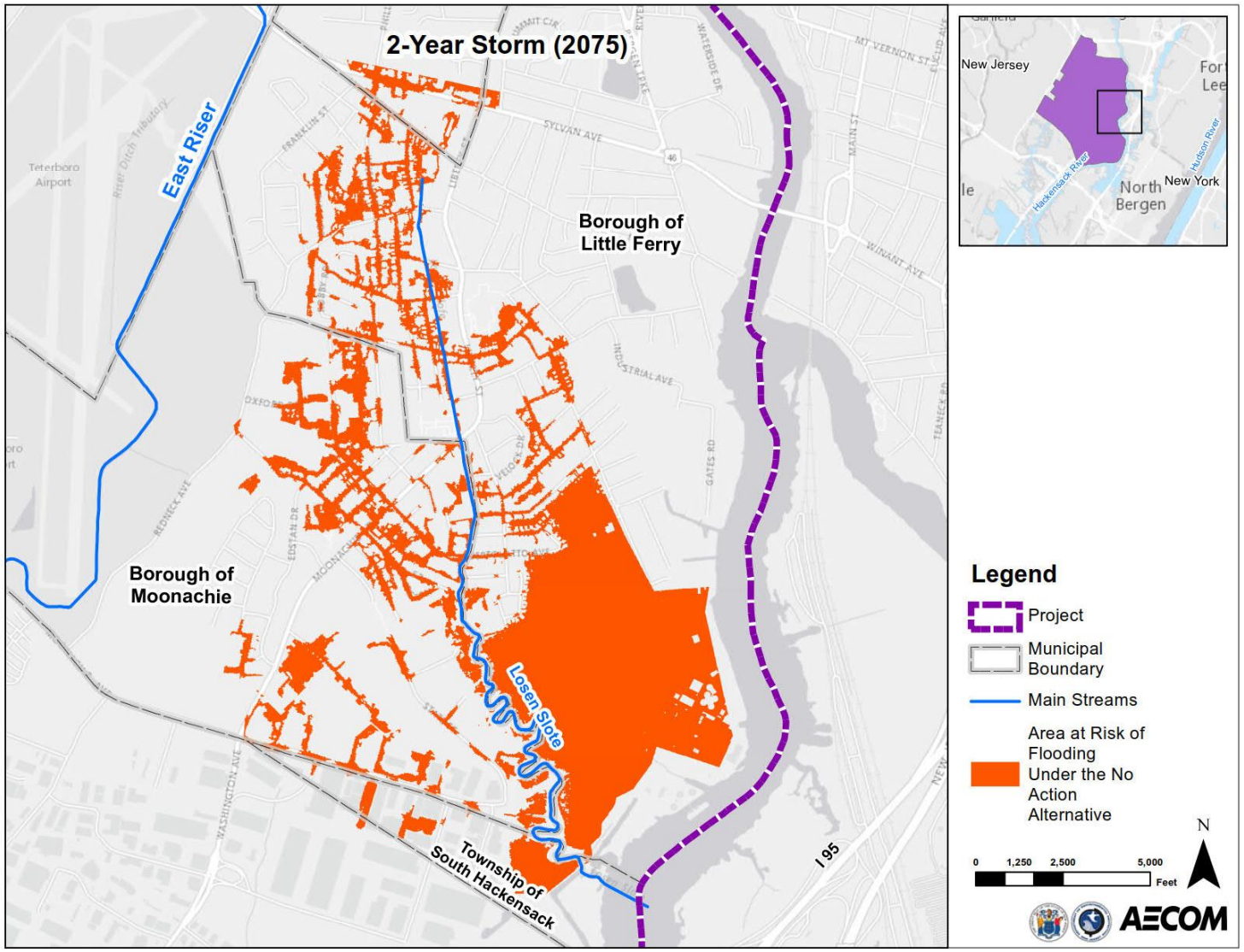


Figure 4.4-6: Losen Slote Creek Area at Risk of Flooding During a 2-year Rainfall under the No Action Alternative

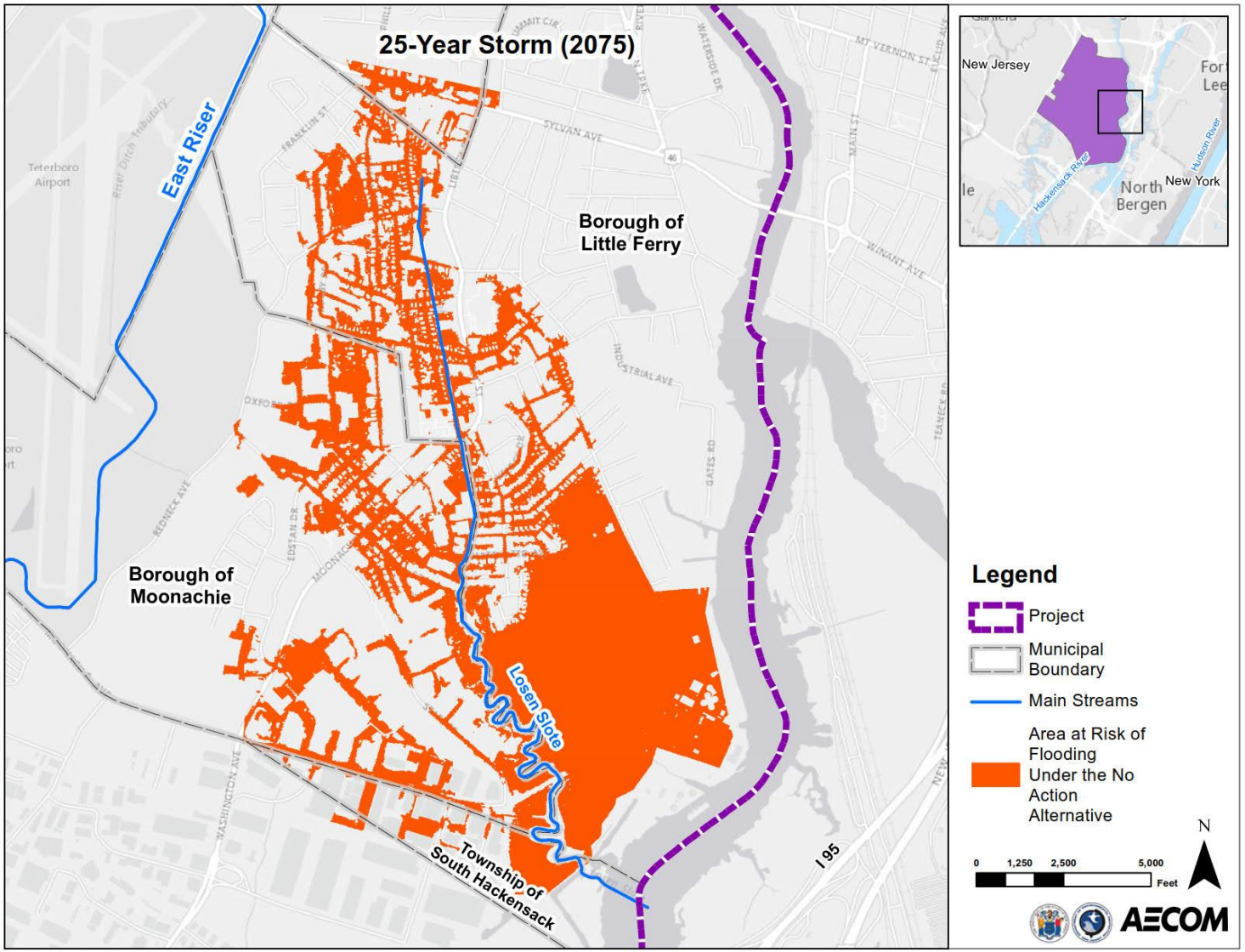


Figure 4.4-7: Losen Slote Creek Area at Risk of Flooding During a 25-year Rainfall under the No Action Alternative

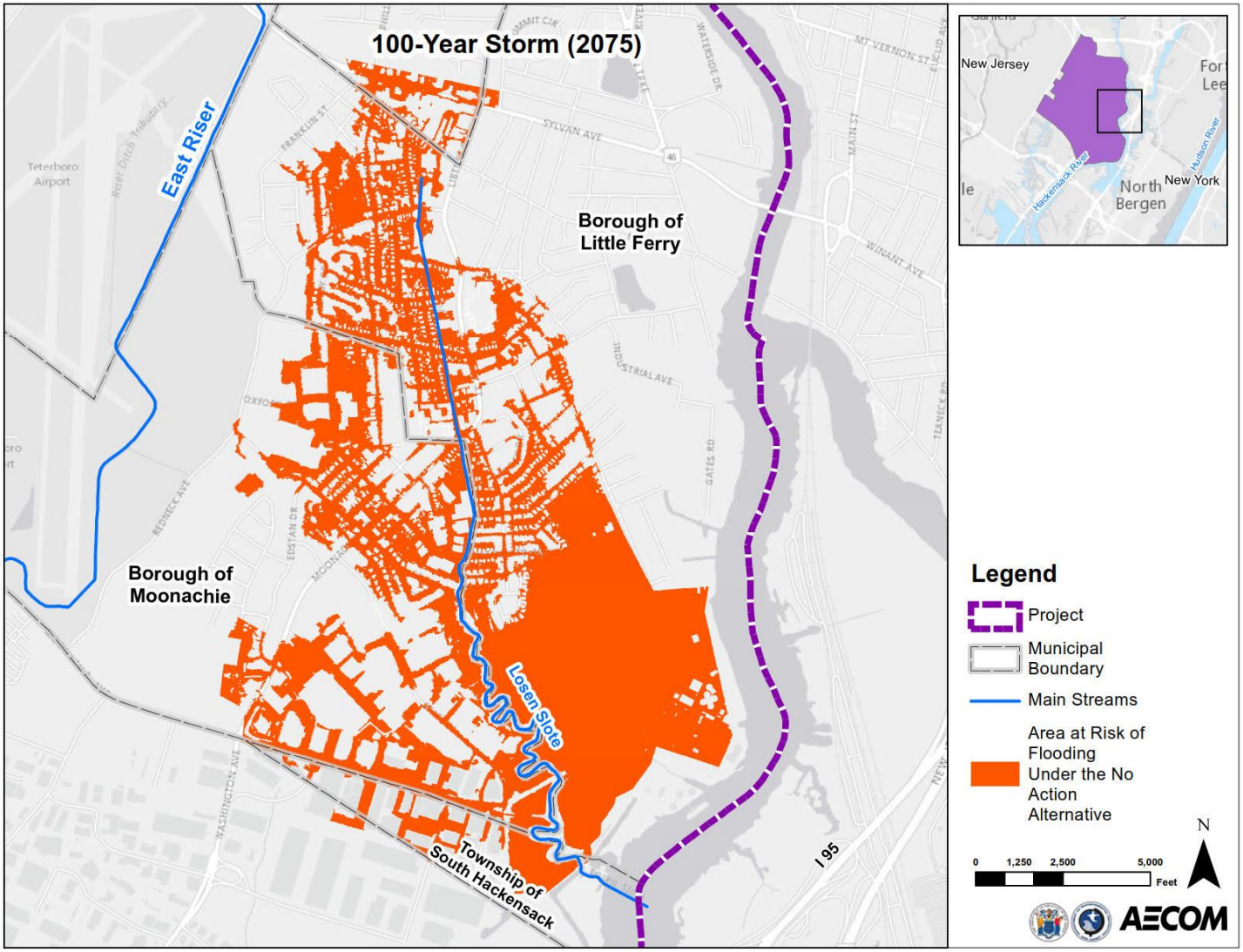


Figure 4.4-8: Losen Slote Creek Area at Risk of Flooding During a 100-year Rainfall under the No Action Alternative

5.0 Plan Development Approach

The Alternatives Development process involved the identification of flooding sources, locations of flooding, and the crafting of potential flood risk reduction alternatives. The RBDM competition team identified three broad Build Alternatives during the RBD competition: Alternative 1 (Structural Flood Reduction), Alternative 2 (Stormwater Drainage Improvement), and Alternative 3 (Hybrid Alternative). Each of the three Build Alternatives seeks to reduce the flood risk within the Project Area.

Each alternative was evaluated through the engineering Feasibility Study and application of preliminary screening criteria. The Feasibility Study was conducted to help determine the feasible designs and strategies that best address the impacts from the two types of flooding (coastal and systemic inland flooding). The community was engaged in developing the screening criteria that will determine how well each of the alternatives meets the Proposed Project's Purpose and Need. The alternatives were further evaluated based on the screening criteria, and defined and modified as the EIS was developed.

A wide array of concepts were identified for each of the three Build Alternatives. These were evaluated against the following general criteria to identify the concept that best achieves the Proposed Project objectives:

- Flood Risk Reduction
- Built Environment / Human Environment
- Constructability / O&M
- Natural Environment
- Costs and Benefits

5.1 Proposed Project Alternatives

The list below summarizes the three Build Alternatives:

- **Alternative 1 (Structural Flood Reduction):** This alternative would analyze various structural, infrastructure-based solutions that would be constructed to provide protection from coastal storm surges. This alternative, to the extent practical, would evaluate a FEMA certifiable level of flood protection to a portion of the Project Area. This alternative would consist of a range of structures, including levees, berms, barriers, drainage structures, pump stations, floodgates, and/or other infrastructure, to achieve the required level of flood protection.
- **Alternative 2 (Stormwater Drainage Improvement):** This alternative would analyze a series of stormwater drainage projects aimed at reducing the occurrence of higher frequency, small- to medium-scale flooding events that impact the communities located in the Project Area. Together, these interventions would provide a system of improved stormwater management, and may include both local drainage improvements and wetland restoration to protect communities located in the Project Area and address day-to-day water management challenges. These interventions may include: drainage ditches, pipes, and pump stations at strategic locations; new green infrastructure (e.g., wetland drainage basins, bioswales, rain gardens), water storage areas, and water control structures; cleaning and de-snagging of existing waterways; and increasing and enhancing public open space.

- **Alternative 3 (Hybrid Alternative):** This alternative would analyze a strategic, synergistic blend of new infrastructure and local drainage improvements to reduce flood risk in the Project Area. Components of Alternatives 1 and 2 would be combined to provide an integrated, hybrid solution that employs a combination of appropriate levees, berms, drainage structures, pump stations, and/or floodgates, coupled with local drainage improvement projects, to achieve a higher level of flood protection within the boundaries of the Project Area.

Each alternative would provide a solution that extends protection and benefits across the Project Area, while not inducing flooding elsewhere. Under the CDBG-DR funding requirements, the Proposed Project must be complete and operational by September 2022. The Proposed Project would have an estimated useful life of 50 years, or approximately 2022 through 2072.

5.2 Concept Development and Screening of Alternatives

The Alternatives Development process involves the identification of flooding sources, locations of flooding, and the crafting of potential flood risk reduction alternatives. As stated previously, the Project Area is subject to two sources of flooding – coastal storm surge events and systemic inland flooding from moderate to severe rainfall events. As part of the engineering Feasibility Study, an integrated coastal and inland flooding model was developed to identify the locations of flooding and evaluate the effectiveness of various flood risk reduction alternatives to reduce flood impacts.

The success of constructing a reliable, permanent, and comprehensive flood risk reduction system depends on designing Proposed Project alternatives that take into consideration existing infrastructure and environmental constraints. The key to the successful implementation of this Proposed Project is to design the flood risk reduction system in accordance with applicable regulatory standards, such as FEMA flood elevation standards, the NJDEP Flood Hazard Area Control Act, and local floodplain ordinances, while verifying that it aesthetically blends with and enhances the existing environment to the extent possible.

The location of existing infrastructure, such as parks, roadways, transit systems, stormwater systems, subsurface utilities, and foundation structures for various types of infrastructure, will dictate the available footprint for implementing the various Proposed Project elements. The size and availability of the footprint area would then dictate the type of potential Proposed Project elements that could be constructed, such as earthen berms, floodwalls, deployable flood systems, street-side green infrastructure, etc. In certain areas, it may be feasible to relocate some infrastructure facilities; however, due to cost considerations and a desire to reduce construction impacts, the Proposed Project seeks to reduce the relocation of such facilities.

The culmination of the Alternatives Development and Screening process is an evaluation of the alternatives through a screening matrix in a community workshop setting. The screening matrix was developed with input from stakeholder groups (including the Citizen Advisory Group (CAG)) informed by RBDM project team Subject Matter Experts (SMEs) and was used to evaluate each alternative on its potential impacts to the many resources within the Project Area. This process allowed for the elimination of alternatives that least satisfy the Proposed Project's Purpose and Need.

Criteria in the screening matrix were utilized to reflect and address the Proposed Project's Purpose and Need, Project Goals and Objectives, its potential impacts to the natural environment and the community, and the Proposed Project's overall feasibility. Examples of criteria to be included are: performance criteria (such as flood risk reduction), environmental constraints (including but not limited to cultural resources, hazardous waste, and environmental justice), and community interests. Criteria also include feasibility

factors, such as constructability and construction cost. Metrics that are measurable, either qualitatively or quantitatively, were developed for each criterion.

After the establishment of the metrics, a matrix was developed to evaluate each alternative. The completed matrix allowed for a comparison of each alternative. The three alternatives that were considered to best meet the Purpose and Need were advanced as the Proposed Project's Build Alternatives and analyzed further in the EIS.

Figure 5.2-1 shows the steps followed to identify Alternative 1 (which provides for protection from storm surges), Alternative 2 (which provides protection from localized storms by providing stormwater drainage improvements), and Alternative 3 (which provides protection from both storm surges and heavy rainfalls).

For both Alternatives 1 and 2, various concepts were identified that could potentially address the Proposed Project purpose of each alternative. The concepts were further developed and subjected to an initial screening process to eliminate those concepts that did not meet the initial screening criteria.

The concepts that were not eliminated were further refined to a preliminary design level that included preparing cost estimates and benefit and cost analyses. A subsequent secondary screening was then performed that included a scoring system to identify the specific features and alignment that would best achieve the Proposed Project purpose of each alternative.

Alternative 3, the hybrid solution, is a combination of Alternatives 1 and 2. Five concepts were developed by integrating the components of Alternatives 1 and 2 and adding various additional measures to achieve the Proposed Project objectives. A separate screening was completed in order to identify a plan meeting the screening criteria.

Section 6.0 provides a detailed discussion of the Alternative 1 Plan development, and **Section 7.0** provides a detailed discussion of the Alternative 2 Plan development. **Section 8.0** provides a detailed discussion of the Alternative 3 Plan development. The selected plan (the "Preferred Alternative") is discussed in **Section 9.0**.

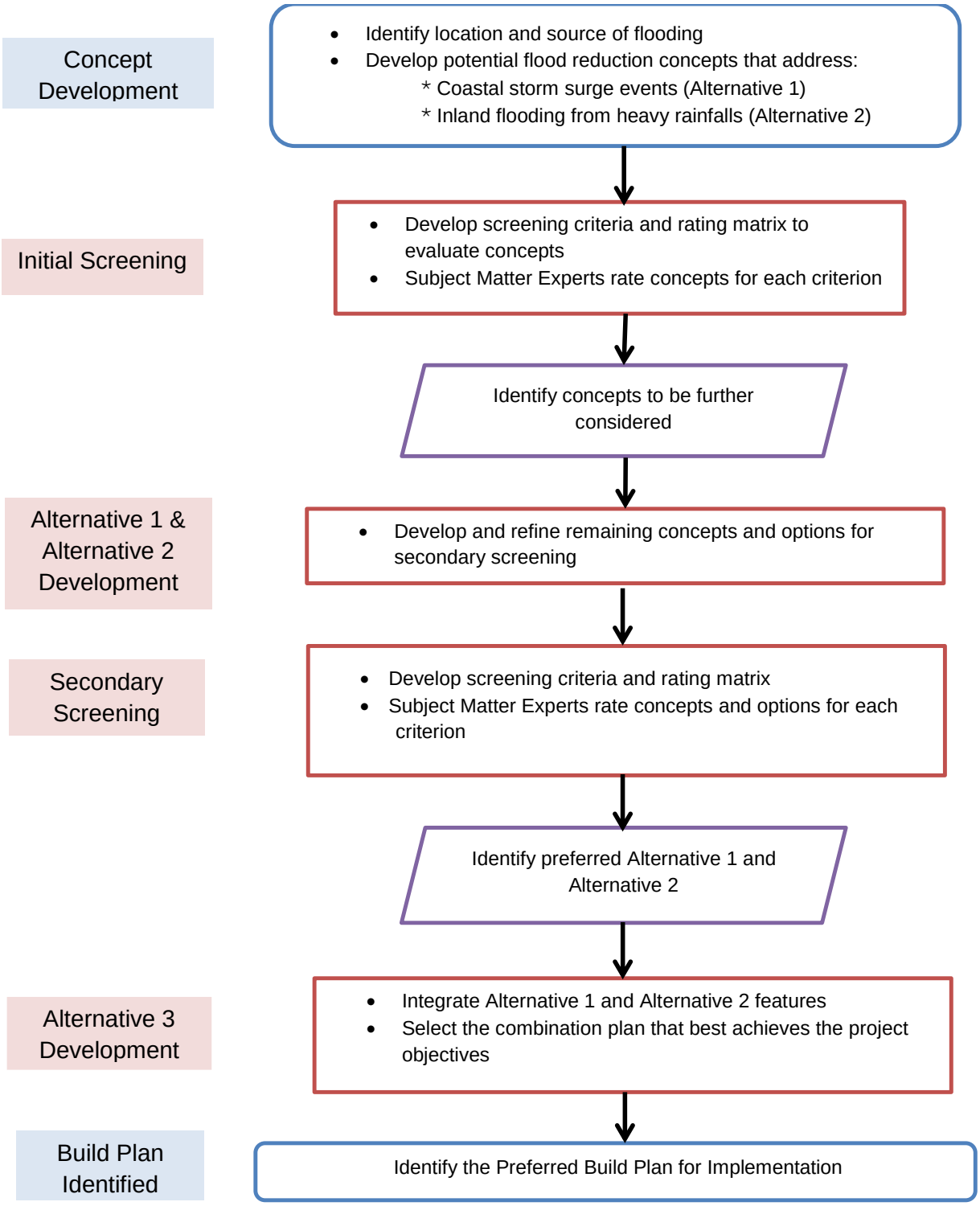


Figure 5.2-1: Alternatives Development and Screening Process

6.0 Alternative 1 – Plan Development

This section describes the screening process used in the plan development of Alternative 1, the Structural Flood Reduction Alternative, which follows the overall process described in **Section 5.0**. This alternative considered a range of structures, including levees, berms, barriers, drainage structures, pump stations, floodgates, and/or other infrastructure alternatives that can reduce flooding from coastal storm surges.

6.1 Concept Development and Comparison

A review of documented flooding in the Project Area indicates the area to be highly vulnerable to tidal surges, associated with coastal storms and nor'easters. A LOP along the Hackensack River and Berry's Creek at certain design flood elevation would help reduce the flooding from storm surges. Design flood elevations are directly related to the level of protection that could be provided to the Project Area and dominate the Proposed Project cost. Broad concepts were proposed and studied with the Proposed Project goals and objectives and budget constraints in mind. If the broad concept meets the initial screening criteria, it would then be refined for further evaluation and screening.

6.1.1 Broad Concepts Development

Various broad concepts were considered during the conceptual phase. Each of the concepts considered different alignments, Proposed Project features, and level of protection as described below and summarized in **Table 6.1-1**. They differ in the area that could be protected (Limited Project Area, Project Area, or expanded Project Area), and the level of protection that could provide (FEMA certifiable vs. Reduced Levels of Protection). For example, some concepts considered a LOP at a crest elevation of 12.6 feet (NAVD 88), which would provide FEMA certifiable protection against the NFIP 1-percent-annual-chance-exceedance flood event. This elevation of 12.6 feet (NAVD 88) includes a still water elevation at 9.4 feet (NAVD 88), plus SLR of 1.2 feet and a freeboard of 2 feet. However, due to the budget constraints, lower design flood elevations at 10 feet, 8 feet, and 7 feet (NAVD 88) were also evaluated and they were referred to as reduced levels of protection.

Maximum Regional Protection Plans

This concept, developed from beginning of the Proposed Project through March 2016, would create a structural LOP constructed along the Hackensack River and Berry's Creek at a height of 12.6 feet (NAVD 88) to protect an expanded Project Area extending south from I-80 to State Route 3. This height would be sufficient to meet NFIP requirements of protection against the NFIP 1-percent-annual-chance-exceedance flood event.

Four different alignments (Alignments A, B, C, and D) were considered under this concept. **Figure 6.1-1** shows the LOP and area protected by Alignment A. The other three Alignments B, C, and D are variations of Alignment A with primarily minor alignment modifications in the immediate vicinity of where I-80 crosses the Hackensack River. The design flood elevation for each of the four alignments is set at 12.6 feet (NAVD 88). **Subappendix F-1** provides details of these four alignments.

Modified RBDM Project Area Protection Plan

This concept, developed from beginning of the Proposed Project through March 2016, revised the original RBD project to include closure gates along I-80 to act as the northern limit of this alternative. The

southern portion of the RBD project had berms to provide flood mitigation originating from Newark Bay via coastal storm surges.

This plan uses the same reaches as identified in the RBDM Maximum Regional Protection Plan–Alignment B for the northern and central sections, but ties into high ground by turning westward away from the Hackensack River along Commerce Boulevard in the Borough of Carlstadt. This plan has no structural components in the southern reach as the proposed LOP crosses Berry's Creek far upstream of the Alignment B plan, and generally follows the original RBD alignment along Peach Island Creek. **Figure 6.1-2** shows the alignment of this plan.

Limited Project Area Flood Protection Plans

This concept, developed from beginning of the Proposed Project through March 2016, considered structural design elements that would provide a NFIP 1-percent-annual-chance-exceedance for small, select areas within the Project Area. As there are a very limited number of points within the Project Area that exceed 12.6 feet (NAVD 88), this level of protection would have taken the form of berms and/or floodwalls constructed in a circle around areas that HUD identified as priority for protection (i.e., LMI areas).

Compared to the regionally based concepts described above, this category of plans provides 100-year flood protection from coastal and riverine flooding events for small and localized portions of the Project Area (**Figure 6.1-3**). **Subappendix F-1** provides detailed descriptions of each plan.

Reduced Levels of Protection for the Project Area

These concepts, developed from beginning of the Proposed Project through March 2016, would provide flood protection for the Project Area, but would not meet the NFIP 1-percent-annual-chance-exceedance requirements of protection. Three concepts with design flood elevations at 7-, 8-, and 10-feet (NAVD 88) were considered that would provide a reduced level of protection. **Figure 6.1-4** shows an example of the elevation 7-feet (NAVD 88) plan.

Storm Surge Barrier across Hackensack River

Also considered during the concept phase (from beginning of the Proposed Project through March 2016) was the construction of surge barriers across the Hackensack River that would be closed in advance of a coastal storm to reduce the potential for flooding from a tidal surge. Four possible coastal storm gate structure ("surge barrier") alignment alternatives were identified during the concept phase as listed below. Each would be located near the confluence of the Hackensack River and Newark Bay and constructed to a design flood elevation of 14 feet (NAVD 88) to accommodate SLR and overtopping.

- New Jersey Transit – Morris-Essex LOP (Plan A – Coastal Storm Surge Barrier)
- PATH LOP (Plan B – Coastal Storm Surge Barrier)
- Portal Bridge LOP (Plan C – Coastal Storm Surge Barrier)
- Newark Jersey City Turnpike LOP (Plan D – Coastal Storm Surge Barrier)

Figure 6.1-5 shows the location of the Plan A: Coastal Storm Surge Barrier. **Subappendix F-1** provides detailed descriptions of each of the four storm surge barrier plans.

6.1.2 Initial Screening

The initial screening of the concepts identified included the following criteria:

- Cost – Alternative 1 must be constructed within the available funds.
- Hydraulic feasibility – There should be no unacceptable induced flooding.
- Potential loss of life – There should be no loss of life.
- Schedule – Construction of the recommended plan must be completed by September 2022.

FEMA stage frequency curves and Advanced Circulation Model (ADCIRC) simulations were used to evaluate these concepts along with costs that were developed for the Passaic River Tidal Flood project for the USACE in 2016.

As shown in **Table 6.1-1**, all of the comprehensive flood protection conceptual plans that provide protection from storms with a recurrence frequency of less than 1 percent exceeded the available funds, and could not be completed by September 2022. This includes the Regional Protection Plan that was originally envisioned in the RBDM proposal, the Modified RBDM Plan that would provide protection to the Project Area, and also the Reduced Area Plan that would provide ring walls to protect portions of the Project Area. The storm surge barriers on the Hackensack River were also eliminated from further consideration because they could induce flooding in other locations. The only acceptable concept was the elevation 7 feet (NAVD 88) Reduced Levels of Protection for the Project Area.

Table 6.1-1: Summary of Conceptual Flood Protection Plans

Conceptual Plans	Figure	Estimated Cost Range (million dollars)[1]	Length of Floodwall (miles)	Length of Levee (miles)	Approximate Protected Area (acres)	% LMI	Design Flood Elevation (feet NAVD 88)	Description of Level of Protection	Concept Advanced to Phase II of Development?
Maximum Regional Protection Plans (from I-80 to Route 3 – Four alignments considered)	6-1	$460–$570	4.8–5.3	3.3–4.0	6,190–6,340	39	12.6	1-percent-annual-chance-exceedance Stillwater + Waves + SLR (Intermediate Low) + Freeboard	No. This concept exceeds the budget limits, and cannot be completed by 2022.
Modified RBDM Project Area Protection Plan (from Patterson Plank Road To Route 17)	6-2	$390–$480	4.1	2.9	4,120	41	12.6	1-percent-annual-chance-exceedance Stillwater + Waves + SLR (Intermediate Low) + Freeboard	No. This concept exceeds the budget limits.
Limited Project Area Flood Protection Plans – Ring walls to protect limited areas (Five alignments considered)	6-3	$130–$195	2.8–3.3	0.9–2.5	470–990	29–51	12.6	1-percent-annual-chance-exceedance Stillwater + Waves + SLR (Intermediate Low) + Freeboard	No. This concept exceeds the budget limits and protects a limited Project Area.
Reduced Levels of Protection for the Project Area (Three levels considered: Elevation 7.0, 8.0, and 10.0 feet NAVD 88)	6-4	$120–$440	2.8–4.1	0.4–2.4	6,190	39	7.0 – 10.0	1-percent to 10% annual-chance-exceedance Stillwater + Waves + SLR (Intermediate Low) + Freeboard	Yes, but only the 7 foot alignment potentially within budget constraints.
Surge Barrier across Hackensack River (Four alignments considered)	6-5	$210–$330	NA	NA	>6,200	NA	14.0	1-percent-annual-chance-exceedance Stillwater + Waves + SLR (Intermediate Low) + Freeboard	No. This concept would induce flooding outside of the Project Area.

SLR = Sea Level Rise
Cost estimate ranges from 25% contingency to 55% contingency.

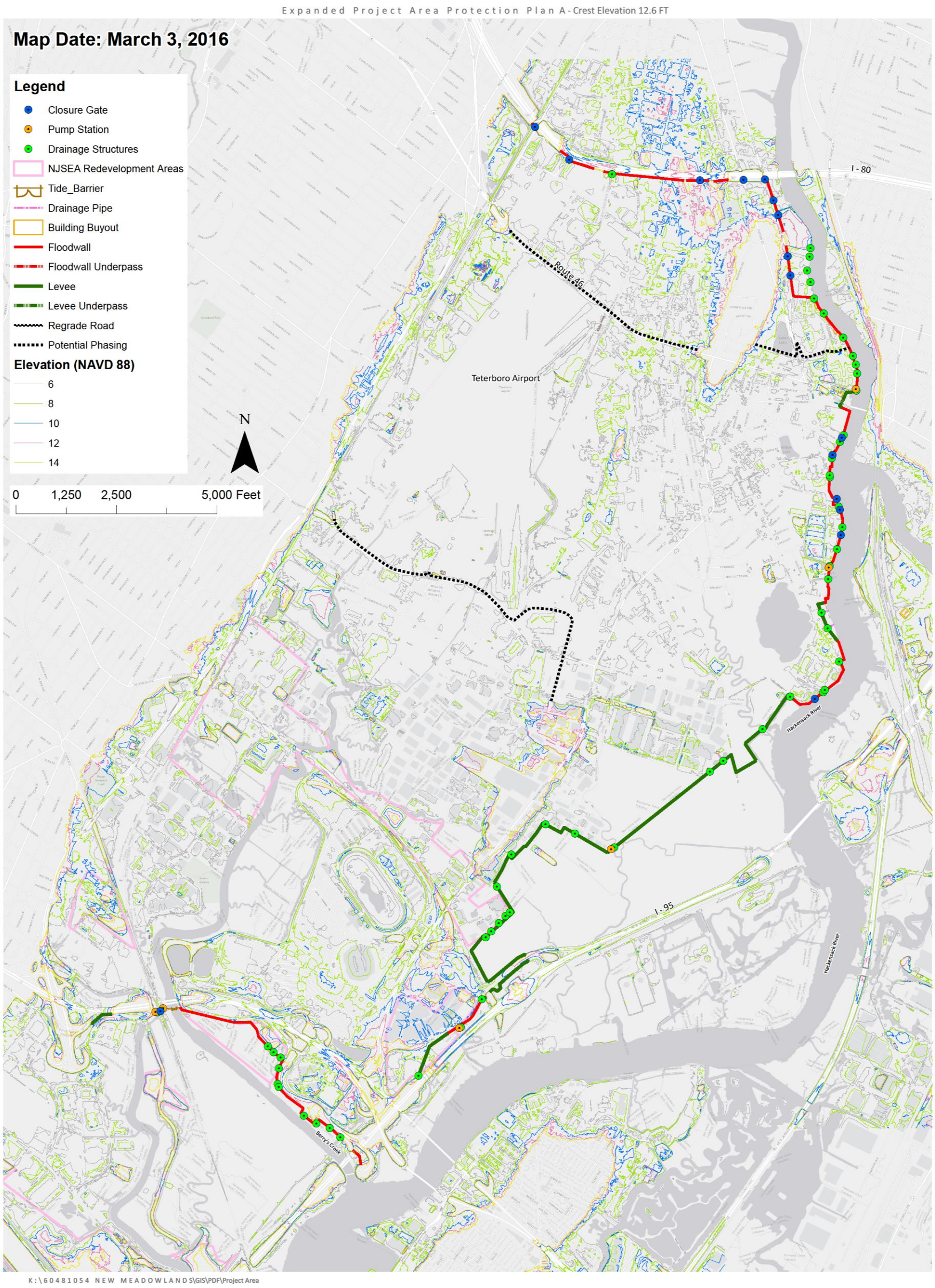


Figure 6.1-1: Maximum Regional Protection Plan (Alignment A as an Example)

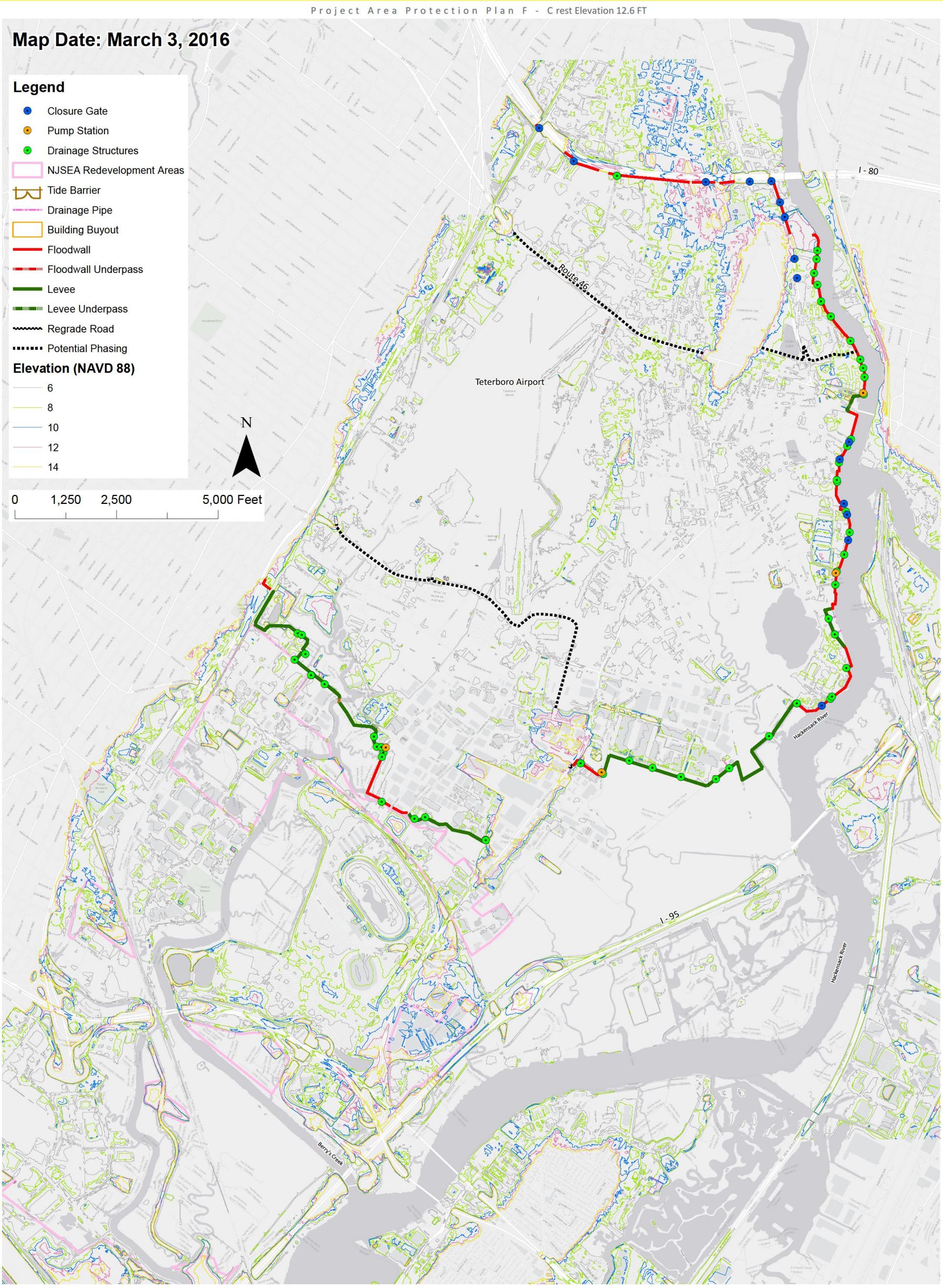


Figure 6.1-2: Modified RBDM Project Area Protection Plan - Alignment F

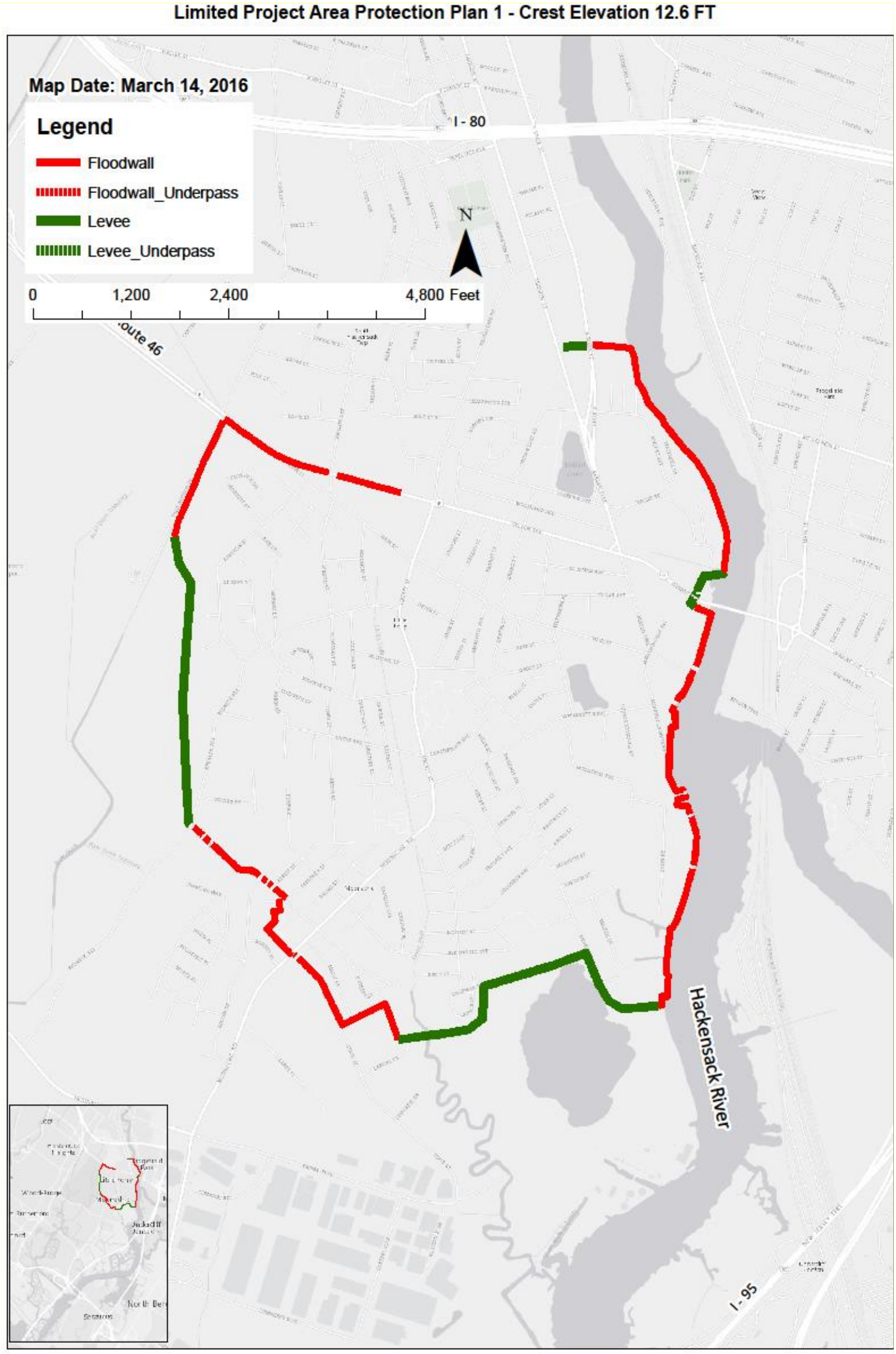


Figure 6.1-3: Limited Project Area Flood Protection Plans (Full Ring Wall Plan as an Example)

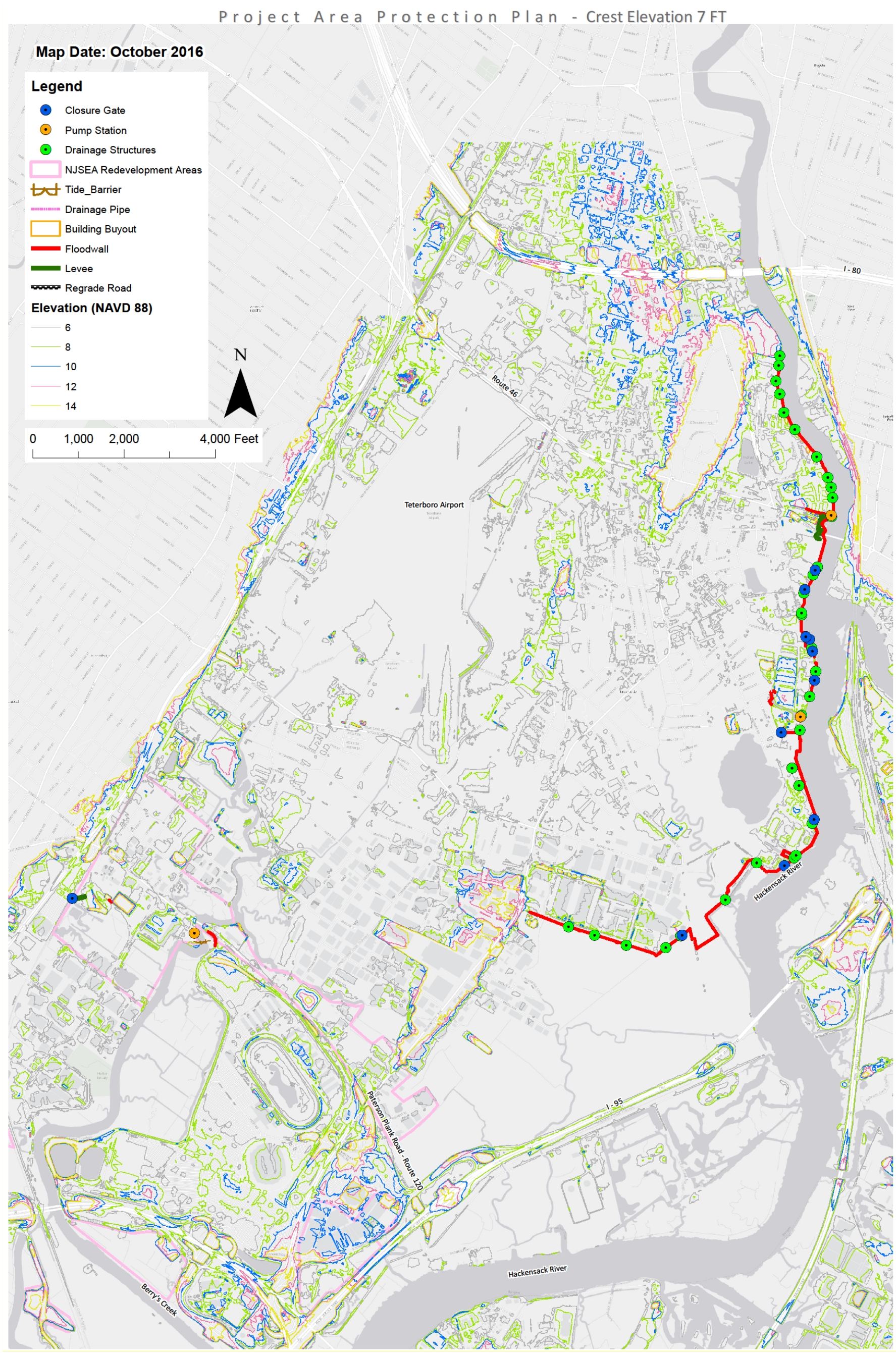


Figure 6.1-4: Reduced Levels of Protection for the Project Area (Elevation 7.0-feet Plan as an Example)

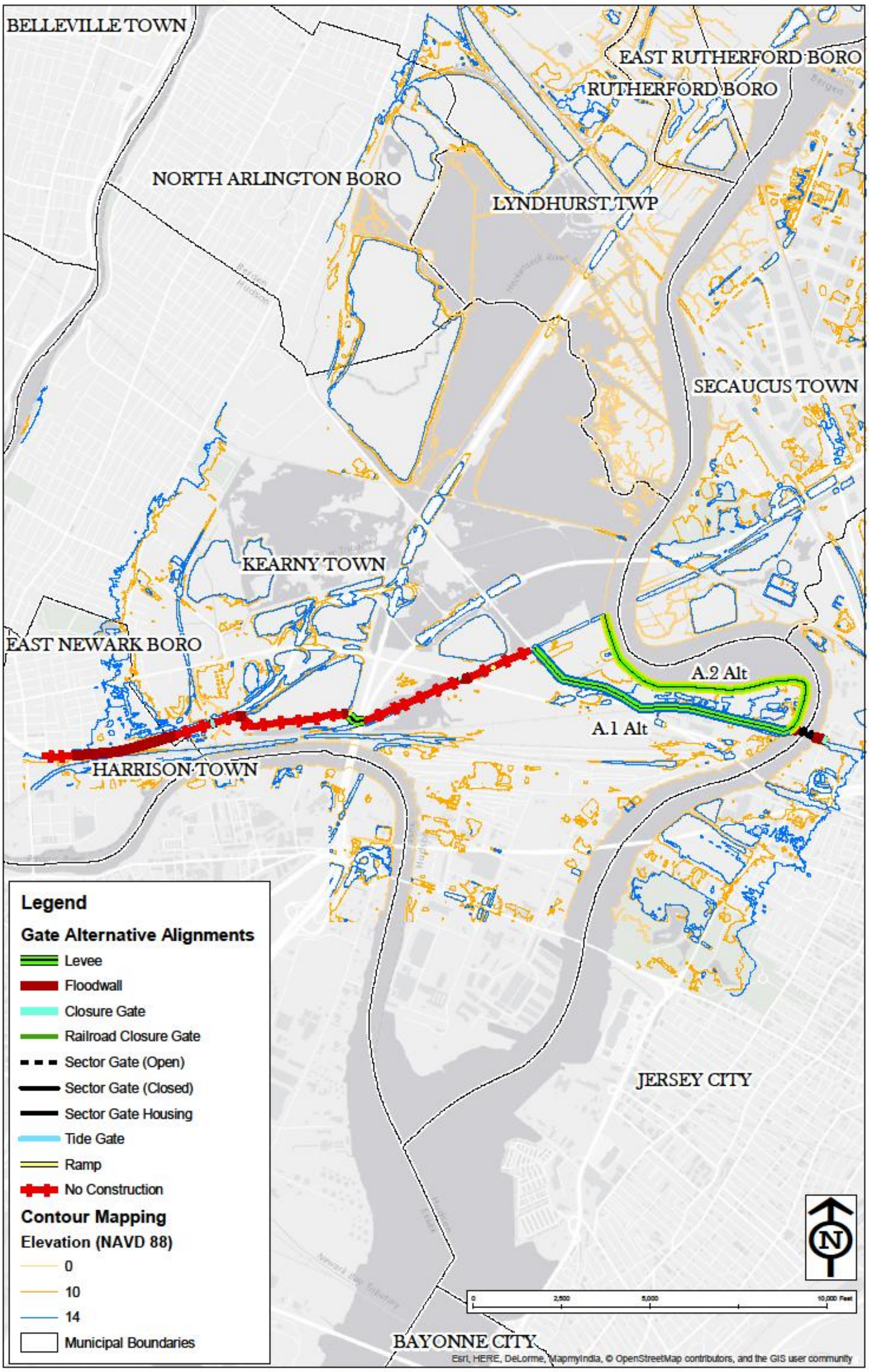


Figure 6.1-5: Storm Surge Barrier across Hackensack River (Morris-Essex Line LOP as an Example)

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6.1.3 Initial Concept Options for 7-foot (NAVD 88) Elevation Plan (Screening 1)

Figure 6.1-6 shows the following four reaches of the LOP for the 7 feet (NAVD 88) elevation concept plan. They were evaluated for further consideration in the pre-feasibility phase (Step 3).

Northern Reach – This reach is on the west bank of the Hackensack River in the Borough of Little Ferry. **Subappendix F-1** provides the specific features and narrative descriptions for the five optional alignments (Northeast Options 1 through 5). Each of the alignments includes a modular floodwall consisting of various structural wall, bench, and planter units. The costs of the five options vary between $15.4 and $17.5 million.

Central Reach – This reach on the west bank of the Hackensack River begins on the north side of US Route 46 and extends to the south side of Transco Williams Pipeline Road. It includes construction of the proposed Fluvial Park and K-town Park, riverside landing open space, a cantilever walkway, floodwalls/levees, and closure gates. **Subappendix F-1** provides the specific features and narrative description. Only one alignment is considered and the estimated cost is $52 million.

Southern Reach – This reach ties into the Central reach at the southern end of the Project Area, with four potential options (Southeast Options SE-1, 2, 3A, and 3C) rated by the SMEs. **Subappendix F-1** provides the specific features and narrative description of each of the options. The costs of the four options vary between $28.2 and $61.5 million.

Berry's Creek Reach – This reach has three potential options (Berry's Creek Options BC-1, BC-2, and BC-3). Option 1 is a dual gate surge barrier across Berry's Creek with short T-wall and earthen berms to reduce flanking. Option 2 is a combined single sheet pile with concrete cap/ reinforced double sheet pile/ earthen levee on the eastern edge of Berry's Creek that provides protection for the majority of the Project Area. Option 3 is a LOP on both eastern and western edges of Berry's Creek to protect the entire Project Area. **Subappendix F-1** provides the specific features and narrative description of each of the options. The costs of the three options vary between $11.5 and $28.2 million.

6.1.4 Secondary Screening (Screening 2)

Each alignment option was evaluated using the screening criteria adapted for the five major Purpose and Need categories identified during the National Environmental Policy Act (NEPA) scoping process:

- Flood Risk Reduction
- Built Environment / Human Environment
- Constructability / O&M
- Natural Environment
- Costs and Benefits

Each of the major categories has between three and eight individual screening criteria with an SME assigned to each criterion. A rating sheet was provided to the SMEs for each criterion.

Table 6.1-2 is an example rating sheet for "Criterion 1a. Reduces Flood Risk from Coastal Strom Surge" for the Northern reach. The SMEs were responsible for assigning "Good" ,"Fair", "Poor" and "Potential Fatal Flaw" metrics for each criterion. A full set of the rating sheets is provided in **Subappendix F-1**.

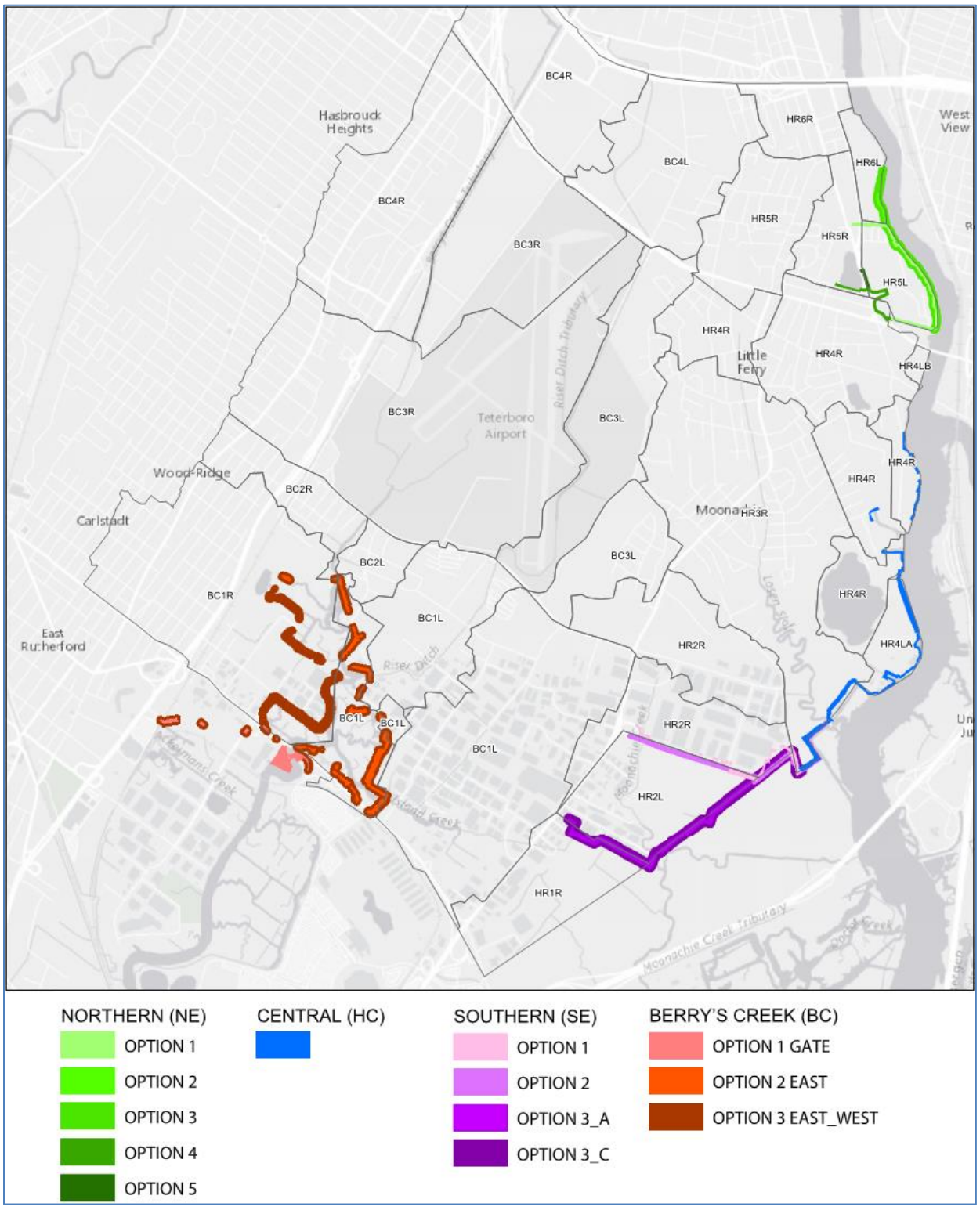


Figure 6.1-6: Alternative 1 Line of Protection Components and Options

Table 6.1-3 through **Table 6.1-6** show the scoring for each of the four reaches. Based on the scoring results of the Alternative 1 Pre-feasibility Phase Analysis, there were clear preferred options for three of the four reaches that make up the 7 feet (NAVD 88) LOP concept:

- Central (only 1 option developed)
- Southern – Option SE-2
- Berry's Creek Option 1 – Tide Gate

For the Northern reach, there was no clear preference between Options 2 and 3, which received approximately the same scores. The Option 2 and Option 3 alignments are identical except that the LOP for Option 3 extends an additional 1,200 feet to the north. **Figure 6.1-7** shows the tentatively selected alignment for Alternative 1 to be further refined and optimized during the feasibility phase. Additional efforts during the feasibility phase include:

- Select preferred alignment with develop cross sections;
- Optimize the elevation of protection;
- Optimize drainage/pump capacity;
- Monetize social and environmental benefits; and
- Complete incremental cost analysis.

Table 6.1-2: Example of a Rating Sheet

Screening Criterion 1a: Reduces Flood Risk from Coastal Storm				
LOP Concept	**Description**	**Rating**	**Addition Notes to Justify Rating**	**Identify any major concerns with the resource area**
Northern (NE)				
Option 1	Remains inside current project boundary; Tie-in west of South River Street; Cost includes passive deployable at roadway crossing	Fair	Provides a moderate **relative** reduction in future coastal storm surge flood risk for design return period, compared with the other options based on annual damages reduced ($207 k/yr); Option can be readily modified or retrofillted to accomodate a larger plan.	Level of Protection will decline over 50 year period of analysis due to SLR if LOP stays the same.
Option 2	No road crossing or regrading required; Provides extended protection along river; Tie-in north of project boundary in City of Hackensack; Requires acquisition of easement across 3 parcels held by single owner	Good	Provides the highest **relative** reduction in future coastal storm surge flood risk for design return period, compared with the other options based on annual damages reduced ($223 k/yr); Option can be readily modified or retrofillted to accomodate a larger plan.	Level of Protection will decline over 50 year period of analysis due to SLR if LOP stays the same.
Option 3	Further extends protection and modular system described under Option 2; Creates important connection to existing segment of Hackensack Riverwalk; Requires acquisition of 2 additional parcels from single private owner	Good	Provides the highest **relative** reduction in future coastal storm surge flood risk for design return period, compared with the other options based on annual damages reduced ($223 k/yr); Option can be readily modified or retrofillted to accomodate a larger plan.	Level of Protection will decline over 50 year period of analysis due to SLR if LOP stays the same.
Option 4	Tie-in west of Indian Lake; Avoids most private properties and structures; Provides new public realm features at existing recreational facility; Cost includes passive deployables for roadway crossings; Presents potential temporary impacts to Green Acres property	Poor	Provides the least **relative** reduction in future coastal storm surge flood risk for design return period, compared with the other options based on annual damages reduced ($192 k/yr); Option can be readily modified or retrofillted to accomodate a larger plan.	Level of Protection will decline over 50 year period of analysis due to SLR if LOP stays the same.
Option 5	Tie-in south of Bergen Turnpike/S. River road split; Avoids most private properties and all structures; Cost includes passive deployables for roadway crossings; Presents potential temporary and permanent impacts to transportation, including evacuation route	Fair	Provides a moderate **relative** reduction in future coastal storm surge flood risk for design return period, compared with the other options based on annual damages reduced ($207 k/yr); Option can be readily modified or retrofillted to accomodate a larger plan.	Level of Protection will decline over 50 year period of analysis due to SLR if LOP stays the same.

Table 6.1-3: Scoring of Northern Alignment Options

CONCEPTS	SCREENING CRITERION	Percent Total Weighting by Purpose and Need Category	Weighting Factor	Northern Segment Options														
				Option 1			Option 2			Option 3			Option 4			Option 5		
				Rating (Good, Fair Poor, Fatal Flaw, NA)	Score (3,2,1,-10000)	Weighted Score	Rating (Good, Fair Poor, Fatal Flaw, NA)	Score (3,2,1,-10000)	Weighted Score	Rating (Good, Fair Poor, Fatal Flaw, NA)	Score (3,2,1,-10000)	Weighted Score	Rating (Good, Fair Poor, Fatal Flaw, NA)	Score (3,2,1,-10000)	Weighted Score	Rating (Good, Fair Poor, Fatal Flaw, NA)	Score (3,2,1,-10000)	Weighted Score
1. FLOOD RISK REDUCTION	1a. Reduces Flood Risk from Coastal Storm Surge	20.0%	6.7	Fair	2	13.3	Good	3	20.0	Good	3	20.0	Poor	1	6.7	Fair	2	13.3
	1b. Provides Protection to Vulnerable and Underserved Populations		6.7	Fair	2	13.3	Fair	2	13.3	Fair	2	13.3	Good	3	20.0	Fair	2	13.3
	1c. Provides Protection to Critical Infrastructure (emergency services, hospitals, transit facilities)		6.7	Poor	1	6.7	Poor	1	6.7	Poor	1	6.7	Poor	1	6.7	Poor	1	6.7
2. BUILT ENVIRONMENT/HUMAN ENVIRONMENT	2a.Effects to Existing Utilities & Utility Infrastructure	20.0%	2.9	Fair	2	5.7	Good	3	8.6	Good	3	8.6	Poor	1	2.9	Poor	1	2.9
	2b1. Effects to Existing Local Roadway Network and Connectivity		1.4	Fair	2	2.9	Good	3	4.3	Good	3	4.3	Poor	1	0.0	Poor	1	0.0
	2b2. Effects to Existing Regional Transportation Network and Connectivity		1.4	Fair	2	2.9	Good	3	4.3	Good	3	4.3	Fair	2	2.9	Fair	2	2.9
	2c. Effects on Land Acquisition / Housing Displacements		2.9	Poor	1	2.9	Poor	1	2.9	Poor	1	2.9	Fair	2	5.7	Fair	2	5.7
	2d. Potential to Provide Increased Waterfront Access		2.9	Good	3	8.6	Good	3	8.6	Good	3	8.6	Fair	2	5.7	Fair	2	5.7
	2e. Effects to Recreational, Civic, and Cultural Amenities and Uses		2.9	Good	3	8.6	Good	3	8.6	Good	3	8.6	Good	3	8.6	Good	3	8.6
	2f.Effects to Viewshed and Local Visual Quality		2.9	Good	3	8.6	Good	3	8.6	Good	3	8.6	Good	3	8.6	Good	3	8.6
	2g. Effects to Air Traffic Safety at Teterboro Airport		2.9	Fair	2	5.7	Fair	2	5.7	Fair	2	5.7	Fair	2	5.7	Fair	2	5.7

CONCEPTS	SCREENING CRITERION	Percent Total Weighting by Purpose and Need Category	Weighting Factor	Northern Segment Options														
				Option 1			Option 2			Option 3			Option 4			Option 5		
				Rating (Good, Fair Poor, Fatal Flaw, NA)	Score (3,2,1,-10000)	Weighted Score	Rating (Good, Fair Poor, Fatal Flaw, NA)	Score (3,2,1,-10000)	Weighted Score	Rating (Good, Fair Poor, Fatal Flaw, NA)	Score (3,2,1,-10000)	Weighted Score	Rating (Good, Fair Poor, Fatal Flaw, NA)	Score (3,2,1,-10000)	Weighted Score	Rating (Good, Fair Poor, Fatal Flaw, NA)	Score (3,2,1,-10000)	Weighted Score
3.. CONSTRUCTION/ MAINTENANCE & OPERATIONS	3a. Constructability	20.0%	6.7	Fair	2	13.3	Good	3	20.0	Good	3	20.0	Fair	2	13.3	Fair	2	13.3
	3b. Minimizes Long-Term Maintenance & Operation Requirements for Overall System		6.7	Fair	2	13.3	Good	3	20.0	Good	3	20.0	Fair	2	13.3	Fair	2	13.3
	3c. Potential to Complete Construction by September 2022-Constructability		6.7	Good	3	20.0	Good	3	20.0	Good	3	20.0	Good	3	20.0	Good	3	20.0
4. NATURAL ENVIRONMENT	4a. Effects to Existing Hazardous Waste Sites	20.0%	3.3	Fair	2	6.7	Good	3	10.0	Fair	2	6.7	Fair	2	6.7	Fair	2	6.7
	4b. Effects to Berry's Creek Remediation		3.3	Good	3	10.0	Good	3	10.0	Good	3	10.0	Good	3	10.0	Good	3	10.0
	4c.Effects on the Transport of Environmental Contaminants/ Sediments during Flood Events		3.3	Good	3	10.0	Good	3	10.0	Good	3	10.0	Good	3	10.0	Good	3	10.0
	4d. Effects on regulated wetlands and waterbodies		3.3	Good	3	10.0	Good	3	10.0	Good	3	10.0	Good	3	10.0	Good	3	10.0
	4e. Positive environmental/habitat impacts		3.3	Poor	1	3.3	Poor	1	3.3	Poor	1	3.3	Poor	1	3.3	Poor	1	3.3
	4f. Effects to Historic and Prehistoric Cultural Resources		3.3	Good	3	10.0	Good	3	10.0	Good	3	10.0	Good	3	10.0	Good	3	10.0
5. COSTS & BENEFITS	5a. Provides Benefits to the Project Area and Community	20.0%	6.7	Fair	2	13.3	Good	3	20.0	Good	3	20.0	Poor	1	6.7	Fair	2	13.3
	5b. Can be Implemented within Available Funding Limits		6.7	Fair	2	13.3	Good	3	20.0	Good	3	20.0	Poor	1	6.7	Poor	1	6.7
	5c. Has a Positive Benefit/Cost Ratio (BCR)		6.7	Fair	2	13.3	Good	3	20.0	Fair	2	13.3	Poor	1	6.7	Poor	1	6.7
	SCORE TOTAL	100.0%	100			215.7			264.8			254.8			190.0			196.7

Table 6.1-4: Scoring of Hackensack Central Alginment Options

CONCEPTS	SCREENING CRITERION	Central Segment Options				
		Percent Total Weighting by Purpose and Need Category	Weighting Factor	Rating (Good, Fair Poor, Fatal Flaw, NA)	Score (3,2,1,-10000)	Weighted Score
1. FLOOD RISK REDUCTION	1a. Reduces Flood Risk from Coastal Storm Surge	20.0%	6.7	Fair	2	13.3
	1b. Provides Protection to Vulnerable and Underserved Populations		6.7	Good	3	20
	1c. Provides Protection to Critical Infrastructure (emergency services, hospitals, transit facilities)		6.7	Poor	1	6.7
2. BUILT ENVIRONMENT/HUMAN ENVIRONMENT	2a.Effects to Existing Utilities & Utility Infrastructure	20.0%	2.9	Fair	2	5.7
	2b1. Effects to Existing Local Roadway Network and Connectivity		1.4	Poor	1	1.4
	2b2. Effects to Existing Regional Transportation Network and Connectivity		1.4	Poor	1	1.4
	2c. Effects on Land Acquisition / Housing Displacements		2.9	Fair	2	5.7
	2d. Potential to Provide Increased Waterfront Access		2.9	Good	3	8.6
	2e. Effects to Recreational, Civic, and Cultural Amenities and Uses		2.9	Good	3	8.6
	2f.Effects to Viewshed and Local Visual Quality		2.9	Fair	2	5.7
	2g. Effects to Air Traffic Safety at Teterboro Airport		2.9	Fair	2	5.7
3.. CONSTRUCTION/ MAINTENANCE & OPERATIONS	3a. Constructability	20.0%	6.7	Fair	2	13.3
	3b. Minimizes Long-Term Maintenance & Operation Requirements for Overall System		6.7	Fair	2	13.3
	3c. Potential to Complete Construction by September 2022-Constructability		6.7	Good	3	20.0
4. NATURAL ENVIRONMENT	4a. Effects to Existing Hazardous Waste Sites	20.0%	3.3	Poor	1	3.3
	4b. Effects to Berry's Creek Remediation		3.3	Good	3	10.0
	4c.Effects on the Transport of Environmental Contaminants/ Sediments during Flood Events		3.3	Fair	2	6.7
	4d. Effects on regulated wetlands and waterbodies		3.3	Poor	1	3.3
	4e. Positive environmental/habitat impacts		3.3	Fair	2	6.7
	4f. Effects to Historic and Prehistoric Cultural Resources		3.3	Fair	2	6.7
5. COSTS & BENEFITS	5a. Provides Benefits to the Project Area and Community	20.0%	6.7	Good	3	20.0
	5b. Can be Implemented within Available Funding Limits		6.7	Good	3	20.0
	5c. Has a Positive Benefit/Cost Ratio (BCR)		6.7	Good	3	20.0
	SCORE TOTAL	100.0%	100			226.2

Table 6.1-5: Scoring of Southern Alignment Options

CONCEPTS	SCREENING CRITERION	Percent Total Weighting by Purpose and Need Category	Weighting Factor	Southern Segment Options							
				Option 1		Option 2		Option 3A		Option 3C	
				Rating (Good, Fair Poor, Fatal Flaw, NA)	Weighted Score	Rating (Good, Fair Poor, Fatal Flaw, NA)	Weighted Score	Rating (Good, Fair Poor, Fatal Flaw, NA)	Weighted Score	Rating (Good, Fair Poor, Fatal Flaw, NA)	Weighted Score
1. FLOOD RISK REDUCTION	1a. Reduces Flood Risk from Coastal Storm Surge	20.0%	6.7	Fair	13.3	Fair	13.3	Good	20.0	Good	20.0
	1b. Provides Protection to Vulnerable and Underserved Populations		6.7	Fair	13.3	Good	20.0	Fair	13.3	Fair	13.3
	1c. Provides Protection to Critical Infrastructure (emergency services, hospitals, transit facilities)		6.7	Poor	6.7	Poor	6.7	Poor	6.7	Poor	6.7
2. BUILT ENVIRONMENT/HUMAN ENVIRONMENT	2a.Effects to Existing Utilities & Utility Infrastructure	20.0%	2.9	Good	8.6	Good	8.6	Good	8.6	Good	8.6
	2b1. Effects to Existing Local Roadway Network and Connectivity		1.4	Fair	2.9	Fair	2.9	Good	4.3	Good	4.3
	2b2. Effects to Existing Regional Transportation Network and Connectivity		1.4	Poor	1.4	Fair	2.9	Fair	2.9	Fair	2.9
	2c. Effects on Land Acquisition / Housing Displacements		2.9	FAIR	5.7	Good	8.6	Good	8.6	Good	8.6
	2d. Potential to Provide Increased Waterfront Access		2.9	FAIR	5.7	Fair	5.7	Fair	5.7	Fair	5.7
	2e. Effects to Recreational, Civic, and Cultural Amenities and Uses		2.9	FAIR	5.7	Fair	5.7	Fair	5.7	Fair	5.7
	2f.Effects to Viewshed and Local Visual Quality		2.9	FAIR	5.7	Fair	5.7	Fair	5.7	Fair	5.7
	2g. Effects to Air Traffic Safety at Teterboro Airport		2.9	FAIR	5.7	Fair	5.7	Fair	5.7	Fair	5.7

CONCEPTS	SCREENING CRITERION	Percent Total Weighting by Purpose and Need Category	Weighting Factor	Southern Segment Options							
				Option 1		Option 2		Option 3A		Option 3C	
				Rating (Good, Fair Poor, Fatal Flaw, NA)	Weighted Score	Rating (Good, Fair Poor, Fatal Flaw, NA)	Weighted Score	Rating (Good, Fair Poor, Fatal Flaw, NA)	Weighted Score	Rating (Good, Fair Poor, Fatal Flaw, NA)	Weighted Score
3. CONSTRUCTION/ MAINTENANCE & OPERATIONS	3a. Constructability	20.0%	6.7	Fair	13.3	Good	20.0	Good	20.0	Good	20.0
	3b. Minimizes Long-Term Maintenance & Operation Requirements for Overall System		6.7	Fair	13.3	Good	20.0	Good	20.0	Good	20.0
	3c. Potential to Complete Construction by September 2022-Constructability		6.7	Good	20.0	Good	20.0	Good	20.0	Good	20.0
4. NATURAL ENVIRONMENT	4a. Effects to Existing Hazardous Waste Sites	20.0%	3.3	Good	10.0	Good	10.0	Poor	3.3	Poor	3.3
	4b. Effects to Berry's Creek Remediation		3.3	Good	10.0	Good	10.0	Good	10.0	Good	10.0
	4c.Effects on the Transport of Environmental Contaminants/ Sediments during Flood Events		3.3	Good	10.0	Good	10.0	Good	10.0	Good	10.0
	4d. Effects on regulated wetlands and waterbodies		3.3	Fair	6.7	Fair	6.7	Poor	3.3	Poor	3.3
	4e. Positive environmental/habitat impacts		3.3	Poor	3.3	Fair	6.7	Poor	3.3	Poor	3.3
	4f. Effects to Historic and Prehistoric Cultural Resources		3.3	Good	10.0	Fair	6.7	Good	10.0	Good	10.0
5. COSTS & BENEFITS	5a. Provides Benefits to the Project Area and Community	20.0%	6.7	Fair	13.3	Fair	13.3	Good	20.0	Good	20.0
	5b. Can be Implemented within Available Funding Limits		6.7	Fair	13.3	Fair	13.3	Poor	6.7	Poor	6.7
	5c. Has a Positive Benefit/Cost Ratio (BCR)		6.7	Fair	13.3	Fair	13.3	Poor	6.7	Poor	6.7
	SCORE TOTAL	100.0%	100		211.4		235.7		220.48		220.48

Table 6.1-6: Scoring of Berry's Creek Alignment Options

CONCEPTS	SCREENING CRITERION	Percent Total Weighting by Purpose and Need Category	Weighting Factor	Berry's Creek Segment Options						
				Option 1		Option 2			Option 3	
				Rating (Good, Fair Poor, Fatal Flaw, NA)	Weighted Score	Rating (Good, Fair Poor, Fatal Flaw, NA)	Score (3,2,1,-10000)	Weighted Score	Rating (Good, Fair Poor, Fatal Flaw, NA)	Weighted Score
1. FLOOD RISK REDUCTION	1a. Reduces Flood Risk from Coastal Storm Surge	20.0%	6.7	Good	20.0	Fair	2	13.3	Good	20.0
	1b. Provides Protection to Vulnerable and Underserved Populations		6.7	Good	20.0	Good	3	20.0	Good	20.0
	1c. Provides Protection to Critical Infrastructure (emergency services, hospitals, transit facilities)		6.7	Fair	13.3	Poor	1	6.7	Fair	13.3
2. BUILT ENVIRONMENT/HUMAN ENVIRONMENT	2a.Effects to Existing Utilities & Utility Infrastructure	20.0%	2.9	Good	8.6	Fair	2	5.7	Fair	5.7
	2b1. Effects to Existing Local Roadway Network and Connectivity		1.4	Poor	1.4	Fair	2	2.9	Good	4.3
	2b2. Effects to Existing Regional Transportation Network and Connectivity		1.4	Poor	1.4	Good	3	4.3	Good	4.3
	2c. Effects on Land Acquisition / Housing Displacements		2.9	Fair	5.7	Poor	1	2.9	Poor	2.9
	2d. Potential to Provide Increased Waterfront Access		2.9	Fair	5.7	Fair	2	5.7	Fair	5.7
	2e. Effects to Recreational, Civic, and Cultural Amenities and Uses		2.9	Fair	5.7	Fair	2	5.7	Fair	5.7
	2f.Effects to Viewshed and Local Visual Quality		2.9	Poor	2.9	Fair	2	5.7	Fair	5.7
	2g. Effects to Air Traffic Safety at Teterboro Airport		2.9	Fair	5.7	Fair	2	5.7	Fair	5.7

CONCEPTS	SCREENING CRITERION	Percent Total Weighting by Purpose and Need Category	Weighting Factor	Berry's Creek Segment Options							
				Option 1		Option 2			Option 3		
				Rating (Good, Fair Poor, Fatal Flaw, NA)	Weighted Score	Rating (Good, Fair Poor, Fatal Flaw, NA)	Score (3,2,1,-10000)	Weighted Score	Rating (Good, Fair Poor, Fatal Flaw, NA)	Weighted Score
3. CONSTRUCTION/ MAINTENANCE & OPERATIONS	3a. Constructability	20.0%	6.7	Good	20.0	Fair	2	13.3	Fair	13.3
	3b. Minimizes Long-Term Maintenance & Operation Requirements for Overall System		6.7	Poor	6.7	Fair	2	13.3	Fair	13.3
	3c. Potential to Complete Construction by September 2022- Constructability (Paul Kovnak)		6.7	Fair	13.3	Fair	2	13.3	Fair	13.3
4. NATURAL ENVIRONMENT	4a. Effects to Existing Hazardous Waste Sites	20.0%	3.3	Fair	6.7	Fair	2	6.7	Poor	3.3
	4b. Effects to Berry's Creek Remediation		3.3	Poor	3.3	Poor	1	3.3	Poor	3.3
	4c.Effects on the Transport of Environmental Contaminants/ Sediments during Flood Events		3.3	Fair	6.7	Fair	2	6.7	Fair	6.7
	4d. Effects on regulated wetlands and waterbodies		3.3	Fair	6.7	Fair	2	6.7	Poor	3.3
	4e. Positive environmental/habitat impacts		3.3	Fair	6.7	Poor	1	3.3	Good	10.0
	4f. Effects to Historic and Prehistoric Cultural Resources		3.3	Fair	6.7	Good	3	10.0	Good	10.0
5. COSTS & BENEFITS	5a. Provides Benefits to the Project Area and Community	20.0%	6.7	Good	20.0	Fair	2	13.3	Poor	6.7
	5b. Can be Implemented within Available Funding Limits		6.7	Good	20.0	Poor	1	6.7	Poor	6.7
	5c. Has a Positive Benefit/Cost Ratio (BCR)		6.7	Good	20.0	Poor	1	6.7	Poor	6.7
	SCORE TOTAL	100.0%	100		227.1			181.9		190.0

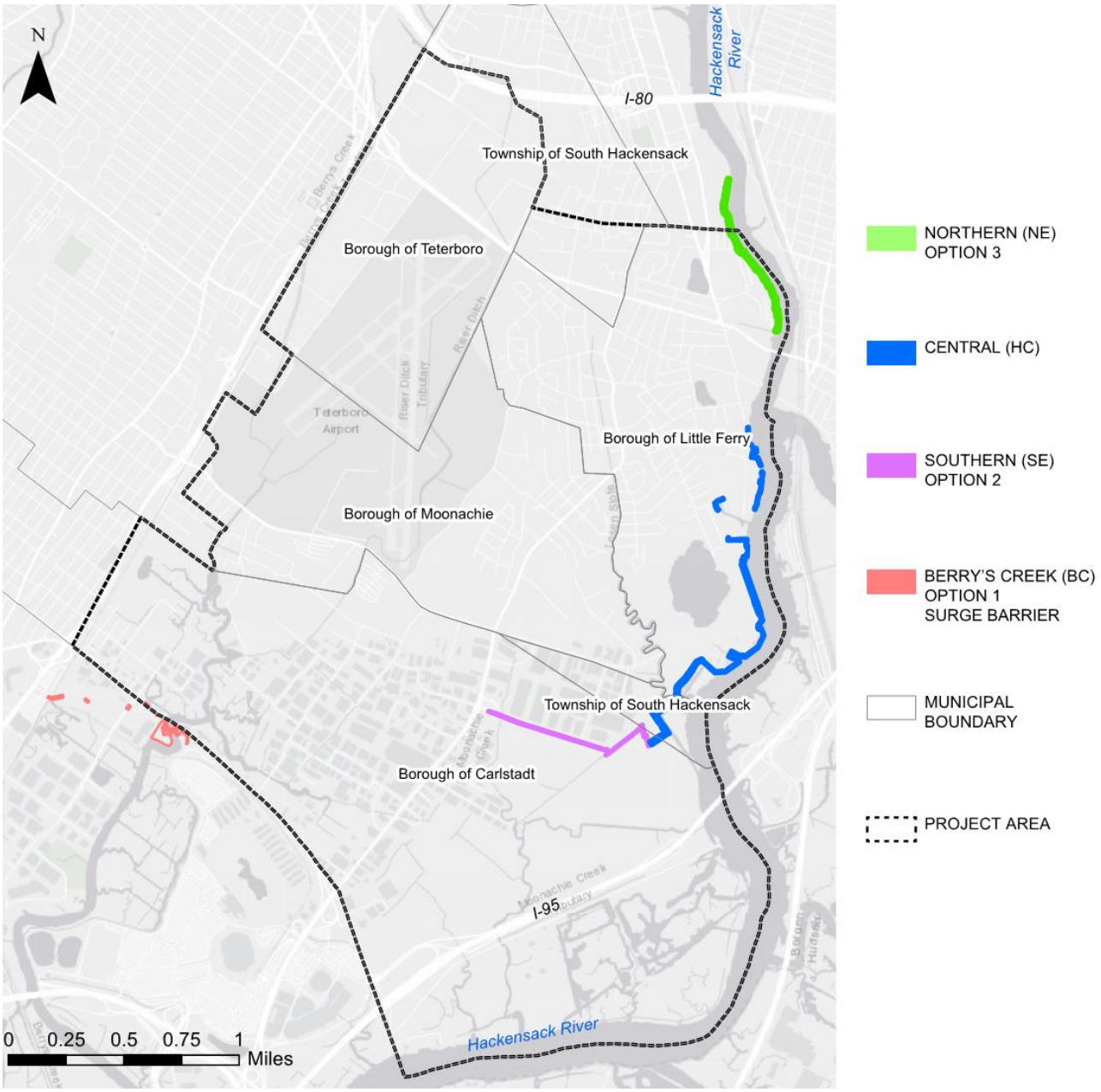


Figure 6.1-7: Selected Alignment of Alternative 1 Line of Protection

6.2 Alternative Description / Detail

Alternative 1's main purpose would be to construct a grey infrastructure-based LOP at elevation 7 feet (NAVD 88) along the Hackensack River and Berry's Creek to provide protection against coastal storm surges (2-percent-annual-chance-exceedance flood event initially). The Alternative 1 LOP would include approximately 19,700 LF of floodwalls, 900 LF of levees/berms, a tide gate, eight closure gates, and a surge barrier and pump station. This alternative is designed to protect the Project Area from coastal flooding. Open space and public realm features would also be integrated into the LOP to provide various co-benefits to the Project Area, thereby meeting this alternative's established goals and objectives.

The proposed Alternative 1 LOP would consist of four reaches as described earlier, i.e., Northern Segment, Central Segment, Southern Segment, and Berry's Creek Storm Surge Barrier (**Figure 6.2-1** through **Figure 6.2-4**). The LOP is not contiguous because some of the existing natural ground is above 7 feet (NAVD 88). **Section 6.6** includes the engineering plan and typical details sheets.

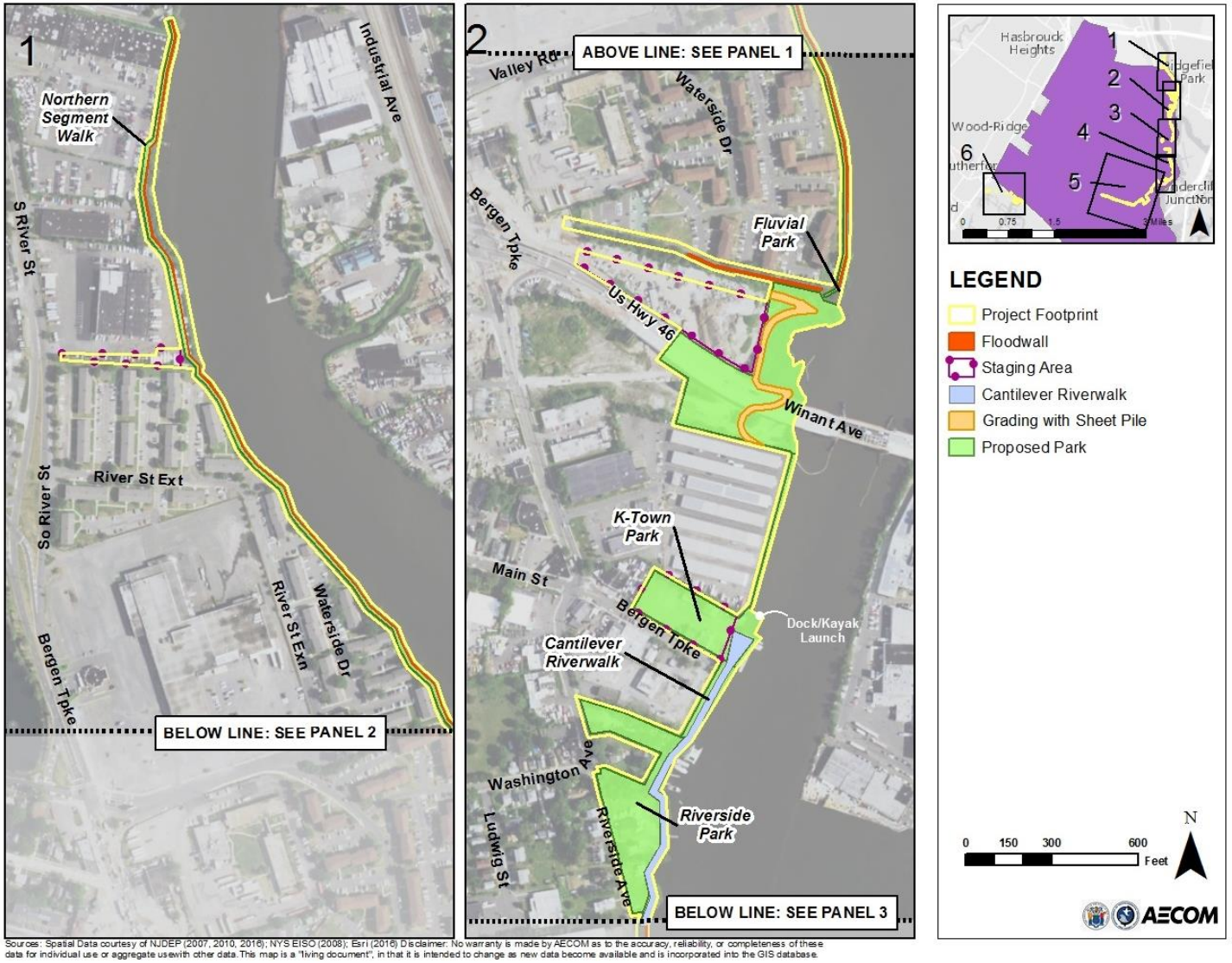
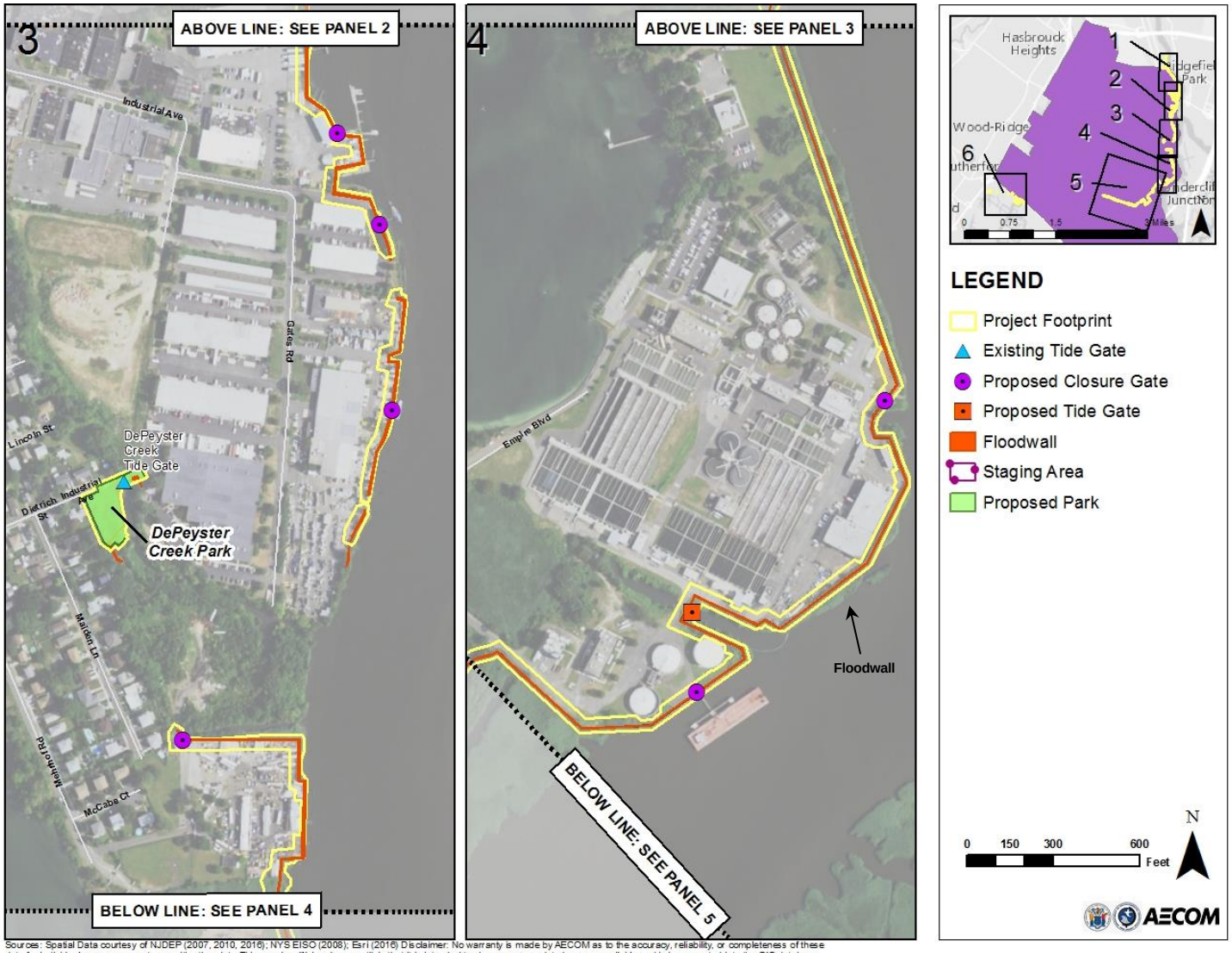


Figure 6.2-1: Northern and Central Segments of Alternative 1 Line of Protection



Sources: Spatial Data courtesy of NJDEP (2007, 2010, 2016); NYS EISO (2008); Esri (2016) Disclaimer: No warranty is made by AECOM as to the accuracy, reliability, or completeness of these data for individual use or aggregate usewith other data. This map is a "living document", in that it is intended to change as new data become available and is incorporated into the GIS database.

Figure 6.2-2: Central Segment of Alternative 1 Line of Protection

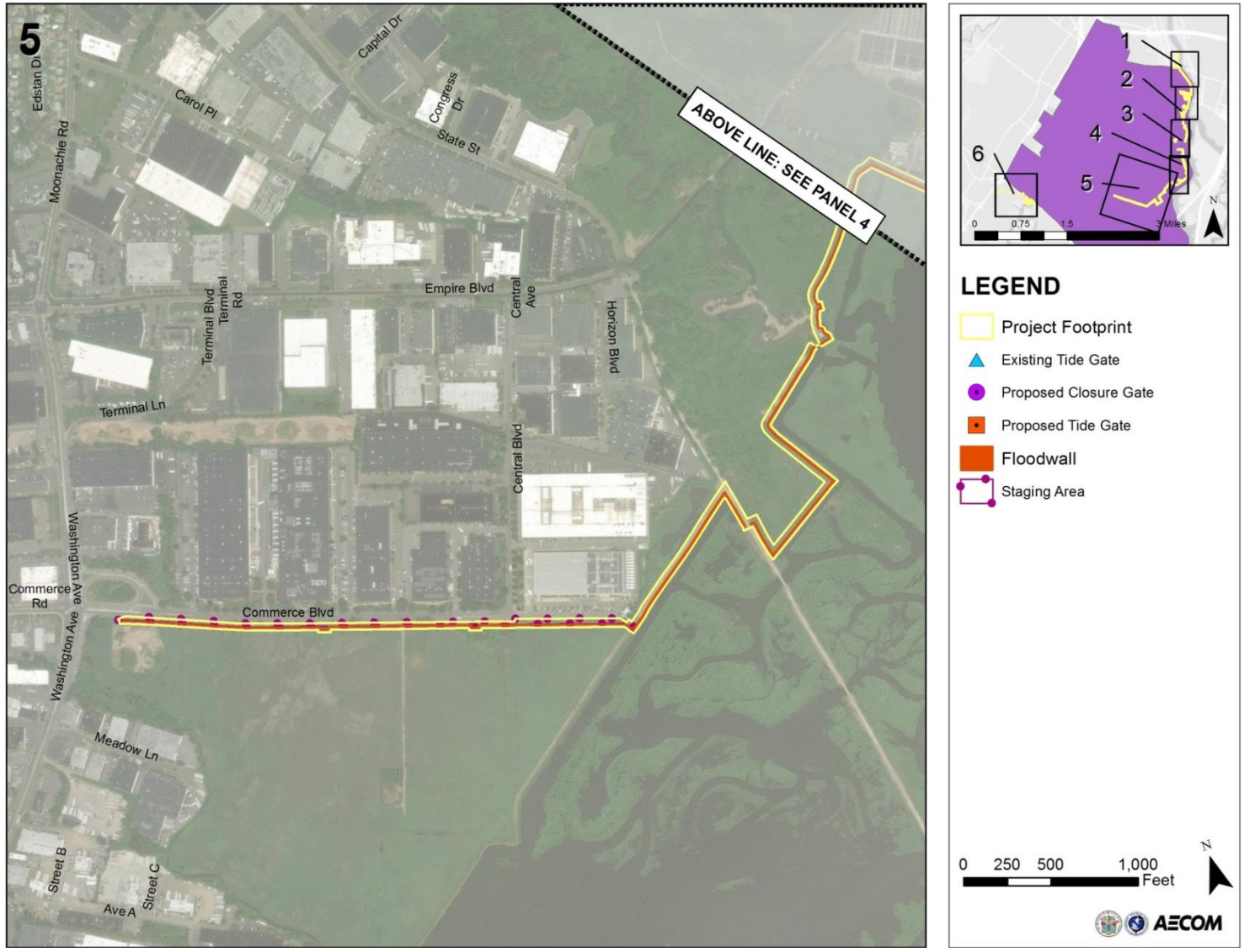
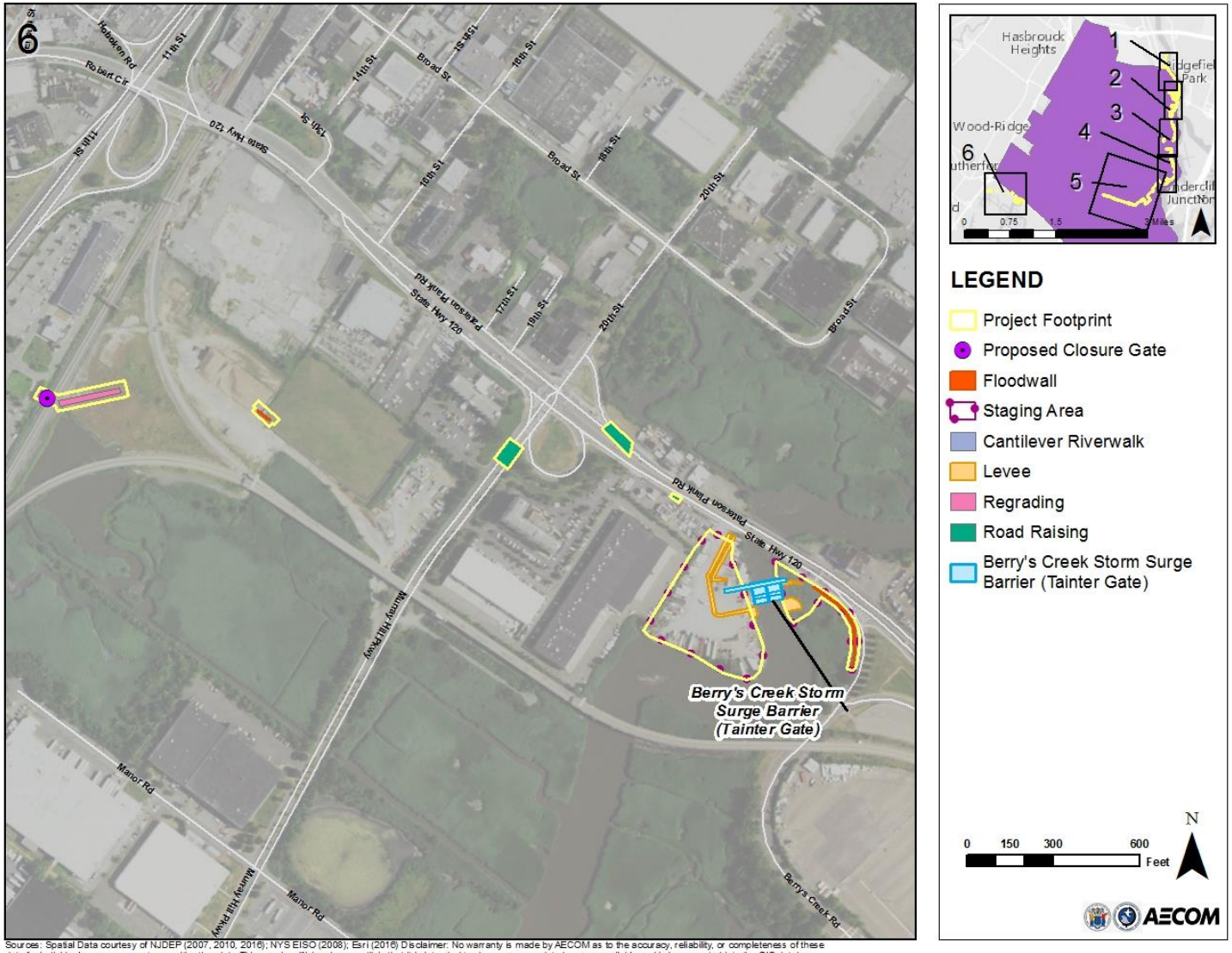


Figure 6.2-3: Central and Southern Segments of Alternative 1 Line of Protection



Sources: Spatial Data courtesy of NJDEP (2007, 2010, 2016); NYS EISO (2008); Esri (2016) Disclaimer: No warranty is made by AECOM as to the accuracy, reliability, or completeness of these data for individual use or aggregate usewith other data. This map is a "living document", in that it is intended to change as new data become available and is incorporated into the GIS database.

Figure 6.2-4: Berry's Creek Storm Surge Barrier of Alternative 1 Line of Protection

6.2.1 Northern Segment

The northern terminus of the LOP would be the Hackensack Riverwalk located at the Riverfront shopping center in the City of Hackensack. From there, the LOP would extend south along the Hackensack River through industrial and residential areas east of South River Street and Bergen Turnpike. This segment of the LOP would provide continuous structural flood protection approximately 0.8 mile to where it meets the proposed Fluvial Park, which would be located adjacent to and beneath the US Route 46 Bridge (see **Figure 6.2-1**). The Northern Segment of the LOP would also include an approximately 450-foot-long floodwall along the northern edge of the existing, unnamed ditch between the proposed Fluvial Park (discussed below in **Section 6.2.2**) and the existing Waterside Village apartments. Along the entire LOP, new backflow preventers would be installed on all stormwater outfalls.

The LOP in this segment would consist of sheet pile floodwall varying between 1 and 4 feet in height (i.e., average height of 2 feet) and about 3,800 feet in length (see Sheets S-406 and S-407 in **Subappendix F4-1** which depict the details of the sheet pile floodwall). The corridor immediately landward of the floodwall would be filled to the height of the floodwall, and a continuous, 11-foot wide concrete access path would be constructed at that elevation. In addition to facilitating emergency and maintenance operations, this access path would be available for public recreation as a riverwalk. A guard rail would be constructed along the access path on the side of the river, and a screening fence would be constructed along the landward edge of the access path. **Figure 6.2-5** presents a conceptual rendering of this portion of the LOP.



Figure 6.2-5: Rendering of Northern Segment of Alternative 1 Line of Protection

The permanent easement required for the Northern Segment would vary between 15 and 40 feet in width; the temporary easement would vary between 37 and 70 feet in width. Throughout the length of the LOP, the temporary easements would maintain at least 10 feet of separation from existing buildings. Additionally, some areas of the LOP would have seating areas and plantings integrated into the design.

6.2.2 Central Segment

From US Route 46, the LOP would continue south along the Hackensack River and enter the central portion of the Project Area where residential areas are more prevalent. The proposed Central Segment of the LOP would consist of various components, including four proposed parks (i.e., Fluvial Park, K-Town Park, Riverside Park, and DePeyster Creek Park), a cantilever riverwalk, and concrete floodwalls. The Central Segment terminates at the proposed Losen Slote Creek tide gate.

The proposed Fluvial Park (see **Figure 6.2-6**), located at the US Highway 46 Bridge, would encompass approximately 3.8 acres. This park would include both upland and wetland components, separated by a flood protection feature (i.e., sheetpile covered by graded earth). The upland portion of the proposed park would contain a seating plaza/performance space (approximately 0.8 acre) and upland plantings (approximately 0.7 acre), while the portion of the park waterward of the flood protection feature would include approximately 1.1 acres of newly created wetlands and 0.4 acre of riparian plantings. Additionally, a pathway would wind throughout the park. This proposed pathway would be a concrete path in the upland portion of the park and an elevated walkway through the wetlands and riparian areas. The pathway would connect to the access paths along the LOP both north and south of the park. Vehicular access would be available as well. The permanent easement required for this park would vary between 100 and 550 feet in width; the temporary easement would vary between 240 and 560 feet in width.

South of Fluvial Park, the LOP would continue along existing high ground. This high ground would not require a floodwall, but would contain a concrete access path. This path would connect to a proposed cantilever riverwalk at the existing K-Town industrial property. The proposed cantilever riverwalk would be an elevated walkway located atop a concrete floodwall integrated with benches and planters. It would be approximately 25 feet wide, nearly 0.2 mile long, and between 1 and 4 feet high. The permanent easement required for this proposed segment would vary between 40 and 55 feet in width; the temporary easement would vary between 50 and 65 feet in width. On the northern end of the proposed cantilever riverwalk, a proposed boat dock / kayak launch would be built in the Hackensack River to allow recreational access to the water. The northern and southern ends of the proposed cantilever riverwalk would be anchored by parks.

At the northern end of the proposed cantilever riverwalk, the proposed approximately 1.4-acre K-Town Park (see **Figure 6.2-7**) would be located on the existing K-Town industrial property. This proposed park would provide approximately 0.6 acre of active recreation space that could be used for formal and informal sports and recreational activities. In addition to this active recreational space, there would be a variety of seating areas and plantings (approximately 0.3 acre), a public parking lot (0.2 acre), and a concrete pathway connecting to the cantilever riverwalk. The permanent easement required for this park would vary between 400 and 430 feet in width; the temporary easement would vary between 410 and 430 feet in width.

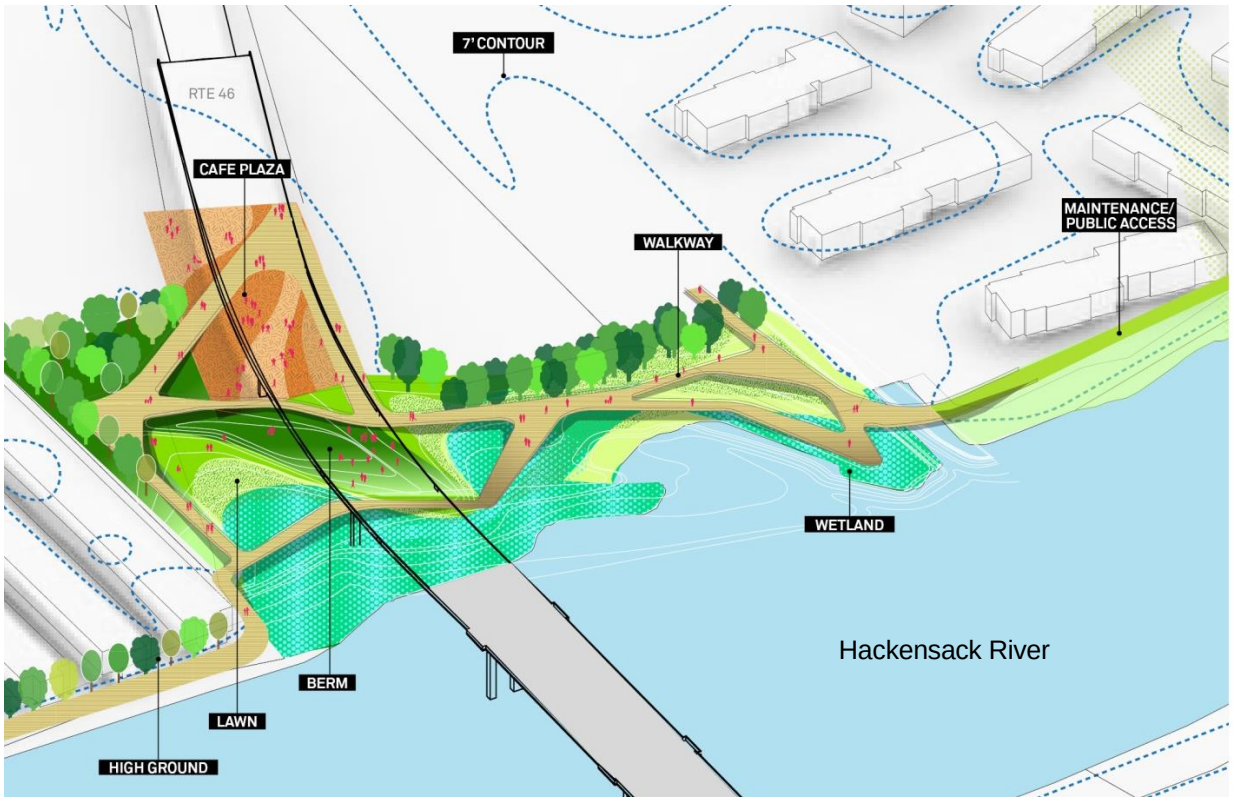


Figure 6.2-6: Concept Drawing of Proposed Fluvial Park



Figure 6.2-7: Concept Drawing of Proposed K-Town Park

At the southern end of the proposed cantilever riverwalk, a proposed approximately 2.2-acre Riverside Park (see **Figure 6.2-8**) would be located along Riverside Avenue and Washington Avenue. This proposed park would incorporate passive open recreation space (approximately 1 acre) with sculptural landforms that would create views of the Hackensack River. There would also be a network of pathways lined with native plantings (approximately 0.5 acre) connecting the proposed park to the proposed cantilever riverwalk in various locations. Riverside Park would constitute the southern terminus of the proposed public access pathway along the LOP. The permanent easement for this park would vary between 45 and 390 feet in width; the temporary easement would vary between 55 and 390 feet in width.

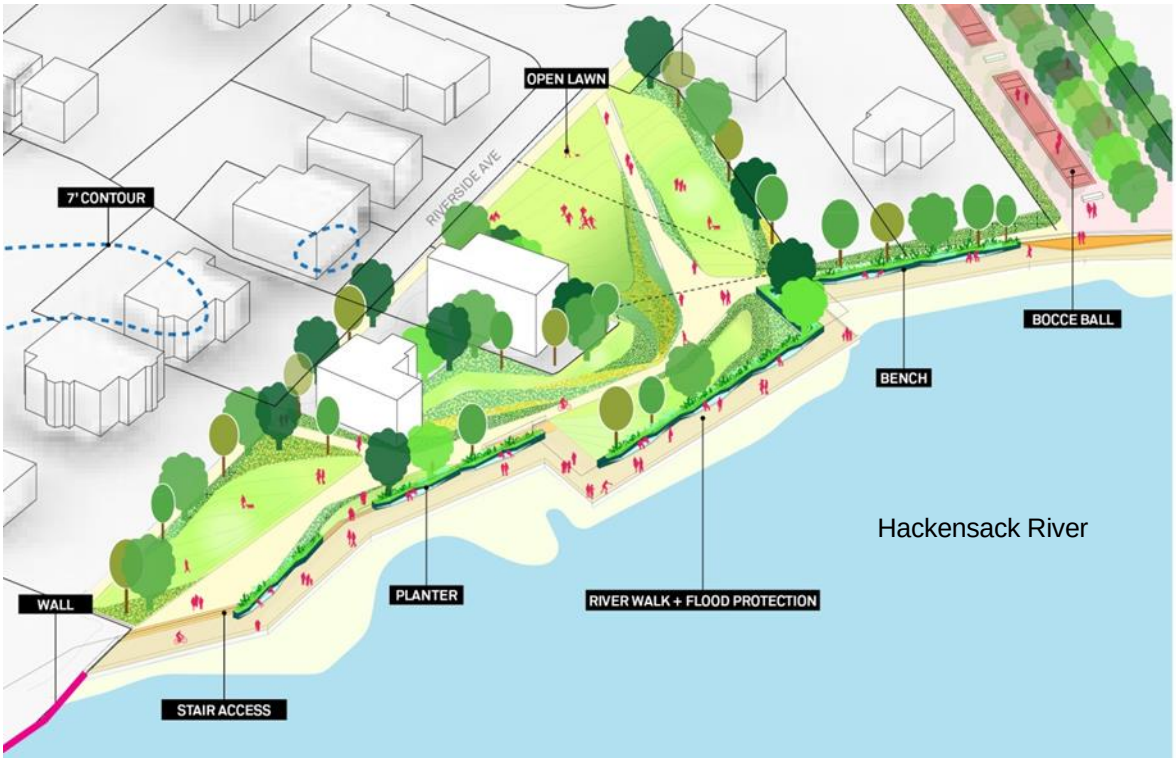


Figure 6.2-8: Concept Drawing of Proposed Riverside Park

South of the proposed cantilever riverwalk, the LOP would consist of a series of concrete floodwalls constructed primarily following the Hackensack River to the northern limit of the BCUA property. The permanent easement required for these floodwalls would vary between approximately 12 and 40 feet in width; the temporary easement would vary between approximately 12 and 50 feet in width. **Figure 6.2-9** presents a conceptual rendering of a concrete floodwall. Small breaks in the floodwall would occur where the existing elevation is already at 7 feet (NAVD 88). These areas include: (1) the area parallel to the Protec Equipment Resources Inc. property, (2) the southern end of the Doka USA Ltd. property, and (3) the largely vegetated area south of DePeyster Creek. Additionally, four closure gates would be installed to maintain access to existing boat docks and access roads. These closure gates would remain open under normal circumstances, but would be closed prior to flood events to seal the LOP.



Figure 6.2-9: Rendering of a Concrete Floodwall

Immediately west of the existing DePeyster Creek tide gate, a proposed 0.6-acre DePeyster Creek Park would be created; this park would comprise an isolated component of the LOP, as it would tie into existing high ground on either side along DePeyster Creek. The proposed park would incorporate approximately 0.3 acre of passive recreational space that could include open lawn, picnic tables, chairs, and a birdwatching platform. The proposed park would be surrounded by a new drainage swale on the northern and western sides, and a proposed floodwall ranging from 1.6 to 3 feet in height on the southern and eastern sides. The proposed floodwall would tie into the existing tide gate to the north and into existing high ground to the south. The permanent easement required for this park would vary between 50 and 220 feet in width; the temporary easement would vary between 50 and 240 feet in width.

Beginning at the northern limit of the BCUA property and following the Hackensack River southward to the existing Losen Slote Creek tide gate, a proposed floodwall would be constructed along the Hackensack River. The proposed floodwall would be between 1.5 and 5.4 feet high. The permanent easement required for the floodwall would vary between approximately 39 and 95 feet in width; the temporary easement would vary between approximately 49 and 105 feet in width. Two additional proposed closure gates and a proposed tide gate would be included in the LOP on the BCUA property as well.

6.2.3 Southern Segment

From the existing Losen Slote Creek tide gate moving southward and westward, a double sheet pile floodwall would be constructed to the south (i.e., following the existing berms) to Commerce Boulevard. At this point, a single sheet pile floodwall would extend northwest along the southern side of Commerce Boulevard. The proposed Southern Segment of the LOP would tie into high ground near the intersection of Commerce Boulevard and Washington Avenue. **Figure 6.2-10** presents a conceptual rendering of Alternative 1 along Commerce Boulevard. The proposed single and double sheet pile floodwalls would vary in height between 2.7 feet and 7.7 feet. The permanent easement required for this segment would vary between approximately 25 and 40 feet in width; the temporary easement would vary between

approximately 40 and 50 feet in width. The proposed floodwall along Commerce Boulevard would also incorporate two birdwatching platforms with picnic tables and chairs. These proposed platforms would be 40 feet long and 15 feet wide, and would have ramps for public access.



Figure 6.2-10: Rendering of Southern Segment of Alternative 1 along Commerce Boulevard

6.2.4 Berry's Creek Storm Surge Barrier

A proposed surge barrier (see **Figure 6.2-11**) would be installed on Berry's Creek just south of where Berry's Creek passes beneath Paterson Plank Road. The proposed surge barrier would be constructed to an elevation of 10 feet (NAVD 88), and would be approximately 118 feet wide. Levees would connect the surge barrier to existing high ground on both banks of Berry's Creek. This proposed surge barrier would include two gates (i.e., a west gate and an east gate) to reduce the potential for flooding of Berry's Creek during large storm events. The surge barrier would typically be operated when the National Weather Service issues a Coastal Flood Warning for the Project Area. A proposed pump station would also be constructed with the surge barrier on the western bank; this pump would have a capacity of 1,000 cubic feet per second, and would house controls for both the pump station and the surge barrier. These features would primarily be powered by electricity, but would also be connected to two backup diesel generators capable of maintaining operation for at least three days. Diesel would be stored in two aboveground storage tanks (ASTs) on site. A permanent acquisition would be required on the parcel of property containing the proposed pump station.

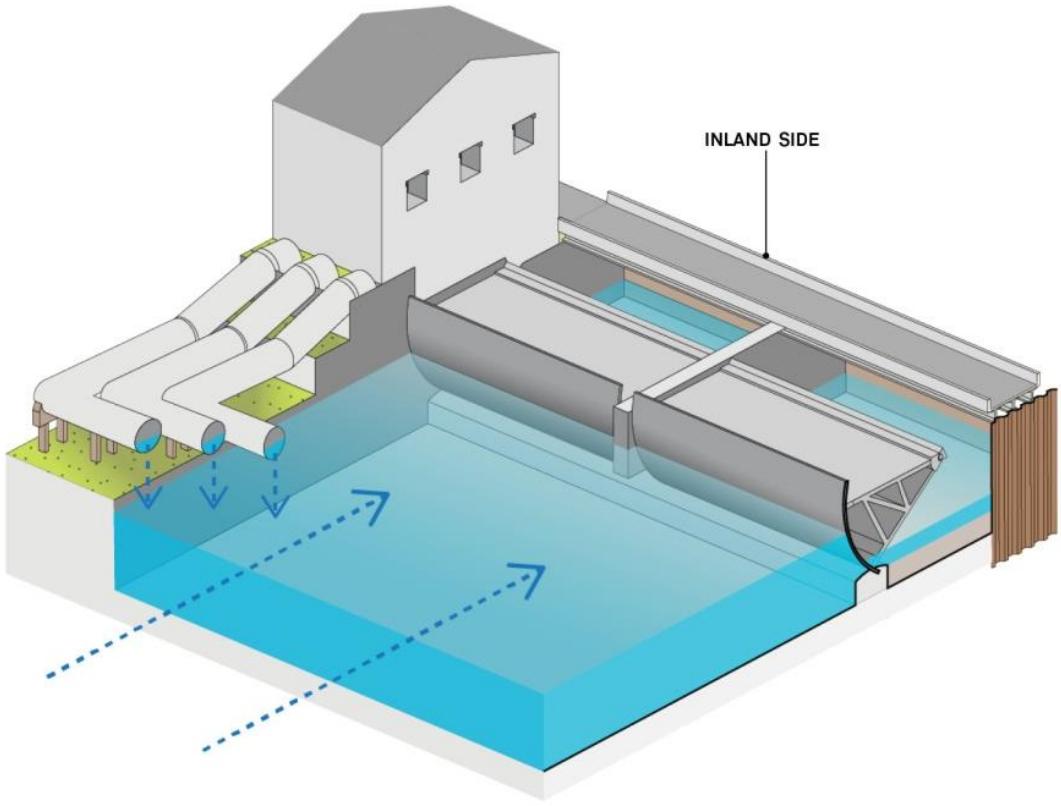


Figure 6.2-11: Rendering of Proposed Berry's Creek Storm Surge Barrier

In addition to the proposed surge barrier, several other small components would be necessary to provide a complete LOP to an elevation of 7 feet (NAVD 88) in the Berry's Creek watershed. These components include:

- A floodwall (approximately 382 feet long and 2.1 feet in height) along the Road A Plaza exit ramp from Paterson Plank Road to just east of the proposed surge barrier;
- Road-raising of certain portions of Paterson Plank Road (approximately 177 LF) and Murray Hill Parkway (approximately 100 LF) northwest of the surge barrier; and
- A small floodwall (approximately 60 LF) and regrading (approximately 245 LF) near the railroad tracks just east of the Rutherford Commons shopping center, as well as a closure gate over the railroad tracks.

6.3 Alternative 1 Cost

As shown in **Table 6.3-1** the total construction cost of the Alternative 1 would be approximately $139,972,000. This includes an average contingency of 25 percent for the construction features and assumes a cost escalation of each feature to the construction midpoint (assumed as 2021) at a rate of 3.5 percent per year. Unit costs used in the estimate is from 2017 RS Means and recent NJDOT bid tabulations, and price data from other recent NY metro area heavy civil projects; it includes appropriate area adjustment to Bergen County, NJ.

The cost of the storm surge protection features (levees and floodwalls, closure gates, interior drainage elements, and the Berry's Creek surge barrier and pump station) would be approximately $100,995,000

(72 percent of construction cost). The cost of the green infrastructure features (parks/open spaces and other associated structures and easements) would be approximately $19,402,000 (14 percent of construction cost). Allowances for utility relocations and for the cost to mitigate unavoidable wetland impacts would be approximately $10,867,000 (8 percent of construction cost). General construction requirements such as mobilization and demobilization, traffic maintenance, erosion control, contractor supervision, and project management would be approximately $8,708,000 (6 percent of construction cost).

When including an allowance of 12.0 percent for detailed engineering, design, and permitting, and 4.3 percent for construction administration, the total estimated Alternative 1 cost, including contingency and escalation, is $162,134,000.

In addition, the Feasibility Study and EIS cost approximately $20.5 million and program administration costs are approximately $15 million. Together, the estimated overall cost of the Alternative 1 is $197,634,000, not including real estate.

If Alternative 1 is completed, there would be annual O&M costs associated with the new pump stations and the other grey and green construction features. The annual cost of O&M would be approximately $1,350,000. A detailed breakdown of costs for both the initial construction and the O&M is provided in **Appendix D**.

Table 6.3-1: Construction Cost Summary with Contingency and Escalation for Alternative 1

Project Summary	COST (2017 PL)	CONTINGENCY	ESCALATION @3.5%/Yr	TOTAL w/ CONTINGENCY & ESCALATION
STORM SURGE PROTECTION	**$ 70,409,000**	**$ 17,603,000**	**$ 12,984,000**	**$ 100,995,000**
Leevees and Floodwalls	$ 42,880,000	$ 10,720,000	$ 7,907,000	$ 61,507,000
Closure and Tide Gates	$ 2,789,000	$ 697,000	$ 514,000	$ 4,000,000
Interior Drainage Elements	$ 6,490,000	$ 1,623,000	$ 1,197,000	$ 9,310,000
Berry's Creek Surge Barrier and Pump Station	$ 18,250,000	$ 4,563,000	$ 3,365,000	$ 26,178,000
GREEN INFRASTRUCTURE FEATURES	**$ 13,526,000**	**$ 3,382,000**	**$ 2,494,000**	**$ 19,402,000**
Southeast Viewing Platform	$ 132,000	$ 33,000	$ 24,000	$ 189,000
Depeyster Park	$ 339,000	$ 85,000	$ 63,000	$ 487,000
Fluvial Park	$ 11,165,000	$ 2,791,000	$ 2,059,000	$ 16,015,000
K-Town	$ 886,000	$ 222,000	$ 163,000	$ 1,271,000
Riverside Ave Park	$ 1,004,000	$ 251,000	$ 185,000	$ 1,440,000
ALLOWANCES	**$ 9,470,000**		**$ 1,397,000**	**$ 10,867,000**
GENERAL REQUIREMENTS	**$ 6,071,000**	**$ 1,518,000**	**$ 1,120,000**	**$ 8,708,000**
TOTAL CONSTRUCTION COSTS	**$ 99,476,000**	**$ 22,503,000**	**$ 17,994,000**	**$ 139,972,000**
Real Estate				
Engineering and Design	$ 11,937,000	$ 2,984,000	$ 1,063,000	$ 15,984,000
Construction Administration	$ 4,307,000	$ 1,077,000	$ 794,000	$ 6,178,000
TOTAL PROJECT COSTS	**$ 115,720,000**	**$ 26,564,000**	**$ 19,851,000**	**$ 162,134,000**

NOTES:

1. Estimate does NOT include Real Estate costs.
2. Estimate includes 25% contingency for construction features.
3. Escalation based on assumed midpoint of construction in 2021, at 3.5% per year compounded.
4. Estimate assumes all excess soils generated by construction will be classified as non-hazardous ID27 solid waste that would be transported/disposed from the site at a cost of $85 per ton. The weight of the excavated material was conseratively estimated to be 2 tons per cubic yard.
5. Estimate assumes that "hot spots" of HTRW encountered can be addressed either through the project contingency or by implementing measures to reduce the volume. If significant "hot spots" are encountered, there would be modifications to the design to minimize the need to remove HTRW material.
6. Allowances provide for utility relocations/protection and for construction of wetlands to mitigate unavoidable impacts to existing wetlands that will not be offset by project features.
7. Estimate assumes deep foundation support will be needed for force mains, stormwater piping & box culverts.
8. GENERAL REQUIREMENTS - includes 6.5% of construction cost for contractor PM and Supervision (3%), Mob/Demob (1%), Traffic Maintenance (2 %), and Erosion-sedimentation controls (0.5%).

6.4 Alternative 1 Benefits

In accordance with the guidance provided in HUD Notice CPD-16-06, this section provides a description of the benefits and costs of Alternative 1. For all economic calculations presented in this section, a 50-year period of analysis was used with a discount rate of 7 percent.

The benefits evaluated and presented in this section are limited to the impacts of tidal storm surge and the potential for storm surges to reduce the discharge from existing and proposed drainage infrastructure.

The benefits calculated for Alternative 1 were based on a comparison of future conditions with and without implementation of Alternative 1. **Section 6.3** discusses the costs of Alternative 1.

The benefit analysis assumed that certain conditions would exist in the future as described in **Section 4.0**. Changes in the future condition assumptions from those anticipated in the Benefit-Cost Analysis (BCA) calculations could result in higher or lower benefits than currently estimated.

The benefits of Alternative 1 are presented in this section in three components:

- Resiliency - flood inundation damage and associated impacts
- Economic revitalization, social, and environmental co-benefits; and
- Proposed Project investment impacts on regional employment.

6.4.1 Resiliency Benefits

The primary resiliency benefits of Alternative 1 derive from reducing direct damages from flooding to infrastructure, residential, apartment, commercial, industrial, municipal, and utility structures. Damages to motor vehicles associated with residential and apartment structures were evaluated. Benefits derived from reductions in post-flood debris removal and disposal, public emergency services costs, public injury and loss of life, and disruption to emergency/first responder facilities within the Project Area and the affected area of the City of Hackensack were considered.

6.4.1.1 Damages to Structures

As part of the resiliency damage analysis, data were collected in all five of the Project Area municipalities, as well as in adjacent areas into which tie-offs of a comprehensive LOP would need to extend (in the City of Hackensack). A database of assets at risk in these six municipalities was developed using a GIS overlay map delineating the FEMA 500-year floodplain and then adding 2 feet to account for future sea level changes. Current building polygon shapefiles obtained from the NJSEA and building tax data obtained from local municipalities were incorporated into the GIS database and merged with Light Detection and Ranging (LiDAR) data to develop building-specific elevation data. Critical facilities and infrastructure assets were also included in the database.

To augment the information in the GIS database, a field survey was conducted during the summer of 2016 to collect data about all residential and non-residential structures in the Project Area and portions of the City of Hackensack. Industrial and commercial land uses are concentrated in the southwestern portion of the Project Area, while residential areas are mostly clustered in the northeast. Teterboro Airport occupies much of the land in the northwest of the Project Area. Land without structures is primarily wetlands in the southern and eastern portions of the Project Area. While GIS and LiDAR provided the ground elevation and footprint area for each potentially flood-vulnerable structure, the field survey

captured the usage, heights/stories, foundation height and configuration, construction material, and current condition of each structure in the Project Area and the applicable portions of the City of Hackensack. Additionally, a number of owners/operators of large industrial and commercial facilities were asked to participate in detailed interviews regarding past flood experiences and future flood risks, with the aim of refining the database. **Section 3.4.2** includes summary tables of structures at risk as derived from the structure inventory.

Using square foot building costs published by RS Means and the survey data, a depreciated replacement value was assigned to each structure and its contents in accordance with current, standard flood-damage estimation practice. An average number of vehicles per residential structure was developed using the 2010 US Census information. The average value for the vehicles was determined using publicly available pre-owned vehicle valuation information.

The data collected from the structure inventory were input into a flood-damage assessment computer program (HEC-FDA v1.4.1) to facilitate the computation of average annual damages with and without Alternative 1, as well as under the existing and assumed future hydrologic conditions.

In addition to the structure inventory and values, other key inputs to the damage estimation model were hydrologic data and depth-damage functions. These inputs enabled the computation of flood damage as a percentage of structure values for a range of flood depths relative to the structure's main floor. For this study, the depth-damage functions for structures and associated vehicles were taken from the following sources:

- Generic functions for single-family residences (USACE 2000, USACE 2003);
- Passaic River Basin functions for non-residential structures, which were specifically derived in the 1980s for use in a region of northern New Jersey adjacent to the Project Area; and
- Generic functions for motor vehicles (USACE 2009).

For categories not directly related to buildings and vehicles, unique damage functions were developed specifically for use in this analysis, based on established guidance and practice.

HEC-FDA, a well-established flood damage computation model developed by the USACE Hydrologic Engineering Center, was selected for the flood damage analyses in this study because it can be applied to study areas of any size, can utilize generic, location specific, and direct damage functions, and provides detailed outputs for individual events and average annual conditions. Although it requires the input of significant hydrologic and hydraulic data, it is an industry-standard flood-damage computation tool for studies of this nature.

HEC-FDA applies Monte Carlo simulation techniques to compute the expected value of damage while accounting for uncertainty in the value of key parameters, such as structure value and elevation, damage as a percent of value at various stages, and hydrologic and hydraulic data such as stage-frequency and stage-discharge relationships. The HEC-FDA program presents results for expected annual damages and equivalent annual damages, where equivalent annual damage is the sum of the discounted value of the expected annual damage, which is then annualized over the period of performance.

Table 6.4-1 presents the number of structures incurring damage and the damages computed by HEC-FDA for selected frequency storm-surge events across Project Area.

Table 6.4-1: Number and Damages of Structure in the Project Area by Type and Tidal Floodplain

Damage Category	10-Year		50-Year		100-Year		500-Year	
	#	Damages	#	Damages	#	Damages	#	Damages
Apartment	3	$389,500	35	$4,246,500	55	$9,636,000	80	$42,177,800
Commercial	62	$27,470,500	241	$202,602,000	312	$324,504,400	376	$697,430,400
Industrial	145	$118,606,500	387	$681,701,400	441	$1,005,249,200	484	$1,733,691,900
Municipal	9	$931,600	24	$17,542,500	29	$30,993,900	37	$74,991,400
Residential	751	$7,452,100	2,026	$36,545,000	2,390	$60,057,400	3,003	$158,149,600
Utility	6	$29,700	23	$224,900	37	$1,071,100	47	$4,107,800
Total	**976**	**$154,880,000**	**2,736**	**$942,862,000**	**3,264**	**$1,431,512,000**	**4,027**	**$2,710,549,000**

6.4.1.2 Other Costs Avoided

As described above, benefits other than direct flood damage to structures and their contents were evaluated using HEC-FDA.

The estimation of flood damage to motor vehicles was conducted using accepted practice for studies of this nature. The number of motor vehicles per housing unit in the Project Area was taken from US Census Bureau Data, and the average value of pre-owned vehicles was obtained from Internet sources. Following guidance in the USACE's Economic Guidance Memorandum 09-04, which also provided the reference for automobile damage functions, the value was adjusted for the probability that owners would be able to move their vehicles to safety in advance of a flood event.

Public emergency costs are costs related to efforts made by local communities and other entities to ensure the safety of the public during storm events. For the purposes of this study, public emergency costs were considered representative of emergency work that must be performed to reduce or eliminate an immediate threat to life, protect public health and safety, and protect improved property that is threatened in a significant way because of a disaster. Direct damage curves were developed for individual drainage areas for input to HEC-FDA based on historical flood events in the project area. The evaluation of public emergency costs in the Project Area was derived from the recorded claims under the FEMA's Public Assistance program from 1999 through 2012 and water elevation data from local river gages to provide stage-damage relationships for use in the model.

The cost of debris removal and disposal was evaluated based on tools developed as part of the recent North Atlantic Coast Comprehensive Study (NACCS). The analysis used a matrix developed by the FEMA Modelling Task Force, debris removal costs from the NACCS Emergency Costs Report, and initial structure damage outputs from the project area HEC-FDA model. The FEMA approach categorizes flood damage into four levels according to water depth: Affected, Minor, Major, and Destroyed. For each level, a matrix is used to assign a debris weight per 1,000 SF of building area, and structures are categorized into one of the damage levels according to water depth. Assumed debris weights for each structure were multiplied by an average tipping fee of $71.14 per ton for the Northeast and Mid-Atlantic States obtained from the NACCS Emergency Costs Report, and the results were aggregated into reaches to form damage functions for input to HEC-FDA. For comparison, the average tipping fee for neighboring Middlesex County is $83 per ton.

Fatalities and injuries can occur during or after a flood event and may be a direct or indirect consequence. The approach used to estimate injuries from flooding is based on the work of Penning-Rowsell et al.(Penning-Rowsell, et al. 2004). Fatality estimates were based on the Reclamation Consequence Estimating Methodology developed by the US Department of the Interior Bureau of Reclamation (US Department of the Interior Bureau of Reclamation 2015). These approaches were used to estimate death and physical injuries as a direct and immediate consequence of flooding, as well as to estimate death and physical injuries associated with the flood event, but occurring in the immediate aftermath. The factors considered in the estimation include the average depth of flooding, flow velocity, and the vulnerability of the specific population involved.

The value of a statistical life (VSL) was obtained from the latest Value of a Statistical Life Guidance from the US Department of Transportation (2016). The guidance indicates that the VSL for 2015 (base year) was $9.6 million. The VSL was updated to $9.7 million for a 2016 base year using the US Bureau of Labor Statistic's Consumer Price Index for Urban Consumers (US Bureau of Labor Statistics 2017).

When a life-threatening situation occurs, timely emergency care is a key factor that affects the chances of survival. When critical emergency facilities, such as fire departments, hospitals, and other EMS providers, are delayed because of a flood event, there may be a cost in lives. Flooding may increase the response time of critical services or cause a critical facility to shut down temporarily.

The approach used to estimate the social cost of an indirect loss of life from loss of EMS is based on FEMA guidance (FEMA 2011). The shorter the response time for emergency service professionals, the greater chance of a successful outcome. Response time is related to the distance between the EMS facility and the location of the emergency. When an emergency facility in the Project Area that provides EMS is temporarily closed, the nearest available EMS facility would serve a larger geographical area and the average response time would increase. When flooding causes a fire station or an EMS provider to shut down temporarily, increased response time can cost lives. Although fire stations offer many services to communities, this approach focused on the EMS provided by fire stations.

6.4.1.3 Total Damages Computations

The results of the damage computations conducted using HEC-FDA are presented in **Table 6.4-2** through **Table 6.4-7**. All values are based on a price level of August 2016, and the economic analyses are based on a 7 percent discount rate with a 50-year period of analysis. Future condition damages assumed 1.2 feet of sea level rise at Battery, NY, which results in an increase of storm surge elevations at the Project Area on the order of 0.8 foot. Similar analyses have been conducted to calculate damages and benefits for a higher rate of SLR, and the detailed results of these analyses will be included in future versions of this report. The analyses for a higher rate of SLR assumed 2.4 feet of sea level rise at Battery Point, which results in 1.6 feet of increase in coastal storm surge elevations.

Table 6.4-2: Annual Average Damage: Without Project, Baseline Condition

Stream	Basins Covered	Category										
		Structures						Other				
		Residential	Apartment	Commercial	Industrial	Municipal	Utility	Motor Vehicles	Debris Disposal	Death/Injury	Public Emergency	Emergency Facility Disruption
Berry's Creek	Dell Rd, Eight Day Swamp, Peach Island Creek S, E Riser Ditch S	$216,100	$0	$3,795,100	$12,268,400	$60,400	$700	$74,900	$63,500	$380,600	$86,800	$0
	Paterson Plank Rd	$5,200	$0	$307,700	$1,994,700	$0	$0	$1,000	$7,000	$6,000	$5,100	$0
	West Riser Ditch – Grand St	$3,800	$0	$207,200	$1,014,700	$0	$0	$800	$4,100	$4,100	$5,300	$0
	Anderson Avenue	$38,600	$0	$96,400	$125,800	$5,400	$0	$5,100	$700	$27,600	$1,200	$0
	East Riser Ditch N, Peach Island Creek N	$207,700	$0	$216,500	$556,500	$0	$100	$22,000	$2,900	$122,700	$7,100	$0
	West Riser Ditch S, West Riser Ditch PS	$20,700	$0	$102,200	$1,264,200	$186,700	$700	$2,000	$5,100	$10,700	$5,000	$0
	East Riser Ditch – Main St	$19,100	$0	$1,939,000	$954,000	$350,600	$100	$2,600	$11,000	$15,700	$8,600	$0
	West Riser Ditch – Main St	$0	$0	$524,200	$4,855,600	$181,900	$500	$0	$23,000	$0	$23,800	$0
Subtotals		*$511,200*	*$0*	*$7,188,400*	*$23,033,900*	*$784,900*	*$2,000*	*$108,400*	*$117,000*	*$566,700*	*$142,900*	*$0*
Berry's Creek Total		*$32,455,330*										
Hackensack River	Washington Ave	$0	$0	$665,100	$1,987,200	$0	$400	$20	$16,600	$100	$36,100	$0
	Moonachie Creek S	$0	$0	$278,900	$4,044,600	$0	$900	$0	$29,400	$0	$48,500	$0
	Moonachie Creek N, Carol Place Ditch	$42,700	$0	$2,179,500	$17,238,000	$0	$7,100	$4,200	$123,700	$23,300	$200,670	$0
	Losen Slote Creek South	$1,798,200	$195,390	$2,934,200	$3,552,000	$463,300	$2,200	$285,000	$41,400	$1,714,700	$96,000	$3,700
	Wastewater Treatment Plant	$0	$0	$115,600	$5,200	$0	$0	$0	$0	$0	$0	$0
	A Self Storage	$0	$0	$0	$0	$0	$49,500	$0	$700	$0	$1,400	$0
	DePeyster Creek, Gates Rd, Losen Slote Creek Cntr, Main St Ditch, Mehrhof Rd	$1,212,400	$216,840	$903,700	$1,245,700	$132,200	$2,800	$195,070	$17,200	$1,153,800	$49,600	$9,600
	Waterside Dr	$0	$156,890	$73,100	$0	$0	$0	$19,180	$800	$104,600	$2,700	$0
	Indian Lake Rd, Losen Slote Creek Main St	$112,400	$0	$358,200	$200,600	$6,300	$0	$18,030	$8,500	$100,400	$4,000	$700
	South River St	$0	$0	$150,300	$0	$0	$0	$0	$800	$0	$2,700	$0
	Pulaski Park	$35,000	$21,640	$15,100	$8,900	$56,000	$0	$8,230	$600	$45,600	$1,000	$0
Subtotal		*$3,201,000*	*$591,000*	*$7,674,000*	*$28,282,000*	*$658,000*	*$63,000*	*$530,000*	*$250,000*	*$3,142,600*	*$442,800*	*$14,000*
Hackensack River Total		*$44,836,850*										
Overall Totals		***$3,712,000***	***$591,000***	***$14,862,000***	***$51,316,000***	***$1,443,000***	***$65,000***	***$638,000***	***$357,000***	***$3,709,000***	***$586,000***	***$14,000***
Grand Total		**$77,300,000**										
Total Present Value		**$1,066,700,000**										

Table 6.4-3: Annual Average Damage: Without Project, Future Condition

Stream	Basins Covered	Category										
		Structures						Other				
		Residential	Apartment	Commercial	Industrial	Municipal	Utility	Motor Vehicles	Debris Disposal	Death/Injury	Public Emergency	Emergency Facility Disruption
Berry's Creek	Dell Rd, Eight Day Swamp, Peach Island Creek S, E Riser Ditch S	$353,700	$0	$14,135,300	$40,634,200	$159,200	$1,200	$317,900	$236,800	$2,061,900	$511,800	$0
	Paterson Plank Rd	$8,700	$0	$632,800	$6,320,100	$0	$0	$1,600	$21,000	$9,500	$20,100	$0
	West Riser Ditch – Grand St	$11,600	$0	$468,800	$2,585,200	$0	$0	$3,000	$13,600	$20,700	$28,900	$0
	Anderson Avenue	$91,700	$0	$232,800	$516,000	$12,500	$0	$12,300	$2,100	$70,400	$4,500	$0
	East Riser Ditch N, Peach Island Creek N	$401,000	$0	$356,400	$995,500	$0	$200	$46,400	$5,000	$246,800	$19,300	$0
	West Riser Ditch S, West Riser Ditch PS	$45,600	$0	$166,700	$3,315,500	$419,800	$1,300	$4,000	$13,600	$18,800	$20,000	$0
	East Riser Ditch – Main St	$32,300	$0	$4,630,000	$1,473,400	$643,700	$100	$4,400	$27,600	$25,300	$21,400	$0
	West Riser Ditch – Main St	$0	$0	$931,900	$17,228,800	$288,300	$1,900	$0	$84,200	$0	$100,100	$0
Subtotals		*$944,700*	*$0*	*$21,554,500*	*$73,068,800*	*$1,523,500*	*$4,700*	*$389,600*	*$404,000*	*$2,453,320*	*$726,000*	*$0*
Berry's Creek Total		*$101,069,000*										
Hackensack River	Washington Ave	$0	$0	$1,297,000	$3,346,400	$0	$700	$40	$38,000	$200	$52,500	$0
	Moonachie Creek S	$0	$0	$583,800	$7,767,100	$0	$1,800	$0	$65,000	$0	$76,400	$0
	Moonachie Creek N, Carol Place Ditch	$79,800	$0	$3,950,900	$34,039,400	$0	$12,400	$8,200	$311,900	$43,900	$434,500	$0
	Losen Slote Creek South	$3,335,700	$338,400	$5,318,500	$6,670,600	$839,200	$3,700	$531,600	$81,200	$3,265,800	$189,500	$7,200
	Wastewater Treatment Plant	$0	$0	$186,800	$9,400	$0	$0	$0	$0	$0	$0	$0
	A Self Storage	$0	$0	$0	$0	$0	$76,400	$0	$1,600	$0	$1,900	$0
	DePeyster Creek, Gates Rd, Losen Slote Creek Cntr, Main St Ditch, Mehrhof Rd	$2,132,700	$369,300	$1,546,000	$2,168,500	$230,700	$4,500	$347,000	$32,000	$2,102,000	$93,000	$17,000
	Waterside Dr	$0	$237,300	$110,000	$0	$0	$0	$30,000	$1,200	$160,700	$4,500	$0
	Indian Lake Rd, Losen Slote Creek Main St	$182,400	$0	$588,700	$321,500	$9,400	$0	$29,500	$12,800	$168,000	$7,000	$1,100
	South River St	$0	$0	$240,000	$0	$0	$0	$0	$1,300	$0	$8,000	$0
	Pulaski Park	$54,500	$37,700	$25,200	$14,00	$89,300	$0	$13,100	$1,000	$73,000	$1,800	$0
Subtotal		*$5,785,100*	*$982,600*	*$13,846,700*	*$54,337,400*	*$1,168,500*	*$99,500*	*$958,900*	*$545,700*	*$5,813,600*	*$869,100*	*$25,300*
Hackensack River Total		*$84,432,000*										
Overall Totals		***$6,730,000***	***$983,000***	***$35,401,000***	***$127,406,000***	***$2,692,000***	***$104,000***	***$1,349,000***	***$950,000***	***$8,267,000***	***$1,595,000***	***$26,000***
Grand Total		**$185,500,000**										
Total Present Value		**$2,560,100,000**										

Note: Future condition assumes 1.2 feet of SLR at Battery, NY by 2075 resulting in an increase of storm surge elevations at the Project Area on the order of 0.8 foot.

Table 6.4-4: Equivalent Annual Damage: Without Project

Stream	Basins Covered	Category										
		Structures						Other				
		Residential	Apartment	Commercial	Industrial	Municipal	Utility	Motor Vehicles	Debris Disposal	Death/Injury	Public Emergency	Emergency Facility Disruption
Berry's Creek	Dell Rd, Eight Day Swamp, Peach Island Creek S, E Riser Ditch S	$250,600	$0	$6,386,100	$19,376,200	$85,100	$900	$135,800	$106,900	$801,900	$193,300	$0
	Paterson Plank Rd	$6,000	$0	$389,200	$3,078,500	$0	$0	$1,200	$10,600	$6,900	$8,900	$0
	West Riser Ditch – Grand St	$5,800	$0	$272,800	$1,408,300	$0	$0	$1,300	$6,500	$8,200	$11,200	$0
	Anderson Avenue	$51,900	$0	$130,600	$223,600	$7,200	$0	$6,900	$1,000	$38,300	$2,000	$0
	East Riser Ditch N, Peach Island Creek N	$256,200	$0	$251,600	$666,500	$0	$100	$28,100	$3,400	$153,300	$10,200	$0
	West Riser Ditch S, West Riser Ditch PS	$26,900	$0	$118,400	$1,778,200	$245,100	$800	$2,500	$7,200	$12,700	$8,800	$0
	East Riser Ditch – Main St	$22,400	$0	$2,613,300	$1,084,100	$424,000	$100	$3,100	$15,100	$18,100	$11,800	$0
	West Riser Ditch – Main St	$0	$0	$626,400	$7,956,000	$208,500	$900	$0	$38,100	$0	$42,900	$0
Subtotals		*$619,800*	*$0*	*$10,788,100*	*$35,571,300*	*$970,000*	*$2,700*	*$178,800*	*$188,900*	*$1,039,400*	*$289,000*	*$0*
Berry's Creek Total		*$49,648,090*										
Hackensack River	Washington Ave	$20	$0	$823,400	$2,327,800	$0	$500	$0	$22,000	$200	$40,200	$0
	Moonachie Creek S	$0	$0	$355,300	$4,977,400	$0	$1,100	$0	$38,300	$0	$55,500	$0
	Moonachie Creek N, Carol Place Ditch	$52,000	$0	$2,623,300	$21,448,000	$0	$8,500	$5,200	$170,900	$28,500	$259,300	$0
	Losen Slote Creek South	$2,183,500	$231,200	$3,531,600	$4,333,400	$557,500	$2,600	$346,800	$51,400	$2,103,400	$119,400	$46090
	Wastewater Treatment Plant	$0	$0	$133,500	$6,200	$0	$0	$0	$0	$0	$0	$0
	A Self Storage	$0	$0	$0	$0	$0	$56,300	$0	$1,000	$0	$1,500	$0
	DePeyster Creek, Gates Rd, Losen Slote Creek Cntr, Main St Ditch, Mehrhof Rd	$1,443,000	$255,000	$1,064,600	$1,476,900	$156,900	$3,040	$233,000	$20,800	$1,391,400	$60,500	$11,500
	Waterside Dr	$0	$177,000	$82,400	$0	$0	$0	$21,900	$900	$118,700	$3,200	$0
	Indian Lake Rd, Losen Slote Creek Main St	$129,900	$0	$415,900	$230,900	$7,000	$0	$20,900	$9,500	$117,400	$4,800	$800
	South River St	$0	$0	$172,780	$0	$0	$0	$0	$900	$0	$4,100	$0
	Pulaski Park	$39,900	$25,670	$17,640	$10,330	$64,340	$0	$9,400	$600	$52,400	$1,200	$0
Subtotal		*$3,848,320*	*$688,940*	*$9,220,420*	*$34,810,950*	*$785,780*	*$72,100*	*$637,300*	*$316,400*	*$3,811,900*	*$549,600*	*$16,900*
Hackensack River Total		*$54,758,450*										
Overall Totals		***$4,468,000***	***$689,000***	***$20,009,000***	***$70,382,000***	***$1,756,000***	***$75,000***	***$816,000***	***$505,000***	***$4,851,000***	***$839,000***	***$17,000***
Grand Total		**$104,400,000**										
Total Present Value		**$1,440,900,000**										

Note: Future condition assumes 1.2 feet of SLR at Battery, NY by 2075 resulting in an increase of storm surge elevations at the Project Area on the order of 0.8 foot.

Table 6.4-5: Annual Average Damage: With Alternative 1, Baseline Conditions

Stream	Basins Covered	Category										
		Structures						Other				
		Residential	Apartment	Commercial	Industrial	Municipal	Utility	Motor Vehicles	Debris Disposal	Death/Injury	Public Emergency	Emergency Facility Disruption
Berry's Creek	Dell Rd, Eight Day Swamp, Peach Island Creek S, E Riser Ditch S	$201,900	$0	$2,661,500	$9,053,000	$48,300	$700	$47,900	$44,200	$203,540	$41,400	$0
	Paterson Plank Rd	$5,000	$0	$273,500	$1,525,500	$0	$0	$1,000	$5,500	$5,900	$3,500	$0
	West Riser Ditch – Grand St	$2,900	$0	$176,600	$829,500	$0	$0	$500	$3,000	$2,300	$2,700	$0
	Anderson Avenue	$33,100	$0	$78,500	$83,300	$4,400	$0	$4,300	$600	$21,800	$800	$0
	East Riser Ditch N, Peach Island Creek N	$187,600	$0	$197,200	$521,600	$0	$100	$19,000	$2,700	$101,700	$5,400	$0
	West Riser Ditch S, West Riser Ditch PS	$17,900	$0	$92,200	$1,015,400	$154,900	$600	$1,700	$4,100	$9,000	$3,300	$0
	East Riser Ditch – Main St	$18,600	$0	$1,641,300	$910,300	$314,900	$100	$2,500	$9,200	$15,100	$7,100	$0
	West Riser Ditch – Main St	$0	$0	$493,900	$3,486,800	$181,900	$400	$0	$16,100	$0	$15,100	$0
Subtotals		*$467,000*	*$0*	*$5,614,700*	*$17,425,300*	*$704,400*	*$1,800*	*$76,900*	*$85,300*	*$359,400*	*$79,300*	*$0*
Berry's Creek Total		*$24,800,000*										
Hackensack River	Washington Ave	$0	$0	$314,200	$622,200	$0	$400	$0	$3,300	$130	$3,600	$0
	Moonachie Creek S	$0	$0	$130,500	$1,261,700	$0	$400	$0	$5,400	$0	$4,000	$0
	Moonachie Creek N, Carol Place Ditch	$30,600	$0	$1,627,200	$7,149,100	$0	$900	$2,500	$32,100	$14,200	$37,000	$0
	Losen Slote Creek South	$949,700	$144,890	$1,727,400	$1,743,400	$275,500	$2,000	$144,900	$16,200	$716,200	$29,100	$1,530
	Wastewater Treatment Plant	$0	$0	$110,800	$3,500	$0	$0	$0	$0	$0	$0	$0
	A Self Storage	$0	$0	$0	$0	$0	$40,000	$0	$440	$0	$500	$0
	DePeyster Creek, Gates Rd, Losen Slote Creek Cntr, Main St Ditch, Mehrhof Rd	$762,000	$161,210	$658,000	$867,600	$91,900	$2,500	$120,000	$8,400	$624,700	$19,800	$5,590
	Waterside Dr	$0	$152,750	$72,400	$0	$0	$0	$18,000	$800	$100,400	$2,000	$0
	Indian Lake Rd, Losen Slote Creek Main St	$95,000	$0	$268,900	$175,700	$6,200	$0	$14,900	$7,600	$82,700	$2,700	$710
	South River St	$0	$0	$140,320	$0	$0	$0	$0	$680	$0	$1,100	$0
	Pulaski Park	$33,400	$12,550	$11,200	$7,320	$50,780	$0	$7,250	$300	$40,510	$720	$0
Subtotal		*$1,870,660*	*$471,400*	*$5,060,670*	*$11,830,610*	*$424,410*	*$46,290*	*$307,760*	*$75,220*	*$1,578,700*	*$101,000*	*$7,830*
Hackensack River Total		*$21,774,550*										
Overall Totals		***$2,337,610***	***$471,400***	***$10,675,390***	***$29,255,880***	***$1,128,790***	***$48,110***	***$384,650***	***$160,530***	***$1,938,050***	***$180,270***	***$7,830***
Grand Total		**$46,588,510**										
Total Present Value		**$642,956,000**										

Table 6.4-6: Annual Average Damage: With Alternative 1, Future Condition

Stream	Basins Covered	Category										
		Structures						Other				
		Residential	Apartment	Commercial	Industrial	Municipal	Utility	Motor Vehicles	Debris Disposal	Death/Injury	Public Emergency	Emergency Facility Disruption
Berry's Creek	Dell Rd, Eight Day Swamp, Peach Island Creek S, E Riser Ditch S	$282,000	$0	$3,617,700	$12,214,900	$65,40	$900	$63,100	$58,900	$266,600	$53,300	$0
	Paterson Plank Rd	$8,400	$0	$389,700	$2,102,600	$0	$0	$1,600	$7,500	$9,500	$4,500	$0
	West Riser Ditch – Grand St	$4,100	$0	$241,200	$1,128,400	$0	$0	$700	$4,000	$3,000	$3,500	$0
	Anderson Avenue	$47,000	$0	$105,400	$110,300	$6,000	$0	$5,800	$700	$28,900	$1,000	$0
	East Riser Ditch N, Peach Island Creek N	$271,700	$0	$278,900	$755,400	$0	$200	$26,500	$3,700	$136,600	$7,000	$0
	West Riser Ditch S, West Riser Ditch PS	$26,100	$0	$126,200	$1,370,500	$208,400	$1,100	$2,400	$5,400	$11,900	$4,300	$0
	East Riser Ditch – Main St	$31,000	$0	$2,254,700	$1,320,600	$430,800	$100	$4,000	$12,400	$23,600	$9,300	$0
	West Riser Ditch – Main St	$0	$0	$714,800	$4,680,000	$280,000	$500	$0	$21,500	$0	$19,500	$0
Subtotals		*$670,200*	*$0*	*$7,728,500*	*$23,682,700*	*$990,500*	*$2,700*	*$104,000*	*$114,200*	*$480,100*	*$102,400*	*$0*
Berry's Creek Total		*$33,875,230*										
Hackensack River	Washington Ave	$0	$0	$573,900	$1,141,700	$0	$700	$40	$6,200	$200	$6,800	$0
	Moonachie Creek S	$0	$0	$232,100	$2,257,600	$0	$800	$0	$9,700	$0	$7,400	$0
	Moonachie Creek N, Carol Place Ditch	$53,400	$0	$2,874,800	$12,792,700	$0	$1,600	$4,400	$57,900	$25,700	$68,600	$0
	Losen Slote Creek South	$1,607,600	$241,400	$2,939,500	$3,003,300	$467,600	$3,300	$248,800	$27,700	$1,252,100	$51,700	$2,600
	Wastewater Treatment Plant	$0	$0	$176,500	$5,900	$0	$0	$0	$0	$0	$0	$0
	A Self Storage	$0	$0	$0	$0	$0	$62,200	$0	$700	$0	$800	$0
	DePeyster Creek, Gates Rd, Losen Slote Creek Cntr, Main St Ditch, Mehrhof Rd	$1,244,700	$259,600	$1,066,000	$1,429,400	$151,700	$4,000	$198,600	$13,800	$1,057,400	$34,300	$9,200
	Waterside Dr	$0	$227,500	$107,500	$0	$0	$0	$27,100	$1,200	$150,900	$3,800	$0
	Indian Lake Rd, Losen Slote Creek Main St	$148,800	$0	$415,400	$270,900	$9,300	$0	$23,200	$11,100	$131,400	$4,400	$1,100
	South River St	$0	$0	$216,700	$0	$0	$0	$0	$1,100	$0	$1,800	$0
	Pulaski Park	$51,200	$20,600	$17,700	$11,500	$78,700	$0	$11,200	$500	$62,900	$1,200	$0
Subtotal		*$3,105,700*	*$749,100*	*$8,620,100*	*$20,912,900*	*$707,300*	*$72,700*	*$513,300*	*$129,800*	*$2,680,700*	*$180,740*	*$12,900*
Hackensack River Total		*$37,685,180*										
Overall Totals		***$3,800,000***	***$700,000***	***$16,300,000***	***$44,600,000***	***$1,700,000***	***$80,000***	***$600,000***	***$200,000***	***$3,200,000***	***$283,200***	***$12,900***
Grand Total		**$71,600,000**										
Total Present Value		**$987,600,000**										

Note: Future condition assumes 1.2 feet of SLR at Battery, NY by 2075 resulting in an increase of storm surge elevations at the Project Area on the order of 0.8 foot.

Table 6.4-7: Equivalent Annual Damage: With Alternative 1

Stream	Basins Covered	Category										
		Structures						Other				
		Residential	Apartment	Commercial	Industrial	Municipal	Utility	Motor Vehicles	Debris Disposal	Death/Injury	Public Emergency	Emergency Facility Disruption
Berry's Creek	Dell Rd, Eight Day Swamp, Peach Island Creek S, E Riser Ditch S	$222,000	$0	$2,901,100	$9,845,300	$52,600	$700	$51,700	$47,900	$219,300	$44,400	$0
	Paterson Plank Rd	$5,800	$0	$302,600	$1,670,100	$0	$0	$1,100	$6,000	$6,800	$3,800	$0
	West Riser Ditch – Grand St	$3,200	$0	$192,800	$904,400	$0	$0	$600	$3,300	$2,500	$2,900	$0
	Anderson Avenue	$36,600	$0	$85,200	$90,000	$4,800	$0	$4,700	$600	$23,600	$900	$0
	East Riser Ditch N, Peach Island Creek N	$208,700	$0	$217,600	$580,200	$0	$100	$20,900	$2,900	$110,400	$5,700	$0
	West Riser Ditch S, West Riser Ditch PS	$19,900	$0	$100,700	$1,104,300	$168,300	$700	$1,900	$4,400	$9,800	$3,600	$0
	East Riser Ditch – Main St	$21,700	$0	$1,795,000	$1,013,100	$343,900	$100	$2,900	$10,000	$17,000	$7,600	$0
	West Riser Ditch – Main St	$0	$0	$549,300	$3,785,800	$206,500	$400	$0	$17,400	$0	$16,200	$0
Subtotals		*$517,900*	*$0*	*$6,144,400*	*$18,993,200*	*$776,100*	*$2,000*	*$83,700*	*$92,600*	*$389,600*	*$85,100*	*$0*
Berry's Creek Total		*$27,084,500*										
Hackensack River	Washington Ave	$20	$0	$379,300	$752,400	$0	$500	$0	$4,030	$200	$4,400	$0
	Moonachie Creek S	$0	$0	$156,000	$1,511,300	$0	$500	$0	$6,500	$0	$4,900	$0
	Moonachie Creek N, Carol Place Ditch	$36,300	$0	$1,939,800	$8,563,200	$0	$1,100	$3,000	$38,600	$17,100	$45,000	$0
	Losen Slote Creek South	$1,114,600	$169,100	$2,031,100	$2,059,100	$323,700	$2,400	$171,000	$19,100	$850,500	$34,700	$1,800
	Wastewater Treatment Plant	$0	$0	$127,200	$4,100	$0	$0	$0	$0	$0	$0	$0
	A Self Storage	$0	$0	$0	$0	$0	$45,600	$0	$500	$0	$600	$0
	DePeyster Creek, Gates Rd, Losen Slote Creek Cntr, Main St Ditch, Mehrhof Rd	$882,900	$185,900	$760,200	$1,008,400	$106,900	$2,900	$139,900	$9,700	$733,100	$23,400	$6,500
	Waterside Dr	$0	$171,500	$81,200	$0	$0	$0	$20,200	$90	$113,000	$2,800	$0
	Indian Lake Rd, Losen Slote Creek Main St	$108,500	$0	$305,600	$199,600	$7,000	$0	$17,000	$8,500	$94,900	$3,100	$800
	South River St	$0	$0	$159,500	$0	$0	$0	$0	$800	$0	$1,300	$0
	Pulaski Park	$37,900	$14,600	$12,900	$8,400	$57,800	$0	$8,200	$300	$46,120	$800	$0
Subtotal		*$2,180,100*	*$541,000*	*$5,952,600*	*$14,106,400*	*$495,300*	*$52,900*	*$359,300*	*$88,900*	*$1,854,800*	*$121,000*	*$9,100*
Hackensack River Total		*$25,761,320*										
Overall Totals		***$2,700,,000***	***$500,000***	***$12,100,000***	***$33,100,000***	***$1,300,000***	***$54,900***	***$400,000***	***$180,000***	***$2,200,000***	***$200,000***	***$9,000***
Grand Total		**$52,800,000**										
Total Present Value		**$729,311,000**										

Note: Future condition assumes 1.2 feet of SLR at Battery, NY by 2075 resulting in an increase of storm surge elevations at the Project Area on the order of 0.8 foot.

Table 6.4-8 shows the expected average annual resiliency damages for the "without" and "with" Alternative 1 that is based on the expected sea level at the base year (2023), and also the annual resiliency benefits (the difference between the "without" and "with" annual damages) at the base year of 2023. **Table 6.4-9** shows the expected average annual resiliency damages for the "without" and "with" Alternative 1, and also the annual project resiliency benefits that assumes an intermediate low level of sea level change (1.4 feet) by the end of the Proposed Project's period of analysis (2073). Due to sea level change the expected annual residual damages and the Proposed Project benefits are both significantly greater by year 50, as compared to year 1, which is the baseline condition. **Appendix E** provides detailed descriptions and analyses performed in determining Alternative 1 benefits.

Table 6.4-8: Alternative 1 - Expected Annual Average Resiliency Damages and Benefits, Baseline Condition

Evaluated Category	Without	With	Benefits
Residential Structures	$3,711,590	$2,337,610	$1,373,980
Apartment Structures	$590,760	$471,400	$119,360
Commercial Structures	$14,861,950	$10,675,390	$4,186,560
Industrial Structures	$51,316,090	$29,255,880	$22,060,210
Municipal Structures	$1,442,740	$1,128,790	$313,950
Utility Structures	$65,010.00	$48,110	$16,900
Motor Vehicles	$638,130	$384,650	$253,480
Debris Disposal	$356,630	$160,530	$196,100
Injury and Loss of Life	$3,709,260	$1,938,050	$1,771,210
Public Emergency	$585,620	$180,270	$405,350
Emergency Facility Disruption	$14,050	$7,830	$6,220
Project Area Total	**$77,291,830**	**$46,588,510**	**$30,703,320**
Present Value	**$1,066,690,000**	**$642,956,000**	**$642,956,000**

Interest rate of 7 percent, 50-year period of analysis.

Table 6.4-9: Alternative 1 - Expected Annual Average Resiliency Damages and Benefits, Future Condition

Evaluated Category	Without	With	Benefits
Residential Structures	$6,729,840	$3,775,900	$2,953,940
Apartment Structures	$982,590	$749,140	$233,450
Commercial Structures	$35,401,180	$16,348,510	$19,052,670
Industrial Structures	$127,406,180	$44,595,610	$82,810,570
Municipal Structures	$2,691,840	$1,697,760	$994,080
Utility Structures	$104,260.00	$75,360	$28,900
Motor Vehicles	$1,348,450	$617,240	$731,210
Debris Disposal	$949,750	$244,060	$705,690
Injury and Loss of Life	$8,266,880	$3,160,760	$5,106,120
Public Emergency	$1,595,090	$283,170	$1,311,920
Emergency Facility Disruption	$25,270	$12,900	$12,370
Project Area Total	**$185,501,330**	**$71,560,410**	**$113,940,920**
Present Value	**$2,560,057,000**	**$987,587,000**	**$1,572,470,000**

6.4.2 Economic Revitalization, Social, and Environmental Co-Benefits

In addition to providing the resiliency benefits as described in **Section 6.4.1**, Alternative 1 has the potential to generate additional economic revitalization, social, and environmental benefits. Economic revitalization benefits include property value benefits from proximity to new parks and the associated property tax benefits and energy savings. Social benefits considered include new recreational opportunities, aesthetic values, and avoided stormwater treatment costs. The alternative can generate environmental benefits, including air quality improvements, pollination, biodiversity, and reduced nitrogen and phosphorus.

This benefits analysis was conducted using the Phase 2 Instructions for Community Development Block Grant National Disaster Resilience Applicants as a guide for preferred methods and monetized values. The parameters of the benefits analysis follow the protocols set by OMB Circular A-94, as well as the recommended benefit quantification methods by the US Department of Transportation, the USACE, and FEMA, except in cases where project-specific value were available. In all such cases, modifications were noted and references were provided for data sources. The analysis follows a conservative estimation of the benefits and assesses some of the benefits qualitatively. By adhering to a strict standard of what could be included in the benefits analysis, actual total benefits may be greater than depicted in the benefits analysis.

A custom model was developed to estimate the future benefits for Alternative 1. Benefits were estimated over a 50-year period beginning in 2023. The base year is 2017 and all values were discounted to the base year. It was assumed that 2023 would be the first year that the Proposed Project would be complete and benefits would begin accruing at the beginning of the year. All benefits are in constant 2017 dollars and were analyzed using a 7 percent interest rate.

The benefits were monetized using established and substantiated economic methods. For additional details pertaining to how the benefits were estimated, see **Appendix E**.

6.4.2.1 Economic Revitalization

For Alternative 1, the economic revitalization benefits include the property value benefit, the property tax benefit, and energy savings from planting trees. Planting trees within 100 feet of a residential property would be expected to increase the value of the property and generate more tax revenue. In addition, newly planted trees provide shade to nearby buildings, thereby reducing costs for heating and cooling and saving energy. A 2009 report from the National Association of Realtors found the premium for homes near parks can extend three blocks and start at 20 percent for those homes directly adjacent (declining as distance from the park increases). This analysis conservatively assumes that properties within 100 feet of new parks would appreciate by 20 percent. Given the uncertainty regarding whether the appreciation rate of homes would be higher or lower than the general rate of inflation, the property value benefit is conservatively estimated based on the 2015 median housing value for each borough from the US Census and then annualized over the period of analysis. The property premium was assumed to occur the first year after the Proposed Project is complete as a one-time benefit. Since residents of properties that appreciate would also be required to pay higher property taxes, the property value benefit is net of the expected increase in annual property taxes to avoid double counting.

When property values increase, property tax revenues also increase. Property taxes are paid annually, whereas the appreciated home value would only be realized when the home is sold. On average, Bergen County collects 1.76 percent of a property's assessed fair market value as property tax and has the fourth highest median property taxes in the country (Cohen 2016). Because there is uncertainty associated with

future property tax rates for each of the boroughs, the average property tax rates from 2015 were held constant over the period of analysis.

The i-Tree Tool is peer-reviewed software from the US Department of Agriculture Forest Service (USDA Forest Service 2017). The i-Tree Tool was used to calculate the average annual electricity benefit of $6.36 per tree and average annual natural gas benefit of $26.04 per tree.

Creating an inviting and pleasant atmosphere with landscaping and trees can make local businesses attractive for shopping and increase property values. Anecdotal evidence from a couple of case studies have shown improved street landscaping has increased retail sales around 50 percent. Because no large-scale economic studies have been performed to support a benefits-transfer approach, increased sales and appreciating property values of businesses in immediate area of the improvements were not monetized.

6.4.2.2 Social Value

The social benefits include the recreation value from new parks, avoided stormwater treatment costs, and the aesthetic value of new green open space. The recreation benefits were monetized using the USACE's recreational day use value for fiscal year 2017 of $5.94 based on the expected characteristics of the new parks (USACE 2016). The estimated number of users for the new parks was based on a study conducted by Active Living Research (Active Living Research 2011). Because some of the new parks are located near each other, only the estimated number of users within ¼ mile of the park were used for the analysis as a conservative estimate. For every person living within ¼ mile of a new park, 24 days of park use per year were calculated for an estimated annual use-value of about $144. The recreational benefits do not include a health benefit.

The stormwater benefits for the newly planted trees and other green infrastructure measures were monetized as the product of the gallons of stormwater that would be reduced annually and the treatment cost. Stormwater reduction from trees were calculated using the i-Tree Tool (USDA Forest Service 2017). The factors used to calculate the minimum and maximum number of stormwater that would be reduced by each green infrastructure measure (in gallons) were obtained from the Center of Neighborhood Technology (Center of Neighborhood Technology 2010) and adjusted to the average annual rainfall in Teterboro (US Climate Data 2017). To estimate the value of rainfall intercepted and potential cost reductions in stormwater-management control—a value that includes the cost of collection, conveyance, and treatment—wastewater user charges for the year 2017 were used as a conservative proxy for the level of service currently provided. At $0.00136 per gallon (Bergen County Utilities Authority 2016), this cost is well below the average price of stormwater-runoff reduction ($0.089 per gal) assessed in similar studies (McPherson, Simpson, et al. 2014).

Redesigned parks, an activated waterfront, and other landscape-based interventions create a more visually appealing system of open spaces throughout the site. The aesthetic value from green open space is $1,787 per acre of new green open space per year as established by FEMA and updated to 2017 dollars (FEMA 2012).

The Proposed Project is expected to produce additional benefits that could not be adequately quantified for inclusion in benefits analysis. The benefits analysis excludes a number of societal or user benefits because they are difficult to measure given the currently available information. Inclusion of these additional benefits would increase the overall benefits of the selected alternative. Social benefits that were not monetized include livability, urban heat-island effect, mobility, physical and mental health from

new parks and green infrastructure, reduced crime, benefits of enhanced and new wetlands and riparian areas, and cultural services.

6.4.2.3 Environmental Value

The environmental benefit is limited to air quality improvements from added vegetation and the pollination value from the creation of new green space for Alternative 1. The creation of additional green space provides opportunities for native bees, butterflies, flies, and beetles to move pollen among flowers so that plants can form seeds and fruit. The pollination value from green open space is $319 per acre of new green open space per year as established by FEMA and updated to 2017 dollars (FEMA 2012).

The monetary values for the reduced emissions used in the benefits analysis were based on US Department of Transportation guidance (USDOT 2016) and adjusted to 2017 dollars. The greenhouse gas (GHG) emission values were based on the Social Cost of Carbon (SCC) developed by the Federal Interagency Working Group on Social Cost of Carbon and suggested by TIGER guidance (USDOT 2016). SCC values were inflated to 2017 dollars. Federal SCC guidance recommends that GHG emissions be valued with a lower discount rate than other benefits because carbon dioxide emissions are long-lived and subsequent damages persist over many years. However, all air quality benefits including GHG emissions were discounted using a 7 percent discount rate for this analysis. The GHG emissions value was calculated by multiplying the quantity in metric tons of carbon dioxide by the appropriate SCC value in that same year. Carbon sequestration of green infrastructure was monetized using the climate regulation annual values from FEMA of $15 per acre of new green open space (FEMA 2012). The i-Tree Tool was used to calculate the average annual emissions benefits from trees (USDA Forest Service 2017).

Bioretention facilities would reduce nutrient pollution from excess nitrogen and phosphorus, however, there are no bioretention facilities planned for Alternative 1. For alternatives that include bioretention facilities, the factors used to determine the number of pounds of nitrogen and phosphorus reduced were obtained from the Watershed Protection Techniques Journal (Schueler 1997). The monetized value per pound of the reduced nitrogen of $3.83 (Shaik, Helmers and Langemeier 2002, Birch and et al. 2011) and phosphorus of $40.20 (Ancev, et al. 2006) come from multiple research journals.

The benefits analysis excludes environmental benefits primarily associated with new riparian and wetland areas. Also, rapid temperature changes in aquatic ecosystems from warm stormwater runoff affects the metabolism and reproduction of many aquatic species and can be particularly stressful, even fatal to aquatic life (USEPA 2016a). Inclusion of these additional benefits would increase the overall benefits.

Table 6.4-10 presents the average annual economic revitalization, social, and environmental co-benefits of Alternative 1. The equivalent annual benefit and the total present value use a 7 percent discount rate and 50-year period of analysis. **Appendix E** includes more detailed descriptions of the approaches used to evaluate each co-benefit category.

Table 6.4-10: Alternative 1: Summary of Economic Revitalization, Social, and Environmental Co-Benefits

Co-Benefit Category	Total Value	Present Value	Equivalent Annual Value
Economic Revitalization	**$31,143,100**	**$20,555,800**	**$1,489,500**
Net Property Value Premium	$30,783,500	20,512,300	$1,486,300
Energy Conservation	$360,000	$43,500	$3,100
Residual Value	0	0	0
Social	**$62,336,700**	**$12,421,400**	**$900,100**
Recreation	$60,542,000	$12,069,800	$874,600
Avoided Stormwater Treatment	$1,355,600	$264,100	$19,100
Aesthetic Value	$372,000	$74,200	$5,400
Water retention/flood hazard risk reduction	$67,200	$13,400	$1,000
Environmental	**$338,200**	**$61,500**	**$4,500**
Air Quality	$271,700	$48,300	$3,500
Pollination	$66,500	$13,300	$1,000
Totals	**$93,818,000**	**$33,038,700**	**$2,394,100**

Note: Values are rounded to the nearest hundred.

6.4.3 Proposed Project Investment Impacts on Regional Employment

Investment in Alternative 1 would positively affect the regional economy through construction and annual maintenance activities. This section estimates the anticipated economic impacts from construction and annual maintenance in terms of job-years and earnings in the region.

The economic impacts generated by the capital and maintenance expenditures depend on the resources and services purchased in the local economy. **Table 6.4-11** lists the local counties from which goods and services are likely to be purchased during construction and maintenance of Alternative 1. These counties collectively represent the regional study area for the economic impact analysis. Because the economic impacts focus on the local economy in which the Proposed Project expenditures will be spent, this study area is broader than the Project Area used in the rest of this Feasibility Study and the EIS.

Table 6.4-11: Project Area – Economic Effects

New Jersey Counties	New York Counties
Bergen	Rockland
Hudson	Orange
Essex	Westchester
Passaic	Bronx
Union	Richmond
Monmouth	
Middlesex	

New Jersey Counties	New York Counties
Somerset	
Hunterdon	
Morris	
Sussex	

The Bureau of Economic Analysis Regional Input-Output Modeling System (RIMS II) 2015 multipliers were used to estimate jobs and earnings effects resulting from construction and operation of Alternative 1. The multipliers were constructed to reflect the structure of economies of the 16 counties listed in **Table 6.4-11**.

Capital investment for Alternative 1 would increase the employment, earnings, and output for the duration of the construction process. Note that these are one-time impacts that last for the duration of construction. The employment effects are expressed in job-years, which are defined as one full-time job for one person for one year. The difference between the total employment and direct employment is the indirect and induced employment, or jobs that are created or supported in other industries because of construction employee spending in the region. Construction of Alternative 1 would result in 570 total direct job-years and 600 total indirect job-years.

Construction spending for Alternative 1 would create 490 direct job-years in the construction industry. Indirect and induced job-years would total 500 in the construction industry. Total earnings for the 990 total construction industry job-years would be $53.9 million.

The professional services spending from Alternative 1 would result in 180 total job-years, 80 of which are direct and 100 of which are indirect. The total earnings for the 180 professional services job-years would be $11.2 million.

The average earnings per job for both the construction and professional services industries would be $55,600 per job-year resulting from Alternative 1 spending. This average earnings value was estimated by dividing the total earnings ($65.1 million) by the total employment (1,170 job-years).

Implementation of this alternative would create jobs and earnings as a result of ongoing O&M expenditures. Under Alternative 1, O&M activities would involve inspections of the flood control structures, including replacement of moving parts, exercising the pumps, cleaning the ditches and channels, etc. The projected O&M expenditures for the various alternatives were provided by the development team. This analysis assumes that funding for O&M would be procured from local government funds. Although these expenses would originate from local sources, they represent spending that would not take place but for the implementation of this alternative. The Proposed Project would expand economic activity in the study area counties and thus generate recurring economic impacts.

The increased operating sector employment would result in positive economic impacts to the study area, counties both through direct hiring to fill the O&M jobs and indirect benefits as these O&M workers spend their earnings, thus creating additional consumer demand and jobs to meet that demand. A further increase of new employment across a variety of industrial sectors and occupational categories would be expected as employers hire to meet this increase in local consumer demand. The latter hiring represents the alternative's indirect and induced impact.

The annual O&M spending would increase the employment in the region. These impacts are long-term annual impacts that would continue for the life of the infrastructure project elements. This section

describes the anticipated direct and total employment impacts from Alternative 1 based on the RIMS II multiplier analysis. Under this alternative, annual O&M activities would result in 20 total job-years, of which 12 are direct and eight are indirect and induced job-years.

The annual O&M of this alternative would increase employee earnings in the region. These impacts are long-term annual impacts that would continue for the life of the infrastructure elements. The current analysis indicates that this alternative would result in average earnings of $41,600 per job-year for those employed by all industries in the study area for jobs created as a result of annual O&M spending. This was estimated by dividing the total annual earnings ($0.80 million) by the total annual employment (20 job-years).

Per Office of Management and Budget Budget Control Act Guidelines, the secondary effects of government expenditures on employment and output were not included in measured social benefits or costs. The regional employment impacts were not quantified in terms of annual average benefits, and hence they are not included in the summary below.

6.5 Benefit-Cost Ratio

Table 6.5-1 summarizes the results of the benefit analyses, combining the quantified benefits described in **Section 6.4** with the costs of this alternative as described in **Section 6.3** and **Appendix C**. The annual benefits presented in this table are equivalent annual benefits, assuming a future condition featuring 1.2 feet of SLR at Battery, NY, which results in an increase of storm surge elevations at the Project Area on the order of 0.8 foot. All economic revitalization computations used a 7 percent discount rate and 50-year period of analysis. As **Table 6.5-1** shows the benefits of Alternative 1 are expected to exceed its costs by a factor of 5.99 to 1.

Table 6.5-1: Alternative 1: Summary of Benefits and Costs

Alternative 1	Total Value	Present Value	Equivalent Annual Value
Resiliency	**$4,663,582,100**	**$713,157,300**	**$51,675,300**
Berry's Creek Resilience	$2,908,658,400	$418,181,100	$30,301,300
Hackensack River Resilience	$1,754,923,800	$294,976,200	$21,373,900
Economic	**$31,143,100**	**$20,555,800**	**$1,489,500**
Property Value	$30,783,500	$20,512,300	$1,486,300
Energy Conservation	$359,600	$43,500	$3,200
Residual Value	$0	$0	$0
Social	**$62,336,700**	**$12,421,400**	**$900,100**
Recreation	$60,542,000	$12,069,800	$874,600
Avoided Stormwater Treatment	$1,355,600	$264,100	$19,100
Aesthetic Value	$372,000	$74,200	$5,400
Water retention/flood hazard risk reduction	$67,200	$13,400	$1,000
Environmental	**$338,200**	**$61,500**	**$4,500**
Air Quality	$271,700	$48,300	$3,500

Alternative 1	Total Value	Present Value	Equivalent Annual Value
Pollination	$66,500	$13,300	$1,000
Nutrient Pollution	$0	$0	$0
TOTAL BENEFITS	**$4,757,400,500**	**$746,196,100**	**$54,069,300**
Capital Investment Costs (2)	$142,284,000	$111,250,000	$8,060,900
O&M	$67,500,000	$13,280,000	$962,500
TOTAL COSTS	**$209,784,000**	**$124,530,000**	**$9,023,000**
Benefit Cost Ratio		**5.99**	**5.99**

Note: Values are rounded to the nearest hundred.

6.6 Alternative 1 Plan Set

The Alternative 1 Plan Set as shown below is provided in Subappendix F4-1.

Letter G in sheet number stands for General; CH for Civil Hackensack; CB for Civil Berry's Creek; LH for Landscape Hackensack; and S for Structural.

Table 6.6-1: Alternative Index of Drawings for Alternative 1

Sheet No.	Title
G-001	Alternative 1-Elevation 7 Cover Sheet
G-002	Alternative 1-Elevation 7 Legend & General Notes
G-003	Alternative 1-Elevation 7 Paneling Key
PLANS	
CH-101	Alternative 1-Elevation 7 Northern Alignment
CH-102	Alternative 1-Elevation 7 Northern Alignment
CH-103	Alternative 1-Elevation 7 Northern Alignment
CH-104	Alternative 1-Elevation 7 Northern Alignment
LH-105	Alternative 1-Elevation 7 Northern Alignment
LH-107	Alternative 1-Elevation 7 Central Alignment
CH-108	Alternative 1-Elevation 7 Central Alignment
CH-109	Alternative 1-Elevation 7 Central Alignment
CH-110	Alternative 1-Elevation 7 Central Alignment
CH-111	Alternative 1-Elevation 7 Central Alignment
CH-112	Alternative 1-Elevation 7 Central Alignment
CH-113	Alternative 1-Elevation 7 Central Alignment
CH-114	Alternative 1-Elevation 7 Central Alignment
CH-115	Alternative 1-Elevation 7 Central Alignment
CH-116	Alternative 1-Elevation 7 Central Alignment
CH-117	Alternative 1-Elevation 7 Central Alignment
CH-118	Alternative 1-Elevation 7 Central Alignment
CH-119	Alternative 1-Elevation 7 Central Alignment
CH-120	Alternative 1-Elevation 7 Central Alignment
CH-121	Alternative 1-Elevation 7 Central Alignment

Sheet No.	Title
CH-122	Alternative 1-Elevation 7 Southern Alignment
CH-123	Alternative 1-Elevation 7 Southern Alignment
CH-124	Alternative 1-Elevation 7 Southern Alignment
CB-130	Alternative 1-Elevation 7 Berry's Creek
CB-147	Alternative 1-Elevation 7 Berry's Creek
CB-148	Alternative 1-Elevation 7 Berry's Creek
ENLARGEMENT PLANS	
CB-201	Alternative 1 - Elevation 7 Berry's Creek Storm Surge Barrier Overall Site Plan
CB-202	Alternative 1 - Elevation 7 Berry's Creek Storm Surge Barrier Site Sections
LH-201	Enlargement Landscape Plans
PROFILES	
CH-301	Alternative 1-Elevation 7 Profile Sta. 0+00 To Sta. 20+00
CH-302	Alternative 1-Elevation 7 Profile Sta. 20+00 To Sta. 40+00
CH-303	Alternative 1-Elevation 7 Profile Sta. 40+00 To Sta. 60+00
CH-304	Alternative 1-Elevation 7 Profile Sta. 60+00 To Sta. 80+00
CH-305	Alternative 1-Elevation 7 Profile Sta. 80+00 To Sta. 100+00
CH-306	Alternative 1-Elevation 7 Profile Sta. 100+00 To Sta. 120+00
CH-307	Alternative 1-Elevation 7 Profile Sta. 120+00 To Sta. 140+00
CH-308	Alternative 1-Elevation 7 Profile Sta. 140+00 To Sta. 160+00
CH-309	Alternative 1-Elevation 7 Profile Sta. 160+00 To Sta. 180+00
CH-310	Alternative 1-Elevation 7 Profile Sta. 180+00 To Sta. 200+00
CH-311	Alternative 1-Elevation 7 Profile Sta. 200+00 To Sta. 220+00
CH-312	Alternative 1-Elevation 7 Profile Sta. 220+00 To Sta. 240+00
CH-313	Alternative 1-Elevation 7 Profile Sta. 240+00 To Sta. 260+00
CH-314	Alternative 1-Elevation 7 Profile Sta. 260+00 To Sta. 268+40
STRUCTURAL SECTIONS	
S-401	Typical Structural Section-Concrete Flood Wall (T-Wall)-Height = 1' To 6'
S-402	Typical Structural Section-Concrete Flood Wall (T-Wall)-Height = 6' To 8'
S-403	Typical Structural Section-Concrete Flood Wall (T-Wall)-Height = 8' To 10'
S-404	Typical Structural Section-Deep Foundation T Wall And Single Sheet Pile Wall
S-405	Typical Structural Section-Double Sheet Pile Wall
S-406	Typical Structural Section-Cantilever Sheet Pile Walkway Bedrock Lower Than -27'
S-407	Typical Structural Section-Cantilever Sheet Pile Walkway Bedrock -27' Or Higher
S-408	Typical Structural Section-Cantilever Walkway
S-409	Typical Structural Section-Elevated Walkway And Grading With Sheet Pile At Fluvial Park
DETAILS	
CH-401	Typical Protection Details: Drainage Outlet
CH-402	Typical Protection Details: Stop Log Gate
CH-403	Typical Protection Details: Swing Gate
CH-404	Typical Protection Details: Roller Gate
CH-405	Typical Protection Details: Tide Gate Structure

Sheet No.	Title
LH-401	Alternative 1 Typical Details Pavement
LH-402	Alternative 1 Typical Details Planting
LH-403	Alternative 1 Typical Details Furnishings & Schedule

7.0 Alternative 2 – Plan Development

7.1 Overview

This section describes the specific screening process used in the plan development of Alternative 2, the Stormwater Drainage Improvement Alternative, which follows the overall process described in **Section 5.0**. Alternative 2 analyzes various grey and green infrastructure-based solutions that would be constructed to reduce the occurrence of higher frequency, small- to medium-scale flooding events that affect the Project Area. This alternative considered a range of solutions, including drainage ditches, pipes, pump stations at strategic locations, new green infrastructure (e.g., wetland drainage basins and bioswales), water storage areas and water control structures, cleaning and de-snagging of existing waterways, increasing and enhancing recreation and public space, and providing positive environmental impacts through improved water quality and habitat restoration.

7.2 Concept Development

A review of documented flooding, from typical rainfall events, indicated that most of the Project Area is vulnerable to flooding. The Alternative 2 concept development began by dividing the Project Area into sub-basins and identifying the major conveyance systems that transfer stormwater from the five municipalities in the Project Area to the Hackensack River (**Figure 7.2-1**).

7.2.1 Initial Concepts

The RBDM project team developed 30 fluvial flood reduction concepts that combine green and grey infrastructure and open space improvements in one or more sub-basins. Each would improve, to some degree, storm drainage in the associated parts of the Project Area. The initial set of Alternative 2 concepts was developed for the following sub-basins:

- Main Street and Indian Lake (Concepts 1.1, 1.2, 1.4, 1.5, 1.6, 2.1): These concepts include improvements to the existing storm drainage system beneath Main Street, installation of a stormwater force main bypass from the East Riser Ditch to the Hackensack River, additional storage in Indian Lake, and upgrades to the Willow Lake pump station. These improvements were combined with connecting open space features adjacent to Willow Lake and the Hackensack River, and green infrastructure features, such as rain gardens, bioswales, and bioretention areas.

- Losen Slote Creek (Concepts 3.1, 7.1, 7.2, 7.3, 10.1, 10.2): These concepts include channel improvements in the lower, marshy portion of Losen Slote Creek, installing pump stations and force mains to divert stormwater downstream toward the Losen Slote Creek tide gate, and upgrading existing storm drainage ditches and pipes. Connecting open space features along residential streets in the area and green infrastructure measures, including bioswales, rain gardens, and permeable pavers, were combined with these improvements.

- East Riser (Concepts 4.1, 4.2, 4.3, 8.1, 8.3, 9.1, 9.2, 9.3, 9.4, 12.1): These concepts include channel improvements and culvert upgrades along the East Riser Ditch and a 500 cfs pump station located upstream of the East Riser tide gate. These improvements were combined with open space features east of Teterboro Airport and adjacent to Caesar Place south of Moonachie Avenue. Bioswales, rain gardens, bioretention basins, and permeable pavers were combined with these features to develop the full complement of concepts in this area.

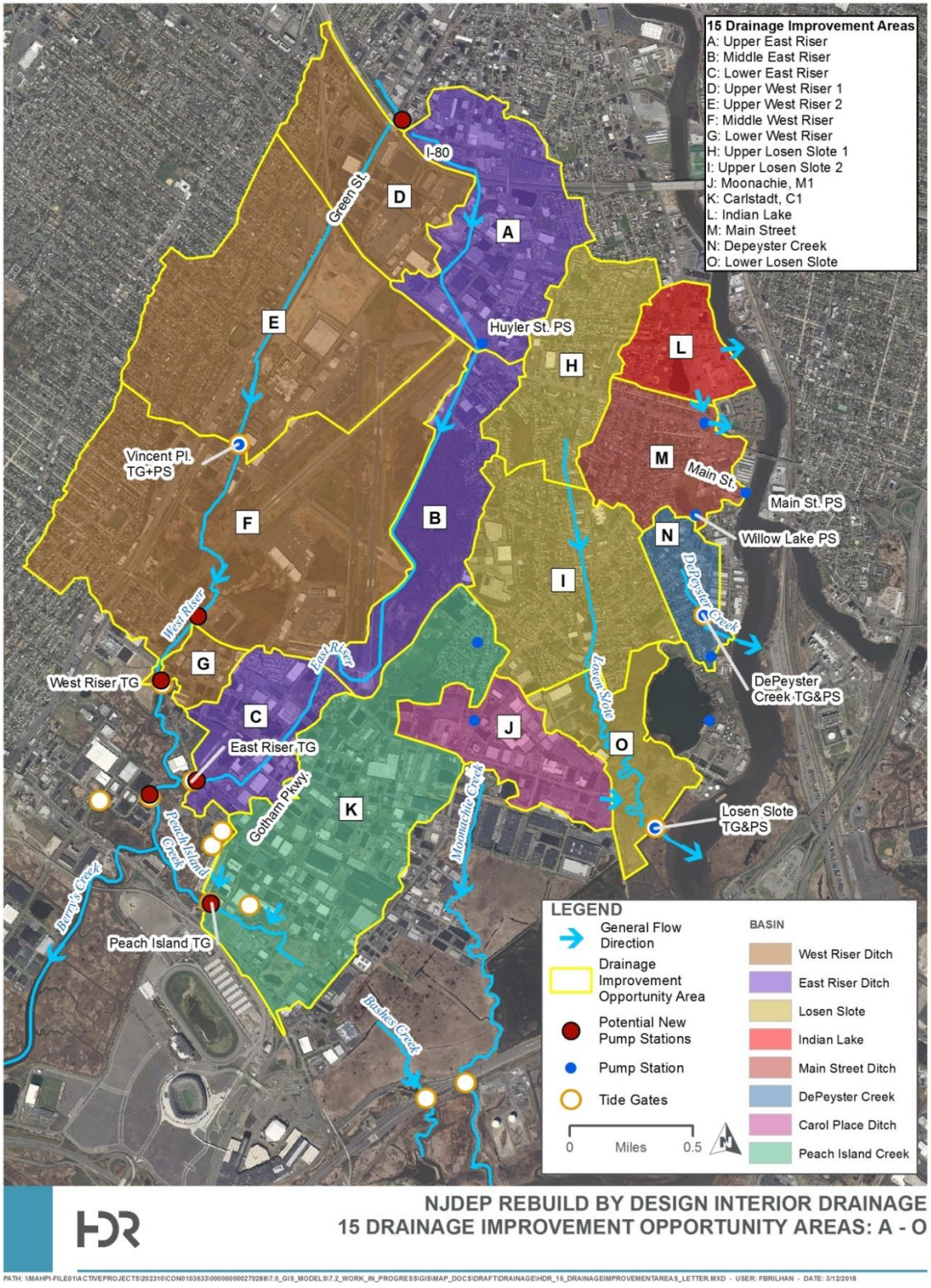


Figure 7.2-1: Project Area Sub-Basins

- West Riser (Concepts 11.1, 11.2): These concepts include channel improvements and culvert upgrades along the West Riser Ditch and a 500 cfs pump station upstream of the West Riser tide gate. Median plantings, bioswales, rain gardens, and street improvements along Moonachie Avenue were combined with these improvements.

- Carlstadt (Concepts 5.1, 5.2, 5.3): Carlstadt concepts include installation of a new tide gate and pump station at Peach Island Creek, channel improvements of Peach Island Creek, drainage improvements along Gotham Parkway, and installation of interior pump stations and force mains to deliver stormwater to the open areas downstream of the area tide gates. Street improvements, bioswales, rain gardens, and median plantings were combined with these improvements along Gotham Parkway and Washington Avenue.

- DePeyster Creek (Concepts 6.1, 6.2, 6.3): DePeyster Creek concepts include channel improvements of the channel upstream and downstream of the existing tide gate, culvert upgrades, and an upgrade of the pump station discharge capacity. Connecting open space features along residential streets in the area, bioswales, permeable pavers, and rain gardens were combined with these improvements.

Table 7.2-1 contains a more detailed breakdown of the components of each concept.

Table 7.2-1: Initial Stormwater Drainage Improvement Flood Reduction Concepts

CONCEPT ID	CONCEPT NAME	DRAINAGE BASINS	GREEN INFRASTRUCTURE FEATURES	GREY INFRASTRUCTURE FEATURES
1.1	Main Street 1	Main Street (M)	Connecting features along Main Street, Willow Lake Park, and Riverside Park, including bioswales, rain gardens, bump outs, new open space, recreation, and open space improvements	Improve Willow Lake pump station and add new forcemain, improve conveyance by increasing culvert sizes; improve Main Street Pump Station at Hackensack
1.2	Main Street 2	Main Street (M)	Connecting features along Main Street, Willow Lake Park, Riverside Park, and Fluvial Park, including bioswales, rain gardens, bump outs, new open space, recreation, and open space improvements	Improve Willow Lake pump station and add new forcemain, improve conveyance by increasing culvert sizes; improve Main Street Pump Station at Hackensack
1.4	Main Street 4	Main Street (M), Indian Lake (L)	Connecting features along Main Street, Bergen Turnpike, Willow Lake Park, Riverside Park, Fluvial Park, and Indian Lake including bioswales, rain gardens, bump outs, median planting, new open space, recreation, and open space improvements	Add berm to increase storage capacity at Indian Lake; improve Little Ferry Circle, Main Street, and Willow Lake Pump Station; improve conveyance by increasing culvert sizes along Main Street; water quality improvement in Indian Lake
1.5	Main Street 5	Main Street (M), Indian Lake (L)	Connecting features along Main Street, Bergen Turnpike, Sylvan Avenue, Willow Lake Park, Riverside Park, Fluvial Park, and Indian Lake including bioswales, rain gardens, bump outs, median planting, new open space, recreation, and open space improvements	Add berm to increase storage capacity at Indian Lake; improve Little Ferry Circle, Main Street, and Willow Lake Pump Station; Sylvan Avenue improvements; improve conveyance by increasing culvert sizes along Main Street

CONCEPT ID	CONCEPT NAME	DRAINAGE BASINS	GREEN INFRASTRUCTURE FEATURES	GREY INFRASTRUCTURE FEATURES
1.6	Main Street 6	Main Street (M), Upper Losen Slote Creek (H), Indian Lake (L)	Connecting features along Main Street, Bergen Turnpike, Willow Lake Park, Riverside Park, Fluvial Park, H-Mart R-O-W and, and Indian Lake including bioswales, rain gardens, bump outs, median planting, new open space, recreation, and open space improvements	None
2.1	Main Street Extension	Main Street (M), Upper Losen Slote Creek (H), East Riser - Middle (B)	Connecting features along Main Street, Willow Lake Park, and Riverside Park, including bioswales, rain gardens, bump outs, median planting, new open space, recreation, and open space improvements	Diversion of water from East Riser Ditch to Hackensack along Main Street with possible booster pump
3.1	Losen Slote Creek	Main Street (M), Upper Losen Slote Creek (H), Upper Losen Slote Creek 2 (I), Lower Losen Slote Creek (O)	Connecting features at Moonachie Police Department, Little Ferry Public Schools, Municipal Building, and Public Library, including, permeable paving, bioswales, rain gardens, wetland improvements, new open space, recreation, and open space improvements	Channel improvements; settling basin/forebay to receive flow from forcemains for Upper Losen Slote Creek; backflow protection for residential outfalls; new pump station and possible booster pumps to pump local stormwater
4.1	East Riser North 1	Upper East Riser (A)	None	New pump station at Green Street with forcemain and improving channel conveyance
4.2	East Riser North 2	Upper East Riser (A)	Corridor public benefit (new open space and recreation) with new bioswales, bioretention basins, rain gardens, and permeable paving	New pump station at Green Street with forcemain and improving channel conveyance
4.3	East Riser North 3	Upper East Riser (A)	Corridor public benefit (new open space and recreation) with bioswales, bioretention, rain gardens, and permeable paving	Improving channel conveyance
5.1	Gotham Parkway	Carlstadt Ave C1 (K)	Bioswales, rain gardens, median planting, and street improvements at Washington Avenue and Gotham Parkway	New pump station and possible booster pumps and forcemain to reach Peach Island Creek; Gotham Parkway conveyance improvement

CONCEPT ID	CONCEPT NAME	DRAINAGE BASINS	GREEN INFRASTRUCTURE FEATURES	GREY INFRASTRUCTURE FEATURES
5.2	Gotham Parkway	Carlstadt Ave C1 (K)	Bioswales, rain gardens, median planting, and street improvements at Washington Avenue and Gotham Parkway	New pump station and possible booster pumps and forcemain along Gotham Parkway to reach Peach Island Creek
5.3	Gotham Parkway	Carlstadt Ave C1 (K)	None	New pump station; channel improvements (with habitat restoration within the footprint), and berms to improve channel conveyance at Peach Island Creek
6.1	DePeyster Creek	DePeyster Creek (N), Upper Losen Slote Creek 2 (I), Lower Losen Slote Creek (O)	Connecting features along Louis Street Ditch, Mehrhof Road, Monroe Street, Maiden Lane Park, Louis Creek Park, including new open space, open space improvements, recreation, bioswales, permeable paving, bioretention, and rain gardens	None
6.2	DePeyster Creek	DePeyster Creek (N), Upper Losen Slote Creek 2 (I), Lower Losen Slote Creek (O)	Connecting features along Louis Street Ditch, Mehrhof Road, Monroe Street, Maiden Lane Park, Louis Creek Park, including new open space, open space improvements, recreation, bioswales, permeable paving, bioretention, rain gardens, and wetland improvements	Relocating pump station to the mouth of DePeyster Creek and add new tide gate
6.3	DePeyster Creek	DePeyster Creek (N), Upper Losen Slote Creek 2 (I), Lower Losen Slote Creek (O)	Connecting features along Louis Street Ditch, Mehrhof Road, Monroe Street, Maiden Lane Park, Louis Creek Park, including new open space, open space improvements, recreation, bioswales, permeable paving, bioretention, and rain gardens	Increase channel conveyance and improve pump station
7.1	Carol Place	Moonachie, M1 (J)	Connecting features along Empire Boulevard, Moonachie Road, and Avanti Park, including bioswales, median planting, new open space, and recreation	Off-channel storage, increase conveyance, local drainage improvements; back flow protection for outfalls to Losen Slote Creek

CONCEPT ID	CONCEPT NAME	DRAINAGE BASINS	GREEN INFRASTRUCTURE FEATURES	GREY INFRASTRUCTURE FEATURES
7.2	Carol Place	Moonachie, M1 (J), East Riser - Middle (B)	Connecting features along Empire Boulevard, Moonachie Road, Avanti Park, and Moonachie Fields including bioswales, permeable paving, median planting, new open space, open space improvements, and recreation	Off-channel storage, increase conveyance, local drainage improvements, Burger King conveyance; back flow protection for outfalls to Losen Slote Creek
7.3	Carol Place	Middle West Riser (F), East Riser - Middle (B), Moonachie, M1 (J), Peach Island Creek (K), Lower East Riser ©	Connecting features along Empire Boulevard, Moonachie Road, Avanti Park, and Moonachie Fields including bioswales, permeable paving, median planting, new open space, open space improvements, and recreation	Off-channel storage, increase conveyance, local drainage improvements, Burger King conveyance; back flow protection for outfalls to Losen Slote Creek
8.1	East Riser Middle 1	East Riser - Middle (B), Peach Island Creek (K), Middle West Riser (F)	Permeable paving, bioswales, and rain gardens	Channel improvements (with habitat restoration within the footprint)
8.3	East Riser Middle 2	East Riser - Middle (B), Peach Island Creek (K), Middle West Riser (F)	Permeable paving, bioswales, rain gardens, recreation, and open space improvements	Habitat restoration and local drainage improvements to ball fields park
9.1	East Riser South 1	Lower East Riser (C)	Recreation and new open space at Caesar Place Park, and Moonachie Avenue Park, bioswales, rain gardens, and permeable paving	New tide gate and pump station at East Riser Ditch; channel improvements (with habitat restoration within the footprint); off- channel storage at Caesar Place Park
9.2	East Riser South 2	East Riser - Middle (B), Lower East Riser (C)	Bioswales, rain gardens, wetland improvements, median planting, and new open space at Moonachie Avenue Park	New tide gate and pump station at East Riser Ditch; off- channel storage at Caesar Place Park; channel improvements (with habitat restoration within the footprint), local drainage improvements to Trailer Park locations

CONCEPT ID	CONCEPT NAME	DRAINAGE BASINS	GREEN INFRASTRUCTURE FEATURES	GREY INFRASTRUCTURE FEATURES
9.3	East Riser South 2	Middle (B), Peach Island Creek (K), Lower East Riser (C)	Permeable paving, bioswales, rain gardens, biorention, and median planting; recreation and new open space at Caesar Place Park and Moonachie Avenue Park with additional corridor open space near Dell Road	New tide gate and pump station at East Riser Ditch; off- channel storage at Caesar Place Park; channel improvements (with habitat restoration within the footprint), local drainage improvements to Trailer Park locations
9.4	East Riser South 2	Middle (B), Peach Island Creek (K),Lower East Riser, West Riser Ditch Basins (G)	Permeable paving, bioswales, rain gardens, bioretention, wetland improvements and median planting, new open space and recreation at Caesar Place Park and Moonachie Avenue Park, and wetland improvements at Ryder Ditch	Off-channel storage; local drainage improvements Trailer Park locations
10.1	Park Street Area	Upper Losen Slote Creek 2 (I), Lower Losen Slote Creek (H, O), East Riser - Middle (B), Main Street (M)	Connecting features at Moonachie Police Department, Robert Craig Elementary School, Little Ferry Public Schools, Municipal Building, Public Library, Joseph Street Park, Baily Park, permeable paving, bioswales, rain gardens, wetland improvements, recreation, and open space improvements	None
10.2	Park Street Area	Upper Losen Slote Creek 2 (I), Lower Losen Slote Creek (H, O), East Riser - Middle (B), Main Street (M)	Connecting features at Moonachie Police Department, Robert Craig Elemenntary School, Little Ferry Public Schools, Municipal Building, Public Library, Joseph Street Park, Baily Park, including, permeable paving, bioswales, rain gardens, wetland improvements, recreation, and open space improvements	Channel improvements (with habitat restoration within the footprint); new pump station, forcemains, and booster pumps
11.1	West Riser Ditch	Upper East Riser (A), West Riser Ditch Basins (D,E,F,G)	None	New pump station near West Riser tide gate; channel improvements (with habitat restoration within the footprint); improved Vincent Street pump station; berms to increase channel conveyance capacity

CONCEPT ID	CONCEPT NAME	DRAINAGE BASINS	GREEN INFRASTRUCTURE FEATURES	GREY INFRASTRUCTURE FEATURES
11.2	West Riser Ditch 2	Upper East Riser (A), West Riser Ditch Basins (D,E,F,G)	Median planting, bioswales, street improvements, and rain gardens on Moonachie Avenue	New pump station near West Riser tide gate; channel improvements (with habitat restoration within the footprint); improved Vincent Street pump station; berms to increase channel conveyance capacity
12.1	Entire East Riser Ditch	Upper East Riser(A), Middle East Riser (B), Middle West Riser (F), Lower East Riser (C), Carlstadt, C1 (K)	New open space at Caesar Place Park	New pump station at Green Street with forcemain and improving channel conveyance; channel improvements (with habitat restoration within the footprint); new tide gate and pump station at East Riser Ditch; channel improvements (with habitat restoration within the footprint)

7.2.2 Grey and Green Infrastructure Features

Each of the concepts described in **Table 7.2-1** included a combination of grey and green infrastructure. The grey infrastructure features that are included in many of the concepts are as follows:

Force Mains: A force main is a pressurized pipe. Stormwater pipes most often operate using the force of gravity to keep the stormwater flowing. However, in some cases, pipes must be installed where gravity is not sufficient to keep stormwater flowing, such as when the pipe must be installed at a nearly flat angle, or when the pipe must go uphill. In these situations, pumps or compressors are used to pressurize the pipes to keep the stormwater flowing.

Backflow Preventers: Backflow preventers are flapgates, valves, or other devices used to keep water from flowing backwards through the stormwater drainage infrastructure.

Channel Improvements: Channel improvements can take several different forms depending on local conditions. Channels can be widened or deepened to increase stormwater capacity. They can also be relocated or reshaped (e.g., straightened) to improve conveyance. Finally, channels can be improved to reduce the potential for erosion and/or enhance ecological conditions and values, which benefit both water quality and biological resources.

Berms: Berms may be installed along ditches or ponds in order to improve their stormwater storage and conveyance capacities. Berms consist of compacted earth. The core of these structures, generally composed of clay, is impermeable so as to reduce the potential for seepage and structural weakening (FEMA 2007). The outer layer is vegetated in order to reduce the potential for erosion. Because berms consist of mounds of compacted earth, their width must be greater than their height in order to maintain structural integrity. Depending on size and location, berms and levees can sometimes be fitted with pathways for pedestrian and bicycle transportation. The type of vegetation used for stabilization can also be chosen and maintained in a manner that creates specific ecological habitats and improvements, such as use of native vegetation. Further, berms can be incorporated into public open space to enhance community recreation areas.

Pump Stations: Pump stations are constructed to move water from one location to another, and vary substantially in terms of the volume of water they are capable of moving reliably. Pump stations may be installed in locations that regularly require water to be pumped, such as flat areas where drainage is naturally difficult, or in locations that accumulate large amounts of water during floods and need to be pumped on occasion. In the Project Area, pump stations are often located behind tide gates (barriers designed to allow one-way directional flow of water from a drainage structure (i.e., a ditch or culvert) to a tidal waterbody) or along ditches, so that they can keep water flowing in locations where drainage is either naturally difficult or impeded by a closed tide gate.

The green infrastructure features that are included in many of the concepts are as follows:

Street Green Infrastructure: Street green infrastructure retrofits are within the public right-of-way and are designed to capture stormwater runoff from streets and sidewalks, provide water quality treatment, and enhance the streetscapes with permanent vegetation or new porous, or permeable, paving (described below). Each green infrastructure system would be sized to capture and treat runoff from the NJDEP Water Quality Design Storm, which is 1.25 inches of rainfall in two hours. Outflow from larger storms would bypass the green infrastructure systems and be conveyed by the existing stormwater

system. The green infrastructure retrofit opportunities identified for the right-of-way based on site constraints include bioswales, rain gardens, and storage trenches/tree trenches (described below).

Rain Gardens: Rain gardens are landscaped stormwater collection basins that are designed, based on the soil and vegetative composition, to absorb and filter stormwater. Rain gardens are often located such that they can collect stormwater from roofs, streets, and other impervious areas. They allow collected stormwater to infiltrate the ground or be absorbed by vegetation, thereby reducing stormwater flow that could cause flooding and relieving stress on the overall stormwater drainage infrastructure. Additionally, rain gardens help to improve water quality. As stormwater travels through these systems, soil, pollutants, sediment, and excess nutrients settle out. Stormwater runoff is a major source of pollution for surface waterbodies, such as streams and rivers. By directing stormwater into the soil or vegetation, rain gardens help to filter out these pollutants before they reach a receiving waterbody (USEPA 2017).

Bioswales: Bioswales are essentially rain gardens in the form of a channel. Often found along streets or parking lots, bioswales collect stormwater and convey it toward an outlet. During this process, the stormwater has the opportunity to infiltrate the ground or be taken up by vegetation, thus decreasing the amount of stormwater that reaches the outlet. Like rain gardens, bioswales also help to filter out pollutants before stormwater reaches a receiving waterbody (USEPA 2016b). Depending on location, bioswales can be 4 to 8 feet wide and up to 40 feet long.

Storage Trenches/Tree Trenches: Storage trenches are non-vegetated subsurface basins typically used where the ground surface needs to be repaved or reestablished as lawn due to the existing site use. Street runoff is diverted to storage trenches by stormwater inlets, where it either infiltrates to native soil, or, where infiltration is not feasible, the system underdrains back into the existing stormwater sewer system. A typical storage trench consists of up to 4-feet of stone aggregate wrapped in geotextile fabric and an underdrain that reconnects to the existing stormwater system. Where existing site conditions allow for small unpaved areas like tree pits, trees may be added to a storage trench to enhance street landscapes, and these systems are typically referred to as **Tree trenches**. Tree trenches do not capture runoff or provide surface runoff treatment like bioswales, but do allow for stormwater uptake through the tree root systems, which reduces the volume of runoff reaching the existing storm sewer system.

Permeable Pavement: Permeable pavement provides a surface that is mostly paved, but that permits some infiltration of rainfall into the ground, thereby decreasing the amount of stormwater that must be conducted offsite by the drainage infrastructure. Permeable pavement can be created with a variety of materials, including porous asphalt, pervious concrete, or spaced paver stones (USEPA 2016b).

Wetland Improvements: Wetlands provide similar functions as rain gardens. However, wetlands remain saturated on a seasonal or year-round basis, while rain gardens are normally dry, except after storm events. Wetlands capture and store stormwater, and remove pollutants, sediment, and nutrients. Additionally, wetlands provide valuable habitat for a wide variety of plant and animal species (ASLA 2017).

Parks/Open Spaces: New or improved parks or open spaces provide additional opportunities for water to be collected and absorbed by the land. These areas also provide additional recreational opportunities, such as playing fields. Within the Project Area, such areas would provide public access to the Hackensack River, as well as include targeted habitat improvements.

7.3 Comparison of Concepts

Figure 7.3-1 illustrates the process for comparing, evaluating, and selecting the stormwater drainage improvement flood reduction concepts. The process involved:

- **Step 1** – Developing the initial 30 concepts at a general level (level of development 1);
- **Step 2** – Performing an initial screening (Screening 1), to reduce the number of concepts being considered;
- **Step 3** – Refining the remaining concepts at a more detailed level of design (pre-feasibility level of development 2); and
- **Step 4** – Performing a second screening (Screening 2) to reduce the 30 concepts for detailed consideration in the Feasibility Study (Step 5).

Figure 7.3-1 shows the specific criteria against which each concept was evaluated during the Screening 1 and Screening 2 steps, respectively. The RBDM project team developed the criteria with input from the CAG. The criteria were developed to align with the five Proposed Project Purpose and Need categories: (1) Flood Risk Reduction, (2) Built/Human Environment, (3) Natural Environment, (4) O&M, and (5) Costs and Benefits.

For each criterion, a rating of “Good,” “Fair,” “Poor,” or “Fatal Flaw” was given by the RBDM project team SMEs. **Table 7.3-1** shows the definitions of the possible ratings for each of the criterion. To quantify the ratings, the RBDM project team utilized a numerical system of “3,” “2,” and “1” for the “Good,” “Fair,” and “Poor” ratings, respectively. A weighing factor was also applied so that each of the categories represented 20 percent of the score. Any concept receiving a “Fatal Flaw” rating was eliminated from further consideration, or refined to remove the fatal flaw.

Subappendix F-2 includes the data sources used at each level of development and the detailed evaluations performed to rate each concept.

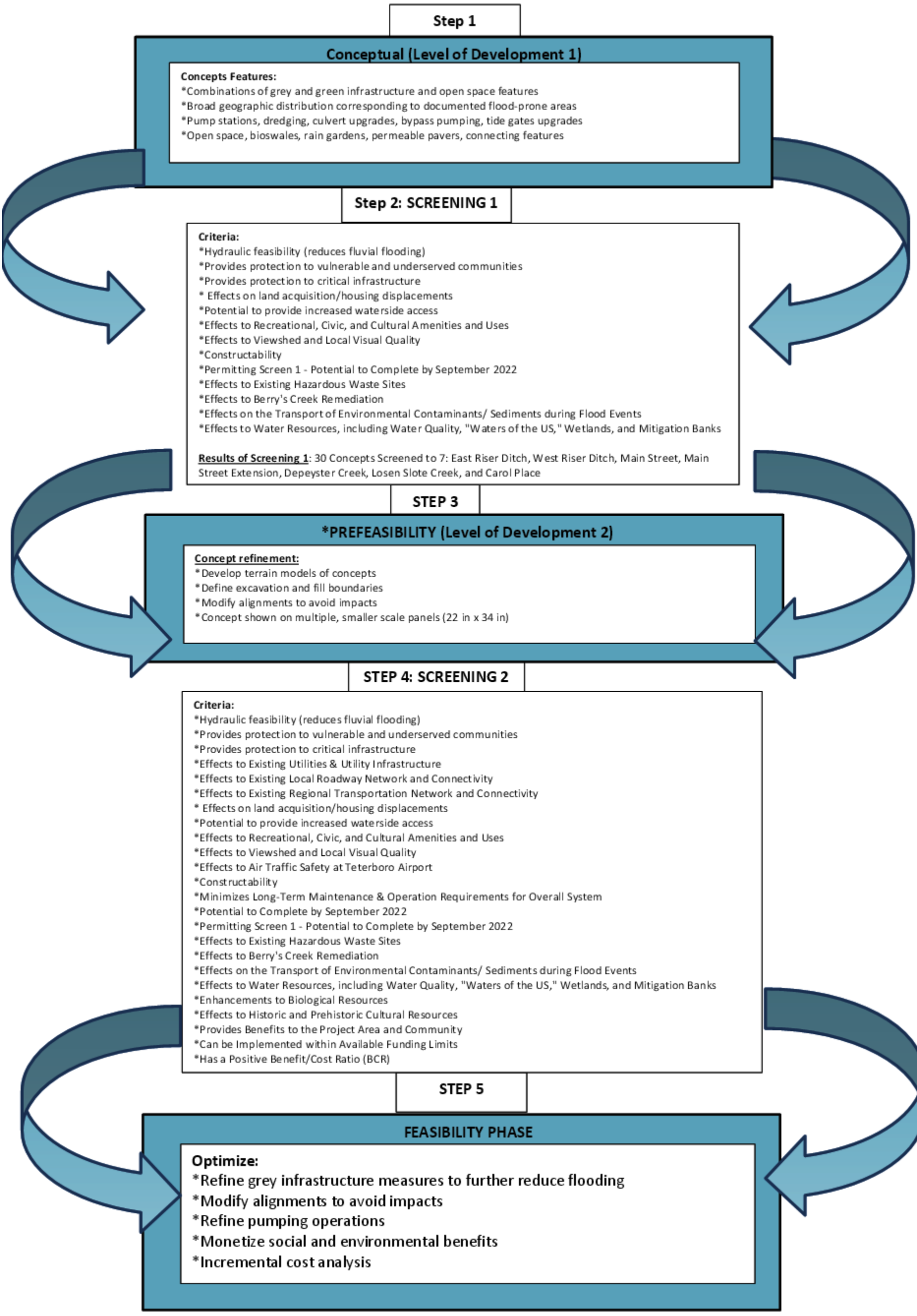


Figure 7.3-1: Fluvial Flood Reduction Concepts Screening Process

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Table 7.3-1: Project Screening Criteria

PURPOSE & NEED COMPONENT	SCREENING CRITERION	COMPARATIVE CONCEPT SCREENING METRICS** ** Use of the terms "relative" or "relatively" indicates that concepts are compared to each other.		
		GOOD	**FAIR**	**POOR**
FLOOD RISK REDUCTION	**Reduces Flood Risk from Coastal Storm Surge (Alternatives 1 and 3)**	Provides **the greatest relative reduction in future flood risk, as measured by annual flood damage reduction,** from coastal storm surge risk.	Provides **a moderate** relative **reduction in future flood risk, as measured by annual flood damage reduction,** from coastal storm surge risk.	Provides **the least** relative **reduction in future flood risk, as measured by annual flood damage reduction,** from coastal storm surge risk.
	Reduces Flood Risk from Rainfall /Interior Drainage Challenges (Alternatives 2 and 3)	Provides improved discharge corridors and/or natural stormwater storage for **most high priority** inflow locations/localized flooding areas in the Project Area.	Provides improved discharge corridors and/or natural stormwater storage for **some high priority** inflow locations/localized flooding areas in the Project Area.	Provides improved discharge corridors and/or natural stormwater storage for **few to none high priority** inflow locations/localized flooding areas in the Project Area.
	Provides Protection to Vulnerable and Underserved Populations	Protects the **greatest relative number** of vulnerable and underserved populations as compared to other concepts.	Protects a **moderate relative number** of vulnerable and underserved populations as compared to other concepts.	Protects **least relative number** of vulnerable and underserved populations as compared to other concepts.
	Provides Protection to Critical Infrastructure (emergency services, hospitals, transit facilities)	Protects the **greatest relative amount** of critical infrastructure as compared to other concepts.	Protects a **moderate relative amount** of critical infrastructure as compared to other concepts.	Protects the **least relative amount** of critical infrastructure as compared to other concepts.
BUILT ENVIRONMENT/HUMAN ENVIRONMENT	**Effects to Existing Utilities & Utility Infrastructure**	Requires **no or only limited relocations** of existing utility infrastructure.	Requires a **moderate amount of relocations** of existing utility infrastructure.	Requires a **large amount of relocations** of existing utility infrastructure. However, these impacts could be mitigated in concert with Proposed Project implementation.
	Effects to Existing Transportation Network, Local Traffic, and Connectivity	Includes features to **improve connectivity** (vehicles, bike, pedestrians) of the street system that would improve connections and traffic circulation. Would result in **long-term benefits** to transportation infrastructure, with **no adverse impacts** to transportation infrastructure.	Does **not** include features to improve connectivity (vehicles, bike, pedestrians) of the street system that would improve connections and traffic circulation. However, the concept would not adversely affect existing or future-planned connectivity. Would **not** result in any long-term transportation improvements. May result in neutral or minor **adverse impacts** to transportation infrastructure.	May **decrease** connectivity or traffic circulation at some locations and/or conflict with future opportunities to improve connectivity (vehicles, bike, pedestrians). Would **not** result in any long-term transportation improvements. **Would result in mitigatable adverse impacts** to transportation infrastructure during construction or operation.
	Effects on Land Acquisition / Housing Displacements	**May result** in land use improvements over the long term. **Would not require** land acquisitions / easements, housing demolition, or permanent relocations.	Would **not** result in land use improvements over the long term. **Would require minimal** land acquisitions / easements. No housing demolition or permanent relocations would be required.	Would **not** result in land use improvements over the long term. **Would require numerous** land acquisitions / easements, and minimal housing demolition or permanent relocations.

PURPOSE & NEED COMPONENT	SCREENING CRITERION	COMPARATIVE CONCEPT SCREENING METRICS** ** Use of the terms "relative" or "relatively" indicates that concepts are compared to each other.		
		GOOD	**FAIR**	**POOR**
	Potential to Provide Increased Waterfront Access	**Includes features that would improve** waterfront access within the Project Area.	**Does not include features that would improve** waterfront access within the Project Area.	**Would result in a minor decrease** in waterfront access within the Project Area.
	Effects to Recreational, Civic, and Cultural Amenities and Uses	**Incorporates many new** and/or improved amenities to support recreational, commercial, and cultural activities.	**Incorporates few new** and/or improved amenities to support recreational, commercial, and cultural activities.	**Incorporates no new** and/or improved amenities to support recreational, commercial, and cultural activities.
	Effects to Viewshed and Local Visual Quality	**Includes features that would enhance** views of water and other natural areas.	**Does not include features that would enhance** views of water and other natural resources.	**Includes features that would result in any decrease in** views of water and natural areas.
	Effects to Air Traffic Safety at Teterboro Airport	Includes features that **would result in no increased threat to air traffic** at Teterboro Airport, such as from plane collisions with wildlife.	N/A	Includes features that **may result in a minor, but mitigatable, increased threat to air traffic** at Teterboro Airport.
CONSTRUCTION/ MAINTENANCE & OPERATIONS	**Constructability**	**No need** to relocate major infrastructure and **minimal disruption** to business operation/public access during construction.	**Some need** to relocate major infrastructure and/or **some major disruption** to business operation/public access during construction.	**Need** to relocate major infrastructure and/or would result in **major disruption** to business operation/public access during construction.
	Minimizes Long-Term Maintenance & Operation Requirements for Overall System	Features include a **large proportion** of permanent, self-sustaining structures, with **fewer** deployable or high maintenance structures, that require a **low**, long-term operations and maintenance commitment. **Few or no features** with potential for human error are included.	Features include a **moderate proportion** of permanent, self-sustaining structures, with **more** deployable or high maintenance structures, that require a **moderate**, long-term operations and maintenance commitment. **Features** with potential for human error are included.	Features include a **small proportion** of permanent, self-sustaining structures, with a **greater** number of deployable or high maintenance structures, that require a **high**, long-term operations and maintenance commitment. **Several features** with potential for human error are included.
	Potential to Complete by September 2022	**High probability** that construction would meet Project temporal requirements. Permits required pose **no/low risk** to project schedule.	**Moderate probability** that construction would meet Project temporal requirements. Permits required pose a **moderate risk** to project schedule.	**Low probability** that construction would meet Project temporal requirements. Permits required pose a **significant risk** to project schedule.
NATURAL ENVIRONMENT	**Effects to Existing Hazardous Waste Sites**	Features **may facilitate** the implementation of remedial investigation and remedial actions or reduce the potential to spread contamination, a long-term beneficial effect.	Features are **primarily compatible** with ongoing remedial investigations and remedial actions.	Features would **interfere** with ongoing remedial investigations or remedial actions, but **not preclude** such investigations or actions.
	Effects to Berry's Creek Remediation	**No potential** for physical, hydrologic, or hydraulic impacts to Berry's Creek Study Area that may impact remediation plan.	**Potential** physical, hydrologic, or hydraulic impacts to Berry's Creek Study Area that may impact remediation plan.	Physical, hydrologic, or hydraulic impacts to Berry's Creek Study Area that may impact remediation plan.

PURPOSE & NEED COMPONENT	SCREENING CRITERION	COMPARATIVE CONCEPT SCREENING METRICS** ** Use of the terms "relative" or "relatively" indicates that concepts are compared to each other.		
		GOOD	**FAIR**	**POOR**
	Effects on the Transport of Environmental Contaminants/ Sediments during Flood Events	In affected areas, would prevent the inadvertent transport of unsecured hazardous materials during flooding. Contaminated sediments would not be re-suspended. No increase in impacts in unaffected areas.	In affected areas, would reduce the inadvertent transport of unsecured hazardous materials during flooding. The resuspension of contaminated sediments may occur, but effects would be of short duration and could be mitigated using best management practices. No increase in impacts in unaffected areas.	In affected areas, unsecured hazardous materials would continue to be subject to transport by floodwaters as under current conditions. The ongoing resuspension of contaminated sediments would occur, as would the continued dispersion of same throughout the environment similar to existing levels.
	Effects to Water Resources, including Water Quality, "Waters of the US," Wetlands, and Mitigation Banks	**Includes features that protect, enhance, and/or create** water resources in the Project Area. Would result in **long-term water resource and water quality improvements**.	**Does not include features that protect, enhance, and/or create** water resources in the Project Area. Would result in **no potential for long-term water resource or water quality improvements.** May have **neutral or minor adverse effects.**	**Does not include features that protect, enhance, and/or create** water resources in the Project Area. **Includes features that would result in adverse, but mitigatable, impacts** to water resources or water quality over the long term. **No adverse effects to wetland mitigation banks and ongoing wetlands restoration activities.**
	Effects to Fisheries and Essential Fish Habitat (EFH)	**Includes features that protect and/or enhance** connectivity of fisheries habitats and/or facilitate fish migration. Would result in long-term beneficial effects. **No adverse impacts** to EFH.	**Does not include features that protect and/or enhance** connectivity of fisheries habitats and/or facilitate fish migration. Would result in **no potential for long-term beneficial effects.** May have neutral or minor **adverse impacts** to EFH.	**Does not include features that protect and/or enhance** connectivity of fisheries habitats and/or facilitate fish migration. P**otential adverse, but mitigatable, impacts** to EFH (including the potential loss of EFH).
	Effects on Protected Species and their Habitats	**Includes features that protect and/or enhance** protected species habitats. Would result in long-term beneficial effects and **no adverse effects** to protected species or their habitats.	**Does not include features that protect and/or enhance** protected species habitats, but **may afford** opportunities for further habitat enhancements. **No adverse effects** to protected species or their habitats.	**Does not include features that protect and/or enhance** protected species habitats, and **does not afford** opportunities for further habitat enhancements. **Potential adverse, but mitigatable, effects** to protected species or their habitats.
	Effects on Other Sensitive Ecological Resources, including Biodiversity, Habitat, and Migration/Movement Corridors	**Includes features that protect, enhance, and/or create wildlife habitat and/or** connectivity of existing habitat. Would result in long-term beneficial effects and **no adverse effects to sensitive ecological resources in the Project Area.**	**Does not include features that protect, enhance, and/or create wildlife habitat and/or** connectivity of existing habitat. Would result in **no potential for long-term beneficial effects.** Overall, neutral or minor **adverse effects** to **sensitive ecological resources in the Project Area.**	**Does not include features that protect, enhance, and/or create wildlife habitat and/or** connectivity of existing habitat. **Potential adverse, but mitigatable, effects** to **sensitive ecological resources in the Project Area.**

PURPOSE & NEED COMPONENT	SCREENING CRITERION	COMPARATIVE CONCEPT SCREENING METRICS** ** Use of the terms "relative" or "relatively" indicates that concepts are compared to each other.		
		GOOD	**FAIR**	**POOR**
	Effects to Historic and Prehistoric Cultural Resources	**Includes features that protect and/or enhance** cultural resources management in the Project Area. **No effects** to cultural resources listed on or potentially eligible for listing on the National Register of Historic Places.	**Does not include features that protect and/or enhance** cultural resources management in the Project Area. **No adverse effects** to cultural resources listed on or potentially eligible for listing on the National Register of Historic Places.	**Does not include features that protect and/or enhance** cultural resources management in the Project Area. Would result in **adverse effects** to cultural resources listed on or potentially eligible for listing on the National Register of Historic Places.
COSTS & BENEFITS	**Provides Benefits to the Project Area and Community**	**Concept has a relatively high potential** to achieve maximum monetary benefits, including flood risk reduction, co-benefits, and others.	**Concept has a relatively moderate potential** to achieve monetary benefits, including flood risk reduction, co-benefits, and others.	**Concept has a relatively low potential** to achieve monetary benefits, including flood risk reduction, co-benefits, and others.
	Can be Implemented within Available Funding Limits	Concept **could be implemented** within available funding limits.	N/A	Cost to implement concept **exceeds available or other identified funds,** but a **subset of the concept's features that achieve independent utility could be implemented** within available funding limits.
	Has a Positive Benefit/Cost Ratio (BCR)	Concept has a **relatively high potential** to have a BCR > 1.0.	Concept has a **relatively moderate potential** to have a BCR > 1.0.	Concept has a **relatively low potential** to have a BCR > 1.0.

Table 7.3-2 identifies the seven concepts resulting from Screening 1 that would undergo further refinement and evaluation. These include two new concepts as shown in **Table 7.3-2** that result from a combination of concepts.

Table 7.3-2: Alternative 2 Concepts Passing Screening 1

Concept Number	Concept Name	Combined Concepts
1.5	Main Street	N/A
6.3	DePeyster Creek	N/A
7.3	Carol Place	N/A
11.2	West Riser	N/A
12.1	East Riser	N/A
13.1	Main Street and Main Street Extension	New concept combining Main Street 1.5 and 1.6
13.2	Losen Slote Creek and Park Street	New concept combining Losen Slote Creek 3.1 and Park Street 10.1

N/A = not applicable

The seven concepts passing Screening 1 were developed further (see **Figure 7.3-1**). This effort included building Computer Assisted Desktop Design (CADD) Civil 3-D terrain models for each concept. Boundary lines (representing the extents of permanent and temporary areas) were built into the models for each concept. The RBDM project team added descriptions of the concept features to the models and exported the line work to GIS software to facilitate screening.

The process of identifying the criteria to be evaluated for Screening 2; defining “Good,” “Fair,” and “Poor” ratings; and developing the data sources to be used for the screening was repeated. These data were incorporated into the GIS software to allow the project footprints to be evaluated. **Table 7.3-3** lists the criteria selected, the concept ratings, and final scores for Screening 2. Data sources and evaluations completed to rate each concept are described in **Subappendix F-2**.

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Table 7.3-3: Screening 2 Scores

CONCEPTS	SCREENING CRITERION	Percent Total Weighting by Purpose and Need Category	Percent Total of Weighting	1.5 Main Street			6.3 DePeyster Creek			7.3 Carol Place			11.2 West Riser Ditch			12.1 East Riser Ditch			13.1 East Riser and Main Street Combo			13.2 Park Street and Losen Slote Creek Combo		
				Rating	Score	Weighted Score	Rating	Score	Weighted Score	Rating	Score	Weighted Score	Rating	Score	Weighted Score	Rating	Score	Weighted Score	Rating	Score	Weighted Score	Rating	Score	Weighted Score
FLOOD RISK REDUCTION	Reduces Flood Risk from Coastal Storm Surge (Alternatives 1 and 3)	20.0%		N/A	0	0	N/A	0	0	N/A	0	0	N/A	0	0	N/A	0	0	N/A	0	0	N/A	0	0
	Reduces Flood Risk from Rainfall /Interior Drainage Challenges (Alternatives 2 and 3)		6.7%	Fair	2	0.13	Fair	2	0.13	N/A	0	0	Good	3	0.2	Fair	2	0.133	Fair	2	0.133	Poor	1	0.07
	Provides Protection to Vulnerable and Underserved Populations		6.7%	Fair	2	0.13	Poor	1	0.07	Fair	2	0.13	Poor	1	0.067	Fair	2	0.133	Good	3	0.2	Good	3	0.2
	Provides Protection to Critical Infrastructure (emergency services, hospitals, transit facilities)		6.7%	Good	3	0.2	Poor	1	0.07	Good	3	0.2	Good	3	0.2	Good	3	0.2	Fair	2	0.133	Good	3	0.2
BUILT ENVIRONMENT/HUMAN ENVIRONMENT	Effects to Existing Utilities & Utility Infrastructure	20.0%	2.86%	Poor	1	0.03	Fair	2	0.06	Fair	2	0.06	Fair	2	0.057	Good	3	0.086	Poor	1	0.029	Poor	1	0.03
	Effects to Existing Local Roadway Network and Connectivity		1.43%	Good	3	0.04	Good	3	0.04	Fair	2	0.03	Fair	2	0.029	Good	3	0.043	Good	3	0.043	Good	3	0.04
	Effects to Existing Regional Transportation Network and Connectivity		1.43%	Fair	2	0.03	Fair	2	0.03	Good	3	0.04	Good	3	0.043	Good	3	0.043	Fair	2	0.029	Good	3	0.04
	Effects on Land Acquisition / Housing Displacements		2.86%	Poor	1	0.03	Good	3	0.09	Good	3	0.09	Good	3	0.086	Fair	2	0.057	Poor	1	0.029	Fair	2	0.06
	Potential to Provide Increased Waterfront Access		2.86%	Good	3	0.09	Good	3	0.09	Fair	2	0.06	Fair	2	0.057	Fair	2	0.057	Good	3	0.086	Fair	2	0.06
	Effects to Recreational, Civic, and Cultural Amenities and Uses		2.86%	Good	3	0.09	Good	3	0.09	Good	3	0.09	Fair	2	0.057	Good	3	0.086	Good	3	0.086	Good	3	0.09
	Effects to Viewshed and Local Visual Quality		2.86%	Good	3	0.09	Good	3	0.09	Good	3	0.09	Fair	2	0.057	Fair	2	0.057	Good	3	0.086	Fair	2	0.06
	Effects to Air Traffic Safety at Teterboro Airport		2.86%	Good	3	0.09	Good	3	0.09	Fair	2	0.06	N/A	0	0	Fair	2	0.057	Good	3	0.086	Fair	2	0.06
CONSTR	Constructability	20.0%	5.0%	Poor	1	0.05	Fair	2	0.1	Fair	2	0.1	Poor	1	0.05	Fair	2	0.1	Poor	1	0.05	Poor	1	0.05

CONCEPTS	SCREENING CRITERION	Percent Total Weighting by Purpose and Need Category	Percent Total of Weighting	1.5 Main Street			6.3 DePeyster Creek			7.3 Carol Place			11.2 West Riser Ditch			12.1 East Riser Ditch			13.1 East Riser and Main Street Combo			13.2 Park Street and Losen Slote Creek Combo		
				Rating	Score	Weighted Score	Rating	Score	Weighted Score	Rating	Score	Weighted Score	Rating	Score	Weighted Score	Rating	Score	Weighted Score	Rating	Score	Weighted Score	Rating	Score	Weighted Score
	Minimizes Long-Term Maintenance & Operation Requirements for Overall System		5.0%	Poor	1	0.05	Fair	2	0.1	Fair	2	0.1	Poor	1	0.05	Fair	2	0.1	Poor	1	0.05	Fair	2	0.1
	Potential to Complete by September 2022-This rating is about construction schedules assuming permits are in place		5.0%	Fair	2	0.1	Good	3	0.15	Good	3	0.15	Poor	1	0.05	Fair	2	0.1	Poor	1	0.05	Fair	2	0.1
	Potential to Complete by September 2022-This rating is about acquiring required permits in required time frame. Other permits to be considered?		5.0%	Fair	2	0.1	Fair	2	0.1	Good	3	0.15	Good	3	0.15	Good	3	0.15	Fair	2	0.1	Fair	2	0.1
NATURAL ENVIRONMENT	Effects to Existing Hazardous Waste Sites	20.0%	3.3%	Poor	1	0.03	Fair	2	0.07	Good	3	0.1	Poor	1	0.033	Fair	2	0.067	Poor	1	0.033	Poor	1	0.03
	Effects to Berry's Creek Remediation		3.3%	Good	3	0.1	Good	3	0.1	Good	3	0.1	Poor	1	0.033	Good	3	0.1	Good	3	0.1	Good	3	0.1
	Effects on the Transport of Environmental Contaminants/ Sediments during Flood Events		3.3%	Poor	1	0.03	Fair	2	0.07	Fair	2	0.07	Poor	1	0.033	Poor	1	0.033	Poor	1	0.033	Poor	1	0.03
	Effects to Water Resources, including Water Quality, "Waters of the US," Wetlands, and Mitigation Banks		3.3%	Good	3	0.1	Good	3	0.1	Fair	2	0.07	Poor	1	0.033	Fair	2	0.067	Fair	2	0.067	Poor	1	0.03
	Enhancements to Biological Resources		3.3%	Good	3	0.1	Good	3	0.1	Fair	2	0.07	Good	3	0.1	Good	3	0.1	Good	3	0.1	Fair	2	0.07
	Effects to Fisheries and Essential Fish Habitat (EFH)			N/A	0	0	N/A	0	0	N/A	0	0	N/A	0	0	N/A	0	0	N/A	0	0	N/A	0	0

CONCEPTS	SCREENING CRITERION	Percent Total Weighting by Purpose and Need Category	Percent Total of Weighting	1.5 Main Street			6.3 DePeyster Creek			7.3 Carol Place			11.2 West Riser Ditch			12.1 East Riser Ditch			13.1 East Riser and Main Street Combo			13.2 Park Street and Losen Slote Creek Combo		
				Rating	Score	Weighted Score	Rating	Score	Weighted Score	Rating	Score	Weighted Score	Rating	Score	Weighted Score	Rating	Score	Weighted Score	Rating	Score	Weighted Score	Rating	Score	Weighted Score
	Effects on Protected Species and their Habitats			N/A	0	0	N/A	0	0	N/A	0	0	N/A	0	0	N/A	0	0	N/A	0	0	N/A	0	0
	Effects on Other Sensitive Ecological Resources, including Biodiversity, Habitat, and Migration/Movement Corridors			N/A	0	0	N/A	0	0	N/A	0	0	N/A	0	0	N/A	0	0	N/A	0	0	N/A	0	0
	Effects to Historic and Prehistoric Cultural Resources		3.3%	Fair	2	0.07	Good	3	0.1	Good	3	0.1	Good	3	0.1	Good	3	0.1	Fair	2	0.067	Good	3	0.1
COSTS & BENEFITS	Provides Benefits to the Project Area and Community	20.0%	6.7%	Fair	2	0.13	Fair	2	0.13	N/A	0	0	Fair	2	0.133	Fair	2	0.133	Fair	2	0.133	Poor	1	0.07
	Can be Implemented within Available Funding Limits		6.7%	Fair	2	0.13	Good	3	0.2	Good	3	0.2	Fair	2	0.133	Poor	1	0.067	Fatal Flaw	-100	-6.67	Poor	1	0.07
	Has a Positive Benefit/Cost Ratio (BCR)		6.7%	Fair	2	0.13	Poor	1	0.07	N/A	0	0	Good	3	0.2	Fair	2	0.133	Fair	2	0.133	Fatal Flaw	-100	-6.67
	SCORE TOTAL	100.0%	100.0%			2.07			2.21			2.03			1.95			2.20			-4.81			-4.92

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Table 7.3-4 identifies the six concepts resulting from Screening 2. The RBDM project team reviewed the top five concepts, giving consideration to reducing negative impacts associated with an otherwise favorable concept, and combining two concepts to create a concept carrying the benefits of both. This process produced one additional concept (Losen Slote Creek/Carol Place). **Table 7.3-4** summarizes the six concepts that passed Screening 2 and are to be further evaluated in the Feasibility Study.

Table 7.3-4: Alternative 2 Concepts Passing Screening 2

Concept Number	Concept Name	Combined Concepts
1.5	Main Street	N/A
6.3	DePeyster Creek	N/A
N/A	Losen Slote Creek / Carol Place	Concept combines Losen Slote Creek 3.1 and Park Street 10.1 and Concept 7.3, with removal of channel improvements from the downstream, marshy portion of Losen Slote Creek
11.2	West Riser	N/A
12.1	East Riser	N/A
N/A	Concept D	Concept is the Losen Slote Creek/ Carol Place concept, minus the grey infrastructure improvements in Carol Place, and plus lower East Riser Ditch conveyance improvements and pump station

N/A = not applicable

7.4 Concept Refinement and Coordination

Each of the concepts described in **Table 7.3-4** were further refined as described in the sections below. Geotechnical investigations such as soil borings and permeability tests will be implemented during the design stage to determine the feasibility of infiltrating stormwater in green infrastructure facilities.

7.4.1 Main Street Concept

Main Street has a number of utilities within the sidewalks and roadway, which limited the feasible green infrastructure opportunities that could be integrated into the concept. Several bioswales and subsurface storage trenches would be placed on side streets intersecting Main Street (Charles Street, Garden Street, Brandt Street, Marshall Avenue, Grand Street, Center Street, Herman Street, Frederick Street, Werneking Place, and Pickens Street). Open space and green infrastructure features would include the creation of these street green infrastructure features and three new waterfront parks (Fluvial Park, K-Town Park, and Riverside Park) and improvements to two existing public parks (Indian Lake and Willow Lake) in the Borough of Little Ferry. The open space concept would include stormwater quality, visual, and pedestrian circulation improvements; wetland improvements; habitat creation in native planting areas; the creation of

basketball, exercise equipment, play, and boat and kayak launch areas; and improved marina docks with opportunities for fishing and birdwatching, as described below:

Indian Lake Park: Indian Lake Park is an existing park in the Borough of Little Ferry. New features would include habitat and pedestrian improvements to 0.6 acres on the southeastern edge adjacent to Lakeview Avenue and the Bergen Turnpike. Such improvements would be designed to improve stormwater infiltration, conveyance, and stormwater quality with ecological and social co-benefits. These improvements would include the creation of an additional approximately 3,200 SF of walking trails; 1,300 SF of plazas and seating with opportunities for birdwatching and passive recreation; landscape improvements to include 11,850 SF of native planting, and 5,100 SF of naturalized wetland edge on Indian Lake.

Fluvial Park: Fluvial Park would be a new 4.4-acre riverfront park that provides stormwater storage and filtration, native habitat, open space, and passive and active recreation. The park would also provide public access to approximately 560 LF of riverfront. The park would include elevated walkways over constructed wetlands and native vegetation, approximately 0.6 acre of permeable play surface; a kayak launch; and opportunities for fishing and birdwatching. Stormwater would be filtered in an approximately 3,484 SF bioswale. The ecological habitat and performance of the site would be improved with approximately 1.0 acre of naturalized wetland and 0.3 acre of native woodland. An approximately 500 LF access path would connect the park to Bergen Turnpike. Lawn areas would provide approximately 1.2 acres for picnicking, sunbathing, and informal games such as Frisbee and bocce ball.

K-Town Park: K-Town Park would be a new 1.4-acre riverfront park. The proposed improvements would transform an existing abandoned hotel, marine facility, and parking lot. This proposed park would provide approximately 0.6 acre of active recreation space that could be used for formal and informal sports and recreational activities. In addition to this active recreational space, there would be a variety of seating areas and plantings (approximately 0.3 acre), a public parking lot (0.2 acre), and a concrete pathway connecting to the cantilever riverwalk.

Riverside Park: Riverside Park would be a new 2.6-acre riverfront park that transforms an existing boat dock area and parking lot into a park with approximately 600 LF of accessible waterfront. Riverside Park would include walking paths that weave through approximately 0.7 acre of native plantings and bioswales, and 0.3 acre of mowed lawn for informal recreation and gathering. A restored riparian wetland (approximately 0.1 acre) would create new intertidal wetland habitat and would be accessible by an elevated walkway, and improved boat docks and a boat launch, which would be capable of launching trailered vessels, would create recreational opportunities for birdwatching, kayaking, and fishing.

Willow Lake Park: Willow Lake Park is an existing 7.0-acre public park that is proposed to be improved for pedestrian circulation and ecological benefit. Existing pedestrian trails would be expanded to connect the northern and southern areas of the park. These trails would be approximately 0.5 mile long, and would be woven through dynamic earthwork mounds supporting approximately 2.0 acres of native vegetation and 1.9 acres of low meadow with scattered trees. These vegetation areas would provide habitat for pollinators and birds. Bioswales (approximately 1,134 SF) would store and filter stormwater from Pickens Street, and a large expanse of open lawn (approximately 2.4 acres) would allow for informal active play.

7.4.2 DePeyster Creek Concept

The DePeyster Creek concept would consist of a ten-fold increase in the existing pump station discharge capacity (to 75 cfs), removal of material along DePeyster Creek upstream of the pump station, and an

upgrade to the existing culvert at the upstream boundary from the existing pump. Green infrastructure systems (i.e., tree trenches and subsurface stone storage trenches) within the DePeyster Creek concept would be located at street side right-of-way areas at Monroe Street and Dietrich Street between Eckel Road and Industrial Avenue. Open space and green infrastructure features would include the creation of these street green infrastructure features and would include improvements to the existing Mehrhof Park and the creation of a new park at DePeyster Creek, as described below:

DePeyster Creek Park: DePeyster Creek Park would be a new 8.0-acre riverfront park and natural area. The park would transform approximately 360 LF of the Hackensack River into publicly accessible riverfront, with approximately 0.7 acre of trails (including an elevated walkway) and plazas (congegration areas) allowing opportunities for walking, running, picnicking, group assembly, and bird-watching along both the river and the newly created intertidal marshland. Disturbed successional shrubland and disturbed upland deciduous forest would be transformed into higher quality habitat, such as a protected shallow embayment with intertidal marsh, native shrub habitat, and native woodland with pollinator habitat.

Mehrhof Park: Mehrhof Park is an existing 4.0-acre public park. Improvement would include bioswales to reduce the impact of a large parking lot serving the existing soccer and hockey fields. The park would be improved with an expanded wetland nature area of approximately 63,000 SF to increase stormwater storage, approximately 17,000 SF of nature trails for birdwatching and connectivity between Mehrhof Road and Monroe Street, and approximately 27,000 SF of naturalized landscape and trees.

7.4.3 Losen Slote Creek/Carol Place Concept

The Losen Slote Creek/Carol Place concept would include the installation of two pump stations within the residential areas east and west of the stream: one 50 cfs pump station adjacent to the stream at Lorena Street and one 100 cfs pump station at West Park Street and Row Street. Stormwater collected at these locations would be discharged via 36-inch or larger size ductile iron pipe force mains to the Losen Slote Creek near the downstream marshy area. Force main size will be re-evaluated during the design phase. An energy dissipation structure would be provided for each pump station to limit erosion at the discharge points. Other storm drainage improvements would include ditch channel improvements and culvert upgrades to the existing system extending from Moonachie Avenue to Losen Slote Creek, located in the commercial/industrial area north of Empire Street and south of State Street.

In addition, the concept would provide ample open space green infrastructure features, combining improvements to five existing parks or public school yards, two wetland improvement areas, a new recreational amenity at Avanti Park, and extensive active recreational and habitat improvements at Moonachie Fields. Both Avanti Park and Moonachie Fields would provide significant footprints dedicated to stormwater filtration and water quality improvements, both on site and collected from adjacent streets and lots. Green infrastructure systems within the Carol Place right-of-way would be located primarily within the sidewalk of Moonachie Avenue and Empire Boulevard. The vegetated portion of these bioswales would be located within the lawn space between the sidewalk and curb. Artificial turf will be further evaluated during the design phase for green infrastructure facilities at schools and parks.

Subsurface stone trenches would expand the storage footprint of each system and allow the surface to be repaved as a sidewalk or driveway entrance. Green infrastructure systems within the Losen Slote Creek right-of-way areas would be located primarily along Moonachie Road, Liberty Street, and Redneck Avenue, with additional green infrastructure on East Joseph Park Street and East Park Street. Subsurface storage trenches are proposed along Moonachie Road because it has a relatively narrow sidewalk without a grass strip between the sidewalk and curb. Storage trenches are also proposed along Liberty

Street because there is a lack of adequate spacing between the curb and sidewalk. Redneck Avenue has no sidewalk; therefore, the proposed bioswales would be in a longer, trapezoid channel formed with internal check dams. In total, the Losen Slote Creek/Carol Place concept green infrastructure systems would manage runoff from roughly 2.8 acres of roadway impervious surface. Open space and green infrastructure features would include the creation of these street green infrastructure features and the improvements described below:

Little Ferry Municipal Improvements: Little Ferry Municipal Improvements would be stormwater management practices installed at the Little Ferry Library and Little Ferry Municipal Building. The improvements to the library would include approximately 0.3 acre of native plantings and rain gardens, as well as replacement of existing asphalt parking lot with permeable paving to improve stormwater infiltration.

Bailey Park: Bailey Park is an existing 2.0-acre park that would be improved with approximately 6,000 SF of native plantings at the existing lawn to improve biodiversity and infiltrate water on site, approximately 6,300 SF of permeable paving for picnic and gathering spaces, and approximately 3,500 SF of rain gardens to collect and treat stormwater from Redneck Avenue.

Little Ferry Public Schools: The neighboring Little Ferry Public Schools would receive a series of campus improvements. The improvements would be made to Washington Elementary School and Memorial Middle School, and would include open space, native habitat, stormwater storage and filtration, and passive and active recreation opportunities. Approximately 0.4 acre of an existing sports field would be improved, while approximately 1.1 acres of native vegetation (with trees) would be planted to increase stormwater filtration and biodiversity. Proposed rain gardens along Liberty Avenue would also collect and infiltrate stormwater. At Washington Elementary School, approximately 0.8 acre of impervious pavement would be converted to permeable pavement or a permeable play area. Existing active programming areas would remain, but overall stormwater filtration and conveyance would be improved on site.

Robert Craig Elementary School: Robert Craig Elementary School is an existing elementary school campus with approximately 1.7 acres of proposed improvements. Improvements would include 0.3 acre of permeable play surface at an existing impermeable play surface, an approximately 2,519 SF rain garden at an existing open lawn, and approximately 1.4 acres of new sports field at an existing baseball diamond and open lawn. Stormwater filtration and conveyance would be improved on site while existing active programming would be unchanged.

Joseph Street Park: Joseph Street Park is an existing public park. Landscape improvements would be made to 0.2 acre of the park through the planting of native vegetation. Bioswales would also improve stormwater storage and filtration, and an existing parking lot would receive treatment to increase its permeability and improve its stormwater filtration capabilities and reduce runoff.

Losen Slote Creek Wetland Improvements: Losen Slote Creek Wetland Improvements would include a 1.5-acre habitat enhancement area, including a 9,000 SF area of reforestation using native tree species, and the creation of approximately 17 vernal pools to improve habitat for amphibians and the overall ecological function of the existing wetland and woodland.

Moonachie Fields: Moonachie Fields is an existing 18.5-acre park that would receive 13.0 acres of sport field improvements, including new bleachers, backstops, and goals. Approximately 2.5 acres of permeable pavement for parking and circulation would improve stormwater infiltration, runoff water quality and mobility between the fields. Approximately 13,000 SF of bioswales would filter stormwater that runs off proposed pavements, as well as from Redneck Avenue, which abuts the western edge of the park.

The remainder of proposed improvements includes native herbaceous plantings, shrubs, and tree plantings that would improve stormwater filtration and biodiversity and 52,000 SF of improved wetland habitat areas.

Avanti Park: Avanti Park would be a new 1.0-acre park on an existing open lot along Moonachie Road just north of Edstan Drive. The park would feature open space, native habitat, stormwater storage and filtration capability, and passive and active recreation opportunities. The primary feature of the park would be an approximately 0.3-acre constructed wetland that would collect and infiltrate stormwater from both the park and the adjacent lot. An elevated walkway (approximately 0.1 acre) would traverse this wetland, and connect back to approximately 0.2 acre of permeable pavement along Moonachie Road. Adjacent to the permeable pavement would be approximately 0.1 acre of permeable play surface. Additional park elements would include approximately 0.1 acre of woodland to screen adjacent warehouses, approximately 0.2 acre of native plantings to increase biodiversity, and stormwater filtration.

7.4.4 West Riser Ditch Concept

The West Riser Ditch concept includes installation of a 500 cfs pump station upstream of the existing tide gate, removal of material from the riser between the Vincent Street pump station and the tide gate, and upgrades to culverts. Green infrastructure features would include the creation of street green infrastructure.

7.4.5 East Riser Ditch Concept

The East Riser Ditch concept provides channel conveyance upgrades, a 500 cfs pump station upstream of the existing tide gate, open space, passive and active recreation, native habitat, and stormwater filtration at Caesar Place. Material would be removed from its origin upstream of I-80 in the East Riser Ditch to the existing tide gate. Culvert crossings would be increased in size and railroad bridges would be removed and replaced with structure providing larger channel flow area. Open space and green infrastructure features include creation of street green infrastructure and the following:

Caesar Place Park: Caesar Place Park would be a new 4.0-acre park along the east side of Caesar Place in Moonachie. This park would provide open space, native habitat, stormwater storage and filtration, wetland enhancement and expansion, and opportunities for passive recreation. Caesar Place Park would improve and expand the existing wetland on site, creating approximately 1.5 acres of wooded wetland and 1.6 acres of emergent wetland. Elevated boardwalks (approximately 0.2 acre), which could potentially include outlooks and viewing platforms, would allow visitors to access these habitats. Further, there would be approximately 0.5 acre of open lawn and approximately 0.3 acre of native vegetation to provide recreational opportunities. Rain gardens (approximately 1,224 SF) would also be located on site to filter stormwater from Caesar Place Road, and additional native plantings would frame the park and provide aesthetic transition within the surrounding urban context.

7.4.6 Additional Concept D

Concept D is a combination of certain features from the five concepts that were described above. It would include the pump stations and force mains from the Losen Slote Creek/Carol Place concept, and the channel conveyance improvements and pump station below Moonachie Avenue from the East Riser Ditch concept. It also includes all street green infrastructure and the following features as described in **Section 7.4.1** through **Section 7.4.5**:

- Residential area and tide gate pump stations on Losen Slote and East Riser Ditch;
- Upgraded culvert and bridge crossings along East Riser Ditch;
- Creation of Fluvial Park;
- Creation of Riverside Park;
- Improvements to Willow Lake Park;
- Creation of DePeyster Creek Park;
- Little Ferry Municipal Improvements;
- Improvements to Little Ferry Public Schools;
- Improvements to Robert Craig Elementary School;
- Improvements to Joseph Street Park;
- Creation of Caesar Place Park; and
- Improvements to Avanti Park.

7.4.7 Coordination and Identification of Alternative 2

As detailed in **Section 7.1** through **Section 7.4**, several individual concepts were developed to address stormwater flooding within discrete drainage sub-basins throughout the Project Area. In some cases, these concepts were distinct and separate; in others, meaningful system-based combinations were possible. Through the development, evaluation, and screening processes described, key components emerged within many individual concepts. In every case, these components possessed performative aspects (flood reduction or water quality improvement) and co-benefits (ecological enhancement, improved access to recreation opportunities, or community revitalization), however; they remained meaningful, but separate, conceptual components.

Having been screened and considered for implementation challenges already, these components were combined into a single plan and organized to form distinct systems aimed at providing a broad distribution of benefits, addressing near-term flood reduction needs, and establishing the backbone needed to support future expansion of drainage improvements in the Berry's Creek and Hackensack River watersheds.

7.5 Detailed Description

The following is a detailed description of each feature of the Alternative 2 Plan. Detailed plan sheets depicting the plan are provided in Subappendix F2.

Civil Design and Grey Infrastructure under Alternative 2:

A ***500 cfs pump station*** would be installed in the open space area immediately northwest of the existing East Riser Ditch tide gate. This new East Riser Ditch pump station would utilize eight Archimedean screw pumps, which would be powered primarily by electricity, but would also be connected to a backup generator in case of electricity outages. The pump type will be further evaluated and determined during the design phase based on the considerations on clogging and solids handling, efficiency, and head requirements. The pump station would collect water from an intake bay constructed along the northern bank of the channel, and discharge into a new modified forebay inlet (approximately 40 feet wide and 60 feet long) to the existing

tide gate. The modified forebay inlet would be installed upstream of Starke Road to convey discharge to the existing culverts under Starke Road and through the existing tide gate. When the pump station is not operating, normal flow from the channel would flow through flap gates in the forebay and tide gate similar to existing conditions. Access to East Riser Ditch pump station would be provided by a 0.2-acre parking lot along Starke Road.

The ***East Riser Ditch channel*** would be dredged between Moonachie Avenue and the East Riser Ditch tide gate. In total, approximately 20,200 cubic yards (CY) of sediment would be removed from the ditch and disposed of off-site at a facility licensed to receive the dredged material in order to improve stormwater conveyance within the channel. To complete this work, the railroad bridge that crosses this reach of East Riser Ditch, as well as the culverts beneath Amor Avenue and West Commercial Avenue, would need to be removed and replaced. Dredged sediment and all debris associated with these channel improvements would be disposed of offsite at a licensed facility, and channel boundaries and adjacent areas (approximately 9.5 acres) would be revegetated following the channel improvements. Long-term O&M activities would be facilitated by establishment of a new two-track O&M access road/easement (at least 10 feet wide) along the ditch.

Losen Slote Creek residential pump stations and force mains would be installed to collect stormwater and discharge it into the marshy open reach to the south of the residential area. Pump station A would be located in the back parking lot of 15 Liberty Street in Little Ferry, immediately east of the Liberty Bell Village. This pump station would have one 50 cfs pump, and would discharge stormwater through a 36-inch or larger size force main in the Lorena Street, Liberty Street, Eckel Road, and Birch Street rights-of-way. This force main would be approximately 3,300 feet long, and would consist of a ductile iron pipe. Force main size will be re-evaluated during the design phase. It would discharge into Losen Slote Creek at the western terminus of Birch Street.

Pump station C would be located in an existing truck bay at an industrial complex, along West Park Street northwest of the intersection with Albert Street. This pump station would have a capacity of 100 cfs (i.e., two 50 cfs pumps), and would discharge stormwater through a 2,200-foot long, 36-inch or larger size ductile iron pipe force main in the West Park Street and East Park Street rights-of-way. The force main would discharge into Losen Slote Creek at the eastern terminus of East Park Street. Force main size will be re-evaluated during the design phase.

Both Losen Slote Creek pump stations would additionally have a backup pump and a backup generator installed in case of pump malfunction or electricity outages. Energy dissipation structures would also be constructed at the discharge points for both force mains A and C in order to reduce the potential for erosion of the Losen Slote Creek channel. Final force main sizes would be determined during the design phase of the Proposed Project.

Green Infrastructure under Alternative 2:

Green infrastructure retrofits within the public right-of-way would be designed to capture stormwater runoff from streets and sidewalks, improve water quality, and enhance the streetscapes with permanent vegetation or new porous paving. Each green infrastructure system would be sized to capture and treat runoff from the NJDEP Water Quality Design Storm, which is 1.25 inches of rainfall in two hours. Larger storms would bypass the green infrastructure systems and be conveyed by the existing stormwater system. The green infrastructure retrofit opportunities identified for the right-of-way based on site constraints include bioswales, rain gardens, storage trenches, and tree trenches.

DePeyster Creek: Green infrastructure systems proposed within the DePeyster Creek concept right-of-way would be located primarily within the sidewalk of Monroe Street and Dietrich Street between Eckel Road and Industrial Avenue (see **Table 7.5-1**). Subsurface stone trenches would expand the storage footprint of each system into the footway and allow the surface to be repaved as sidewalk or driveway entrance. In total, the DePeyster Creek concept green infrastructure systems would be expected to manage runoff from roughly 0.5 acre of impervious roadway.

Table 7.5-1: DePeyster Creek Green Infrastructure

System Type	Location	Drainage Area (SF)	System Footprint (SF)
Storage/Tree Trench	Monroe Street at Eckel Road	5,934	535
Storage/Tree Trench	Monroe Street from dead end to Bertolotto Avenue	3,136	440
Storage/Tree Trench	Monroe Street from Bertolotto Avenue to Eckel Street	6,490	1,024
Storage/Tree Trench	Dietrich Street from Maiden Lane to Mehrhof Road	1,314	128
Storage/Tree Trench	Dietrich Street from Maiden Lane to Mehrhof Road	1,781	294
Tree Trench	Dietrich Street from dead end to Maiden Lane	2,497	395
	Total:	**21,152**	**2,816**

SF = square feet

Carol Place: Green infrastructure systems proposed within the Carol Place concept right-of-way would be located primarily within the sidewalk of Moonachie Avenue and Empire Boulevard between Caesar Place and State Street (see **Table 7.5-2**). The vegetated portion of these bioswales would be located within the lawn space between the sidewalk and curb. Subsurface stone trenches would expand the storage footprint of each system and allow the surface to be repaved as sidewalk or driveway entrance. In total, the Carol Place concept green infrastructure systems would be expected to manage runoff from approximately 1.4 acres of impervious roadway.

Table 7.5-2: Carol Place Green Infrastructure

System Type	Location	Drainage Area (SF)	System Footprint (SF)
Bioswale	Moonachie Avenue at Redneck Avenue	11,412	902
Bioswale	Moonachie Avenue from Commercial Avenue to Eastern Avenue	16,351	3,345
Bioswale	Moonachie Avenue from Eastern Avenue to Washington Avenue	10224	1,411
Bioswale	Moonachie Avenue from Eastern Avenue to Washington Avenue	8,528	755
Bioswale	Empire Boulevard from Moonachie Road to Terminal Lane	4,889	663
Bioswale	Moonachie Road from Moonachie Avenue to Edstan Drive	3,143	794
Bioswale	Moonachie Road from Moonachie Avenue to Edstan Drive	3,587	573

System Type	Location	Drainage Area (SF)	System Footprint (SF)
Bioswale	Empire Boulevard from Central Boulevard to Horizon Boulevard	4,546	480
	Total:	**62,861**	**8,923**

SF = square feet

West Riser Ditch: Green infrastructure systems proposed within the West Riser Ditch concept right-of-way would be located on Moonachie Avenue near the intersection with Oak Street (see **Table 7.5-3**). This green infrastructure system would capture runoff from Moonachie Avenue and treat the runoff in a rain garden located in a grassed area adjacent to the roadway. In total, the West Riser Ditch concept green infrastructure systems would be expected to manage runoff from roughly 0.5 acres of impervious roadway.

Table 7.5-3: West Riser Ditch Green Infrastructure

System Type	Location	Drainage Area (SF)	System Footprint (SF)
Rain Garden	Moonachie Ave from Park Place to Oak Street	20,329	2,853
	Total:	**20,329**	**2,853**

SF = square feet

East Riser: The East Riser concept does not include any green infrastructure retrofits within the public right-of-way.

Park Street: Green infrastructure systems within the Park Street concept right-of-way would be located primarily along Moonachie Road, Liberty Street, and Redneck Avenue (see **Table 7.5-4**). Storage trenches are proposed along Moonachie Road because it has a relatively narrow sidewalk without a grass strip between sidewalk and curb. Storage trenches are also proposed along Liberty Street because there is a lack of adequate spacing between the curb and sidewalk. Redneck Avenue has no sidewalk; therefore, the proposed bioswales would be the longer, trapezoid channel form with internal check dams. In total, the Park Street concept green infrastructure systems would be expected to manage runoff from approximately 1.4 acres of impervious roadway.

Table 7.5-4: Park Street Green Infrastructure

System Type	Location	Drainage Area (SF)	System Footprint (SF)
Bioswale	East Joseph Street at Moonachie Road	8,660	1,460
Bioswale	East Park Street from Moonachie Road to Graphic Place	2,309	405
Storage/Tree Trench	Liberty Street at Kavrik Street	3,329	720
Bioswale	Redneck Avenue from Union Avenue to Franklin Street	10,906	2,735

System Type	Location	Drainage Area (SF)	System Footprint (SF)
Bioswale	Redneck Avenue from Wilson Street to Mariani Drive	9,254	863
Storage/Tree Trench	Liberty Street from Redneck Avenue to William Street	11,346	1,028
Storage Trench	Moonachie Road from Garden Street to Maple Street	3,026	448
Storage Trench	Moonachie Road from Park Street to Joseph Street	5,351	468
Storage Trench	Moonachie Road from Park Street to Broad Street	6,889	423
	Total:	**61,070**	**8,549**

SF = square feet

Main Street: Main Street has several subsurface utilities within the sidewalks and roadway; therefore, feasible green infrastructure opportunities are limited. System 69 would be a series of stone trenches located below the sidewalk. Several bioswales and storage trenches would be placed on side streets intersecting Main Street (Charles Street, Garden Street, Brandt Street, Marshall Ave, Grand Street, Center Street, Herman Street, Frederick Street, Werneking Place). Systems 79 and 80 would be rain gardens within medians at the intersection of Bergen Turnpike and Sylvan Avenue (US Route 46). The current design of these rain gardens makes use of the best available information at this time. Further refinement may be necessary following a formal survey of the area. In total, the Main Street concept green infrastructure systems would be expected to manage runoff from roughly 2.8 acres of impervious roadway. **Table 7.5-5** summarizes green infrastructure proposed in this area.

Table 7.5-5: Main Street Green Infrastructure

System Type	Location	Drainage Area (SF)	System Footprint (SF)
Storage Trench	Main Street at Garden Street west	10,317	1,890
Storage Trench	Charles Street at Main Street (northeast)	13,762	1,307
Storage Trench	Main Street from Brandt Street to Grant Street	2,400	132
Storage Trench	Main Street from Garden Street to Brandt Street	1,978	169
Storage Trench	Center Street from Park Street to Main Street	6,796	939
Storage Trench	Herman Street from dead end to Main Street	2,482	147
Bioswale	Frederick Street from Poplar Street to Main Street	3,793	624
Bioswale	Werneking Place from Poplar Street to Main Street	6,923	936
Bioswale	Werneking Place from Poplar Street to Main Street	6,151	700
Rain Garden	Valley Road at Bergen Turnpike	14,400	1,867
Rain Garden	Sylvan Avenue at Bergen Turnpike	16,479	1,572
Rain Garden	Sylvan Avenue at Bergen Turnpike	14,395	1,159

System Type	Location	Drainage Area (SF)	System Footprint (SF)
Storage Trench	Brandt Street from Sylvan Avenue to Main Street	10,249	866
Storage Trench	Marshall Avenue from Kavrik Street to Main Street	3,116	450
Storage Trench	Grand Street from US Route 46 to Main Street	1,294	275
Storage Trench	Frederick Street from Poplar Street to Main Street	5,788	760
Storage Trench	Pickens Street from Park Street to Main Street	1,561	185
	Total:	**121,884**	**13,977**

SF = square feet

Note 1: After work began on this project, the Little Ferry Traffic Circle was eliminated and replaced by a cross intersection. New locations for the proposed rain gardens, near the new intersection, will be investigated. Current design makes use of the best available information; however, further refinement may be necessary following a formal survey of the area.

Parks and Improvements under Alternative 2:

Alternative 2 would include the construction of five new parks within the Project Area: **Fluvial Park**, **Riverside Park**, **DePeyster Creek Park**, **Caesar Place Park**, and **Avanti Park**. In total, approximately 20.0 acres of new park space would be established, which would be designed to assist with storage and treatment of both on-site stormwater, as well as stormwater from adjacent roadways. To this end, each park would focus on wetland restoration or creation, additional green infrastructure, and increased pervious surfaces and native plantings, while providing varied recreational opportunities. Additionally, Alternative 2 would include improvements to five existing open spaces within the Project Area: **Willow Lake Park**, **Little Ferry Municipal Improvements**, **Little Ferry Public Schools**, **Joseph Street Park**, and **Robert Craig Elementary School**. Generally, these improvements would include features such as replacement of impervious surfaces with permeable materials (i.e., permeable paving of parking lots), installation of additional native plantings and green infrastructure systems, and sports field renovations. Like the proposed new parks, these improvements would be intended to increase overall stormwater storage and treatment at these locations. Details for each park and improvement are as previously provided in **Section 7.4.1** through **Section 7.4.5**.

7.6 Alternative 2 Cost

As shown in **Table 7.6-1** the total construction cost of Alternative 2 would be approximately $142,551,000. This includes an average contingency of 25 percent for the construction features and assumes a cost escalation of each feature to the construction midpoint (assumed as 2021) at a rate of 3.5 percent per year. The majority of unit costs used in the estimate is from 2017 RS Means data and includes appropriate area adjustment to Bergen County, NJ.

The cost of the grey infrastructure features (pump stations, force mains, and channel and drainage improvements) would be approximately $107,908,000 (76 percent of construction cost). The cost of the green infrastructure features (bioswales, rain gardens, storage trenches/tree trenches, permeable pavement, wetland improvements, parks/open spaces, and other associated structures and easements) would be approximately $20,106,000 (14 percent of construction cost). Allowances for utility relocations and for the cost to mitigate unavoidable wetland impacts would be approximately $5,749,000 (4 percent

of construction cost). General construction requirements such as mobilization and demobilization, traffic maintenance, erosion control, contractor supervision, and project management would be approximately $8,790,000 (6 percent of construction cost).

When including an allowance of 12.0 percent for detailed engineering, design, and permitting, and 4.3 percent for construction administration, the total estimated Alternative 2 cost, including contingency and escalation, is $164,916,000, not including real estate.

In addition, the Feasibility Study and EIS cost approximately $20.5 million and program administration costs are approximately $15 million. Together, the estimated overall cost of Alternative 2 is $200,416,000.

If Alternative 2 is completed, there would be annual O&M costs associated with the new pump stations and the other grey and green construction features. The annual cost of O&M would be approximately $1,500,000. A detailed breakdown of costs for both the initial construction and the O&M is provided in **Appendix D**.

Table 7.6-1: Construction Cost Summary with Contingency and Escalation for Alternative 2

Project Summary	COST (2017 PL)	CONTINGENCY	ESCALATION @3.5%/Yr	COST w/ CONTINGENCY & ESCALATION
GREY INFRASTRUCTURE FEATURES	**$ 75,228,000**	**$ 18,807,000**	**$ 13,872,000**	**$ 107,908,000**
East Riser Ditch (ERD), Losen Slote and Carol Place (LS)				
New Pump Stations	$ 48,750,000	$ 12,188,000	$ 8,990,000	$ 69,930,000
Force Mains (Losen Slote/Carol PL)	$ 15,648,000	$ 3,912,000	$ 2,886,000	$ 22,450,000
Channel Improvements (Lower East Riser)	$ 4,832,000	$ 1,208,000	$ 891,000	$ 6,930,000
Local Drainage Improvements (Lower East Riser Ditch)	$ 1,416,000	$ 354,000	$ 261,000	$ 2,030,000
Pilings and Cradles for support of culverts, & pump station	$ 4,292,000	$ 1,073,000	$ 791,000	$ 6,160,000
Energy Dissipation structures	$ 290,121	$ 73,000	$ 53,000	$ 53,495
GREEN INFRASTRUCTURE FEATURES	**$ 14,017,000**	**$ 3,504,000**	**$ 2,585,000**	**$ 20,106,000**
Revegetation - Riparian Habitat	$ 160,000	$ 40,000	$ 29,000	$ 229,000
Avanti Park	$ 1,155,000	$ 289,000	$ 213,000	$ 1,657,000
Caesar Place	$ 1,594,000	$ 398,000	$ 294,000	$ 2,286,000
Depeyster Park	$ 2,063,000	$ 516,000	$ 380,000	$ 2,959,000
Fluvial Park	$ 3,170,000	$ 793,000	$ 585,000	$ 4,547,000
Little Ferry Muncipal	$ 684,000	$ 171,000	$ 126,000	$ 981,000
Little Ferry Schools	$ 561,000	$ 140,000	$ 104,000	$ 805,000
Riverside Ave Park	$ 1,563,000	$ 391,000	$ 288,000	$ 2,242,000
Robert Craig School	$ 248,000	$ 62,000	$ 46,000	$ 356,000
St. Joseph Park	$ 274,000	$ 68,000	$ 50,000	$ 393,000
Willow Lake	$ 1,708,000	$ 427,000	$ 315,000	$ 2,450,000
Green features for Street infrastructure	$ 838,000	$ 210,000	$ 155,000	$ 1,202,000
ALLOWANCES	**$ 5,010,000**		**$ 739,000**	**$ 5,749,000**
GENERAL REQUIREMENTS	**$ 6,127,000**	**$ 1,532,000**	**$ 1,130,000**	**$ 8,790,000**
TOTAL CONSTRUCTION COSTS	**$ 100,382,000**	**$ 23,843,000**	**$ 18,326,000**	**$ 142,551,000**
Real Estate			$ -	$ -
Engineering and Design	$ 12,046,000	$ 3,011,000	$ 1,072,000	$ 16,130,000
Construction Administration	$ 4,347,000	$ 1,087,000	$ 802,000	$ 6,235,000
TOTAL PROJECT COSTS	**$ 116,775,000**	**$ 27,941,000**	**$ 20,200,000**	**$ 164,916,000**

NOTES:

1	Estimate does NOT include Real Estate costs.
2	Includes 25% contingency on Construction Costs.
3	Escalation based on assumed midpoint of construction in 2021, at 3.5% per year compounded.
4	Estimate assumes all excess soils generated by construction will be classified as non-hazardous ID27 solid waste. These excess soils are assumed to be Transported/Disposed from the site at a cost of $85 per ton.
5	Estimate assumes that "hot spots" of HTRW encountered can be addressed either through the project contingency or by implementing measures to reduce the volume. If significant "hot spots" are encountered, design modifications would be made to minimize the need to remove HTRW material.
6	Allowances provide for utility relocations/protection and for construction of wetlands to mitigate unavoidable impacts to existing wetlands that will not be ofset by project features.
7	Estimate assumes deep foundation support will be needed for force mains, stormwater piping & box culverts.
8	GENERAL REQUIREMENTS - includes 6.5% of construction cost for contractor PM and Supervision (3%), Mob/Demob (1%), Traffic Maintenance (2 %), and Erosion-sedimentation controls (0.5%).

7.7 Alternative 2 Benefits

In accordance with the guidance provided in HUD Notice CPD-16-06, this section provides a description of the benefits and costs of Alternative 2. A 50-year period of analysis has been used with a discount rate of 7.0 percent for all economic calculations presented in this section.

The benefits evaluated and presented in this section are limited to the impacts of stormwater drainage improvements and were evaluated independently of the tidal storm surge benefits presented and evaluated in **Section 6.0**.

The benefits calculated for Alternative 2 are based on a comparison of future conditions with and without implementation of Alternative 2. **Section 7.6** discusses the costs of Alternative 2.

The benefits analysis assumes that certain conditions would exist in the future as described in **Section 4.0**. Changes in the future condition assumptions from those anticipated in the benefit calculations could result in higher or lower benefits than currently estimated.

The benefits of Alternative 2 are presented in this section in three components:

- Resiliency - flood inundation damage and associated impacts
- Economic revitalization, social, and environmental co-benefits; and
- Proposed Project investment impacts on regional employment.

7.7.1 Resiliency Benefits

The primary resiliency benefits of Alternative 2 derive from reducing direct damages from fluvial flooding to infrastructure, residential, apartment, commercial, industrial, municipal, and utility structures. Damages to motor vehicles associated with residential and apartment structures were also evaluated. Benefits derived from reductions in post-flood debris removal and disposal, public emergency services costs, public injury and loss of life, and disruption to critical/first responder facilities within the Project Area.

The analysis of flood damage benefits for Alternative 2 followed the same approach and methodology utilized for Alternative 1, as described in **Section 6.4.1**. The Alternative 2 benefit analysis used the same structure inventory that was developed for Alternative 1, but applied it only to the portions of the Project Area impacted by Alternative 2 (i.e. the drainage areas associated with East Riser Ditch, West Riser Ditch, and Losen Slote Creek). The inventory for these areas was input to a separate HEC-FDA model, in conjunction with the same depth-damage functions as described in **Section 6.4.1**, and fluvial hydrologic/hydraulic data developed specifically for the Alternative 2 analysis.

Table 7.7-1 presents the number of structures incurring damage under the “without project” condition and their total estimated depreciated structure replacement value for selected frequency fluvial flood events across the Project Area.

Table 7.7-1: Number and Values ($000) of Structures Impacted in the Project Area by Type for Selected Frequency Flood Events

Damage Category	10-Year		50-Year		100-Year		500-Year	
	#	Value	#	Value	#	Value	#	Value
Apartment	1	$1,400	1	$1,400	1	$1,400	2	$4,000
Commercial	24	$93,500	33	$162,800	37	$173,300	52	$209,500
Industrial	41	$258,300	62	$342,800	67	$375,100	82	$421,700
Municipal	4	$36,700	6	$54,400	6	$54,400	7	$63,800
Residential	115	$15,900	204	$31,000	241	$36,700	329	$49,400
Utility	3	N/A*	3	N/A*	3	N/A*	3	N/A*
Total	**188**	**$400,000**	**309**	**$600,000**	**355**	**$600,000**	**472**	**$700,000**

*Passaic River Basin damage functions for utility structures are based on square footage of the structure, not dollar values.

As for Alternative 1, benefits other than direct flood damage to structures and their contents were evaluated using HEC-FDA. Alternative 2 benefits associated with reductions to damage to motor vehicles, public emergency costs, debris removal and disposal, emergency facility disruption, and injuries/loss of life were all computed in HEC-FDA using the same approach and methodology described in **Section 6.4.1**. **Appendix E** includes more detailed descriptions of the approaches used to evaluate each category.

The damages and benefits resulting from the Alternative 2 damage computations conducted using HEC-FDA are presented by impacted streams. All values are based on a price level of August 2016, and the economic analyses are based on a 7 percent discount rate with a 50-year period of analysis. Future condition damages assumed 1.2 feet of SLR at Battery, NY. Storm surge simulations with and without SLR indicates a 1.2-foot increase in sea level, which results in an increase of storm surge elevations at the Project Area on the order of 0.8 foot. Similar analyses have been conducted to calculate damages and benefits for a higher rate of SLR, and the detailed results of these analyses will be included in future versions of this report.

Table 7.7-2 shows the expected average annual resiliency damages for the “without” and “with” Alternative 2 that is based on the expected sea level at the base year (2023), and also the annual resiliency benefits (the difference between the “without” and “with” annual damages) at the base year of 2023. **Table 7.7-3** shows the expected average annual resiliency damages for the “without” and “with” Alternative 2, and also the annual project resiliency benefits that assumes an intermediate low level of sea level change (1.4 feet) by the end of the Proposed Project’s period of analysis (2073). Due to sea level change the expected annual residual damages and the Proposed Project benefits are both significantly greater by year 50, as compared to year 1, which is the baseline condition.

Table 7.7-2: Alternative 2 – Expected Annual Average Resiliency Damages and Benefits, Baseline Condition

Evaluated Category	Without	With	Benefits
Residential Structures	$1,088,290	$829,490	$258,800
Apartment Structures	$20,560	$18,950	$1,610
Commercial Structures	$12,084,980	$9,880,120	$2,204,860
Industrial Structures	$61,033,210	$58,858,080	$2,175,130
Municipal Structures	$679,350	$514,800	$164,550
Utility Structures	$7,700	$7,600	$100
Motor Vehicles	$226,220	$111,310	$114,910
Emergency Facilities Disruption	$50	$10	$40
Injury and Loss of Life	$3,542,510	$1,328,350	$2,214,160
Emergency Services Costs	$2,620	$2,570	$50
Debris Removal and Disposal	$358,090	$352,620	$5,470
Totals	***$79,043,580***	***$71,903,900***	***$7,139,680***

Table 7.7-3: Alternative 2 - Expected Annual Average Resiliency Damages and Benefits, Future Condition

Evaluated Category	Without	With	Benefits
Residential Structures	$1,310,490	$995,720	$314,770
Apartment Structures	$32,160	$27,440	$4,720
Commercial Structures	$16,599,080	$12,730,450	$3,868,630
Industrial Structures	$75,133,650	$70,505,980	$4,627,670
Municipal Structures	$1,083,740	$862,880	$220,860
Utility Structures	$9,280	$9,260	$20
Motor Vehicles	$337,590	$145,160	$192,430
Emergency Facilities Disruption	$310	$190	$120
Injury and Loss of Life	$6,525,570	$1,978,540	$4,547,030
Emergency Services Costs	$3,090	$3,050	$40
Debris Removal and Disposal	$412,550	$404,280	$8,270
Totals	***$101,447,510***	***$87,662,950***	***$13,784,560***

7.7.2 Economic Revitalization, Social, and Environmental Co-Benefits

In addition to providing resiliency benefits as described in **Section 7.7.1**, Alternative 2 has the potential to generate additional economic revitalization, social, and environmental benefits. Economic revitalization benefits include property value benefits from proximity to new parks and the associated property tax benefits and energy savings. Social benefits considered include new recreational opportunities, aesthetic values, and avoided stormwater treatment costs. The alternative can generate environmental benefits, including air quality improvements, increased opportunities for pollination, and reduced nitrogen and phosphorus.

The analysis of economic revitalization, social, and environmental co-benefits for Alternative 2 utilized the same approach and methodology that was used in calculating the benefits of Alternative 1. These methodologies are discussed in **Section 6.4.1** and described in more detail in **Appendix E**.

As for Alternative 1, a custom model was developed to estimate the future benefits for Alternative 2. Benefits were estimated over a 50-year period beginning in 2023. The base year is 2017 and all values were discounted to the base year. The first year that the Proposed Project would be complete was assumed to be 2023 and benefits would begin accruing at the beginning of the year. All benefits are in constant 2017 dollars and were analyzed using a 7 percent interest rate.

Table 7.7-4 presents the average annual economic revitalization, social, and environmental co-benefits of Alternative 2. The equivalent annual benefit is $2,216,900 and the net present value is $30,594,700, using a 7 percent discount rate and 50-year period of analysis.

Table 7.7-4: Summary of Alternative 2 Economic Revitalization, Social, and Environmental Co-Benefits

Co-Benefit Category	Total Value	Present Value	Equivalent Annual Value
Economic Revitalization	**$37,581,400**	**$17,331,200**	**$1,255,800**
Property Value	$25,270,700	$16,838,900	$1,220,100
Energy Conservation	$2,010,700	$242,900	$17,600
Residual Value	$10,300,000	$249,300	$18,100
Social	**$65,147,400**	**$12,953,400**	**$938,600**
Recreation	$52,650,500	$10,496,600	$760,600
Avoided Stormwater Treatment	$10,468,200	$2,052,400	$148,700
Aesthetic Value	$1,676,500	$334,200	$24,200
Water retention/flood hazard risk reduction	$352,100	$70,200	$5,100
Environmental	**$1,720,400**	**$310,100**	**$22,500**
Air Quality	$1,397,300	$245,700	$17,800
Pollination	$299,800	$59,800	$4,300
Nutrient Pollution	$23,300	$4,600	$300
Totals	**$104,449,200**	**$30,594,700**	**$2,216,900**

Note: Values are rounded to the nearest hundred.

7.7.3 Proposed Project Investment Impacts on Regional Employment

Investment in Alternative 2 would positively affect the regional economy through construction and annual maintenance activities. This section estimates the anticipated economic impacts from construction and annual maintenance in terms of job-years and earnings in the region.

The economic impacts generated by the capital and maintenance expenditures depend on the resources and services purchased in the local economy. The analysis assumes that the same local counties listed

for Alternative 1 in **Table 6.4-11**, from which goods and services are likely to be purchased during construction and maintenance, would be applicable for Alternative 2. These counties collectively represent the regional study area for the economic impact analysis. Because the economic impacts focus on the local economy in which the Proposed Project expenditures would be spent, this study area is broader than the Project Area used in the rest of this Feasibility Study and the EIS.

The Bureau of Economic Analysis RIMS II 2015 multipliers were used to estimate jobs and earnings effects resulting from construction and operation of Alternative 2. The multipliers were constructed to reflect the structure of economies of the 16 counties listed in **Table 6.4-11**.

Capital investment for Alternative 2 would increase the employment, earnings, and output for the duration of the construction process. Note that these are one-time impacts that last for the duration of construction. The employment effects are expressed in job-years, which are defined as one full-time job for one person for one year. The difference between the total employment and direct employment is the indirect and induced employment, or jobs that are created or supported in other industries because of construction employee spending in the region. Construction of this alternative would result in 580 total direct job-years and 610 total indirect job-years.

Construction spending for this alternative would create 500 direct job-years in the construction industry. Indirect and induced job-years would total 500 in the construction industry. Total earnings for the 1000 total construction industry job-years would be $54.3 million.

The professional services spending for this alternative would result in 190 total job-years, 80 of which are direct and 110 of which are indirect. The total earnings for the 180 professional services job-years would be $11.4 million.

The average earnings per job for both the construction and professional services industries would be $55,200 per job-year resulting from spending for this alternative. This average earnings value was estimated by dividing the total earnings ($65.7 million) by the total employment (1190 job-years).

Implementation of this alternative would create jobs and earnings as a result of ongoing O&M expenditures. Under this alternative, O&M activities would involve inspections of the flood control structures, including replacement of moving parts, exercising the pumps, cleaning the ditches and channels, etc. The projected O&M expenditures for the various alternatives were provided by the development team. This analysis assumes that funding for O&M would be procured from local government funds. Although these expenses would originate from local sources, they represent spending that would not take place but for the implementation of this alternative. The Proposed Project would expand economic activity in the study area counties and thus generate recurring economic impacts.

The increased operating sector employment would result in positive economic impacts to the study area counties both through direct hiring to fill the O&M jobs and indirect benefits as these O&M workers spend their earnings, thus creating additional consumer demand and jobs to meet that demand. A further increase of new employment across a variety of industrial sectors and occupational categories would be expected as employers hire to meet this increase in local consumer demand. The latter hiring represents the alternative's indirect and induced impact.

The annual O&M spending would increase the employment in the region. These impacts are long-term annual impacts that would continue for the life of the infrastructure elements. This section describes the anticipated direct and total employment impacts from this alternative based on the RIMS II multiplier

analysis. Under this alternative, annual O&M activities would result in 22 total job-years, of which 13 are direct and nine are indirect and induced job-years.

The annual O&M of this alternative would increase employee earnings in the region. These impacts are long-term annual impacts that would continue for the life of the infrastructure elements. The current analysis indicates that this alternative would result in average earnings of $41,600 per job-year for those employed by all industries in the study area for jobs created as a result of annual O&M spending. This was estimated by dividing the total annual earnings ($0.90 million) by the total annual employment (22 job-years).

The regional employment impacts were not quantified in terms of annual average benefits, and hence they are not included in the summary below.

7.8 Benefit-Cost Ratio

Table 7.8-1 summarizes the results of the benefit analyses, combining the quantified benefits described in **Sections 7.7.1** and **7.7.2** with the costs of Alternative 2 as described in **Section 7.6** and **Appendix C**. The annual benefits presented in this table are equivalent annual benefits, assuming a future condition featuring 1.2 feet of SLR at Battery, NY, which results in an increase of storm surge elevations at the Project Area on the order of 0.8 foot. All economic computations used a 7 percent discount rate and 50-year period of analysis. As **Table 7.8-1** shows, the benefits of Alternative 2 are expected to exceed its costs by a factor of 1.14 to 1.

Table 7.8-1: Alternative 2 – Summary of Benefits and Costs

Alternative 2	Total Value	Present Value	Equivalent Annual Value
Resiliency	**$653,292,700**	**$115,904,700**	**$8,398,400**
East Riser Ditch Resilience	$537,431,000	$92,958,600	$6,735,800
West Riser Ditch Resilience	$32,941,500	$7,384,400	$535,100
Losen Slote Creek Resilience	$82,920,200	$15,561,700	$1,127,600
Economic	**$37,581,400**	**$17,331,200**	**$1,255,800**
Property Value	$25,270,700	$16,838,900	$1,220,100
Energy Conservation	$2,010,700	$242,900	$17,600
Residual Value	$10,300,000	$249,300	$18,100
Social	**$65,147,400**	**$12,953,400**	**$938,600**
Recreation	$52,650,500	$10,496,600	$760,600
Avoided Stormwater Treatment	$10,468,200	$2,052,400	$148,700
Aesthetic Value	$1,676,500	$334,200	$24,200
Water retention/flood hazard risk reduction	$352,100	$70,200	$5,100
Environmental	**$1,720,400**	**$310,100**	**$22,500**
Air Quality	$1,397,300	$245,700	$17,800
Pollination	$299,800	$59,800	$4,300
Nutrient Pollution	$23,300	$4,600	$300
TOTAL BENEFITS	**$757,742,000**	**$146,499,000**	**$10,615,000**

Alternative 2	Total Value	Present Value	Equivalent Annual Value
Capital Investment Costs (2)	$144,715,000	$113,148,000	$8,198,700
O&M	$75,950,000	$15,456,000	$1,119,900
TOTAL COSTS	**$220,665,000**	**$128,604,000**	**$9,318,600**
Benefit Cost Ratio		**1.14**	**1.14**

Note: Values are rounded to the nearest hundred.

7.9 Alternative 2 Plan Set

The Alternative 2 Plan Set as shown below is provided in Subappendix F4-2.

Letter G in sheet number stands for General; C for Grey Infrastructure Civil; CG for Green Infrastructure Civil; L for Landscape Architecture; and R for Real Estate.

Table 7.9-1: Index of Drawings for Alternative 2

Sheet No.	Title
G-00-001	Alternative 2 Cover Sheet
G-00-002	Alternative 2 Legend Sheet
G-00-003	Alternative 2 Project Paneling Layout
PLANS	
C-08-001	Alternative 2 Plan View Station 0+00 - 8+13
C-07-002	Alternative 2 Plan View Station 8+13 - 19+80
C-09-003	Alternative 2 Plan View Station 19+80 - 30+06
C-10-004	Alternative 2 Plan View Station 30+06 - 39+16
C-11-005	Alternative 2 Plan View Station 39+16 - 42+79
C-22-006	Alternative 2 Plan View Station 0+00c - 5+22c
C-19-007	Alternative 2 Plan View Station 16+69c -20+93c
C-18-008	Alternative 2 Plan View Station 20+68a - 28+49a
C-25-009	Alternative 2 Plan View Station 16+44a - 20+68a
C-24-010	Alternative 2 Plan View Station 9+11a - 16+44a
C-29-011	Alternative 2 Plan View Station 0+00a - 9+11a
C-20-012	Alternative 2 Plan View Station 12+19c - 16+83c
C-23-013	Alternative 2 Plan View Station 5+36c - 12+19c
CG-01-001	Alternative 2 Empire Blvd Area
CG-04-002	Alternative 2 Moonachie Road Area
CG-05-003	Alternative 2 Moonachie Ave Area
CG-06-004	Alternative 2 Moonachie Ave Area
CG-10-005	Alternative 2 Caesar Place Area
CG-11-006	Alternative 2 Caesar Place Area
CG-12-007	Alternative 2 Empire Blvd Area
CG-13-008	Alternative 2 Moonachie Ave Area
CG-14-009	Alternative 2 Moonachie Ave Area
CG-15-010	Alternative 2 Moonachie Road Area

Sheet No.	Title
CG-18-011	Alternative 2 Monroe Street Area
CG-19-012	Alternative 2 E Park Street Area
CG-20-013	Alternative 2 E Joseph Street Area
CG-21-014	Alternative 2 Moonachie Road Area
CG-22-015	Alternative 2 E Joseph Street Area
CG-23-016	Alternative 2 Moonachie Road Area
CG-26-017	Alternative 2 Mehrhof Road Area
CG-27-018	Alternative 2 Dietrich Street Area
CG-30-019	Alternative 2 Teresa Court Area
CG-31-020	Alternative 2 Redneck Ave Area
CG-33-021	Alternative 2 Liberty Street Area
CG-34-022	Alternative 2 Redneck Ave Area
CG-35-023	Alternative 2 Redneck Ave Area
CG-37-024	Alternative 2 Liberty Street Area
CG-38-025	Alternative 2 Riverside Ave Area
CG-39-026	Alternative 2 Pickens Street Area
CG-40-027	Alternative 2 Main Street Area
CG-41-028	Alternative 2 Main Street Area
CG-42-029	Alternative 2 Winant Ave Area
CG-43-030	Alternative 2 Bergen Turnpike Area
CG-44-031	Alternative 2 Bergen Turnpike Area
CG-46-032	Alternative 2 Moonachie Ave Area
CG-47-033	Alternative 2 Liberty Street Area
CG-48-034	Alternative 2 Main Street Area
L-10-001	Alternative 2 Caesar Place Park
L-11-002	Alternative 2 Caesar Place Park
L-12-003	Alternative 2 Empire Blvd
L-01-004	Alternative 2 Empire Blvd
L-04-005	Alternative 2 Moonachie Road Area
L-05-006	Alternative 2 Moonachie Ave
L-15-007	Alternative 2 Avanti Park
L-14-008	Alternative 2 Moonachie Ave
L-13-009	Alternative 2 Moonachie Ave
L-46-010	Alternative 2 Moonachie Ave
L-20-011	Alternative 2 E Joseph St Area
L-21-012	Alternative 2 St. Joseph Park
L-22-013	Alternative 2 St. Joseph Park
L-28-014	Alternative 2 DePeyster Creek
L-27-015	Alternative 2 DePeyster Creek
L-29-016	Alternative 2 Little Ferry Schools
L-30-017	Alternative 2 Robert Craig Elementary
L-31-018	Alternative 2 Redneck Ave

Sheet No.	Title
L-32-019	Alternative 2 Little Ferry Schools
L-33-020	Alternative 2 Little Ferry Schools
L-34-021	Alternative 2 Redneck Ave
L-35-022	Alternative 2 Redneck Ave
L-36-023	Alternative 2 Little Ferry Municipal
L-37-024	Alternative 2 Little Ferry Municipal
L-41-025	Alternative 2 Willow Lake
L-40-026	Alternative 2 Willow Lake
L-39-027	Alternative 2 Willow Lake
L-38-028	Alternative 2 Riverside / Willow Lake
L-43-029	Alternative 2 Bergen Turnpike Area
L-42-030	Alternative 2 Fluvial Park
L-44-031	Alternative 2 Bergen Turnpike
C-00-100	Alternative 2 Typical Sections
C-00-101	Alternative 2 Typical Sections
C-00-102	Alternative 2 Typical Sections
C-00-103	Alternative 2 Typical Sections
C-00-104	Alternative 2 Typical Sections
CG-00-100	Alternative 2 Typical Sections
CG-00-101	Alternative 2 Typical Sections
CG-00-102	Alternative 2 Typical Sections
CG-00-103	Alternative 2 Typical Sections
L-00-100	Alternative 2 Typical Details - Pavement & Walkways
L-00-101	Alternative 2 Typical Details - Planting
L-00-102	Alternative 2 Typical Details - Furnishings & Schedule
C-00-300	Alternative 2 Construction Phasing Plan
R-01-001	Alternative 2 Real Estate Plan
R-47-002	Alternative 2 Real Estate Plan
R-48-003	Alternative 2 Real Estate Plan
R-04-004	Alternative 2 Real Estate Plan
R-05-005	Alternative 2 Real Estate Plan
R-06-006	Alternative 2 Real Estate Plan
R-07-007	Alternative 2 Real Estate Plan
R-08-008	Alternative 2 Real Estate Plan
R-09-009	Alternative 2 Real Estate Plan
R-10-010	Alternative 2 Real Estate Plan
R-11-011	Alternative 2 Real Estate Plan
R-12-012	Alternative 2 Real Estate Plan
R-13-013	Alternative 2 Real Estate Plan
R-14-014	Alternative 2 Real Estate Plan
R-15-015	Alternative 2 Real Estate Plan
R-44-016	Alternative 2 Real Estate Plan

Sheet No.	Title
R-46-017	Alternative 2 Real Estate Plan
R-18-018	Alternative 2 Real Estate Plan
R-19-019	Alternative 2 Real Estate Plan
R-20-020	Alternative 2 Real Estate Plan
R-21-021	Alternative 2 Real Estate Plan
R-22-022	Alternative 2 Real Estate Plan
R-23-023	Alternative 2 Real Estate Plan
R-24-024	Alternative 2 Real Estate Plan
R-25-025	Alternative 2 Real Estate Plan
R-26-026	Alternative 2 Real Estate Plan
R-27-027	Alternative 2 Real Estate Plan
R-28-028	Alternative 2 Real Estate Plan
R-29-029	Alternative 2 Real Estate Plan
R-30-030	Alternative 2 Real Estate Plan
R-31-031	Alternative 2 Real Estate Plan
R-32-032	Alternative 2 Real Estate Plan
R-33-033	Alternative 2 Real Estate Plan
R-34-034	Alternative 2 Real Estate Plan
R-35-035	Alternative 2 Real Estate Plan
R-36-036	Alternative 2 Real Estate Plan
R-37-037	Alternative 2 Real Estate Plan
R-38-038	Alternative 2 Real Estate Plan
R-39-039	Alternative 2 Real Estate Plan
R-40-040	Alternative 2 Real Estate Plan
R-41-041	Alternative 2 Real Estate Plan
R-42-042	Alternative 2 Real Estate Plan
R-43-043	Alternative 2 Real Estate Plan

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8.0 Alternative 3 – Plan Development

8.1 Overview

This section describes the development, proposed cost, and benefits of Alternative 3.

Alternative 3, or the Hybrid Alternative, analyzes a synergistic blend of new infrastructure and local drainage improvements to reduce flood risk in the Project Area. Components of Alternatives 1 and 2 would be combined to provide an integrated, hybrid solution that employs a combination of storm surge protection features, drainage structures, pump stations, and/or floodgates, coupled with local drainage improvement projects, to achieve desired project goals within the boundaries of the Project Area.

8.2 Concept Development and Comparison

The goal of Alternative 3 development is to utilize the previously developed Alternative 1 and Alternative 2 features to result in a holistic solution for the Project Area that provides flood risk reduction and benefits the communities with new or improved public open spaces.

8.2.1 Initial Concepts

The RBDM project team developed five concepts for Alternative 3. This section describes each of these concepts: Concepts A through E.

Figure 8.2-1 presents a schematic of **Concept A**. This concept consists of the utilitarian Alternative 1 alignment and the final Alternative 2 concept. With a utilitarian alignment, only the public realm connection would be built to connect two of the riverfront parks and stabilize the Main Street pump station site. The rest of the storm surge protection would be constructed of sheet pile or concrete walls without public open spaces and recreation. This concept would initiate expandable fluvial protection along the East Riser Ditch and the upper Losen Slote Creek.

Figure 8.2-2 presents a schematic of **Concept B**. This concept consists of the final Alternative 1 alignment, the final Alternative 2 concept, and flow conveyance improvement to the entire East Riser Ditch. This concept would provide coastal storm surge protection and reduced fluvial flood risk to the Project Area. It would also initiate expandable fluvial protection surrounding the East Riser Ditch (Route 46 and I-80) and the upper Losen Slote Creek. The proposed improvement would cover the entire East Riser Ditch, resulting in fluvial benefits extending to the middle and upper reach of East Riser Ditch.

Figure 8.2-3 presents a schematic of **Concept C**. This concept consists of the final Alternative 1 alignment, the final Alternative 2 concept, flow conveyance improvement to the lower and upper reach of East Riser Ditch, and Main Street grey infrastructure. This concept would provide coastal storm surge protection and reduced fluvial flood risk to the Project Area. It would also initiate expandable fluvial protection surrounding the East Riser Ditch (Route 46 and I-80) and the upper Losen Slote Creek. The Main Street area's grey infrastructure would allow improvements to the drainage system in the area and connect to the surrounding street network.

Figure 8.2-4 presents a schematic of **Concept D**. This concept consists of the utilitarian Alternative 1 alignment constructed to elevation 7 feet (NAVD 88), the final Alternative 2 concept, and West Riser Ditch channel improvement from the West Riser tide gate to Vincent Street pump station. Future additions could include additional Alternative 1 public realm features and Alternative 2 pump stations at both East Riser Ditch and West Riser Ditch. This concept would provide coastal storm surge protection and reduced

fluvial flood risk to the Project Area. Only the public realm connection would be built to protect Main Street Pump Station and connect Riverside and Fluvial Park.

Figure 8.2-5 presents a schematic of **Concept E**. This concept consists of the Alternative 1 surge barrier (constructed to a 50-year flood event and operated as a tide gate to protect the Berry's Creek area), the final Alternative 2 concept, and a West Riser Ditch channel improvement from the West Riser tide gate to Vincent Street pump station. This concept would install backflow prevention at all Hackensack River outfalls instead of floodwalls along the Hackensack River. Future additions could include the Alternative 1 Hackensack River alignment, a Paterson Plank Road gate operating as flood control device, and Alternative 2 pump stations at both East Riser Ditch and West Riser Ditch.

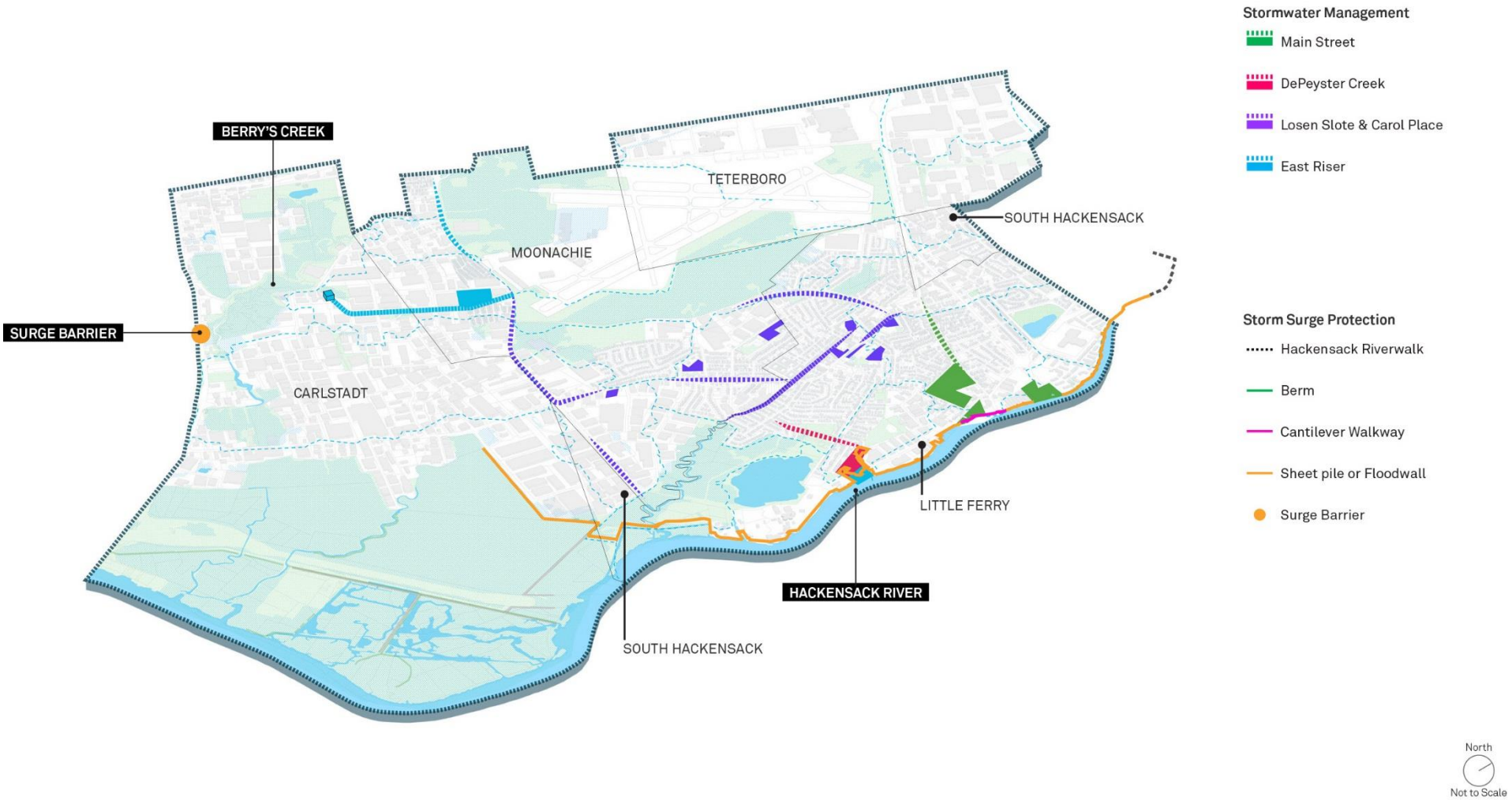


Figure 8.2-1: Alternative 3 – Concept A



Figure 8.2-2: Alternative 3 – Concept B

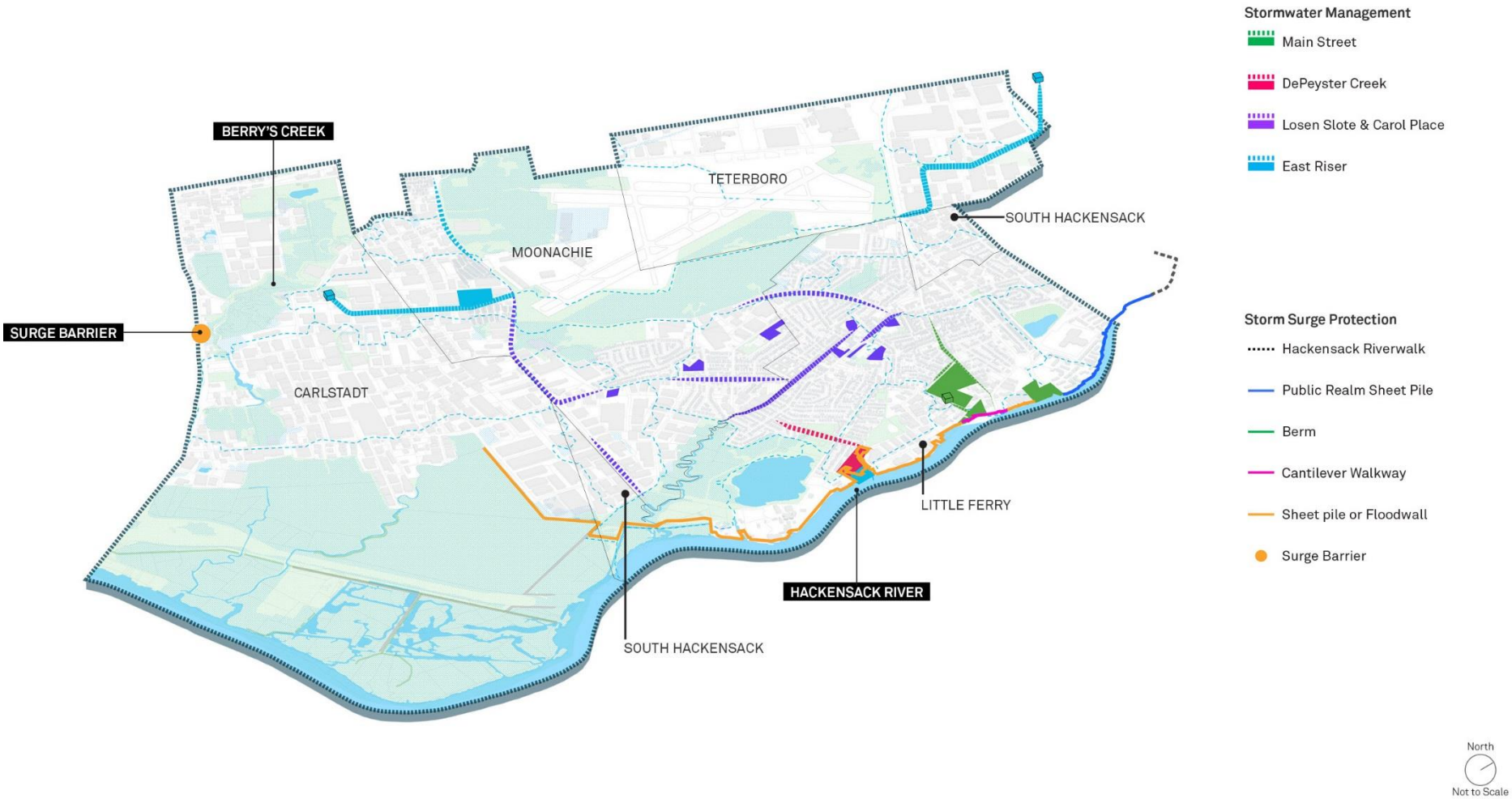


Figure 8.2-3: Alternative 3 – Concept C

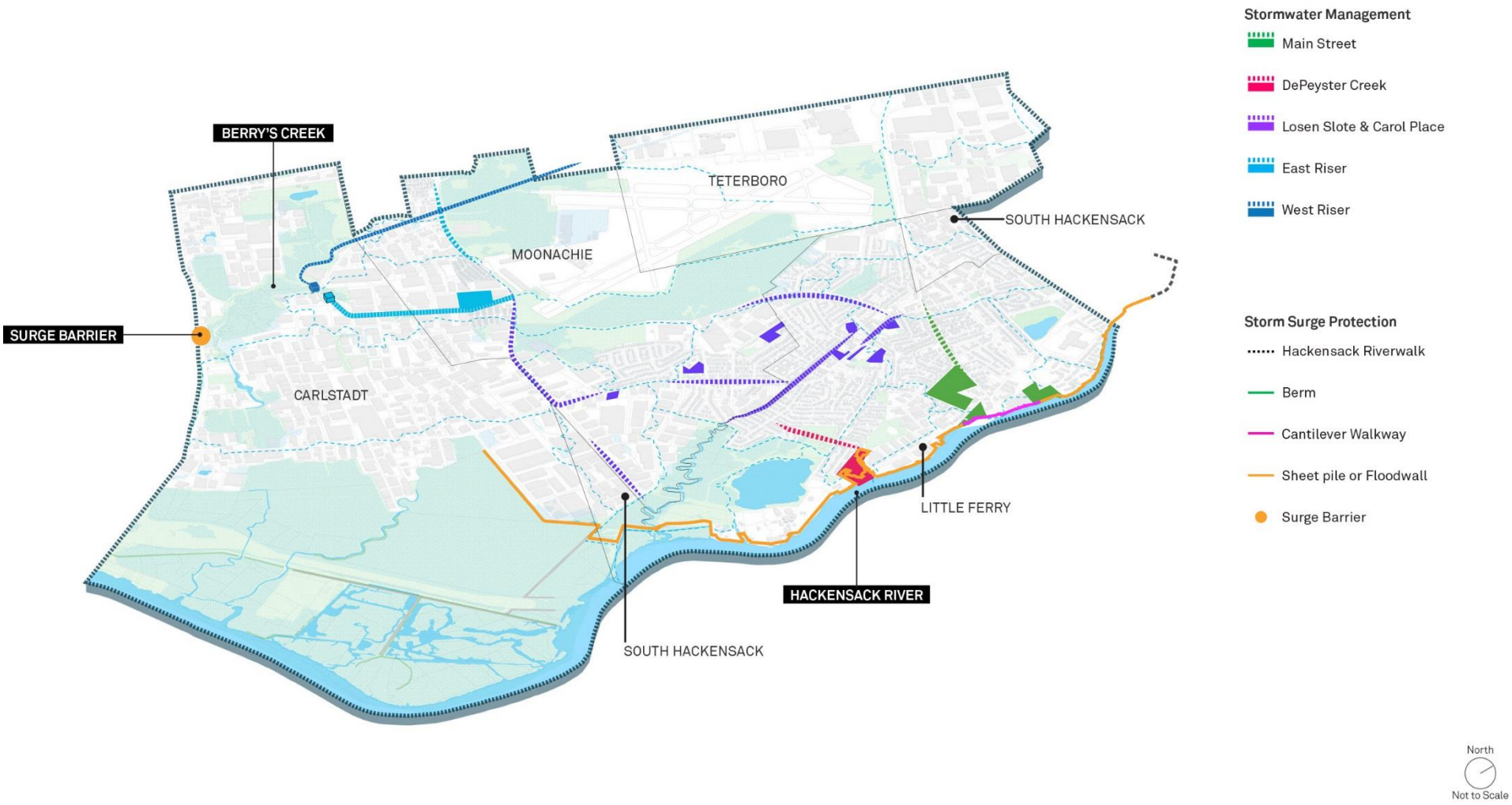


Figure 8.2-4: Alternative 3 – Concept D

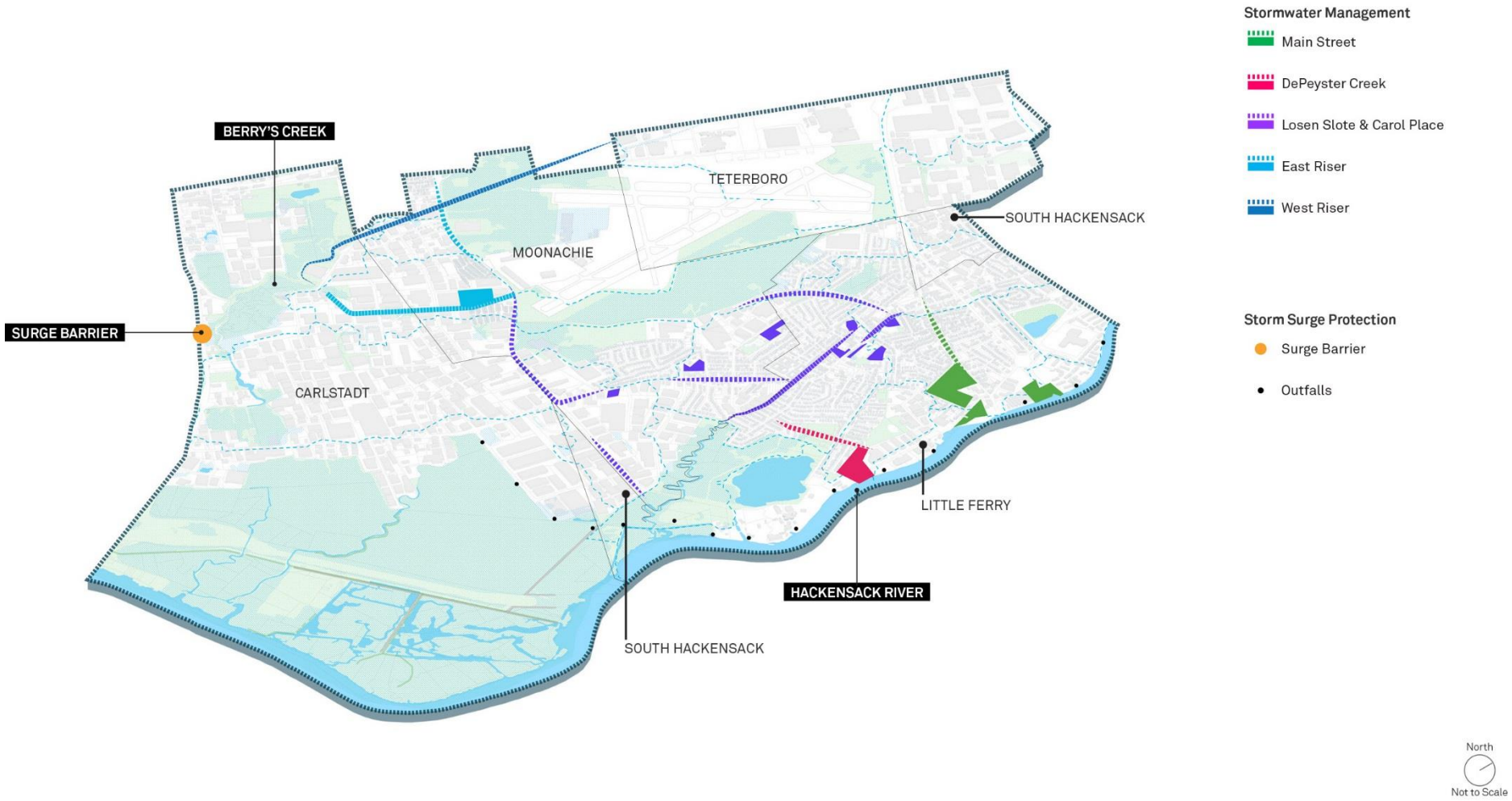


Figure 8.2-5: Alternative 3 – Concept E

8.2.2 Comparison of Concepts

This section compares the five Alternative 3 concepts based on the following criteria:

- Ability to provide storm surge protection;
- Ability to provide fluvial risk reduction;
- Coverage of protection to LMI residential areas; and
- Inclusion of public parks or open spaces and other public realm amenities.

Concepts A, B, C, and D would all provide coastal storm surge protection along the Hackensack River, but only Concept E provides backflow protection against seasonal high tides because of the absence of a full LOP along the Hackensack River. Therefore, under Concept E, there will only be limited reduction of coastal flooding compared to the No Action Alternative. The surge barrier on Berry's Creek at Paterson Plank Road was proposed to function as a tide gate under Concept E, which would simplify the improvement modifications to the upper stream tide gates along Berry's Creek. However, protection afforded by the Paterson Plank Road gate would be limited without the protection on the Hackensack River side.

All five concepts incorporate the final Alternative 2 concept. Therefore, they would all provide fluvial flood risk reduction to the Project Area through the installation of grey and green infrastructure features. In addition, all five concepts propose public open space, and thus they all provide improved access to public realm amenities and enhancement to the communities.

Concept A and Concept D both employ the utilitarian Alternative 1 alignment, which would include a public realm connection only to connect riverfront parks and to protect the Main Street Pump Station site. However, the alignment would not provide public open spaces and other public realm amenities, such as parks, benches, and planters, built into the LOP along the Hackensack River. Though the utilitarian Alternative 1 would reduce the Proposed Project cost, it would also eliminate almost all public realm features, recreation, and community revitalization benefits. Concept D includes West Riser Ditch modifications in addition to Concept A. Channel improvements on East Riser Ditch and West Riser Ditch would improve flow conveyance for both concepts. However, reliance on single pump station at Paterson Plank Road would not meet the confidence threshold for claiming riser ditches improvements. From a Proposed Project Purpose and Need perspective, Concepts A and D do not fully meet the Proposed Project objectives.

In addition to the final Alternative 1 and Alternative 2 plans, Concept C includes Main Street grey infrastructure to improve stormwater drainage for the Project Area during heavy or frequent precipitation. However, this concept would need to address a significant amount of utility conflicts and traffic impacts along Main Street. In addition, Concept C would only benefit a relatively small area associated with Main Street. It would not include the channel improvements to West Riser Ditch and the middle reach of East Riser Ditch, which would reduce the flood protection extension to the LMI residential areas along the East and West Riser Ditches.

In addition to the final Alternative 1 and Alternative 2 plans, which would provide coastal storm surge protection and reduced fluvial flood risk, as well as public open spaces, Concept B includes the channel improvement to the full East Riser Ditch. This would extend the fluvial protection benefits to the LMI residential areas along the East Riser Ditch. Therefore, Concept B is the preferred Alternative 3 plan for further feasibility analyses.

8.3 Alternative Description

Alternative 3 consists of all the features in Alternative 1 and Alternative 2, as well as flow conveyance improvement to the entire East Riser Ditch. Alternative 3 would provide coastal storm surge protection and reduce fluvial flood risk in the Project Area. **Section 6.0** provides the details of Alternative 1, and **Section 7.0** provides the details of Alternative 2.

Figure 8.3-1 shows the components of Alternative 3. Given the funding and construction constraints, the Alternative 3 features would be separated into two stages: a *Build Plan*, which includes some of the features to be constructed as part of Alternative 3, and a *Future Plan*, which includes the remaining features that could be constructed over time by others as funding and construction feasibility permit.

The Alternative 3 *Build Plan* would consist of all of the Alternative 2 components identified and described in **Section 7.0**, with the exceptions of Fluvial Park, DePeyster Creek Park, Losen Slote Creek pump station C, and Losen Slote Creek force main C. These four features would not be constructed under the *Build Plan*. Additionally, the improvements proposed for Willow Lake Park under Alternative 2 would be altered under the Alternative 3 *Build Plan*, as described below. **Section 10.0** provides detailed descriptions of the Alternative 3 *Build Plan*.

Willow Lake Park: The proposed improvements include pedestrian circulation, recreation, play, and ecological benefits. Existing pedestrian trails would be expanded to connect the northern and southern areas of the park, and programed activity areas, including two lawns of approximately 2.7 acres, would be added to support informal active play and recreation, such as picnicking, Frisbee, or lawn games. Approximately 1.6 acres of plazas and circulation trails, with a centralized plaza near Willow Lake, would frame the park and draw people in from Main Street, Pickens Street, and Washington Avenue. A new play area would be added to expand the existing playground with approximately 0.4 acre of permeable play surface and play equipment for the community. Approximately 1.3 acres of native plantings and low meadows with scattered trees would provide habitat for pollinators and birds, while approximately 1.0 acre of woodland areas would frame the park and provide habitat. Approximately 1,134 SF of rain gardens would filter stormwater from Pickens Street.

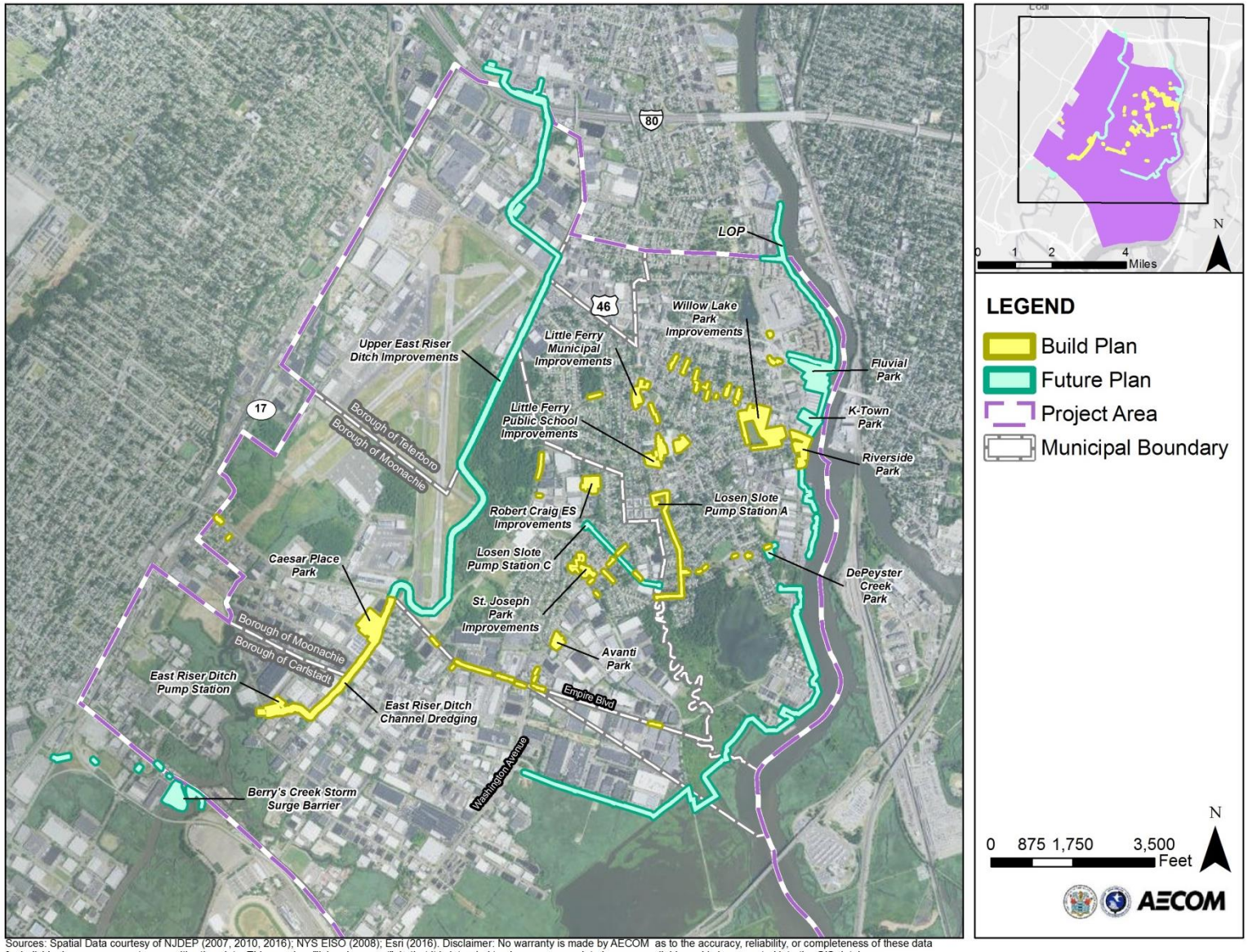
Under the Alternative 3 *Build Plan*, the total area of new parks would be approximately 7.6 acres, which is 12.4 acres fewer than would be created under Alternative 2 because of the elimination of Fluvial Park and DePeyster Creek Park. Riverside Park, Caesar Place Park, and Avanti Park, which would be constructed as described under Alternative 2, would still be designed to improve local stormwater drainage and would include wetlands, green infrastructure, and increased pervious surfaces and native plantings.

The Alternative 3 *Future Plan* would consist of all of the features from Alternative 1 described in **Section 6.0**, including Fluvial Park, DePeyster Creek Park, and K-Town Park. The addition of these three parks would provide approximately 5.7 additional acres of new park space, bringing the total new park acreage under Alternative 3 to approximately 13.3 acres. Losen Slote Creek pump station C and Losen Slote Creek force main C, as described under Alternative 2, would also be included. In addition to these features from Alternatives 1 and 2, the *Future Plan* would include channel improvements (i.e., channel improvements and culvert replacement) to the remainder of East Riser Ditch (i.e., Upper East Riser Ditch) from Moonachie Avenue to Wesley Street.

Table 8.3-1 summarizes the components included in both the *Build Plan* and the *Future Plan* under Alternative 3.

Table 8.3-1: Summary of Build Plan and Future Plan under Alternative 3

Build Plan	**Additional Components Under *Future Plan***
All green infrastructure systems, Riverside Park, Caesar Place Park, Avanti Park, Little Ferry Municipal improvements, Little Ferry Public Schools improvements, Robert Craig Elementary School improvements, and Joseph Street Park improvements, *as described under Alternative 2*	Complete Alternative 1 design, including Fluvial Park, DePeyster Creek Park, and K-Town Park, *as described under Alternative 1*
Willow Lake Park improvements, *as described in Alternative 3*	Losen Slote Creek pump station C and force main C, *as described under Alternative 2*
East Riser Ditch channel improvements and pump station, Losen Slote Creek pump station A, and Losen Slote Creek force main A, *as described in Alternative 2*	Upper East Riser Ditch improvements, *as described under Alternative 3*



Sources: Spatial Data courtesy of NJDEP (2007, 2010, 2016); NYS EISO (2008); Esri (2016). Disclaimer: No warranty is made by AECOM as to the accuracy, reliability, or completeness of these data for individual use or aggregate use with other data. This map is a "living document", in that it is intended to change as new data become available and is incorporated into the GIS database.

Figure 8.3-1: Alternative 3 Components

8.4 Alternative 3 Cost

As shown in **Table 8.4-1**, the total construction cost of Alternative 3 would be approximately $309,403,000. This includes an average contingency of 25 percent for the construction features and assumes a cost escalation of each feature to the construction midpoint (assumed as 2021) at a rate of 3.5 percent per year. The majority of unit costs used in the estimate are from 2017 RS Means data and include appropriate area adjustment to Bergen County, NJ.

The cost of the storm surge protection features (levees and floodwalls, closure gates, interior drainage elements, and the Berry's Creek surge barrier and pump station) would be approximately $100,995,000 (33 percent of the construction cost). The cost of the grey infrastructure features (pump stations, force mains, and channel and drainage improvements) would be approximately $139,182,000 (45 percent of the construction cost). The cost of the green infrastructure features (bioswales, rain gardens, storage trenches/tree trenches, permeable pavement, wetland improvements, parks/open spaces, and other associated structures and easements) would be approximately $33,472,000 (11 percent of the construction cost). Allowances for utility relocations, and for the cost to mitigate unavoidable wetland impacts, would be approximately $16,616,000 (5 percent of the construction cost). General construction requirements, such as mobilization and demobilization, traffic maintenance, erosion control, contractor supervision, and project management, would be approximately $19,138,000 (6 percent of the construction cost).

With an allowance of 12.0 percent for detailed engineering, design, and permitting, and 4.3 percent for construction administration, the total estimated Alternative 3 cost, including contingency and escalation, is $358,105,000, not including real estate.

In addition, the Feasibility Study and EIS costs are approximately $20.5 million and program administration costs are approximately $15 million. Together, the estimated overall cost of Alternative 3 is $393,605,000.

If Alternative 3 is completed, annual O&M costs associated with the new pump stations and the other grey and green construction features would be incurred. The annual O&M costs would be approximately $2,400,000. A detailed breakdown of costs for both the initial construction and the O&M is provided in **Appendix D**.

Table 8.4-1: Construction Cost Summary with Contingency and Escalation for Alternative 3

Project Summary	COST (2017 PL)	CONTINGENCY	ESCALATION @3.5%/Yr	COST w/ CONTINGENCY & ESCALATION
STORM SURGE PROTECTION	**70,409,000**	**17,602,000**	**$ 12,984,000**	**$ 100,995,000**
Leevees and Floodwalls	$ 42,880,000	$ 10,720,000	$ 7,907,000	$ 61,507,000
Closure and Tide Gates	$ 2,789,000	$ 697,000	$ 514,000	$ 4,001,000
Interior Drainage Elements	$ 6,490,000	$ 1,622,000	$ 1,197,000	$ 9,309,000
Berry's Creek Surge Barrier and Pump Station	$ 18,250,000	$ 4,563,000	$ 3,365,000	$ 26,178,000
GREY INFRASTRUCTURE FEATURES	**$ 97,031,000**	**$ 24,258,000**	**$ 17,893,000**	**$ 139,182,000**
East Riser Ditch (ERD), Losen Slote and Carol Place (LS)	$ -			
New Pump Stations	$ 48,750,000	$ 12,188,000	$ 8,990,000	$ 69,927,000
Force Mains (Losen Slote/Carol PL)	$ 15,648,000	$ 3,912,000	$ 2,886,000	$ 22,446,000
Channel Improvements (Lower East Riser)	$ 4,832,000	$ 1,208,000	$ 891,000	$ 6,931,000
Channel Improvements (Middle and Upper East Riser)	$ 9,834,000	$ 2,458,000	$ 1,813,000	$ 14,106,000
Local Drainage Improvements (Lower East Riser Ditch)	$ 1,416,000	$ 354,000	$ 261,000	$ 2,031,000
Local Drainage Improvements (Middle and Upper East Riser)	$ 11,969,000		$ -	$ -
Pilings and Cradles for support of culverts, & pump station	$ 4,292,000	$ 1,073,000	$ 791,000	$ 6,156,000
Energy Dissipation structures	$ 290,000	$ 73,000	$ 53,000	$ 416,000
GREEN INFRASTRUCTURE FEATURES	**$ 23,335,000**	**$ 5,834,000**	**$ 4,303,000**	**$ 33,472,000**
Revegetation - Riparian Habitat	160000	$ 40,000	$ 30,000	$ 230,000
Southeast Viewing Platform	$ 132,000	$ 33,000	$ 24,000	$ 189,000
Avanti Park	$ 1,155,000	$ 289,000	$ 213,000	$ 1,657,000
Caesar Place	$ 1,594,000	$ 399,000	$ 294,000	$ 2,286,000
Depeyster Park	$ 1,806,000	$ 452,000	$ 333,000	$ 2,591,000
Fluvial Park	$ 11,186,000	$ 2,797,000	$ 2,063,000	$ 16,045,000
K-Town	$ 886,000	$ 222,000	$ 163,000	$ 1,271,000
Little Ferry Muncipal	$ 684,000	$ 171,000	$ 126,000	$ 981,000
Little Ferry Schools	$ 561,000	$ 140,000	$ 103,000	$ 805,000
Riverside Ave Park	$ 938,000	$ 235,000	$ 173,000	$ 1,345,000
Robert Craig School	$ 248,000	$ 62,000	$ 46,000	$ 356,000
St. Joseph Park	$ 274,000	$ 69,000	$ 51,000	$ 393,000
Willow Lake	$ 2,873,000	$ 718,000	$ 530,000	$ 4,121,000
Green features for Street infrastructure	$ 838,000	$ 210,000	$ 155,000	$ 1,200,000
ALLOWANCES	**$ 14,480,000**		**$ 2,136,000**	**$ 16,616,000**
GENERAL REQUIREMENTS	**$ 13,342,000**	**$ 3,336,000**	**$ 2,460,000**	**$ 19,138,000**
TOTAL CONSTRUCTION COSTS	**$ 218,597,000**	**$ 51,029,000**	**$ 39,776,000**	**$ 309,403,000**
Real Estate		$ -		$ -
Engineering and Design	$ 26,232,000	$ 6,558,000	$ 2,335,000	$ 35,125,000
Construction Administration	$ 9,465,000	$ 2,366,000	$ 1,745,000	$ 13,577,000
	$ -			
TOTAL PROJECT COSTS	**$ 254,294,000**	**$ 59,954,000**	**$ 43,856,000**	**$ 358,105,000**

NOTES:

1. Estimate does NOT include Real Estate costs.
2. Estimate includes 25% contingency for construction features.
3. Escalation based on assumed midpoint of construction in 2021, at 3.5% per year compounded.
4. Estimate assumes all excess soils generated by construction will be classified as non-hazardous ID27 solid waste that would be transported/disposed from the site at a cost of $85 per ton. The weight of the excavated material was conseratively estimated to be 2 tons per cubic yard.
5. Estimate assumes that "hot spots" of HTRW encountered can be addressed either through the project contingency or by implementing measures to reduce the volume. If significant "hot spots" are encountered, there would be modifications to the design to minimize the need to remove HTRW material.
6. Allowances provide for utility relocations/protection and for construction of wetlands to mitigate unavoidable impacts to existing wetlands that will not be offset by project features.
7. Estimate assumes deep foundation support will be needed for force mains, stormwater piping & box culverts.
8. GENERAL REQUIREMENTS - includes 6.5% of construction cost for contractor PM and Supervision (3%), Mob/Demob (1%), Traffic Maintenance (2 %), and Erosion-sedimentation controls (0.5%).

8.5 Alternative 3 Benefits

In accordance with the guidance provided in HUD Notice CPD-16-06, this section provides a description of the benefits and costs of Alternative 3. All economic calculations in this section use a 50-year period of analysis with a discount rate of 7 percent.

The benefits evaluated and presented in this section are limited to the impacts of tidal storm surge and the potential for storm surges to reduce the discharge from existing and proposed drainage infrastructure. The benefits calculated for Alternative 3 are based on a comparison of future conditions with and without implementation of Alternative 3. **Section 8.4** discusses the costs of Alternative 3.

The benefit analysis assumed that certain conditions would exist in the future, as described in **Section 4.0**. Changes in the future condition assumptions from those anticipated in the BCA calculations could result in higher or lower benefits than currently estimated.

The benefits of Alternative 3 are presented in this section in three components:

- Resiliency - flood inundation damage and associated impacts;
- Economic revitalization, social, and environmental co-benefits; and
- Proposed Project investment impacts on regional employment.

8.5.1 Resiliency Benefits

The primary resiliency benefits of Alternative 3 derive from reducing direct damages from flooding to infrastructure, residential, apartment, commercial, industrial, municipal, and utility structures. The reduction in damages to motor vehicles associated with residential and apartment structures were also evaluated. In addition, the analysis considered benefits derived from reductions in post-flood debris removal and disposal, public emergency services costs, public injury and loss of life, and disruption to emergency/first responder facilities within the Project Area and the affected area of the City of Hackensack.

The analysis of flood damage benefits for Alternative 3 followed the same approach and methodology utilized for Alternative 1 and described in **Section 6.4.1**. The estimated number of structures incurring damage and their total estimated depreciated structure replacement value are shown for selected frequency storm surge and fluvial and flood events across the Project Area in **Table 6.4-1** and **Table 7.7-1,** respectively.

As with Alternatives 1 and 2, Alternative 3 benefits associated with reductions to direct flood damage to structures and their contents, damage to motor vehicles, public emergency costs, debris removal and disposal, emergency facility disruption, and injuries/loss of life were all computed in HEC-FDA using the same approach and methodology described in **Section 6.4.1**. **Appendix E** describes in more detail the approaches used to evaluate each category.

The damages and benefits resulting from the Alternative 3 damage computations conducted using HEC-FDA are presented by impacted streams. All values are based on an August 2016 price level, and the economic analyses are based on a 7 percent discount rate with a 50-year period of analysis. Future condition damages assumed 1.2 feet of SLR at Battery, NY. Storm surge simulations with and without SLR indicate that a 1.2-foot increase in sea level, which results in an increase of storm surge elevations at the Project Area on the order of 0.8 foot.

Table 8.5-1 shows the expected average annual resiliency damages for the "without" and "with" Alternative 3 that is based on the expected sea level at the base year (2023), and also the annual resiliency benefits (the difference between the "without" and "with" annual damages) at the base year of 2023. **Table 8.5-2** shows the expected average annual resiliency damages for the "without" and "with" Alternative 3, and also the annual project resiliency benefits that assumes an intermediate low level of sea level change (1.2 feet) by the end of the Proposed Project's period of analysis (2073). Due to sea level change, the expected annual residual damages and the Proposed Project benefits are both significantly greater by year 50, as compared to year 1, which is the baseline condition. As described earlier, the fluvial component of Alternative 3 is similar to Alternative 2, but with additional features providing resiliency benefits along East Riser Ditch. Refer to **Table 6.4-8** for the annual damages and benefits associated with the Alternative 1 (storm surge) component.

Table 8.5-1: Alternative 3 – Expected Annual Average Resiliency Damages and Benefits, Baseline Condition

Evaluated Category	Without	With	Benefits
Residential Structures	$1,088,290	$828,360	$259,930
Apartment Structures	$20,560	$18,950	$1,610
Commercial Structures	$12,084,980	$6,735,990	$5,348,990
Industrial Structures	$61,033,210	$58,347,550	$2,685,660
Municipal Structures	$679,350	$396,960	$282,390
Utility Structures	$7,700	$7,600	$100
Motor Vehicles	$226,220	$112,830	$113,390
Emergency Facilities Disruption	$50	$10	$40
Injury and Loss of Life	$3,542,510	$1,361,510	$2,181,000
Emergency Services Costs	$2,620	$2,570	$50
Debris Removal and Disposal	$358,090	$352,170	$5,920
Totals	***$79,043,580***	***$68,164,500***	***$10,879,080***

Table 8.5-2: Alternative 3 - Expected Annual Average Resiliency Damages and Benefits, Future Condition

Evaluated Category	Without	With	Benefits
Residential Structures	$1,310,490	$995,670	$314,820
Apartment Structures	$32,160	$27,440	$4,720
Commercial Structures	$16,599,080	$12,385,800	$4,213,280
Industrial Structures	$75,133,650	$70,477,900	$4,655,750
Municipal Structures	$1,083,740	$853,060	$230,680
Utility Structures	$9,280	$9,260	$20
Motor Vehicles	$337,559	$145,230	$192,329
Emergency Facilities Disruption	$310	$190	$120
Injury and Loss of Life	$6,525,570	$1,978,310	$4,547,260
Emergency Services Costs	$3,090	$3,050	$40
Debris Removal and Disposal	$412,550	$404,270	$8,280
Totals	***$101,447,479***	***$87,280,180***	***$14,167,299***

8.5.2 Economic Revitalization, Social, and Environmental Co-Benefits

In addition to providing resiliency benefits as described in **Section 8.5.1**, Alternative 3 has the potential to generate additional economic revitalization, social, and environmental benefits. Economic revitalization benefits include property value benefits from proximity to new parks and the associated property tax benefits and energy savings. Social benefits include new recreational opportunities, aesthetic values, and avoided stormwater treatment costs. Environmental benefits include air quality improvements, increased opportunities for pollination, and reduced nitrogen and phosphorus.

The analysis of economic revitalization, social, and environmental co-benefits for Alternative 3 used the same approach and methodology used in calculating the benefits of Alternatives 1 and 2. These methodologies are discussed in **Section 6.1** and described in more detail in **Appendix E**.

As with Alternatives 1 and 2, a custom model was developed to estimate the benefits for Alternative 3. Benefits were estimated over a 50-year period beginning in 2023. The base year is 2017 and all values were discounted to the base year. The first year that the Proposed Project would be complete was assumed to be 2023 and benefits would begin accruing at the beginning of that year. All benefits are in constant 2017 dollars and were analyzed using a 7 percent interest rate.

Table 8.5-3 presents the average annual economic revitalization, social, and environmental co-benefits of Alternative 3. The equivalent annual benefit is $3,515,000 and the net present value is $48,509,200 using a 7 percent discount rate and 50-year period of analysis. **Appendix E** describes in detail the approaches used to evaluate each co-benefit category.

Table 8.5-3: Alternative 3: Summary of Economic Revitalization, Social, and Environmental Co-Benefits

Co-Benefit Category	Total Value	Present Value	Equivalent Annual Value
Economic Revitalization	**$58,530,300**	**$31,239,000**	**$2,263,600**
Net Property Value Premium	$46,125,600	$30,735,500	$2,227,100
Energy Conservation	$2,104,700	$254,300	$18,400
Residual Value	$10,300,000	$249,300	$18,100
Social	**$85,269,000**	**$16,963,300**	**$1,229,200**
Recreation	$73,425,100	$14,638,200	$1,060,700
Avoided Stormwater Treatment	$9,924,300	$1,942,300	$140,700
Aesthetic Value	$1,588,200	$316,600	$22,900
Water retention/flood hazard risk reduction	$331,400	$66,100	$4,800
Environmental	**$1,710,700**	**$306,900**	**$22,200**
Air Quality	$1,402,000	$245,300	$17,800
Pollination	$284,000	$56,600	$4,100
Nutrient Pollution	$24,700	$4,900	$400
Totals	**$145,510,000**	**$48,509,200**	**$3,515,000**

8.5.3 Proposed Project Investment Impacts on Regional Employment

Investment in Alternative 3, through construction and annual maintenance activities, would positively affect the regional economy. This section estimates the anticipated economic impacts from construction and annual maintenance in terms of job-years and earnings in the region.

The economic impacts generated by the capital and maintenance expenditures depend on the resources and services purchased in the local economy. The analysis assumed that the same local counties listed for Alternative 1 in **Table 6.4-11**, from which goods and services are likely to be purchased during construction and maintenance, would be applicable for Alternative 3. These counties collectively represent the regional study area for the economic impact analysis. Because the economic impacts focus on the local economy where the project expenditures would be spent, this study area is broader than the Project Area used in the rest of this Feasibility Study and the EIS.

The Bureau of Economic Analysis RIMS II 2015 multipliers were used to estimate jobs and earnings effects resulting from construction and operation of Alternative 3. The multipliers were constructed to reflect the structure of economies of the 16 counties listed in **Table 6.4-11**.

Capital investment for Alternative 3 would increase the employment, earnings, and output for the duration of the construction process. Note that these are one-time impacts that last for the duration of construction. The employment effects are expressed in job-years; a job-year is defined as one full-time job for one person for one year. The difference between the total employment and direct employment is the indirect and induced employment, or jobs that are created or supported in other industries because of

construction employee spending in the region. Construction of this alternative would result in 1,250 total direct job-years and 1,300 total indirect job-years.

Construction spending for this alternative would create 1,070 direct job-years in the construction industry. Indirect and induced job-years would total 1,080 in the construction industry. Total earnings for the 2,150 total construction industry job-years would be $116.9 million.

The professional services spending for this alternative would result in 400 total job-years, 180 of which are direct and 220 of which are indirect. The total earnings for the 180 professional services job-years would be $24.3 million.

The average earnings per job for both the construction and professional services industries would be $55,400 per job-year resulting from spending for this alternative. This average earnings value was estimated by dividing the total earnings ($141.2 million) by the total employment (2,550 job-years).

Implementation of this alternative would create jobs and earnings as a result of ongoing O&M expenditures. Under this alternative, O&M activities would involve inspections of the flood control structures, including replacement of moving parts, exercising the pumps, and cleaning the ditches and channels. The development team provided the projected O&M expenditures for the various alternatives. This analysis assumes that funding for O&M would be procured from local government funds. Although these expenses would originate from local sources, they represent spending that would not take place but for the implementation of this alternative. The Proposed Project would expand economic activity in the study area counties and, thus, generate recurring economic impacts.

The increased operating sector employment would result in positive economic impacts to the study area counties both through direct hiring to fill the O&M jobs and indirect benefits as these O&M workers spend their earnings, creating additional consumer demand and jobs to meet that demand. A further increase of new employment across a variety of industrial sectors and occupational categories would be expected as employers hire to meet this increase in local consumer demand. The latter hiring represents the alternative's indirect and induced impact.

The annual O&M spending would increase employment in the region. These impacts are long-term annual impacts that would continue for the life of the infrastructure project elements. This section describes the anticipated direct and total employment impacts from this alternative based on the RIMS II multiplier analysis. Under this alternative, annual O&M activities would result in 35 total job-years, of which 21 are direct and 14 are indirect and induced job-years.

The annual O&M of this alternative would increase employee earnings in the region. These impacts are long-term annual impacts that would continue for the life of the infrastructure project elements. The current analysis indicates that this alternative would result in average earnings of $41,600 per job-year for those employed by all industries in the study area for jobs created as a result of annual O&M spending. This was estimated by dividing the total annual earnings ($1.5 million) by the total annual employment (35 job-years).

The regional employment impacts were not quantified in terms of annual average benefits, and hence they are not included in the summary below.

8.6 Benefit-Cost Ratio

Table 8.6-1 summarizes the results of the benefit analyses, combining the quantified benefits described in **Sections 8.5.1** and **8.5.2** with the costs of Alternative 3 as described in **Section 8.4** and **Appendix C**. The annual benefits presented in this table are equivalent annual benefits, assuming a future condition featuring 1.2 feet of SLR at Battery, NY, which results in an increase of storm surge elevations at the Project Area on the order of 0.8 foot. All economic computations used a 7 percent discount rate and 50-year period of analysis. As **Table 8.6-1** shows, the benefits of Alternative 3 are expected to exceed its costs by a factor of 3.33 to 1.

Table 8.6-1: Alternative 3 – Summary of Benefits and Costs

Alternative 3	Total Value	Present Value	Equivalent Annual Value
Resiliency	**$5,370,340,200**	**$850,960,900**	**$61,660,500**
East Riser Ditch Resilience	$590,896,400	$114,857,600	$8,322,600
West Riser Ditch Resilience	$32,941,500	$7,384,400	$535,100
Losen Slote Creek Resilience	$82,920,200	$15,561,700	$1,127,600
Berry's Creek Resilience	$2,908,658,400	$418,181,100	$30,301,300
Hackensack River Resilience	$1,754,923,800	$294,976,200	$21,373,900
Economic	**$58,530,300**	**$31,239,000**	**$2,263,600**
Property Value	$46,125,600	$30,735,500	$2,227,100
Energy Conservation	$2,104,700	$254,300	$18,400
Residual Value	$10,300,000	$249,300	$18,100
Social	**$85,269,000**	**$16,963,300**	**$1,229,200**
Recreation	$73,425,100	$14,638,200	$1,060,700
Avoided Stormwater Treatment	$9,924,300	$1,942,300	$140,700
Aesthetic Value	$1,588,200	$316,600	$22,900
Water retention/flood hazard risk reduction	$331,400	$66,100	$4,800
Environmental	**$1,710,700**	**$306,900**	**$22,900**
Air Quality	$1,402,000	$245,300	$17,800
Pollination	$284,000	$56,600	$4,100
Nutrient Pollution	$24,700	$4,900	$400
TOTAL BENEFITS	**$5,515,850,200**	**$899,470,100**	**$65,175,500**
Capital Investment Costs (2)	$314,247,000	$245,698,700	$17,803,300
O&M	$120,950,000	$24,311,800	$1,761,600
TOTAL COSTS	**$435,197,000**	**$270,010,500**	**$19,564,900**
Benefit-Cost Ratio		**3.33**	**3.33**

Note 1: Values are rounded to the nearest hundred.

Note 2: For the purposes of this analysis, the combined resiliency benefits for Alternative 3 are assumed to be a simple addition of the resiliency benefits of Alternatives 1 and 2. While it is possible that this approach will entail some double counting of benefits, the effect of this is not considered significant. A simple sensitivity test conducted by removing all the Alternative 2 resiliency benefits from this analysis still returns a BCR for Alternative 3 of 2.82.

8.7 Alternative 3 Plan Set

The Alternative 3 Future Plan Set as shown below is provided in Subappendix F4-3 with additional references and locations to other subappendices as listed. The Alternative 3 Build Plan Set is provided in Subappendix F4-4.

Letter G in sheet number stands for General; C for Grey Infrastructure Civil; CG for Green Infrastructure Civil; L for Landscape Architecture; and R for Real Estate.

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9.0 Comparison of Alternatives – Selection of Build Plan

The previous three sections identify three alternative plans for achieving the Proposed Project's purpose of reducing flood hazard risk and related public health risks with available funding. This section compares the three alternatives, provides the basis for the selection of the Preferred Alternative, and recommends a Build Plan to be implemented with the current RBD funding.

9.1 Evaluation Criteria

The Proposed Project is needed to address: (1) systemic inland flooding from high-intensity rainfall/runoff events; and/or (2) coastal flooding from storm surges, as the interplay between the two forces contributes to the reoccurring flooding conditions throughout the Project Area. A related project goal is to increase the resiliency of the communities and ecosystems in the Project Area, thereby protecting infrastructure, facilities, residences, businesses, and ecological resources from the more frequent and intense flood events anticipated to occur in the future. Each of the three alternatives was evaluated against the Proposed Project's objectives identified in **Section 1.2**.

9.2 Comparison of Alternatives

This section compares the alternatives with regard to meeting the Proposed Project's objectives and the potential environmental impacts.

9.2.1 Project Objective Achievement and Associated Costs

Table 9.2-1 evaluates each of the three alternatives with regard to achieving the Proposed Project's objectives.

Table 9.2-1: Comparison of How Alternatives Achieve Proposed Project Objectives

Project Objectives, Costs & BCR Ratio	Alternative 1	Alternative 2	Alternative 3
Contribute to Community Resiliency	Provides flood protection from flooding from storm surge, but not from fluvial/rain events.	Provides flood protection from fluvial/rain events but not from storm surges.	Provides flood protection from both fluvial/rain events, and storm surge flooding.
Reduce Risks to Public Health	Provides risk reduction to public health by reducing the frequency of storm surge flooding events.	Provides risk reduction to public health by reducing the frequency of flooding from fluvial/rain events.	Provides greatest risk reduction to public health since it reduces the frequency of both storm surge and fluvial/rain events.
Deliver Co-Benefits	Provides about $2.4 million in annual benefits through economic revitalization, and enhanced social, recreational, aesthetic and environmental values.	Provides about $2.2 million in annual benefits through economic revitalization, and enhanced social, recreational, aesthetic and environmental values.	Provides about $3.5 million in annual benefits through economic revitalization, and enhanced social, recreational, aesthetic and environmental values.
Enhance and Improve Use of Public Space	Provides about 14.2 acres of new and improved parks and recreation space.	Provides about 30.8 acres of new and improved parks and recreation space.	Provides about 32.2 acres of new and improved parks and recreation space.
Consider Impacts from Sea Level Change	Provides resiliency benefits from coastal storm surges that will increase over time due to SLR, although overall level of protection will decrease.	Provides increased drainage reliability in response to SLR.	Provides both increased resiliency from coastal storm surges and increased drainage reliability in response to SLR.
Protect Ecological Resources	Provides about 2.5 acres of new and/or enhanced habitat.	Provides about 15.7 acres of new and/or enhanced habitat.	Provides about 15.7 acres of new and/or enhanced habitat.
Improve Water Quality	Provides about 1 acre of green infrastructure (tree trenches, bioswales, rain gardens) that will reduce storm water runoff and enhance water quality.	Provides about 4 acre of green infrastructure (tree trenches, bioswales, rain gardens) that will reduce storm water runoff and enhance water quality.	Provides about 4 acre of green infrastructure (tree trenches, bioswales, rain gardens) that will reduce storm water runoff and enhance water quality.
Project Cost	Total Cost: $162,134,000 Annual O&M: $1,350,000	Total Cost: $164,916,000 Annual O&M: $1,500,000	Total Cost: $358,105,000 Annual O&M: $2,400,000
Benefit to Cost Ratio	5.99	1.14	3.33

9.2.2 Comparison of Potential Impacts

All three Build Alternatives considered would meet the Proposed Project's Purpose and Need, but they have different environmental consequences. The EIS analyzes in detail the potential environmental consequences of each Build Alternative.

Table 9.2-2 is a summary and comparison of the alternatives' impacts by each technical resource area. The major conclusions of the EIS are summarized below.

Each of the Build Alternatives would have beneficial impacts on all technical resource areas except for *Noise and Vibration* and *Air Quality and Greenhouse Gas Emissions*. Additionally, with the exception of *Sustainability/Green Infrastructure* and *Agricultural Resources and Prime Farmlands*, all technical resource areas would experience ***less-than-significant, adverse*** impacts from construction and/or operation of either Alternative 1, Alternative 2, or Alternative 3 (*Build Plan*). The No Action Alternative would be expected to have ***less-than-significant, adverse*** impacts on *Noise and Vibration* and *Air Quality and Greenhouse Gas Emissions*.

Implementation of the Proposed Project would result in ***potentially significant and unavoidable adverse*** impacts to multiple technical resource areas. Technical resource areas that could experience potentially significant adverse impacts are listed by Build Alternative below:

Alternative 1

- Land Use and Land Use Planning
- Cultural and Historical Resources
- Noise and Vibration
- Biological Resources
- Water Resources, Water Quality, and WOUS
- Hydrology and Flooding
- Hazards and Hazardous Materials

Alternative 2 and Alternative 3 (*Build Plan*)

- Cultural and Historical Resources
- Noise and Vibration
- Biological Resources
- Water Resources, Water Quality, and WOUS
- Hazards and Hazardous Materials

Additionally, it should be noted that the No Action Alternative would result in ***potentially significant adverse*** impacts to all technical resource areas except for *Noise and Vibration* and *Air Quality and Greenhouse Gas Emissions* due to the anticipated continuation of coastal flooding during severe coastal storm events, inland flooding during heavy rainfall events, and increased exposure to the effects of climate change and sea level change. Climate change would also have ***potentially significant adverse*** impacts on the ability of the Proposed Project to provide flood reduction to the Project Area.

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Table 9.2-2: Summary and Comparison of Potential Impacts of Alternatives

Resource Area	No Action Alternative	Alternative 1: Structural Flood Reduction	Alternative 2: Stormwater Drainage Improvement	Alternative 3: Hybrid
Land Use and Land Use Planning	*Direct:* No direct impacts. *Indirect:* ***Potentially significant adverse*** impacts from future flooding to existing land use (conflicts or restrictions on land use patterns or options) and zoning (zoning changes that could substantially decrease development intensity).	*Direct:* Long-term, ***potentially significant adverse*** impacts due to the displacement of 1 business; Short-term, less-than-significant adverse impacts to existing land uses during construction from temporary easements on 8.3 acres (63 parcels); Long-term, less-than-significant adverse impacts to existing land uses from permanent land easements (26.6 acres over 63 parcels, including 6 full parcel acquisitions) and potential zoning changes (12.2 acres); Long-term, beneficial impacts due to the improved utility of land use types. *Indirect:* Long-term, beneficial impacts to existing land uses from increased coastal flood protection.	*Direct:* Short-term, less-than-significant adverse impacts to existing land uses during construction from temporary easements on 5.6 acres (36 parcels); Long-term, less-than-significant adverse impacts to existing land uses from permanent land easements (45.2 acres over 61 parcels, including 3 full parcel acquisitions) and potential zoning changes (20.4 acres); Long-term, beneficial impacts due to the improved utility of land use types. *Indirect:* Long-term, beneficial impacts to existing land uses from increased inland flood protection. Additionally, short-term, less-than-significant adverse impacts to adjacent land uses (275 parcels) during construction in public rights-of-way; Long-term, less-than-significant adverse impacts on land use compatibility with Teterboro Airport and on aviation safety from increased wildlife hazards.	*Direct:* Same as Alternative 2, except there would be fewer temporary easement impacts (5.6 acres on 34 parcels), fewer permanent easement impacts (31.8 acres over 55 parcels, including 2 full parcel acquisitions), and fewer zoning changes (8.0 acres). *Indirect:* Beneficial impacts would be the same as Alternative 2, but adverse impacts would be slightly less than Alternative 2 due to fewer impacted adjacent land uses (242 parcels) and a decrease in proposed habitat improvements (i.e., fewer wildlife hazards).
Visual Quality / Aesthetics	*Direct:* No direct impacts. *Indirect:* ***Potentially significant adverse*** impacts from degradation of, or loss of access to, a high-value visual resource due to future flooding.	*Direct:* Short-term, less-than-significant adverse impacts to the natural harmony, cultural order, and visual quality within Landscape Unit 4a (Commercial/Industrial Area) and Landscape Unit 5 (Hackensack River Waterfront Area) during construction; Long-term, less-than-significant adverse impacts to the natural harmony, cultural order, and visual quality of Landscape Unit 4a from proposed LOP elements; Long-term, beneficial impacts to the natural harmony, cultural order, and visual quality within Landscape Unit 5 from proposed waterfront improvements. *Indirect:* Long-term, beneficial impacts to the visual sensitivity of the viewing population to visual resources within Landscape Unit 4a and Landscape Unit 5, and to visual resources within all landscape units due to increased flood protection against coastal storm surges.	*Direct:* Short-term, less-than-significant adverse impacts to the natural harmony, cultural order, and visual quality within Landscape Unit 2 (Residential Area), Landscape Unit 4a, and Landscape Unit 5 during construction; Long-term, beneficial impacts to the natural harmony, cultural order, and visual quality within Landscape Unit 2, Landscape Unit 4a, and Landscape Unit 5 from proposed waterfront improvements. *Indirect:* Long-term, beneficial impacts to the visual sensitivity of the viewing population to visual resources within Landscape Unit 2, Landscape Unit 4a, and Landscape Unit 5, and to visual resources within all landscape units due to increased flood protection against inland flooding.	*Direct:* Impacts would be the same as Alternative 2 in Landscape Unit 4a, but adverse and beneficial impacts in Landscape Unit 2 and Landscape Unit 5 would be slightly less because Fluvial Park, DePeyster Creek Park, and Losen Slote pump station C and its force main would not be constructed. *Indirect:* Alternative 3 would not include Fluvial Park and DePeyster Park within Landscape Unit 5 and Losen Slote pump station C and its force main in Landscape Unit 2; therefore, the beneficial impacts to visual sensitivity and increased flood protection would be slightly less than Alternative 2.
Socioeconomics, Community / Populations, and Housing	*Direct:* No direct impacts. *Indirect:* ***Potentially significant adverse*** impacts from future flooding to public safety; business finances, employment, access, and services; demographic composition; and/or journey-to-work times.	*Direct:* Short-term and long-term, less-than-significant adverse impacts to businesses and residents in the Project Area from land acquisition, traffic/limited access, dust, noise, and vibration during construction; Long-term, less-than-significant adverse impacts to vacant buildings that would be demolished during construction; Short-term and-long term, beneficial impacts from created jobs during construction (990 job-years) and operation (20 annual jobs); Long-term, beneficial impacts on social amenities due to increased access to greenspace and the Hackensack River waterfront. *Indirect:* Long-term, beneficial effects to sense of safety, community infrastructure, property values, employment, and resident/visitor perceptions from increased coastal storm surge protection.	*Direct:* Short-term and long-term, less-than-significant adverse impacts to businesses, schools, municipal facilities, and residents in the Project Area from land acquisition, traffic/limited access, dust, noise, and vibration during construction; Short-term and long-term, beneficial impacts from created jobs during construction (1,000 job-years) and operation (22 annual jobs); Long-term beneficial effects on social amenities due to increased access to greenspace and the Hackensack River waterfront. *Indirect:* Long-term beneficial effects to community infrastructure, property values, and resident/visitor perception from increased protection against inland flooding.	*Direct:* Same as Alternative 2, except there would be approximately 640 job-years created during construction and 16 annual jobs during operation. *Indirect:* Slightly less beneficial effects than Alternative 2 since there would be fewer stormwater drainage improvements constructed, thereby providing less protection against inland flooding.

Resource Area	No Action Alternative	Alternative 1: Structural Flood Reduction	Alternative 2: Stormwater Drainage Improvement	Alternative 3: Hybrid
Environmental Justice	*Direct:* No direct impacts. *Indirect:* ***Potentially significant adverse*** impacts from future flooding to housing, public/community safety, long-term employment, short-term and/or long-term access to community facilities, and/or demographic composition.	*Direct:* Short-term, less-than-significant adverse impacts to EJ populations from dust, noise, vibration, traffic/access restrictions during construction (there are 13 residential units within 100 feet of the proposed LOP; all 13 units occur in areas where the percentage of EJ populations exceeds County thresholds); Short-term, beneficial impacts from created jobs during construction and operation. *Indirect:* Long-term, beneficial effects to EJ community infrastructure, sense of safety, housing and property values, and long-term employment from increased coastal flood protection.	*Direct:* Same as Alternative 1, except there are 385 residential units within 100 feet of the proposed footprint, and some of these units occur in areas where the percentage of EJ populations exceeds County thresholds: 219 units are in areas where the percentage of persons in poverty is higher; 287 units are in areas where the percentage of minority persons is higher, and 383 units are in areas where the percentage of LMI persons is higher. *Indirect:* Long-term, beneficial effects from reduced damages to EJ community infrastructure from reduced inland flooding.	*Direct:* Same as Alternatives 1 and 2, except there are 339 residential units within 100 feet of the proposed features in areas where the percentage of EJ populations exceeds County thresholds: 204 units are in areas where the percentage of persons in poverty is higher; 264 units are in areas where the percentage of minority persons is higher, and 337 units are in areas where the percentage of LMI persons is higher. *Indirect:* Slightly less beneficial effects than Alternative 2 since there would be fewer stormwater drainage improvements constructed, thereby providing less protection against inland flooding.
Cultural and Historical Resources	*Direct:* No direct impacts. *Indirect:* ***Potentially significant adverse*** impacts from future flooding to the character-defining features, viewshed, acoustic environment, or other environmental component of historic resources.	*Direct:* Long-term, ***potentially significant adverse*** impacts to known or unanticipated archaeological sites (5 high archaeological sensitivity areas), and to the US Route 46 Bascule Bridge; Short-term, less-than-significant adverse effects to the US Route 46 Bascule Bridge from dust, noise, and vibration during construction. *Indirect:* Long-term, ***potentially significant adverse*** impacts to the viewshed of the US Route 46 Bascule Bridge; Short-term, less-than-significant adverse effects to the physical and acoustic environment of the US Route 46 Bascule Bridge and 4 potentially NRHP-eligible historic architectural resources within the indirect APE during construction; Long-term, less-than-significant adverse effects to the viewshed of 4 potentially NRHP-eligible historic architectural resources in the Project Area; Long-term beneficial effects to the protection of archaeological and historic architectural resources from increased coastal flood protection.	*Direct:* Same as Alternative 1, including the long-term, ***potentially significant adverse*** impacts, except there are only 3 high archaeological sensitivity areas associated with Alternative 2. *Indirect:* Same as Alternative 1, including the long-term, ***potentially significant adverse*** impacts, except there is only 1 potentially NRHP-eligible historic architectural resource (besides the US Route 46 Bascule Bridge) that would experience short-term, less-than-significant adverse effects to the physical and acoustic environment during construction and long-term, less-than-significant adverse effects to the viewshed. Additionally, beneficial effects would be associated with reduced inland flooding instead of reduced coastal flooding.	*Direct:* Slightly less long-term, ***potentially significant adverse*** impacts than Alternative 2 since there are only 2 high archaeological sensitivity areas associated with Alternative 3, and the US Route 46 Bascule Bridge would not be impacted. *Indirect:* Slightly less adverse impacts than Alternative 2 since there would be no indirect impacts to the US Route 46 Bascule Bridge (and therefore no potentially significant indirect impacts), and slightly less beneficial effects since there would be fewer stormwater drainage improvements constructed.
Transportation and Circulation	*Direct:* No direct impacts. *Indirect:* ***Potentially significant adverse*** impacts from future flooding to traffic, safety, available parking, pedestrian and bicycle facilities, transit demand, and/or freight operations.	*Direct:* Short-term, less-than-significant adverse impacts to traffic and circulation (87 additional vehicles projected in the AM peak hour in the peak month), on-street parking supply, and transit and freight services during construction; Long-term, less-than-significant adverse impacts to traffic (6 additional vehicle trips are projected in the weekday AM and PM peak hours) and the NJ Transit railroad track (suspended service during major flood events) during operation; Long-term, beneficial effects to pedestrian transportation and circulation from proposed paths, walkways, and boat dock/kayak launch. *Indirect:* Long-term, beneficial effects to the sustainability of existing transportation and circulation from increased coastal flood protection.	*Direct:* Generally the same as Alternative 1, except only 59 additional vehicles are projected in the AM peak hour in the peak month during construction, and only 5 additional vehicle trips are projected in the weekday AM and PM peak hours during operations. Additionally, there would be short-term, less-than-significant adverse impacts to the Seaman Lead due to the removal and replacement of a railroad bridge, and to pedestrian circulation due to sidewalk closures, during construction; however, there would be no impacts to the NJ Transit railroad track under this alternative. *Indirect:* Same as Alternative 1, except beneficial effects would be associated with inland flooding instead of coastal flooding.	*Direct:* Slightly less than Alternative 2, as only 54 additional vehicles are projected in the AM peak hour in the peak month during construction, and only 3 additional vehicle trips are projected in the weekday AM and PM peak hours during operation; impacts to road/lane closures and parking during construction would be slightly less than Alternative 2 since fewer stormwater drainage improvements would be constructed, but impacts to transit and freight services and pedestrian circulation would be the same as Alternative 2. *Indirect:* Slightly less than Alternative 2 since fewer stormwater drainage improvements would be constructed, thereby providing less protection against inland flooding.

Resource Area	No Action Alternative	Alternative 1: Structural Flood Reduction	Alternative 2: Stormwater Drainage Improvement	Alternative 3: Hybrid
Noise and Vibration	*Direct:* No direct impacts. *Indirect:* Less-than-significant adverse impacts due to increased vibration and noise levels from traffic congestion and the diversion of vehicles in flooded areas.	*Direct:* Short-term, ***potentially significant adverse*** impacts to properties and buildings from noise and vibration due to construction activities; Short-term, less-than-significant adverse impacts to marine life from noise during construction, Long-term, less-than-significant adverse impacts to properties due to increased noise during operation from generators at one pump station. *Indirect:* No indirect impacts.	*Direct:* Impacts would be similar to, but slightly greater than, those under Alternative 1, including the short-term, ***potentially significant adverse*** impacts, since more properties and buildings have the potential to be impacted by noise and vibration during construction, and there would be generators at three pump stations during operations. *Indirect:* No indirect impacts (same as Alternative 1).	*Direct:* Impacts from noise and vibration during construction, including the short-term, ***potentially significant adverse*** impacts, would be slightly less than under Alternative 2, but greater than under Alternative 1, and there would be generators at two pump stations during operations. *Indirect:* No indirect impacts (same as Alternatives 1 and 2).
Air Quality and Greenhouse Gas Emissions	*Direct:* No direct impacts. *Indirect:* Less-than-significant adverse impacts on regional air quality due to traffic congestion and diversion of vehicles in flooded areas, fugitive dust from flooding carrying fine sediments into the Project Area, and to human health of sensitive populations due to negligible emissions of criteria pollutants and HAPs within an attainment area.	*Direct:* Short-term and long-term, less-than-significant adverse impacts to air quality and human health of sensitive populations in the Project Area due to criteria pollutant and HAP emissions; criteria pollutant emissions would not cause a NAAQS exceedance, change the category of non-attainment status, or conflict with applicable air quality plans; HAP emissions would not would not exceed major source thresholds or health benchmarks, or conflict with applicable air quality plans. *Indirect:* Short-term, less-than-significant adverse impacts outside the Project Area due to criteria pollutant and HAP emissions; criteria pollutant emissions would not cause a NAAQS exceedance, change the category of non-attainment status, or conflict with applicable air quality plans; HAP emissions would not would not exceed major source thresholds or health benchmarks, or conflict with applicable air quality plans.	*Direct:* Impacts would be similar to Alternative 1, except criteria pollutant and GHG emissions would be slightly less, and HAP emissions would be slightly greater. *Indirect:* Impacts would be similar to Alternative 1, except criteria pollutant and GHG emissions would be slightly less, and HAP emissions would be slightly greater.	*Direct:* Impacts would be similar to Alternatives 1 and 2, except criteria pollutant, HAP, and GHG emissions would be slightly less than both Alternatives 1 and 2. *Indirect:* Impacts would be similar to Alternatives 1 and 2, except criteria pollutant, HAP, and GHG emissions would be slightly less than both Alternatives 1 and 2.
Global Climate Change and Sea Level Change	***Potentially significant adverse*** impacts on the study area from future coastal and inland flooding, and because the effects of climate change and SLR would not be addressed.	***Potentially significant adverse*** impacts from climate change and SLR to the overall performance of Alternative 1 over time, and from future increased precipitation and inland flooding; Beneficial impacts through increased coastal flood protection.	***Potentially significant adverse*** impacts from future coastal flooding in the Project Area over time, and from climate change and SLR on the overall performance of Alternative 2 over time; Beneficial impacts to the Project Area through increased flood protection against inland flooding.	Same as Alternative 2, including the ***potentially significant adverse*** impacts, except benefits would be slightly less since Losen Slote pump station C and its force main would not be constructed, thereby providing less protection against inland flooding.
Recreation	*Direct:* No direct impacts. *Indirect:* ***Potentially significant adverse*** impacts from damage, reduced visitation, and/or reduced accessibility to recreational resources due to future flooding.	*Direct*: Short-term, less-than-significant adverse impacts to the accessibility of recreational resources (i.e., public access to Riverside Boat Works and boat access at the Riverside Boat Works Marina and Little Ferry Marina) during construction; Long-term, beneficial effects due to the creation of new recreational resources (10.1 acres of new public recreational land) and improved accessibility (approximately 9,270 LF of new public paths and walkways, 0.2 acre of parking areas, and a new boat dock/kayak launch). *Indirect:* Long-term, beneficial effects to supply, capacity, and access to recreational resources from increased coastal flood protection.	*Direct:* Short-term, less-than-significant adverse impacts to the accessibility of recreational resources during construction due to lane closures and the establishment of staging areas in the parking lots and driveways of Little Ferry Public Schools, Robert Craig Elementary School, Joseph Street Park, and Willow Lake Park; Beneficial effects would be greater than under Alternative 1 since more land (20.0 acres) would be converted to accessible, public recreational land and there would be more accessibility improvements (9,900 LF of new trails and walkways, the conversion of existing private boat docks and a boat launch into public use, and a new kayak launch). *Indirect:* Same as Alternative 1, except beneficial effects would be associated with inland flooding instead of coastal flooding.	*Direct:* Adverse impacts to accessibility would be the same as Alternative 2; Beneficial effects would be less than both Alternatives 1 and 2 since less land would be converted to accessible, public recreational land (7.6 acres) and there would be less accessibility improvements (6,400 LF of new trails and walkways and the conversion of existing private boat docks and a boat launch into public use). *Indirect:* Slightly less than Alternative 2 since fewer stormwater drainage improvements would be constructed, thereby providing less protection against inland flooding.

Resource Area	No Action Alternative	Alternative 1: Structural Flood Reduction	Alternative 2: Stormwater Drainage Improvement	Alternative 3: Hybrid
Utilities and Service Systems	*Direct:* No direct impacts. *Indirect:* ***Potentially significant adverse*** impacts on utility services by damaging infrastructure, increasing utility prices, and/or increasing service disruptions due to future flooding.	*Direct:* Short-term, less-than-significant adverse impacts to the supply, demand, capacity, and availability of utility services during construction; Long-term, less-than-significant adverse impacts to existing demand for electricity (from public lighting features and the Berry's Creek storm surge barrier), solid waste (from public parks and pathways), and telecommunication services (from a landline telephone at the Berry's Creek storm surge barrier). *Indirect:* Long-term, beneficial effects from increased coastal flood protection, which would reduce damages to utilities infrastructure and service disruptions, and decrease utility prices.	*Direct:* Same as Alternative 1, except electricity demands would be from public lighting features and the three proposed pump stations, and there would be no long-term demand for telecommunication services. Additionally, there would be long-term, beneficial impacts on stormwater drainage due to the proposed East Riser Ditch improvements and three new pump stations. *Indirect:* Same as Alternative 1, except beneficial effects would be associated with inland flooding instead of coastal flooding.	*Direct:* Slightly less than Alternative 2 since fewer Proposed Project components would be constructed, thereby reducing potential construction impacts, operational utility demands, and beneficial impacts to stormwater drainage. *Indirect:* Slightly less than Alternative 2 since fewer stormwater drainage improvements would be constructed, thereby providing less protection against inland flooding.
Public Services	*Direct:* No direct impacts. *Indirect:* ***Potentially significant adverse*** impacts on public services by increasing service disruptions, response times, and/or demand, and from reducing access, supply, capacity, and/or reliability due to future flooding.	*Direct*: Short-term, less-than-significant adverse impacts to response times of public services due to road and/or lane closures during construction. *Indirect:* Short-term, less-than-significant adverse impacts to demand for public services during construction due to an influx of construction workers; Long-term, beneficial impacts to public service demand (fewer flood-related emergencies) and service reliability (fewer service interruptions and road closures) due to increased flood protection against coastal storm surges.	*Direct:* Impacts to response times would be slightly less than Alternative 1 because no road closures or realignments are proposed and lane closures under Alternative 2 are anticipated to be shorter in duration; however, Alternative 2 would have additional short-term, less-than-significant adverse impacts to access to public service facilities due to temporary lane closures and staging areas, and to disruption of public service facilities from increased noise during construction. *Indirect:* Generally the same as Alternative 1, but beneficial effects would be associated with inland flooding instead of coastal flooding.	*Direct:* Slightly less than Alternative 2 since fewer Proposed Project components would be constructed, and therefore fewer impacts on response times, facility access, and disruptions from noise would be expected. *Indirect:* Adverse impacts would be slightly less than Alternative 2 due to fewer anticipated construction workers; beneficial effects would be slightly less since fewer stormwater drainage improvements would be constructed, thereby providing less protection against inland flooding.

Resource Area	No Action Alternative	Alternative 1: Structural Flood Reduction	Alternative 2: Stormwater Drainage Improvement	Alternative 3: Hybrid
Biological Resources	*Direct:* No direct impacts. *Indirect:* ***Potentially significant adverse*** impacts from shoreline erosion, habitat alterations, reduction of ecological function, and/or increases in turbidity, sedimentation, or nutrient/contaminant inputs due to future flooding.	*Direct:* Long-term, ***potentially significant adverse*** impacts to aquatic habitats from dredge and fill activities; Short-term and long-term, less-than-significant adverse impacts to terrestrial habitats from vegetation removal; Short-term, less-than-significant impacts to terrestrial and aquatic habitats, wildlife (including threatened and endangered species), and EFH during construction (including increased turbidity, physical disturbance, and noise/vibration); Long-term, less-than-significant adverse impacts to aquatic habitats during operation from minor hydrology alterations, and to aquatic and terrestrial wildlife from limited loss of habitat; Long-term, beneficial impacts to terrestrial and aquatic habitats and wildlife from the removal of invasive species and proposed habitat enhancements. Under Alternative 1, about 6.3 acres of uplands would be impacted (4.0 acres permanently, 2.3 acres temporarily), and 7.4 acres of aquatic habitats would be impacted (5.9 acres permanently, 1.5 acres temporarily). Approximately 1.1 acres of vegetative habitat enhancements, and 1.1 acres of wetlands, would be created or enhanced. *Indirect:* Long-term, less-than-significant adverse impacts to terrestrial and aquatic wildlife (including threatened and endangered species) due to reductions in riparian habitat and increased human activity; Long-term beneficial effects to aquatic habitats and wildlife from the removal of invasive plants and improvements to wetlands, and to habitats from increased protection against coastal flooding and SLR, and decreasing turbidity, sedimentation, and nutrient/contaminant inputs.	*Direct:* Short-term, less-than-significant adverse impacts to terrestrial habitats from vegetation removal and disturbance during construction, and to terrestrial and aquatic habitats, wildlife (including threatened and endangered species), and EFH during construction (including increased turbidity, physical disturbance, and noise/vibration); Long-term, beneficial impacts to terrestrial and aquatic habitats and wildlife from proposed habitat and wetland enhancements. Under Alternative 2, approximately 20.3 acres of uplands would be impacted (0.6 acre permanently, 19.7 acres temporarily), and approximately 5.3 acres of aquatic habitats would be impacted (0.1 acre permanently, 5.2 acres temporarily). Additionally, approximately 11.9 acres of vegetative enhancements, and 7.2 acres of wetlands, would be created or enhanced. *Indirect:* Long-term, less-than-significant adverse impacts to terrestrial and aquatic wildlife, including threatened and endangered species, due to increased human activity; Long-term, beneficial effects to aquatic habitats and wildlife from anticipated reductions in sedimentation, turbidity, and nutrient/contaminant inputs in aquatic habitats.	*Direct:* Under Alternative 3, adverse impacts and beneficial effects would be slightly less than Alternative 2 due to fewer stormwater drainage improvements being constructed. Approximately 12.9 acres of uplands would be impacted (0.6 acre permanently, 12.3 acres temporarily), and approximately 4.0 acres of aquatic habitats would be impacted (0.1 acre permanently, 3.9 acres temporarily). Additionally, approximately 3.5 acres of wetlands would be created or enhanced. *Indirect:* Adverse and beneficial impacts would be slightly less than under Alternative 2 since Fluvial Park, DePeyster Creek Park, and the Losen Slote pump station C and its force main would not be constructed.
Geology and Soils	*Direct:* No direct impacts. *Indirect:* ***Potentially significant adverse*** impacts to soil resources through an increase in the potential for land subsidence within the Project Area and an increase in turbidity, sedimentation, nutrient input, and contaminant input due to soil erosion from future flooding.	*Direct:* Short-term, less-than significant adverse impacts to existing geologic and soil conditions in the Project Area during construction (approximately 39 acres of land disturbance and 84,900 CY of soil removed); Long-term, beneficial impacts to soil resources due to a slight decrease in impervious surface area (approximately 0.8-acre decrease). *Indirect:* Short-term, less-than-significant adverse impacts on the exposure of people within the Project Area to radon; Long-term, beneficial effects from reduced hydrocompaction, soil erosion, turbidity, sedimentation, and nutrient/contaminant transport due to reduced coastal flooding.	*Direct:* Same as Alternative 1, except there would be approximately 51 acres of land disturbance and 32,300 CY of soils removed during construction and the long-term decrease in impervious area would be approximately 3.4 acres. *Indirect:* Same as Alternative 1, except there would be no reduction in hydrocompaction since Alternative 2 would not address coastal flooding.	*Direct:* Adverse impacts would be slightly less than Alternative 2 since there would be less ground-disturbing activities and 28,000 CY of potentially contaminated soil would be removed; beneficial effects would be slightly greater than Alternative 2 since the long-term decrease in impervious area would be approximately 3.7 acres. *Indirect:* Adverse impacts and beneficial effects would be slightly less than Alternative 2 since fewer stormwater drainage improvements would be constructed.

Resource Area	No Action Alternative	Alternative 1: Structural Flood Reduction	Alternative 2: Stormwater Drainage Improvement	Alternative 3: Hybrid
Water Resources, Water Quality, and Waters of the US	*Direct:* No direct impacts. *Indirect:* ***Potentially significant adverse*** impacts from future flooding to surface water quality and quantity (including scour and transport of sediment, nutrients, and pollutants); groundwater flow, quantity, and quality; and/or the hydrology of WOUS or State-regulated waterbodies or wetlands.	*Direct:* Long-term, ***potentially significant adverse*** impacts to surface water quantity, flow, and quality from construction in surface waters, and to wetlands, open waters, wetland functions and services, and riparian zones from construction in wetlands or open water; Short-term less-than-significant adverse impacts to localized surface water flow and quality, and to wetland areas, functions, and services, and riparian zones from construction activities; Short-term and long-term less-than significant adverse impacts to localized groundwater flow and quality during construction and operation; Long-term, beneficial effects to wetland functions and services where wetlands would be enhanced or created. Under Alternative 1, approximately 2.8 acres of wetlands would be impacted (1.2 acres permanently, 1.6 acres temporarily), 1.5 acres of open waters would be impacted (1.0 acre permanently, 0.5 acre temporarily), and 11.1 acres of riparian zones would be impacted (8.8 acres permanently, 2.3 acres temporarily). Approximately 1.1 acres of wetlands would be created or enhanced. *Indirect*: Short-term, less-than-significant adverse impacts to surface water from construction activities; Long-term, less-than-significant adverse impacts to wetland area, functions, and services upstream of the proposed tide gate on the unnamed tributary to the Hackensack River; Long-term, beneficial effects to surface water quantity, flow, quality, and sediment quality and transport by increasing coastal flood protection, to wetland functions and services by providing protection from SLR effects and increasing coastal flood protection, and to localized surface water quality from proposed parks and habitat enhancements.	*Direct:* Long-term, ***potentially significant adverse*** impacts to surface water quantity, flow, and quality from proposed construction over the Hackensack River, to localized sediment and contaminant transport in East Riser Ditch and Losen Slote, and to wetlands, open waters, wetland functions and services, and riparian zones from construction in wetlands or open waters; Short-term less-than-significant adverse impacts to localized surface water flow and quality, to groundwater flow and quality, and to wetland areas, functions, and services, and riparian zones from construction activities; Long-term less-than-significant adverse impacts to groundwater quality during operation of green infrastructure systems from the localized accumulation of contaminants; Long-term, beneficial effects to wetland functions and services were wetlands would be created or enhanced. Under Alternative 2, approximately 4.5 acres of wetlands would be impacted (0.3 acre permanently, 4.2 acres temporarily), 5.4 acres of open waters would be impacted (0.3 acre permanently, 5.1 acres temporarily), and 8.7 acres of riparian zones would be impacted (1.4 acres permanently, 7.3 acres temporarily). Approximately 7.2 acres of wetlands would be created or enhanced. *Indirect:* Short-term less-than-significant adverse impacts to surface water from vegetation removal and grading activities during construction; Long-term less-than-significant adverse impacts to surface water flow, water quality, and sediment and contaminant transport downstream of proposed Losen Slote force main discharges and in the upper reach of East Riser Ditch; Long-term beneficial effects to surface water quantity, flow, quality, and sediment and contaminant transport, and to off-site wetland functions and services from proposed improvements and enhancements.	*Direct:* Adverse impacts (including the long-term, ***potentially significant adverse*** impacts) and beneficial effects would be slightly less than Alternative 2 since fewer stormwater drainage improvements would be constructed. Under Alternative 3, approximately 3.4 acres of wetlands would be impacted (0.3 acre permanently, 3.1 acres temporarily), 3.8 acres of open waters would be impacted (0.3 acre permanently, 3.5 acres temporarily), and 4.9 acres of riparian zones would be impacted (0.8 acre permanently, 4.1 acres temporarily). Approximately 3.5 acres of wetlands would be created or enhanced. *Indirect:* Adverse impacts and beneficial effects would be slightly less than Alternative 2 since fewer stormwater drainage improvements would be constructed.
Hydrology and Flooding	*Direct:* ***Potentially significant adverse*** impacts by permanently altering hydrology, flooding, or flood elevations; substantially and/or permanently disrupting the water table due to changes in surface water runoff; and substantially and/or permanently increasing normal water or flood levels. Over time, depending on SLR, an additional 11 to 26 percent of the Project Area could be at risk of coastal flooding during a 50-year storm surge. *Indirect:* No indirect impacts.	*Direct:* Short-term, less-than-significant adverse impacts to existing flood protection (berms) during construction; Long-term, less-than-significant adverse impacts to the normal water surface elevations of waterways in the Project Area due to disrupted groundwater movement from the LOP; Long-term, beneficial effects to the Project Area due to reduced coastal flooding, reduced impervious surfaces, and improved stormwater management in localized areas. During a 50-year storm surge, Alternative 1 would provide coastal flood protection to between 12 and 21 percent of the Project Area, as compared to the No Action Alternative, depending on SLR. *Indirect:* Long-term, ***potentially significant adverse*** impacts to developed areas outside the Project Area resulting from induced coastal flooding.	*Direct:* Long-term, less-than-significant adverse impacts to the groundwater table in localized areas; Long-term, beneficial effects to the Project Area due to reduced inland flooding from increased stormwater infiltration and conveyance capacity. Under Alternative 2, flood depths in the lower reach of East Riser Ditch would be reduced between 2.5 and 2.9 feet during a 2-year storm and between 1.6 and 2.2 feet during a 100-year storm, with residual flood reduction in the upper reach of East Riser Ditch. During a 100-year storm, approximately 182 buildings would receive inland flood protection against East Riser Ditch, totaling approximately $7.8M in avoided damages. For Losen Slote, flood depths would be reduced by up to 0.9 foot in the Main Reach between approximately Bertolotto Avenue and Niehaus Avenue, and by up to 0.6 foot in the Park Street Reach between its confluence with the Main Reach and approximately the south end of Teresa Court. Approximately 60 buildings would receive inland flood protection against Losen Slote during a 100-year storm, totaling approximately $1.1M in avoided damages. *Indirect:* No indirect impacts.	*Direct:* Generally the same as Alternative 2, except Alternative 3 would not provide flood reduction in the Park Street Reach of Losen Slote due to Losen Slote pump station C and its force main not being constructed. As such, only 44 buildings would receive inland flood protection against Losen Slote, totaling approximately $0.6M in avoided damages. *Indirect:* No indirect impacts (Same as Alternative 2).

Resource Area	No Action Alternative	Alternative 1: Structural Flood Reduction	Alternative 2: Stormwater Drainage Improvement	Alternative 3: Hybrid
Coastal Zone Management	*Direct:* No direct impacts. *Indirect:* ***Potentially significant adverse*** impacts from increased long-term risks of coastal zone resources to identifiable hazards, reduced value of the coastal zone, alteration or diminishment of the coastal zones, and/or failure to achieve CZM compliance due to future flooding.	*Direct:* Short-term and long-term, less-than-significant adverse impacts to coastal zone-regulated areas and coastal resources in the Project Area during construction; Long-term, less-than-significant adverse impacts to existing marina access; Long-term, beneficial impacts to public open space, flood hazard areas, and public use due to increased public open spaces and recreational opportunities. *Indirect:* Long-term, beneficial effects to the coastal economy, human health, traffic, and human activities by increasing coastal flood protection.	*Direct:* Same as Alternative 1, except there would be no impacts to marina access, and beneficial effects due to increased public open spaces and recreational opportunities would extend to riparian zones and stormwater management/water quality. *Indirect:* Same as Alternative 1, except beneficial effects would be associated with inland flooding instead of coastal flooding.	*Direct:* Adverse impacts and beneficial effects would be slightly less than Alternative 2 since fewer Proposed Project components would be constructed. *Indirect:* Slightly less than Alternative 2 since Losen Slote pump station C and its force main would not be constructed.
Sustainability / Green Infrastructure	*Direct:* No direct impacts. *Indirect:* ***Potentially significant adverse*** impacts from future flooding to drainage patterns that could increase the runoff rate to receiving waters without water quality treatment.	*Direct:* Long-term, beneficial impacts to hydrology due to a decrease in impervious surfaces (a net decrease of 0.8 acre), to communities through increased open space (four new parks and 10.1 acres of public open space, as well as 1.1 acres of created wetlands), to the quality of runoff due to decreased peak runoff rates from drainage enhancements, and to the coastal economy, human health, and human activities from reduced flooding and associated damages. *Indirect:* Long-term, beneficial effects by inducing activities that increase the future potential for green infrastructure construction through demonstrating the performance and community benefits of green infrastructure as part of open space improvements.	*Direct:* Slightly greater than Alternative 1 since there would be a net decrease of 3.4 acres of impervious surfaces, five new parks and 20.0 acres of public open space, 7.2 acres of wetland creation and/or enhancement, and improvements to the quantity, as well as quality, of runoff due to both decreased peak runoff rates and stormwater management through the installation of 41 green infrastructure systems. *Indirect:* Same as Alternative 1.	*Direct:* While there would be a net decrease of 3.7 acres of impervious surfaces under Alternative 3, beneficial impacts would overall be slightly less than Alternative 2 due to the exclusion of two new parks (only 7.6 acres of public open space), only 3.7 acres of wetland creation and/or enhancement, and some decreases in stormwater conveyance capacity since only one pump station and force main would be built for Losen Slote. *Indirect:* Slightly less than Alternative 2 since fewer Proposed Project components would be constructed.

Resource Area	No Action Alternative	Alternative 1: Structural Flood Reduction	Alternative 2: Stormwater Drainage Improvement	Alternative 3: Hybrid
Hazards and Hazardous Materials	*Direct:* No direct impacts. *Indirect:* ***Potentially significant adverse*** from future flooding to contaminated sites, the potential introduction or mobilization of contaminants, and/or conflicts with existing or planned remedial investigations.	*Direct:* Short-term, ***potentially significant adverse*** impacts from potentially triggering near-term remediation under the ISRA during construction; Long-term, ***potentially significant adverse*** impacts from the disruption or mobilization of previously known hazardous materials encountered during construction; Short-term, less-than-significant adverse impacts from subsurface disturbance of hazardous materials at known or suspected contaminated sites during construction, and to planned remedial activities that could be delayed temporarily; Short-term and long-term, less-than-significant adverse impacts from potential spills (e.g. gasoline and diesel) during construction and operational activities; Long-term beneficial impacts from the removal of potentially contaminated soils during construction (84,900 CY). Under Alternative 1, up to 13 contaminated sites could be directly impacted. *Indirect:* Long-term, ***potentially significant adverse*** impacts from potential creation of VOC/methane preferential pathways, mobilization of contaminant plumes in soil or groundwater, risk of thermal radiation or blast-overpressure damage from one aboveground storage tank (AST), and interference with future remedial investigations; Long-term, beneficial impacts from the protection of contaminated sites from the erosive effects of coastal flooding. Under Alternative 1, up to 11 contaminated sites could be indirectly impacted.	*Direct:* Same as Alternative 1, including the short- and long-term, ***potentially significant adverse*** impacts, except there are 20 contaminated sites that potentially could be impacted directly by Alternative 2, 32,300 CY of potentially contaminated soil would be exported, and long-term, beneficial impacts could also be realized from the capping of potentially contaminated soil by Alternative 2 components. *Indirect:* Same as Alternative 1, including the long-term, ***potentially significant adverse*** impacts, except there are 20 contaminated sites that potentially could be impacted indirectly by Alternative 2, and beneficial impacts would be realized from reduced erosive effects of inland flooding instead of coastal flooding. Additionally, there would be long-term, less-than-significant adverse impacts from localized increases in water velocity that could cause scour and mobilize contaminated sediments in East Riser Ditch and Losen Slote.	*Direct:* There are 19 contaminated sites that potentially could be impacted directly by Alternative 3, but adverse impacts (including the short- and long-term, ***potentially significant adverse*** impacts) and benefits would be slightly less than Alternative 2 since there would be less ground-disturbing activities, and only 28,000 CY of potentially contaminated soil would be exported. *Indirect:* There are 19 contaminated sites that potentially could be impacted indirectly by Alternative 3, but adverse impacts (including the long-term, ***potentially significant adverse*** impacts) and benefits would be slightly less than Alternative 2 since there would be less ground-disturbing activities (for example, a lower risk of scouring the Losen Slote channel because the Losen Slote C pump station and its force main would not be constructed).
Mineral and Energy Resources	*Direct:* No direct impacts. *Indirect:* ***Potentially significant adverse*** effects from future flooding to energy resources due to the increase of long-term risks to identifiable hazards, increases in consumer prices, a minimal diminishment of these resources in the Project Area, and/or short-term decreases in their supply, availability, or capacity.	*Direct:* Short-term, less-than-significant adverse impacts to the supply, availability, capacity, or costs of mineral and energy resources during construction. *Indirect:* Long-term, beneficial effects from increased coastal flood protection, which would reduce damages to energy resources; benefit their supply, availability, capacity, and cost; and commensurately reduce the need for reconstruction and rebuilding of facilities damaged by flood events, thereby reducing potential future need/use of mineral resources.	*Direct:* Slightly less than Alternative 1 since the amounts of mineral and energy resources required for construction are less for most materials. *Indirect:* Same as Alternative 1, except beneficial effects would stem from increased inland flood protection.	*Direct:* Slightly less than Alternative 2 since fewer Proposed Project components would be constructed, and fewer mineral and energy resources would be required. *Indirect:* Slightly less than Alternative 2 since the Losen Slote pump station C and its force main would not be constructed.

Resource Area	No Action Alternative	Alternative 1: Structural Flood Reduction	Alternative 2: Stormwater Drainage Improvement	Alternative 3: Hybrid
Agricultural Resources and Prime Farmland	*Direct:* No direct impacts. *Indirect:* Less-than-significant adverse impacts from the long-term risk of community and residential gardens to identifiable hazards and/or the prohibition of the use of and access to community and residential gardens for future agricultural use due to future flooding.	*Direct:* No direct impacts. *Indirect:* Long-term, beneficial effects on residential and community gardens due to increased coastal flood protection.	*Direct:* No direct impacts (Same as Alternative 1). *Indirect:* Same as Alternative 1, except beneficial effects would stem from increased inland flood protection and stormwater drainage improvements.	*Direct:* No direct impacts (Same as Alternatives 1 and 2). *Indirect:* Slightly less than Alternative 2 since there would be fewer stormwater drainage improvements.

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9.3 Recommendation of Preferred Alternatives

Although all three alternatives achieve the Proposed Project objectives, only Alternative 3 addresses both coastal storm surge and systemic inland flooding. Therefore, the State of New Jersey recommends Alternative 3 as the RBDM Project since it provides a more holistic solution than Alternatives 1 and 2. Alternative 3 incorporates integral flood protection components of Alternative 1 and 2. This alternative reflects the public input received, including the suggestion that the Proposed Project have an increased focus on drainage improvements in the Project Area.

However, given the Proposed Project's funding and schedule constraints, Alternative 3 would exceed the Proposed Project's available funding and mandated schedule (i.e., to be implemented by September 2022). To address these constraints, Alternative 3 would be implemented in two project stages: the initial stage as reflected in a *Build Plan*, which includes all features to be constructed as part of the Proposed Project, and a second stage as reflected in a *Future Plan*, which includes the remaining features of Alternative 3. This second stage could be constructed over time by others as funding and construction feasibility permit. Implementation of the *Build Plan* could be completed within both the budget and schedule associated with the RBD funding.

The *Build Plan* is an integrated plan that primarily addresses systemic inland flooding from heavy or frequent precipitation in the Project Area. The *Build Plan* includes both grey and green stormwater management infrastructure features. The grey stormwater management infrastructure features would reduce flooding damages by capturing and more rapidly evacuating stormwater in the Project Area. The green stormwater management infrastructure features would capture stormwater runoff from streets and sidewalks to reduce local flooding, improve water quality, and enhance the streetscapes with permanent vegetation or new porous paving. Specific features include bioswales, rain gardens, storage trenches, permeable pavement, new/improved parks/open spaces, and wetland improvements. Green infrastructure features would be located within new and existing parks and along existing streets. The *Build Plan* also incorporates community co-benefits through the enhancement and improvement of public spaces in the Project Area.

The following section describes the *Build Plan* components that would be constructed by September 2022 using the $150 million allocated HUD RBD CDBG-DR funds.

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10.0 Alternative 3 Build Plan Description

As discussed in the previous section, Alternative 3 is the Preferred Alternative because it addresses both coastal storm surge and systemic inland flooding. However, given the funding and schedule constraints associated with the Proposed Project, Alternative 3 would be implemented in two project stages: the initial stage as reflected in a *Build Plan*, which includes some features to be constructed as part of Alternative 3, and a second stage as reflected in a *Future Plan*, which includes the remaining features of Alternative 3.

10.1 Overview

The *Build Plan* is an integrated plan that primarily addresses the systemic inland flooding that results from heavy or frequent precipitation in the Project Area. The *Build Plan* includes both grey and green stormwater management infrastructure features. The grey stormwater management infrastructure features would be designed to reduce flooding damage by capturing and more rapidly evacuating stormwater in the Project Area. The green stormwater management infrastructure features would be designed to capture stormwater runoff from streets and sidewalks to reduce local flooding, improve water quality, and enhance the streetscapes with permanent vegetation or new porous paving. The *Build Plan* also incorporates community co-benefits associated with enhancing and improving of public spaces in the Project Area.

10.2 Plan Description

This section provides a description of the Alternative 3 *Build Plan*, which includes grey stormwater management infrastructure, green stormwater management infrastructure, and public open spaces.

The *Build Plan* would reduce the depths and spatial extent of inland flooding in the East Riser Ditch and Losen Slote Creek watersheds. Stormwater conveyance in East Riser Ditch would primarily be improved between the East Riser Ditch tide gate and US Route 46, while stormwater conveyance in Losen Slote Creek would be improved between Bertolotto Avenue and Niehaus Avenue. Under the *Build Plan*, 7.6 acres of new park space would be created.

10.2.1 *Build Plan* Grey Stormwater Management Infrastructure

Grey infrastructure included in the *Build Plan* would consist of components in East Riser Ditch and Losen Slote Creek. These components would be the same as described for Alternative 2; however, the Losen Slote Creek Pump Station C and Losen Slote Creek force main C would be not be constructed under the Alternative 3 *Build Plan*. Please refer to **Section 7.5** for a detailed description of these grey infrastructure features.

10.2.2 *Build Plan* Green Stormwater Management Infrastructure and Open Space

The green infrastructure features include bioswales, rain gardens, storage trenches/tree trenches, permeable pavement, wetland improvements, parks/open spaces, and other associated structures and easements. These features would have the same components and elements, and in the same locations, as described for Alternative 2. Refer to **Section 7.5** for a detailed description of these green infrastructure features. These features are also described in more detail in **Subappendix F-3**.

The *Build Plan* also includes flood management measures, which provide additional water quality benefits, integrated with new open space and improvements to existing open space. These features would have the same components and elements, and in the same locations, as described for Alternative

2. However, Fluvial Park and DePeyster Creek Park would not be constructed under the Alternative 3 *Build Plan*, and improvements to Willow Lake Park would be altered under the Alternative 3 *Build Plan*. Please refer to **Section 7.5** for a detailed description of these open space and improvement features, and to **Section 8.3** for a detailed description of Willow Lake Park under the Alternative 3 *Build Plan*.

10.3 Hazardous Materials

Construction and operational activities could potentially disturb hazardous materials in the Project Area. **Table 10.3-1** shows the potentially contaminated sites and direct impacts under the *Build Plan*. **Section 4.20** of the EIS provides additional detail regarding potential impacts on contaminated sites.

Table 10.3-1: Potentially Contaminated Sites and Direct Impacts under the Alternative 3 Build Plan

Site Name / Location	Site Categories	Location / Distance to Alternative 3 *Build Plan* Footprint	Potential Short-Term Impacts	Potential Long-Term Impacts
A E&A Service Station Inc.	KCS, CEA, Active UST Remediation Site	Adjacent to green infrastructure on Moonachie Avenue	Potential temporary exposure during construction because of proximity to groundwater contamination.	Potential risk of spreading contaminants or introducing contaminants to the environment, resulting in release/transport of contaminants; could cause conflict with remedial activities addressing groundwater contamination.
Amerada Hess Little Ferry	KCS, CEA	Across street from green infrastructure along US Route 46	Potential temporary exposure during construction because of proximity to groundwater contamination.	Potential risk of spreading contaminants or introducing contaminants to the environment, resulting in release/transport of contaminants; could cause conflict with remedial activities addressing groundwater contamination.
Caesar Place Pump Station	KCS, Active UST Remediation Site	Adjacent to East Riser Ditch improvements	Potential temporary exposure during dredging because of proximity to groundwater contamination; could cause conflict with remedial activities addressing sediment.	Could cause conflict with remedial activities addressing sediment, surface water, and groundwater to surface water discharges.
Carretta Trucking	KCS, CEA, Spills, Releases	Nearest CEA boundary 40 feet from green infrastructure along Moonachie Avenue	Potential temporary exposure during construction because of proximity to groundwater contamination.	Potential risk of spreading contaminants or introducing contaminants to the environment, resulting in release/transport of contaminants; could cause conflict with remedial activities addressing groundwater contamination.

Site Name / Location	Site Categories	Location / Distance to Alternative 3 *Build Plan* Footprint	Potential Short-Term Impacts	Potential Long-Term Impacts
Con-Way Central Express	KCS, Spills, Releases	Across street from green infrastructure along Moonachie Avenue	Potential temporary exposure during construction because of proximity to groundwater contamination.	Potential risk of spreading contaminants or introducing contaminants to the environment, resulting in release/transport of contaminants; could cause conflict with remedial activities addressing groundwater contamination.
Esselte Pendaflex	Releases, leaking UST, soil contamination	Underlies southwest corner of Caesar Place Park	Potential temporary exposure during construction because of proximity to soil and/or groundwater contamination; could cause conflict with remedial activities.	Potential risk of spreading contaminants or introducing contaminants to the environment, resulting in release/transport of contaminants; could cause conflict with remedial activities addressing soil and/or groundwater contamination.
Foot of Industrial Avenue	KCS	Adjacent to Riverside Park	Potential temporary exposure during construction because of proximity to groundwater contamination.	Potential risk of spreading contaminants or introducing contaminants to the environment, resulting in release/transport of contaminants; could cause conflict with remedial activities addressing groundwater contamination.
J S Popper Inc.	KCS, Spills, Releases	Across street from green infrastructure along Liberty Street and Little Ferry Municipal Improvements	Potential temporary exposure during construction because of proximity to groundwater contamination.	Potential risk of spreading contaminants or introducing contaminants to the environment, resulting in release/transport of contaminants; could cause conflict with remedial activities addressing groundwater contamination.

Site Name / Location	Site Categories	Location / Distance to Alternative 3 *Build Plan* Footprint	Potential Short-Term Impacts	Potential Long-Term Impacts
Jake & Toms Meadowland Service	KCS, CEA	Adjacent to green infrastructure along Moonachie Avenue	Potential temporary exposure during construction because of proximity to groundwater contamination.	Potential risk of spreading contaminants or introducing contaminants to the environment, resulting in release/transport of contaminants; could cause conflict with remedial activities addressing groundwater contamination.
Martin Picard/Verflex	KCS	Across street from green infrastructure along Moonachie Avenue	Potential temporary exposure during construction because of proximity to groundwater contamination.	Potential risk of spreading contaminants or introducing contaminants to the environment, resulting in release/transport of contaminants; could cause conflict with remedial activities addressing groundwater contamination.
Melnor Industries Incorporated	KCS, CEA	CEA is 650 feet from Avanti Park; KCS parcel is adjacent to Avanti Park	Potential temporary exposure during construction because of proximity to groundwater contamination.	Potential risk of spreading contaminants or introducing contaminants to the environment, resulting in release/transport of contaminants; could cause conflict with remedial activities addressing groundwater contamination.
Moonachie Road Pump Station	KCS	Adjacent to Joseph Street Park improvements	Potential temporary exposure during construction because of proximity to groundwater contamination.	Potential risk of spreading contaminants or introducing contaminants to the environment, resulting in release/transport of contaminants; could cause conflict with remedial activities addressing groundwater contamination.
President Container Inc.	KCS, CEA, Historical Fill, Spills, Releases	KCS parcel adjacent to East Riser Ditch improvements	Potential temporary exposure during dredging because of proximity to groundwater contamination; could cause conflict with remedial activities addressing sediment.	Could cause conflict with remedial activities addressing sediment, surface water, and groundwater to surface water discharges.

Site Name / Location	Site Categories	Location / Distance to Alternative 3 *Build Plan* Footprint	Potential Short-Term Impacts	Potential Long-Term Impacts
Starke Road	KCS, Releases	Adjacent to East Riser Ditch improvements	Potential temporary exposure during dredging because of proximity to groundwater contamination; could cause conflict with remedial activities addressing sediment.	Could cause conflict with remedial activities addressing sediment, surface water and groundwater to surface water discharges.
UPS Ground Freight	KCS, Spills, Releases, Active UST Remediation Site	Adjacent to green infrastructure along Moonachie Avenue	Potential temporary exposure during construction because of proximity to groundwater contamination.	Potential risk of spreading contaminants or introducing contaminants to the environment, resulting in release/transport of contaminants; could cause conflict with remedial activities addressing groundwater contamination.
Walker Poroswall Pipe Co.	KCS, Releases, Active UST Remediation Site	Across street from green infrastructure along US Route 46	Potential temporary exposure during construction because of proximity to groundwater contamination.	Potential risk of spreading contaminants or introducing contaminants to the environment, resulting in release/transport of contaminants; could cause conflict with remedial activities addressing groundwater contamination.
Esposito / Willow Lake Landfill	Landfill	Underlies Willow Lake Park	Potential temporary exposure to contaminants during construction because the site is an improperly closed historical landfill.	Potential risk of spreading contaminants or introducing contaminants to the environment, resulting in off-site or future release/transport of contaminants. Alternative 2 landscape features could act as caps over historical fill, substantially reducing or eliminating the risk of exposure from direct contact with contaminants, creating a beneficial impact.

Site Name / Location	Site Categories	Location / Distance to Alternative 3 *Build Plan* Footprint	Potential Short-Term Impacts	Potential Long-Term Impacts
Morris Park Avenue Corporation	Landfill	Small portion of landfill underlies East Riser Ditch Pump Station construction area	Potential temporary exposure to contaminants during construction because the site is a capped landfill.	N/A
To Be Named	ISRA	To be determined – should ISRA be triggered during construction	Potential temporary exposure during construction because of proximity to soil and/or groundwater contamination; could cause conflict with remedial activities.	N/A
N/A (historic fill)	Historic fill	Underlies Caesar Place Park; Willow Lake Park; Riverside Park; green infrastructure along Bergen Turnpike	Potential temporary exposure to contaminants during construction because historical fill is frequently contaminated with PAHs and metals.	Potential risk of spreading contaminants or introducing contaminants to the environment, resulting in release/transport of contaminants. Alternative 2 landscape features could act as caps over historical fill, substantially reducing or eliminating the risk of exposure from direct contact and mobilization of contaminants, creating a beneficial impact.

10.4 *Build Plan* Project Cost

Table 10.4-1 shows the elements of the capital construction costs for the *Build Plan*, as well as the entire program costs, including the NJDEP program administration and the Feasibility Study and EIS. **Appendix E** includes more detailed capital cost tables. The summary below includes adjustments for inflation and contingencies within the totals shown.

As shown in **Table 10.4-1**, the total construction cost of the *Build Plan* would be approximately $90,925,000. This construction cost includes an average contingency of 25 percent for the construction features and assumes a cost escalation of each feature to the construction midpoint (assumed as 2021) at a rate of 3.5 percent per year. The majority of unit costs used in the estimate are from 2017 RS Means data and include appropriate area adjustment to Bergen County, NJ.

The cost of the grey infrastructure features (pump stations, force mains, and channel and drainage improvements) would be approximately $65,153,000 (72 percent of the construction cost). The cost of the green infrastructure features (bioswales, rain gardens, storage trenches/tree trenches, permeable pavement, wetland improvements, parks/open spaces, and other associated structures and easements) would be approximately $14,386,000 (16 percent of the construction cost). Allowances for utility relocations and for the cost to mitigate unavoidable wetland impacts would be approximately $5,749,000 (6 percent of the construction cost). General construction requirements, such as mobilization and demobilization, traffic maintenance, erosion control, contractor supervision, and project management, would be approximately $5,637,000 (6 percent of the construction cost).

When including an allowance of 12.0 percent for detailed engineering, design, and permitting, and 4.3 percent for construction administration, the total estimated Proposed Project cost, including contingency and escalation, is $114,500,000.

In addition, the Feasibility Study and EIS cost approximately $20.5 million and program administration costs are approximately $15 million. Together, the estimated overall cost of the Alternative 3 *Build Plan* is approximately $150 million.

If the *Build Plan* is completed, annual O&M costs associated with the new pump stations and the other grey and green construction features would be incurred. The annual O&M costs would be approximately $1,100,000. A detailed breakdown of costs for both the initial construction and the O&M is provided in **Appendix D**.

Table 10.4-1 shows total costs treated as expenditures that would be phased in, in annual increments over the construction period spanning from 2017 to 2022. Therefore, within the BCA, these future year amounts are discounted to present value by applying the Proposed Project discount rate of 7 percent. Consequently, the cumulative present value costs shown in the BCA summary tables will appear lower than the nominal (undiscounted) costs shown in **Table 10.4-1**.

In addition, the HUD Benefit Cost Guidance specifies that the price level be held constant (at 2017 constant prices) throughout the Proposed Project evaluation period, 2017 to 2072 (HUD CPD 16-06, p.8). Because of this convention, the capital cost price escalation contingency to the year 2021 was removed within the BCA. **Table 10.5-1** and **Table 10.5-3** show the adjustments made to all costs and the reconciliation to nominal budgeted amounts.

Table 10.4-1: Cost Summary with Contingency and Escalation for Alternative 3 Build Plan

Project Summary	COST (2017 PL)	CONTINGENCY	ESCALATION @3.5%/Yr	COST w/ CONTINGENCY & ESCALATION
GREY INFRASTRUCTURE FEATURES	$ 45,422,000	$ 11,355,000	**$ 8,376,000**	**$ 65,153,000**
East Riser Ditch (ERD), Losen Slote and Carol Place (LS)				
New Pump Stations	$ 28,100,000	$ 7,025,000	$ 5,182,000	$ 40,307,000
Force Mains (Losen Slote/Carol PL)	$ 7,866,000	$ 1,967,000	$ 1,451,000	$ 11,283,000
Channel Improvements (Lower East Riser)	$ 4,832,000	$ 1,208,000	$ 891,000	$ 6,931,000
Local Drainage Improvements (Lower East Riser Ditch)	$ 1,416,000	$ 354,000	$ 261,000	$ 2,031,000
Pilings and Cradles for support of culverts, & pump station	$ 3,086,000	$ 771,000	$ 569,000	$ 4,426,000
Energy Dissipation structures	$ 121,000	$ 30,000	$ 22,000	$ 174,000
GREEN INFRASTRUCTURE FEATURES	**$ 10,029,000**	**$ 2,507,000**	**$ 1,849,000**	**$ 14,386,000**
Revegetation - Riparian Habitat	$ 160,000	$ 40,000	$ 29,000	$ 229,000
Avanti Park	$ 1,155,000	$ 289,000	$ 213,000	$ 1,656,000
Caesar Place	$ 1,594,000	$ 398,000	$ 294,000	$ 2,286,000
Little Ferry Muncipal	$ 684,000	$ 171,000	$ 126,000	$ 981,000
Little Ferry Schools	$ 561,000	$ 140,000	$ 104,000	$ 805,000
Riverside Ave Park	$ 1,643,000	$ 411,000	$ 303,000	$ 2,356,000
Robert Craig School	$ 248,000	$ 62,000	$ 46,000	$ 355,000
St. Joseph Park	$ 274,000	$ 68,000	$ 50,000	$ 393,000
Willow Lake	$ 2,873,000	$ 718,000	$ 530,000	$ 4,121,000
Green features for Street infrastructure	$ 838,000	$ 210,000	$ 155,000	$ 1,203,000
ALLOWANCES FOR UTILITY AND WETLAND MITIGATION	**$ 5,010,000**	**$ -**	**$ 739,000**	**$ 5,749,000**
GENERAL REQUIREMENTS	**$ 3,930,000**	**$ 982,000**	**$ 725,000**	**$ 5,637,000**
TOTAL CONSTRUCTION COSTS	**$ 64,391,000**	**$ 14,845,000**	**$ 11,689,000**	**$ 90,925,000**
Real Estate	$ 10,300,000			$ 10,300,000
Engineering and Design	$ 7,727,000	$ 927,000	$ 616,000	$ 9,270,000
Construction Administration	$ 2,791,000	$ 698,000	$ 515,000	$ 4,000,000
TOTAL PROJECT COSTS	**$ 85,209,000**	**$ 16,470,000**	**$ 12,820,000**	**$ 114,500,000**
Feasibilty Study/EIS	$ 20,500,000			**$ 20,500,000**
NJDEP Program Administration	$ 15,000,000			**$ 15,000,000**
TOTAL PROGRAM COSTS	**$ 120,710,000**	**$ 16,470,000**	**$ 12,820,000**	**$ 150,000,000**

NOTES:

1	Estimate does NOT include Real Estate costs
2	Includes 25% contingency on Construction Costs.
3	Escalation based on assumed midpoint of construction in 2021, at 3.5% per year compounded.
4	Estimate assumes all excess soils generated by construction will be classified as non-hazardous ID27 solid waste. These excess soils are assumed to be Transported/Disposed from the site at a cost of $85 per ton.
5	Estimate assumes that "hot spots" of Hazardous, Toxic, and Radioactive Waste (HTRW) encountered can be addressed either through the project contingency or by implementing measures to reduce the volume. If significant "hot spots" are encountered, design modifications would be made to minimize the need to remove HTRW material.
6	Allowances provide for utility relocations/protection and for construction of wetlands to mitigate unavoidable impacts to existing wetlands that will not be ofset by project features.
7	Estimate assumes deep foundation support will be needed for force mains, stormwater piping & box culverts.
8	GENERAL REQUIREMENTS - includes 6.5% of construction cost for contractor PM and Supervision (3%), Mob/Demob (1%), Traffic Maintenance (2 %), and Erosion-sedimentation controls (0.5%).

10.5 *Build Plan* Benefits

In accordance with the guidance provided in HUD Notice CPD-16-06, this section provides a description of the benefits and costs of the *Build Plan*. All economic calculations in this section use a 50-year period of analysis with a discount rate of 7 percent.

The benefits evaluated and presented in this section are limited to the impacts of tidal storm surge and the potential for storm surges to reduce the discharge from existing and proposed drainage infrastructure. The benefits calculated for the *Build Plan* were based on a comparison of future conditions with and without implementation of the *Build Plan*. **Section 10.4** discusses the costs of the *Build Plan*.

The benefit analysis assumed that certain conditions would exist in the future as described in **Section 4.0**. Changes in the future condition assumptions from those anticipated in the BCA calculations could result in higher or lower benefits than currently estimated.

The benefits of the *Build Plan* are presented in this section in three components:

- Resiliency - flood inundation damage and associated impacts;
- Economic revitalization, social, and environmental co-benefits; and
- Proposed Project investment impacts on regional employment.

10.5.1 Resiliency Benefits

The primary resiliency benefits of the *Build Plan* derive from reducing direct damages from fluvial flooding to infrastructure, residential, apartment, commercial, industrial, municipal, and utility structures. The reduction in damages to motor vehicles associated with residential and apartment structures were also evaluated. In addition, the analysis considered benefits derived from reductions in post-flood debris removal and disposal, public emergency services costs, public injury and loss of life, and disruption to critical/first responder facilities within the Project Area.

The analysis of flood damage benefits for the *Build Plan* followed the same approach and methodology used for Alternative 1 and described in **Section 6.4.1**. The *Build Plan* benefit analysis used the same structure inventory developed for Alternative 1, but applied it only to the portions of the Project Area impacted by the *Build Plan* (i.e., the drainage areas associated with East Riser Ditch, West Riser Ditch, and Losen Slote Creek). The inventory for these areas was input into a separate HEC-FDA model, in conjunction with the same depth-damage functions as described in **Section 6.4.1**, and fluvial hydrologic/hydraulic data developed specifically for the *Build Plan* analysis.

As for Alternatives 1 and 2, benefits other than reduction in direct flood damage to structures and their contents were evaluated using HEC-FDA. *Build Plan* benefits associated with reductions to damage to motor vehicles, public emergency costs, debris removal and disposal, emergency facility disruption, and injuries/loss of life were all computed in HEC-FDA using the same approach and methodology described in **Section 6.4.1**.

The damages and benefits resulting from the *Build Plan* damage computations conducted using HEC-FDA are presented by impacted drainages. All values are based on an August 2016 price level, and the economic analyses are based on a 7 percent discount rate with a 50-year period of analysis. Future condition damages assumed 1.2 feet of SLR at Battery, NY. Storm surge simulations with and without

SLR indicate that a 1.2-foot increase in sea level, which results in an increase of storm surge elevations at the Project Area on the order of 0.8 foot. Similar analyses have calculated damages and benefits for a higher rate of SLR, and the detailed results of these analyses will be included in future versions of this report.

Table 10.5-1 shows the expected average annual resiliency damages for the "without" and "with" *Build Plan* that is based on the expected sea level at the base year (2023), and also the annual resiliency benefits (the difference between the "without" and "with" annual damages) at the base year of 2023. **Table 10.5-2** shows the expected average annual resiliency damages for the "without" and "with" *Build Plan*, and also the annual project resiliency benefits that assumes an intermediate low level of sea level change (1.4 feet) by the end of the Proposed Project's period of analysis (2073). Due to sea level change the expected annual residual damages and the Proposed Project benefits are both significantly greater by year 50, as compared to year 1, which is the baseline condition.

Table 10.5-1: Build Plan – Expected Annual Average Resiliency Damages and Benefits, Baseline Condition

Evaluated Category	Without	With	Benefits
Residential Structures	$1,088,290	$1,033,760	$54,530
Apartment Structures	$20,560	$18,020	$2,540
Commercial Structures	$12,084,980	$10,138,320	$1,946,660
Industrial Structures	$61,033,210	$58,875,590	$2,157,620
Municipal Structures	$679,350	$586,610	$92,740
Utility Structures	$7,700	$7,600	$100
Motor Vehicles	$226,220	$127,900	$98,320
Emergency Facilities Disruption	$50	$20	$30
Injury and Loss of Life	$3,542,510	$1,735,300	$1,807,210
Emergency Services Costs	$2,620	$2,570	$50
Debris Removal and Disposal	$358,090	$352,540	$5,550
Totals	***$79,043,580***	***$72,878,230***	***$6,165,350***

Table 10.5-2: Build Plan - Expected Annual Average Resiliency Damages and Benefits, Future Condition

Evaluated Category	Without	With	Benefits
Residential Structures	$1,310,490	$1,178,810	$131,680
Apartment Structures	$32,160	$27,340	$4,820
Commercial Structures	$16,599,080	$12,998,690	$3,600,390
Industrial Structures	$75,133,650	$70,533,620	$4,600,030
Municipal Structures	$1,083,740	$934,740	$149,000
Utility Structures	$9,280	$9,260	$20
Motor Vehicles	$337,559	$160,510	$177,049
Emergency Facilities Disruption	$310	$220	$90
Injury and Loss of Life	$6,525,570	$2,357,390	$4,168,180
Emergency Services Costs	$3,090	$3,050	$40
Debris Removal and Disposal	$412,550	$404,250	$8,300
Totals	***$101,447,479***	***$88,607,880***	***$12,839,599***

10.5.2 Economic Revitalization, Social, and Environmental Co-Benefits

In addition to providing resiliency benefits as described in **Section 10.5.1**, the *Build Plan* has the potential to generate additional economic revitalization, social, and environmental benefits. Economic revitalization benefits include property value benefits from proximity to new parks and the associated property tax benefits and energy savings. Social benefits include new recreational opportunities, aesthetic values, and avoided stormwater treatment costs. Environmental benefits include air quality improvements, increased opportunities for pollination, and reduced nitrogen and phosphorus.

The analysis of economic revitalization, social, and environmental co-benefits for the *Build Plan* used the same approach and methodology used in calculating the benefits of Alternatives 1 and 2. These methodologies are discussed in **Section 6.4.2** and described in more detail in **Appendix E**.

As with alternative evaluations, a custom model was developed to estimate the future benefits for the *Build Plan*. Benefits were estimated over a 50-year period beginning in 2023. The base year is 2017 and all values were discounted to the base year. The first year that the Proposed Project would be complete was assumed to be 2023 and benefits would begin accruing at the beginning of the year. All benefits are in constant 2017 dollars and were analyzed using a 7 percent discount rate.

Table 10.5-3 presents the average annual economic revitalization, social, and environmental co-benefits of the *Build Plan*. The equivalent annual benefit is $1,449,000 and the present value is $20,003,900, using a 7 percent discount rate and 50-year period of analysis.

Table 10.5-3: Build Plan: Summary of Economic Revitalization, Social, and Environmental Co-Benefits

Co-Benefit Category	Total Value	Present Value	Equivalent Annual Value
Economic Revitalization	**$24,275,000**	**$10,996,700**	**$796,800**
Net Property Value Premium	$16,022,900	$10,676,700	$773,600
Energy Conservation	$1,252,100	$150,500	$10,900
Residual Value	$7,000,000	$169,400	$12,300
Social	**$44,977,500**	**$8,830,300**	**$639,800**
Recreation	$35,830,100	$7,051,200	$510,900
Avoided Stormwater Treatment	$7,888,800	$1,531,500	$111,000
Aesthetic Value	$1,026,900	$202,100	$14,600
Water retention/flood hazard risk reduction	$231,700	$45,600	$3,300
Environmental	**$999,000**	**$176,900**	**$12,800**
Air Quality	$794,600	$136,700	$9,900
Pollination	$183,600	$36,100	$2,600
Nutrient Pollution	$20,800	$4,100	$300
Totals	**$70,251,500**	**$20,003,900**	**$1,449,400**

10.5.3 Proposed Project Investment Impacts on Regional Employment

Investment in the *Build Plan*, through construction and annual maintenance activities, would positively affect the regional economy. This section estimates the anticipated economic impacts from construction and annual maintenance in terms of job-years and earnings in the region.

The economic impacts generated by the capital and maintenance expenditures depend on the resources and services purchased in the local economy. The analysis assumed that the same local counties listed for Alternative 1 in **Table 6.4-11**, from which goods and services are likely to be purchased during construction and maintenance, would be applicable for the *Build Plan*. These counties collectively represent the regional study area for the economic impact analysis. Because the economic impacts focus on the local economy where the Proposed Project expenditures would be spent, this study area is broader than the Project Area used in the rest of this Feasibility Study and the EIS.

The Bureau of Economic Analysis RIMS II 2015 multipliers were used to estimate jobs and earnings effects resulting from construction and operation of the *Build Plan*. The multipliers were constructed to reflect the structure of economies of the 16 counties listed in **Table 6.4-11**.

Capital investment for the *Build Plan* would increase the employment, earnings, and output for the duration of the construction process. Note that these are one-time impacts that last for the duration of construction. The employment effects are expressed in job-years; a job-year defined as one full-time job for one person for one year. The difference between the total employment and direct employment is the indirect and induced employment, or jobs that are created or supported in other industries because of

construction employee spending in the region. Construction of this alternative would result in 370 total direct job-years and 390 total indirect job-years.

Construction spending for the *Build Plan* would create 320 direct job-years in the construction industry. Indirect and induced job-years would total 320 in the construction industry. Total earnings for the 640 total construction industry job-years would be $34.7 million.

The professional services spending for the *Build Plan* would result in 120 total job-years, 50 of which are direct and 70 of which are indirect. The total earnings for the 120 professional services job-years would be $7.5 million.

The average earnings per job for both the construction and professional services industries would be $55,500 per job-year resulting from spending for the *Build Plan*. This average earnings value was estimated by dividing the total earnings ($42.2 million) by the total employment (760 job-years).

Implementation of the *Build Plan* would create jobs and earnings as a result of ongoing O&M expenditures. Under the *Build Plan*, O&M activities would involve inspections of the flood control structures, including replacement of moving parts, exercising the pumps, and cleaning the ditches and channels. The development team provided the projected O&M expenditures for the various alternatives. This analysis assumes that funding for O&M would be procured from local government funds. Although these expenses would originate from local sources, they represent spending that would not take place but for the implementation of the *Build Plan*. The Proposed Project would expand economic activity in the study area counties and thus generate recurring economic impacts.

The increased operating sector employment would result in positive economic impacts to the study area counties both through direct hiring to fill the O&M jobs and indirect benefits as these O&M workers spend their earnings, creating additional consumer demand and jobs to meet that demand. A further increase of new employment across a variety of industrial sectors and occupational categories would be expected as employers hire to meet this increase in local consumer demand. The latter hiring represents the alternative's indirect and induced impact.

The annual O&M spending would increase employment in the region. These impacts are long-term annual impacts that would continue for the life of the infrastructure elements. This section describes the anticipated direct and total employment impacts from this alternative based on the RIMS II multiplier analysis. Under the *Build Plan*, annual O&M activities would result in 16 total job-years, of which 10 are direct and 6 are indirect and induced job-years.

The annual O&M of the *Build Plan* would increase employee earnings in the region. These impacts are long-term annual impacts that would continue for the life of the infrastructure elements. The current analysis indicates that the *Build Plan* would result in average earnings of $41,600 per job-year for those employed by all industries in the study area for jobs created as a result of annual O&M spending. This was estimated by dividing the total annual earnings ($0.70 million) by the total annual employment (16 job-years).

The regional employment impacts were not quantified in terms of annual average benefits, and hence they are not included in the summary below.

10.6 Benefit-Cost Ratio

Table 10.6-1 summarizes the results of the benefit analyses, combining the quantified benefits described in **Sections 10.5.1** and **10.5.2** with the costs of the *Build Plan* as described in **Section 10.4** and **Appendix C**. The annual benefits presented in this table are equivalent annual benefits, assuming a future condition featuring 1.2 feet of SLR at Battery, NY, which results in an increase of storm surge elevations at the Project Area on the order of 0.8 foot. All economic computations used a 7 percent discount rate and 50-year period of analysis. As **Table 10.6-1** shows, the benefits of the *Build Plan* are expected to exceed its costs by a factor of 1.15 to 1.

Table 10.6-1: Build Plan – Summary of Benefits and Costs

Alternative 3 *Build Plan*	Total Value	Present Value	Equivalent Annual Value
Resiliency	**$491,970,700**	**$84,770,700**	**$6,142,500**
East Riser Ditch Resilience	$430,167,400	$72,751,600	$5,271,600
West Riser Ditch Resilience	$35,329,300	$7,834,200	$567,700
Losen Slote Creek Resilience	$26,474,000	$4,184,900	$303,200
Economic	**$27,576,300**	**$11,077,500**	**$802,700**
Property Value	$16,022,900	$10,676,700	$773,600
Energy Conservation	$1,253,400	$151,400	$11,000
Residual Value	$10,300,000	$249,300	$18,100
Social	**$45,201,300**	**$8,989,900**	**$651,400**
Recreation	$36,009,200	$7,178,900	$520,200
Avoided Stormwater Treatment	$7,927,100	$1,558,800	$113,000
Aesthetic Value	$1,032,100	$205,800	$14,900
Water retention/flood hazard risk reduction	$232,800	$46,400	$3,400
Environmental	**$1,003,000**	**$179,800**	**$13,000**
Air Quality	$797,600	$138,800	$10,100
Pollination	$184,500	$36,800	$2,700
Nutrient Pollution	$20,900	$4,200	$300
TOTAL BENEFITS	**$565,751,300**	**$105,017,800**	**$7,609,600**
Capital Investment Costs	$101,680,000	$79,500,000	$5,760,600
O&M	$55,950,000	$11,520,000	$834,800
TOTAL COSTS	**$157,630,000**	**$91,020,000**	**$6,595,300**
Benefit Cost Ratio		**1.15**	**1.15**

10.7 Build Plan Set

The Alternative 3 Build Plan Set as shown below is provided in **Subappendix F4-4**.

Letter G in sheet number stands for General; C for Grey Infrastructure Civil; CG for Green Infrastructure Civil; L for Landscape Architecture; and R for Real Estate.

Table 10.7-1: Index of Drawings for the Build Plan

Sheet No.	Title
G-00-001	Alternative 3 Build Plan Cover Sheet
G-00-002	Alternative 3 Build Plan Legend Sheet
G-00-003	Alternative 3 Build Plan Project Paneling Layout
PLANS	
C-08-001	Alternative 3 Build Plan Plan View Station 0+00 - 8+13
C-07-002	Alternative 3 Build Plan Plan View Station 8+13 - 19+80
C-09-003	Alternative 3 Build Plan Plan View Station 19+80 - 30+06
C-10-004	Alternative 3 Build Plan Plan View Station 30+06 - 39+16
C-11-005	Alternative 3 Build Plan Plan View Station 39+16 - 42+79
C-19-007	Alternative 3 Build Plan Plan View Station 16+69c -20+93c
C-18-008	Alternative 3 Build Plan Plan View Station 20+68a - 28+49a
C-25-009	Alternative 3 Build Plan Plan View Station 16+44a - 20+68a
C-24-010	Alternative 3 Build Plan Plan View Station 9+11a - 16+44a
C-29-011	Alternative 3 Build Plan Plan View Station 0+00a -9+11a
CG-01-001	Alternative 3 Build Plan Empire Blvd Area
CG-04-002	Alternative 3 Build Plan Moonachie Road Area
CG-05-003	Alternative 3 Build Plan Moonachie Ave Area
CG-06-004	Alternative 3 Build Plan Moonachie Ave Area
CG-10-005	Alternative 3 Build Plan Caesar Place Area
CG-11-006	Alternative 3 Build Plan Caesar Place Area
CG-12-007	Alternative 3 Build Plan Empire Blvd Area
CG-13-008	Alternative 3 Build Plan Moonachie Ave Area
CG-14-009	Alternative 3 Build Plan Moonachie Ave Area
CG-15-010	Alternative 3 Build Plan Moonachie Road Area
CG-18-011	Alternative 3 Build Plan Monroe Street Area
CG-19-012	Alternative 3 Build Plan E Park Street Area
CG-20-013	Alternative 3 Build Plan E Joseph Street Area
CG-21-014	Alternative 3 Build Plan Moonachie Road Area
CG-22-015	Alternative 3 Build Plan E Joseph Street Area
CG-23-016	Alternative 3 Build Plan Moonachie Road Area
CG-26-017	Alternative 3 Build Plan Mehrhof Road Area
CG-27-018	Alternative 3 Build Plan Dietrich Street Area
CG-30-019	Alternative 3 Build Plan Teresa Court Area
CG-31-020	Alternative 3 Build Plan Redneck Ave Area
CG-33-021	Alternative 3 Build Plan Liberty Street Area
CG-34-022	Alternative 3 Build Plan Redneck Ave Area
CG-35-023	Alternative 3 Build Plan Redneck Ave Area
CG-37-024	Alternative 3 Build Plan Liberty Street Area
CG-38-025	Alternative 3 Build Plan Riverside Ave Area
CG-39-026	Alternative 3 Build Plan Pickens Street Area
CG-40-027	Alternative 3 Build Plan Main Street Area

Sheet No.	Title
CG-41-028	Alternative 3 Build Plan Main Street Area
CG-43-029	Alternative 3 Build Plan Bergen Turnpike Area
CG-44-030	Alternative 3 Build Plan Bergen Turnpike Area
CG-46-031	Alternative 3 Build Plan Moonachie Ave Area
CG-47-033	Alternative 3 Build Plan Liberty Street Area
CG-48-033	Alternative 3 Build Plan Main Street Area
L-10-001	Alternative 3 Build Plan Caesar Place Park
L-11-002	Alternative 3 Build Plan Caesar Place Park
L-12-003	Alternative 3 Build Plan Empire Blvd
L-01-004	Alternative 3 Build Plan Empire Blvd
L-04-005	Alternative 3 Build Plan Moonachie Road Area
L-05-006	Alternative 3 Build Plan Moonachie Ave
L-15-007	Alternative 3 Build Plan Avanti Park
L-14-008	Alternative 3 Build Plan Moonachie Ave
L-13-009	Alternative 3 Build Plan Moonachie Ave
L-46-010	Alternative 3 Build Plan Moonachie Ave
L-20-011	Alternative 3 Build Plan E Joseph St Area
L-21-012	Alternative 3 Build Plan St. Joseph Park
L-22-013	Alternative 3 Build Plan St. Joseph Park
L-27-014	Alternative 3 Build Plan DePeyster Creek
L-29-015	Alternative 3 Build Plan Little Ferry Schools
L-30-016	Alternative 3 Build Plan Robert Craig Elementary
L-31-017	Alternative 3 Build Plan Redneck Ave
L-32-018	Alternative 3 Build Plan Little Ferry Schools
L-33-019	Alternative 3 Build Plan Little Ferry Schools
L-34-020	Alternative 3 Build Plan Redneck Ave
L-35-021	Alternative 3 Build Plan Redneck Ave
L-36-022	Alternative 3 Build Plan Little Ferry Municipal
L-37-023	Alternative 3 Build Plan Little Ferry Municipal
L-41-024	Alternative 3 Build Plan Willow Lake
L-40-025	Alternative 3 Build Plan Willow Lake
L-39-026	Alternative 3 Build Plan Willow Lake
L-38-027	Alternative 3 Build Plan Riverside/Willow Lake
L-43-028	Alternative 3 Build Plan Bergen Turnpike Area
L-44-029	Alternative 3 Build Plan Bergen Turnpike
C-00-100	Alternative 3 Build Plan Typical Sections
C-00-101	Alternative 3 Build Plan Typical Sections
C-00-102	Alternative 3 Build Plan Typical Sections
C-00-103	Alternative 3 Build Plan Typical Sections
C-00-104	Alternative 3 Build Plan Typical Sections
CG-00-100	Alternative 3 Build Plan Typical Sections
CG-00-101	Alternative 3 Build Plan Typical Sections

Sheet No.	Title
CG-00-102	Alternative 3 Build Plan Typical Sections
CG-00-103	Alternative 3 Build Plan Typical Sections
L-00-100	Alternative 3 Build Plan Typical Details - Pavement & Walkways
L-00-101	Alternative 3 Build Plan Typical Details - Planting
L-00-102	Alternative 3 Build Plan Typical Details - Furnishings & Schedule
C-00-300	Alternative 3 Build Plan Construction Phasing Plan
R-01-001	Alternative 3 Build Plan Real Estate Plan
R-47-002	Alternative 3 Build Plan Real Estate Plan
R-48-003	Alternative 3 Build Plan Real Estate Plan
R-04-004	Alternative 3 Build Plan Real Estate Plan
R-05-005	Alternative 3 Build Plan Real Estate Plan
R-06-006	Alternative 3 Build Plan Real Estate Plan
R-07-007	Alternative 3 Build Plan Real Estate Plan
R-08-008	Alternative 3 Build Plan Real Estate Plan
R-09-009	Alternative 3 Build Plan Real Estate Plan
R-10-010	Alternative 3 Build Plan Real Estate Plan
R-11-011	Alternative 3 Build Plan Real Estate Plan
R-12-012	Alternative 3 Build Plan Real Estate Plan
R-13-013	Alternative 3 Build Plan Real Estate Plan
R-14-014	Alternative 3 Build Plan Real Estate Plan
R-15-015	Alternative 3 Build Plan Real Estate Plan
R-44-016	Alternative 3 Build Plan Real Estate Plan
R-46-017	Alternative 3 Build Plan Real Estate Plan
R-18-018	Alternative 3 Build Plan Real Estate Plan
R-19-019	Alternative 3 Build Plan Real Estate Plan
R-20-020	Alternative 3 Build Plan Real Estate Plan
R-21-021	Alternative 3 Build Plan Real Estate Plan
R-22-022	Alternative 3 Build Plan Real Estate Plan
R-23-023	Alternative 3 Build Plan Real Estate Plan
R-24-024	Alternative 3 Build Plan Real Estate Plan
R-25-025	Alternative 3 Build Plan Real Estate Plan
R-26-026	Alternative 3 Build Plan Real Estate Plan
R-27-027	Alternative 3 Build Plan Real Estate Plan
R-28-028	Alternative 3 Build Plan Real Estate Plan
R-29-029	Alternative 3 Build Plan Real Estate Plan
R-30-030	Alternative 3 Build Plan Real Estate Plan
R-31-031	Alternative 3 Build Plan Real Estate Plan
R-32-032	Alternative 3 Build Plan Real Estate Plan
R-33-033	Alternative 3 Build Plan Real Estate Plan
R-34-034	Alternative 3 Build Plan Real Estate Plan
R-35-035	Alternative 3 Build Plan Real Estate Plan
R-36-036	Alternative 3 Build Plan Real Estate Plan

Sheet No.	Title
R-37-037	Alternative 3 Build Plan Real Estate Plan
R-38-038	Alternative 3 Build Plan Real Estate Plan
R-39-039	Alternative 3 Build Plan Real Estate Plan
R-40-040	Alternative 3 Build Plan Real Estate Plan
R-41-041	Alternative 3 Build Plan Real Estate Plan
R-43-043	Alternative 3 Build Plan Real Estate Plan

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11.0 Build Plan Implementation

The Alternative 3 *Build Plan* is recommended as the Preferred Alternative for implementation and would involve the following: design of the *Build Plan* components, submission of the relevant required permits for approval, real estate acquisition for construction use, construction, and field O&M of the Proposed Project features. This section will describe what is required for plan implementation in further detail.

11.1 Design

Upon approval of the Alternative 3 *Build Plan*, the RBDM project team would initiate the engineering detailed design and construction drawing work. Considering the Proposed Project schedule constraints (i.e., construction completed and functional by September 2022), separation of the *Build Plan* into six contracts as shown below is recommended for design and construction. Design of these six contracts' work could be carried out concurrently.

1. Green Infrastructure Improvements: Carol Place, West Riser Ditch, DePeyster Creek, Park Street, and Main Street;
2. Open Space Improvements: Riverside Park, Willow Lake Park, Little Ferry Municipal Improvements, Washington & Memorial Elementary Schools, and Robert Craig Elementary School;
3. Open Space Improvements: Joseph Street Park and Avanti Park;
4. Open Space Improvements: Caesar Place Park;
5. East Riser Ditch Improvements: Pump Station, Channel Improvements, Culvert and Bridge Remove and Replace; and
6. Losen Slote Creek pump station A and force main A.

Geotechnical and structural analyses in this Feasibility Study were based on limited subsurface soil information from borings near the Project Area. In design phase of the Proposed Project, a more comprehensive geotechnical evaluation of the flood protection measures would be required. Detailed site investigations would have to be conducted and borings would have to be drilled to collect data on soil and groundwater for the comprehensive geotechnical investigations. The structural team would work with the geotechnical team for the pump station and force main design, as well as the structures in the green infrastructure measures. Green infrastructure design should involve the collaboration of drainage engineers and landscape designers in order for green infrastructure measures to be properly designed to mitigate flooding and provide public amenities and community enhancement as co-benefits.

The RBDM project team would prepare engineering design and construction plans, drawings, specifications, and support documents that precisely depict and define the selected flood protection design, components, and construction materials at the 30-, 60-, 90-, and 100-percent design completion stages. Permitting and easement acquisition would be started as soon as the design meets the requirement of such tasks. Contract bid and award could occur once the design is 100 percent complete with the permitting approved and land acquired for construction use.

11.2 Agency Coordination and Permitting

Obtaining permits in the Meadowlands District is challenging and directly affects the feasibility of the *Build Plan* implementation. Below is a list of the agencies that would require coordination, and, if applicable, the permits that would potentially be needed for plan implementation:

- Cooperating Federal Agencies:
    - FEMA;
    - Federal Transit Administration, Region 2;
    - National Railroad Passenger Corporation (Amtrak);
    - New Jersey Transit;
    - Port Authority of New York and New Jersey;
    - USACE, New York District; and
    - USEPA, Region 2.
- Communication with the following potential partners:
    - Meadowlands Interagency Mitigation Advisory Committee;
    - Federal Review and Permitting; and
    - Meadowlands Technical Coordination Team.

The following is a list of ongoing agency coordination needs:

- Cultural Resources
    - New Jersey's Historic Preservation Office for National Historic Preservation Act (NHPA) Section 106 Consultation;
    - Advisory Council on Historic Preservation for NHPA compliance (if historic properties will be adversely affected); and
    - Native American tribes throughout the NEPA and Section 106 processes.
- Wetlands, Floodplains, and Threatened and Endangered Species
    - FEMA and USACE consultation and review throughout the design and required permitting processes;
    - NJDEP Division of Land Use Regulation and Division of Fish Wildlife for wetlands and state threatened and endangered species;
    - USFWS, Endangered Species Act (ESA) Section 7, for additional informal consultation, which may be necessary during the permitting process since species lists can change; and
    - NOAA Fisheries Office of Protected Resources, ESA Section 7, for additional informal consultation, which may be necessary during the permitting process since species lists can change.
- Other
    - PANYNJ for compliance with Federal Aviation Administration regulations through design and construction;
    - NJ Transit during design for closure gate on railroad tracks;
    - NJDOT for roadway right-of-way construction impacts (see **Table 11.2-1**);

Table 11.2-1: Potential Permits Required for the Project Implementation

Law and/or Regulation	Type of Permit	Issuing Agency
River and Harbor Act / Federal Clean Water Act	Individual Section 10/ 404 permit	USACE New York District
Federal Clean Water Act	Individual Section 401 Water Quality Certification	NJDEP Division of Land Use Regulation (DLUR)
Federal Coastal Zone Management Act	Federal Consistency (issued through Waterfront Development permit)	NJDEP DLUR
NJ Waterfront Development Law / NJ Coastal Zone Management Rules	Individual Upland and In-Water Waterfront Development Permits (jurisdiction waterward of Mean High Water in NJ Meadowlands District; in-water and upland jurisdiction outside of NJ Meadowlands District)	NJDEP DLUR
NJ Freshwater Wetlands Protection Act / Rules	Individual Freshwater Wetland Permit (tidal and non-tidal wetlands outside NJ Meadowlands)	NJDEP DLUR
NJ Flood Hazard Area Control Act / Rules	Individual Flood Hazard Permit	NJDEP DLUR
NJ Tidelands Law	Tidelands License (for short term/construction) Tidelands Lease (for long term/life of project)	NJDEP DLUR – Bureau of Tidelands
NJ Soil Erosion and Sediment Control Act / Standards	Soil Erosion / Sediment Control Plan Certification	Bergen County Soil Conservation District
NJ Water Pollution Control Act	NJ Pollutant Discharge Elimination System Stormwater – Construction Activities General Permit (5G3)	NJDEP Division of Water Quality
NJ Water Pollution Control Act	Treatment Works Approval (for pump station, if combined sewer/stormwater)	NJDEP Division of Water Quality
Meadowlands District Zoning Regulations (N.J.A.C. 19:4-1.1 et. seq.)	Zoning Certificate Site Plan Approval Construction Permit(s) Stormwater Permit	NJSEA
Municipal Land Use Law / Local Ordinances	Zoning Certificate Site Plan Approval Construction Permit(s)	Individual Municipalities (outside NJ Meadowlands District Boundary)
Air Quality Permit (NJAC 7:27-8.2(c)1)	Preconstruction permit and operational certificate for any fuel-burning equipment (i.e., emergency generators at pump stations)	NJDEP Division of Air Quality
Remedial Action Permit	At project completion (if a new feature is intended to act as a cap for contaminated soil)	NJDEP Site Remediation Program
NJDOT permits	Permits for utility accommodations, lane closures, temporary access, air safety, and zoning (as applicable)	NJDOT

- Land planning/zoning entities with jurisdiction in the Project Area (i.e., NJSEA within Meadowlands District and municipalities outside of the Meadowlands District);
- NJDEP Green Acres Program if existing parkland is affected during construction and for coordination for new open space listing on recreation and open space inventories; and
- NJDEP Bureau of Dam Safety for coordination related to impoundments (e.g., tide gate, levee, and floodwall segments).

11.3 Real Estate Acquisition

The purpose of the Real Estate Assessment is to estimate the real estate cost to be incurred to build the Preferred Alternative (Alternative 3 *Build Plan*) of the RBDM Flood Protection Project. The real estate encompassed by this estimate is directly impacted by the construction and placement of the improvements necessary for the Proposed Project. Impact is defined herein by interference to the Property Owner of any of the following:

- Loss of use (temporary or permanent);
- Ownership;
- Quiet enjoyment; or
- Habitability.

Conditions and Exclusions: Real estate acquisition estimates are based on the amounts and locations of real estate to be "taken" (occupied), whether by eminent domain or by easement. Price levels are based on current market values as of fourth quarter 2017, as provided by CoStar, Zillow, as well as property tax records. A recent revaluation took place in the subject communities. Real Estate Valuations are not tied to inflation. Instead, they are tied to cyclical market fluctuations that already incorporate inflation. Public parcels are excluded since their "contribution" to this initiative is considered to be a "quid pro quo" to the improvements they would obtain resulting from the Proposed Project.

Required Lands, Easements, and Rights-of-Way: Types of easements and acquisitions needed are as follows:

- Temporary Easement - occupied during construction to access areas to be built, store materials and equipment, and stage construction activities;
- Permanent Easement – occupied permanently to access areas built, as well as house permanent facilities and fixtures built as part of the Proposed Project; and
- Permanent Taking – occupied permanently to own and access areas built, as well as house permanent facilities and fixtures built as part of the Proposed Project. Those permanent facilities and fixtures include pumping stations, greenways, and open space/parks.

The Proposed Project would require the acquisition of easements or land in fee to facilitate the construction and maintenance of the resilience features and public access to achieve social co-benefits. **Table 11.3-1** shows a summary of the parcels that would be impacted by municipality.

Table 11.3-1: Summary of Parcels Impacted by Municipality

Municipality	No. of Parcels Impacted	Area of Easement or Taking (ft^2)		Total Impact Area (ft^2)	Total Impact Area (acres)
		Permanent	Temporary		
Carlstadt	21	193,631	58,759	252,390	5.79
Little Ferry	47	180,205	677	180,882	4.15
Moonachie	31	328,240	20,062	348,302	8.00
Total	**99**	**702,076**	**79,498**	**781,574**	**17.94**

Budget for Acquisitions and Easements: The budget for these is approximately $10.3 million, which includes the acquisition of sites for three areas that would become public parks ("Caesar Place Park", "Avanti Park", and "Riverside Park"). Certain easements (i.e., for sites along East Riser Ditch) are treated as less impactful than others because they run along inaccessible portions of the Project Area. Those conditions are taken into account in this budget.

Additional information on real estate acquisitions and analysis is available in **Appendix G**.

11.4 Construction

The Alternative 3 *Build Plan* would be separated into six contracts as shown below for design and construction. The construction schedule including design, permitting and real estate acquisition, the bidding and award process, and construction for the Alternative 3 *Build Plan* is summarized in **Table 11.4-1**. The six construction contracts are planned that would overlap as shown in the table. Detailed design is assumed to start in May 2018 with construction completion in September 2022.

1. Green Infrastructure Improvements: Carol Place, West Riser Ditch, DePeyster Creek, Park Street, and Main Street;

2. Open Space Improvements: Riverside Park, Willow Lake Park, Little Ferry Municipal Improvements, improvements at Little Ferry Public Schools, and improvements at Robert Craig Elementary School;

3. Open Space Improvements: Joseph Street Park and Avanti Park;

4. Open Space Improvements: Caesar Place Park;

5. East Riser Ditch Improvements: Pump Station, Channel Improvements, Culvert and Bridge Remove and Replace; and

6. Losen Slote Creek Pump Station A and associated force main.

Open Space Improvements at Riverside Park etc. would be the first construction award, scheduled to be awarded in December 2019, with an estimated construction duration of 14 months.

The East Riser Ditch Improvements contract is scheduled for award in January 2020, with an estimated construction duration of 20 months. Completion of this contract would provide immediate benefits to the Project Area.

The Green Infrastructure Improvements contract is scheduled for award in March 2020, with an estimated construction duration of 10 months.

The Open Space Improvements at Joseph Street Park and Avanti Park is scheduled for award in January 2021, with an estimated construction duration of 10 months.

The Losen Slote Creek Pump Station A and associated force main is scheduled for award in June 2021, with an estimated construction duration of 15 months.

The Open Space Improvements at Caesar Place Park is scheduled for award in January 2022, with an estimated construction duration of 8 months.

Table 11.4-1: Overall Schedule of Alternative 3 Build Plan for Completion by September 2022

Construction Durations are based on July 2017 Design Concepts			2018												2019												2020					
ID	Construction Duration	Task Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
1		**Green Infrastructure Improvements: Carol Place,West Riser Ditch, DePeyster Creek, Park Street, Main Street**																														
2		Design & Construction Drawings																														
3		Permitting & Easement Acquisition																														
4		Bid & Award																							BID							
5	**10 months**	Construction																												1	2	3
5a		Initial submittals/approvals, procurement, and mobilization activities.																														
5b		Field Construction Operations																														
6		**Open Space Improvements: Riverside Park, Willow Lake Park, Little Ferry Municipal Improvements, Washington & Memorial Elementary Schools, Robert Craig Elementary School**																														
7		Design & Construction Drawings																														
8		Permitting & Easement Acquisition																														
9		Bid & Award																														
10	**14 months**	Construction																									1	2	3	4	5	6
10a		Initial submittals/approvals, procurement, and mobilization activities.																														
10b		Field Construction Operations																														
11		**Open Space Improvements: St. Joseph Park, Avanti Park**																														
12		Design & Construction Drawings																														
13		Permitting & Easement Acquisition																														
14		Bid & Award																														
15	**10 months**	Construction																														
15a		Initial submittals/approvals, procurement, and mobilization activities.																														
15b		Field Construction Operations																														
16		**Open Space Improvements: Caesar Place Park**																														
17		Design & Construction Drawings																														
18		Permitting & Easement Acquisition																														
19		Bid & Award																														
20	**8 months**	Construction																														
20a		Initial submittals/approvals, procurement, and mobilization activities.																														
20b		Field Construction Operations																														
21		**East Riser Ditch Improvements: Pump Station, Dredging, Culvert and Bridge Remove and Replace**																														
22		Design & Construction Drawings																														
23		Permitting & Easement Acquisition																														
24		Bid & Award																					BID									
25	**20 months**	Construction																									1	2	3	4	5	
25a		Initial submittals/approvals, procurement, and mobilization activities.																														
25b		Field Construction Operations																														
31		**Losen Slote Pump Station A and Force Main A**																														
32		Design & Construction Drawings																														
33		Permitting & Easement Acquisition																														
34		Bid & Award																														
35	**15 months**	Construction																														
35a		Initial submittals/approvals, procurement, and mobilization activities.																														
35b		Utility Relocation																														
35c		Field Construction Operations																														

Construction Durations are based on July 2017 Design Concepts			2020						2021												2022											
ID	Construction Duration	Task Name	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1		**Green Infrastructure Improvements: Carol Place,West Riser Ditch, DePeyster Creek, Park Street, Main Street**																														
2		Design & Construction Drawings																														
3		Permitting & Easement Acquisition																														
4		Bid & Award																														
5	**10 months**	Construction	4	5	6	7	8	9	10																							
5a		Initial submittals/approvals, procurement, and mobilization activities.																														
5b		Field Construction Operations																														
6		**Open Space Improvements: Riverside Park, Willow Lake Park, Little Ferry Municipal Improvements, Washington & Memorial Elementary Schools, Robert Craig Elementary School**																														
7		Design & Construction Drawings																														
8		Permitting & Easement Acquisition																														
9		Bid & Award																														
10	**14 months**	Construction	7	8	9	10	11	12	13	14																						
10a		Initial submittals/approvals, procurement, and mobilization activities.																														
10b		Field Construction Operations																														
11		**Open Space Improvements: St. Joseph Park, Avanti Park**																														
12		Design & Construction Drawings																														
13		Permitting & Easement Acquisition																														
14		Bid & Award						BID																								
15	**10 months**	Construction								1	2	3	4	5	6	7	8	9	10													
15a		Initial submittals/approvals, procurement, and mobilization activities.																														
15b		Field Construction Operations																														
16		**Open Space Improvements: Caesar Place Park**																														
17		Design & Construction Drawings																														
18		Permitting & Easement Acquisition																														
19		Bid & Award																		BID												
20	**8 months**	Construction																			1	2	3	4	5	6	7	8				
20a		Initial submittals/approvals, procurement, and mobilization activities.																														
20b		Field Construction Operations																														
21		**East Riser Ditch Improvements: Pump Station, Dredging, Culvert and Bridge Remove and Replace**																														
22		Design & Construction Drawings																														
23		Permitting & Easement Acquisition																														
24		Bid & Award																														
25	**20 months**	Construction	6	7	8	9	10	12	13	14	15	16	17	18	19	20																
25a		Initial submittals/approvals, procurement, and mobilization activities.																														
25b		Field Construction Operations																														
31		**Losen Slote Pump Station A and Force Main A**																														
32		Design & Construction Drawings																														
33		Permitting & Easement Acquisition																														
34		Bid & Award										BID																				
35	**15 months**	Construction													1	2	3	4	5	6	7	8	9	10	11	12	13	14	15			
35a		Initial submittals/approvals, procurement, and mobilization activities.																														
35b		Utility Relocation													Utility Relocation																	
35c		Field Construction Operations																														

11.5 Operations and Maintenance

The RBDM project team developed O&M requirements for the Alternative 3 *Build Plan*. **Table 11.5-1** and **Table 11.5-2** show the maintenance requirements for green and grey infrastructure under the Alternative 3 *Build Plan*, respectively.

Table 11.5-1: Maintenance Requirements for Right-of-Way Green Infrastructure under the Alternative 3 Build Plan

Feature	Activity	Frequency	Equipment Needed	Material Movement
Bioswales and rain gardens	Erosion repair, weeding, pruning/replanting, mulching, structural repair, vacuum cleaning inlets, cleaning piping	Once per year and as needed	Vacuum truck, Hydro-jet cleaner	Collected trash, plant waste, replacement landscape stone
Trees (within tree trenches)	Mulch and prune, irrigate	Once per year and as needed	Hand tools	Plant waste

Table 11.5-2: Maintenance Requirements for Grey Infrastructure under the Alternative 3 Build Plan

Feature	Activity	Frequency	Equipment Needed	Material Movement
Channel improvements	Inspections (routine)	Four times per year	Truck, gas	N/A
	Inspections (flood event)	Twice per year (before and after storm)	Truck, gas	N/A
	Ditch/culvert cleaning (routine)	Once per year	Track-hoes, bulldozers, front-end loaders and dump trucks, utilize O&M corridor	Soil and dredged water, debris/garbage
	Ditch/culvert cleaning (flood event)	Twice per year (before and after storm)	Track-hoes, bulldozers, front-end loaders and dump trucks, utilize O&M corridor	Soil and dredged water, debris/garbage
East Riser Ditch pump station and Losen Slote Creek pump station A	Inspection	Four times per year	Truck, gas	N/A
	Daily operation, including cleaning and minor repairs	52 man days, 192 operating hours	Truck, gas, electrical power, replacement pumps (main and sump), lawn mower	N/A

N/A = not applicable

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Table 11.5-3 shows the maintenance requirements for the proposed parks and improvements under the Alternative 3 *Build Plan*.

Table 11.5-3: Maintenance Requirements for Parks and Improvements under the Alternative 3 Build Plan

Feature	Activity	Frequency	Equipment Needed	Material Movement	Associated Proposed Park or Improvement
Lawn (non-irrigated, non-athletic)	Mow	Typically every 7 to 10 days	Mower	Plant debris	Riverside Park, Little Ferry Public Schools, Caesar Place Park
Permeable play surface	Sweep and wash	Once per year	Power washer up to 2,800 pounds per square inch, carpet extraction machine, or leaf blower	N/A	Little Ferry Public Schools, Robert Craig Elementary School, Avanti Park
Stabilized granite pathway	Repair damage with application of stabilizer to area and compact, re-wet, and re-roll for minor repairs; larger repairs require application of a new mix of material	As needed	Hand tamp, 300 pound roller, or 1-ton roller	N/A	Riverside Park, Willow Lake Park, Little Ferry Public Schools, Robert Craig Elementary School, Joseph Street Park, Caesar Place Park, Avanti Park
Synthetic wood deck	Clean with soap and water	As needed	Bristle brush and hose	N/A	Riverside Park
Wood deck	Clean and strip	As needed	N/A	N/A	Riverside Park
Boat launch	Maintain paved surfaces and signage	As needed	N/A	N/A	Riverside Park

Feature	Activity	Frequency	Equipment Needed	Material Movement	Associated Proposed Park or Improvement
Permeable pavers	Clean and remove snow	Monthly snow removal within day after snowfall	Garden hose and stiff bristle brush; snow removal with standard plow in vehicular applications with rubber or nylon tip	N/A	Riverside Park, Willow Lake Park, Little Ferry Municipal, Little Ferry Public Schools, Robert Craig Elementary School, Joseph Street Park, Caesar Place Park, Avanti Park
Cast stone bench	Clean	As needed	Soft cloth, water, mild detergent; high-pressure hot water for aggressive cleaning	N/A	Riverside Park, Willow Lake Park, Caesar Place Park, Avanti Park
Wood and aluminum bench	Clean	As needed	Soft cloth, water, mild detergent	N/A	Riverside Park, Willow Lake Park, Caesar Place Park, Avanti Park
Litter Receptacle	Clean	As needed	Water, mild detergent	N/A	Riverside Park, Willow Lake Park, Caesar Place Park, Avanti Park
Light pole	Clean	As needed	Water, mild detergent	N/A	Riverside Park, Willow Lake Park, Caesar Place Park, Avanti Park
Light	Replace	As needed	N/A	N/A	Riverside Park, Willow Lake Park, Caesar Place Park, Avanti Park
Shade structure	Replace	As needed	N/A	N/A	Avanti Park
Play equipment	Replace, safety inspections	As needed	N/A	N/A	Avanti Park
Sports fields	Re-sod, mow, and irrigate	Twice per year, or as needed (May through October)	N/A	N/A	Little Ferry Public Schools
Bleachers	Clean	As needed	Power-washer		Caesar Place Park
Sports field backstop	Replace panels	As needed	N/A	N/A	Caesar Place Park

Feature	Activity	Frequency	Equipment Needed	Material Movement	Associated Proposed Park or Improvement
Trees	Mulch and prune, irrigate	Once in early spring and once every two weeks	N/A	N/A	Riverside Park, Willow Lake Park, Little Ferry Public Schools, Robert Craig Elementary School, Joseph Street Park, Caesar Place Park, Avanti Park
Native plants planting area	Weeding	As needed (May through October)	Hand tools	N/A	Riverside Park, Willow Lake Park, Little Ferry Municipal, Little Ferry Public Schools, Robert Craig Elementary School, Joseph Street Park, Caesar Place Park, Avanti Park
Native plants planting area	Pruning, mowing, re-planting	Once per year	N/A	N/A	Riverside Park, Willow Lake Park, Little Ferry Municipal, Little Ferry Public Schools, Robert Craig Elementary School, Joseph Street Park, Caesar Place Park, Avanti Park
Bioswales and rain gardens	Erosion repair, weeding, pruning/replanting, mulching, structural repair, vacuum cleaning inlets, cleaning piping	Once per year and as needed	Vac truck, cleaning truck	N/A	Riverside Park, Willow Lake Park, Little Ferry Municipal, Little Ferry Public Schools, Robert Craig Elementary School, Joseph Street Park, Caesar Place Park, Avanti Park
Wetlands	Invasive species removal	Once per year	Hand tools, no vehicular access needed	N/A	Caesar Place Park, Avanti Park

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