CONEY ISLAND CREEK
RESILIENCY STUDY

NYCEDC

NYC
Mayor's Office of
Recovery & Resiliency

#ONENYC

FOREWORD

Nearly four years ago, Hurricane Sandy roared into New York Harbor with unprecedented force, causing record-breaking water levels. Many neighborhoods were devastated, with homes and businesses becoming flooded, public services interrupted, and infrastructure damaged. After the storm passed and the water receded, a new reality emerged: New Yorkers must confront the implications of living in a coastal city in an era of climate change.

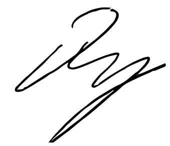
In April 2015, Mayor de Blasio put forward a new vision of resiliency in New York City – one borne out of the devastation of Hurricane Sandy and focused on additional shocks and stresses the city faces. *The Coney Island Creek Resiliency Study* is a key component of that OneNYC vision to ensure our neighborhoods, economy, and public services will be ready to withstand and emerge stronger from the impacts of climate change and other 21st century threats.

The *Coney Island Creek Resiliency Study*, which began in fall 2014, is an early step in a long-term strategy to protect the life, property, and livelihoods of Coney Island and Gravesend communities from the effects of storm surge and sea level rise. Over the past year, the study developed a shared resiliency agenda between the City and community members that included both short-term investments and long-term measures, complementing over $2 billion that is already being invested to make the neighborhoods of Coney Island safer.

As the study shows, there are significant short-term investments that the City can make now to enhance the resiliency of Coney Island. And the long-term resiliency of communities adjacent to Coney Island Creek relies on a comprehensive approach to the risks from climate change. To this end, we are proud to announce that the City worked successfully with the U.S. Army Corps of Engineers (USACE) to expand its Rockaway Reformulation Study area to include the neighborhoods of Southern Brooklyn adjacent to Coney Island Creek. By adopting a comprehensive regional solution for coastal flooding, including storm surge and sea level rise, which extends from Jamaica Bay to Gravesend Bay, the USACE is incorporating the lessons we've learned together during this study process. This is a critical project that deserves our support.

The City of New York would like to recognize the support of our local, state and federal officials; their support has been vital in building a stronger and more resilient Coney Island.

New York City is safer now than we were before Hurricane Sandy – and we also have much more to do before we'll be satisfied. Working together, we will continue to implement this vision for a more resilient Coney Island.



Daniel A. Zarrilli, PE
Senior Director, Climate Policy and Programs
Chief Resilience Officer
NYC Office of the Mayor

LEFT (from Left to Right): Informational sign at Calvert Vaux Park waterfront; School tour of Creek and Parks

PREFACE

The New York City Economic Development Corporation (NYCEDC) is pleased to release the *Coney Island Creek Resiliency Study* in coordination with the Mayor's Office of Recovery and Resiliency (ORR), and other key City, State, and Federal agencies. The study reflects a shared community and City vision for a resilient Coney Island Creek created through thoughtful input from area residents, business-owners, community organizations, and local experts in resiliency planning. These diverse perspectives were gathered and compiled during a 15-month long community engagement process with targeted stakeholder meetings, large-format public open houses and workshops, and engagement with citywide organizations that are strong advocates for our waterfront, the environment, and healthy resilient communities. Through this engagement process, the *Coney Island Creek Resiliency Study* achieves two equally important goals: providing a framework of options and tools to advance a more resilient Coney Island Creek, and strengthening a broad network of advocates focused on realizing this shared vision through future City, State, and Federal actions.

For more than a decade, NYCEDC has worked to spearhead and implement a comprehensive planning and a multi-hundred million dollar investment strategy for Coney Island. This has included infrastructure investments, enhanced access to open spaces and improved recreational areas, new and expanded community facilities, the creation of additional housing opportunities, and increased job growth and local job access for area residents. While it has always been the belief of NYCEDC that a vibrant neighborhood with opportunities for everyone is key to Coney Island being an economic engine for southern Brooklyn, Hurricane Sandy demonstrated that a coordinated economic development strategy is incomplete without a thorough look at how the community can protect itself from the devastating effects of climate change. This Coney Island Creek Resiliency Study shows that communities can protect themselves against rising sea levels and threats of storm surge, while also finding ways to enhance its social, economic, and environmental assets.

Rather than being an area of vulnerability to its neighbors, Coney Island Creek can be an asset and part of the long-term vitality of the Coney Island, Sea Gate, and Gravesend communities. Implementation of flood risk mitigation measures within the 100-year floodplain around the Creek communities could reduce flood risks for nearly 50,000 people and 6,000 buildings, representing 30 percent of residents currently living within a 100-year flood zone within Brooklyn. The *Coney Island Creek Resiliency Study* presents a diversity of approaches needed to deal with this challenge, establishes key community priorities and guiding principles for future resiliency planning and implementation, and describes near-term actions that begin to implement this shared vision for resiliency. A significant short-term step NYCEDC is excited to advance is the implementation of shoreline raising and ecological enhancements in critically low-lying areas around the Creek. This study is also a critical step towards long-term comprehensive planning and regional coordination with our State and Federal partners in the United States Army Corps of Engineers and the Federal Emergency Management Agency.

The *Coney Island Creek Resiliency Study* is the product of a collective effort and NYCEDC would like to acknowledge and thank the community partners and meeting participants that provided thoughtful insight throughout this study, particularly the Coney Island Creek Committee and Brooklyn Community District 13. Their commitment and expertise was and will continue to be critical in advancing a resilient Coney Island community.

Thomas McKnight
Executive Vice President
New York City Economic Development Corporation

LEFT (from Left to Right): View to mouth of Creek and Verrazano–Narrows Bridge; View from Home Depot Publicly Accessible Waterfront trail during winter

ACKNOWLEDGEMENTS

The New York City Economic Development Corporation (NYCEDC) and the Coney Island Creek Resiliency Team would like to thank and acknowledge the participants who attended community meetings and provided thoughtful input throughout the Study including Congressman Hakeem Jeffries, Councilmember Mark Treyger, Assemblywoman Pamela Harris, Community Board 13, Coney Island Creek Committee, Coney Island Public Meeting Attendees, United States Army Corps of Engineers, New York City Department of Parks and Recreation, New York City Department of Environmental Protection, New York City Department of Transportation, and New York City Department of City Planning. The expertise of these individuals, agencies and organizations was critical to creating a path to a more resilient Coney Island community. The Coney Island Creek Resiliency Team would also like to thank and acknowledge Charles Denson and Eddie Mark for sharing and allowing the usage of their photography throughout the Study.

The Narrows to Jamaica Bay
SOURCE: Bien & Company, 1890

1890's shoreline with an overlay of the current shoreline. Nearly a century of infill has intensified erosion and flooding in the area.

Hurricane Sandy Impact Analysis
SOURCE: FEMA Modeling Task Force (MOTF)

Map showing Hurricane Sandy inundation levels. The greatest extent of flooding occurred in regions that match where historic waterways and wetlands were located

This report was the result of a collaborative effort between Arcadis and its team members: HDR, Mathews Nielsen Landscape Architects, HR&A Advisors, Beyer Blinder Belle Architects and Planners, AKRF, COWI, and eDesign Dynamics.

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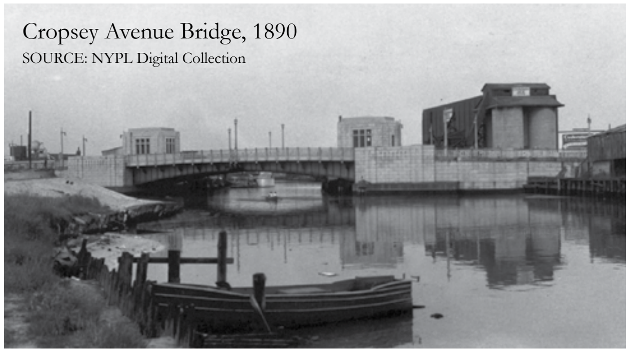
INTRODUCTION



Cropsey Avenue Bridge, 1890
SOURCE: NYPL Digital Collection

WHY STUDY CONEY ISLAND CREEK?

Coney Island Creek ("the Creek") is situated between the Gravesend and Coney Island neighborhoods of Brooklyn and was originally composed of two inlets: Gravesend Bay on the west and Sheepshead Bay on the east. Before the 1960s, the Creek was a strait uniting these waterbodies, but through industrialization and urbanization, wetlands and the natural shoreline were filled in from the 1890s to the 1960s.

Coney Island Creek is approximately 2 miles long with varying widths. The head of the Creek, at the intersection of Shell Road and the Belt Parkway, is approximately 60 feet wide. Winding to the west, the width of the Creek varies from 60 to 250 feet before opening up at the mouth to 700 feet. Historical changes in hydrology, or the movement of water, combined with the effects of low-lying topography (elevation) and climate change, make this area of the New York Harbor susceptible to tidal flooding and storm surge.

Hurricane Sandy highlighted the City's vulnerability to severe weather events, with Coney Island Creek being the first breach point of storm surge for the peninsula due to its particularly low-lying edges (ranging from 6-10 feet lower than that of the beachside of the peninsula) and the surge experienced during Sandy. In response to Sandy and in anticipation of future climate change, the City formed the Special Initiative for Rebuilding and Resiliency in order to (i) assess the risks faced by New York City's infrastructure, buildings, and communities in connection with climate change and (ii) create a strategy that increases New York City's resiliency to such risks. A comprehensive strategy was ultimately outlined in the June 2013 report, "*A Stronger, More Resilient New York*," which recommended 257 specific initiatives to rebuild the neighborhoods that were hardest hit by Sandy and prepare the city's infrastructure for future risks.

One of the 257 initiatives, Southern Brooklyn Initiative #5, proposes a rethinking of Coney Island Creek using a combination of edge-strengthening and edge-softening measures, such as wetland construction and a tidal barrier or dam across the Creek, to control storm surge and mitigate flooding. New York City Economic Development Corporation (NYCEDC), in partnership with the Mayor's Office for Recovery and Resiliency (ORR) and in coordination with other key City, State, and Federal agencies, was called to lead a study (the "Coney Island Creek Resiliency Study" or "Study") to evaluate the feasibility of long-term flood protection for Coney Island Creek and to understand its potential implications. This Study is a critical step in a long-term strategy to mitigate the effects of storm surge and sea level rise (SLR) around Coney Island Creek. The primary goals of the Study are presented to the right.

The Study focuses on the entirety of the Creek, from Gravesend Bay at the mouth to the head end, as well as neighborhoods directly upland of the Creek (the "Study Area"). For the purposes of the Study, feasibility was defined as being technically sound from an engineering and ecological standpoint, implementable, and coordinated with the Coney Island Creek community. Feasibility was determined by evaluating unique considerations, such as the target level of flood risk reduction and how the measures evaluated would be constructed and perform within the existing and proposed conditions for Coney Island. Of key importance is that the strategies and concepts considered were discussed and developed with the Coney Island community, who were asked to provide insight, feedback, and local expertise on formulating and defining what a resilient Coney Island Creek could look like in the future.

Primary goals of this Study are to:

1. Test the **feasibility of the flood mitigation concept** presented in *A Stronger, More Resilient New York* as Southern Brooklyn Initiative #5
2. Consider **community benefits** in a comprehensive and coordinated approach
3. Identify **immediate action** items to enhance resiliency in the near-term
4. Define implementation strategy for **long-term vision** to inform City and United States Army Corps of Engineers (USACE) planning activities
5. Conduct robust **community engagement**, empowering and mobilizing community stakeholders around the topic of resiliency

"WITH THE IMPACTS OF CLIMATE CHANGE UPON US, WE MUST THINK DIFFERENTLY ABOUT COASTAL RESILIENCY AND EXPLORE NEW TYPES OF MEASURES TO REDUCE FUTURE RISKS"

—Daniel Zarrilli, Director of the Mayor's Office of Recovery and Resiliency for the City of New York

Resiliency for Coney Island Creek means:

Comprehensive ecologically resilient and reliable flood mitigation measures for the Coney Island Community.

FRAMEWORK AND PROCESS

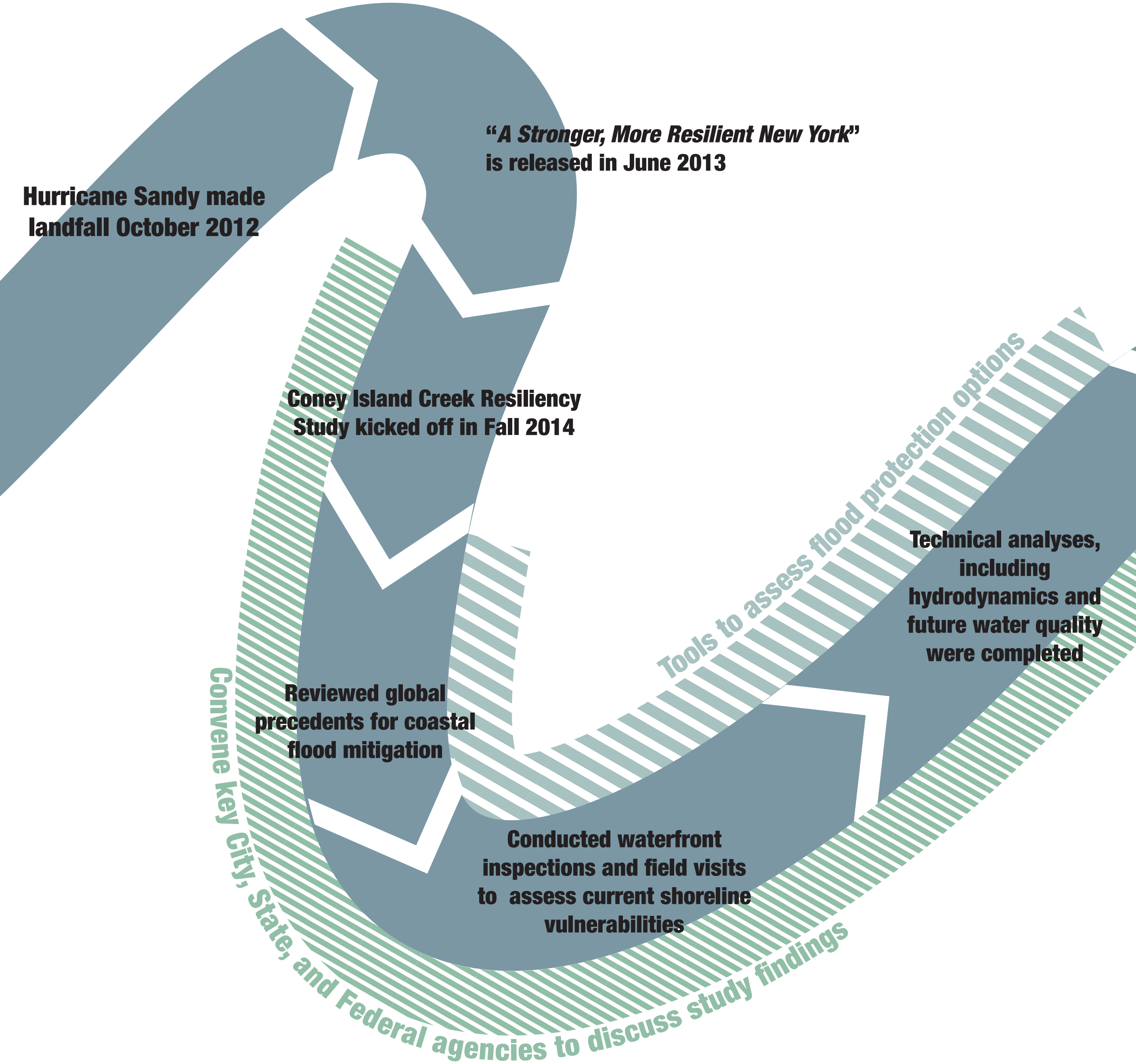
The Study set out to conduct robust technical analyses and test the feasibility of the coastal flood hazard mitigation concept presented in *"A Stronger, More Resilient New York"* as Southern Brooklyn Initiative #5: The Coney Island Creek Tidal Barrier and Wetland Concept. This Study was reinforced by the goals of OneNYC, which included strengthening New York City's coastal defenses against flooding SLR.

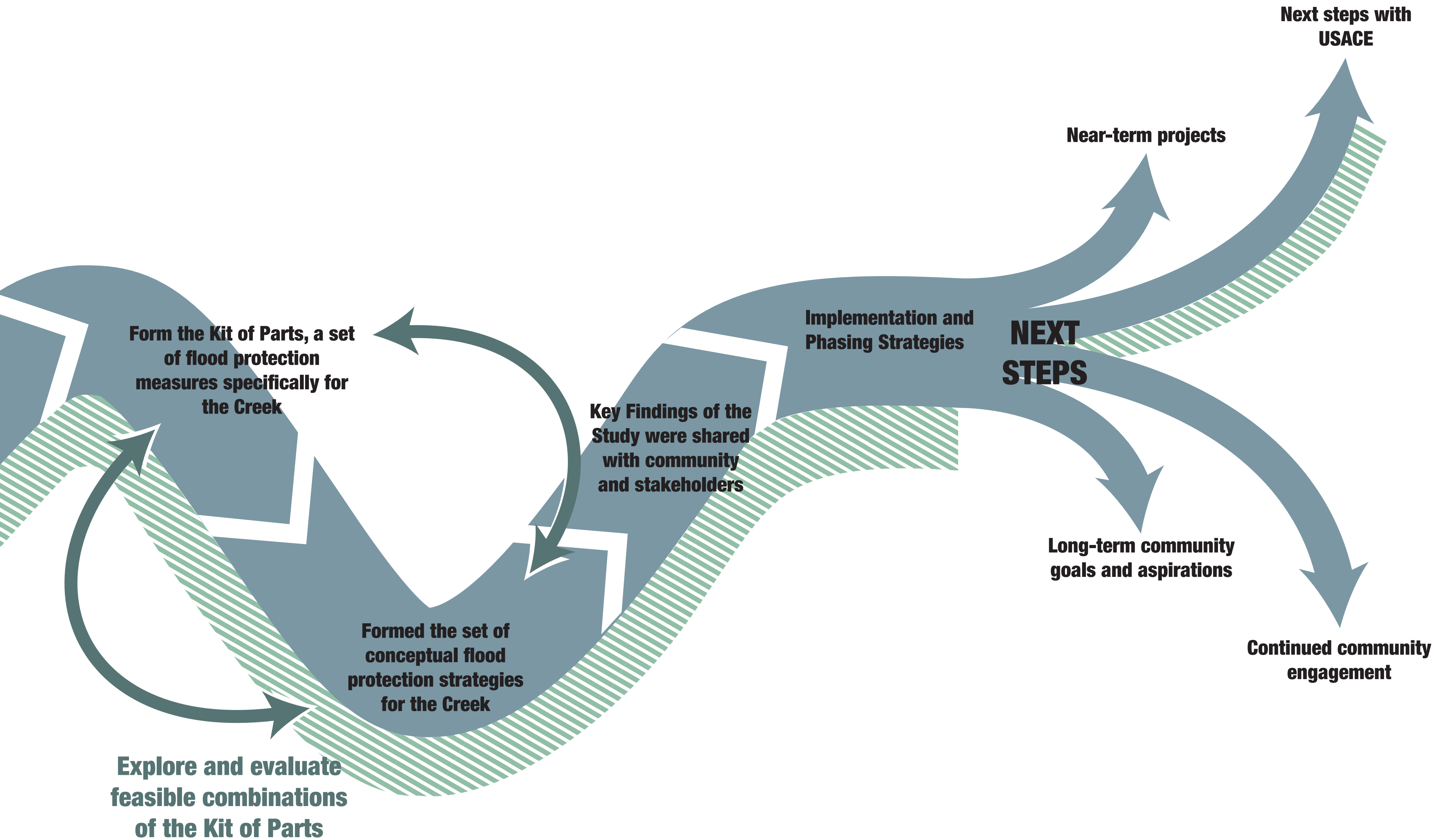
The first step was to understand the existing conditions of the Creek, such as the historic and current state of the shoreline, sediment, soil and water quality, and how a long-term flood protection strategy could fit into the urban framework of the Coney Island community. With a strong understanding of the current state of the Creek, engagement with the community and city, state, and federal agencies commenced to develop a set of guiding principles to inform the Study.

The existing conditions and guiding principles helped to narrow the universe of flood protection tools and strategies that could be employed in Coney Island Creek as not all met the site conditions or the goals of community members and stakeholders. These strategies were further evaluated with robust technical analyses, and the options that were still appropriate for Coney Island Creek formed the "Kit of Parts."

The "Kit of Parts" became the foundation, or "toolkit," that was used to form different strategies for long-term flood protection for Coney Island Creek. These strategies include different combinations and variations of in-water and shoreline measures, the pros and cons of which are presented within.

Key study findings, based on community and stakeholder feedback, technical analyses, and Coney Island context, as well as next steps after the Study concludes, are also discussed in later sections.





Next steps with USACE
Near-term projects
Form the Kit of Parts, a set of flood protection measures specifically for the Creek
Implementation and Phasing Strategies
NEXT STEPS
Key Findings of the Study were shared with community and stakeholders
Long-term community goals and aspirations
Formed the set of conceptual flood protection strategies for the Creek
Continued community engagement
Explore and evaluate feasible combinations of the Kit of Parts

COMMUNITY ENGAGEMENT

From kick-off to completion, the Coney Island Creek Resiliency Study was informed and guided by community members and stakeholders at the City, State, and Federal level. The feedback received shaped the questions that drove the study, the analyses completed, and the prioritization of flood protection measures in Coney Island Creek.

Stakeholder engagement included large public meetings and participation by the team in various Coney Island community events. These meetings provided opportunities for the community to share their feedback and further discuss the study methods and analysis.

CONEY ISLAND CREEK COMMITTEE

In addition to public community outreach events, NYCEDC convened the Coney Island Creek Committee, a group of local residents and organizations, to help define resiliency in the context of the Coney Island community. This Committee allowed for meaningful discussion, which helped further guide the project approach and goals. The Coney Island Creek committee met before public community meetings and discussed the key questions, analyses, and results pertinent to the Study.

The first community meeting introduced the Coney Island Creek Resiliency Study and Study team, led by NYCEDC, to the Coney Island community.

PRE KICK-OFF | OCTOBER 2014

SOURCE: Eddie Mark

"Flood protection should protect all components of the Coney Island Community and include additional open space"

WATER QUALITY AND ECOLOGY KICKOFF WITH NYSDEC

MARCH

FALL 2014

"What are we doing to make Coney Island more resilient?"

DEEP DIVES | JANUARY & FEBRUARY 2015

The Study Team held several meetings to delve into existing conditions and further understand the Creek.

MARCH

Community meetings throughout the course of the study provided opportunities for the community to provide perspective and discuss the analysis and findings.

COMMUNITY MEETING 1 | APRIL 2015

"The Creek is a crucial part of the Coney Island community and it is important that it continue to be an educational and recreational asset."

MAY

LONG TERM FLOOD PROTECTION DISCUSSIONS WITH USACE

NYCEDC CONVENED CONEY ISLAND CREEK ECO COUNCIL, A TEAM OF LOCAL AND REGIONAL TECHNICAL EXPERTS, TO DISCUSS ENVIRONMENTAL CONCERNS AND RESILIENCY FROM AN ECOLOGICAL PERSPECTIVE.

CITY OF WATER DAY | JULY 2015

At this community meeting the study team updated the community on the analysis and the components that could be included in flood risk mitigation measure.

COMMUNITY MEETING 2 | AUGUST 2015

SUMMER 2015

FLOOD PROTECTION, OPEN SPACE, AND COMMUNITY INFRASTRUCTURE DISCUSSIONS WITH NYCEDC, NYCDPR, NYCDEP, AND NYCDCP.

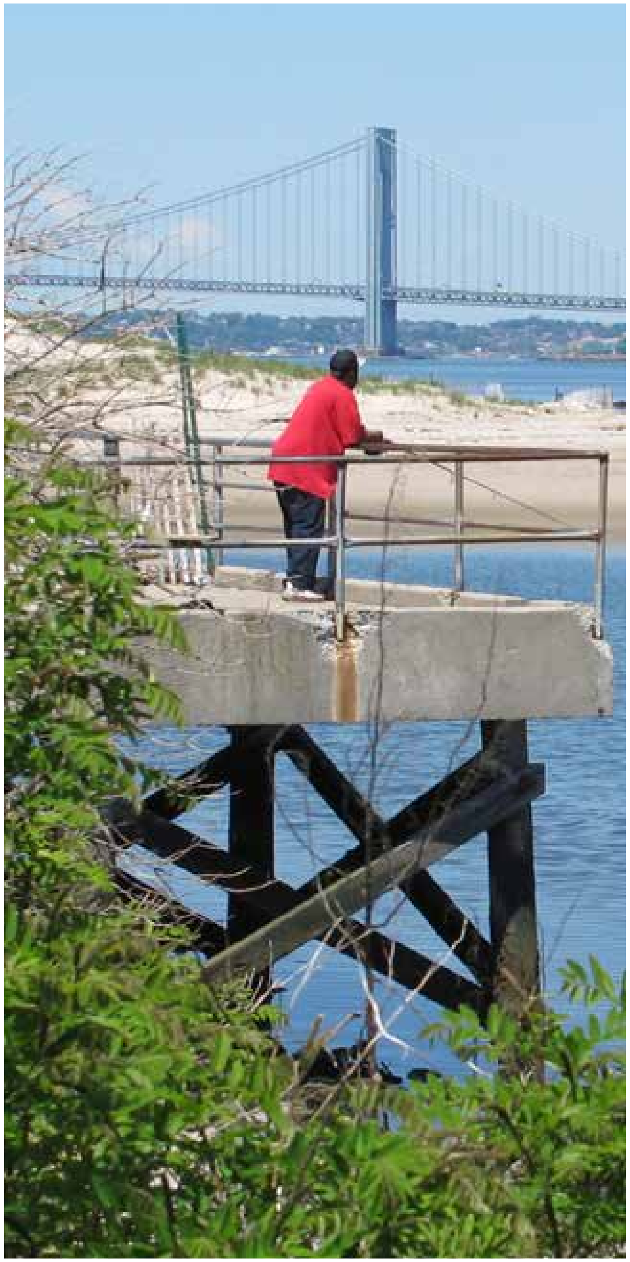
INTERNATIONAL COASTAL CLEANUP DAY | SEPTEMBER 2015

WINTER 2016

NYCEDC participated in the S.W.I.M. Coalition Clean Water Steward Workshop for Coney Island Creek. The workshop was organized and co-hosted by Coney Island Beautification Project, Partnership for Parks, S.W.I.M. Coalition, and The Wildlife Conservation Society's New York Aquarium and included many Coney Island community stakeholders.

S. W. I. M meeting | FEBRUARY 2016

GUIDING PRINCIPLES



Engaging the community and stakeholders was critical to shaping the parameters of the study and creating recommendations for a more resilient Coney Island.

The guiding principles presented below were arrived at after several public community meetings and close coordination with the Coney Island Creek Committee. These principles were interwoven with engineering and ecological considerations in the creation of flood protection strategies for the Creek. The following principles should be considered in future phases of planning and design for flood risk mitigation.

INVESTMENTS ARE NEEDED ALONG THE CREEK TO ACHIEVE A 100-YEAR FLOOD RISK REDUCTION AND A FEMA CERTIFIABLE PROJECT

Hurricane Sandy highlighted the vulnerabilities of Coney Island Creek to coastal storm events. The aftermath of Sandy left the area with damaged infrastructure, homes and critical facilities. Of top priority is to better understand the investments and improvements that are needed along the Creek to reduce this damage in the future, with the goal of achieving a 100-year flood risk reduction via a comprehensive system that addresses all portions of the Creek and takes into account future sea-level rise. Opportunities should be explored to certify flood protection systems with the Federal Emergency Management Agency (FEMA) to lower flood insurance premiums for residents who are a part of the National Flood Insurance Program.

IMPROVE OPEN SPACE ACCESS, CONNECTIONS, AND FLEXIBLE USE

Although flood protection is often thought of as a physical barrier to floodwaters, it can also serve as a benefit to the neighborhood. Many community members voiced concerns about open space and the ability to safely utilize Six Diamonds and Calvert Vaux Park to the north of the Creek. Flood protection strategies can be designed to address this concern because often flood protection is continuous and parallel to the shoreline and can serve as an ecologically enhanced waterfront pathway. The reconstruction of the waterfront edge that often accompanies the construction of a flood protection system can be designed in a way that also facilitates access to the water.

CREATE FLOOD PROTECTION WITH SECONDARY BENEFITS

Structural flood protection measures are major infrastructure improvements that are typically expensive to build, especially in existing urban environments. These measures will not only be a part of the Creek landscape during storm conditions but will also occupy space during non-flood conditions. Therefore, it is desirable for flood protection to provide community and ecological benefits at all times, whenever possible. Flood protection should be integrated into the community such that it creates a high quality and engaging addition to the environment.

CREATE OR PRESERVE VIEWS TO WATERFRONT

Currently, there are tremendous views out toward Gravesend Bay and New York Harbor from the Coney Island Creek area. These views can be expanded even further because flood protection infrastructure is typically elevated above low-lying areas. For instance, because flood protection infrastructure is typically elevated above low-lying areas, it can create higher vantage points with better views. Allowing low-lying floodable parkland to exist on the water side of flood protection will enhance these views further by creating an engaging and biologically active foreground to the distant harbor views.

IMPROVE ECOLOGY AND WATER QUALITY

The wildlife in Coney Island Creek is a valued resource that the local community members are proud of and wish to protect. Groups such as The Audubon Society regard Coney Island Creek, specifically the mudflats and shallow littoral zones, as one of the best places in the city to watch birds. The sheltered beaches provide areas for horseshoe crab spawning, and fishing a popular activity in the area. Although current conditions in shallow marine, wetland, and adjacent upland habitats contribute to the success of these species and others, there is room to further enhance these habitats. Flood protection measures often interface with adjacent waterways creating opportunities to modify the topography and vegetation in these areas to benefit appropriate target species.

CREATE SECURE SPACE

While most community members regard the four Creekside parks (i.e., Coney Island Creek Park, Calvert Vaux Park, Six Diamonds Park and Kaiser Park) as safe when compared to some of the busier streets or areas near the east end of the Creek, there are still areas of concern in and around the parks. For instance, along the waterfront of Six Diamonds Park, sightlines are obscured in places by dense vegetation, and zones of illegal activity are reported. As a result, park users and local residents sometimes feel unsafe in these public spaces. The analysis and urban design elements have focused on these concerns and will be a critical component of any future implementation.

ACCOUNT FOR DRAINAGE

Projects and efforts to improve the current state of drainage to accommodate future development in Coney Island are currently underway by the City. Therefore, it is important that any long-term flood protection measure recommended for the Creek be further analyzed to ensure it does not negatively impact current flow patterns or hinder drainage in the Creek. If necessary, additional stormwater management strategies are recommended as part of a comprehensive long-term plan. Opportunities can include adding green infrastructure and water retention technologies near the Creek as well as further upland in the area draining towards the Creek.

ABOVE: Native plants at edge of Creek

Community preferences:

- **Improved water, sediment and soil quality**
- **An additional means of emergency egress from the west end of Coney Island**
- **All flood hazard mitigation alternatives should equally protect the community**
- **A regional solution, including investigating a wide array of alternatives and the tradeoffs associated with each**
- **Enhanced recreational spaces and educational opportunities concerning ecology and flood protection**
- **An in-depth analysis of hazardous materials disposal and monitoring, if dredging is suggested**
- **Investigating the opportunity for dunes and other beachside resiliency measures**
- **A low-maintenance system that provides not only wave attenuation, but also flood protection**
- **A solution that coexists and builds off of existing parks programming and planned improvements, and allows for potential ferry service to the Creek**
- **The creation of workforce development opportunities and local job access should be prioritized if any resiliency related jobs are created**

TECHNICAL ANALYSIS

A critical step in understanding potential future options for flood risk mitigation was to fully establish an understanding of the existing conditions within the Creek and the surrounding communities of Coney Island and Gravesend. This included an investigation of the history of the Coney Island region and the Creek through a review of technical studies, community plans, and available reports, as well as site visits, boat trips, and in-water inspections. The current hydrologic and ecological conditions of the Creek were documented and closely examined. Also, current upland conditions, including stormwater infrastructure extent and capacity, land use, and zoning, were also studied. These existing conditions were the foundation on which the Coney Island Creek Resiliency Study was built, and examples of key findings are presented below.

SHORELINE CONDITIONS

An inspection of the existing waterfront structures was conducted in accordance with Waterfront Facilities Maintenance Management Systems guidelines. These guidelines are for above water and underwater inspections of waterfront structures and are based on standards currently used by the American Society of Civil Engineers (ASCE), the United States Navy, and the Port Authority of New York and New Jersey. Results show that, along the shoreline, there are many segments of engineered structures, such as bulkheads and revetments at the eastern section of Coney Island Creek and at Calvert Vaux Park. Additionally, there are stretches of non-engineered shoreline comprising debris-strewn embankments and "homemade" bulkheads, or bulkheads that are not city-regulated, from West 23rd Street up to Kaiser Park. Many stretches are in need of repair and/or maintenance, such as from West 22nd Street to Cropsey Avenue.

STORMWATER DRAINAGE

The Coney Island peninsula experiences flooding during large rain events due to its low-lying topography, high water table, and significant amount of impermeable and paved surfaces. Additionally, runoff from approximately 5 percent of Brooklyn's land area is conveyed through drainage pipes and overland flow in areas adjacent to the Creek. There are approximately 50 permitted and unpermitted discharge pipes and outfalls throughout the Creek. Of these, NYCDEP operates one combined sewer outfall and eight separate storm sewer outfalls. NYCDEP has plans underway to significantly upgrade and improve stormwater infrastructure to improve drainage. In addition, outfall construction is expected to support the resiliency of Coney Island Railyards. The City is also developing a Stormwater Management Program for separately sewered areas in accordance with new State MS4 Permit requirements.

WATER QUALITY

Water circulation in the Creek is limited by the confined nature of the waterbody, and the quality of water is largely attributed to low tidal flushing, background concentrations, debris and refuse from dumping or direct drainage in the Creek, and illicit discharges, which are illegal connections to sewer outfalls and pipes that convey discharges other than stormwater runoff. Currently, the Creek is classified by New York State as a Class I Waterbody, meaning it is best used for secondary contact recreation, such as boating and fishing, and suitable for fish propagation and survival. In October 2014, NYCDEP completed the construction of the Avenue V Pumping Station upgrade, which is expected to significantly reduce CSO discharges in the Creek. This upgrade, in addition to decades of greater City, State, and Federal regulations, will significantly improve water quality in the Creek. For instance, NYSDEC adopted a new rule to require that the quality of Class I water be suitable for primary contact recreation and adopted the corresponding total and fecal coliform standards.

URBAN DESIGN

The neighborhoods surrounding Coney Island Creek are characterized by an eclectic and layered built environment, wide east-west vehicular arterials, and a mix of residential and industrial land uses. There is also significant open space, particularly immediately adjacent to the Creek and a number of critical facilities and historical assets in the area. From an urban design and development point of view, these neighborhoods face challenges related to poor connectivity and complicated rebuilding or redevelopment conditions. At the same time, the broad boulevards, the ubiquity of open space, and the diversity of building types and zoning districts present opportunities for creative and inter-connected solutions—especially where resiliency measures require re-examining the relationship of the Creek to adjacent land and roadways.

SEDIMENT AND SOIL QUALITY

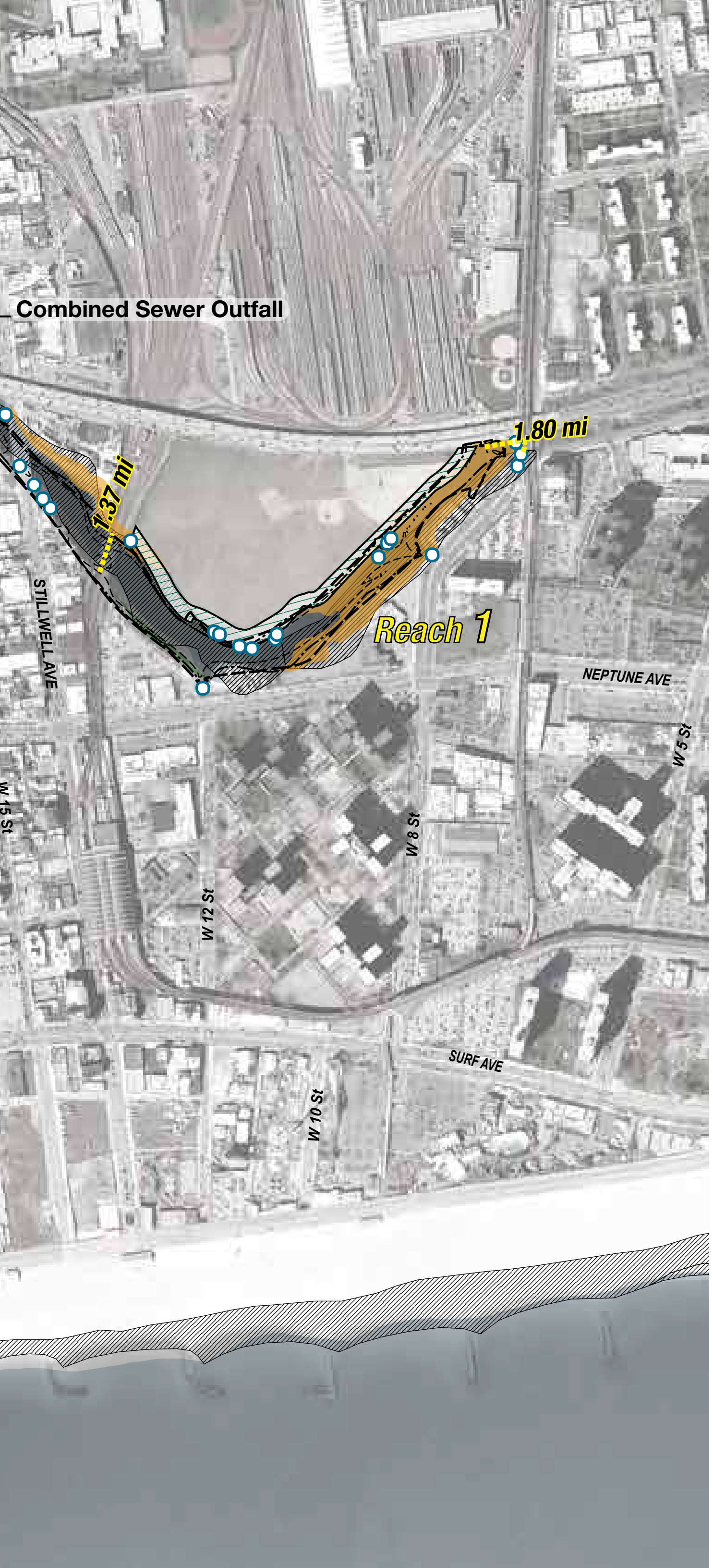
Adjacent upland areas bordering the Creek have been subject to contamination primarily as a result of historic industrial activities. In addition, drainage outfalls can convey sediment and/or pollutants from CSOs or stormwater runoff to the Creek. The sediment at the eastern end of the Creek was recently remediated as a result of a NYSDEC Record of Decision issued for the former Brooklyn Gas Works Site. In 2001 and 2002, the top three feet of sediments in the Creek between Shell Road and Stillwell Avenue were removed and treated off-site. The excavated area was then filled with three to four feet of clean materials, such as sand. In addition, a 50-foot ecological buffer zone was created alongside the shoreline of the Creek, and planted with native species. In all, approximately 60,000 cubic yards of contaminated sediment were removed and backfilled with quality sediment materials.

ECOLOGICAL DIVERSITY

The Creek is home to a wide range of plants and animals, including birds, intertidal salt marsh species, crustaceans, shellfish, small fish, rodents, reptiles, shrubs, upland grass, and organisms living in the Creek sediment. Regionally significant species such as the Harbor Herons (e.g., egrets, ibises, and herons), wintering waterfowl, horseshoe crab, and predator and prey finfish (e.g., bluefish, striped bass, blueback herring, and alewives) are found in the Creek. New York City Department of Parks and Recreation (NYCDPR) has restored portions of the shoreline along Calvert Vaux Park to an area suitable for horseshoe crab habitat and nesting. Based on annual monitoring, NYCDPR has observed a horseshoe population increase since 2002. A greater diversity of species is found along the western parts of the Creek, as it connects to the open waters of the Lower New York Bay.

EXISTING CREEK ECOLOGY

The Creek is a diverse waterbody with a range of ecological conditions. This is largely attributed to its geometry and form, which impacts tidal flushing and circulation. Therefore, when discussing water quality and the aquatic habitat, the Creek has been divided into five reaches, or continuous stretches, defined by bends or similar uniform features. The reaches begin at the head of the Creek, Reach 1, and move in a westerly direction until the mouth of the Creek, Reach 5.



Reach 5	Reach 4	Reach 3	Reach 2	Reach 1

WATER QUALITY GOALS:

The water quality in the Creek ranges from the west (the mouth) to the east (the head). The following categories can be used to measure the ecological health of the Creek. Water quality in the Creek is expected to improve significantly with the Avenue V Pumping Station upgrade reducing CSO volumes.

What percentage of the year is each reach of the Creek achieving its water quality goals?

	Reach 5	Reach 4	Reach 3	Reach 2	Reach 1
DISSOLVED OXYGEN	100%	99%	90%	88%	90%
FECAL COLIFORM	100%	100%	92%	80%	75%
COLIFORM	100%	100%	100%	92%	92%

SEDIMENT:

Sediment quality, which involves measuring the chemical and physical make up of the soils in the Creek, can influence the quality of overlying waters and the aquatic ecosystem.

What is the quality of soil at the bottom of the Creek?

MEASURED LEVELS OF CONTAMINATION ARE GENERALLY SIMILAR TO THOSE OF OTHER WATERBODIES IN THE NY/NJ HARBOR FOR METAL AND OTHER ORGANIC COMPOUNDS (Reaches 5–1)

CLEAN-UP OF CONTAMINATED SEDIMENTS (Reach 1)

FISH AND WILDLIFE:

Coney Island Creek is home to a variety of fish and wildlife, in the intertidal marshes, and on the rocks and beaches of the shoreline.

What wildlife or habitat conditions have been identified in the Creek?

LOW FISH SPECIES DIVERSITY - NORTHERN KINGFISH, STRIPED BASS, AND ATLANTIC SILVERSIDE REPORTED

URBAN-ADAPTED SONGBIRDS, WATERFOWL, SHOREBIRDS, AND MIGRATORY SPECIES

HORSESHOE CRAB BREEDING AREAS

AMPHIBIANS AND REPTILES, INCLUDING FROGS AND TURTLES

PEREGRINE FALCONS OBSERVED

TECHNICAL ANALYSIS

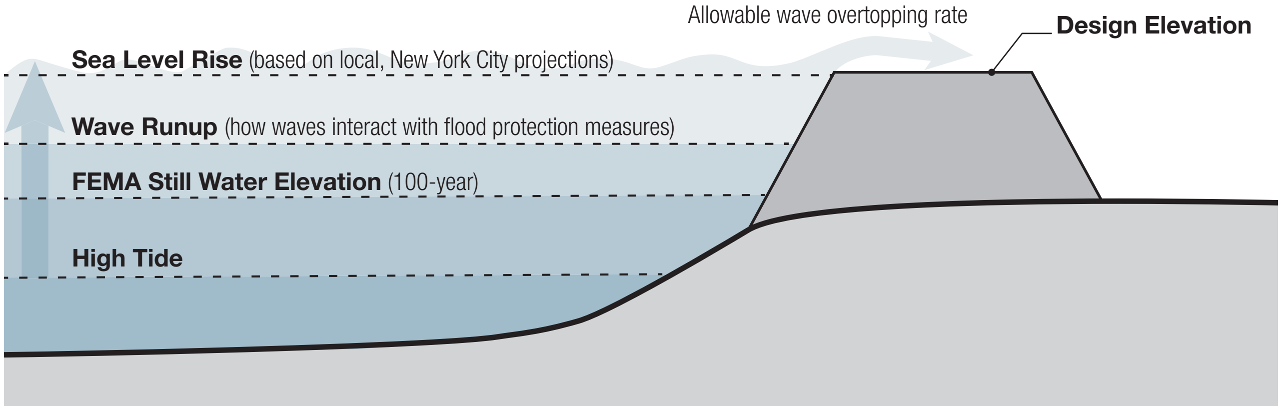
DRAINAGE ANALYSIS

To make informed decisions about how different flood protection strategies, both on-land and in-water, affect the drainage conditions of Coney Island Creek, an assessment of stormwater-related discharges to Coney Island Creek via existing outfalls and overland flow was completed. To do so, the City's existing models for drainage were employed, and the analyses included examining different rainfall intensities over the areas of Southern Brooklyn that currently drain into Coney Island Creek. Further analyses on stormwater runoff management will need to be explored as part of all comprehensive long-term flood protection strategies to ensure that no alternative results in unacceptable levels of surface ponding.

ABOVE: Stormwater and combined sewershed draining to the Creek

CONCEPTUAL DESIGN ELEVATIONS

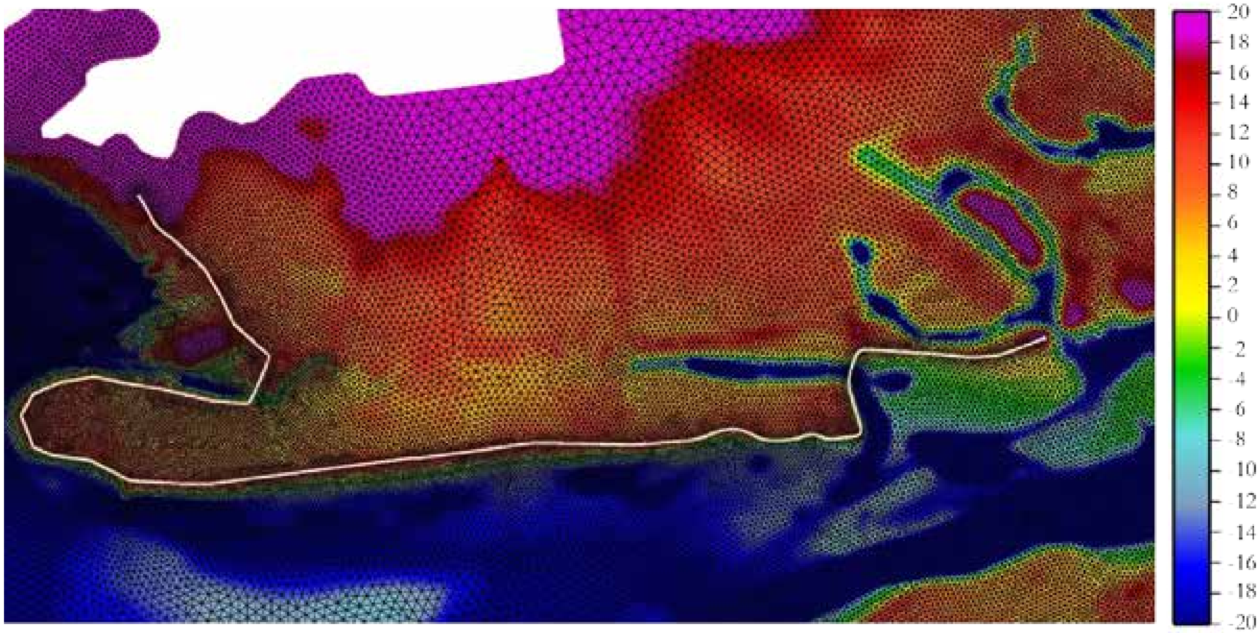
In order to determine how high flood protection measures would need to be to achieve different levels of flood risk reduction for upland neighborhoods, conceptual design elevations for a variety of measures were computed. A set of representative locations along the Creek were selected, and hydraulic conditions (i.e., water levels and wave heights) were then estimated based on FEMA data in the area. Understanding that wave run-up, or how a flood protection measure interacts with waves, is dependent on how close the measure is to the shore as well as the angle at which the wave strikes the structure. A levee with a 1 to 3 slope, a vertical bulkhead directly at the coast, and a vertical floodwall set 100 feet inland from the coast were evaluated. In addition to current conditions, a 2050s SLR projection was assessed based on the New York City Panel on Climate Change high-estimate (90th percentile) recommendations.



ABOVE: Schematic of different components of design elevations

HYDRODYNAMIC MODELING

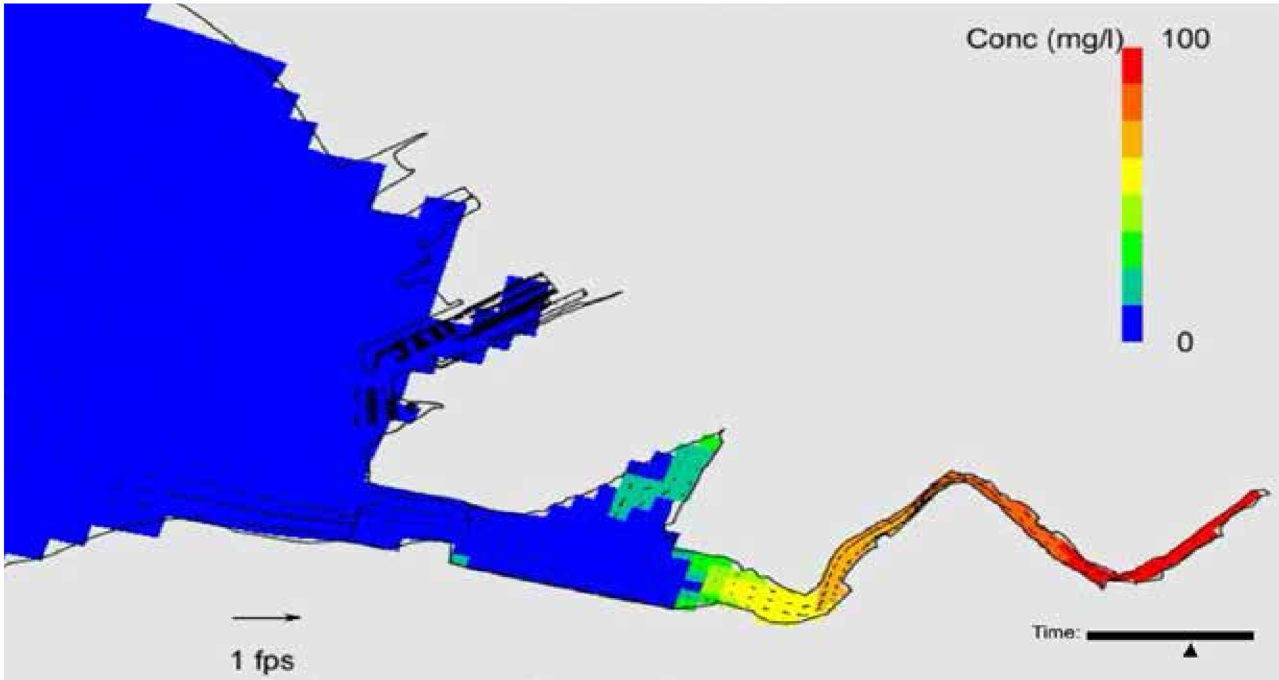
The ADvanced CIRCulation hydrodynamic model (ADCIRC) and Simulating WAves Nearshore wave model (SWAN) simulated the storm surge and waves from Hurricane Sandy (similar to a 100-year storm event) with 2050s SLR for Coney Island Creek and the surrounding waterbodies. The ADCIRC+SWAN model was selected because it was used for The Special Initiative for Rebuilding and Resiliency in 2012, has been extensively validated and subjected to peer review and is used by FEMA, and is commonly used for storm-tide analysis. In Coney Island, the model was used to understand wave and storm surge activity with flood protection measures in place, as compared to a future scenario without flood protection measures in place. It was also used to understand how an in-water tidal barrier could impact water velocities in the Creek and ensure that the tidal barrier would not induce flooding elsewhere as a result of its implementation.



ABOVE: Superstorm Sandy ADCIRC+SWAN hydrodynamic model (Units in feet NAVD88)

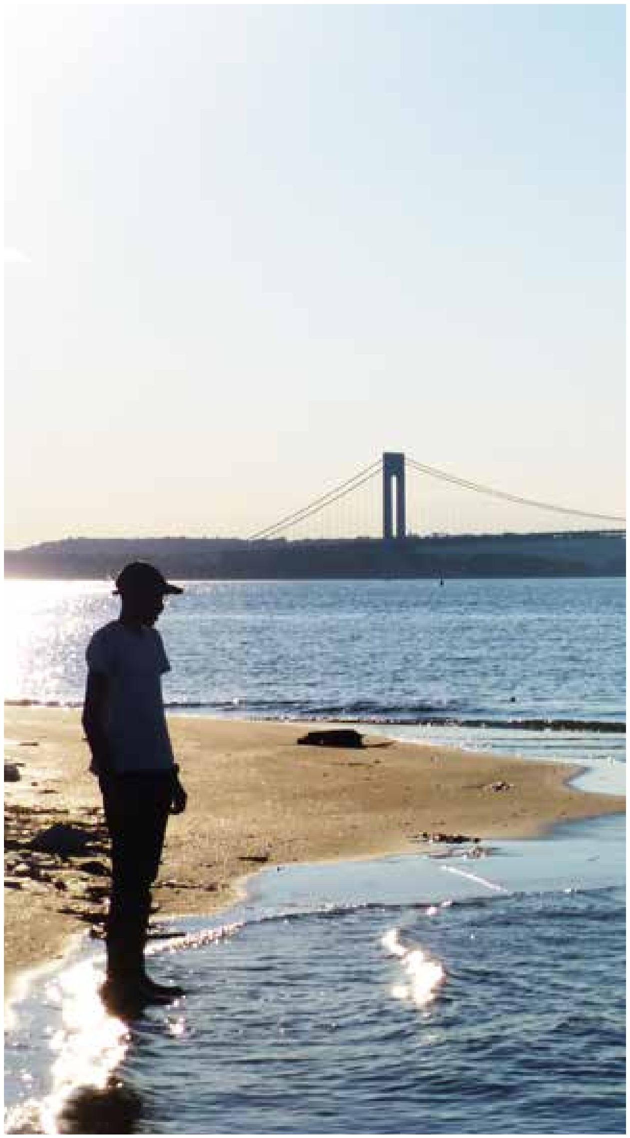
FUTURE WATER QUALITY

The same water quality model used for NYCDEP's CSO Long Term Control Plan (LTCP) and the new enlarged outfalls to be constructed by the New York City Department of Design and Construction (NYCDDC) as part of NYCDEP's Coney Island Amended Drainage Plan (Dec. 2010) was used to evaluate impacts of a tidal barrier on water quality conditions in the Creek. The model allows for a future scenario with a tidal barrier to be compared to existing and baseline (i.e., future without tidal barrier) scenarios and to illustrate differences in water quality conditions. A barrier alignment further into the Creek (near West 21st Street) was selected for water quality modeling purposes because this alternative was more conservative than a barrier location near the mouth of the Creek. A worst-case scenario at this location was assumed: the barrier was closed for four days during wet weather events, impeding tidal flows and obstructing stormwater-related discharges from escaping the Creek. Preliminary results suggest that the Creek would be expected to rebound to its current state once the barrier is reopened, or, more simply stated, an in-water tidal barrier would not have negative, long-term impacts on the Creek.



ABOVE: Coney Island Creek tracer model performed to illustrate water quality conditions within the Creek

KEY FINDINGS



1 Regional Resiliency planning is critical in order to protect the Creek.

One of the first findings of the Study was that the Coney Island peninsula is very low-lying. As a result, locating high ground in which to tie in flood protection measures to create a continuous system is challenging. Building upon this finding, as well as the guiding principle to strive for 100-year flood risk reduction for communities that are upland of the Creek, it became apparent that any flood protection measures proposed for the Creek must integrate into regional efforts currently being explored and constructed. Many of these initiatives are presented later in the report.

2 A FEMA certified flood protection system is feasible.

One of the guiding principles for the Study was to evaluate whether long-term flood protection for the Creek was feasible and whether or not it could meet the design criteria to be certified by FEMA in the future. The benefit of having FEMA certification is that flood insurance premiums can be lowered for those residents who are part of the National Flood Insurance Program.

The process began with understanding conceptual design elevations for different structural flood protection measures near the perimeter of Coney Island Creek to protect the region from a 1-percent annual chance flood event (or 100-year flood risk), as per FEMA guidelines. Future sea level rise was also incorporated into the design height such that a flood protection system could continue to be certified in the future should sea levels continue to rise. Then, how the system could be phased and implemented, operated and maintained, and different flood protection measures interacting with the urban fabric of Coney Island were considered to determine if FEMA certified flood protection fit within the context of the community. Five flood protection alternatives, including both in-water and on-land strategies, demonstrated the ability to achieve 100-year flood risk reduction and be certifiable by FEMA.

3 Stormwater drainage and surface water mitigation must be an integral part of all flood protection strategies.

The study recognizes that as part of any coastal protection option, there would need to be an integrated drainage solution to mitigate rainwater and groundwater impacts during a storm event as part of a long-term flood protection strategy for the region. To address this, preliminary rainfall and storage capacity analyses were conducted. The capacity of the Creek varies by the time of year, the time of day, the shape of any given storm. On average, however, it can hold roughly 45-65 million gallons of stormwater runoff if an average height of the shoreline is around 7-8 feet NAVD88 is assumed.

The initial findings reveal that, both with and without an in-water flood protection measure, the Creek system has a difficulty containing water from high-frequency storm events. For example, the eastern barrier alignment, among the most conservative flood protection strategies, the maximum volume that the Creek can hold behind a closed

WHAT ELSE DID WE LEARN DURING THE STUDY?

barrier is much smaller than the runoff volume generated by a 10-year flood event.

Equally important for drainage is to confirm that, on land, runoff generated by rainfall events can safely discharge into the Creek. This means ensuring that the flow of surface water is not impeded by new on-land measures that are part of the flood protection system. There are, however, potential opportunities to route flows to the new Ave V Pumping Station or manually close a tidal barrier (if one was installed) at low tide to make room for more storage.

Future analyses are recommended to understand the timing between peak storm surge and rainfall, how to best manage stormwater runoff to the Creek, and how the Creek's storage is part of a long-term flood protection strategy.

4 An in-water barrier with a wide opening does not negatively impact tidal circulation or water quality in the Creek.

The Creek is home to a diverse range of aquatic species, and, improving the current state of the ecology and soil, sediment and water quality of the Creek, was a key priority for community members. Therefore, it was stressed that no detriment to tidal circulation or water quality in the Creek would be permitted for any long-term flood protection solution during non-storm conditions. Through the use of water quality models for the eastern barrier alignment, which was considered the most sensitive due to the volume of water behind the structure, it was demonstrated that there were no long-term effects on water quality or water circulation in the Creek.

5 A flood protection system with fewer parts that need to be deployed or operated is preferred, where possible.

Different flood protection measures included in the "Kit of Parts" require varying levels of operation prior to and during a storm event, as well as year round maintenance to ensure the measures perform as expected. Through regular workshops and meetings, the community voiced a strong preference for implementing a system that does not require off-site storage of deployable parts and requires minimal human operation or maintenance in order to perform during a storm event. This could include repairing or constructing new bulkheads, selecting types of floodgates as part of a tidal barrier, and ensuring native plant species are selected for any restoration or plantings to help with wave attenuation.

6 Community and stakeholder involvement is a critical element in furthering a long-term flood protection strategy.

It is imperative that the community of Coney Island Creek and stakeholders continue to be involved in the planning and design process for flood protection in the area. As residents voice their priorities regarding the design, new analyses will need to be completed in order to understand the feasibility of different strategies that satisfy the desires of all invested parties.

7 There are large uncertainties associated with many key cost drivers associated with implementing flood protection.

An approximation of the cost to implement a long-term flood protection strategy for Coney Island Creek (from Gravesend through the Coney Island Beach) is on the order of $800 million- $1 billion; however, great uncertainty is associated with this estimate. Drivers of this uncertainty include the quality of the soils along the conceptual flood protection alignment and to what degree environmental remediation would be needed, whether utilities and service diversions would be required, the floodgate typology selected should an in-water barrier be recommended, as well as right-of-way and real estate considerations to construct the flood protection system. While contingencies were built into the cost estimate to account for these potential drivers, it is recommended that these areas be further investigated in future phases of design to refine the cost estimate.

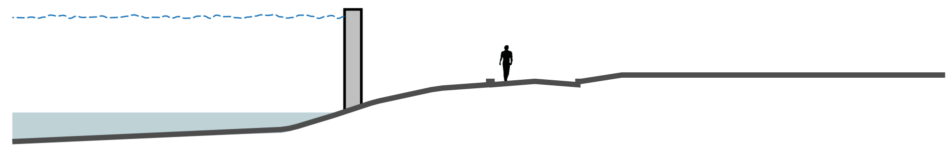
CONEY ISLAND CREEK KIT OF PARTS

At the onset of the Coney Island Creek Resiliency Study there were a range of potential coastal flood mitigation options that were considered. However, our guiding principles, existing Creek conditions, and technical analyses helped focus the options to a smaller subset, or, a "Kit of Parts." The flood protection measures in the "Kit of Parts" vary and include those both on-land and in-water, those that are green and those that are grey, those that are permanent and those that are deployed, and those that help attenuate wave energy and those that keep shorelines dry. Ultimately, there is no one "silver bullet" approach for flood protection and different combinations of these parts form different, feasible, flood protection strategies. The measures presented to the right are examples of the flood protection options that could be a part of a comprehensive flood protection strategy for the Creek.

A COMPREHENSIVE SYSTEM TO PROTECT THE ENTIRE PENINSULA WILL HAVE TO INCORPORATE A VARIETY OF STRATEGIES.

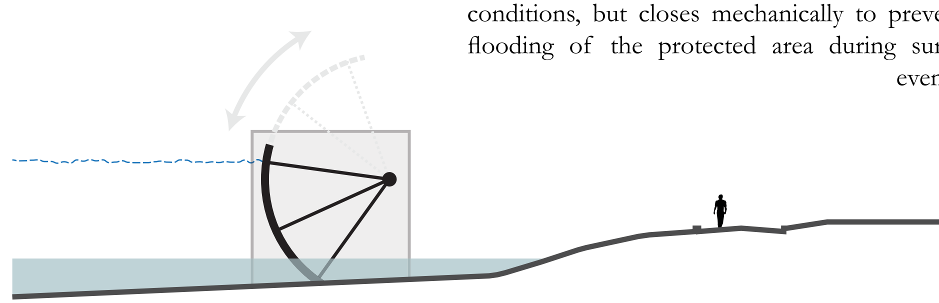
FLOODWALL

A structural, vertical barrier built to prevent flooding for upland areas. Floodwalls have a small footprint and can be easily integrated with other flood protection strategies.



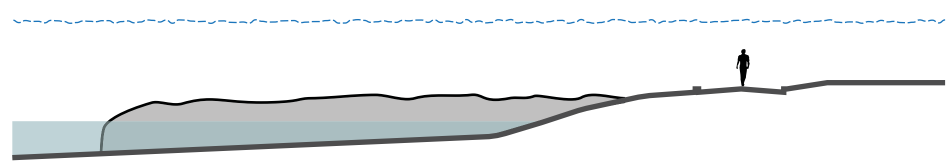
FLOODGATE / TIDAL BARRIER

An in-water structure that remains open to allow water and vessels to pass during non-storm conditions, but closes mechanically to prevent flooding of the protected area during surge events.



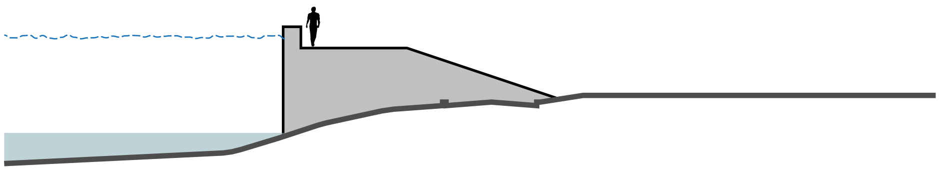
GROIN

An embankment perpendicular to the shore, intended to attenuate waves and limit the transport of sediment over time.



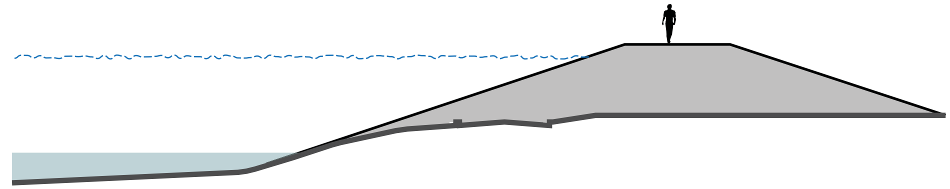
BULKHEAD

A vertical wall, usually made of steel, concrete, or timber, designed to protect adjacent land from damaging wave action. Bulkheads are typically implemented along the shore and backfilled with earthen material behind the structure.



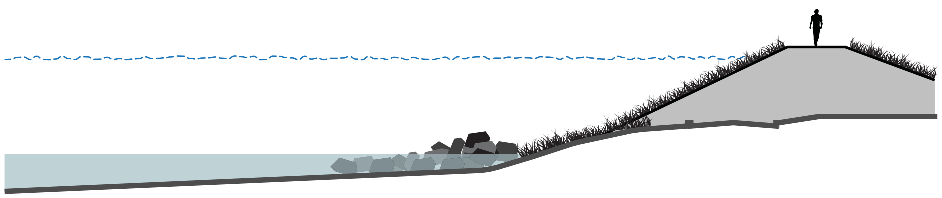
LEVEE

An artificial embankment made of compacted earthen material, designed to block floodwaters. Levees can be designed to have a road or pedestrian walkway on the crest.



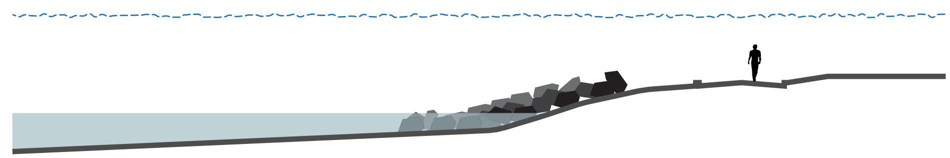
LIVING SHORELINE

A gently sloped shore covered in vegetative growth, designed to attenuate wave energy. Living shorelines can be paired with levees to provide more substantial flood protection.



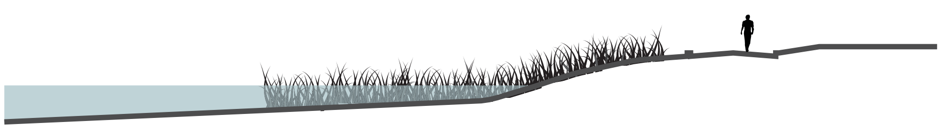
STONE ARMOR

Sloped structures on the shore that prevent erosion and help to dissipate incoming wave energy.



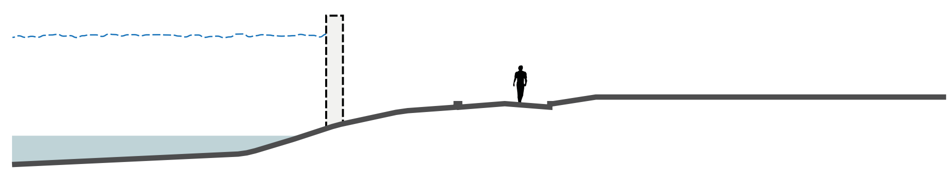
WETLANDS

Tidally influenced marshes that are connected to open water. Wetlands attenuate wave energy and provide a habitat for many species.



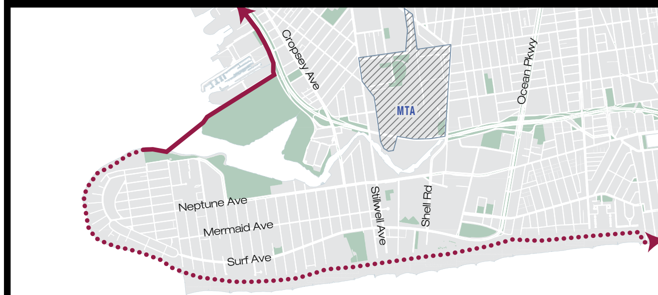
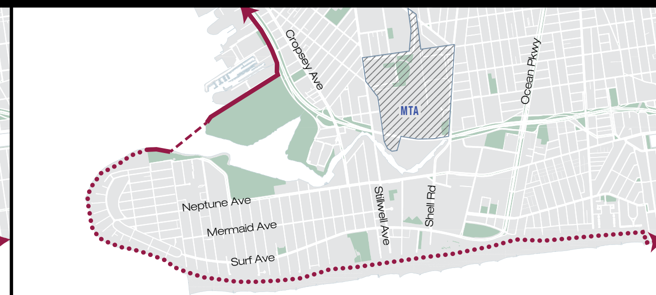
DEPLOYABLE SOLUTIONS

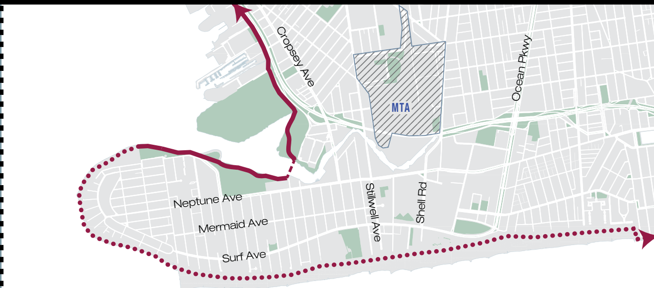
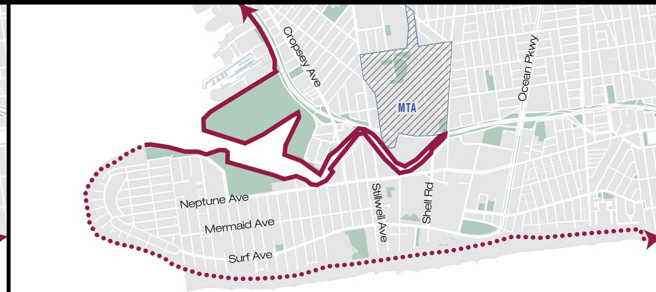
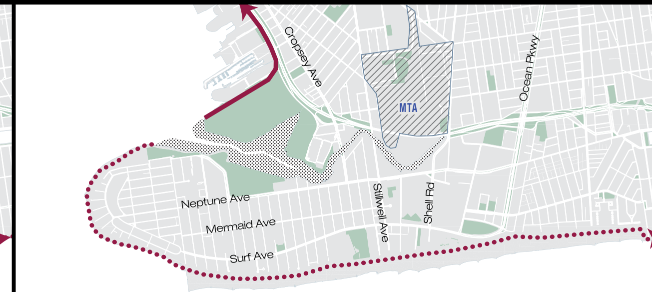
Structures that need to be constructed or assembled in preparation for a surge event. Examples of deployable solutions include sandbags, tiger dams, and roller gates.



POTENTIAL FLOOD MITIGATION ALIGNMENTS AND TRADE-OFFS

Note: Options are described further on page 26.

GOALS		BARRAGE	CALVERT VAUX ALIGNMENT
		 In-water barrier; closed at all times	 Longer, wide open in-water barrier; closed only during storm events
COASTAL FLOOD RISK REDUCTION AND RELIABILITY	Provide flood mitigation for adjacent neighborhoods	(+) Will provide significant flood risk reduction for upland neighborhoods (+) Largely passive flood protection system (+) Could be FEMA certified	(+) Will provide significant flood risk reduction for upland neighborhoods (+) Could be FEMA certified (−) Active flood protection (i.e. gates) to be deployed prior to storm event (−) Greater wave energy at mouth of the Creek results in taller design elevation in order to achieve same level of flood protection
ECOLOGICAL CONSIDERATIONS	Improve water quality and enhance Creek ecology	(−) Fill significantly changes ecology of creek (−) Will compromise existing fish habitat and reduce water quality	(+/−) Wide opening floodgate should not impair tidal circulation or mixing, therefore having minimal impact to aquatic habitat
COMMUNITY BENEFITS	Increasing public access to the waterfront and strengthening physical connections	(+) Potential to enhance connectivity between neighborhoods across the Creek (−) Solid in water connecting infrastructure may have impacts on people's perception and/or experience of the Creek (−) Would reduce water-dependent recreational opportunities in the Creek	(+) Potential to enhance connectivity between neighborhoods across the Creek (−) Height of flood protection has potential to limit access to and visibility of the water
MAJOR COST DRIVERS	Identification of items that have large impact to costs, as well as a comparison of the a range of capital needed for implementation	Will require significant utility relocation May interfere with flow of existing and planned storm sewer outfalls (NYCDEP's Amended Drainage Plan) Approximate capital needs: **$$**	In-water construction near the mouth of the Creek will be costly due to increased design elevation and length of in-water footprint Approximate capital needs: **$$$**
IMPLEMENTABILITY	Regulatory and permitting considerations, as well as property ownership	(−) Significantly impacts hydrology of Creek, may create greater permitting hurdles (−) Filling to create wetland behind the partition will create permitting obstacles	(−) Larger and more pristine area of the Creek and hydrology impacted by barrier (−) Potential permitting obstacles
FEASIBILITY	Does alignment achieve study goals?	Ecological considerations make this concept difficult to implement	Greater in-water construction would be costly and difficult to permit

SIX DIAMONDS ALIGNMENT	SHORELINE PERIMETER	RECONTOURING
		
Shorter, wide open in-water barrier; closed only during storm events	On-land flood protection along Creek shoreline	In-water plantings for wave energy reduction
(+) Will provide significant flood risk reduction for upland neighborhoods (+) Reduced wave energy further upstream in Creek results in needing a lower design elevation for same level of flood protection (+) Could be FEMA certified (−) Active flood protection (i.e. gates) to be deployed prior to storm event	(+) Will provide significant flood risk reduction for upland neighborhoods (+) Largely passive flood protection system (+) Could be FEMA certified	(+) May help dissipate wave energy (−) Will not provide significant flood risk reduction for upland neighborhoods (−) Could be FEMA certified
(+) Moving barrier inland minimizes in-water footprint (+/−) Wide opening floodgate should not impair tidal circulation or mixing, therefore having minimal impact to aquatic habitat	(+) No impact to tidal circulation or mixing, therefore having minimal impact to aquatic habitat (−) Limit wildlife movement between upland and aquatic habitats	(+) Expansion of aquatic habitat (+/−) Potential to improve water quality
(+) Potential to enhance connectivity between neighborhoods across the Creek (+) Longer on-land flood protection measures present the opportunity for infrastructure doubling as new investments in open space and recreational opportunities (+) Shorter design height than west barrier minimizing visibility impacts	(+) Longer on-land flood protection measures present the opportunity for infrastructure doubling as new investments in open space and recreational opportunities (−) Will not change connectivity between neighborhoods across the Creek perception / experience of the creek (−) Height of flood mitigation has potential to limit access to and visibility of the water	(+) Potential ecological enhancements to Creek habitat may make the region a more attractive destination (+) Will not impact views or access to the Creek (−) Will not improve connectivity across the Creek (−) Would reduce water-dependent recreational opportunities in the Creek
In-water construction further upstream will be less costly due to decreased design elevation and smaller in-water footprint Approximate capital needs: **$$**	Much of shoreline is privately owned, increasing real estate cost Prior shoreline uses may necessitate soil remediation prior to construction Approximate capital needs: **$$**	Leaves portion of Coney Island at risk without flood protection Approximate capital needs: **$**
(+) Minimizes impact to hydrology, potentially reducing permitting (+) On-shore flood protection measures could incorporate short-term investments, potentially making the strategy more cost-effective (−) Tree removal near Six Diamonds Park could be significant	(−) Much of the shoreline is privately owned, complicating the implementation pathway forward (−) Universal cooperation of all Creek-adjacent property owners	(−) Filling the Creek to create wetland will create permitting obstacles
Most feasible due to smaller in-water footprint and ecological impact	Extensive private property at shoreline complicates implementation	Does not reduce flood risk and significantly impacts open water

CONCEPTUAL COASTAL FLOOD MITIGATION STRATEGIES

Long-term coastal flood mitigation conceptual strategies for the Creek were developed by combining and building upon the individual measures presented in the "Kit of Parts." These strategies stem from a large-scale flood protection strategy, akin to what was described in "*A Stronger, More Resilient New York*" as Southern Brooklyn Initiative 5, including the use of tidal barriers in-water to detain storm surge. In addition, on-land flood or perimeter protection measures, including but not limited to levees and floodwalls, are components of many of the strategies, whether complementing the in-water measures to create a continuous line of flood protection, or as part of a perimeter strategy where flood protection measures only exist on-land.

Reflecting on the community and stakeholder guiding principles, the site conditions unique to the Creek, and the findings from the technical analyses, six alternative conceptual strategies were developed and evaluated. These strategies include two tidal barrier configurations, one perimeter protection configuration, one configuration where a portion of the Creek is closed off, and one configuration where the Creek is recontoured and filled with wetlands. A detailed description of the configurations is presented below, and a comparison table is presented on the previous page.

BARRAGE

One alternative evaluated involved closing off a portion of the Creek using a marine floodwall and filling in the Creek behind the structure with either fill or wetlands. This variation, similar to Southern Brooklyn Initiative 5, has the benefit of being a passive system, meaning it has no mechanical parts that need to be operated before or after a coastal storm event, and minimal maintenance during non-storm conditions. However, closing off a portion of the Creek to tidal flushing could create a stagnant pool of stormwater and sewage that would have many environmental and ecological impacts. If tidal waters are impeded by the barrage, the area will no longer be a natural estuarine environment and anadromous fish passage up the creek would be eliminated. It is also unlikely that the constructed wetlands would adequately treat the CSO discharge to support valuable fish and wildlife habitat, meaning there would be a major change in the species composition of the creek bed and associated habitats. In addition to ecological impacts, surrounding neighborhoods may experience increased nuisance odors and poor aesthetics from the lack of tidal flushing.

Moreover, as a result of the given the low- lying topography and numerous outfalls and other drainage outlets throughout the water body, stormwater storage potential would be limited and the lack of storage could exacerbate flooding from rain events.

WIDE OPENING TIDAL BARRIER

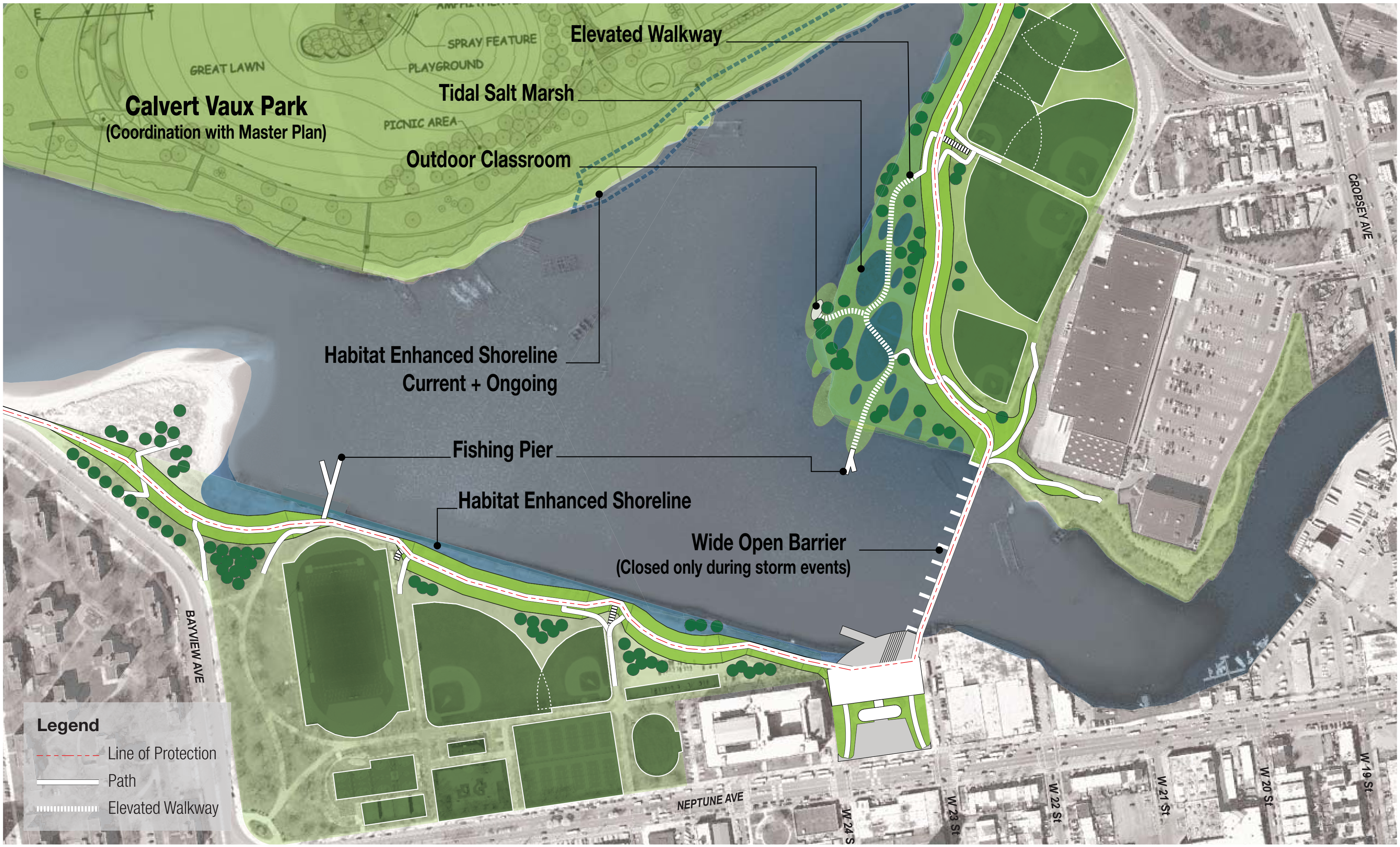
Two potential tidal barrier alignments were considered: one near the mouth of the Creek (Calvert Vaux Alignment) and one located further upstream in the Creek (Six Diamonds Alignment). Both alignments are assumed to provide the same level of flood risk reduction for the Study Area, with the eastern alignment requiring additional flood protection measures on land to provide comprehensive flood protection for the Coney Island and Gravesend communities.

In addition to considering potential alignments for the tidal barrier alternatives, the opening size of the gate structure, whether it had a narrow opening or a wide opening in the Creek, were considered. A narrow opening typically comprises a marine floodwall and a floodgate, with the floodgate portion allowing for the passage of water during non-storm conditions. While a more cost-effective strategy when compared to a wide opening, this configuration can result in unfavorable conditions in the Creek. First, the large stretch of permanent closure could lead to an ecological imbalance. Second, the reduction in channel width can cause higher flow velocities through the navigable region, resulting in higher rates of scour and erosion, which may subsequently harm the foundation of the gate itself. Alternatively, a wide opening typically comprises a floodgate or a series of floodgates. The main benefit of this configuration is its ability to maintain tidal flow, circulation, and navigation traffic. During non- storm conditions, the floodgates would remain open, allowing for water to pass through (similar to existing conditions). Minimizing in-water constrictions is critical to maintaining water quality condition and, specific to the Creek, would allow for the current drainage systems that discharge to the Creek to function without major modification. Because the wide opening configuration has the least adverse impact to existing site conditions including water quality, ecology, and drainage, a wide opening is recommended should an in-water flood protection alternative be selected. It is important to note that there would still be permitting obstacles with any recommended in-water construction, which will be identified in later stages of design.

PERIMETER FLOOD PROTECTION

Perimeter flood protection comprises a series of measures, such as levees, floodwalls, and hybrid combinations of the two, placed adjacent to each other on-land in order to create a continuous barrier on land either along or near the shoreline of Coney Island Creek. While the measures recommended are primarily structural, including bulkheads, levees, and

BELOW: Conceptual site plan showing potential flood protection alignment and ecological enhancement opportunities



CONCEPTUAL COASTAL FLOOD MITIGATION STRATEGIES

floodwalls, ecological enhancements, such as pairing levees with living shorelines, are encouraged, wherever feasible.

While not extensively evaluated as part of this Study, it is recommended that on-land structural measures include appropriate drainage features to ensure that any perimeter protection alternative does not exacerbate flooding or result in unacceptable levels of surface ponding. It is also encouraged that, should this alternative be selected, future phases of design integrate ongoing drainage improvements, such as the storm sewer system that NYCDDC is currently implementing, as these advancements will improve conveyance of stormwater within the catchment area.

RECONTOURING

Another variation considered for the Creek was recontouring (commonly referred to as dredging and filling) the bottom to create wetlands. However, when the potential of wetlands to attenuate wave energy and therefore minimize storm surge to reduce flood risk was quantified, it was apparent that this configuration no long fulfilled the guiding principle of achieving substantial flood protection for the Creek. Preliminary calculations illustrated that constructed wetlands and marshes would attenuate wave energy by less than 10 percent. This is largely because of the limited space in which to construct wetlands and the types of species that could be planted in the Creek.

Other feasibility issues associated with an all-wetlands strategy center on constructability, given that the existing drainage system discharges to the Creek. Stormwater and sewer infrastructure surrounding the Creek would require reconfiguring to avoid stagnant pools of stormwater. In addition, converting the open water column into wetlands may also reduce the capacity of the Creek to receive runoff from the tributary drainage area and also has significant permitting obstacles.

While not recommended as a stand-alone flood protection strategy, tidal wetlands do have many ecological and secondary benefits and are advised to be integrated into any long-term flood protection strategy for the Creek, where feasible.

ECOLOGICAL ENHANCEMENTS

Ecological enhancements are recommended as a complement to any long-term flood protection strategy. Some of the opportunities are identified on the map located on the previous page. Key focus areas were selected based on existing conditions specific to the bathymetry, habitat, and hydrodynamic environment of the Creek. Ecological enhancements toward the western end of the Creek include a potential stormwater treatment green infrastructure improvement between Calvert Vaux Park and 43rd Street and a coastal wetland restoration between Calvert Vaux and Six Diamonds Parks along the north shore of the Creek. Along the south shore of the Creek, enhancements could include dune and maritime forest along the peninsula, as well as a living shoreline along revetments. Habitat enhanced bulkhead designs, such as the inclusion of reef blocks, are also recommended for further evaluation as part of the implementation of flood protection measures in an effort to extend functional habitat toward the east end of the Creek and support the movement of finfish and other aquatic species through the corridor.


A conceptual perspective view from on top of a flood protection structure in Six Diamonds Park, looking South across the Creek.

RESILIENCY INVESTMENTS CAN ALSO ENHANCE PUBLIC SPACES

BENEFITS OF COASTAL FLOOD MITIGATION

A comprehensive long-term flood protection system provides many benefits including protecting community assets, avoiding future damages, and supporting the future development of additional community amenities and infrastructure. A comprehensive long-term flood protection strategy with drainage considerations, if certified by FEMA, could also remove or minimize mandatory National Flood Insurance Program (NFIP) requirements for properties located within the protected region; however, such removal or minimization is dependent upon other factors within the region and requires further analysis.

COMMUNITY ASSETS PROTECTED

Comprehensive long-term flood protection would protect vulnerable populations in an area with a large elderly and youth population, as well as low-income households. The Study Area's economic fabric would also be strengthened through the protection of jobs, buildings, and community facilities.

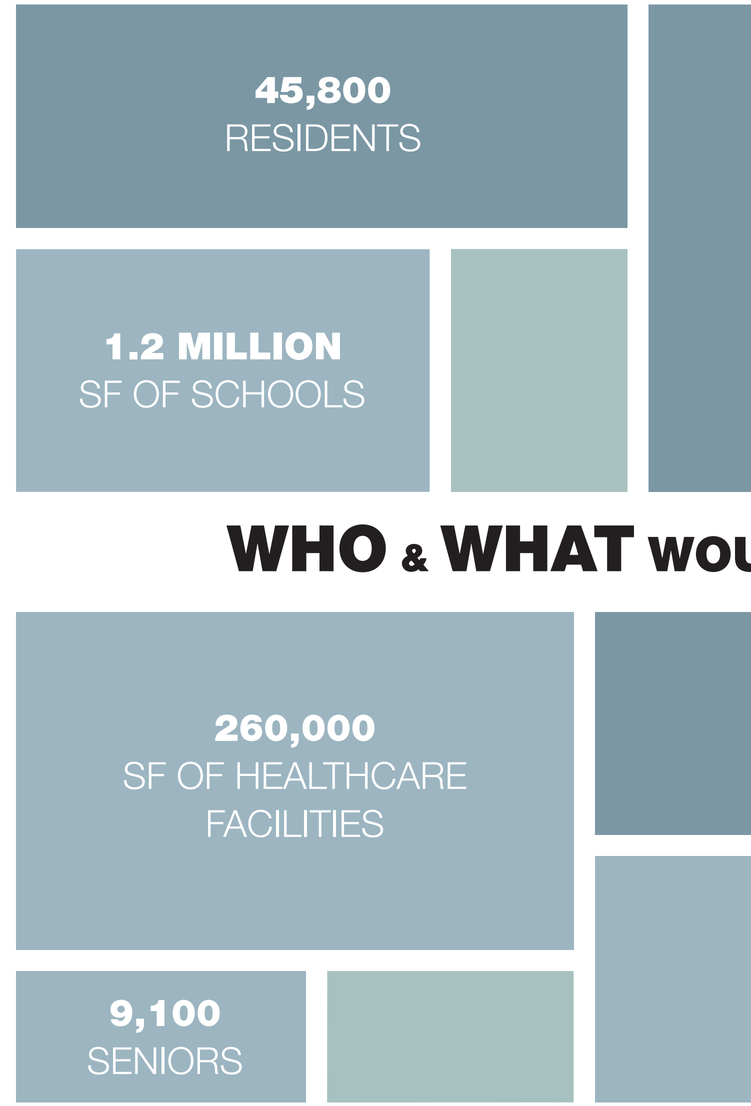
RESIDENTS

Many residents, particularly those in Coney Island, are economically disadvantaged, as measured by average incomes, unemployment rates, and levels of subsidized housing. Many residents live in public housing, affordable housing (including senior housing), and middle-income co-ops. Over a quarter of residential units in the region, or 5,900 units, are located within New York City Housing Authority (NYCHA) buildings. An additional 5,800 units are affordable. Within the region, 28 percent of residents are considered low income with household incomes at or below 60 percent of the Average Median Income. Within the region, 18 percent of the population is over the age of 65, compared with 11 percent for Brooklyn as a whole.

For a 100-year flood event, modeling results show that roughly 1,300 acres would be protected within the Study Area. Flood protection for this area equates to protection for nearly 50,000 individuals, representing 30 percent of residents currently living within a 100-year flood zone within Brooklyn, or 13 percent of total New York City residents living in the flood zone. This translates into flood protection for a significant number of vulnerable populations. For example, over 9,000 seniors (i.e., adults above the age of 65) reside in the Study Area, and nearly 11,000 residents are under the age of 18.

BUILDINGS AND FACILITIES

Implementation of an integrated flood protection system would reduce flood risk for nearly 6,000 buildings, including residential, retail, commercial, industrial, and community- serving buildings. These buildings contain over 1,200 businesses employing over 12,100 people. The highly concentrated healthcare and social service organizations in the area employ over 3,200 people, more than any other sector. Comprehensive protection of these properties means that residents can continue to access critical facilities in the case of a storm event. Additionally, there will be significant damages avoided and employees can quickly return to work after a storm event.



For the purposes of the analysis discussed herein, a representative area was examined. The Study Area evaluated is bounded by Coney Island Beach shoreline to the south, Ocean Parkway to the east, Avenue X and 86th Street to the north, and Bay Parkway and Gravesend Bay to the west.

500,000
SF OF CULTURAL AND COMMUNITY FACILITIES

960
BUSINESSES

ULD BE PROTECTED?

21,900
RESIDENTIAL UNITS

5,900
BUILDINGS

74
ACRES OF PARKS AND OPEN SPACE

POTENTIAL FOR FLOOD INSURANCE SAVINGS

A comprehensive long-term flood protection strategy with drainage considerations, if certified by FEMA, could remove or minimize mandatory National Flood Insurance Program (NFIP) requirements for properties located within the protected region, and any future flood insurance costs could be realized as savings. Potential savings were calculated based upon the removal of NFIP policies currently within the Study Area, which total $1.4 million in annual savings and over $33.6 million in 50 year annual savings in 2015 dollars. However, due to other factors contributing to NFIP policies, such as internal drainage issues within the Study Area, further analysis is required to determine accurate savings within the Study Area.

DECREASED BUILDING COSTS

Capital flood mitigation improvements to buildings within the 100-year flood zone currently adds to construction costs. The lowest floor of residential buildings located in the flood zone is required to be elevated to at or above the design flood elevation per New York City Department of Buildings (NYCDOB) standards. In residential buildings, NYCDOB requires utilities to be located above the design flood elevation or constructed to prevent water from entering or accumulating in the equipment. Non-residential buildings must comply with residential elevation requirements or provide dry flood-proofing. A FEMA-certified flood protection system would reduce the need to mitigate existing buildings within the region.

SUPPORT LOCAL RETAIL AND AMENITIES

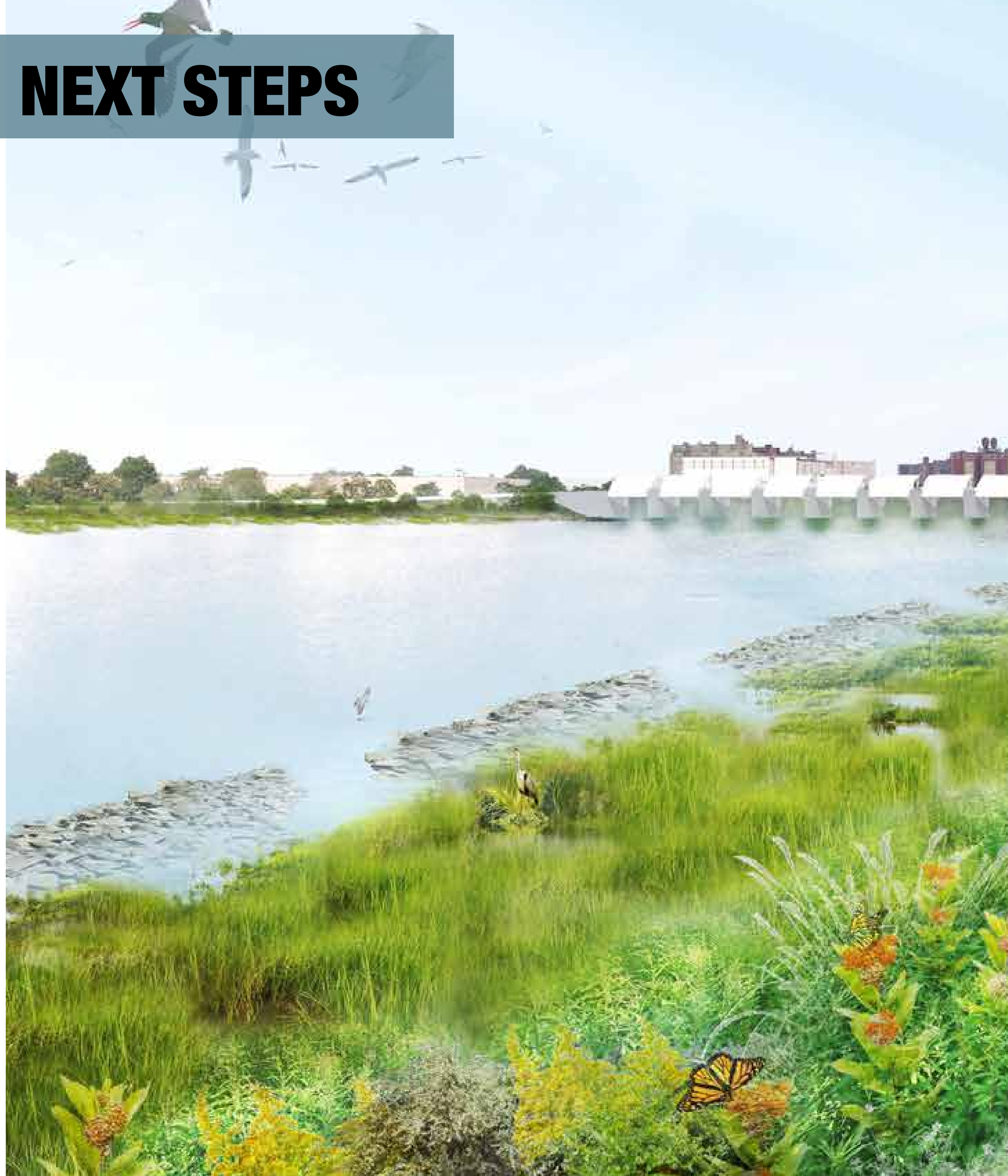
Currently, the Study Area lacks mid-range retail, including pharmacies, restaurants, and medium-sized grocers. Retail development in the Study Area has been limited, and, while retail rents are close to Brooklyn averages (presumably carried by big box retailers), vacancy rates are at 6 percent, higher than the Brooklyn average of 4 percent. In this challenging market, retailers within the 100-year flood zone also face the ongoing risk of incurring significant losses due to damaged inventory, repairs to flooded spaces and utilities, and lost revenue when businesses are not able to open.

Dry flood-proofing requirements for smaller retail stores in Coney Island are cost prohibitive (between $36 and $56 per SF) and limit the opportunity for retail corridors to thrive and grow in an already constrained market. This represents a significant expense to property owners and, with current achievable rents, makes such improvements to existing buildings or construction of new retail space within the flood zone prohibitively expensive for landlords and developers. Capital flood mitigation improvements would decrease construction costs, and reduced flood risk would support the development of community infrastructure in the Study Area. Reduced costs would strengthen interest among developers, retail building owners, and local and national retailers in investing in Coney Island, and thereby providing needed services, generating more jobs, and activating key area corridors.

INITIATIVES AND NEXT STEPS

After the completion of the Coney Island Creek Resiliency Study, key near-term action includes coordinating with USACE to identify the next steps for realizing flood risk mitigation for Coney Island. At this time, the vehicle for continued study in Coney Island is still under review. Opportunities include the Jamaica Bay Reformulation Study, the New York–New Jersey Harbor and Tributaries Study, or the existing USACE authorization. The City will work closely with USACE to ensure a fluid sharing of analyses completed to date, as well as recommend continued coordination on future phases conducted by USACE. These studies could include refining flood protection alignments, calculating probable order-of-magnitude cost estimates for different flood protection strategies, and furthering engineering considerations, such as geotechnical and environmental analyses, potential impact on utilities, and stormwater management strategies. Community engagement will continue to be a key component of the design process.

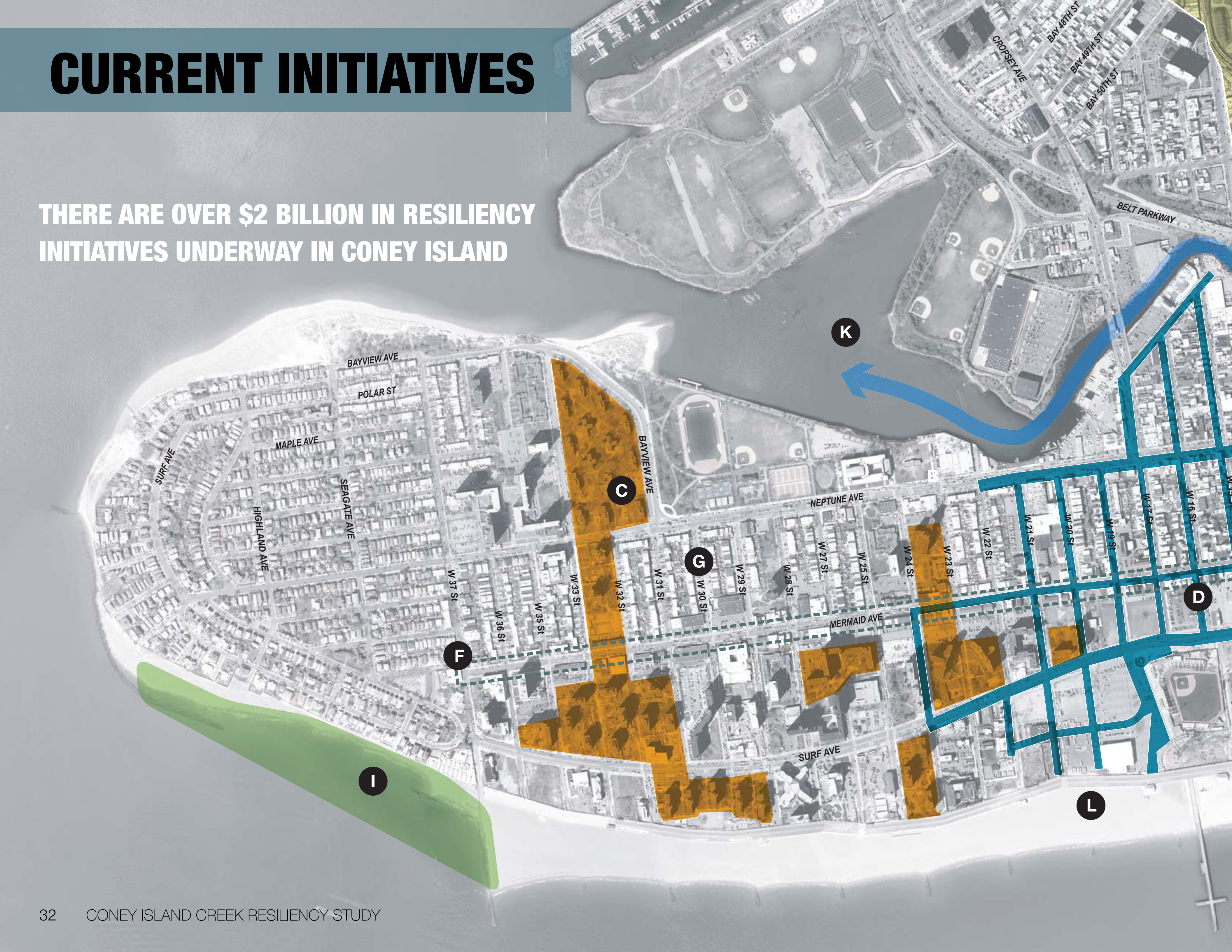
Along with the Coney Island Creek Resiliency Study, the City is leading a multitude of initiatives to create a stronger and more resilient Southern Brooklyn. These initiatives include the projects and additional near-term strategies described in the following pages.

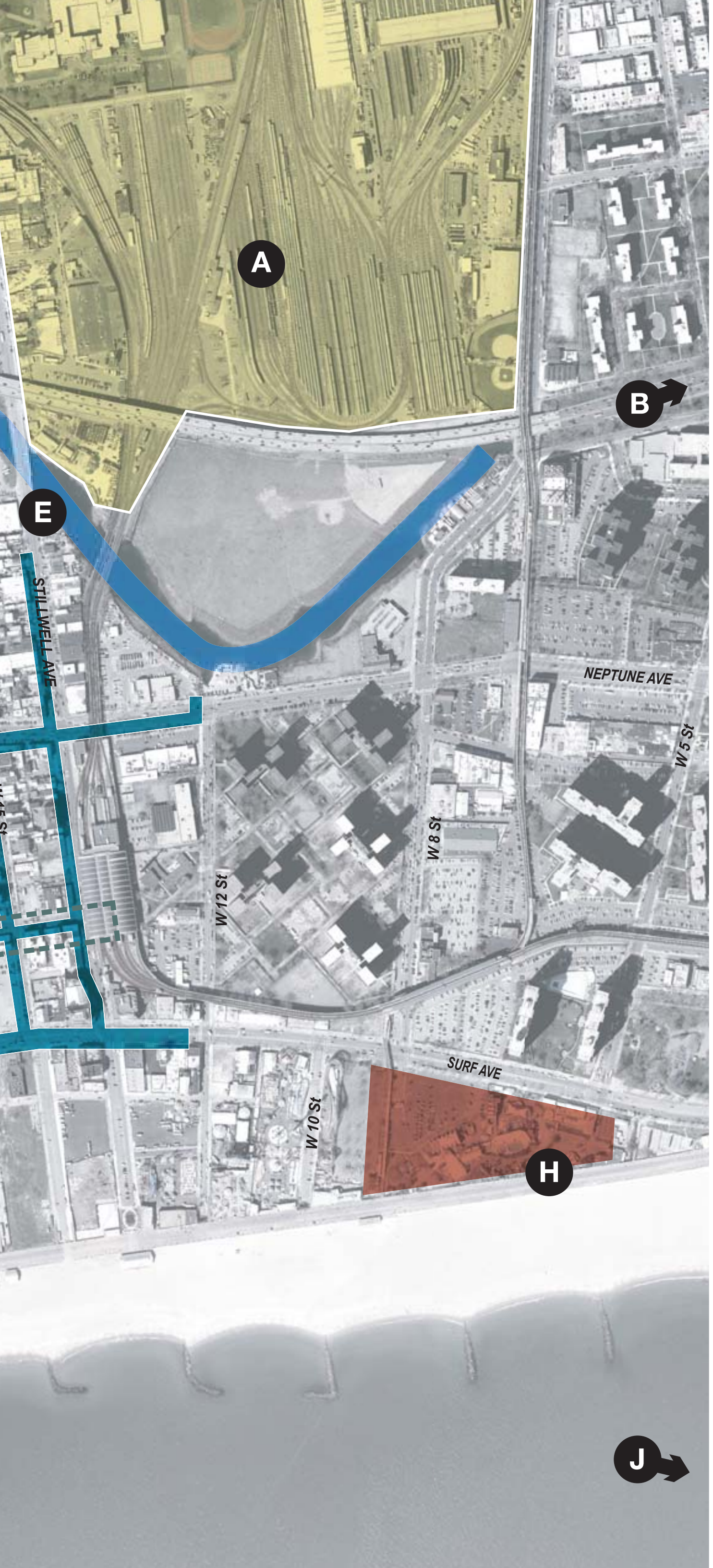


RIGHT: A conceptual perspective view looking East along the shoreline of Kaiser Park

CURRENT INITIATIVES

THERE ARE OVER $2 BILLION IN RESILIENCY INITIATIVES UNDERWAY IN CONEY ISLAND





CRITICAL INFRASTRUCTURE

(A) MTA Rail Yards Floodwall

The MTA received funding from New York State to plan and design improvements for flood mitigation at the Coney Island rail yards which were inundated after Sandy. The protection of these facilities is critical to ensuring that subway service can continue to operate and/or quickly recover after major weather events.

(B) Coney Island Hospital

Coney Island Hospital is receiving $923 million from FEMA to repair their facility and construct new resilient critical services that include an Emergency Department on the second floor along with other critical services and mechanical systems. Additionally, there will be 1,720 Foot flood wall that will protect the hospital from a 500-year flood event.

(C) New York City Housing Authority

Nine NYCHA developments in Coney Island have received over $720 million in FEMA funding to repair and flood-proof Sandy damaged buildings and elevate critical mechanical and electrical systems.

STORMWATER MANAGEMENT

(D) Amended Drainage Plan Implementation

The City is investing in more than $240 million in infrastructure upgrades, including new sewers and raising of street grades between W 2nd and W 22nd Streets. The construction to implement these improvements began in 2014 and when completed will allow the peninsula to have better drainage for weather related events.

(E) Water Quality Improvements

In 2014, New York City Department of Environmental Protection rehabilitated the Avenue V Pumping Station to address combined sewer overflow (CSO) issues. This almost $200 million upgrade allows for a reduction in combined sewer overflow (CSO), or a mixture of untreated rainwater and sewage, by up to 87%. NYCDEP is currently working on a Long-Term Control Plan (LTCP) to better understand CSO impacts on water quality in Coney Island Creek.

NEIGHBORHOOD INVESTMENTS

(F) Small business recovery and resiliency

SBS launched the NYC Business Preparedness and Resiliency Program (Business PREP) to provide opportunities and resources for small business owners to better prepare for future emergencies.

(G) Housing Recovery

100 percent of reimbursement checks have now been sent out to homeowners. Goal to have Build it Back single-family home program complete by the end of 2016.

(H) New York Aquarium

FEMA has allocated over $62 million to the New York Aquarium to upgrade and protect facilities from future weather events. This work will include dry flood-proofing and elevating critical equipment.

REGIONAL RESILIENCY

(I) T-groins and Beach Renourishment

USACE allocated over $25 million to improve the functioning of coastal storm risk management structures on the peninsula. The project, to be completed by summer 2016, will prevent flanking of the West 37th Street groin and place an additional 125,000 cubic yards of sand on the beach.

(J) Jamaica Bay Reformulation Study

USACE study to assess coastal storm risk management opportunities in the Jamaica Bay area. A tentatively selected plan (TSP) for the region will be available by summer 2016.

(K) Coney Island Creek Resiliency Study

This study, as a critical component of resiliency planning for the communities around Coney Island Creek, investigated hydrological management strategies to prevent and mitigate flooding, improve open space and community infrastructure, and provide opportunities for economic development around the Creek.

(L) Beachside Resiliency Study

In coordination with New York City Department of Parks & Recreation, NYCEDC and ORR are taking a first step in a long-term strategy to protect the life, property, and livelihoods of Coney Island & Gravesend communities from the effects of storm surge and SLR.

2016 INITIATIVES

Phase 1 Implementation

The Coney Island Creek Resiliency Study is one component to creating a more resilient community. The implementation of infrastructure and initiatives recommended by this report is critical to mitigating flood risk for years to come. This plan creates the foundations for the USACE to further study and examine the ways in which the Creek can be protected, for which coordinated advocacy by the City and community will be key. The forthcoming Jamaica Bay Reformulation Study, the New York-New Jersey Harbor and Tributaries Study, and the Coney Island Reach of the Rockaway Inlet to Norton Point Project all provide the opportunity for the USACE to ensure that the analyses completed to date can comprehensively inform and further refine the costs and engineering considerations in the implementation of future flood risk mitigation measures. While coordination with USACE and long-term planning continue, the following are near-term initiatives that can advance to provide immediate benefits.

SOURCE: Charles Denson

1. BEACHSIDE RESILIENCY

Status: EDC/Parks analysis in progress

Next Steps: Investigate alternatives and cost estimates

From the outset of the Coney Island Creek Resiliency Study it was clear that there was a need for future assessment of the beachside to create resilient flood mitigation system. A study of the beachside will assess the current conditions from West 37th Street to Corbin Place and will examine strategies to protect the peninsula from future weather events, followed by an investigation of potential funding sources.

2. CONEY ISLAND GREEN INFRASTRUCTURE

Status: Assess viability of green infrastructure installations in Coney Island

Next Steps: NYCDEP, in coordination with ORR and the Governor's Office of Storm Recovery NY Rising Community Reconstruction Program investigate opportunity for bioswales

Green infrastructure promotes the natural movement of water by collecting and managing stormwater runoff from streets, sidewalks, parking lots and rooftops and directing it to engineered systems that typically feature soils, stones, and vegetation. This process prevents stormwater runoff from entering the City's sewer systems. While not a common practice in separately sewered areas, particularly those with high water tables, the City is exploring opportunities for implementation.

3. CONEY ISLAND PUMPING STATION

Status: EDC/DCAS analysis in progress

Next Steps: Test structural useful life

The Coney Island Fire Pumping Station was built in 1938 and is located next to Mark Twain High School directly adjacent to Coney Island Creek. Its historic nature and location next to the Creek creates many possibilities for its future use. It is recommended that the building be structurally assessed and identify whether the station can be repurposed in the future.

SOURCE: Charles Denson

4. CONEY ISLAND CREEK SHORELINE RAISING

Status: City has allocated $32M for Coney Island shoreline protection

Next Steps: The City issued a request for proposal (RFP) in Spring 2016

The City has allocated $32 million for near term projects to protect areas adjacent to Coney Island Creek from 10-year wet weather events. This project will repair areas such as bulkheads along the creek to ensure that they the lowest lying areas have a mitigated risk for flooding of the Creek into the surrounding neighborhoods.

5. SMALL BUSINESS AND HOMEOWNER RESILIENCY ASSESSMENTS

Status: Program launched by NYC Department of Small Business Services

Next Steps: Launch resiliency assessment services in 2016

The NYC Department of Small Business Services' Business Preparedness and Resiliency Program (Business PREP), aims to help small businesses better prepare for emergencies and enhance the resiliency of their operations, assets, and physical space. The program will provide on-site resiliency assessments and micro-grants to implement specific recommendations. The program launched business resiliency workshops across the City in the fall of 2015, and going forward will also develop online resources that can be utilized by the general public to learn about resiliency measures.

6. ADD CONEY TIE-IN TO USACE JAMAICA BAY REFORMULATION STUDY

Status: Coordination with Army Corps ongoing

Next Steps: Include new "Coney Tie-In" in Jamaica Bay planning

As the USACE advances the Jamaica Bay Study, it is essential that tie-ins to adjacent areas and communities, such as Coney Island, be incorporated to create a regional flood mitigating system. Coordination with USACE is ongoing as part of Phase 1 Implementation to ensure that flood protection is being considered at a regional scale and is reflective of the analyses completed as part of this Study.

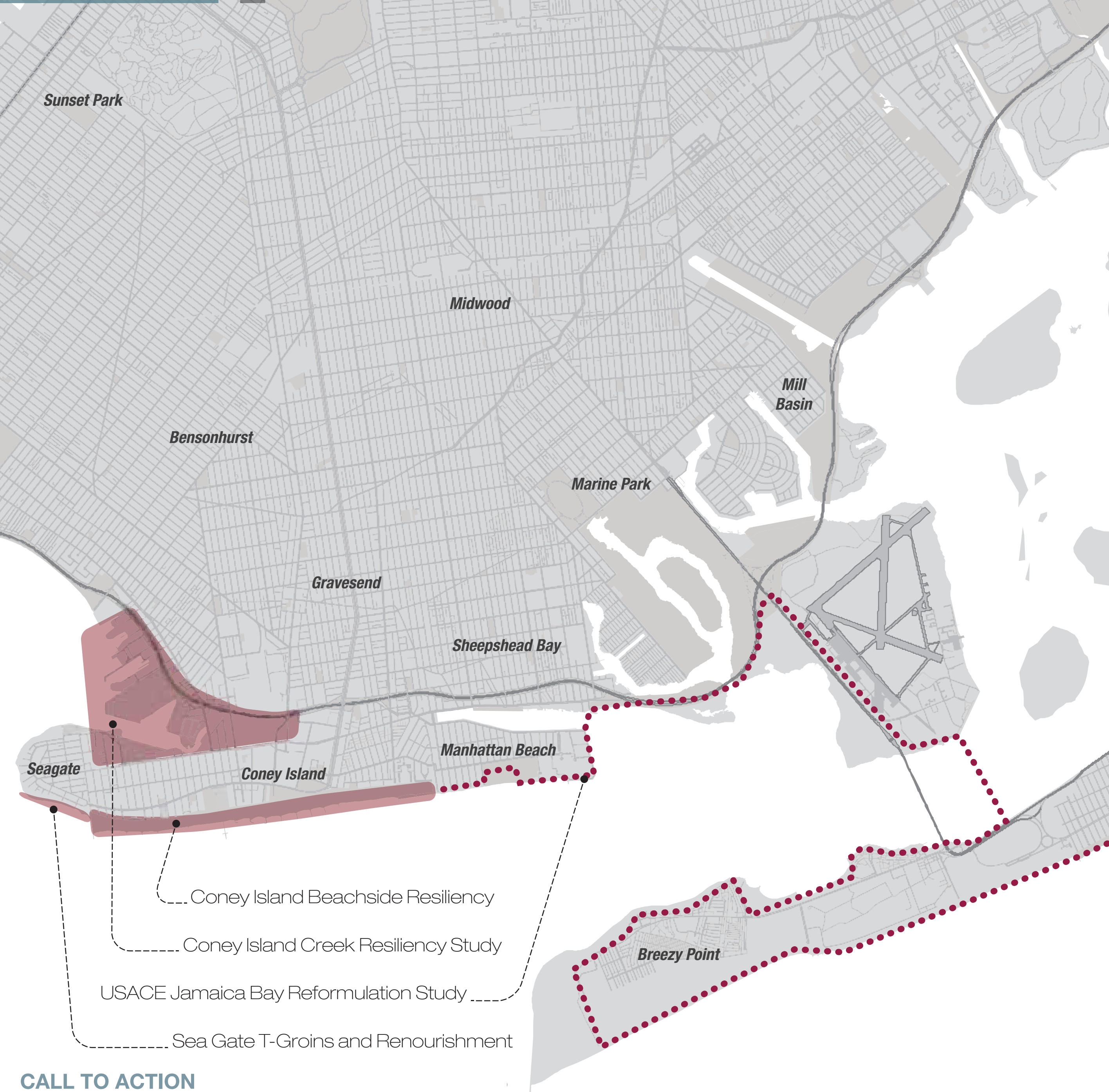
CALL TO ACTION

REGIONAL RESILIENCY

Coney Island Creek is part of a larger hydrologic system and in order to defend Coney Island Creek from a 100-year flood event, a large portion of Southern Brooklyn and Southern Queens must also be protected.

A deeper understanding of the dynamics of this hydrologic system were gathered throughout the course of the study. This insight, in addition to meeting and collaborating with USACE, is part of the scientific reasoning as to why Coney Island should be included in the evaluation of flood protection for Jamaica Bay as part of the USACE Jamaica Bay Reformulation Study.

A key next step for this study is ensuring that all of the technical studies conducted as part of this analysis are shared with USACE and can be used to inform future studies and implementation strategies for Coney Island Creek. Many of the analyses completed were the direct result of feedback and questions heard from local stakeholders and engaged community members, and it is critical to the vision of a more resilient Coney Island that this work not only be preserved, but also iterated upon and advanced as part of next steps towards design and implementation.



1 The City will continue to strongly advocate alongside our federal, state and local elected officials for USACE to include Coney Island in their Jamaica Bay Reformulation Study.

2 The City will continue to work with our partners to advance New York/New Jersey Harbor & Tributaries Feasibility Study.

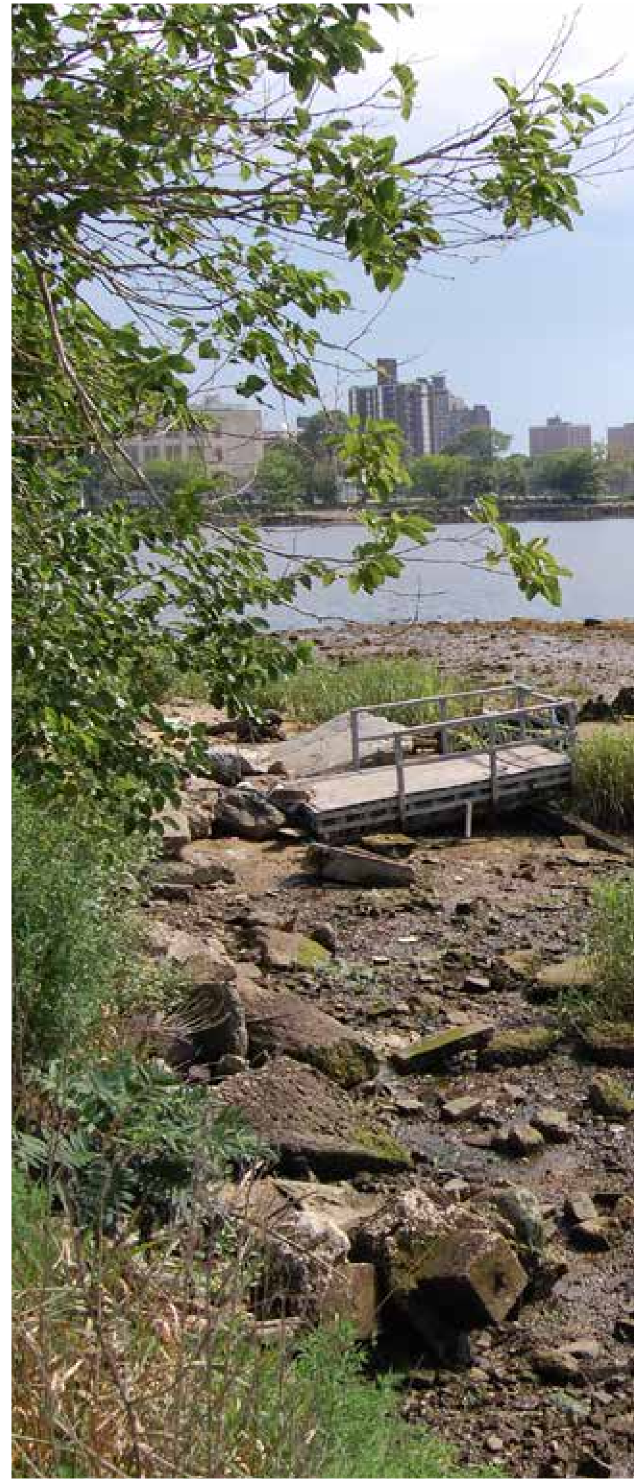
3 The City will continue working with elected officials and community organizations on planning for future Coney Island resiliency initiatives.

GLOSSARY & INDEX

FROM LEFT TO RIGHT: Kaiser Park; Kaiser Park; Six Diamonds Park; Six Diamonds Park

ADCIRC	ADvanced CIRCulation hydrodynamic model
Creek	Coney Island Creek
CSO	Combined Sewer Overflow
DCAS	Department of Citywide Administrative Services
DO	Dissolved oxygen
FEMA	Federal Emergency Management Agency
MTA	Metropolitan Transit Authority
NAVD88	North American Vertical Datum of 1988
NFIP	National Flood Insurance Program
NYCDCP	New York City Department of City Planning
NYCDDC	New York City Department of Design and Construction
NYCDEP	New York City Department of Environmental Protection
NYCDOB	New York City Department of Buildings
NYCDOT	New York City Department of Transportation
NYCDPR	New York City Department of Parks and Recreation
NYCEDC	New York City Economic Development Corporation
NYCHA	New York City Housing Authority
NYSDEC	New York State Department of Environmental Conservation
PFIRM	Preliminary Flood Insurance Rate Map
SF	Square feet
SFHA	Special Flood Hazard Area
SLR	Sea level rise
Study	Coney Island Creek Resiliency Study
Study Area	The entirety of Coney Island Creek from Gravesend Bay to the head end, as well as neighborhoods directly upland of the Creek
SWAN	Simulating WAves Nearshore wave model
USACE	U.S. Army Corps of Engineers





NYCEDC