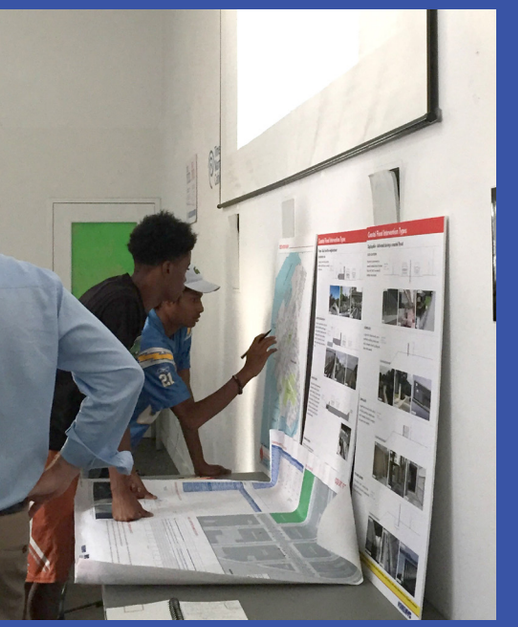
RED HOOK

INTEGRATED FLOOD PROTECTION SYSTEM FEASIBILITY STUDY FINDINGS



The Mayor's Office of Recovery and Resiliency (ORR), in partnership with the New York City Economic Development Corporation (NYCEDC), is working with local stakeholders to advance resiliency in Red Hook. The Integrated Flood Protection System (IFPS) Project is a federally and City-funded coastal protection initiative aimed at reducing flood risk due to coastal storms and sea level rise in Red Hook, Brooklyn.

#ONENYC

NYC Mayor's Office of Recovery & Resiliency

NYCEDC

Project Overview

The Red Hook neighborhood saw unprecedented flooding during Hurricane Sandy which left many residents and businesses without basic services for weeks. The Red Hook IFPS was first recommended in 2013 in *A Stronger, More Resilient New York* as a critical step toward ensuring a more resilient Red Hook community in the face of future extreme weather and a changing climate.

The Red Hook IFPS is an important part of *OneNYC,* Mayor de Blasio's multilayered, $20 billion resiliency plan that the City is implementing around the five boroughs. The plan takes a comprehensive approach to resiliency with the vision that 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.

Integrated Flood Protection System (IFPS) Feasibility Study Goals

- Gain an understanding of flood risk in Red Hook and whether an IFPS is a feasible way to address these flood risks.
- Build a broader understanding of what comprehensive resiliency means in Red Hook.
- Identify a project for the Federal Emergency Management Agency (FEMA) Hazard Mitigation Grant Program (HMGP) application.
- Develop a proposal for a FEMA-eligible project that 1) reduces Red Hook's coastal flood risk with minimal impact on the neighborhood when there isn't a storm; 2) incorporates community and stakeholder priorities; and 3) is tailored to Red Hook and its unique waterfront.

Feasibility Criteria: What We Analyzed

Key Terms

10-YEAR FLOODPLAIN
The area that has a 10% chance of flooding in any given year (not an area that will flood only once in 10 years. Note - Several 10-year floods may follow one another in rapid succession.)

BASE FLOOD ELEVATION (BFE)
The height of flooding that might be expected in a 100-year flood. It is not measured from ground or sea level, but from a benchmark called the North American Vertical Datum of 1988 (NAVD88). It can be found on FEMA's Flood Insurance Rate Maps (FIRMs).

DESIGN FLOOD ELEVATION (DFE)
The Design Flood Elevation (DFE) corresponds to an elevation above sea level which flood protection interventions would have to be built to depending on the strength of the storm and location.

SEA LEVEL RISE
An increase of volume of the ocean's water, resulting in an increase in the mean sea level.

STORM SURGE
An abnormal rise of water generated by a storm, as a result of atmospheric pressure changes and wind. Storm surges are especially damaging if water is already at high astronomical tide.

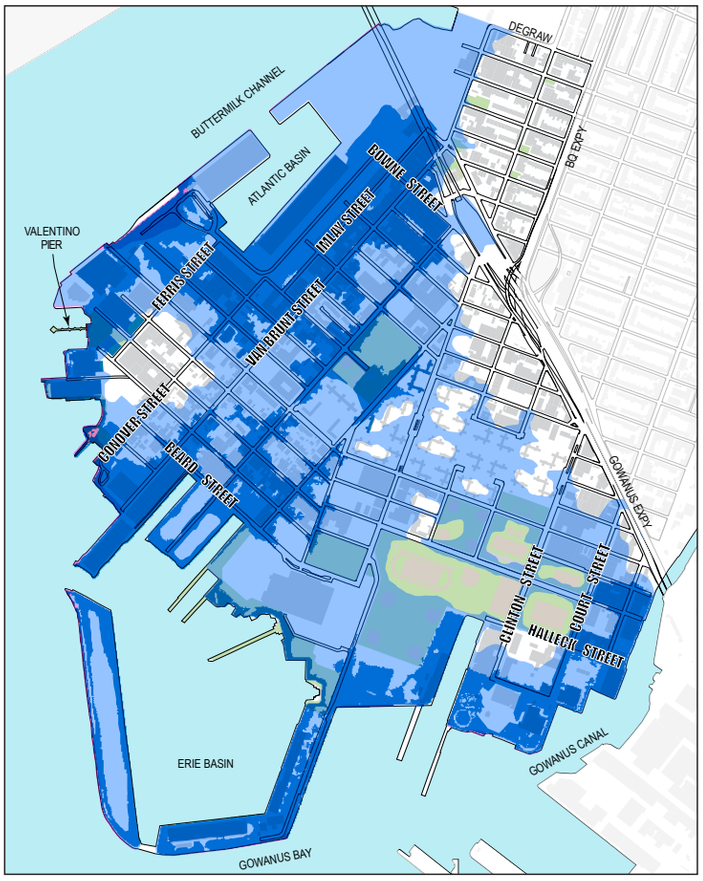
What is a Feasibility Study?

- A feasibility study analyzes and evaluates a proposed project to see if it 1) is technically able to be built; 2) addresses community needs and goals; and 3) meets federal and other legal requirements.
- A feasibility study is the first step to develop a technically feasible project that meets FEMA HMGP funding requirements.
- The feasibility study for the IFPS builds upon the important resiliency work that has already been done in Red Hook and the City as a whole.

Funding

- This project has $50 Million FEMA Hazard Mitigation Grant Program (HMGP) funds from New York State and $50 Million in New York City Capital funds for a total of $100 Million committed for design, environmental review, and construction.
- FEMA needs to approve the IFPS project proposal in order for the City to access funding for design and construction.

Flood Risk & Vulnerability



Red Hook Flood Risk

LEGEND

- 10-Year + 1 foot of Sea Level Rise (8 feet NAVD88 Floodplain)
- 2015 FEMA Preliminary 100-Year Floodplain
- NYC Parks

Summary of Vulnerability

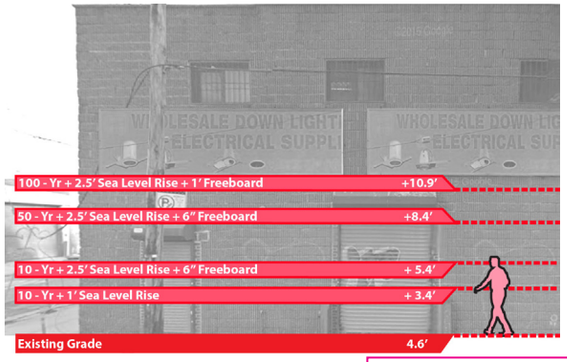
The proposed project reduces flood risk from a 10-year storm, taking into account coastal storm surge and 1 foot of sea level rise. There are currently approximately 190 acres, 3,150 residents, and 500 buildings at risk of flooding during this level of storm in Red Hook.

FEMA requires the following for this project:

- Must have independent utility - cannot depend on other separate projects or features to fully function
- Cannot have a negative impact on existing conditions or worsen flooding in other nearby locations
- Must have a Benefit-Cost Ratio (BCR) greater than 1, according to FEMA's Benefit Cost Analysis
- Must be permanent - no temporary measures such as sandbags

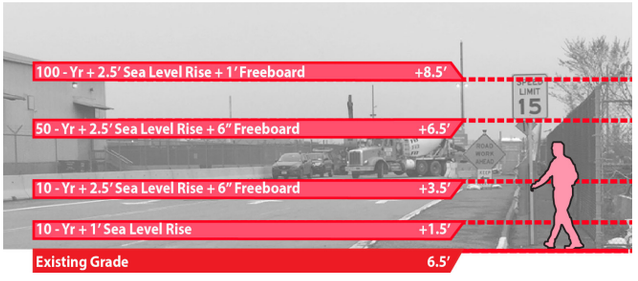
Design Flood Elevations & Example Structure Heights

Four DFE scenarios that provide varying levels of flood risk reduction benefits were considered as part of the feasibility analysis. These images demonstrate the intervention heights above ground level that would be required to protect from the four coastal storm event (DFE) scenarios Depending on the DFE scenario, average intervention heights at these locations range from approximately 1.5 feet to more than 10 feet above ground level.



Commerce Street and Imlay Street

Beard Street and Richards Street Intersection



Atlantic Basin at Clinton Wharf

ENGAGEMENT

CITIWIDE RESILIENCY PLANS

- **A Stronger, More Resilient New York (2013)**
- **OneNYC: The Plan for a Strong & Just City (2015)**

NOV-DEC 2015

Initial Stakeholder Meetings

JANUARY 2016

MEETING #1
Project Introduction and Community Priorities

Small Group Discussions

COMMUNITY PRIORIT

- Integrate with the comm
- Don't just build a wall.
- Maintain and improve
- Consider drainage issu
- Provide jobs and job tr

Connecting the High Points of Red Hook

Red Hook Topography:
A coastal flood protection structure is designed to connect high ground locations, reducing the risk of inundation via areas of low ground.

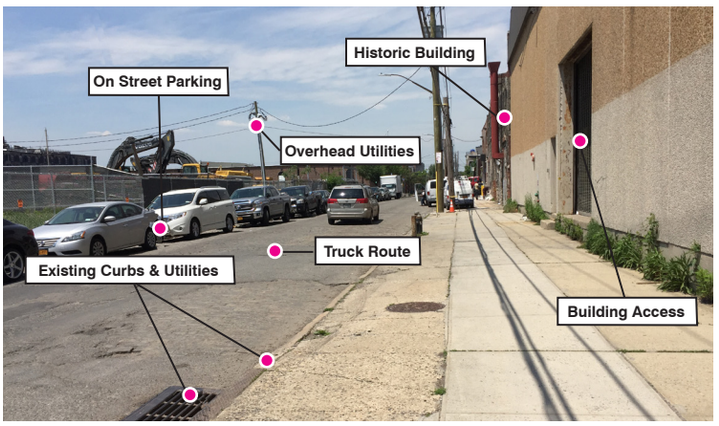
Site Conditions

Site conditions were an important consideration of the IFPS feasibility analysis because of their impact on how it can be designed and where it can be located.

- Elevations for 10-year to 100-year coastal storm surge events vary between 7 feet and 16 feet North American Vertical Datum (NAVD88)
- Low topographic ("low ground") areas are by the Gowanus Canal, the intersection at Beard Street and Richards Street, and Atlantic Basin by Clinton Wharf
- Transportation routes include bus, truck, bicycle, and NYC Ferry
- Older, often attached buildings with multiple pedestrian and garage openings make placement of a curb/sidewalk-area intervention and maintenance of access difficult.
- Active working waterfront structures would require retrofitting to provide flood protection which would add complexity to the current on-going operations and cost.
- Waterfront property is mostly privately owned

Site Conditions Examples

Residential Street: These conditions constrain the space available within the public Right-of-Way, the intervention type, and create public safety and access concerns with higher DFE and structure heights.



Commercial Street: These conditions constrain the height and location of proposed intervention types as well as the number of deployables needed to maintain access.

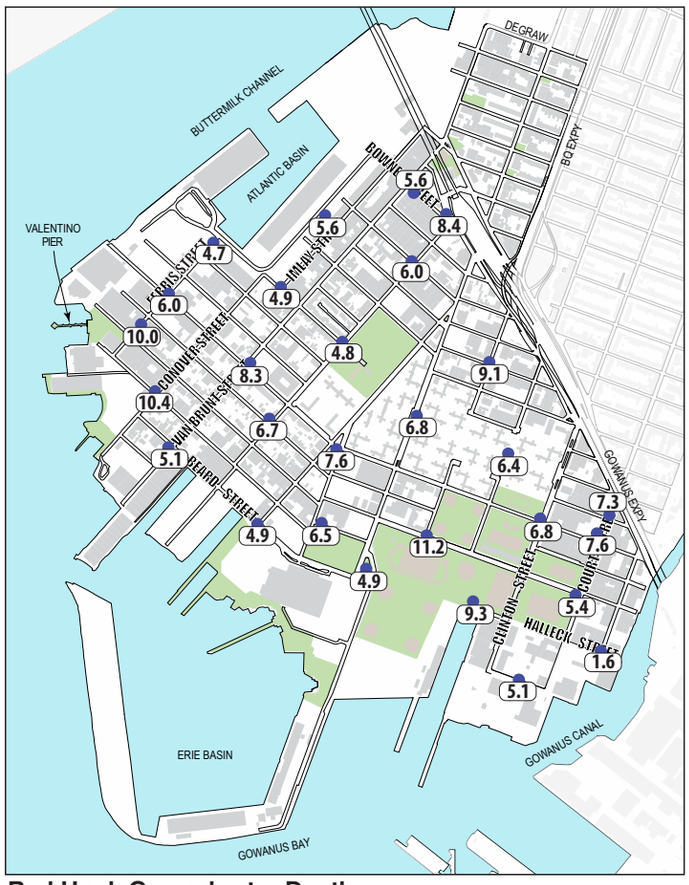
IES
munity.
maritime capacity and waterfront access.
ues, include upgrades to sewer system.
aining for local residents.

- The system should actually work.
- Enhance bike-friendly environment.
- Coordinate with other major projects in the neighborhood.
- Keep the community engaged and informed.
- Continue to focus on storm preparedness.

APRIL 2016

MEETING # 2
Existing Conditions and Flood Protection Options

Field Investigation Results

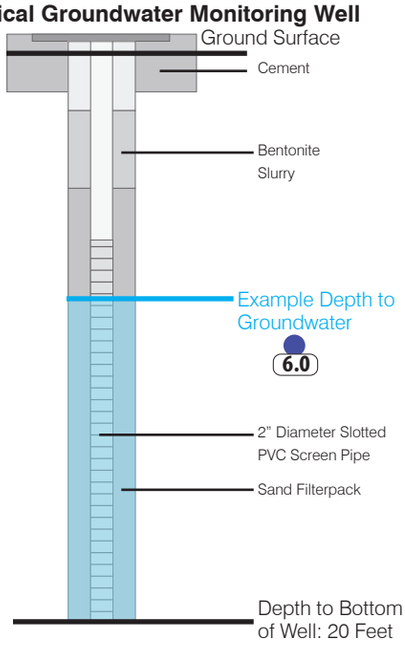


Red Hook Groundwater Depth

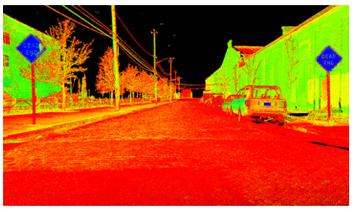
LEGEND Temporary Groundwater Monitoring Well Location (6.0) Groundwater Depth

NYC Parks

Typical Groundwater Monitoring Well



Groundwater Monitoring



LiDAR/Topographic Survey

Soil Borings

Soil and Groundwater Investigation Findings:

- Shallow groundwater depth (<10-feet below ground level)
- Potential seepage problems may allow coastal storm surge to enter through the soil

Impacts:

- Shallow groundwater depth makes green infrastructure ineffective in managing storm water
- Seepage barrier is needed and included in conceptual design
- Temporary or solely above-ground interventions may not effectively address seepage

Topographic, Utility, and Boundary Survey:

The light detection and ranging (LiDAR)/topographic and utility survey identifies, in detail, potential conflicts with utilities, Right-of-Way, road width, sidewalk width, building entrances, and driveways.

ITY STUDY

ENGAGEMENT

SUMMER 2016

Red Hook Initiative Digital Stewards
Red Hook National Night Out
Red Hook Initiative Local Leaders
Community Board 6
New York Rising Committee

Red Hook National Night Out

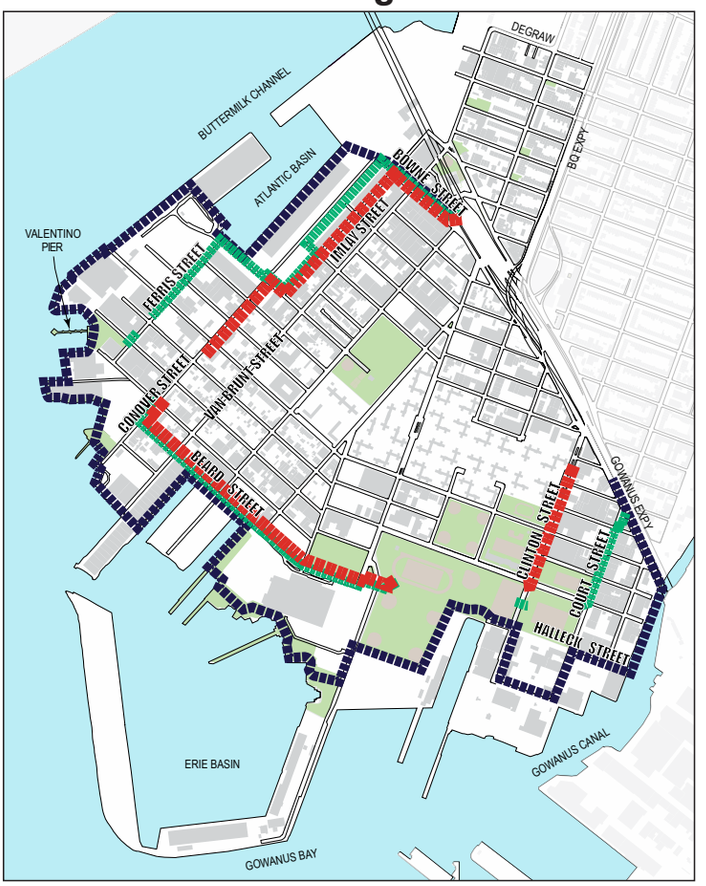
RHI Local Leaders

OCTOBER 2016

MEETING # 3
Alignment Scenarios & DFE Examples

How the Proposed Conceptual Project Was Developed

Coastal Protection Alignment Scenarios Analysis



LEGEND

Outermost Alignment | In-Between Alignment | Innermost Alignment | NYC Parks

Based on our analysis of existing conditions in Red Hook and flood risk from coastal storm surge and sea level rise, three alignment scenarios were developed and analyzed. Alignments are potential locations for the IFPS, and the scenarios can be mixed and matched. Generally, an alignment closer to the waterfront requires higher structure heights, and alignments further inland require lower structure heights for the same level of protection. Each alignment presented various benefits and significant challenges.

The Outermost Alignment follows mostly privately-owned land along the waterfront, and has no public land to construct an IFPS in the public right-of-way. It is approximately 19,000 feet (3.6 miles) long and requires higher and stronger walls to account for wave action and potential physical impacts from water-born objects. It has the greatest negative impacts to waterfront access and views.

The In-Between Alignment is approximately 11,850 feet (2.25 miles) long, takes advantage of natural high points, and is inland from the waterfront. It follows along public streets, and as such requires 43 deployable barriers when crossing intersections and building openings for pedestrians and vehicle access.

The Innermost Alignment is approximately 10,000 feet (1.9 miles) long and takes advantage of natural high points. It is the furthest inland from the waterfront, providing flood risk reduction benefit for the least land area compared to the other two alignment scenarios. Because it follows along public streets, it requires 38 deployable barriers when crossing intersections and building openings for pedestrians and vehicle access.

Given the goals of the project, the City wanted to identify an alignment that has the greatest potential to integrate into and enhance the unique urban fabric of Red Hook while also providing flood risk reduction benefits. The City decided to focus on analyzing the In-Between alignment at different DFEs.

Analysis of Four Design Flood Elevations

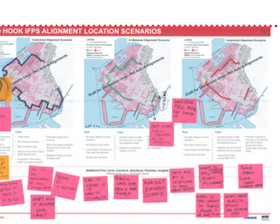
The study analyzed four DFE Alternatives, outlined in the chart below, for the In-Between alignment.

1: 10 year + 1' SLR (DFE 8 feet NAVD88)	Requires approx. 1.5 - 3 feet maximum intervention height above grade
2: 10 year + 2.5' SLR + 0.5' FB (DFE 10 feet NAVD88)	Requires approx. 3 feet of average intervention height above grade
3: 50 year + 2.5' SLR + 0.5' FB (DFE 13 feet NAVD88)	Requires approx. 6 feet of average intervention height above grade
4: 100 year + 2.5'SLR + 1' FB (DFE 16 feet + NAVD88)	Requires approx. 9 feet of average intervention height above grade
SLR = Sea Level Rise FB = Freeboard, an additional amount of height above the BFE to provide a factor of safety.	

- DFE 1 focuses the IFPS on the two lowest points in the neighborhood at Atlantic Basin and Beard Street.
- DFE 1 can be integrated into the neighborhood, avoiding the need for deployable structures, which impact the reliability of the whole system. DFEs 2, 3, and 4 would require 25 or more deployable structures
- DFE 1 has negligible impacts on views and pedestrian/ vehicle flow compared to other alternatives
- DFE 1 allows for future adaptability of the flood protection structure along Beard Street
- All DFEs, except DFE. 1, have drainage impacts

The City's Proposed Conceptual Project

DFE 1 (10-year storm + 1' SLR) maximizes coastal resiliency benefits while minimizing negative impacts on the neighborhood, and was selected as the City's proposed project.



SPRING 2017

Additional Engagement

Resilient Red Hook (Former New York Rising Community Reconstruction Planning Committee)

JUNE 2017

MEETING # 4

Presentation of City's Proposed Project

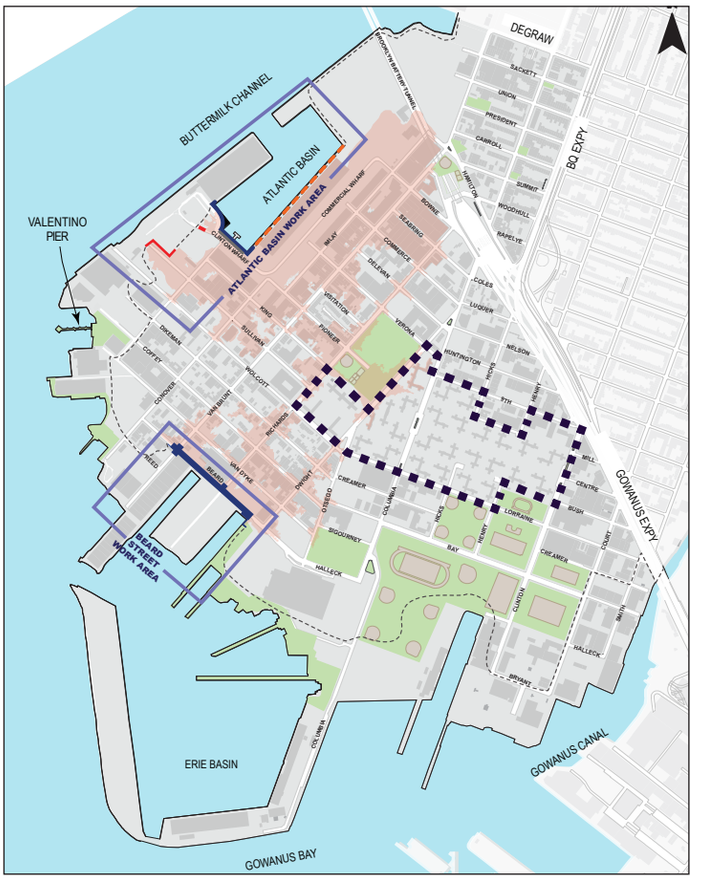
FUTURE PHASES

DESIGN & ENGINEERING

ENVIRONMENTAL REVIEW

CONSTRUCTION

Proposed Conceptual Project for Review and Approval by FEMA



Proposed Project Features

Based on the feasibility assessment analysis, the City is proposing to focus on two low points that are most vulnerable to coastal storm surge and sea level rise along Beard Street and on Atlantic Basin. This approach maximizes coastal flood risk reduction benefits while minimizing negative impacts on the neighborhood.

The project will consist of flood walls covered by raised and re-graded streets to fully integrate the flood protection system into the community:

- A floodwall underneath a portion of Beard Street to be covered by raising and regrading the street
- A floodwall under regraded streets and an upgraded bulkhead at Atlantic Basin

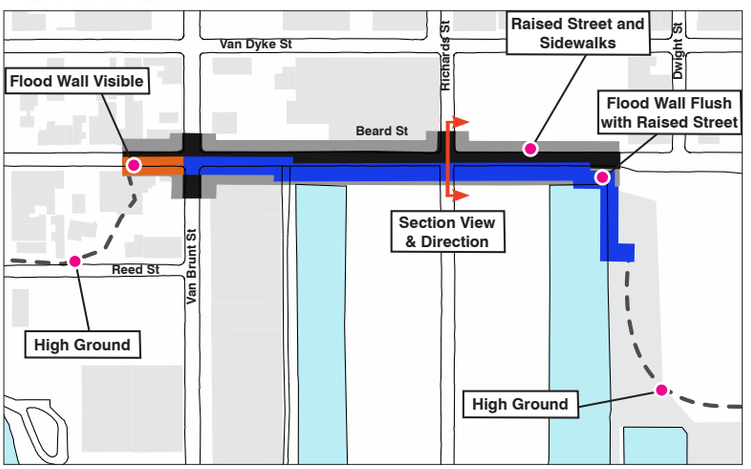
Proposed Project Benefits

- Reduces flood risks from a 10-year coastal storm surge accounting for 1-foot of future sea level rise
- Provides flood risk reduction benefits for approximately 3,000 residents and 400 buildings
- The foundation of the coastal flood structure along Beard Street will allow for future adaptability
- Does not require use of deployable structures
- Does not have negative impacts on drainage

LEGEND Flood Risk Reduction Area; Work Area; High Ground Elevation (>8ft NAVD88); NYC Parks; NYCHA*

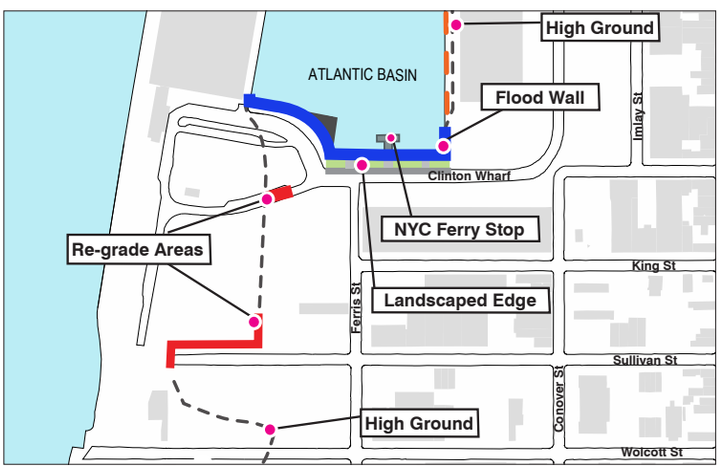
*Separate NYCHA FEMA-funded Recovery and Resiliency Project. For more information visit: on.nyc.gov/nycha-sandy.

Beard Street



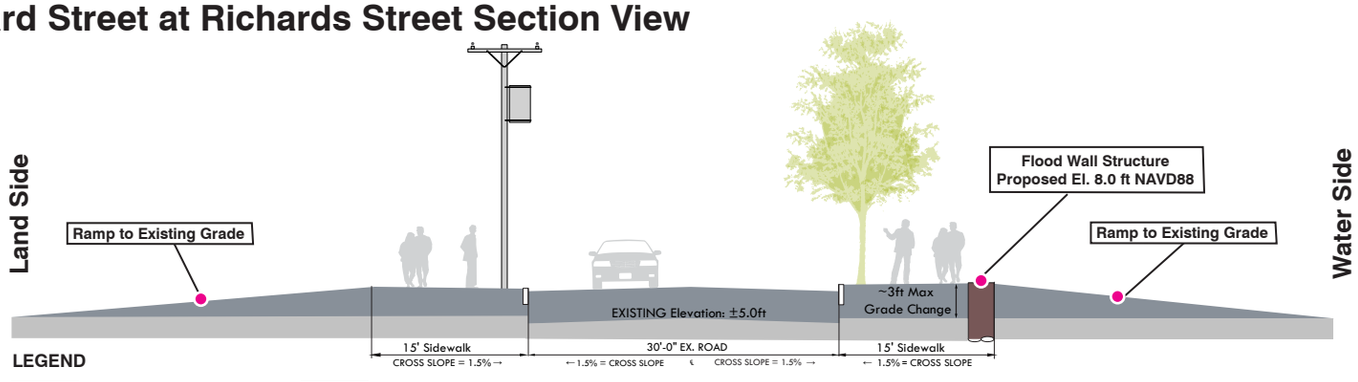
LEGEND
Raised Street; Raised Sidewalk; Flood Wall Flush with Raised Street/Sidewalks; Flood Wall Structure Visible (Max 1ft Above Ground); High Ground Elevation (>8ft NAVD88)

Atlantic Basin



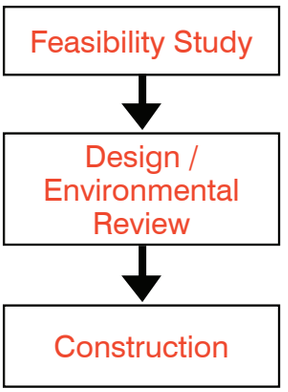
LEGEND
Flood Wall Structure; Re-grade Area; Landscaped Edge; Reinforce Existing Bulkhead; High Ground Elevation (>8ft NAVD88)

Beard Street at Richards Street Section View



LEGEND
Existing Grade (~5ft NAVD88); Proposed Grade (8' NAVD88 at Flood Wall Structure; Maximum 3 feet increase)

What happens next?



1. To advance to design, the City must first propose a feasible / implementable project and submit that proposed conceptual project to FEMA for review.
2. If that proposed conceptual project is approved by FEMA, FEMA releases funding to begin the design phase.
3. If the design is approved by FEMA, FEMA provides funding for construction.

Feasibility Study Team

Mayor's Office of Recovery and Resiliency (ORR)
Leadership on Citywide Resiliency Initiatives

New York City Economic Development Corporation (NYCEDC)
Feasibility Study Project Management

Coordination with City / State / Federal Agencies
NYCDEP, NYCDOT, NYCDCP, NYCDPR, NYCEM
NYCHA, GOSR, MTA, PANYNJ, NYDHSES, FEMA

Consultant Team

Dewberry Engineers Inc.
Project Lead/Engineering

Mott MacDonald
Engineering and Environmental Science

W Architecture and Landscape Architecture
Landscape Architecture and Stakeholder Engagement

BJH Advisors
Economic Analysis

Cooper Robertson & Partners
Architecture and Urban Design

Toscano Clements Taylor
Cost Estimation

Grain Collective
Stakeholder Engagement and Strategy

Hester Street Collaborative
Stakeholder Engagement and Strategy

Sustainable Ports
Strategy and Engagement

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