Financial District and Seaport Climate Resilience Master Plan

NYC/EDC

NYC Mayor's Office of Climate Resiliency

ARCADIS

Photo Credit: Getty Images

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Acknowledgments

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Alliance for Downtown New York
The Battery Conservancy
C40 Cities Climate Leadership Group
Financial District Neighborhood Association
Manhattan Community Board 1
Manhattan Community Board 3
Natural Resources Defense Council
New York League of Conservation Voters
Pace University
Partnership for New York City
Pasanella and Son Vintners
Real Estate Board of New York
Rebuild by Design
Resilient Cities Catalyst
The Rockefeller Foundation
South Street Seaport Coalition, Inc.
South Street Seaport Museum
Trinity Church Wall Street
Tri-State Transportation Campaign
Trust for Governors Island
Trust for Public Land
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Waterfront Alliance
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New York City Department of Small Business Services
New York City Department of Transportation
New York City Emergency Management
New York City Housing Authority
New York City Landmarks Preservation Commission
New York City Law Department
New York City Office of Management and Budget
New York City Department of Parks & Recreation
New York City Police Department
New York State Empire State Development
New York State Department of Environmental Conservation
New York State Department of State
New York State Department of Transportation
New York State Historic Preservation Office
Port Authority of New York and New Jersey
National Marine Fisheries Service
United States Army Corps of Engineers
United States Coast Guard

Letter from the Mayor

December 2021

Dear Friends,

Climate change is real, and its effects are already with us. New Yorkers are painfully aware of the threats that warming temperatures and rising seas pose to our prosperity and safety. My administration has moved aggressively to tackle these threats and protect the City and its residents, including implementing the New York City Green New Deal to reduce carbon emissions and accelerate the transition to a green economy; building flood protection for vulnerable coastal communities like Red Hook and the Rockaways; and upgrading our early warning systems to better prepare for extreme weather events like Hurricanes Sandy and Ida. The Financial District and Seaport Climate Resilience Master Plan is a bold step toward showing the world what a resilient 21st-century waterfront can be.

Among the biggest gaps in our coastal defenses is in the critical hub of Lower Manhattan. Our entire region depends on its survival and ability to thrive. It is where our vast network of subways, ferries, and highways converge and connect, and it welcomes 300,000 daily workers, half of them commuting from the outer boroughs. And, of course, Lower Manhattan is where much of our city's vibrant history is enshrined - from the Battery to Broadway to the 9/11 Memorial.

If we do not act, parts of this vital neighborhood will begin to flood all too frequently by the 2040s, monthly by the 2050s, and almost daily by the 2080s. Our biggest challenge is securing the Financial District and South Street Seaport, almost one mile of waterfront from The Battery to the Brooklyn Bridge. Here, a lack of space combined with dense infrastructure makes building flood defenses on land impractical, and could threaten its survival in the decades to come.

But here's the good news: we are investing over $900 million in a series of major capital projects that will protect much of Lower Manhattan, and we will once again do what we have always done: reimagine the shoreline of Lower Manhattan to serve the needs of New Yorkers. Through our plan, we envision extending the shoreline to make room for flood walls that will provide permanent, 24/7 protection against rising tides and severe storms. Above these structures, a new park will welcome New Yorkers of all ages and abilities with green spaces, incredible views, access to improved ferry terminals, and safe connections for cyclists. It is a vision informed by many conversations with the Lower Manhattan community and extensive technical and environmental analysis.

Now is the time to act. Adapting to climate change and preventing its worst effects will take all our efforts, including strong support from our state and federal partners. Most of all, New Yorkers like you must demand action. Together, we can protect Lower Manhattan and secure the future of the city we love.

Sincerely,

Bill de Blasio
Mayor

Chapter One

Introduction

Climate Change is not Coming, it is Here

The *Financial District and Seaport Climate Resilience Master Plan* is a shared **City-community vision for a resilient 21st-century waterfront.** This vision responds to the increasing hazards posed by climate change, while transforming the waterfront to better serve all New Yorkers for generations to come. Grounded in community and regulatory input, climate science, engineering, and feasibility analysis, the master plan reflects an ambitious vision that can be realized. The next step is to advance design and identify the funding to make this master plan a reality.

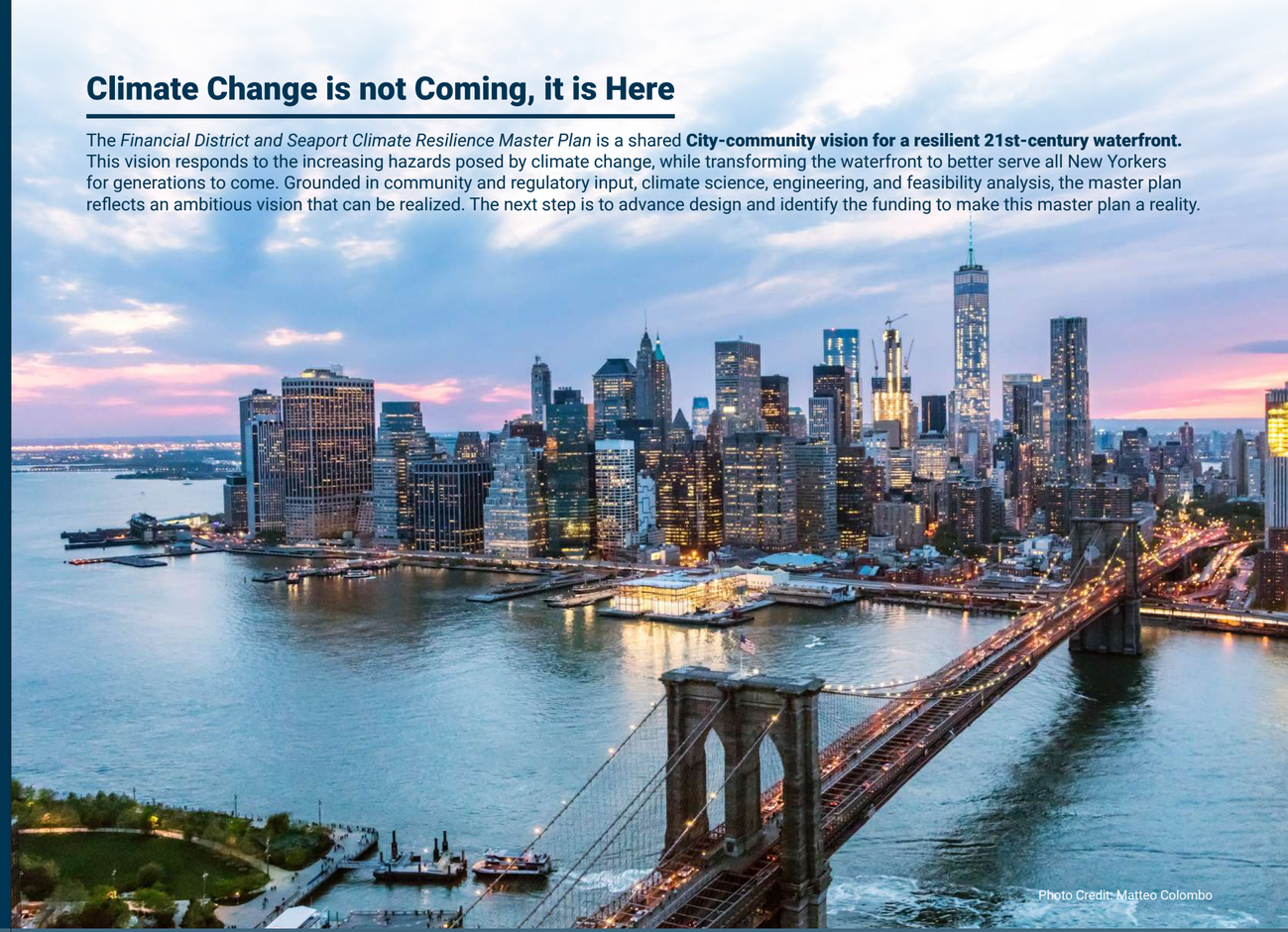


Photo Credit: Matteo Colombo

Why Lower Manhattan?

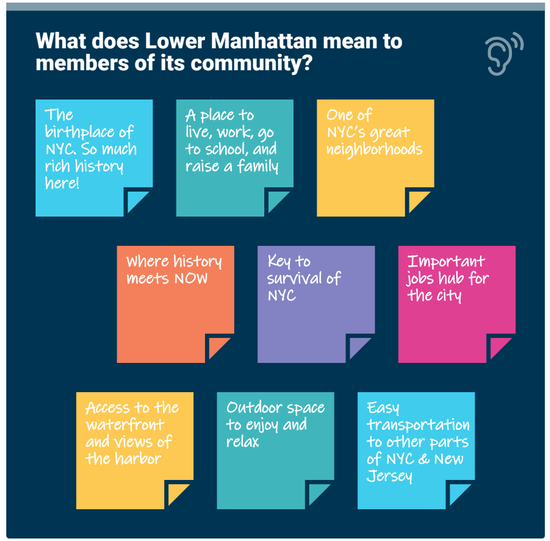
Lower Manhattan is at the core of New York City's transportation system, economy, and civic life. It also serves as both a destination and gateway for residents, workers, and visitors from across the city, region, and world. Millions of people travel through Lower Manhattan by rail, bus, car, and ferry every day, and people and goods flow through the area's highways, tunnels, and bridges. With over 415,000 daily subway and PATH (Port Authority Trans-Hudson) Train riders, and 93,000 daily ferry riders, Lower Manhattan provides connections across all five boroughs and to other regional centers like Midtown, Jersey City, and Downtown Brooklyn.[1, 2]

> What happens in Lower Manhattan impacts New Yorkers in every corner of our city.

New Yorkers from every neighborhood work in Lower Manhattan, from small business owners to construction and building trade workers, to those in the healthcare, education, technology, civic, and financial sectors. As one of the largest business districts in the United States, Lower Manhattan is central to the economy of the city and region.

In recent decades, Lower Manhattan has transformed into a growing mixed-use neighborhood with 24/7 services and amenities for residents, students, workers, and visitors. Over the past two decades, the residential population has grown by 170 percent.[3] The Lower Manhattan of today is a residential community, as well as a business district, transportation hub, and cultural destination.

Lower Manhattan is also the birthplace of New York City dating back to the 17th century. However, this area's human history began much earlier when the Lenape people settled here over 3,000 years ago. Over the centuries, Lower Manhattan has continued to reinvent itself as part of a transforming and growing city. Today, it remains an iconic global symbol and an exemplar of dynamism and resilience in the face of change.



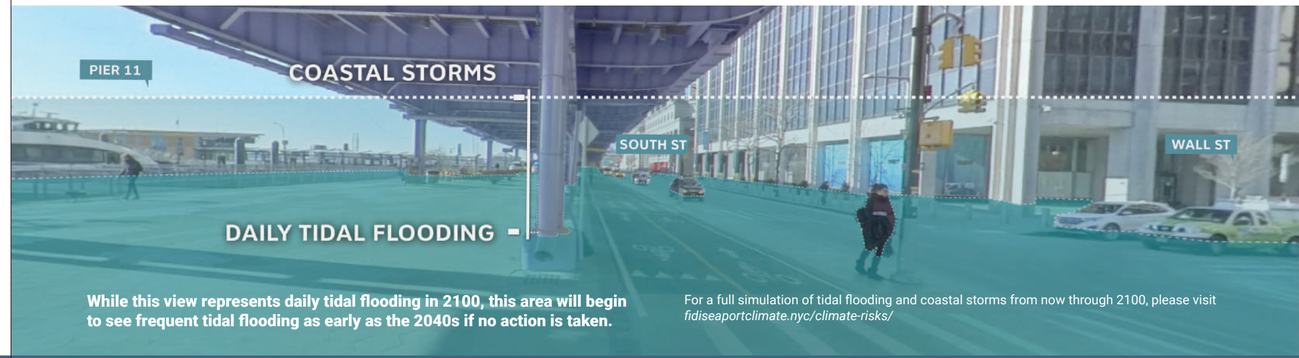
Statements collected throughout the public engagement process about the importance of Lower Manhattan

Why Now?

By the 2040s, Lower Manhattan's shoreline will begin to experience frequent tidal flooding from sea level rise, impacting streets, sidewalks, buildings, and critical infrastructure. By the 2050s, this flooding will occur monthly, and, by the 2080s, it will happen every day. The Whitehall Terminal for the Staten Island Ferry—the busiest passenger ferry route in the country—will begin to see operational impacts by the 2050s. By 2100, daily high tides will reach up to three blocks inland at Pearl Street. Failure to act will render much of this area unusable, leading to the loss of Lower Manhattan—along with its critical citywide functions—as we know it today. **Such a devastating impact on our economy, transportation system, and identity, affecting the lives and livelihoods of millions of New Yorkers, is not an option.**

> We are not planning for the Lower Manhattan that exists today. We are planning for the Lower Manhattan of the future that will be underwater every day if we do not act now.

In addition to tidal flooding, Lower Manhattan is at risk from more frequent and severe storms, like hurricanes and nor'easters. Hurricane Sandy devastated the area in 2012, taking two lives and damaging buildings, streets, and infrastructure. In 2021, Tropical Storm Henri and Hurricane Ida brought record rainfall to the city. These threats will only increase over time. By the 2050s, annual losses from coastal storms, including building damage, healthcare costs, and lost services are expected to be over a billion dollars a year if no action is taken. By 2100, severe storms will bring up to 15 feet of flooding and reach up to William Street, five blocks from the East River shoreline. The drainage system will also be increasingly stressed due to the combined effects of increased rainfall and coastal storms, leading to flooding of streets and basements, if no action is taken.



While this view represents daily tidal flooding in 2100, this area will begin to see frequent tidal flooding as early as the 2040s if no action is taken.

For a full simulation of tidal flooding and coastal storms from now through 2100, please visit *fidiseaportclimate.nyc/climate-risks/*

Lower Manhattan by the Numbers

Lower Manhattan is both a destination and a gateway, serving as a transit hub, a thriving residential community, a central business district, and home to dozens of cultural and civic institutions. This graphic and accompanying data represents a snapshot of the importance of Lower Manhattan and the critical functions it serves – for the New York City region and beyond.

14 subway lines
17 ferry routes
510,000 commuters
290,000 workers[4]
62,000 residents[3]
55,000 students

- Lower Manhattan
- NYC Ferry Landing
- Other Ferry Landing
- Subway Station
- Ferry Route
- Subway Route

Building Area

- 20,000 - 250,000 SF
- 250,000 - 750,000 SF
- 750,000 - 1,500,000 SF
- 1,500,000 - 3,000,000 SF
- 3,000,000+ SF

Land Use

- Mixed-Use
- Commercial
- Residential
- Public Facilities

Sources
LEHD Origin-Destination Employment Statistics (LODES).
NYC Permitted Event Information - Historical: NYC Open Data.
Primary Land Use Tax Lot Output (PLUTO). NYC DCP.
Subway and Bus Ridership for 2019. MTA.
Surging Ahead: Lower Manhattan's Economic Revival and What It Means for New York. Alliance for Downtown New York, 2015.
Unique Visitor to Lower Manhattan 2019/2020. Audience Research & Analysis (ARA).

Notes
Data based on 2019 transit ridership figures

0ft 500ft 1000ft N

A Center of Culture, Community, and Civic Life

62K
23K
170%
increase in residents since 2000[3]

21
higher learning institutions

17.7
million annual visitors to major attractions in the area[3]

550
major civic events in the last decade, such as parades, protests, and marches[5]

A Critical Hub of Transportation for the City and Region

50%
of Lower Manhattan workers come from the other four boroughs

33%
of Lower Manhattan workers come from outside NYC

17%
of Lower Manhattan workers come from Manhattan[4]

370,000 **93,000** **47,000**
daily riders use the subway, ferry, and PATH, respectively, in Lower Manhattan[6]

A Driver of the City's Economy and Workforce

$6.5
billion in estimated tax contributions in 2019[7]

1 in 10
jobs in New York City

10%
of the City's assessed property value[3]

Why a Climate Resilience Plan?

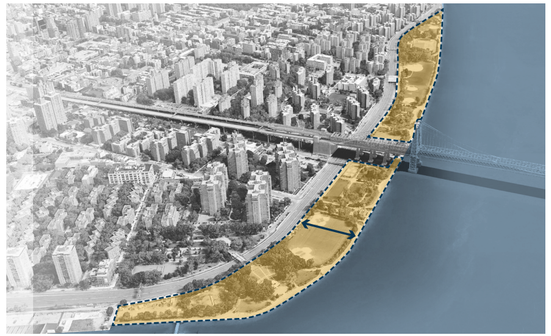
Lower Manhattan is particularly vulnerable to the impacts of climate change due to its low-lying shoreline, which is why the City is advancing over $900 million in capital projects to protect this area. In 2019, the City released the *Lower Manhattan Climate Resilience Study*, a comprehensive multi-hazard climate risk assessment, highlighting the vulnerabilities of the area. The report identified capital projects to adapt and protect 70 percent of Lower Manhattan's shoreline but found the areas between The Battery and the Brooklyn Bridge particularly challenging and in need of further study. This included examining the need to extend the shoreline of Lower Manhattan into the East River to construct flood defense infrastructure. **This master plan sets out to fill this critical gap in realizing a resilient Lower Manhattan**. Combined, these capital projects along with the master plan comprise the Lower Manhattan Coastal Resiliency (LMCR) strategy.

> Brooklyn Bridge to The Battery is a missing link in realizing a resilient Lower Manhattan.

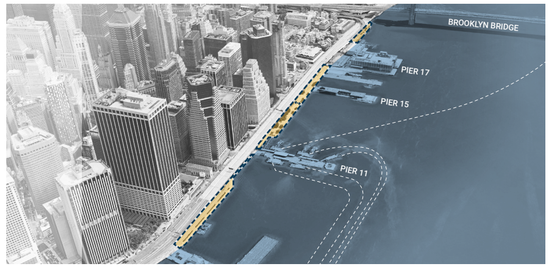
The Financial District and South Street Seaport (Seaport) neighborhoods are unique within the geography of Lower Manhattan, facing unprecedented challenges to implementing a flood defense system. Along this one-mile stretch, a complex mix of infrastructure—subway tunnels and stations, vehicular tunnels, subsurface utilities, and an elevated highway—limit what can be built on existing land. Combined with limited space along the waterfront, in addition to the presence of active ferries, vessel traffic, and other maritime operations, constructing a flood defense system here is a monumental challenge. This area is also low-lying and experiences larger waves during coastal storms compared to neighboring areas, further limiting the types of flood defense infrastructure that can provide protection.

Solving this challenge is a once-in-a-generation opportunity to create a better waterfront for all, while preserving the essential functions and historic character of the area. This master plan knits flood defense into the fabric of these neighborhoods, overcomes highly complex technical constraints, and envisions a transformed public waterfront for all to enjoy.

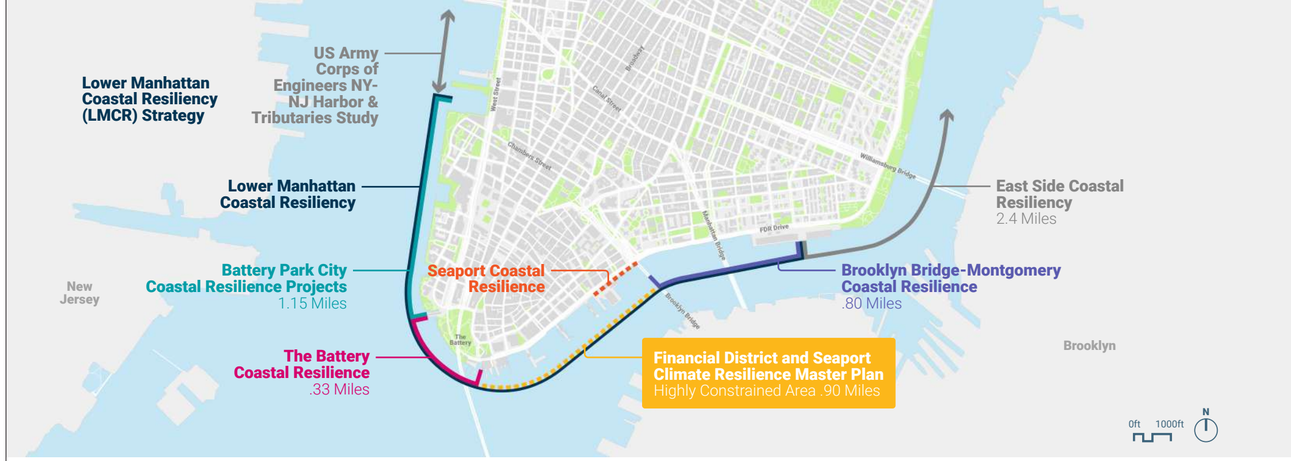
What makes constructing this infrastructure on land so challenging?



Other neighborhoods – like the Lower East Side – have wide-open spaces that can accommodate coastal flood protection infrastructure.



By contrast, space is limited along the shoreline in the Financial District and Seaport.



Battery Park City Coastal Resilience Projects

Lead: Battery Park City Authority (BPCA)

This includes a series of resilience projects and drainage improvements to provide flood risk reduction for Battery Park City and parts of adjacent neighborhoods in response to the threats of coastal storm surge and sea level rise.

The Battery Coastal Resilience

Lead: NYC Economic Development Corporation (NYCEDC), NYC Parks

This project will raise and harden the esplanade that runs along The Battery, protecting this important open space while preserving its historic character and active waterfront uses. The flood defense will be designed to protect against sea level rise through 2100.

Brooklyn Bridge-Montgomery Coastal Resilience (BMCR)

Lead: NYCEDC, NYC Department of Design and Construction

This project combines permanent floodwalls with floodgates that are hidden during normal weather conditions and flip-up during a coastal storm to create a complete line of flood protection. This project also includes drainage improvements and community amenities, such as playgrounds, benches, and seating.

Seaport Coastal Resilience (SPCR)

Lead: NYCEDC, Mayor's Office of Climate Resiliency (MOCR)

The City is acting now to protect the Seaport, which is the lowest-lying and most vulnerable portion of the master plan's study area. The project will raise the esplanade approximately three to five feet to defend against tidal flooding and coastal storms and includes drainage improvements. The project will also improve waterfront access for pedestrians and cyclists. The City is seeking federal funding to complement the City's commitment.

What is a climate resilience master plan?

This master plan is not set in stone, but rather is intentionally flexible so it can adapt to future needs and priorities.

The master plan:

- Is a guiding document for long-term decision-making
- Is grounded in extensive community engagement
- Demonstrates what this area could look like in the future

What did this Master Plan set out to Achieve?

This master plan set out to define a viable resilience solution to adapt the Financial District and Seaport neighborhoods to the impacts of climate change. In Fall 2019, the New York City Economic Development Corporation (NYCEDC) and Mayor's Office of Climate Resiliency (MOCR) launched a two-year public planning process, bringing together City agencies, local experts, and an interdisciplinary team led by the Dutch engineering firm Arcadis, to shape the master plan. The master plan's ultimate success depends on fostering widespread community support, ensuring technical feasibility, and charting a clear pathway to implementation.

Grounded in a Shared Vision

In developing this master plan, the City worked closely with representatives of the Lower Manhattan community, citywide organizations and individuals, and the broader public to reflect a shared vision for the waterfront. The Climate Coalition for Lower Manhattan (CCLM), a stakeholder group formed to guide this master plan, brought together residents, business representatives, community organizations, and environmental and resilience groups to actively shape the master plan.

Technically Feasible

Key to the master plan's success is proposing a reliable and technically feasible flood defense system. To do this, the project team conducted extensive technical analyses, including studying how water in the East River moves during both coastal storms and normal weather conditions; the viability of different flood defense tools in this location; and, the potential impacts to waterborne transportation and aquatic ecosystems. The project team also studied how the current drainage system works and developed a strategy to manage stormwater behind the proposed flood defense system.

Implementable

In addition to technical feasibility and community engagement, the master plan charts out a path through design, permits and approvals, and construction. While this includes many considerations, from funding to governance to constructability, state and federal permitting requirements will have the greatest impact on the final design. As implementation will require state and federal permits, it is critical that the City carefully balance these requirements with the master plan goals and City policy priorities.

Sustainable

In line with *OneNYC 2050* and the City's goal of carbon neutrality by 2050, the master plan aims to guide the Financial District and Seaport's adaptation to the impacts of climate change without compromising the needs of future generations.

What is the Climate Coalition for Lower Manhattan?

Members of the CCLM, the master plan's primary stakeholder group, include representatives from:

- Alfred E. Smith Houses Resident Association, Inc.
- Alliance for Downtown New York
- The Battery Conservancy
- C40 Cities Climate Leadership Group
- Financial District Neighborhood Association
- Manhattan Community Board 1
- Manhattan Community Board 3
- Natural Resources Defense Council
- New York League of Conservation Voters
- Pace University
- Partnership for New York City
- Pasanella and Son Vintners
- Real Estate Board of New York
- Rebuild by Design
- Resilient Cities Catalyst
- The Rockefeller Foundation
- South Street Seaport Coalition, Inc.
- South Street Seaport Museum
- Trinity Church Wall Street
- Tri-State Transportation Campaign
- Trust for Governors Island
- Trust for Public Land
- Urban Assembly New York Harbor School
- Waterfront Alliance
- Assembly Member Niou
- Borough President Brewer
- Council Member Chin
- Congressman Nadler
- Senator Gillibrand
- Senator Schumer
- State Senator Kavanagh

Master Plan Goals

To protect Lower Manhattan, we must transform this waterfront to be resilient while maintaining its vibrancy and critical functions.

Goals

Ingredients

Protect Lower Manhattan from tidal flooding and coastal storms by

- Building **new coastal flood defense infrastructure**
- Building **new drainage infrastructure** to manage stormwater

Integrate climate resilience infrastructure into the city by

- Ensuring **universal accessibility** and **emergency vehicular connections** to the waterfront and along the shoreline, and a **continuous bikeway**
- Constructing **new resilient maritime facilities** to support ferries, historic ships, and other waterfront operations
- Limiting impacts to the East River's **ecology** while enhancing habitats where possible

Enhance the public waterfront by

- Preserving and enhancing **existing public destinations**
- Creating **multi-level waterfront open space**
- Providing **community-serving uses**

What is a Resilient 21st-Century Waterfront?

The *Financial District and Seaport Climate Resilience Master Plan* will **ensure that Lower Manhattan withstands rising sea levels and increasingly intense coastal storms**, while knitting a new flood defense system into the fabric of the city and creating a waterfront that serves all New Yorkers for generations to come.

Central to this master plan's success is the need to identify reliable and technically viable infrastructure to defend the one-mile stretch from the Brooklyn Bridge to The Battery from future tidal flooding and coastal storms. The primary design challenge is to achieve these resilience goals while continuing to provide universal accessibility to, from and along this waterfront, reconstructing ferries and maritime uses to make them resilient, and respecting the ecology of the East River. The master plan also presents an opportunity to improve how people experience the waterfront with welcoming entrances, multi-level open spaces, and strong connections to the existing historic destinations along the waterfront.

After detailed study as a part of the master plan, the City has concluded that achieving these goals requires extending the shoreline of Lower Manhattan into the East River to create the space necessary to build flood defense infrastructure. With such limited space along this waterfront and most of the esplanade built on pile-supported structures, a shoreline extension into the East River is needed just to construct the floodwall itself. Beyond space for the floodwall, the City is proposing a shoreline extension that ensures the community is not walled off from the waterfront.

The proposed design will seamlessly integrate flood defense infrastructure into a new multi-level public waterfront open space for all to enjoy. The upper level will protect against coastal storms, with buried floodwalls that double as elevated open spaces with expansive views of the harbor and the city. A lower-level esplanade will be close to the water itself and connect to piers and ferries. This esplanade will be high enough to remain dry as sea levels rise and designed to flood safely during coastal storms.

Bird's-Eye View Facing South
Illustration of what a resilient waterfront could look like in the future

The City is prioritizing *passive flood defense*, which means permanently raising the height of the shoreline to protect the area. Passive measures are needed because this area will eventually face flooding every day due to sea level rise; deploying floodgates every day is not feasible. Further, the Financial District and Seaport's low-lying topography combined with strong wave action during coastal storms makes relying solely on floodgates less suitable. In select locations, floodgates will accompany the passive flood defense, limiting additional weight over subway tunnels and providing entrances for emergency and maintenance vehicles to reach the shoreline. Absent a coastal storm, these floodgates will be hidden, opening views to the river and providing direct access to the shoreline edge.

The City is also proposing new stormwater infrastructure to keep stormwater from backing up and flooding the area behind the new coastal flood defense infrastructure. A combination of both traditional, or "grey" infrastructure, as well as green infrastructure, will help manage stormwater runoff, limiting the additional stress placed on the sewer system during heavy rain and coastal storm events.

> This flood defense system poses a once-in-a-generation opportunity to transform the waterfront, creating a place that serves New Yorkers better than before.

This waterfront is not a blank slate. The flood defense needs to be integrated into the existing city fabric and continue to support the diverse uses that serve the city and region. Ferry terminals along the waterfront will be redeveloped into new modern facilities with room for future expansion. People will be able to access the waterfront with frequent and inviting entrances designed for universal accessibility. The bike path and waterfront esplanade will be replaced and improved to provide safe and uninterrupted connections between the Brooklyn Bridge and The Battery.

This waterfront will also be designed to help advance the City's sustainability goals. The new shoreline edge will incorporate opportunities for ecological enhancements, providing new habitats for fish and other aquatic organisms. Nature-based solutions will be woven throughout to help manage stormwater, provide shade, and reduce local summer temperatures. Further, the master plan identifies opportunities to integrate renewable energy as part of any new buildings or structures along the waterfront.

Pine Street Cove Facing North
Illustration of what a resilient waterfront could look like in the future

What's Next?

This master plan is comparable in scale to other major infrastructure projects essential to New York City's future. These include the Gateway Program to expand and renovate the Northeast Corridor between Manhattan and New Jersey, or Water Tunnel No. 3, which will secure the city's fresh water supply. The master plan will likely take 15 to 20 years to fully implement and cost over five to seven billion dollars. No one funding source will cover the entire cost; therefore, a variety of local, state, and federal sources—both existing and new—will need to be considered. Critically, the City will need to secure permits from state and federal entities to move forward. As a next step, the City will advance the design process and work closely with the community and regulators throughout future phases of work.

Take Action

This moment belongs to all New Yorkers who work in, live in, travel through, and enjoy Lower Manhattan and want to help build a more resilient, livable city. This master plan is the first step toward closing a major gap in the Lower Manhattan Coastal Resiliency strategy, but the work does not end here. New York City needs you—your vision, your advocacy, your participation—to make this master plan a reality.

Learn more about the next phase of work and how you can get involved at ***fidiseaportclimate.nyc.***

Illustrations of #MyResilientLowerManhattan drawn by children at a community open house (Photo courtesy of project team)

Sources

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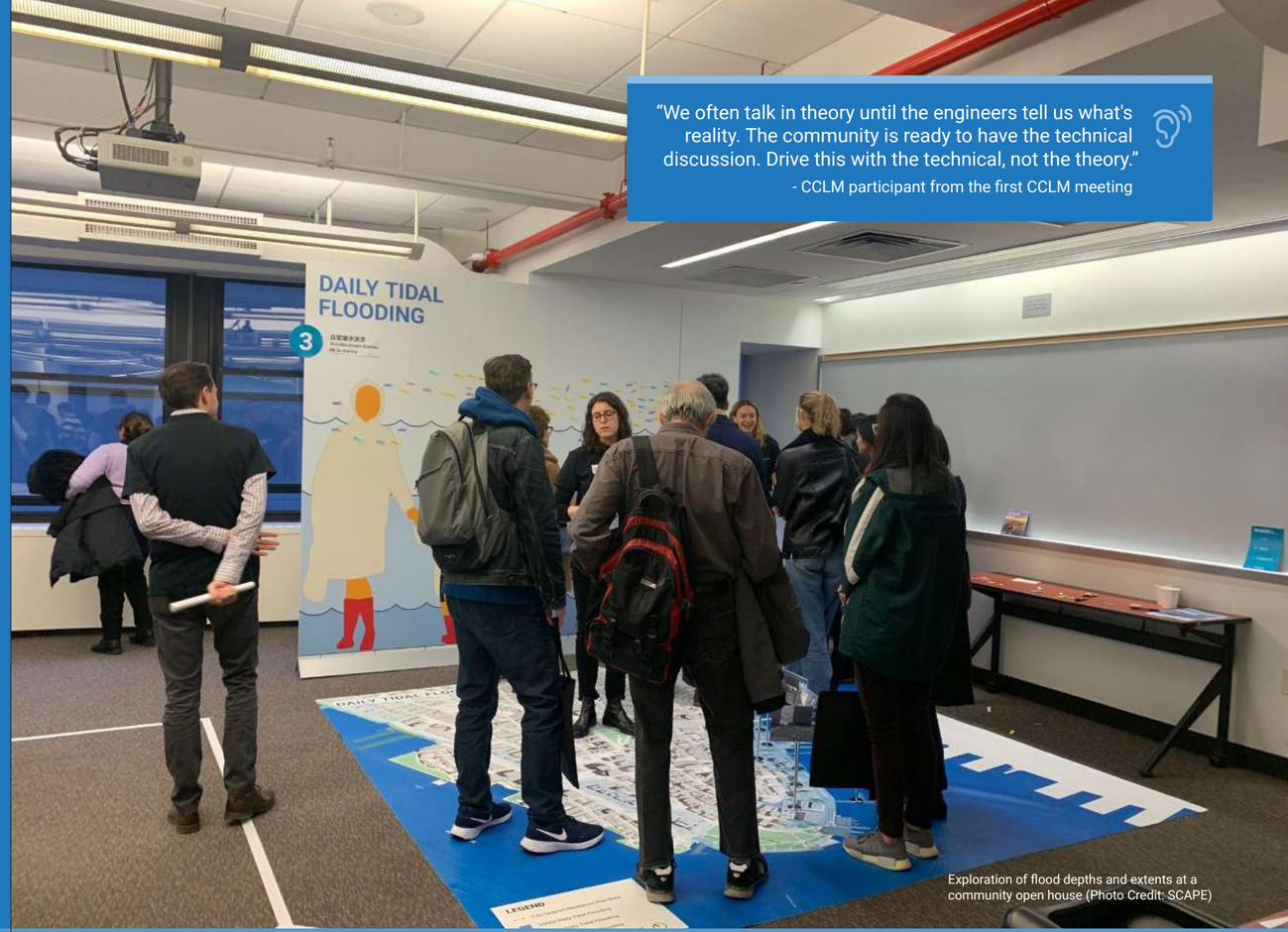
Chapter Two

Master Plan Process



"We often talk in theory until the engineers tell us what's reality. The community is ready to have the technical discussion. Drive this with the technical, not the theory."

- CCLM participant from the first CCLM meeting

Exploration of flood depths and extents at a community open house (Photo Credit: SCAPE)

How was this Master Plan Created?

Creating a master plan for a resilient 21st-century waterfront requires bold interdisciplinary thinking to ensure feasibility, broad community support, and a pathway to implementation. Over two years, the New York City Economic Development Corporation (NYCEDC) and the Mayor's Office of Climate Resiliency (MOCR) led a multi-disciplinary planning process on behalf of the City of New York to develop this master plan. This included engagement with the community (both in-person and online), technical analysis on a variety of topics core to the creation of the master plan, and building an implementation plan. Combined, these three workstreams ensured that the master plan was shaped by a diversity of voices, perspectives, and expertise and has the necessary elements for long-term success.

The City approached the work by dividing the master plan process into four phases. It began with evaluating the broadest range of possible resilience solutions and ended with a proposed conceptual design, along with a roadmap for implementation. Throughout this process, each potential resilience solution was explored in depth before reaching any conclusions.

Community engagement, technical analyses, and implementation planning all began on day one. Additionally, the project team ensured that the workstreams all related to one another throughout the process. For example, community feedback shaped questions during the technical analyses and considerations around permitting and costs influenced design decisions.

The development of the master plan was also informed by previous community engagement and resilience planning in Lower Manhattan. Since Hurricane Sandy, much has been done to advance climate change adaptation in the area. One year after Sandy, the City released *A Stronger, More Resilient New York*, where an initial idea for a shoreline extension along the Financial District, South Street Seaport, and Two Bridges neighborhoods was first presented. Upon the release of the *Southern Manhattan Coastal Protection Study* in 2014, which analyzed a potential shoreline extension in more detail, Lower Manhattan leaders and community members called for a more comprehensive solution as well as the further exploration of on-land resilience options.

These efforts led to the creation of the *Lower Manhattan Climate Resiliency Study*, a comprehensive multi-hazard climate risk assessment, highlighting the vulnerabilities of the area. This study was the first comprehensive assessment of climate change impacts across Lower Manhattan, informed by the findings of the New York City Panel on Climate Change (NPCC). The NPCC is a group of climate scientists tasked with advising the City on climate impacts and resilience initiatives. The study led to on-land projects across 70 percent of Lower Manhattan's coastline with over $900 million in capital investments to date. The study also found that an entirely on-land resilience solution in the Financial District and Seaport would likely be incredibly challenging and that a shoreline extension should be explored further. The *Financial District and Seaport Climate Resilience Master Plan* is the missing link, building off previous analysis and developing a solution for one of the most unique and challenging shorelines to adapt in Lower Manhattan. For the purposes of analysis, the master plan's study area goes from the base of the Brooklyn Bridge through The Battery and inland up to Broadway, in line with the general area that will be protected by this plan.

Who Created the Master Plan?

NYCEDC and MOCR led the project team to develop the master plan. The project team also consisted of City agency partners, and an interdisciplinary consultant team of technical experts assembled by the City. This project team met and consulted with a broad range of additional state and federal agencies, outside technical experts, community members, and other public stakeholders to inform the plan.

City Agencies

NYC EDC
NYC Mayor's Office of Climate Resiliency
NEW YORK CITY DOT
NYC Parks
NYC PLANNING
NYC Environmental Protection

Consultant Team

ARCADIS
SCAPE
one architecture (new york city · amsterdam)

AKRF
BJH Advisors
Ernst & Young
Matrix New World
Sam Schwartz Engineering
Sive Paget Riesel

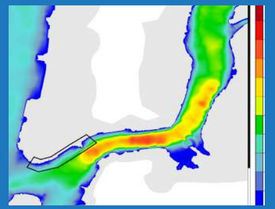
Advisory Role: HR&A Advisors, Karp Strategies, Public Works Partners

In developing this master plan, the process was just as important as the outcome to ensure that this is the right plan for this place.

The Master Plan Process

Phase I

Assess existing conditions, and begin key systems analyses (flood defense, drainage, maritime, public and emergency access, ecology, and public programming)



Screenshot from a hydrodynamic model, used to understand how water currently moves in the East River

Phase II

Identify constraints and opportunities across systems and develop the broadest range of potential resilience solutions

Early development of project options, including on land and in-water flood defense approaches

Phase III

Narrow the resilience solutions based on technical feasibility and community and regulatory feedback

An early rendering of what a resilience solution could look like, standing atop the upper level

Phase IV

Develop the conceptual design and implementation roadmap

An Illustration of what a resilient waterfront could look like in the future

Building a Shared Vision

Approach to Engagement

It is critical that the future of the Financial District and Seaport waterfront reflects a shared vision between the City and the community. To accomplish this, the City worked closely with community members throughout the master planning process to share updates on the technical work, educate about climate change hazards and impacts, gather input and feedback, and incorporate diverse perspectives and voices. This feedback directly informed everything from the master plan process itself to the technical analysis as well as the eventual conceptual design proposal. To foster broad participation and reach a diversity of voices, the City employed a variety of digital and non-digital tools, conducted extensive marketing and outreach, and ensured the project team was available for one-on-one conversations.

The following principles helped to shape this engagement process:

- **Empowering community members by** advancing their understanding of the science of climate change and its potential impacts, as well as the technical constraints and tradeoffs of building flood protection in the study area
- **Ensuring opportunities for co-creation** to develop resilience infrastructure solutions that meet the needs and priorities of local and citywide groups
- **Delegating power** to planning partners to expand engagement and bring more people into the conversation
- **Actively consulting** with individuals and organizations and incorporating their feedback into the master plan
- **Keeping the community informed** of the planning process and crucial decision points, and highlighting how their input shaped the master plan
- **Closely coordinating** across local, state, and federal agencies to ensure that the proposed conceptual design is feasible and implementable

The City convened the Climate Coalition for Lower Manhattan (CCLM), a group of local and citywide organizations and resilience advocates who helped advise on the development of the master plan. Additionally, the City held public meetings, worked with local elementary, middle, and high schools to bring in youth perspectives, and met one-on-one with community members, advocates, and other waterfront users. The City also coordinated with local, state, and federal elected officials, convened an independent panel of technical advisors who reviewed the project team's work, and launched an interactive online engagement portal specifically for the master plan.

The City regularly met with the Aquatic Resources Advisory Committee (ARAC), a group of representatives from state and federal regulatory agencies, formed for the master plan, who advised the project team on considerations regarding issuing of permits for any proposed work in the East River to help pave a clear pathway to implementation. As with any engagement process, different groups had varying priorities that needed to be reconciled and integrated. This master plan reflects a balance across the diverse feedback received.

Most of this engagement happened in the context of the COVID-19 pandemic, which dramatically shifted the framework for engagement. In place of in-person meetings and gatherings, the City transitioned its engagement to an online format, holding meetings over Zoom, building out an interactive online engagement portal, and live-streaming public meetings. While the format of community conversations changed, the quality of input and participation was sustained. The City learned valuable lessons around inclusive online engagement and how to ensure broad representation, even during an unprecedented time.

Who Shaped this Master Plan?

The City led the master plan process, which was informed and supported by hundreds of interested members of the public. This input and feedback was integral to the development of the master plan.

Engagement Timeline

Over the past two years, the City conducted extensive community outreach to ensure this master plan reflects a shared vision. The work was divided into four phases, as described below. While engagement was ongoing throughout the process, the project team organized meetings around key decision points and milestones to ensure transparency and meaningful engagement around master plan priorities and decision-making.

Phase I

Assess existing conditions, and begin key systems analyses

Fall 2019 - Winter 2020

What was shared: What the latest science says about the climate hazards these neighborhoods face now and in the future; how other cities and countries are adapting their waterfronts to climate change; possible flood defense strategies

What community gave feedback on: How to make this an open, equitable, and transparent planning process; the types of technical analyses to prioritize

Phase II

Identify constraints and opportunities across systems and develop the broadest range of potential resilience solutions

Spring 2020 - Winter 2021

What was shared: How existing conditions in the study area shape what is feasible; how the climate threats influence design; early thinking around flood defense infrastructure

What community gave feedback on: Guiding principles for the overall master planning process; what makes this area unique; what people want to see here in the future; overall master plan footprint

Local elementary school students learn about flood risk in Lower Manhattan at Public Open House #1 (Photo Credit: SCAPE)

Phase III

Narrow the resilience solutions based on technical feasibility and community and regulatory feedback

Winter 2021 - Spring 2021

What was shared: Flood defense proposal focusing on a narrow-to-moderate shoreline extension to achieve the master plan's goals and reflect community feedback

What community gave feedback on: How to make this an exciting and inviting public space in the future; the width of the shoreline extension

Phase IV

Develop the conceptual design and implementation roadmap

Spring 2021 - Fall 2021

What was shared: Conceptual design that incorporates community feedback; an implementation roadmap for funding and financing

What community gave feedback on: Feedback on the proposed design; priorities for implementation

Screenshot of the master plan website during a virtual public open house

Ongoing Community Engagement

- **Climate Coalition Meeting #1** Dec 2019
- **Regulators Meeting #1** Dec 2019
- **Technical Advisors Meeting** Dec 2019
- **Regulators Meeting #2** Jan 2020
- **Community Board & Elected Briefing** Jan 2020
- **Public Open House #1** Feb 2020
- **COVID-19 Pause** Spring 2020 - Summer 2020
- **Technical Advisors Meeting** Mar 2020
- **Community Board & Elected Briefing** May 2020
- **Climate Coalition Meeting #2** Oct 2020
- **Regulators Meeting #3** Nov 2020
- **Community Board & Elected Briefing** Nov 2020
- **Climate Coalition Meeting #3** Dec 2020
- **Technical Advisors One-on-Ones** Dec 2020
- **Ecology & Coastal Defense Workshop** Jan 2021
- **Community Board & Elected Briefing** Jan 2021
- **Public Open House #2** Feb 2021
- **Regulators Meeting #4** Feb 2021
- **Envisioning a 21st Century Waterfront Workshop** March 2021
- **Funding & Financing Workshop** April 2021
- **Climate Coalition Meetings #4&5** May 2021
- **Technical Advisors Meeting** May 2021
- **Public Open House #3** June 2021
- **Regulators Meeting #5&6** June 2021
- **Community Board & Elected Briefing** June 2021
- **Technical Advisors Meeting** Aug 2021
- **Technical Advisors Meeting** Sep 2021
- **Public Open House #4** Nov 2021
- **Climate Coalition Meeting #6** Nov 2021
- **Regulators Meeting #7** Nov 2021

Community Feedback

Over the course of this two-year engagement process, the City spoke to hundreds of organizations and individuals and got feedback on all parts of the master plan, including process, design, and implementation. This feedback shaped the master plan. Below are highlights from the feedback that the City received:

Process

- Identify new forms of online engagement
- Host dedicated conversations on funding and financing to better understand this topic
- Educate on climate hazards and the future impact they will have on neighborhoods and communities
- Engage with youth and local students
- Be transparent with sharing the technical findings
- Study the impacts of replacing the FDR Drive viaduct and explore taking down the elevated highway up to Montgomery Street

Design

Flood defense and infrastructure

- Protect this area for the next generation of New Yorkers
- Incorporate green infrastructure and other natural ways to manage stormwater

Connecting to the surrounding neighborhoods

- Do not wall off the city from the East River
- Preserve and protect the Historic South Street Seaport
- Complement the existing character of the waterfront and surrounding neighborhoods
- Highlight and celebrate the history of this area

Sustainability

- Design for a sustainable future with carbon-neutral and nature-based solutions
- Ensure compatibility with the use of electric ferries
- Look for ways to support local habitats and ecosystems
- Explore the use of shade structures to provide shelter from extreme heat

Parks and open space

- Excitement about the opportunity for a new elevated waterfront experience
- Incorporate a continuous bike path and waterfront esplanade to connect with the Manhattan Waterfront Greenway
- Incorporate opportunities to connect with and get closer to the water
- Set a new global standard for design excellence
- Include a combination of passive and active recreational spaces
- Support other community needs, like additional open space

Buildings

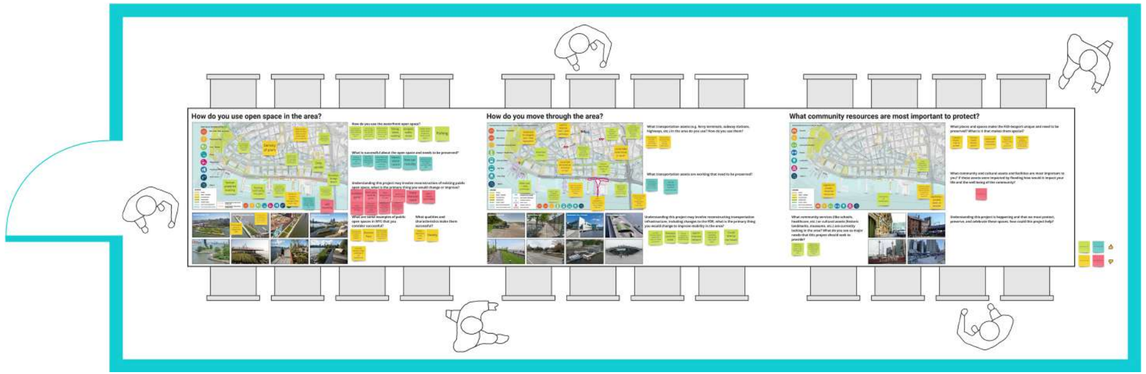
- Interest in integrating small-scale buildings for community-serving amenities, like kiosks, restaurants, ferry ticketing stations and waiting areas, coffee shops, etc.
- Preserve the historic character of the Seaport by not including any high-rise development in this area
- Limit large-scale development, if any is present at all

Transportation & waterborne structures

- Preserve or enhance the ferries, ships, and piers in the area, which add to the character of the waterfront
- Enable strong connections between waterborne transportation and subways and buses
- Protect the critical local and regional transportation connections present in the study area
- Openness to replacing the FDR Drive viaduct with an at-grade boulevard, but some concern about impacts to local traffic

Implementation

- As much as possible, minimize construction impacts on surrounding neighborhoods
- Use sustainable materials in construction
- Consider equitable financing mechanisms to ensure that those who benefit most from this investment are paying their fair share while simultaneously ensuring that this burden does not fall on the most vulnerable or those who are unable to pay
- Continue to coordinate with the community throughout design and implementation



Breakout Room from Public Open House #2, in which participants discussed and documented feedback on open space, circulation, and community amenities

Building a Technically Feasible Plan

Core to the master plan's success is ensuring it is technically feasible and can effectively respond to climate change while maintaining the critical functions that the waterfront provides today. To achieve this, the project team conducted numerous analyses focused on building a technically feasible plan.

Existing Conditions

To identify constraints and opportunities within the study area, the project team extensively studied the existing conditions of the Financial District and Seaport neighborhoods. This included a review of above and below-ground infrastructure, including subway tunnels, drainage infrastructure, utilities, and transportation networks, in addition to soil properties and the condition of structures along the waterfront. The project team also examined the current state of the waterfront esplanade, including how people use and access the space, as well as the amenities that exist along it today.

Wave and Hydrodynamic Modeling

The project team conducted extensive wave and hydrodynamic computer modeling to understand both current and future tides and storm surge in the study area. Early in the master plan process, the project team ran a suite of wave models (ADCIRC and SWAN) to determine the design flood elevation (DFE). The DFE is the height of the flood defense measures necessary to defend the study area from future coastal storms, including waves. Once the project team determined the shoreline will need to be extended into the East River to make space for flood defense infrastructure, the project team ran additional hydrodynamic models (ADCIRC and Delft3D) to understand how creating new land could alter the way water moves in the East River. The project team also analyzed potential impacts to adjacent communities and across the East River in Brooklyn to ensure that the resilience solution for the Financial District and Seaport would not exacerbate flooding elsewhere.

Interior Drainage Modeling

To effectively protect the study area, flood defense infrastructure must be paired with a drainage strategy to manage stormwater behind the flood defense system. To understand drainage needs, the project team analyzed the existing drainage system and the volumes of stormwater that must be managed during coastal storms. Computer modeling software (InfoWorks ICM) simulated future conditions and estimated the magnitude and location of flooding in the future. The project team then developed strategies to address these impacts, working closely with NYC Department of Environmental Protection (DEP).

Sampling and Testing

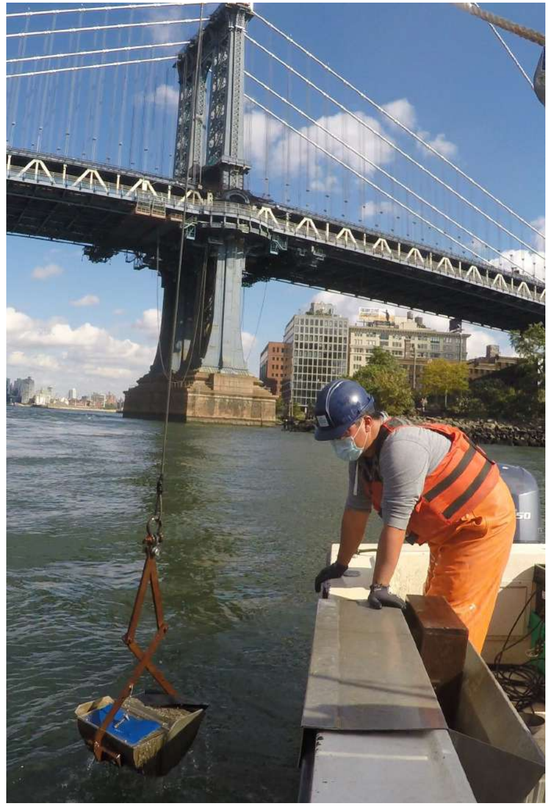
Early in the master plan process, the project team embarked on one year of sampling and testing in the East River to understand current ecological conditions. Sampling and testing was important because there was limited existing information characterizing the species and habitats in the East River, and what information did exist, was out of date. The findings from the sampling and testing program directly informed the design of the master plan and will inform any future assessments of potential adverse environmental impacts of the master plan.

Maritime Analysis and Vulnerability Studies

This waterfront is home to a robust network of ferry terminals, vessel operations, and piers. To understand how the maritime functions and assets within the study area will be impacted by climate change, as well as how to plan for future operations, the project team took an in-depth look at each asset. This included the Whitehall Ferry Terminal, Battery Maritime Building, Piers 11, 15, and 16, and the Downtown Manhattan Heliport. Based on the findings from maritime analyses and sea level rise vulnerability studies, the project team developed strategies to ensure maritime assets in the area are resilient and designed for long-term adaptability to changing needs and conditions.

Engineering and Design Studies

Engineering and design studies were core to the development of the master plan. The engineering and design teams worked together to understand the types of flood defense tools that could be feasible in the study area. The project team conducted detailed engineering studies to test the feasibility of different solutions, including how to integrate flood defense into buildings, how to cross over subway tunnels, how to ensure long-term adaptability of the flood defense system, and how to tie the new infrastructure into higher ground, which is critical to ensuring no water moves around the new coastal flood barrier. While the master plan's primary goal is providing flood defense, the design team also put substantial thought into how this new infrastructure can fit into and improve the urban fabric. This began with better understanding the implications of this infrastructure and how it will impact the waterfront and the day-to-day experience for those who live in, work in, visit, and move through this area. In later phases, this stream of work evaluated how to best weave together the different technical components to create a universally accessible waterfront for all New Yorkers, with programming opportunities that reflect community and citywide needs.



A member of the project team retrieves a sample of sediment and organisms from the bottom of the East River next to the Manhattan Bridge (Photo Credit: Normandeau Associates)

Building a Plan that Can be Realized

From the outset of this process, the project team considered what will be necessary to make the master plan a reality. Implementation planning included four components:

1. Determining required permits and approvals
2. Evaluating sources of funding to pay for implementation of the master plan
3. Considering constructability and phasing
4. Investigating the future responsibilities of a governance entity

By planning for implementation every step of the way, the City is ensuring that the master plan has a clear pathway to success.

Required Permits and Approvals

The master plan will be subject to several local, state, and federal reviews and approvals based on existing historic resources and potential environmental impacts. To better understand the regulatory approvals needed, the project team studied the anticipated approval processes and coordinated closely with local, state, and federal agencies. Given the complexity associated with implementing a plan of this scale, the City took a proactive approach to permitting and protection of aquatic resources starting early in the master plan process. The US Army Corps of Engineers (USACE), as a key regulator overseeing in-water construction, recognized the importance of the master plan and agreed to convene a series of working sessions with relevant regulatory agencies to advise the project team on permitting considerations for any work proposed in the East River. Chaired by the USACE Regulatory Branch of the NY District, the ARAC—convened specifically for the master plan process—includes the New York State Department of Environmental Conservation, the New York Department of State, the National Marine Fisheries Service, and the United States Coast Guard. By working with the ARAC from the outset of the master planning process, the project team was able to incorporate feedback from these agencies into the master plan.

Funding and Financing

Funding the master plan will require significant public investment. As part of the master plan process, the project team developed estimates for both upfront capital investment and long-term costs associated with operating and maintaining the flood defense system. Based on these cost estimates, the project team looked at a variety of local, state, and federal funding sources that could help cover the potential costs of the master plan, as well as identify opportunities for the master plan's goals to align with currently available funding sources. The project team also looked at a range of new and creative funding sources, analyzing the potential contributions from each.

Constructability and Phasing

Fully building the proposed flood defense infrastructure will involve a complex design, permitting, and construction process. Balancing costs, executing timely construction, and ensuring continuity of critical maritime operations along the waterfront will be critical to implementing the master plan. To support the implementation of the master plan, the project team studied different ways in which the master plan could be phased, or constructed, including as a series of projects versus a single capital project.

Governance

The City must identify an entity that can oversee the master plan from design and approvals through to construction and long-term operations and maintenance. The project team explored three options for an entity to implement the master plan: existing agencies, a new governance entity, or a hybrid structure that combines the two approaches. The project team considered different types of potential governing bodies and researched precedents from comparable projects to determine several ways to carry this master plan forward.

The City, State, and U.S. Army Corps of Engineers recently began construction on the Rockaways – Atlantic Shorefront project (Photo Credit: NYC Mayor's Office)

Citywide Initiatives

The *Financial District and Seaport Climate Resilience Master Plan* exists within the larger context of ongoing New York City climate resilience initiatives and adheres to citywide policy goals.

Advancing a Multilayered Climate Adaptation Strategy

Across the five boroughs, the City is advancing a climate resilience strategy that addresses four main climate threats: (1) coastal storm surge; (2) extreme rainfall; (3) tidal flooding caused by sea level rise; and (4) extreme heat, the deadliest form of extreme weather in New York City. This work has been in progress for more than a decade and includes hundreds of completed projects and policy reforms.

Reducing Risk from Coastal Storms

To address coastal flooding, the City is:

- **Investing in coastal flood defense across the city** such as the Red Hook Coastal Resiliency and USACE's South Shore Staten Island Coastal Storm Risk Reduction projects. Other projects under construction include the Rockaways-Atlantic Shorefront and the East Side Coastal Resiliency projects
- **Elevating, hardening, and protecting** critical utilities across the city, including wastewater treatment facilities, energy systems, and transportation assets
- **Strengthening existing buildings** to withstand climate impacts, including New York City Housing Authority (NYCHA) campuses
- **Leveraging land use and regulatory policy** such as updating the Building Code and Zoning Resolution as well as publishing the New York City Climate Resiliency Design Guidelines
- **Supporting communities** with programs assisting small businesses and individual New Yorkers

Managing Stormwater

While Hurricane Sandy recovery primarily concentrated on protecting shorelines, the City is expanding its focus to adapt to extreme rainfall for both inland and waterfront neighborhoods. In September 2021, the City released *The New Normal: Combating Storm-Related Extreme Weather in New York City*. In addition to policy changes, the Mayor announced the following investments:

- $2.1 billion in new funding for DEP;
- $238 million in accelerated funding for crucial DEP projects;
- $400 million in new funding for other priority capital projects among City agencies including NYC Parks, Department of Transportation, New York City Housing Authority, and the School Construction Authority; and
- $42 million in expense funding for Fiscal Years 2022 and 2023.

The City also released its first Stormwater Maps in 2021. Equipped with new data, the City is advancing a program for four "cloudburst neighborhoods," bringing planning and investments to communities with the highest vulnerability to stormwater flooding. The City is also integrating more nature-based solutions to reduce the stress on the city's sewer system, including more than 11,000 rain gardens as well as bioswales. The City has also built out an expansive network of Bluebelts in Staten Island. Bluebelts are ecologically rich systems that naturally handle the runoff from rain on streets and sidewalks.

Addressing Sea Level Rise Impacts

With 520 miles of coastline, sea level rise is among the most challenging climate risks facing the city. The City is confronting this challenge directly, including:

- **Raising Shorelines** through the Raised Shoreline Citywide program, where the City is investing $125 million to reduce the impacts of tidal flooding and address sea level rise
- **Advancing new zoning designations**, including "Special Coastal Risk Districts" to ensure new development is consistent with open space and infrastructure plans in highly vulnerable areas that are already experiencing frequent flooding from high tides
- **Restoring coastal wetlands** as outlined in NYC Parks' *Wetlands Management Framework*, released in 2021, which identifies more than 300 acres of wetland restoration projects, helping to create a natural buffer against flooding

The city is also working to better document tidal flooding. Together with the Science and Resilience Institute at Jamaica Bay and New York Sea Grant, the City is working with residents through the Flood Watch program to document the scale, scope, and impacts of frequent flooding. In addition, the City is leading a consortium of research institutions to expand a flood sensor network, FloodNet NYC, to get real-time, hyper-local data.

Staying Safe from Rising Temperatures

As extreme heat is New York City's deadliest type of natural hazard, building long-term resilience to this threat is critical. In 2017, the City released its first heat adaptation plan, *Cool Neighborhoods NYC*, which includes both physical and programmatic initiatives to combat extreme heat. The plan includes a $100 million investment in tree plantings in the City's most heat vulnerable neighborhoods to help lower temperatures. Through CoolRoofs NYC the City has covered over 11 million square feet of rooftops with white, reflective coatings.

During heat waves, the City activates a network of several hundred cooling centers at libraries, senior centers, and other community facilities. Low-income New Yorkers can request cooling assistance through the Home Energy Assistance Program (HEAP), which provides up to $800 for the purchase and installation of an air conditioner. The City also manages a network of cooling features highlighted in the *Cool It! NYC* online map, including misting stations, spray showers, and water fountains. In 2020, during the COVID-19 pandemic, the City transformed select Open Streets in heat vulnerable areas into "Cool Streets" by equipping them with cooling features such as spray caps installed on fire hydrants and portable drinking fountains to allow for socially distanced cooling.

The City also operates a social resilience program in partnership with community-based organizations called "Be A Buddy," which trains volunteers in climate health education and community preparedness to reach at-risk New Yorkers during heat waves and other emergencies.

Coordinating With Key Partners

Building resilience is a massive undertaking that involves collaboration across multiple levels of government, public service providers, and the private sector. The City's work is complemented by other resilience efforts being undertaken by partners, including:

- Governor's Office of Storm Recovery
- NY State Department of Environmental Conservation
- Metropolitan Transit Authority
- Port Authority of New York and New Jersey
- Federal Emergency Management Agency
- US Army Corps of Engineers
- Investor-owned regional utilities, such as Con Edison
- Private sector building owners

Developing and implementing solutions to respond to the impacts of climate change on New York's communities cannot be achieved with a one-size-fits-all approach. Rather, every neighborhood has unique needs and constraints, as well as vulnerabilities, that must be taken into consideration when planning for a resilient future. Responding to the existential threat of climate change will require communities and decision-makers coming together in new ways to solve this unprecedented challenge.

Chapter Three

Waterfront Past to Present

"We need a critical review of the history of the planning of the area because it has a long history. Extending the shoreline has been proposed since the 1970s, and it would be helpful to see the process that got us here."

- CCLM participant from the first CCLM meeting

National Historic Landmark 1908 Lightship Ambrose docked at Pier 16 as part of the South Street Seaport Museum (Photo Credit: Joe Mabel CC BY-SA 2.0 <https://creativecommons.org/licenses/by-sa/2.0>, via Wikimedia Commons)

History of the Waterfront

While Lower Manhattan's future is threatened by the impacts of climate change, this area's past is defined by a process of continuous reinvention to adapt to the needs of an evolving city. **At its core, this is the definition of resilience.** This dynamic waterfront has adapted time and time again over the last 400 years, from expanding the shoreline to support growing maritime trade, to its rise as an office district and residential neighborhood, to the rebuilding in the face of the September 11 terrorist attacks. Responding to the threats of climate change will take this same type of bold thinking.

This area's human history began thousands of years ago, when the native Lenape originally settled in what is now New York City.[1] About 3,000 years later, in the early 1600s, the Dutch arrived on the Southern tip of the island of Manhattan and founded New Amsterdam. This event also marked the beginning of the aggressive removal of the native Lenape people from their homeland.[2] The Lenape legacy is reflected to this day in the name of the island Itself, originally called *Manahatta*.

The early development of the waterfront is also deeply tied to the African diaspora and transatlantic slave trade. Beginning in the 1600s, enslaved Africans arrived in Lower Manhattan by boat, and in 1711 a slave market opened on Wall Street near the East River.[3] Local merchants supplied ships that transported enslaved Africans and traded the goods they produced. By the mid-1700s, enslaved Africans comprised about 20 percent of the city's total population.[4] Their forced labor played a major role in building the city and growing its economy.

It is critical to acknowledge how the history of Lower Manhattan has been shaped by both the suffering and the contributions of enslaved Africans, Indigenous Peoples, and other oppressed people. This legacy reinforces the importance of centering equity and inclusion in planning for the city's future.

A photochrom postcard of South Street Seaport in about 1900 CE (Photo Credit: Detroit Publishing Co.)

An Evolving Shoreline

The first major step in shaping New York City's modern-day waterfront took place as early as 1686, when the British Crown transferred legal ownership of the waterfront to the City. Since the City did not have the capacity to make improvements along the waterfront at the time, it began selling waterfront lots to individuals under the condition that the lot owners would build the street and wharf along the shoreline edge. The private development dedicated the shoreline edge to industrial uses, leaving New Yorkers with little public access to the waterfront.[5]

Though disconnected from most residents, the waterfront was a hub of economic activity. As maritime trade expanded in the late 1600s, the City responded by extending the shoreline of Manhattan to increase available commercial space. By 1730, the eastern edge of Lower Manhattan reached what is now Water Street, by 1780 it extended to Front Street, and by 1800 it went all the way to South Street.[6] Many inlets along the Lower Manhattan waterfront were left as slips for docking ships. As these inlets were filled in over time, the streets, now known as "slips," were created.[7] The waterfront also became the site of several military facilities around the Harbor, such as The Battery and Governors Island.

As the island of Manhattan developed and expanded, so did its maritime capacity. By the 19th century, pierhead lines defined the boundaries of navigation channels. Large steam ferries also became a vital form of transportation during this time. In 1909, the Battery Maritime Building was completed to support 17 ferry lines that connected Manhattan and Brooklyn. The Art Deco building, decorated with cast-iron columns and stained-glass windows, is the last surviving East River ferry building of its time and was listed on the National Register of Historic Places in 1976.

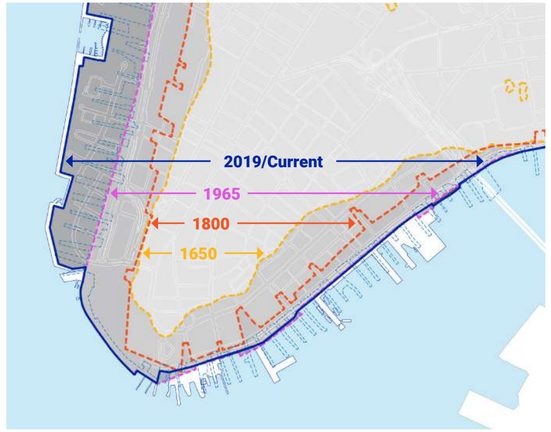
Throughout the 19th and 20th centuries, Manhattan's waterfront continued to sustain maritime-related development and South Street became a major center of maritime activity. The construction of the FDR Drive viaduct during the first half of the 20th century dramatically changed the character of the waterfront. Since the viaduct elevated most traffic above street level, goods could be more easily moved from the piers to the inland city streets. However, the practice of building highways along the waterfront in New York City hindered public access to the shoreline edge, blocking physical access in places and obstructing views of the harbor.

Aerial view of Lower Manhattan in 1931 (Photo Credit: National Archives)

During the mid-20th century, industry moved away from Lower Manhattan and the once bustling port underwent a period of economic decline. By the 1960s, the area surrounding South Street consisted of decaying low-rise commercial and industrial buildings. In 1967, the formation of the South Street Seaport Museum recognized the history of South Street and its significant role in the advancement of the city's maritime economy.[8] South Street Seaport was listed on the National Register of Historic Places in 1972, and in 1977, it was expanded and designated a city Historic District by the Landmarks Preservation Commission.

Aerial view of Lower Manhattan today (Photo Credit: Cameron Davidson)

The movement of industry away from the Lower Manhattan waterfront also changed the landscape along the shoreline edge. When the City was the primary port for trade on the East Coast, over 40 piers lined the waterfront; today, fewer than ten of those piers remain. By the late 20th century, the only remaining maritime commercial use along the East River waterfront in Lower Manhattan was the Fulton Fish Market, which was relocated to a new facility in the South Bronx in 2005.



Shoreline extents of Lower Manhattan over time, identifying where the shoreline has been extended over the past few centuries

Though industry moved away from this area, new land continued to be created into the 20th century. This time, the Hudson River was filled in for housing. Excavated material from the World Trade Center construction was used to expand Lower Manhattan by an additional 24 acres to create Battery Park City in 1976. In total, the use of fill throughout Lower Manhattan's history has pushed the original location of the shoreline four city blocks, or almost 1,000 feet, outwards on each side.

A Waterfront for People

During the 19th and early 20th centuries, many residents avoided the city's waterfronts. Dominated by industry and pollution, the shoreline was often seen as dangerous and foul-smelling.[5] Events during the last three decades have begun to shape a waterfront for the people, bringing New Yorkers closer to the harbor than ever before.

The Clean Water Act of 1972 was the first major shift in the city's waterways, leading to a much cleaner and healthier harbor for both the people of New York City and aquatic life. Twenty years later, the City released its first Comprehensive Waterfront Plan with a focus on "environmental remediation, infrastructure investment, and redevelopment."[9] This was followed by the Manhattan Waterfront Greenway Plan in 1993, which envisioned new public open spaces and a continuous pedestrian and bicycle pathway along the perimeter of Manhattan. These federal and city policies led to the transformation of this waterfront from a declining maritime industrial hub to a thriving waterfront focused on recreation and transportation.

While the Financial District and Seaport neighborhoods suffered greatly due to the tragic events of September 11, the neighborhoods demonstrated their strength by seizing the opportunity to rebuild and prosper. Since 2001, more than $20 billion worth of public and private investments have been dedicated to transforming Lower Manhattan into a thriving, 24-hour live-work district, with new open spaces and recreational uses along the waterfront.[10]

Then in 2012, Hurricane Sandy revealed a new vulnerability along the city's waterfronts. Hurricane Sandy significantly impacted this waterfront, including extensive damage to the South Street Seaport Historic District and other maritime uses. It forced subway stations and office buildings on Water Street to shut down due to the damage. Public and private investments since Hurricane Sandy have made Lower Manhattan more resilient and further enhanced the public waterfront experience.

Get-downs bring people closer to the water (Photo Credit: SCAPE)

New seating, paving, and planted beds at Peck Slip (Photo Credit: SCAPE)

Seating with views of the East River (Photo Credit: SCAPE)

Ferry docks on Pier 11 (Photo Credit: SCAPE)

Bike path and esplanade under the Brooklyn Bridge (Photo Credit: SCAPE)

Piers with elevated views of the East River (Photo credit: Several Seconds)

The Waterfront Today

Lower Manhattan's waterfront is unique. It houses maritime functions that serve residents, workers, and visitors throughout the entire region, includes historic landmarks, and links together sections of the Manhattan Waterfront Greenway. Adjacent to this waterfront is the Financial District, a hub of the city's economy and a growing residential district, and the South Street Seaport, with dozens of small businesses and historical assets. Protecting this one-mile stretch between The Battery and the Brooklyn Bridge requires an understanding of what exists there today, as well as the services this waterfront provides – both to the adjacent neighborhoods and the city as a whole.

Transportation

Lower Manhattan is a transportation hub with connections to all five boroughs and the broader tri-state region. The ferry terminals are a central node for waterborne transportation, handling almost 100,000 daily ferry riders and connecting them to the subway system. The waterfront's character is defined in part by the waterborne transportation network: Whitehall Ferry Terminal, which services the Staten Island Ferry; the Battery Maritime Building, which services the Governors Island Ferry; and the Wall Street Ferry terminal at Pier 11, which services the citywide NYC Ferry system, among other operators. The area also contains multiple piers, including the Downtown Manhattan Heliport, space for chartered vessels and historic ship docking, and public open spaces and amenities.

Several major streets and roadways in the area provide important connections for cyclists, pedestrians, and vehicles. The FDR Drive is a major thoroughfare connecting the Battery Park Underpass to the Brooklyn Bridge, as well as local streets and the regional highway network. The stretch of the Manhattan Waterfront Greenway that runs along this shoreline connects pedestrians and cyclists to The Battery to the south and the Brooklyn Bridge Esplanade to the north. While this area has robust transportation infrastructure and connections, many areas along the Lower Manhattan waterfront still suffer from poor pedestrian and cyclist conditions.

Essential Underground Infrastructure

Beyond the more visible transportation infrastructure lies a network of critical, dense underground infrastructure that serves the area and all of New York City. Subway tunnels connect Manhattan to Brooklyn and include the 4/5, R/W, 2/3, and A/C lines. The 1 and J/Z subway tunnels also pass through the study area. Many waterfront structures, including piers and parts of the East River Esplanade, are built on piles with foundations that extend deep into the ground. Citywide utilities along the waterfront include Con Edison's oil-o-static line, which supports the electrical grid, and the City's sewer interceptor line, which carries wastewater and stormwater. A gas pipeline and fire prevention pipeline also run underground. While this infrastructure is invisible to most who visit and enjoy this area, it delivers critical services to Lower Manhattan and the city as a whole.

Open Space and Retail

More visible are the beloved open spaces and community amenities that line this waterfront. Approximately ten acres of open space run along the waterfront between The Battery and the Brooklyn Bridge. Most of this space comprises the esplanade, which provides a pedestrian walkway and seating. Pier 15 also houses an elevated green space with views of the harbor, but larger open spaces appropriate for gathering and recreation are currently lacking in the area. In addition to the open spaces along the water, adjacent open spaces in the Financial District and Seaport neighborhoods include pedestrian plazas like the Vietnam Veterans Memorial, green spaces like The Elevated Acre, and playgrounds like Imagination Playground.

Many food, beverage, and entertainment establishments line the esplanade and occupy the piers, including restaurants and other retail in Piers 15 and 17. Pier 17 also contains a rooftop performance venue. These amenities serve both local workers and residents and draw tourists and visitors from across the city.

Historic Districts and Landmarks

Many historic structures contribute to the overall identity of the Financial District and Seaport waterfront. The Battery Maritime Building, a landmarked structure that historically serviced ferries throughout the East River, is now home to an event space and the Governors Island ferry. The South Street Seaport Historic District features renovated mercantile buildings and a dock for historic ships, like the *Wavertree* at Pier 16, serves as a reminder of the area's history as a port. The South Street Seaport Museum also houses many historic artifacts, such as art and books.

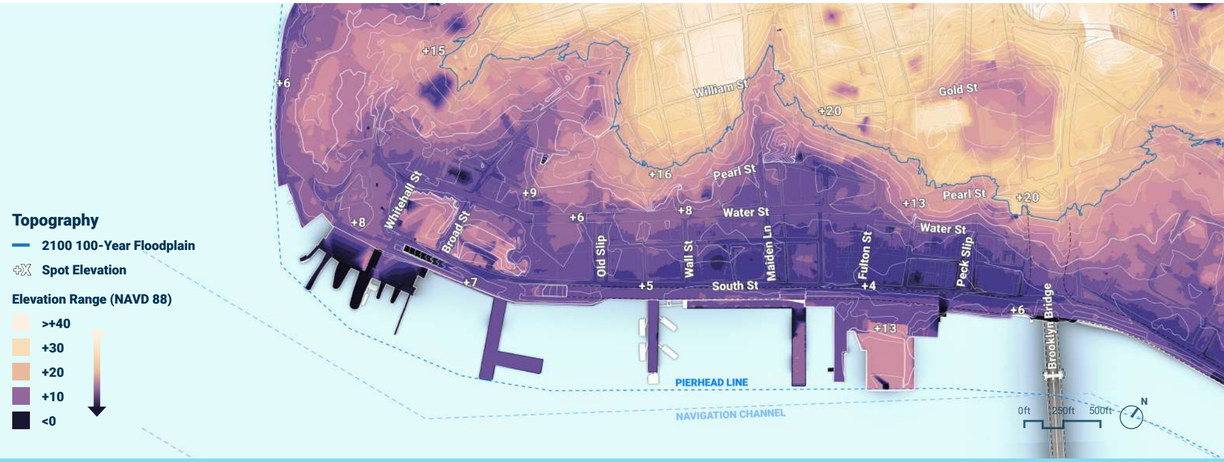
Topography

In the Financial District and Seaport neighborhoods, the topography shifts from the shoreline to the upland neighborhoods. With elevations only a few feet above mean sea level near the shoreline, the neighborhood gently slopes upward, with higher ground located further inland. However, in certain locations, the elevation of the shoreline is higher than the inland streets, which can cause a dangerous "bathtub" effect, trapping water behind higher areas during flooded conditions. A map of the topography in the study area is shown below.

East River Bathymetry

The Financial District and Seaport waterfront runs along the East River, which, despite its name, is a tidal strait linking western Long Island Sound with New York Harbor. As a tidal strait, water flows in both directions, and the waterway experiences low tides and high tides twice a day – much like the ocean tides one might experience at the beach. As discussed in depth in the next chapter, high tides will increase over time with sea level rise.

The East River is approximately 16 miles long and between 600 and 4,000 feet wide. Near the shoreline, the waterway is relatively shallow (less than 10 feet deep); however, it deepens significantly as it approaches the edge of the current pier structures and is even deeper towards the center of the river.



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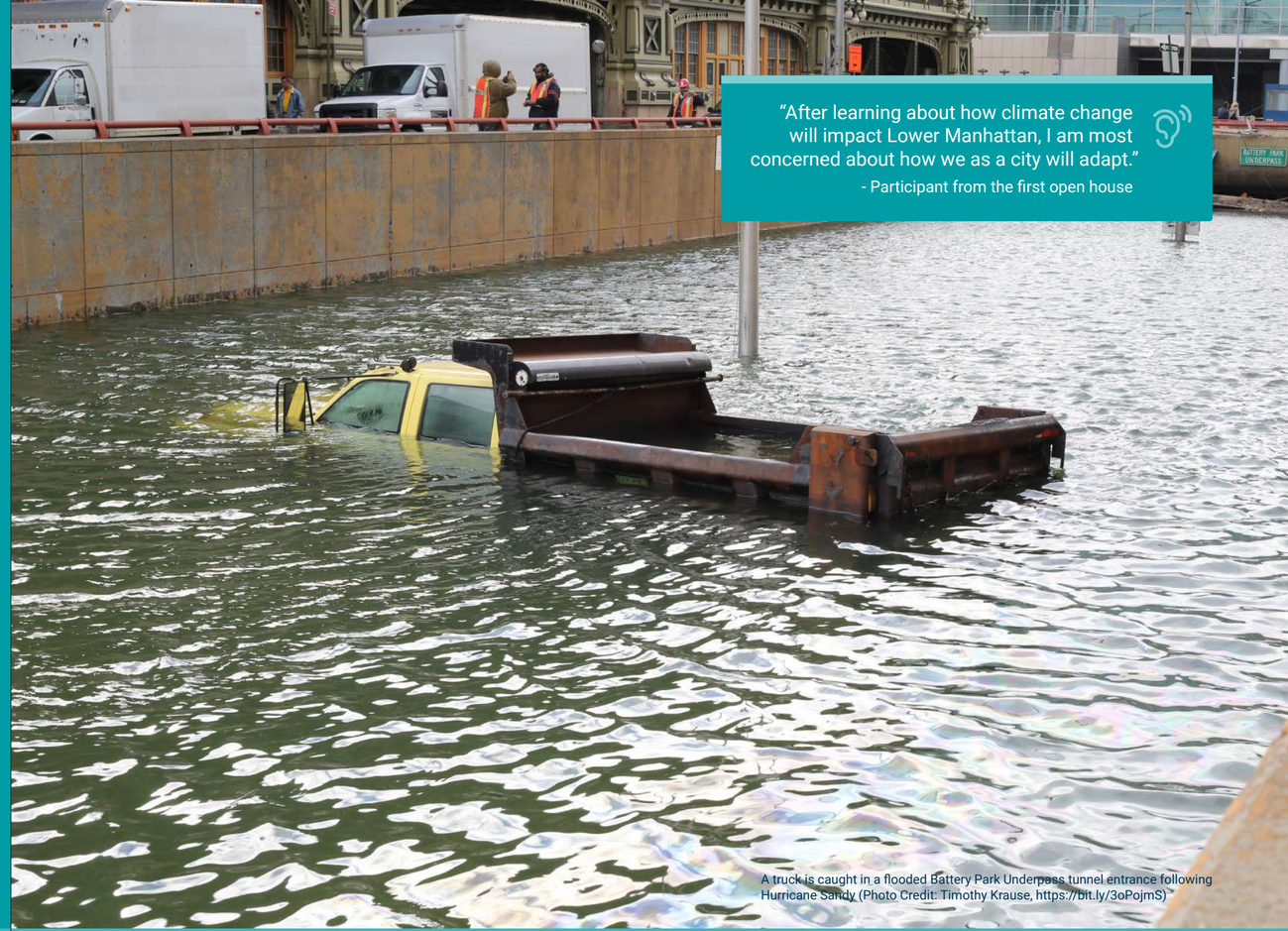
Chapter Four

The Impacts of Climate Change



"After learning about how climate change will impact Lower Manhattan, I am most concerned about how we as a city will adapt."

- Participant from the first open house

A truck is caught in a flooded Battery Park Underpass tunnel entrance following Hurricane Sandy (Photo Credit: Timothy Krause, https://bit.ly/3oPojmS)

How is Climate Change Already Impacting Lower Manhattan?

While Lower Manhattan's shoreline has transformed time and time again, it must once again be reimagined to respond to the impacts of climate change. **Numerous storms over the last decade have already exposed Lower Manhattan's vulnerabilities to the impacts of extreme weather, which are only expected to get worse.**

In 2012, Hurricane Sandy claimed 44 lives and caused $19 billion in damages and lost economic activity throughout the city.[1] The storm devastated Lower Manhattan, killing two people and damaging thousands of buildings. Hurricane Sandy damaged transportation assets, power lines, open space, and water and sewer infrastructure. Some of these damages had long-term implications, with repairs to Sandy-damaged subway tunnels continuing through to the time of writing this master plan. The combined volume of stormwater and wastewater during the hurricane overwhelmed the City's drainage system, and over five billion gallons of untreated or partially treated sewage were discharged into the City's waterways.[2]

In addition, thousands of jobs in Lower Manhattan were lost or displaced due to Hurricane Sandy's direct, indirect, and induced impacts. This job loss disproportionately affected low- to moderate-income households, as many of the jobs lost were in industries such as food services and retail that typically have fewer resources to reopen immediately after a disaster. Hurricane Sandy underscored not only Lower Manhattan's value as an economic, civic, and cultural heart of New York City, but also revealed how the impacts of climate change to Lower Manhattan are felt across the city and beyond.

In Summer 2021, New York City faced a whole different reality when record high temperatures hit the City and unprecedented rainfall rushed into homes and basements, resulting in significant loss of life and infrastructure damage across the city. Tropical Storm Henri and Hurricane Ida brought rainfall of record-breaking intensity to the region. Tropical Storm Henri produced New York City's heaviest hour of rainfall ever recorded (nearly two inches per hour), breaking a record set in 1888.[3]

Only two weeks later, Hurricane Ida surpassed Henri, when over three inches of rain fell in a single hour and triggered the first-ever flash flood emergency across the city.[4] The city also faced above-average heat, with 17 days breaking 90 degrees.[5] These events demonstrate how vulnerable both coastal and inland neighborhoods are to extreme storms, flooding, and heat, all likely to get worse with climate change.

As the City plans for the future, it must respond to a new normal. Sea levels in New York City have already risen by a foot since 1900 and are expected to rise up to six feet higher by the end of the century. Higher sea levels will produce higher tides, causing monthly and then daily flooding. Rising sea levels also increase the height of coastal storm surges and bring flooding further inland.[6] To estimate how high sea levels will be in the future, the City is using the New York City Panel on Climate Change (NPCC) high estimate (90th percentile) sea level rise projections for the 2020s through to 2100.[7]

Coastal storms, extreme precipitation, and extreme heat have all resulted in devastating impacts, and these impacts will only get worse in the future. Extreme heat is impacting the health of New Yorkers, storm surge is reaching further inland, extreme precipitation is stressing the city's sewer system and flooding streets, and now, rising sea levels also threaten to flood areas with high tides. Building on the findings of the *Lower Manhattan Climate Resilience Study,* the master plan responds to future tidal flooding and coastal storms along the shoreline between The Battery and the Brooklyn Bridge.

What are the Main Threats of Climate Change in Lower Manhattan?

Daily Tidal Flooding

Tidal flooding is the temporary inundation of low-lying areas as a result of high tides. Sea level rise will cause tides to be higher than they are today, resulting in higher water levels and tidal flooding in the Financial District and South Street Seaport.

The Lower Manhattan waterfront will experience frequent tidal flooding by the 2040s, putting critical infrastructure and jobs at risk. Tidal flooding will continue to become more frequent, occurring monthly by the 2050s and daily by the 2080s. By 2100, daily high tides will reach up to three blocks inland at Pearl Street.

Coastal Storms

Tropical storms, hurricanes, and nor'easters are major storm events that cause an abnormal rise in water levels along the coast, also known as storm surge. Flooding from coastal storms is more destructive than daily tidal flooding because of both the higher water levels as well as the forceful waves often associated with coastal storms.

As climate change progresses, warmer oceans will likely contribute to more frequent and intense storms with higher levels of flooding. By 2100, a 100-year (or one-percent annual chance) storm is projected to cause flooding over 15 feet deep above the existing East River Esplanade in parts of the Financial District and Seaport.

Extreme Precipitation

Extreme precipitation corresponds to heavy rainfall exceeding one inch of rain in one hour, or a total of three inches in a 24-hour period.

The New York City Panel on Climate Change (NPCC) anticipates that, by the end of the century, New York City could experience a 25-percent increase in annual rainfall, and one and a half times as many days with more than one inch of rain.[8] These events are already occurring more frequently, stressing the sewer system, and flooding inland streets.

Extreme Heat

Extreme heat events are defined as a period of three consecutive days with maximum temperatures at or above 90 degrees Fahrenheit.

Over the next 30 years, New York City could see an increase of 5.7 degrees in average annual temperatures and a doubling of the number of days above 90 degrees. Extreme heat has major health implications, including dehydration, heat exhaustion, heat stroke, and mortality.[9] In Lower Manhattan, the urban heat island effect causes an increase in temperature due to building density and high amounts of asphalt that absorb and emit heat, further amplifying the impacts of climate change.

How will Tidal Flooding Impact the Study Area?

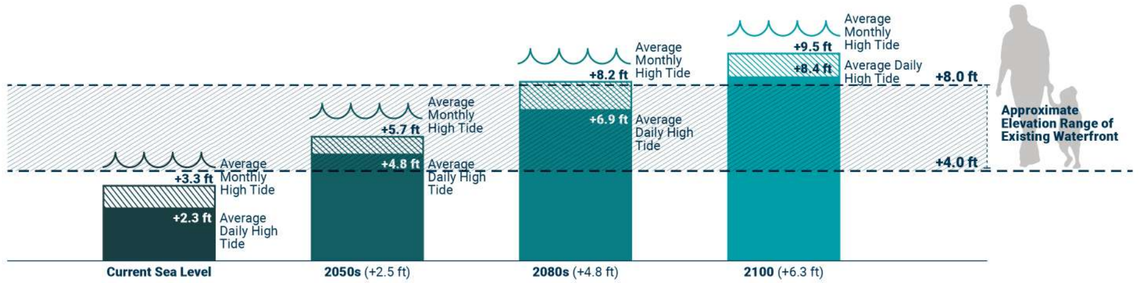
The waterfront in Lower Manhattan will experience frequent tidal flooding by the 2040s, monthly tidal flooding by the 2050s, and daily flooding by the 2080s. By 2100, daily high tides will reach up to three blocks inland at Pearl Street and be up to four feet higher than the esplanade today. By 2100, monthly high tides will be up to five and a half feet higher than the existing esplanade. Frequent tidal flooding in this area will damage streets, infrastructure, and critical maritime facilities, eventually rendering the area and its critical citywide uses nonfunctional, with vast negative consequences for the entire city.

As tidal flooding becomes more frequent, the NPCC uses the mean monthly high water (MMHW) – an event that is typically exceeded 25-35 times per year – as a useful threshold indicator of repeated flooding that is sufficient to justify large-scale adaptation investments. This is in comparison to mean higher high water (MHHW), or daily high tide, that is exceeded hundreds of times per year. In the Financial District and Seaport, MMHW is approximately a foot above the mean higher high water (MHHW), or daily high tide today. How the project team determined the design flood elevation (DFE)—the height of flood defense measures needed to protect the Financial District and Seaport from future tidal flooding—is further described in *Chapter 5* under Flood Defense.

Defining Key Terms

Mean Monthly High Water (MMHW): this is the average of all monthly maxima in predicted astronomical tide levels. This event is typically exceeded 25-35 times per year. Throughout this report, it is easily referred to as average monthly high tide.

Mean Higher High Water (MHHW): this is the average of the higher tides that occur each day. Throughout this report, it is easily referred to as average daily high tide.



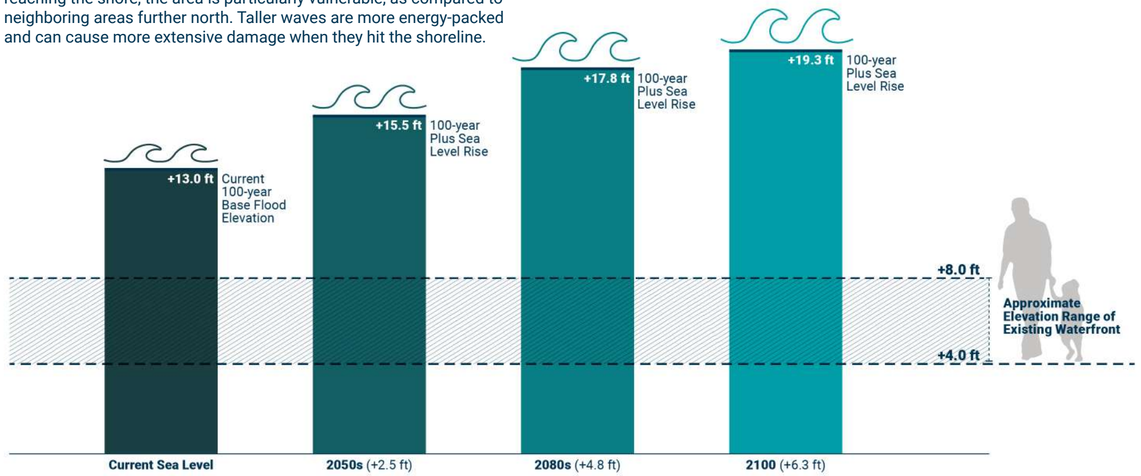
Projected Tidal Flooding Levels

How will Coastal Storm Flooding Impact the Study Area?

Tropical cyclones, such as tropical storms and hurricanes, and extratropical cyclones, such as nor'easters, cause substantial flooding in low-lying coastal areas, like the Financial District and Seaport. Sea level rise and rising tides will make the impacts of storm surge even greater, leading to substantial flooding. Climate change is also making these kinds of storms more intense and potentially more frequent.

Coastal storms also produce large waves that can crash over the existing shoreline and damage nearby buildings and structures. Because of the Financial District and Seaport's location in New York Harbor, where there is substantial space for waves to gain energy across open water before reaching the shore, the area is particularly vulnerable, as compared to neighboring areas further north. Taller waves are more energy-packed and can cause more extensive damage when they hit the shoreline.

Today, a 100-year storm could cause flooding up to nine feet deep.[1] By the 2050s, this depth will be up to 12 feet and by 2100, up to 15 feet. Currently, a coastal storm would reach inland about three city blocks; by 2100, flooding will reach inland more than five city blocks, past William Street. Flooding to this extent will significantly impact assets and buildings on the waterfront, including Pier 11, Whitehall Ferry Terminal, and the Battery Maritime Building.



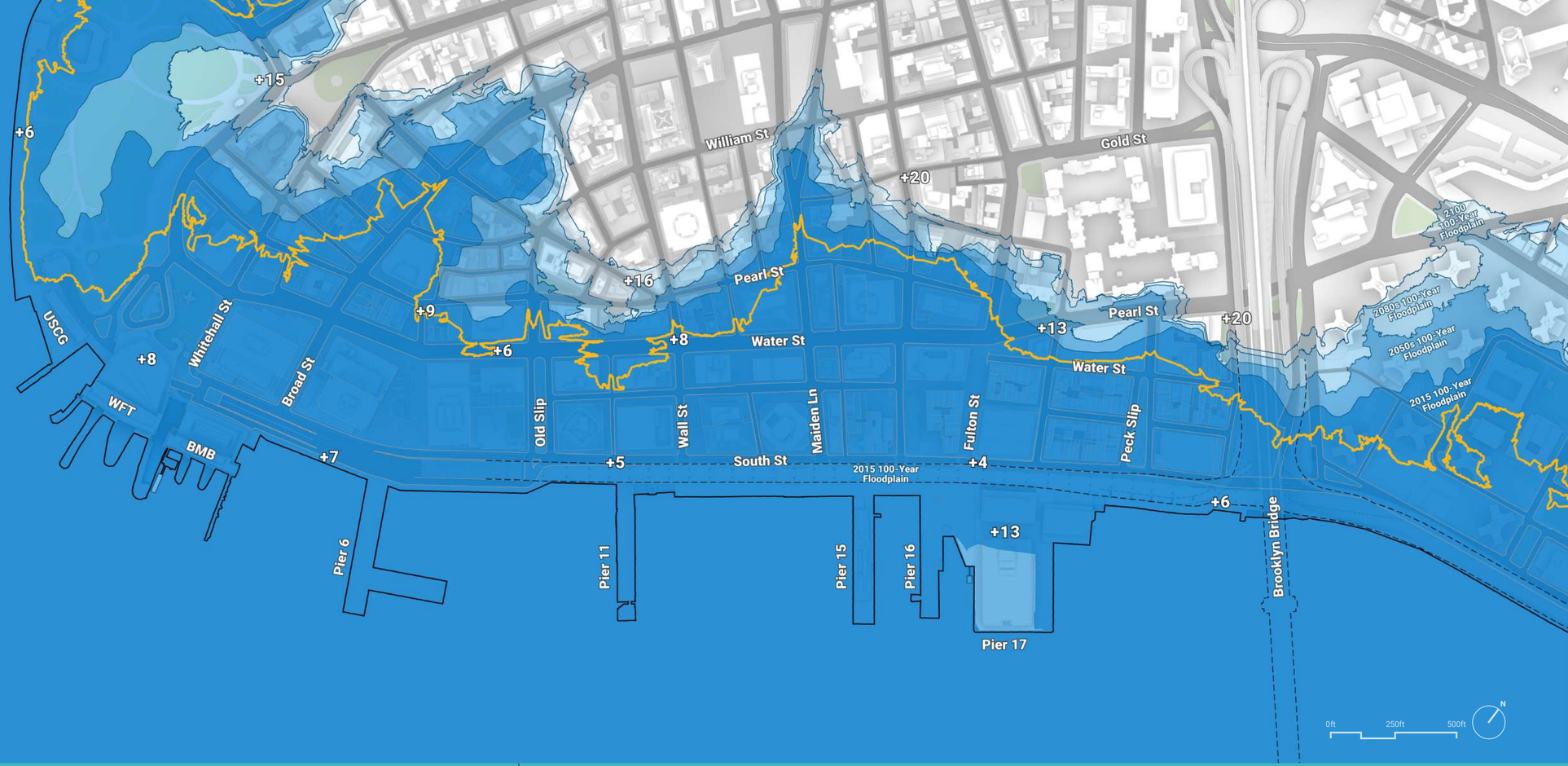
Projected Coastal Flooding Levels

What Happens if Nothing is Done?

Failure to address the potential impacts of climate change in Lower Manhattan bears a steep cost and impacts all of New York City. **Inaction is not an option.** The Financial District and Seaport waterfront is critical to the economic development and identity of Lower Manhattan and damage to the area would have negative ripple effects throughout the tri-state region and the nation. From now through 2100, if no action is taken, repetitive flooding is projected to cause up to **$20.3 billion in estimated cumulative total losses** to the region. While this represents tremendous economic impacts, it still does not take into account many other costs that are challenging to quantify, including losses to citywide services from subway, electrical, and stormwater infrastructure.[ii]

Modeling suggests that if nothing is done to protect the area, estimated quantified losses would include:

- **$8.4 billion** in **direct economic impacts**[iii] to businesses in the study area
- **$6.7 billion** in **indirect and induced economic impacts** to businesses within the New York City Metropolitan Statistical Area (MSA)
- **$2.5 billion** in **building damages**
- **$1.7 billion** in **relocation costs**
- **$770 million** in **contents damage**
- **$264 million**[iv] in **social disruption**, including health costs from injuries and mental stress, and lost income due to health issues



Future Flooding from Daily Tides and Coastal Storms

- 2100 Daily High Tide
- 2015 100-Year Floodplain
- 2050s 100-Year Floodplain
- 2080s 100-Year Floodplain
- 2100 100-Year Floodplain
- +X Ground Elevation (NAVD88)

In addition to the losses quantified on the previous page, if no action is taken, the following impacts in the master plan study area will be felt across Lower Manhattan, the region, and even the country:

Roads and highways

- Flooding from major storms will impact over six miles of roadways by the 2050s and over seven miles by 2100. This will affect the movement of bikes and cars and could damage roadway infrastructure like traffic signals
- Flooding from major storms by the 2050s will impact 11 bus lines that have 59,000 daily riders

Critical community services and assets

- By 2100, an estimated 219 buildings in the Financial District and Seaport will experience monthly flooding, ultimately rendering them unusable. These buildings currently serve 86,000 workers and 6,200 residents as well as students, visitors and New Yorkers using public services in this area

Subway and rail infrastructure

- Fourteen of the city's 28 subway lines, serving 370,000 daily riders, run through Lower Manhattan. Seven of those lines (1, 4/5, R/W, and J/Z) have a combined four subway stations at risk of coastal storm flooding in the study area

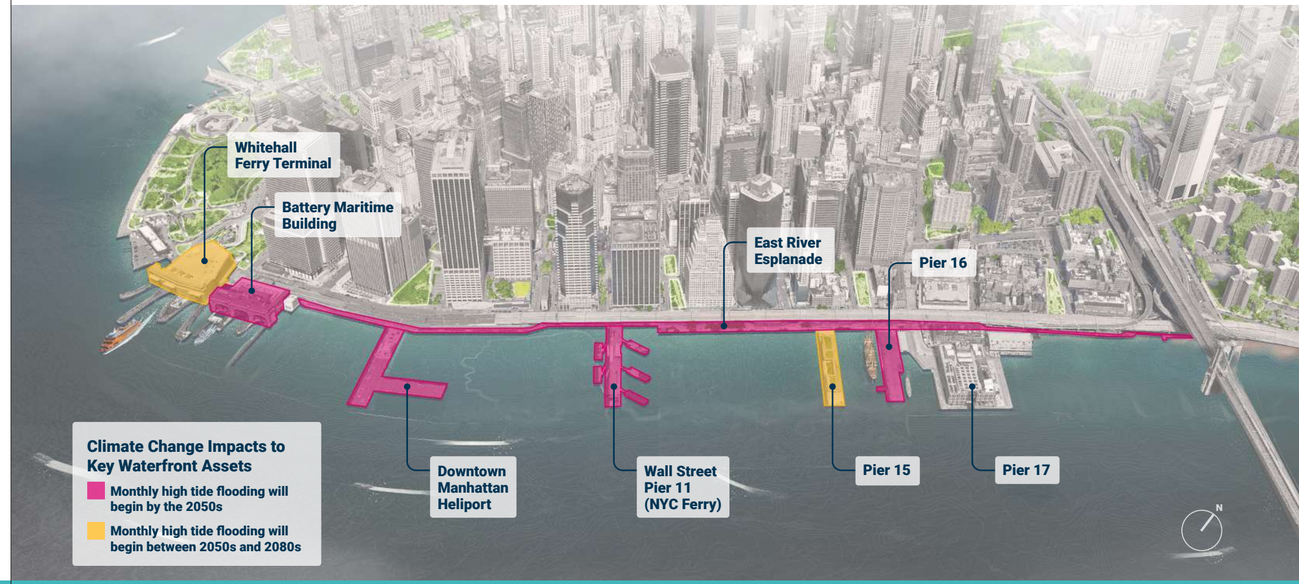
Electrical services and sewers

- Critical citywide electrical infrastructure would be impacted by coastal storm flooding in the study area, including Con Edison's oil-o-static line, an important piece of infrastructure that helps provide electricity throughout Lower Manhattan
- Flooding also puts stress on sewers, making them more likely to become overwhelmed and back up onto Lower Manhattan streets and basements

South Ferry Station in Lower Manhattan flooded to the mezzanine level after Hurricane Sandy (Photo Credit: MTA)

Ferries and piers

- Whitehall Ferry Terminal – home to the Staten Island ferry, the busiest passenger ferry route in the country with over 70,000 daily riders — will see operational impacts due to tidal flooding by the 2050s and will become significantly impaired by 2100
- The Battery Maritime Building, a historic structure that currently houses the Governors Island ferry and regional ferry service, will see operational impacts by the 2050s due to monthly tidal flooding
- Pier 11, which is the NYC Ferry Wall Street landing, will face monthly tidal flooding by the 2050s
- Pier 15, which has public open space, a restaurant, and the City Cruises line, will be impacted by monthly tidal flooding by the 2080s, though the portion closest to land will begin to experience monthly tidal flooding as early as the 2050s
- Pier 16, which provides docking space to historic ships, will face monthly tidal flooding by the 2050s
- Pier 17, which has retail space and a performance venue, will not be impacted by tidal flooding within this century because it was recently reconstructed at a higher elevation



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Notes

i. Reference point at Beekman and South Street

ii. Represents present value of direct, indirect, and induced losses with 6.25% discount rate. The region is defined as the New York City Metropolitan Statistical Area. Does not include any cost escalation and assumes existing building stock and business activity. In 2021 dollars, based on current property values and tax income.

iii. In the form of lost output.

iv. Does not account for potential population change.

Chapter Five

A Resilient 21st-Century Waterfront

"This plan should address other key resiliency challenges to improve daily quality of life."
- Participant from the first open house

Illustrative view facing North from the top of the upper level

Overview

How will the Master Plan Transform this Waterfront?

To respond to the impacts of climate change, the City is proposing a master plan for a resilient 21st century waterfront that will protect the Financial District and South Street Seaport for generations to come. **The master plan builds on extensive technical analysis, close community collaboration, and state and federal regulatory feedback, and represents a shared City-community vision that can be implemented.** The image at right demonstrates how the goals of the master plan weave together to shape an exciting future for this waterfront.

1 Protect Lower Manhattan from tidal flooding and coastal storms by

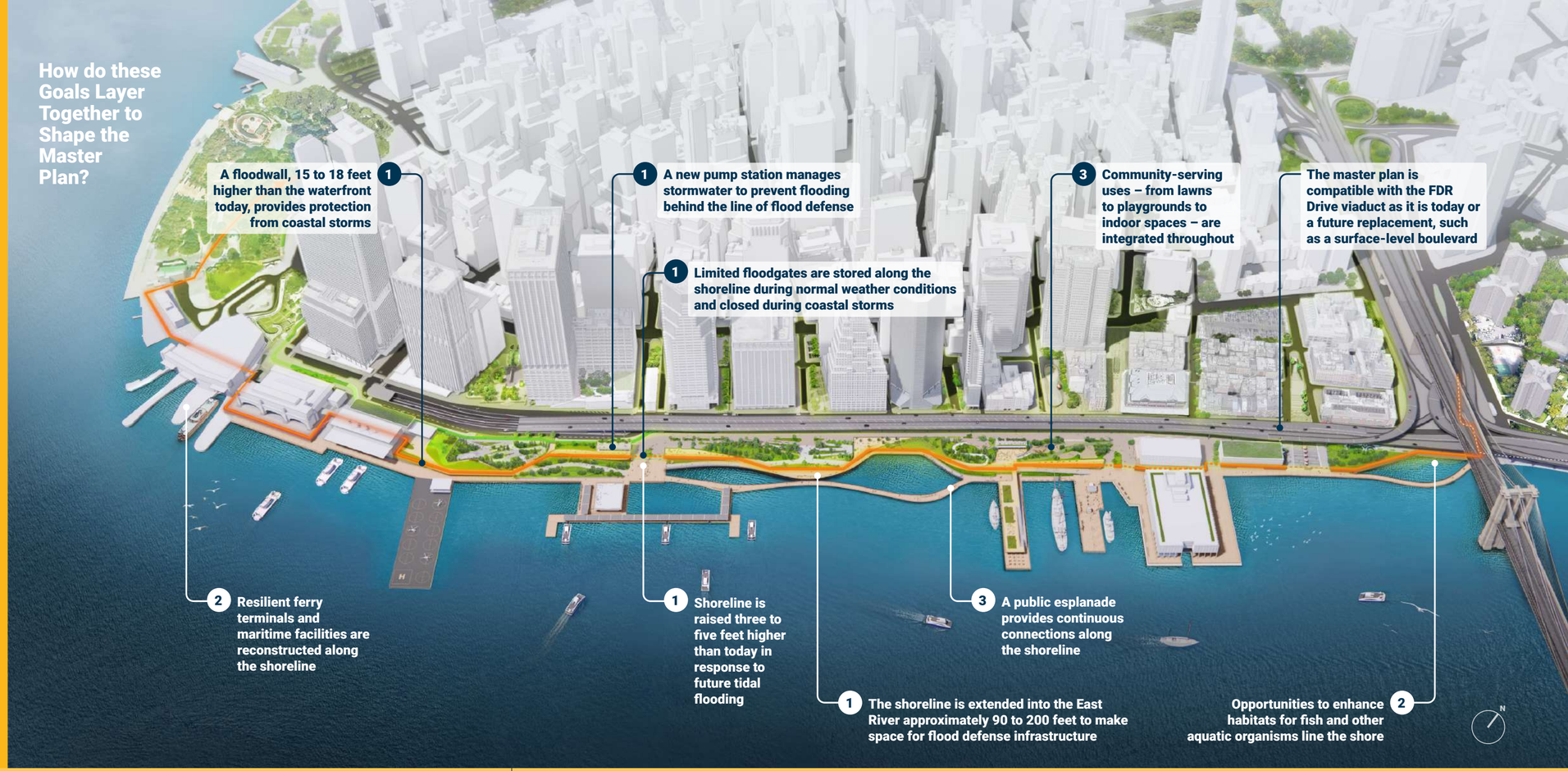
- Building **new coastal flood defense infrastructure**
- Building **new drainage infrastructure** to manage stormwater behind the flood defense

2 Integrate climate resilience infrastructure into the city by

- Ensuring **universal accessibility** and **emergency vehicular connections** to the waterfront and along the shoreline, as well as a **continuous bikeway**
- Constructing **new resilient maritime facilities** to support ferries, historic ships, and other waterfront operations
- Limiting impacts to the East River's **ecology** while enhancing aquatic habitats where possible

3 Enhance the public waterfront by

- Preserving and enhancing **existing public destinations**
- Creating **multi-level waterfront open space**
- Providing **community-serving uses**



Design Strategy for a 21st-Century Waterfront

Designing a resilient 21st-century waterfront for the Financial District and Seaport requires carefully balancing each of the master plan goals. Most notably, the master plan needs to ensure that the flood defense infrastructure does not disconnect people and emergency vehicles from the waterfront and critical maritime uses, while also avoiding and minimizing impacts to aquatic habitats in the East River. Below is a description of how the technical analysis, public feedback, and conversations with regulatory agencies shaped the master plan.

Passive protection is critical to a reliable flood defense system.

Due to the low-lying topography of this area and strong waves it experiences during storms, the shoreline will need to be significantly higher than it is today to respond to the impacts of climate change. Most of the flood defense infrastructure will consist of passive – or permanently in-place – resilience solutions. Passive protection is critical because deployable measures such as flip-up floodgates are not viable in an area that is expected to flood frequently simply from high tides.

The proposed flood defense is up to two stories higher than the waterfront today.

To achieve this passive flood protection and protect against the dual threats of tidal flooding and coastal storms, the master plan proposes raising the shoreline to two different heights. First, the entire shoreline will be raised three to five feet higher than the esplanade today to protect against frequent tidal flooding. The master plan includes a second level of protection, built on top of the first, to raise the shoreline 15 to 18 feet higher than today to defend against coastal storms. In select areas, where subway tunnels cannot bear additional weight, deployable floodgates are integrated into the flood defense system. These floodgates, which will remain open and hidden except during coastal storms, also provide direct pedestrian and emergency access to the waterfront.

Flood defense infrastructure takes up significant space and cannot be achieved on existing land.

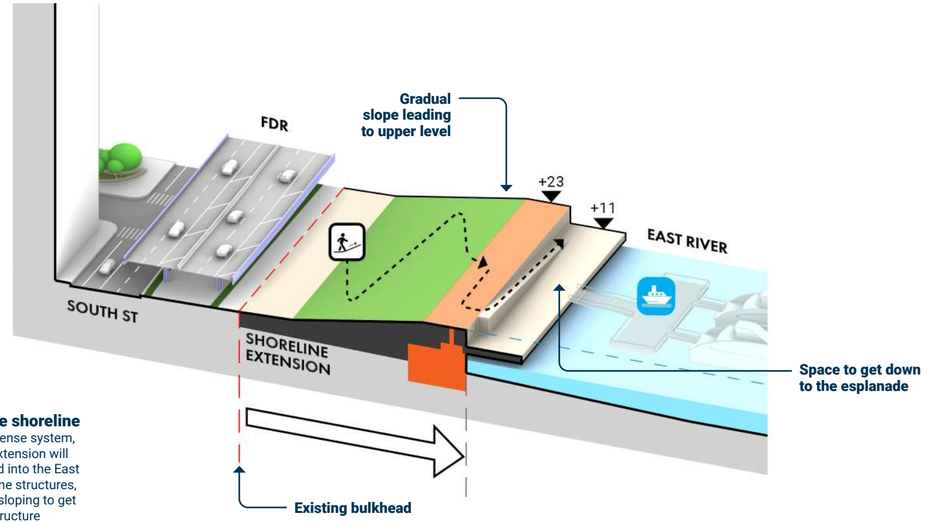
In the Financial District and Seaport, a unique convergence of climate change hazards and physical constraints makes it challenging to construct flood defense infrastructure entirely on land. Building an 18-foot-tall floodwall requires not only vertical space to achieve this height but also extensive underground space to anchor the floodwall and ensure its reliability. The existing waterfront has limited space available on existing land, and much of the area on the water side of the FDR Drive Viaduct is built on pile-supported structures. The dense concentration of above- and below-ground infrastructure further limits on land options. Complex circulation needs, highway ramps, active waterfront uses, and the presence of many historic buildings all exacerbate the complexity of building this infrastructure.

The shoreline must extend into the East River to make space for flood defense infrastructure without walling off the waterfront.

The conceptual design proposal defends the area from flooding while also ensuring that people and emergency vehicles can still reach the water's edge, as they do today. The proposed flood defense infrastructure provides this protection without walling off the city from the waterfront, ensuring sustained connections for New Yorkers to their waterways. The shoreline extension is driven by the space needed for flood defense; universal accessibility and direct access for emergency vehicles to, from, and along the waterfront; and new, resilient maritime facilities.

The proposed design has been refined throughout the master plan process and aims to avoid and minimize fill in the East River wherever possible.

The project team began by evaluating the broadest range of potential strategies for flood protection, eventually arriving at the conceptual design proposed in this master plan. The City did not make the determination to extend into the East River lightly; rather, it resulted from extensive technical engineering analysis and detailed review of existing laws, regulations, and permitting requirements. State and federal regulators require that the master plan demonstrate that an on land alternative is not practicable before any shoreline extension is proposed. If extending the shoreline is deemed to be necessary, it must be minimized, and any potential impacts mitigated. Ultimately, the master plan aims to minimize the in-water footprint, including both new land and pile-supported structures, while upholding goals rooted in City policy.



Approach to extending the shoreline
Section diagram of the flood defense system, highlighting how the shoreline extension will be integrated into the city, extend into the East River, maintain access to maritime structures, and include gradual, accessible sloping to get up and over the flood defense structure

What could this resilient infrastructure look and feel like during normal weather conditions?

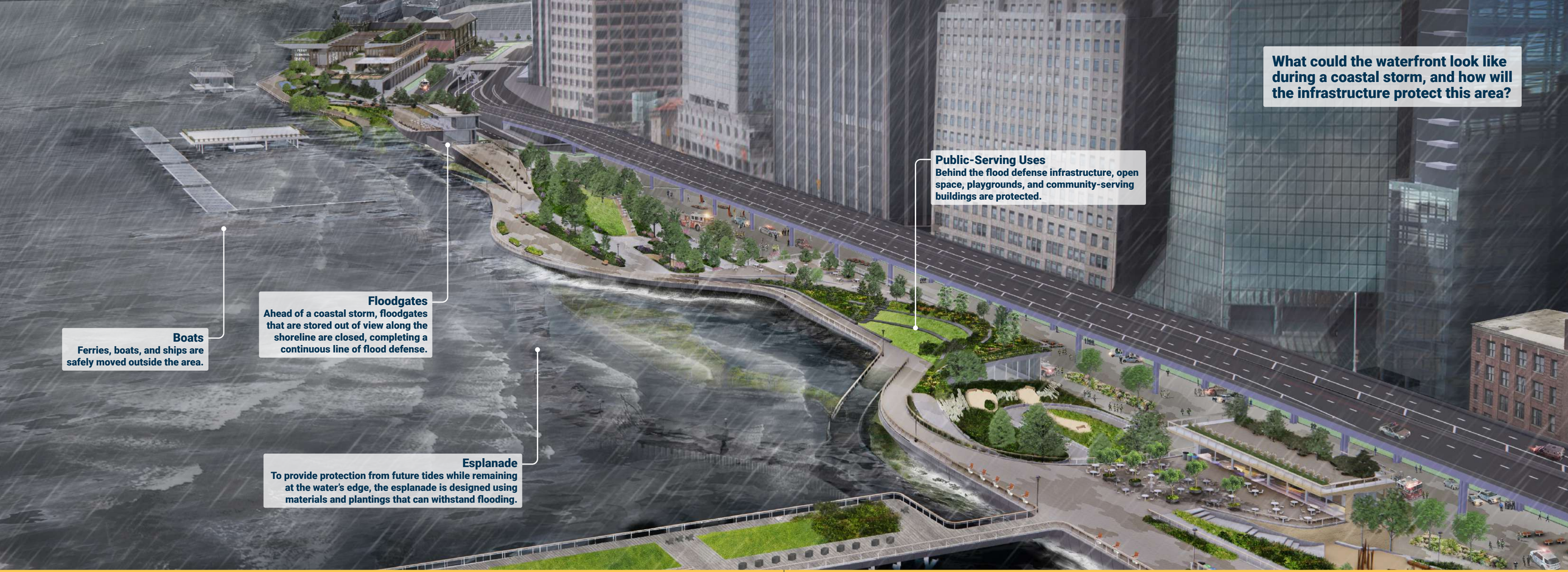
Coves
New coves, with wave screening and habitat enhancements, support the health of the river's aquatic ecosystems and provide educational opportunities for New Yorkers to learn about harbor ecosystems.

Ridges
Floodwalls buried under the landscape create a line of ridges along this waterfront, permanently protecting Lower Manhattan from coastal storm flooding and creating new open spaces with expansive views of the harbor.

Gateways
During normal weather conditions, gateways provide openings in the ridges for people to walk directly to the esplanade, providing views of the river from the city. Floodgates will be closed ahead of a coastal storm.

Slopes
Universally accessible pathways sloping up and down the ridges create connections between the city and the water's edge.

Esplanade
A raised esplanade protects against tidal flooding and provides access along the entire waterfront for people to connect to the water's edge and the ferries, boats, and piers located here.

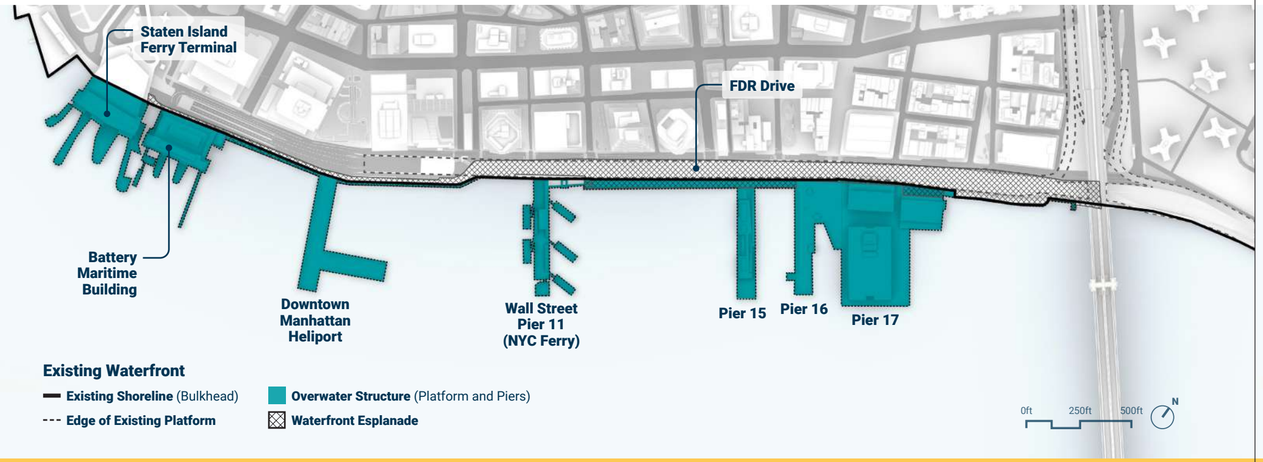

What could the waterfront look like during a coastal storm, and how will the infrastructure protect this area?
Public-Serving Uses
Behind the flood defense infrastructure, open space, playgrounds, and community-serving buildings are protected.
Floodgates
Ahead of a coastal storm, floodgates that are stored out of view along the shoreline are closed, completing a continuous line of flood defense.
Boats
Ferries, boats, and ships are safely moved outside the area.
Esplanade
To provide protection from future tides while remaining at the water's edge, the esplanade is designed using materials and plantings that can withstand flooding.

How will the Waterfront Change from Today?

To implement the master plan, this waterfront will change significantly.

The shoreline itself will extend approximately 90 to 200 feet into the East River with a series of caissons (an airtight structure that holds water back) lining the shoreline. Behind the caissons, clean fill will create new land. Outboard of this new land, piers and other platform structures will be elevated. These areas will be designed to flood during coastal storms.

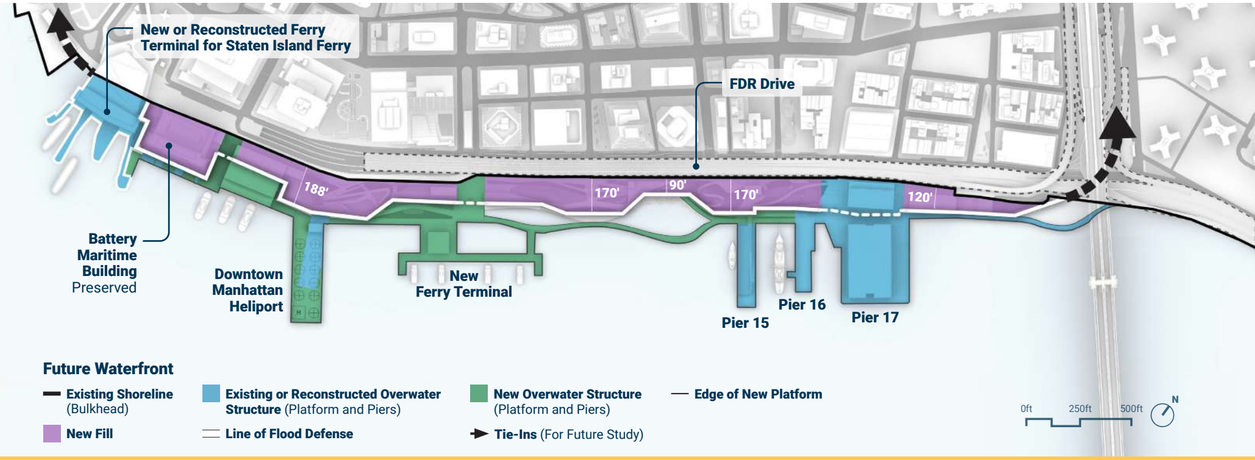
View north from the top of Pier 17 of the Financial District and Seaport waterfront in December 2021 (Photo Credit: ONE Architecture)



Most of the maritime uses that line the shoreline will need to be redesigned to accommodate the flood protection system through the buildings. The buildings will be protected from coastal storms as well as future tidal flooding. There is also flexibility along the shoreline for future expansion of maritime uses such as ferries to ensure the waterfront has space to grow in response to the changing needs of the city. The historic South Street Seaport piers will largely remain the same, as Pier 17 was rebuilt and elevated after Hurricane Sandy. Piers 15 and 16 will need to be reconstructed and elevated but are proposed to remain similar in character to what exists today.

After this waterfront transforms, it will continue to provide the same essential functions as it does today for New York City and the region. It will also serve New Yorkers better than before with resilient ferry terminals, continuous waterfront esplanades, bike paths, and other open space.

Illustrative view north from the top of Pier 17 of what the waterfront could look and feel like after the master plan is complete



Flood Defense

Overview

To protect the Financial District and Seaport neighborhoods from the impacts of climate change, the City is prioritizing flood defense infrastructure that responds to both future tidal flooding and coastal storms.

The unique conditions of this area create a complex environment for constructing this infrastructure. With larger waves than nearby areas due to its location in New York Harbor, compounded by low-lying topography and unique above- and below-ground conditions, the City needs to take a bold approach to defend this area from climate change.

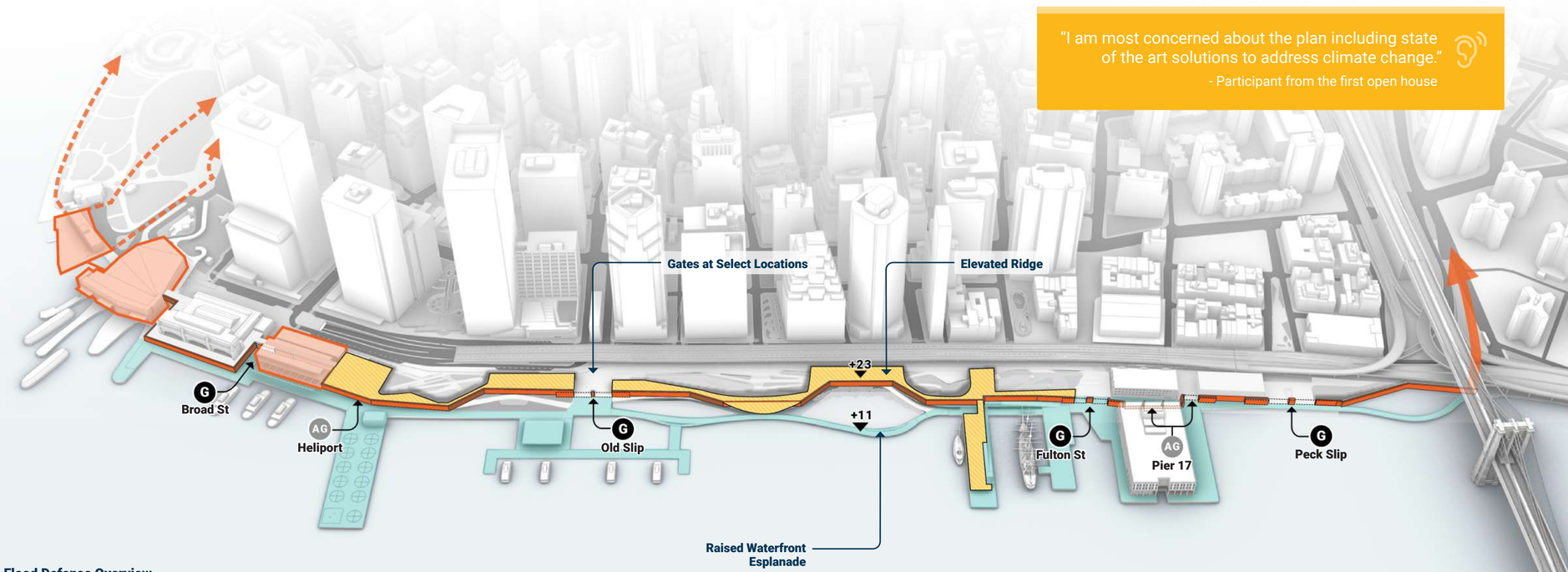
In most portions of the study area, there is insufficient space available on existing land to construct flood defense infrastructure. In these locations, the master plan proposes extending the shoreline into the East River to create the space needed to defend the study area from future tidal flooding and coastal storms, while maintaining access and connections to the waterfront.

The proposed flood defense system has two design levels. **This is due to the dual flood hazards the study area faces: the threat of daily inundation from future high tides and the threat of coastal storms.** The proposed flood defense system is a primarily passive—or permanently in-place—system, composed of floodwalls embedded inside a raised landscape. These permanent walls are complemented with floodgates in strategic locations. Floodgates provide direct access to the shoreline, while reducing the weight of infrastructure over subway tunnels. Wherever possible, aligning these openings with existing streets helps maintain direct visual and physical access to the water. During normal weather conditions, the floodgates remain open and non-visible. Ahead of a coastal storm, the floodgates will be closed to complete the flood defense system.

The esplanade, along with piers and maritime facilities like Pier 11, will be elevated to protect against future tidal flooding while remaining close to the water. These facilities will be designed to withstand temporary flooding during coastal storms. This is discussed in greater detail in the *Maritime* section of this chapter.

"I am most concerned about the plan including state of the art solutions to address climate change."

- Participant from the first open house



Technical Analysis

The project team studied several key questions to determine the recommended approach to make the Financial District and Seaport resilient to future tidal flooding and coastal storms. Two of these initial questions were:

1. How tall does the flood defense system need to be?
2. What are the potential flood defense tools that can be applied here?

How Tall Does the Flood Defense System Need to Be?

The height of the flood defense is determined by how tides and coastal storms currently impact the study area and, crucially, how this will change in the future with rising sea levels. Computer modeling helped the project team answer various "what if" scenarios to evaluate how future conditions would impact the performance of flood defense structures.

Designing for Future Tidal Flooding

The first condition that the project team addressed was how to protect the study area from future tidal flooding, which is expected to impact the area frequently by the 2040s, monthly by the 2050s, and daily by the 2080s. To estimate the height to which the waterfront needs to be permanently elevated, or the design flood elevation (DFE), the project team used the New York City Panel on Climate Change's (NPCC) future sea level rise projections as well as mean monthly high water (MMHW). Different from daily tidal flooding, which is exceeded hundreds of times a year, MMHW is only surpassed 25-35 times per year and, per NPCC guidance, is a more useful threshold indicator for when sea level rise impacts will begin.[1] An additional foot of freeboard – used to provide an additional safety margin – was added above the future MMHW.

For the Financial District and Seaport, the 2100 tidal flooding DFE is +11 feet NAVD88 (North American Vertical Datum of 1988). Datums, such as NAVD88, provide a useful reference point to understand heights relative to a recognized benchmark. In the master plan study area, NAVD88 elevations closely correlate with height above mean sea level.[2] Applied to this waterfront, +11 feet NAVD88 means that the flood defense will be three to five feet higher than the esplanade is today. Further, because tidal flooding will occur on a frequent and eventually daily basis in the future, relying solely on deployable measures, such as flip-up floodgates, is not a viable solution. Designing for future daily tidal flooding means creating a passive line of protection along the waterfront.

Designing for Future Coastal Storms

Next, the project team looked at how to protect the study area from coastal storms. To characterize future storms, the team used data from the Federal Emergency Management Agency (FEMA) to estimate the depth and extent of present-day flood hazards combined with data from NPCC for future sea level rise projections. The project team then conducted more detailed computer modeling to understand how these hazards interact with local conditions.

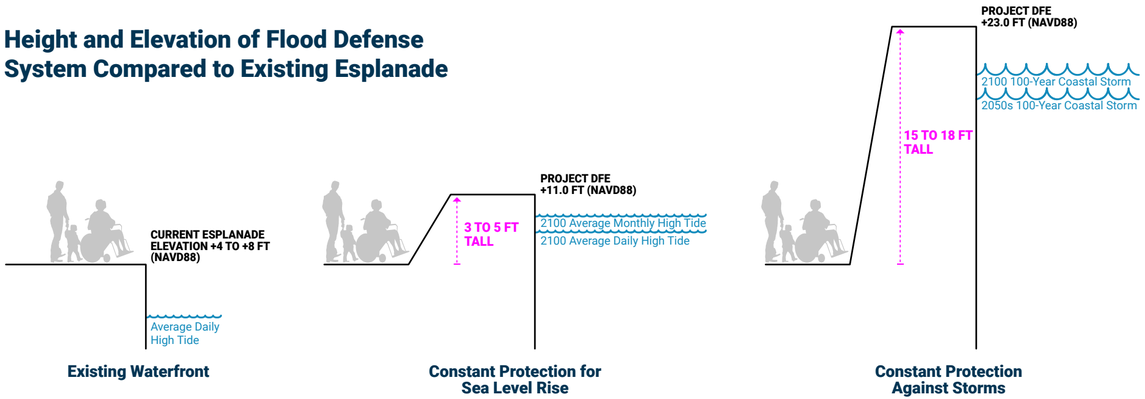
The first component that the project team identified was the stillwater elevation, which is the projected height of floodwaters caused by tides and storm surge (not including waves). FEMA has defined the stillwater elevation for a 100-year flood, or a flood that has a one-percent chance of occurring in any given year, across the study area.[3] To estimate the expected increase in stillwater elevation by 2100, the project team added NPCC's future sea level rise projections to FEMA's current stillwater elevation definition.

The project team also used numerical wave models, including the Advanced CIRCulation Model (ADCIRC) and Simulating Waves Nearshore (SWAN), to better understand future wave behavior, including wave heights and wave frequency. The computer model simulates the local wave action and identifies the expected wave heights in the study area under varying storm conditions. The project team used best-available data, including FEMA's statistical information on waves and water heights, in combination with these additional computer models to better understand the potential height of waves on- and off-shore for a one-percent annual chance storm through the year 2100.

The project team learned that the Financial District and Seaport area experiences higher waves during coastal storms as compared to neighboring areas to the north. Wave impacts in this area are between three and four feet due to the study area's relative location in New York Harbor, where there is substantial space for waves to gain energy across open water before reaching the shore in the Financial District and Seaport.

To withstand these higher waves during a coastal storm, it is necessary to construct flood defense infrastructure that is taller than would be needed in neighboring areas, with a DFE of +23 feet NAVD88 to protect against a one-percent chance annual storm in 2100. This accounts for sea level rise, stillwater, waves, and freeboard. Applied to this waterfront, +23 feet NAVD88 means that the flood defense will be 15 to 18 feet higher than the esplanade today.[1]

Height and Elevation of Flood Defense System Compared to Existing Esplanade



What Are the Potential Flood Defense Tools That Can Be Applied Here?

The project team began by reviewing a broad range of flood defense tools for their applicability in the Financial District and Seaport neighborhoods, understanding multiple flood defense measures would ultimately comprise the flood defense system. This initial review included floodwalls, levees, and on land floodgates as well as street raising, building level floodproofing, in-water gates (e.g., storm surge barriers), breakwaters, and other in-water structures that protect from waves. After this initial review, the project team selected the following measures because they can adapt the shoreline to protect from future tidal flooding and coastal storms while accomplishing the master plan's other goals, including ensuring continuity and resilience of maritime functions and universal access throughout the waterfront. The primary flood defense measures that are proposed include:

Floodwall (Buried or Exposed)

A floodwall is the most versatile tool for flood defense in the study area due to its narrow footprint and proven track record of protecting communities from coastal storms. Floodwalls can be either freestanding and visible or buried. While a freestanding floodwall has a narrow width above ground – around two or three feet wide – the foundation is much wider to ensure that the floodwall can withstand wave action and other forces. For example, a 15-foot-high floodwall may require a 15-foot-wide foundation. Buried floodwalls offer a way to integrate the floodwall into the landscape so that the wall itself is not visible and the waterfront can be accessible.

Raised Shoreline (Caissons and Buried Floodwall)

The master plan includes a combination of caissons and floodwalls to raise the shoreline. A series of caissons— large watertight retaining structures (approximately 40 feet wide)— form the outer extent of the line of defense. It is also the outer extent of new fill proposed as part of the shoreline extension. On top of the caissons, buried floodwalls —narrow vertical barriers —will be constructed so that the flood defense can be integrated within the existing fabric of the city. Using a combination of caissons and buried floodwalls as the primary type of passive flood defense, as compared to just caissons alone, allows for greater integration of the flood defense into the shoreline extension because the floodwall is narrow and can be situated anywhere on top of a caisson structure. This approach also helps to minimize the master plan's in-water footprint.

Raised Shoreline (New Bulkhead and Exposed Floodwall)

The master plan includes a raised bulkhead in locations where the flood defense is close enough to the shoreline that a caisson structure is not necessary. The bulkhead can form the outer extent of the line of defense and new fill proposed as part of the shoreline extension. On top of the bulkhead, the floodwalls can integrate with the proposed program and existing fabric of the city.

Integrated Floodwall with New or Reconstructed Buildings

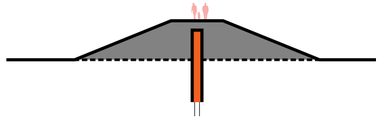
To realize a complete flood defense system while protecting buildings and facilities across the study area, most of the existing maritime buildings along the shoreline will need to be reconstructed to withstand wave forces and pressures from standing water. In these instances, the master plan proposes a floodwall integrated into the new or reconstructed building. Refer to the *Maritime* section of this chapter for additional details on the master plan's approach to buildings and facilities along the waterfront.

Floodgates and Bridging Structures

As the flood defense crosses over subway tunnels, the master plan is mindful of the potential additional load, or weight, that is placed on the subway tunnels. In these locations, the master plan proposes bridging structures, which allow the flood protection to be anchored on either side of the subway tunnel without placing undue stress on the tunnel itself. A floodgate can be built on top of a bridging structure to provide direct emergency vehicular access and visual connections to the waterfront. This ensures the flood defense system has no gaps, while limiting impacts to critical infrastructure.

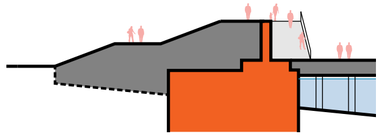
Even at locations where the master plan proposes floodgates, the shoreline must first be raised to protect the area from flooding every day due to sea level rise. At these locations, the shoreline needs to be gradually elevated at a slope of five percent – designed to meet Americans with Disabilities Act (ADA) standards and be universally accessible – to reach +11 feet NAVD88. On top, floodgates are stored in-place during normal weather conditions and can be quickly closed in the event of a coastal storm to provide a continuous line of flood defense to +23 feet NAVD88.

Flood Defense Toolkit

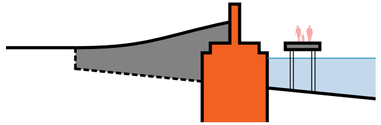


Floodwall (Buried)

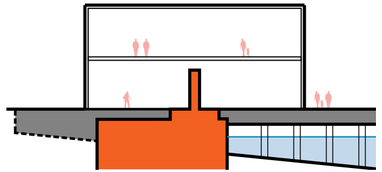
Floodwall (Exposed)



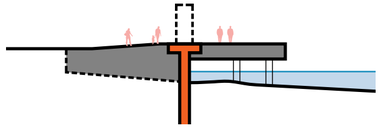
Raised Shoreline (Caissons and Buried Floodwall)



Raised Shoreline (New Bulkhead and Exposed Floodwall)



Integrated Floodwall with New or Reconstructed Buildings

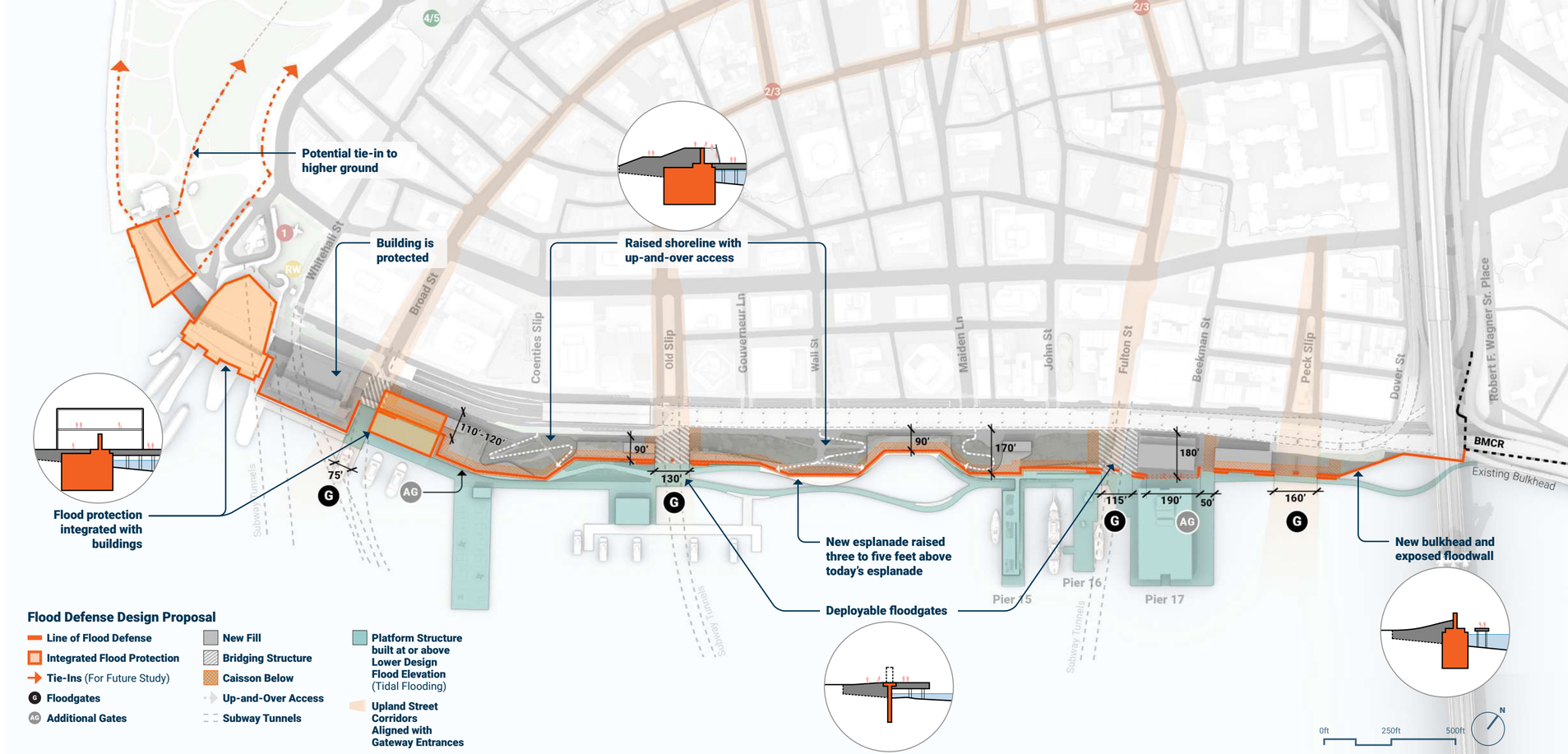


Floodgates

Flood Defense Design Proposal

The diagram on the right illustrates the proposed flood defense system for the master plan. This is a primarily passive flood defense system complemented by the limited use of floodgates. The flood defense system has two levels to protect against the different climate hazards — frequent tidal flooding and coastal storms. This proposal includes:

- **A lower level that will protect the Financial District and Seaport from future tidal flooding**, permanently raising the shoreline three to five feet above today's esplanade. This lower level will remain connected to the waterfront and maritime uses and will be floodable during larger storm events.
- **An upper level that will be 15 to 18 feet tall to protect against coastal storms** and create a continuous high line of protection from The Battery to the Brooklyn Bridge. This will primarily comprise permanent floodwalls with space for universally accessible sloping pathways up and over the line of defense.
- Floodgates will be used selectively, including at Broad Street, Old Slip, Fulton, and Peck Slip. At these locations, the shoreline will be gradually raised to protect from future tidal flooding while providing direct access to the shoreline. On top, floodgates will be stored along the shoreline and closed in the event of a coastal storm.
- **Ferry terminals** will be rebuilt to integrate flood defense through the buildings and ensure the resilience of these facilities.
- Flood defense will be integrated at Pier 17 between buildings with a series of walls and gates.
- North of Peck Slip, the flood defense is proposed closer to the existing bulkhead to minimize hydrodynamic and ecological impacts to this unique area under the Brooklyn Bridge. This short segment is the only area where the master plan proposes a new bulkhead and exposed floodwall.
- The flood defense ties into high ground on both sides. In the south, this is near Bowling Green. In the north, the flood defense connects to the adjacent flood defense project, Brooklyn Bridge-Montgomery Coastal Resilience (BMCR).
- Between access points, the flood defense pulls back closer to the existing shoreline to minimize the in-water footprint.



Flood Defense Design Proposal

- Line of Flood Defense
- Integrated Flood Protection
- Tie-Ins (For Future Study)
- Floodgates
- Additional Gates
- New Fill
- Bridging Structure
- Caisson Below
- Up-and-Over Access
- Subway Tunnels
- Platform Structure built at or above Lower Design Flood Elevation (Tidal Flooding)
- Upland Street Corridors Aligned with Gateway Entrances

Tie-Ins

To create a complete flood defense system and ensure that water cannot breach the system from behind, the flood defense must connect into high ground at both the northern and southern ends of the study area. This creates a compartment, ensuring that the water does not just go around a floodwall at the shoreline edge. In the south, the master plan proposes tying into high ground near Bowling Green. In the north, the master plan proposes tying into higher ground near the Brooklyn Bridge. While the project team studied several different options for both tie-ins, additional analysis and coordination with the community will be needed as part of future phases of work to further define the preferred design for both tie-ins.

Southern Tie-In

In the southern portion of the study area, the flood defense needs to navigate a complex web of subsurface infrastructure to ensure a continuous line of flood defense between Whitehall Ferry Terminal and Bowling Green. This includes the following:

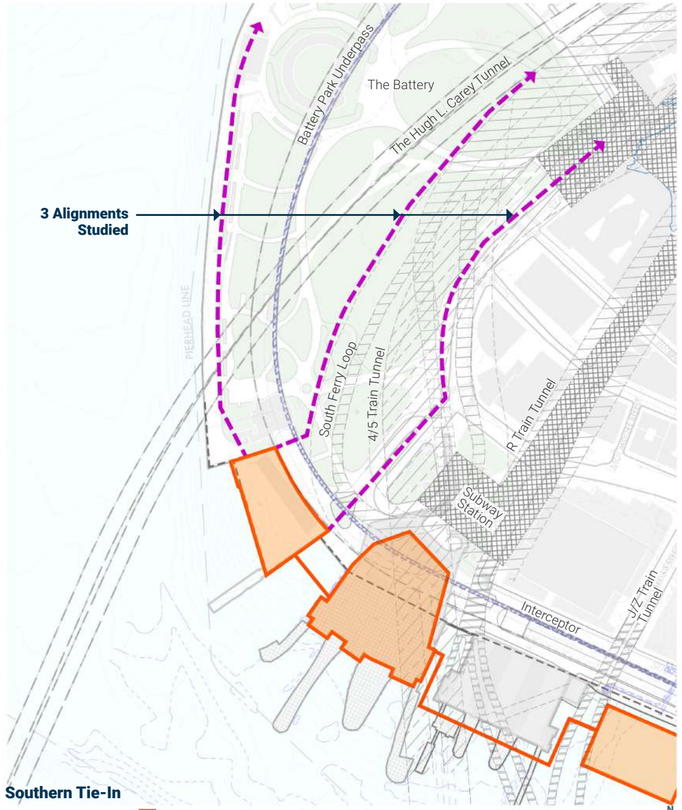
- The 1 and 4/5 subway lines run under State Street and under the back edge of The Battery
- The R subway runs along Whitehall Street and the J/Z tunnel runs beneath Broad Street
- The Battery Park Underpass runs though The Battery, connecting the FDR Drive and West Street, running just upland of Castle Clinton
- The South Ferry subway loop is beneath portions of The Battery and Peter Minuit Plaza. Given its shallow depth and its width, it is very challenging to cross or integrate into the line of defense
- The Hugh L. Carey Tunnel (Brooklyn-Battery Tunnel) crosses under the Battery Park Underpass on its way to Brooklyn

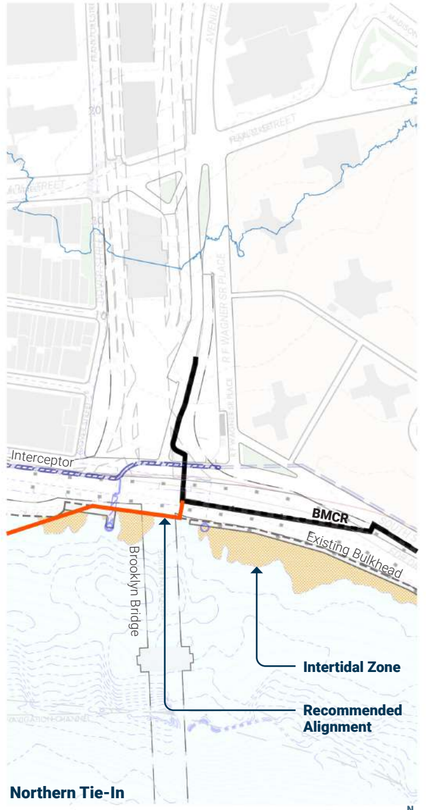
To achieve the Southern tie-in, while minimizing disturbance with critical subsurface infrastructure, there will be impacts to The Battery. Additional coordination with NYC Parks, the community, and other interested stakeholders will be critical to advancing a design that achieves the flood defense while ensuring a sensitive approach to this important and historic park.

Northern Tie-In

In the northern portion of the study area, the flood defense needs to navigate existing transportation assets, including the FDR Drive viaduct and the Brooklyn Bridge ramps that run directly parallel to the shoreline, to ensure a continuous line of flood defense.

To avoid complex infrastructure coordination, including crossing South Street, while still providing the benefits of a complete flood defense system, the master plan recommends that the flood defense connect to the to-be-constructed BMCR project. Additional technical analysis and study on how best to integrate and coordinate with the BMCR project will be needed as a part of future phases of work.





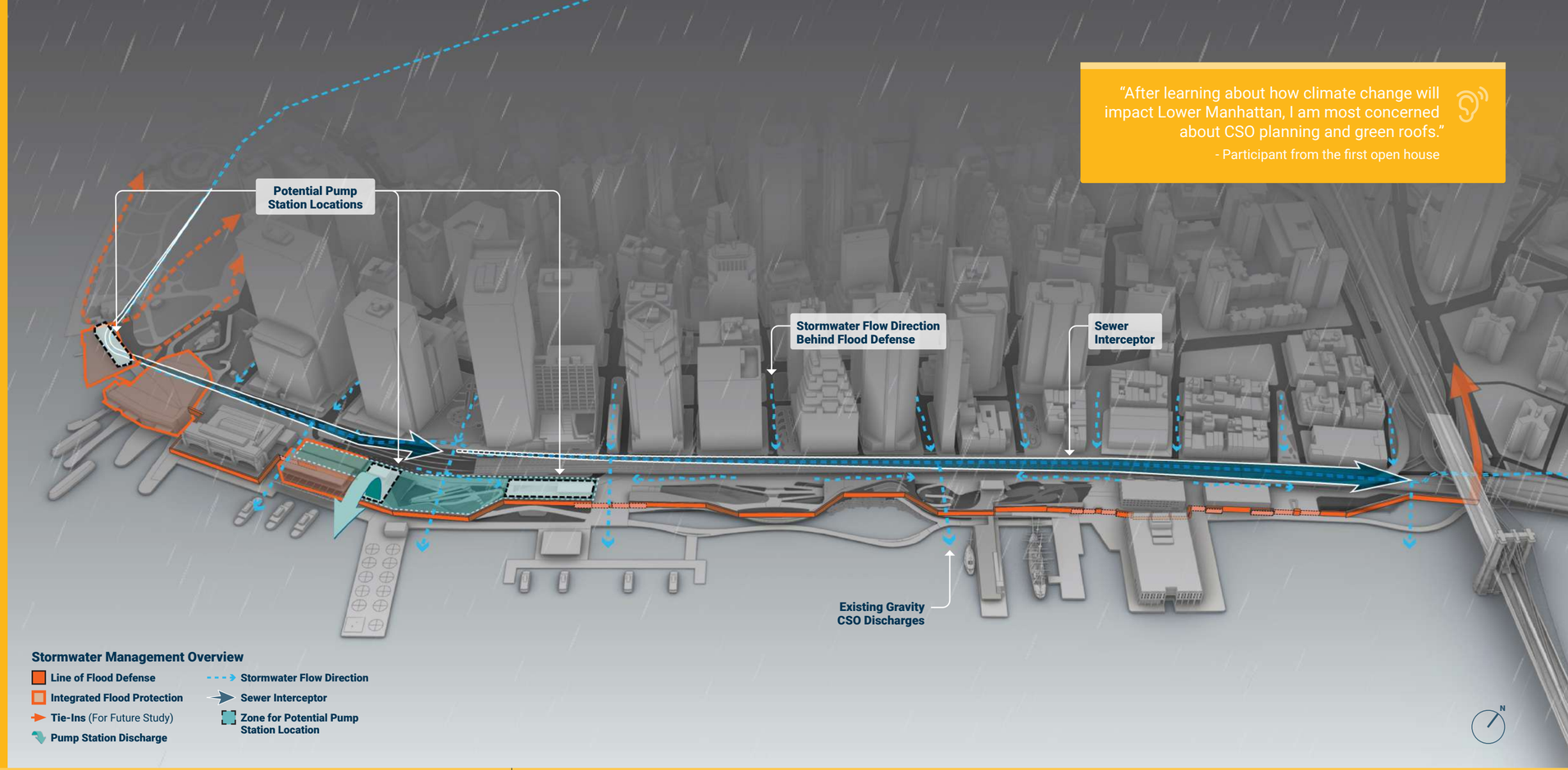
Stormwater Management

Overview

To make the Financial District and Seaport neighborhoods resilient to both future coastal flooding and increased rainfall, new drainage infrastructure is needed to manage stormwater behind the flood defense system. Drainage refers to the movement of stormwater and wastewater away from a certain area, typically through underground sewer pipes.

The Financial District and Seaport is characterized by paved surfaces with little green space to absorb water into the ground. As a result, water directly enters the sewer system, primarily through storm drains along the streets. During heavy rainstorms, the sewer system does not have enough capacity to manage both the stormwater and wastewater and instead discharges the excess directly into the city's waterways, otherwise known as a combined sewer overflow (CSO) event. In the future, when outfalls are blocked from higher tides or coastal storm surges, the combined stormwater and wastewater flow will back up and flood onto streets and into basements instead of being discharged to surrounding waterbodies.

To manage flooding in the study area, the master plan proposes a combination of both traditional drainage infrastructure and green infrastructure elements. First, the master plan includes a new pump station to discharge water out of the study area during heavy rain events and coastal storms. Additional sewer pipes are also needed to route water to the new pump station. Nature-based solutions, such as green infrastructure, can also help manage stormwater from smaller rain events and are an important component of the overall drainage strategy.



"After learning about how climate change will impact Lower Manhattan, I am most concerned about CSO planning and green roofs."

- Participant from the first open house

Technical Analysis

The project team studied several key questions in developing the recommended approach for managing stormwater behind the flood defense. Key questions included:

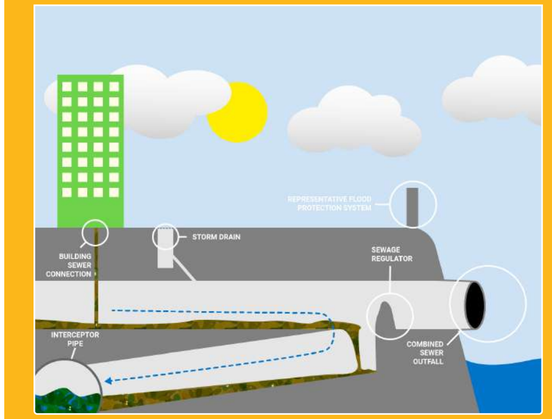
1. How will the sewer system be impacted by climate change?
2. Without drainage improvements, what would the flooding from rainfall look like?
3. What types of drainage infrastructure can be used in the study area to mitigate flooding?

How will the Sewer System be Impacted by Climate Change?

In the future, sea level rise will cause high tides to block existing outfalls along the East River that drain the system during heavy rain events. This issue is also exacerbated during storm events, when outfalls are blocked by coastal storm surge, again blocking the sewer system from draining. The blocking of these outfalls will cause the combined stormwater and wastewater flow to back up into streets and basements instead of being discharged to surrounding waterbodies.

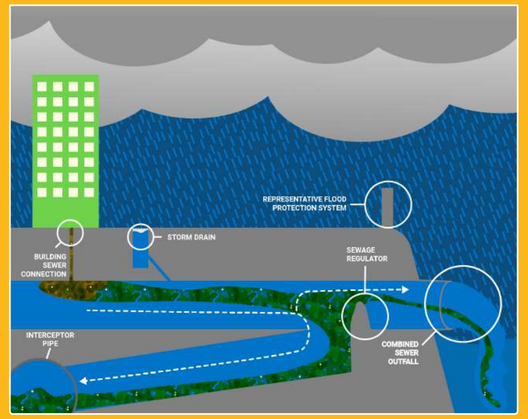
Additionally, the BMCR project, directly north of the study area, will be using an interceptor gate during storms, blocking water from flowing out of the Financial District and Seaport neighborhoods to the wastewater treatment facility in Brooklyn. Therefore, an intervention is needed to move water up and over the new flood defense system in the Financial District and Seaport and ensure the sewers can drain during coastal storms and heavy rain events.

How Does the Current Sewer System Work?



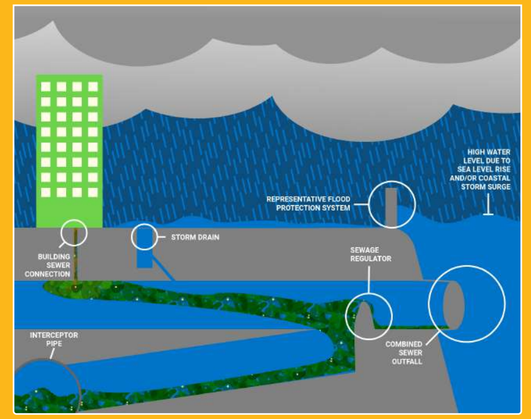
Normal Weather Conditions

Today, the drainage system largely works as a gravity-based sewer system, with water flowing from higher elevations to lower elevations. Underground sewers direct these flows towards the shoreline. Lower Manhattan's drainage system is also largely a combined system, meaning that sewage from kitchens and bathrooms flows into the same underground pipes as stormwater from rain events. During normal weather conditions or light rain, sewage (wastewater) and stormwater is collected in a large pipe along the shoreline (known as an interceptor sewer). This combined flow is then transported to a facility in Brooklyn to be treated before being released into Newtown Creek.



Heavy Rainstorms

During heavy rainstorms, the sewer system does not have enough capacity to manage both the stormwater and wastewater and instead discharges the excess directly into the city's waterways, resulting in a CSO event.



Present & Future Coastal Storms

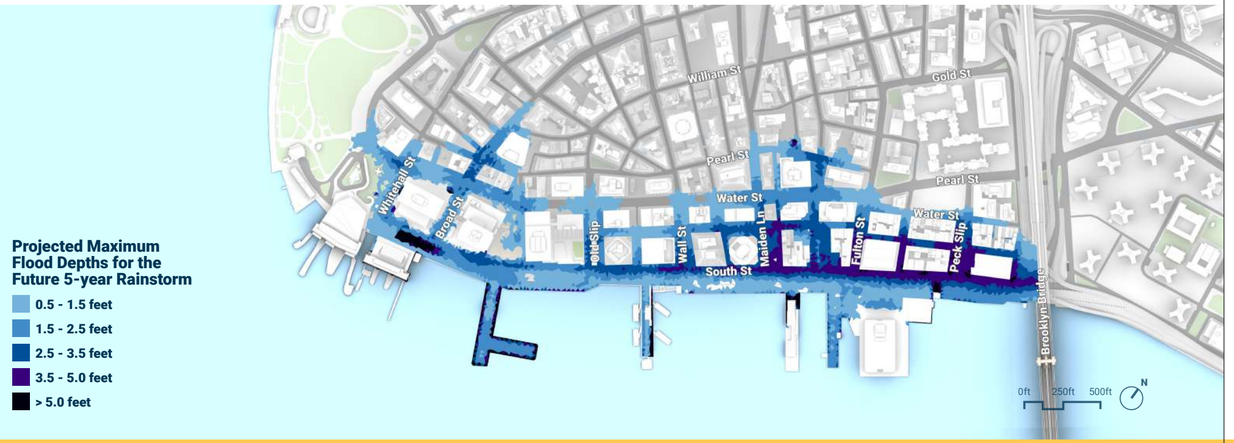
During coastal storms, the sewer system is unable to drain naturally by gravity. The blocking of these outfalls causes the combined stormwater and wastewater flow to back up into streets and basements instead of being discharged into the East River.

Without Drainage Improvements, What Would Flooding from Rainfall Look Like?

Both future high tides and coastal storm surge will block existing CSO outfalls that typically release combined stormwater and wastewater during heavy rain events, resulting in flooding behind the flood defense system if no action is taken. The project team studied two different-sized rain events to understand the amount of rainfall flooding that could occur in the study area.

1. The first is a present-day five-year rainstorm, meaning that it has a 20 percent chance of occurring in any given year.[ii] The project team chose a five-year rainstorm because the NYC Department of Environmental Protection (DEP) typically designs storm sewer infrastructure for a storm of this magnitude.
2. The second rainstorm is a present-day 50-year rainstorm, meaning it has a two percent chance of occurring in any given year. Because rainstorms will become more frequent and more intense due to climate change, a present-day 50-year rainstorm was used to approximate what a future five-year rainfall event could be, based on precipitation trends.

The project team used computer modeling software (Innovyze's InfoWorks ICM) to understand the magnitude and location of flooding that may occur with a flood defense barrier in place but absent new drainage infrastructure. The model simulated the five-year and 50-year rainstorms coincident with a 100-year storm surge event and sea level rise by 2100. The modeling revealed that, absent new drainage infrastructure, flooding could be more than five feet deep in some areas and that this will only get worse over time. Most of this flooding will come from the combined sewer system overflowing onto the streets in low-lying areas near the shoreline. In total, new drainage infrastructure will need to manage significant volumes of water to prevent flooding, a volume equivalent to 750 to 1,250 New York City subway cars.



What Types of Drainage Infrastructure can be Used in the Study Area to Mitigate Flooding?

New drainage infrastructure needs to be integrated with the flood defense to manage large volumes of stormwater flooding. The water can either be captured before it enters the sewer system or be managed below ground by upgrading the sewer system so that it does not back up onto the streets.

The project team studied several ways to manage stormwater flooding:

1. **Green infrastructure** replicates the natural processes of capturing and infiltrating water into the ground before it enters the sewer system. While it can be implemented at a smaller scale wherever possible to support larger-scale strategies, it is unable to manage large volumes of stormwater associated with heavy rainfall. These strategies serve two primary purposes: slowing and/or reducing the amount of stormwater that reaches the sewer system and filtering pollutants out of the water along the way.[4]
2. **Underground storage** collects water during storms. The stormwater is then pumped back to the sewer system after the storm ends and sewer capacity is available. This strategy is effective when no space is available above ground, but it requires a lot of space underground. Limited underground space in the study area makes this strategy challenging. Moreover, storage facilities are less adaptable to changing conditions because it is hard to increase capacity once they are built. Additionally, since the stormwater would be mixed with wastewater, odors may be generated by storing this mixture in underground spaces beneath streets for extended periods of time, requiring significant cleaning and maintenance.
3. **Pumping** moves water from lower to higher ground. Pumps push water out against high tides and coastal storm surge conditions, ensuring water does not collect behind the flood defense system. A pump station can manage a large volume of combined sewage and stormwater within a relatively small footprint. New pipes would be needed to convey water to a pump station.
4. **Conveyance** refers to using gravity to move water from one location to another, often through underground sewer pipes. While conveyance is a useful strategy it does not stand on its own. Rather, conveyance improvements must be paired with other drainage strategies to ensure the water is discharged to a safe location, whether to be stored underground or pumped out.

The Many Benefits of Green Infrastructure

In addition to managing stormwater, green infrastructure provides multiple benefits. Depending on the technique used, green infrastructure can improve water and air quality, reduce urban heat island effect, improve energy sustainability, provide habitats for plants and animals, and provide recreational space that beautifies the streetscape. Higher concentrations of green space have also been linked to improved mental health and well-being, as well as physical health.

An example of green infrastructure in the form of a bioswale near a bike path at Gantry Plaza State Park (Photo Credit: Arcadis)

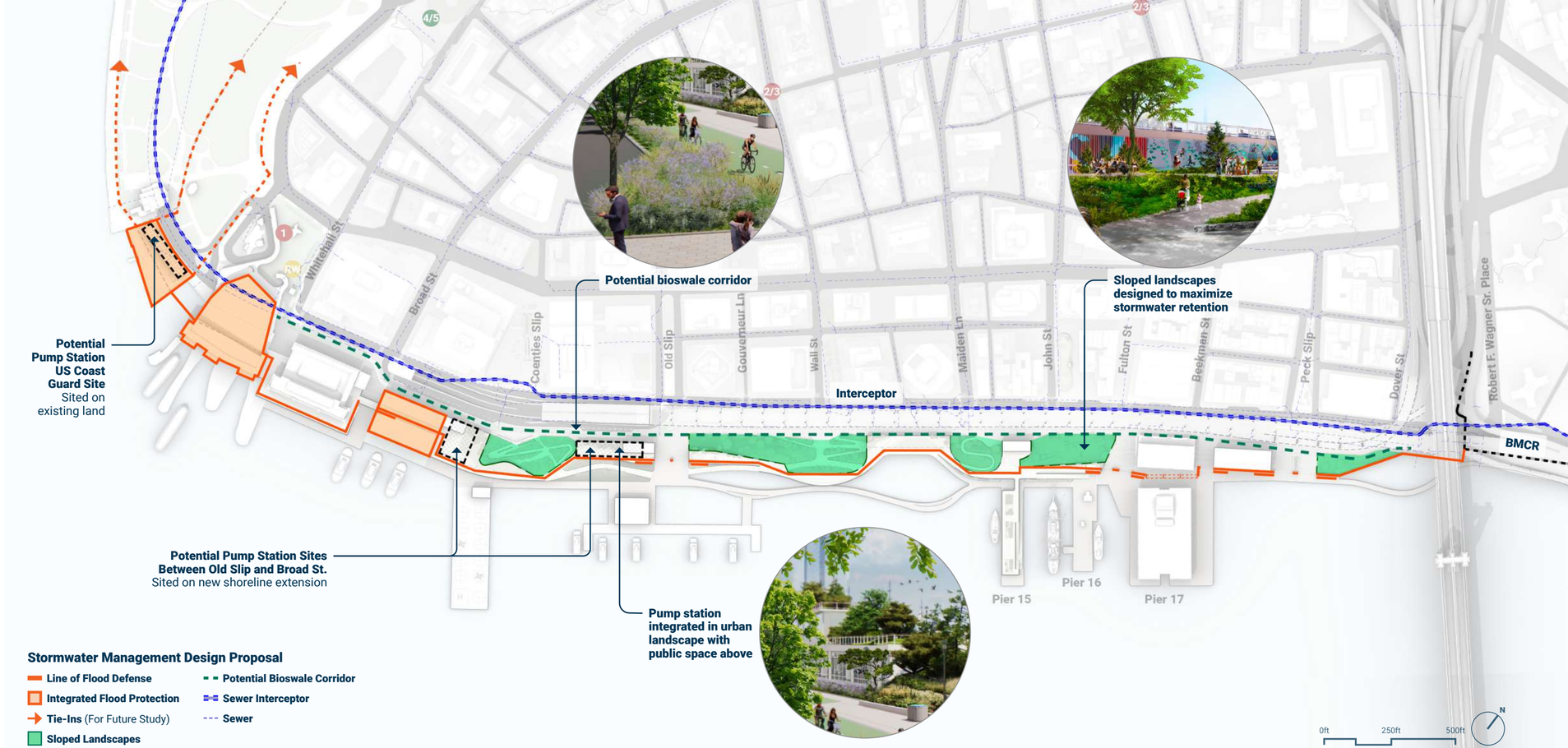
Stormwater Management Design Proposal

The master plan proposes a combination of traditional gray infrastructure and nature-based solutions to manage stormwater in the study area.

Behind the flood defense system, the study area needs a new pump station, as well as additional pipes to help route water. The master plan identifies several possible locations for the pump station south of Old Slip since this portion of the study area offers sites that minimize conflicts with existing infrastructure. The pump station requires space both above and below ground to collect water and pump it out from behind the flood defense during storm events. The master plan includes additional sewer pipes to bring the combined flows from areas further away to this new centralized pump station location so that wastewater can be pumped out of the Financial District and Seaport during storm events.

To complement the pump station, the master plan integrates green infrastructure, such as bioswales and permeable pavement, to manage the stormwater associated with smaller rain events before it enters the combined sewer system. This lessens the stress placed on the existing sewer system and manages stormwater in sustainable ways. Opportunities identified as part of the master plan include:

- A bioswale (a shallow vegetated area designed to capture and treat stormwater runoff) corridor along the newly constructed pedestrian and bike corridor in the southern portion of the study area
- Green roofs that manage stormwater runoff on top of the proposed pump station and other one to two story buildings
- Sloped landscapes across the study area that are designed to maximize stormwater retention



Access and Circulation

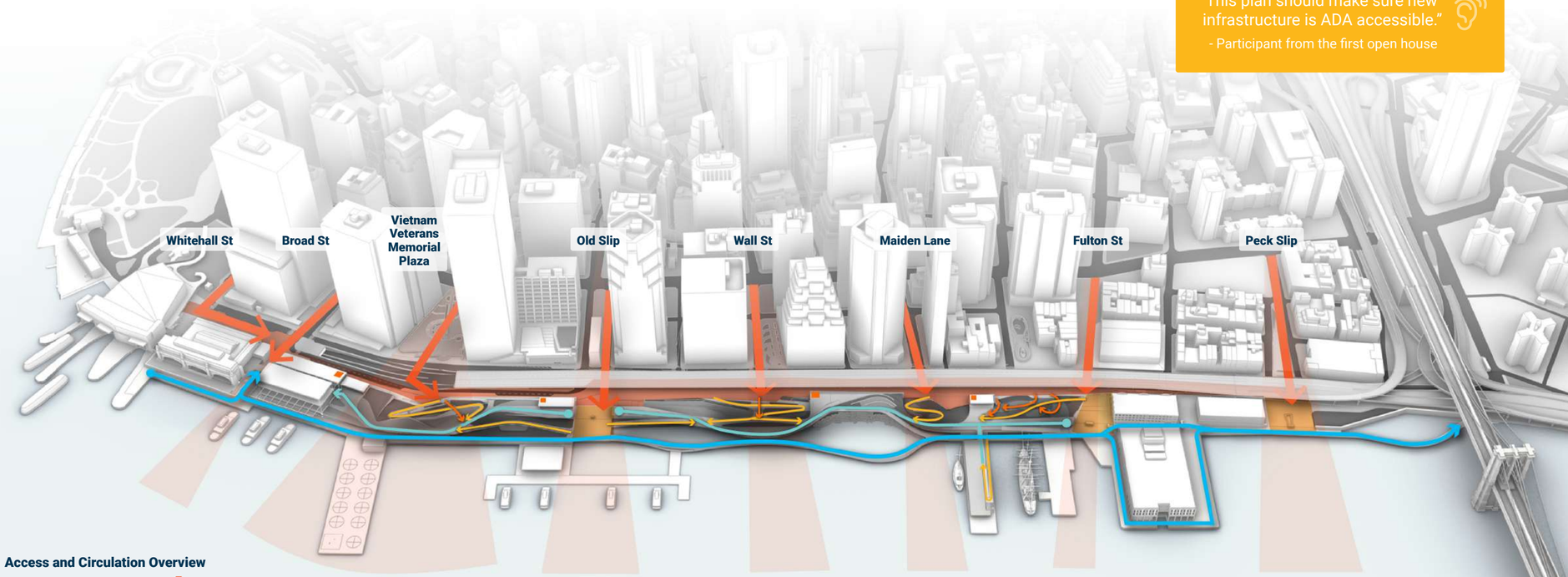
Overview

Protecting this area from flooding requires significantly raising the shoreline edge while also continuing to connect residents, commuters, and visitors of all ages and abilities to, from and along this waterfront.

Today, the Financial District and Seaport waterfront is easily accessible. It connects people between the Brooklyn Bridge and The Battery, links key transportation facilities, and hosts open space and recreational amenities. The master plan continues to connect people to the East River and supports lively, thriving neighborhoods. Further, the master plan ensures that emergency, operations, and maintenance vehicles can continue to make the waterfront safe and run smoothly.

While the height of the flood defense system could represent a major barrier between the city and the water, the master plan avoids this by integrating the proposed flood defense into a new landscape. To overcome the height difference—nearly two stories in some locations—the master plan includes a multi-level waterfront with several ways to enter and get around this waterfront. It also includes open spaces that take advantage of multiple heights and grade changes to provide unique public waterfront experiences.

"This plan should make sure new infrastructure is ADA accessible."
- Participant from the first open house



Access and Circulation Overview

- Waterfront Esplanade
- Upper Level
- Ramp (UP)
- Stairs and Elevators (UP)
- Neighborhood Connection (WATER)
- Extensions of Street Corridor
- Gateways
- South Street Sidewalk

Technical Analysis

Four key questions helped guide the project team to shape priorities and strategies for preserving universal access to the waterfront:

1. Where and how frequent do waterfront access points need to be?
2. What are the different ways the master plan can provide waterfront access?
3. How can this master plan preserve or enhance the esplanade or bike path?
4. How can this master plan ensure safe emergency and operations vehicle access?

Where and how Frequent do Waterfront Access Points need to be?

Between Whitehall Street and Wagner Place, 13 streets provide important east-west connections between the Financial District and Seaport neighborhoods and the waterfront.

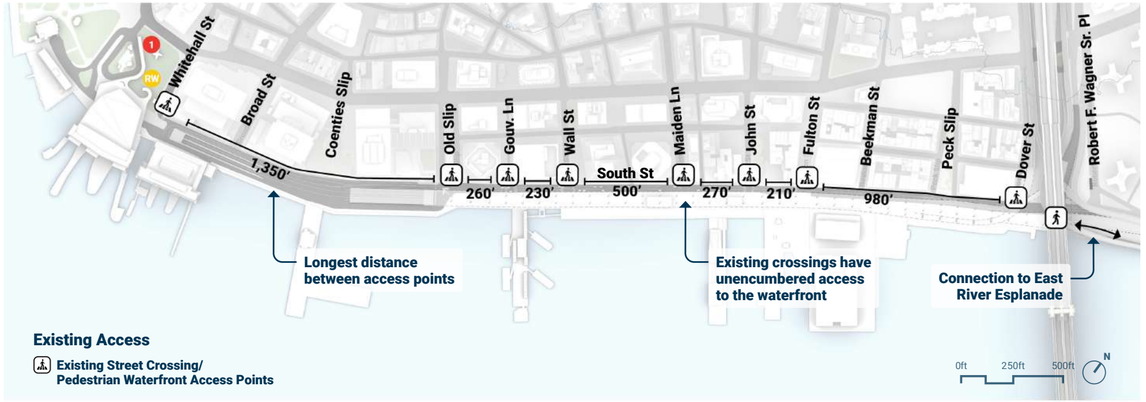
Today, pedestrians can cross South Street at eight locations to reach the shoreline, as shown in the diagram on the top right. While some of these access points are close together (just over 200 feet), existing infrastructure blocks pedestrians from directly reaching the waterfront in other areas. For example, the Battery Park Underpass ramps up to the elevated FDR Drive viaduct between Whitehall Street and Old Slip and blocks access to the water for over 1,000 feet, a distance longer than a typical avenue in Manhattan. North of Old Slip, there is a nearly continuous pedestrian connection along South Street to access the waterfront. This area is relatively flat, providing universal access throughout the waterfront without restriction.

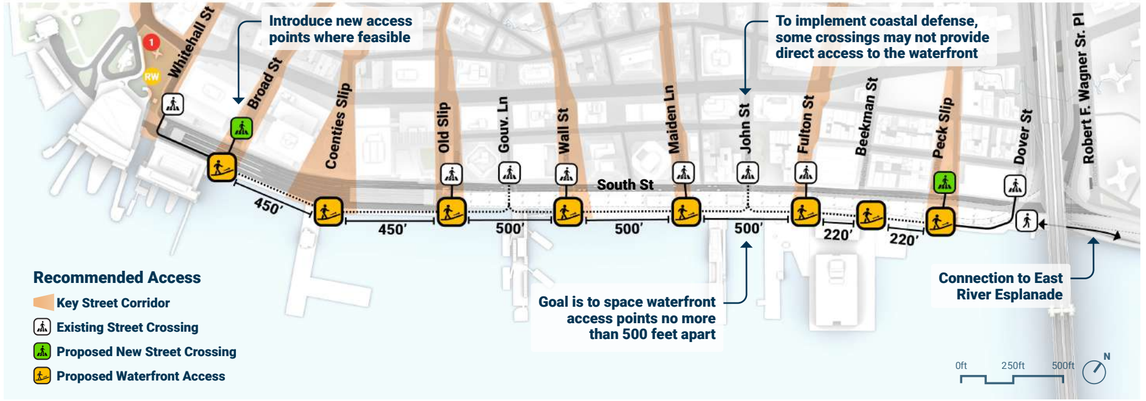
The master plan maintains existing crosswalks. The City is also further exploring the possibility of adding new crosswalks to preserve or reduce the distances people need to travel to cross South Street, where feasible.

Existing street crossing and waterfront access at the corner of Wall Street and South Street (Photo Credit: SCAPE)

However, to build the flood defense, the shoreline will be raised 15 to 18 feet higher than it is today. Given this height, raising the waterfront without significantly extending the shoreline would wall off the city from the water. Instead, the master plan proposes to extend the shoreline to provide the necessary space to construct flood defense infrastructure while maintaining universal accessibility to the waterfront and its maritime functions.

To maintain strong connections to the adjacent neighborhoods and streets, waterfront access points need to be planned along the line of flood defense. The master plan provides waterfront access at points no more than 500 feet apart. By comparison, the Hudson River Park includes entrances every 200 to 600 feet, and Hunter's Point South Park includes entrances every 250 to 550 feet. The diagram on the bottom right identifies where the master plan proposes to locate waterfront entrances.





What are the Different Ways the Master Plan can Provide Waterfront Access?

Just as the waterfront is easy to access today, the master plan creates a universally accessible waterfront, where everyone can access and enjoy the waterfront as directly as possible. This is accomplished with the following strategies.

Primary Access

All primary waterfront access routes are accessible paths that are clearly visible from the city and invite the user to the waterfront.[iii] The master plan accomplishes this using two distinct strategies: up-and-over pathways and gateway entrances.

Up-and-Over Pathways

At entrances where the flood defense is a tall, passive ridge, access is provided through sloped pathways up and over the ridges. These paths are designed to have a maximum slope of five percent to meet Americans with Disabilities Act (ADA) standards and be universally accessible.[5]

When someone enters from South Street, it is important that they arrive at the waterfront at a location directly across from where they entered for easy navigation and accessibility. To achieve this, the master plan includes back-and-forth ramps – or a switchback configuration – to bring people directly up from South Street to the upper level. Rest areas, landscaping, and public amenities will be located along these ramps for an enjoyable journey. Once on the upper level, paths gently slope down to the waterfront at a maximum five percent slope to connect people directly to important waterfront destinations.

Gateway Entrances

At gateway entrances, the shoreline is first raised to protect the area from flooding every day due to sea level rise. Gently sloped paths (maximum five percent slope) perpendicular to the shoreline provide direct waterfront access for pedestrians and emergency, operations, and maintenance vehicles. On top, floodgates, aligning with upland street corridors, provide direct physical access and visual connections to key waterfront facilities during normal weather conditions. The floodgates are stored along the shoreline and will be closed in the event of a coastal storm.

Secondary Access

The master plan includes multiple routes to the waterfront. Secondary paths, such as stairs, elevators, and escalators provide options for navigating the waterfront.

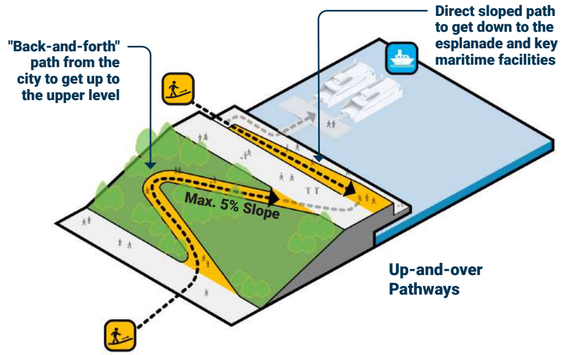
Stairs and Ramps

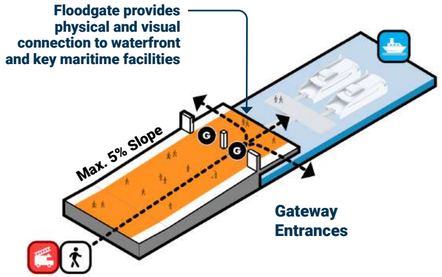
To supplement primary up-and-over pathways, the master plan leverages stairs to provide more direct connections to the upper level. These stairs begin and end near primary access paths to ensure that all users have a similar experience regardless of their age or ability.

Elevators and Escalators

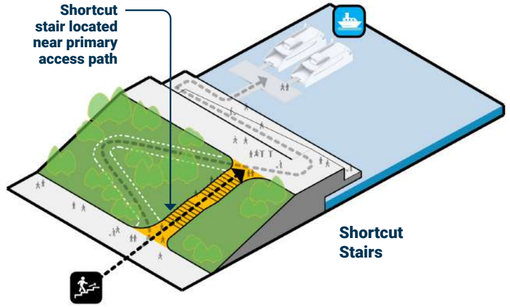
In addition to stairs and ramps, the master plan provides elevators and escalators within ferry terminals and other buildings along the waterfront to complement other access routes.

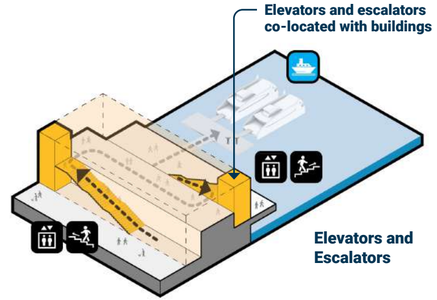
Primary Access





Secondary Access





Waterfront Access Toolkit

- Ferry Terminal
- Pedestrian Waterfront Access Points (Up & Over Access)
- Emergency Vehicles
- Pedestrian Access
- Stair
- Elevator
- Floodgates

How can this Master Plan Preserve and Enhance the Esplanade and Bike Path?

Waterfront Esplanade

The *East River Waterfront Esplanade* provides important north-south connections for pedestrians and bicyclists between The Battery and Montgomery Street. Today, the Esplanade's width is between 14 and 55 feet wide; by comparison, the Hudson River Park and Brooklyn Bridge Park esplanades are 20 and 25 to 30 feet wide, respectively. The master plan proposes a continuous waterfront esplanade. Based on a review of multiple New York City precedents, the recommended esplanade is between 20 and 40 feet, with wider widths reserved for areas with higher anticipated pedestrian activity and additional space for emergency vehicle staging.

Bike Path and the Manhattan Greenway

The Manhattan Waterfront Greenway is a network of bike paths and green spaces that will soon connect all of Manhattan's waterfront neighborhoods. In the Financial District and Seaport, the bike path connects to The Battery in the south and the Brooklyn Bridge Esplanade in the north. The path is about 11 feet wide with one lane of travel in each direction. Conditions vary along the study area.

As part of the master plan, the City is committed to reincorporating the bike path to preserve this important connection for cyclists. Recently completed bike paths along the Hudson River and Brooklyn Bridge Park Greenways are 14 to 16 feet wide with one lane of travel in each direction. A similar path design would be appropriate along the Financial District and Seaport waterfront.

How can this Master Plan Ensure Safe Emergency and Operations Vehicle Access?

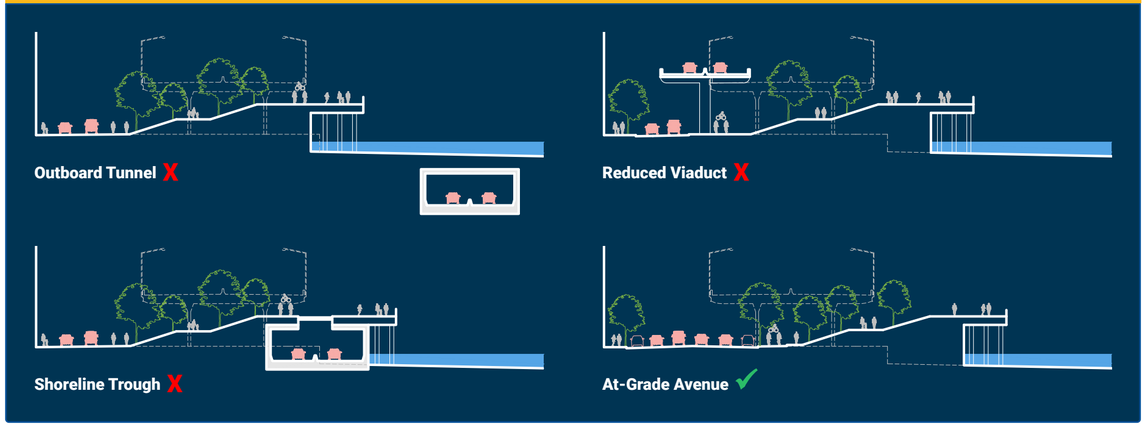
The master plan allows vehicles to access the waterfront in limited areas to support the long-term maritime and waterfront operations. Further, it is critical that emergency vehicles remain able to move throughout the study area.

The resilient waterfront supports continued emergency vehicle access, including fire engines, ambulances, and police vehicles. Today, emergency vehicles can access the full waterfront along the esplanade and under the FDR Drive viaduct. To accommodate emergency vehicles, the master plan incorporates frequent access points and access loops so that vehicles do not have to turn around along the shoreline edge. For example, fire engines must be able to access all key waterfront facilities, have space for staging, and have clear circulation routes. It is especially important that the master plan maintain fire truck access to piers along the waterfront because fire boats alone cannot sufficiently respond to potential emergencies. Moreover, police and ambulances need access to ensure the safety of users along the waterfront and respond to emergencies, where needed.

The master plan provides continued vehicular access to the Downtown Manhattan Heliport and Pier 17. Private vehicles supporting these facilities are limited to dedicated access driveways to ensure pedestrian safety. The master plan also provides continued vehicular access and emergency frontage at key maritime facilities, such as the Battery Maritime Building.

Compatibility With Potential Alterations to the FDR Drive Viaduct

While the master plan does not include a specific proposal to remove the FDR Drive Viaduct, given the long time horizon of the master plan, it was important to ensure the compatibility of the master plan with potential alterations to the roadway The project team conducted a high-level analysis of many possible ways that the roadway could be reconfigured to ensure that the flood defense will not limit the City's options for the viaduct. If the City seeks to remove the viaduct structure in the future, the project team determined that replacing the viaduct and South Street with a multi-modal, at-grade boulevard would be the best solution to balance cost, engineering, traffic, and pedestrian experience considerations. The project team also explored tunnel and trough options but determined these would be infeasible due to constraints imposed by existing underground infrastructure. Additionally, the project team determined that a narrowed viaduct would be too costly and would provide little additional benefit.



Access and Circulation Design Proposal

At 15 to 18 feet above the existing esplanade, the height of the flood defense could be a major barrier between the city and the water. To continue to connect people to the shoreline, the master plan proposes a multi-level waterfront with several primary and secondary access routes. The diagram to the right illustrates how these multiple access strategies work together.

Access to the Waterfront

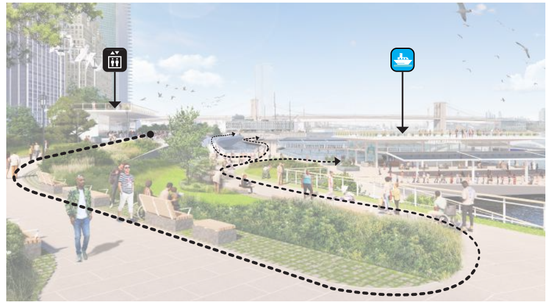
Across the study area, access points are proposed no more than 500 feet apart. From anywhere along South Street, people can visibly see a clear way to get to the waterfront. Gateway entrances are located within street corridors and adjacent to ferry terminals to provide direct visual and physical access to the shoreline and to ensure seamless access to ferries. To navigate access up and over the flood defense, the master plan includes gradually sloping pathways, ensuring ADA compliance and universal accessibility, as well as secondary access with stairs and elevators.

Access Along the Waterfront

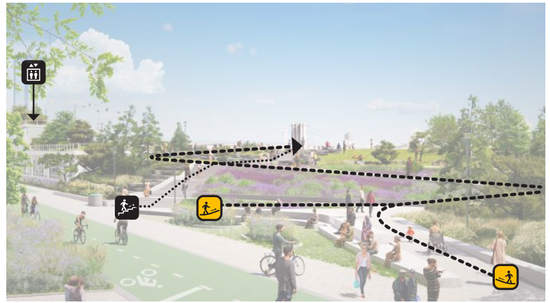
The proposed esplanade provides continuous north-south access along the shoreline edge, providing additional opportunities for people to get down to the water in select locations. In high traffic areas, additional space is provided for circulation and gathering. To minimize conflicts with pedestrians on the esplanade, the master plan proposes the Manhattan Greenway continue along the South Street corridor.

Integrating Access

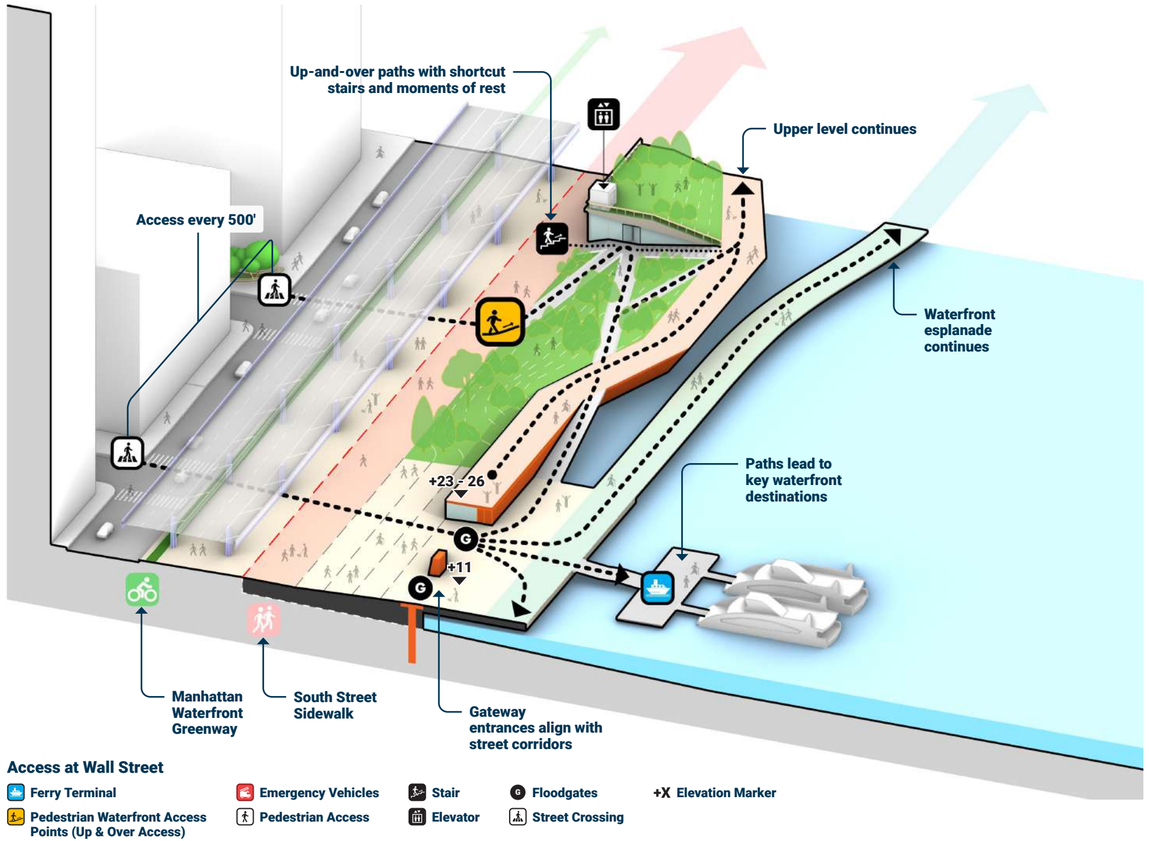
To make the flood defense system a seamless part of the waterfront, proposed access areas also provide opportunities for public space. Grand and inviting paths visually connect back to the many open plazas, parks, and playgrounds that already exist along South Street. Access paths along the waterfront also serve as places of rest and for leisure.



Along the waterfront, direct paths connect the two levels and provide direct access to key destinations



Accessible slopes and shortcut stairs provide ease of access to the waterfront at key access points



Pedestrian Access and Circulation

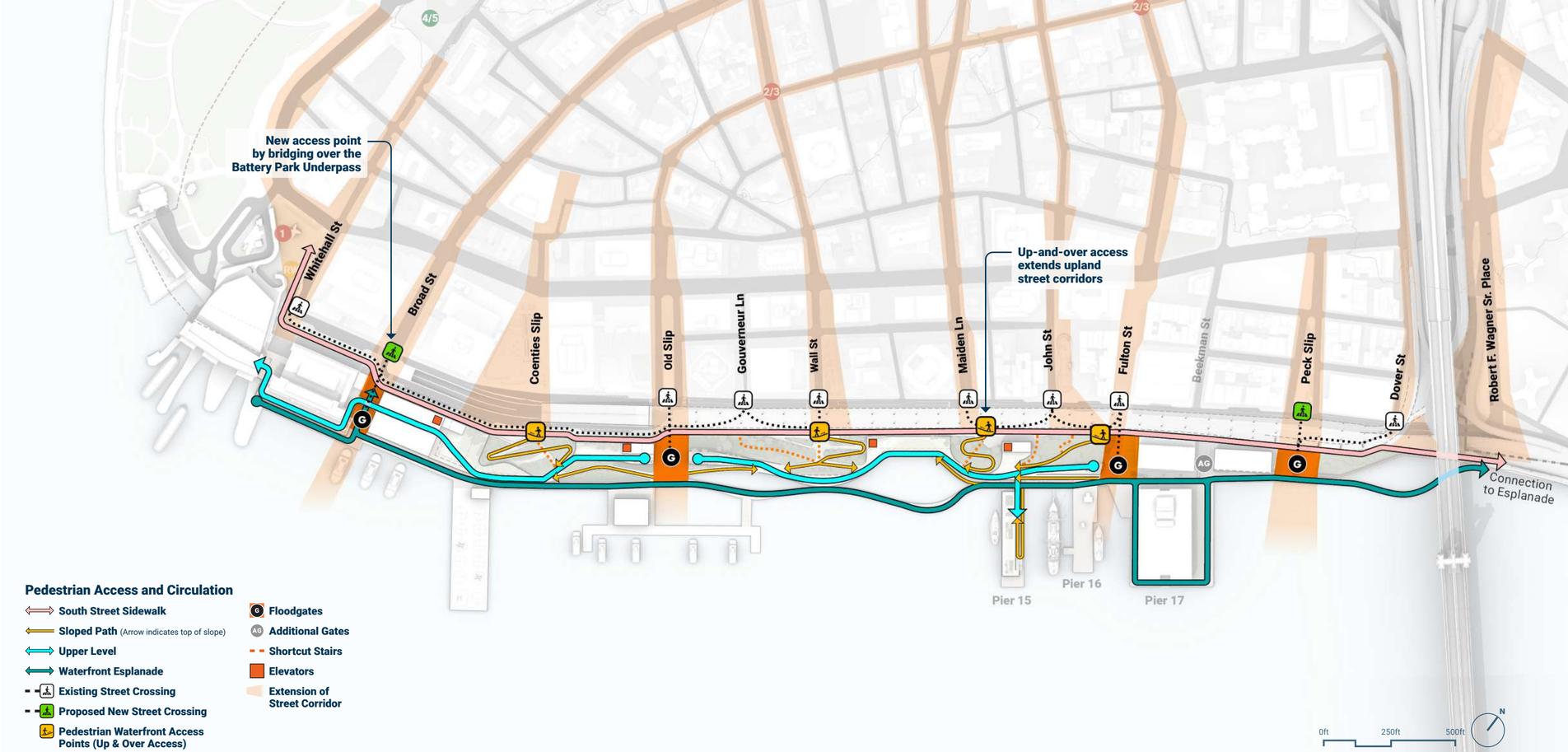
The project team prioritized pedestrian access and circulation in designing the master plan. All proposed primary waterfront access routes are universally accessible paths that are clearly visible from the city and invite the user to the waterfront esplanade. The master plan proposes the following to achieve this:

Access to the Waterfront

- Maintaining all existing crosswalks, as shown in white along South Street. The City is also considering adding crosswalks at Broad Street (facilitated by extending the Battery Park Underpass) and at Peck Slip, as shown in green
- Providing gateway entrances at Broad Street, Old Slip, Fulton Street, Beekman Street, and Peck Slip
- Extending the Battery Park Underpass to provide more space for pedestrian circulation in front of the Battery Maritime Building and direct access to the new ferry terminal at Broad Street
- Providing up-and-over access at Coenties Slip, Wall Street, Maiden Lane, and Fulton Street
- Leveraging elevators within one-to-two story buildings, such as at the proposed new ferry terminal

Access Along the Waterfront

- Maintaining the relatively free and open pedestrian circulation that exists today under the FDR Drive viaduct
- Creating a continuous esplanade along the waterfront that extends from Broad Street to the Brooklyn Bridge Esplanade to the north



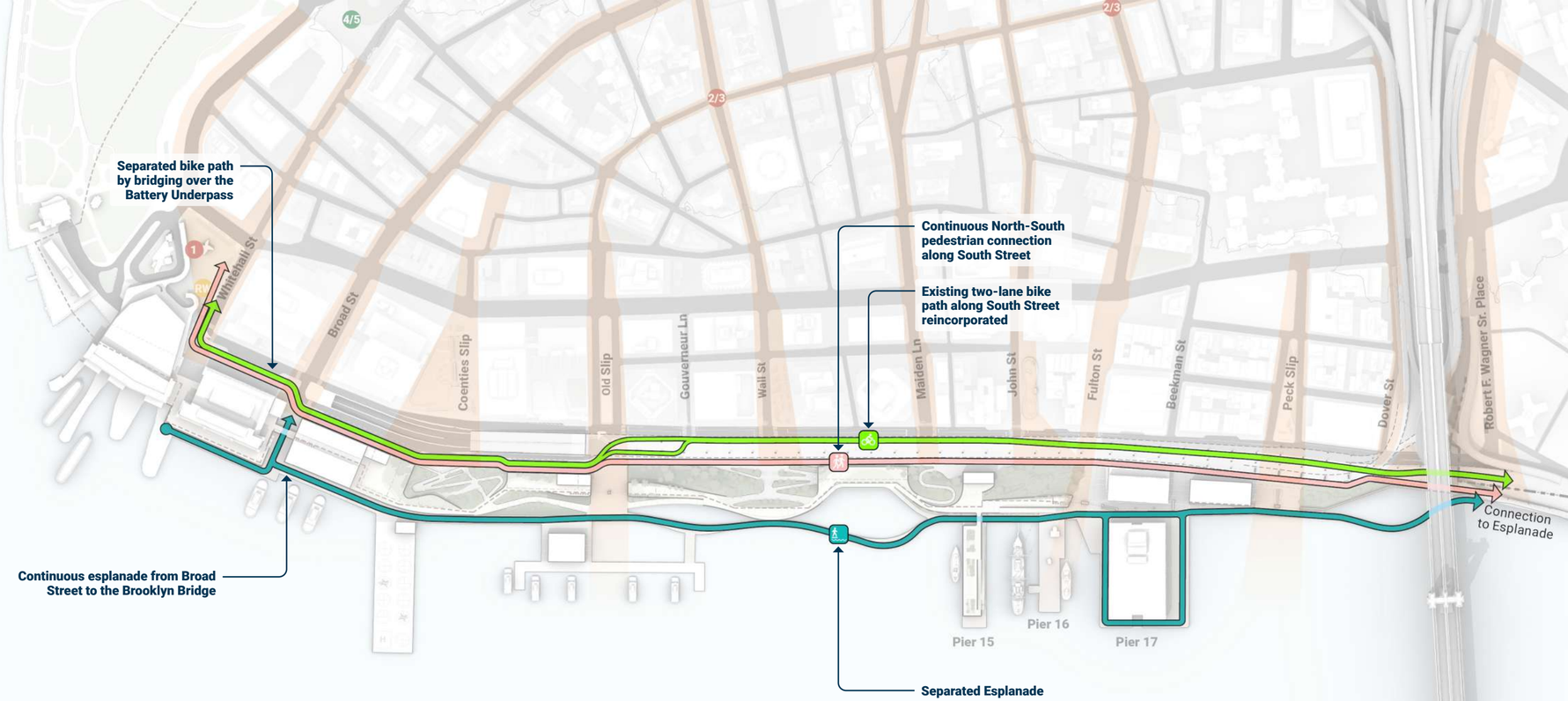
The Esplanade and Manhattan Greenway

Waterfront Esplanade

The master plan includes a continuous waterfront esplanade from Broad Street to the Brooklyn Bridge Esplanade, where it then continues north. The esplanade is close to the water to provide the necessary connections to piers and ferries, as well as an immersive waterfront experience. The proposed esplanade is high enough to prevent frequent flooding and designed to withstand temporary flooding during coastal storms. Based on a review of multiple New York City precedents, the recommended esplanade width is between 20 and 40 feet, with wider areas where higher pedestrian activity is anticipated and additional space for emergency vehicle staging.

Bike Path

The master plan includes a two-lane bike path that is physically separated from South Street as part of the Manhattan Waterfront Greenway. The proposed bike path is wider than today and continues to run along South Street. Additionally, the proposed bike path is lined with vegetation to provide shading for cyclists and increase permeable surfaces to capture stormwater runoff. Extending the Battery Park Underpass would also provide space to separate the bike path in front of the Battery Maritime Building.

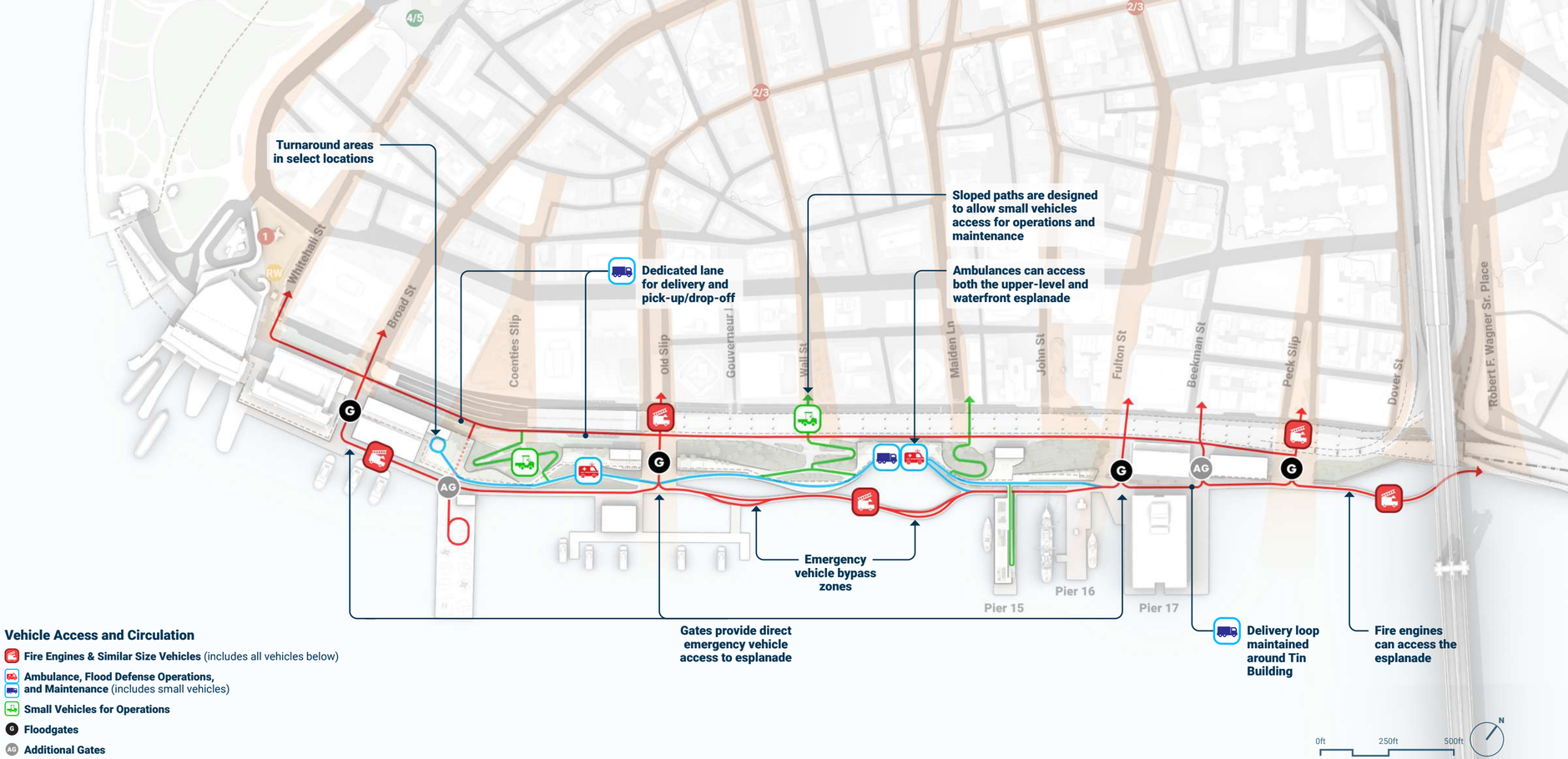


The Waterfront Esplanade and Manhattan Greenway

- Manhattan Waterfront Greenway
- South Street Sidewalk
- Waterfront Esplanade

Vehicle Access and Circulation

The master plan proposes emergency, maintenance, and operations vehicles use gateway entryways at Broad Street, Old Slip, Fulton Street, and Peck Slip to enter and exit the waterfront. Fire engines, the largest vehicle to be accommodated, must access all parts of the proposed waterfront esplanade, which includes a wide path to allow ease of movement. Mid-size vehicles, such as ambulances and operational vehicles, must also have access to the waterfront esplanade, as well as the upper-level flood defense. Mid-size vehicles can use proposed ramps from the Old Slip and Fulton gateways to access the upper level. Small vehicles, such as gators for trash collection, can maneuver all pedestrian pathways across the study area.



Vehicle Access and Circulation

- **Fire Engines & Similar Size Vehicles** (includes all vehicles below)
- **Ambulance, Flood Defense Operations, and Maintenance** (includes small vehicles)
- **Small Vehicles for Operations**
- **Floodgates**
- **Additional Gates**

Maritime

Overview

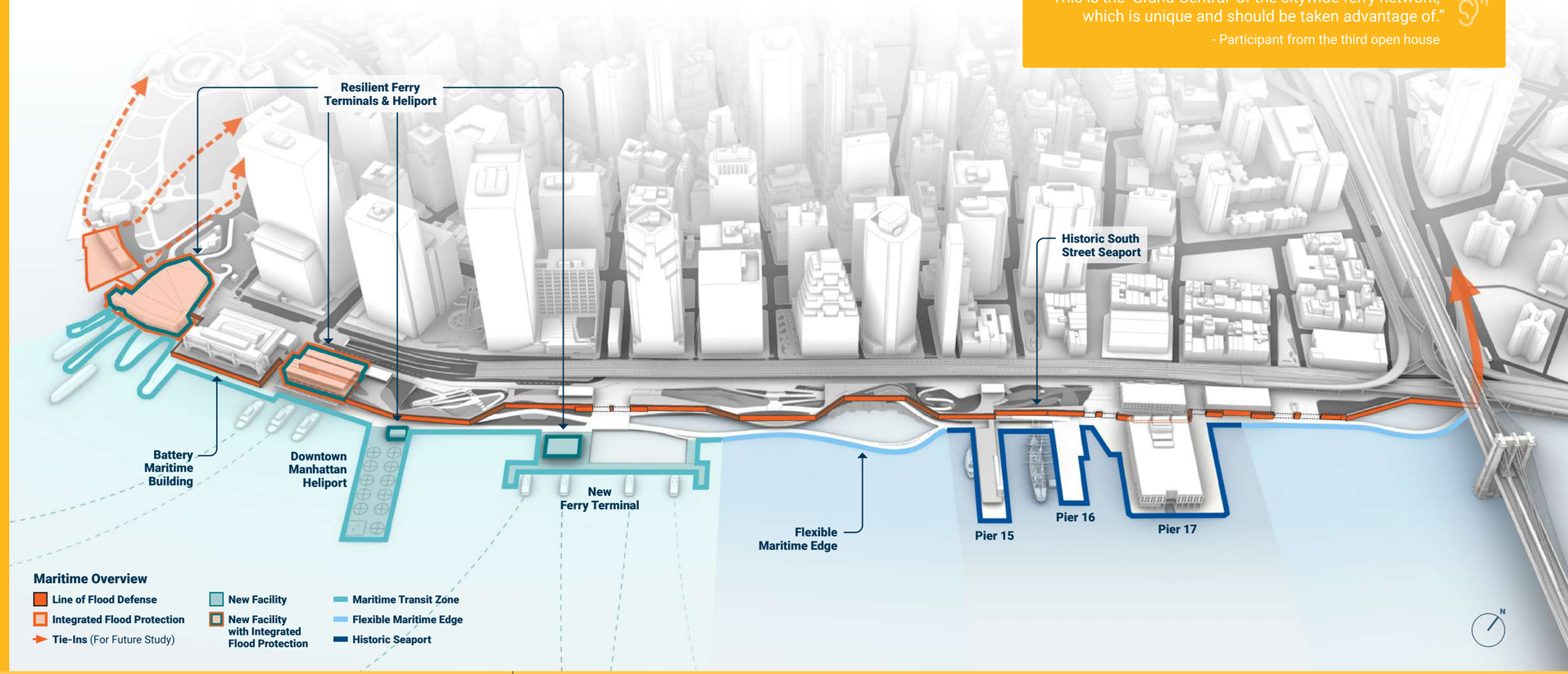
The Financial District and Seaport neighborhoods are a major hub of maritime activity, including ferries, historic ships, sightseeing excursion vessels, and other forms of waterborne transportation. At the end of the 20th century, only a fraction of the maritime uses that once thrived along the Financial District and Seaport waterfront remained. However, in more recent years, water-based transportation has been returning to the area, including the growth of commuter ferries and recreational services. Catastrophic events, such as the September 11 attacks, have also reinforced the critical importance of the waterfront for supporting emergency evacuation.[6]

Existing piers and ferry terminals are vulnerable to the impacts of climate change. In the Financial District and Seaport, some of the piers and ferry terminals that exist today, like Pier 11, will be flooded monthly by the 2050s and daily by the 2080s, if no action is taken. Frequent inundation will create significant challenges to daily operations. These facilities must be adapted to function with higher sea levels over time while maintaining connections to the water.

This master plan ensures that the maritime uses along the Financial District and Seaport waterfront will be resilient to future tidal flooding and coastal storms while also allowing for long-term flexibility to support the City's changing maritime needs. Each asset has unique needs and constraints, and this master plan proposes how to adapt each asset to continue to serve New Yorkers.

"This is the 'Grand Central' of the citywide ferry network, which is unique and should be taken advantage of."

- Participant from the third open house



Technical Analysis

Several key questions guided the project team in planning for the future of the Financial District and Seaport's maritime uses. Key questions included:

1. What are the existing maritime facilities and functions and how vulnerable are they to sea level rise?
2. What are the future maritime needs in this area?
3. What needs to be considered when building resilient maritime facilities?

What are the Existing Maritime Facilities and Functions, and how Vulnerable are they to Sea Level Rise?

The maritime uses in the Financial District and Seaport primarily provide waterborne transportation across the city. This important function needs to be safeguarded in the face of climate change, while also accommodating potential future growth as the City's maritime needs change.

To understand the impacts from climate change that each asset faces, the project team reviewed technical drawings to document each facility's existing above-ground elevations. The project team then compared building elevations with current and future sea level rise to determine when, how, and to what degree each asset will be affected. The following highlights the major maritime facilities in the study area and the potential impacts of climate change to each asset.

Whitehall Ferry Terminal

This terminal serves the Staten Island Ferry, the busiest passenger ferry route in the country. The Staten Island Ferry is a free ferry service that provides a critical link for about 70,000 daily passengers between Staten Island and Lower Manhattan (based on 2019 transit ridership figures).[7] If no action is taken, by the 2050s, daily tides will reduce the clearance between the top ferry deck and roof of the terminal. This could require steeper boarding ramps which can be challenging for all users. By the 2080s, the lower level will be submerged daily, which will not only affect lower-level boarding, but operations of the whole facility.

Battery Maritime Building

The Battery Maritime Building, a national historic landmark, provides service for passengers and freight vehicles to Governors Island, which is operated by the Trust for Governors Island. One of the slips is also operated by NYC Department of Transportation (DOT) and provides regional commuter ferry service. The terminal is one of the lowest-lying assets in the area. If no action is taken, the boarding area of the Battery Maritime Building will experience monthly tidal flooding by the 2050s, leading to significant impacts and frequent service closures.

Pier 6 Downtown Manhattan Heliport

This heliport provides landings for the New York Police Department (NYPD), emergency access, and a secure landing spot for important government officials, including the President of the United States. The heliport also provides private tourism flights and charter service to area airports and other local/regional destinations. By the 2050s, the deck of Pier 6 will be flooded monthly, rendering it non-functional.

Pier 11/Wall Street Ferry Stop

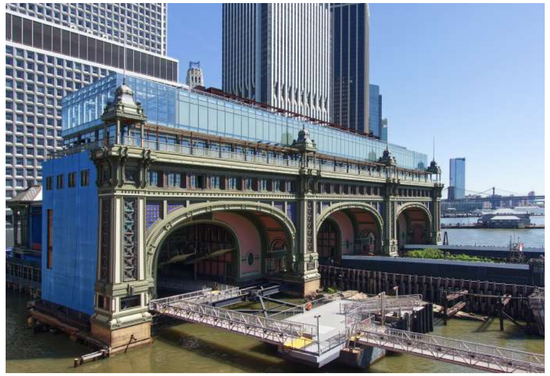
Pier 11 is the busiest ferry landing in the NYC Ferry service and serves several other regional ferry operators.[8] Pier 11 will face monthly tidal flooding by the 2050s, if no action is taken.

Piers 15, 16, and 17

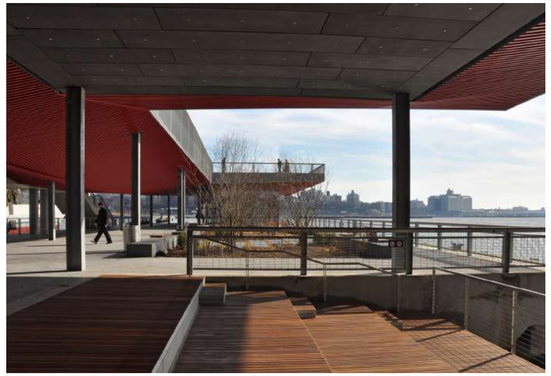
Piers 15, 16, and 17 serve as public gathering spaces, including where people can view historic ships and board sightseeing cruises. The part of Pier 15 closest to land will be impacted by monthly tidal flooding by the 2050s, with the main portion impacted by the 2080s. Pier 16 will face monthly tidal flooding by the 2050s as well. Pier 17 was built most recently and is at a significantly higher elevation. While Pier 17 is still vulnerable to coastal storms, it will not be impacted by monthly tidal flooding within this century.

View of the Whitehall Ferry Terminal entrance from Peter Minuit Plaza (Photo Credit: NYCEDC)

View north from the Downtown Manhattan Heliport at Pier 6 in 2009
(Photo Credit: Cpl. Patrick Fleischman, https://bit.ly/3m34sPh)



View of the historic Battery Maritime Building from the East River (Photo Credit: NYCEDC)



View of the lower level of Pier 15 showing a get-down to the water and seating areas
(Photo Credit: NYCEDC)

What are the Future Maritime Needs in this Area?

To understand the future needs of maritime uses in the Financial District and Seaport neighborhoods, the project team examined the expected lifespan of existing maritime facilities, as well as historic trends and growth projections, to determine the potential for future changes in operations. The project team also examined the potential for new uses, such as waterborne freight. Once estimates of future ferry ridership for each facility were developed, the project team identified where additional slips, or spaces for ferries to dock, may be needed to accommodate future growth and long-term adaptability. The project team also examined additional space needs, such as passenger loading and waiting areas.

Due to the uncertainties involved in projecting the needs associated with future maritime uses, the project team developed two scenarios: low and moderate growth. These projections are intended to give a broad sense of potential needs, acknowledging that demand for ferry services can be heavily affected by investments in the expansion of services and pricing. These projections are based on existing peak hour ridership for each service and apply growth factors based on historic trends or, in the case of the Governors Island Ferry, development plans. The project team then analyzed the operations of each terminal to determine if additional slips would be needed to accommodate the demand. In addition to ferries, the project team also accounted for additional space for emergency maritime evacuation, potential future freight services, and growth of visiting ships and other excursion vessels.

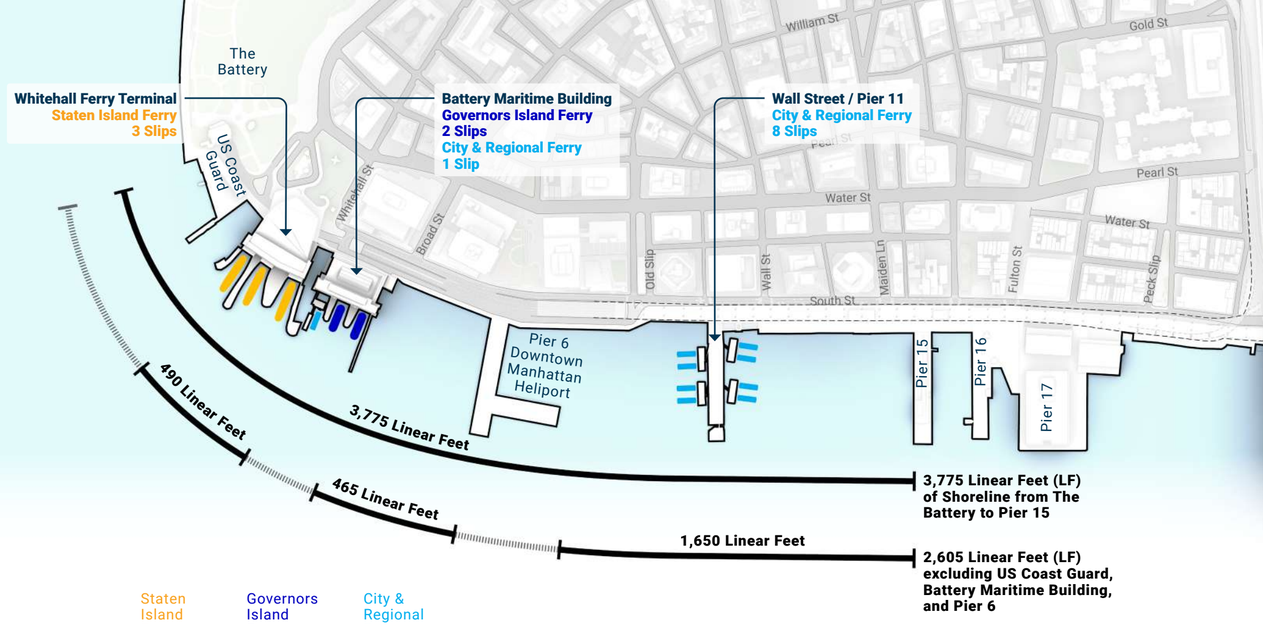
- There are 3,775 linear feet of shoreline from Pier 15 to The Battery. This is the area where current ferry services are located, and the area best positioned for accommodating any additional growth.
- In the low growth scenario, a total of 15 ferry slips would be needed, which would require 1,730 linear feet of shoreline to accommodate. **With an additional 200 linear feet for other uses than ferries, a total of 1,930 linear feet would be needed for all maritime uses—74 percent of the entire shoreline south of Pier 15.**
- In the moderate growth scenario, a total of 19 ferry slips would be needed, which would require 2,150 linear feet of shoreline to accommodate. **With an additional 400 linear feet for other uses than ferries, a total of 2,550 linear feet would be needed for all maritime uses—nearly the entire shoreline south of Pier 15.**

While the conceptual design assumes the existing level of maritime activity along this waterfront, these projections provided the project team with a sense of scale for potential future maritime uses. They also demonstrated the need to design a waterfront esplanade that can be flexible to accommodate future changes.

Hydrodynamic Modeling

To understand how water moves in and around the study area, the project team used multiple computer models to predict future water speeds and tides in the East River with the new flood defense infrastructure in place.

The project team completed an impact assessment to understand how the master plan and any shoreline extension could potentially affect tides and water-based navigation in the East River. Placing any new fill into the East River can alter the way that water currently flows. The results show that, while there may be increases in water speeds in select locations across the study area, these increases are limited to areas directly adjacent to the proposed master plan and do not cause additional impacts outside of the study area. As part of future work, the City will need to coordinate with maritime operators to understand how these potential changes could impact them and whether different shoreline configurations in and around maritime facilities could avoid or mitigate these impacts.



Projections of Future Maritime Needs
Future space needs under low and moderate maritime growth scenarios, as compared to the existing shoreline, in Linear Feet (LF)

What Needs to be Considered When Building Resilient Maritime Facilities?

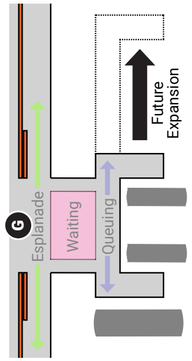
The project team explored a wide range of approaches for how to weave the flood defense system into an active maritime waterfront. This included assessing strategies for adapting existing maritime facilities to be protected from coastal storms and tidal flooding, as well as how to plan for flexibility in accommodating additional growth and changes in uses over time. The master plan includes the following strategies to simultaneously meet resilience and maritime goals:

Create a Resilient and Flexible Maritime Edge

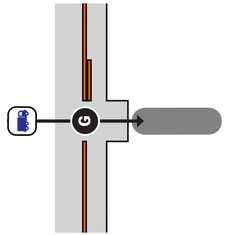
While some places along the waterfront must be set aside for specific maritime uses, like the NYC Ferry or the South Street Seaport museum's historic ships, the master plan proposes the shoreline throughout the study area be designed to accommodate vessel access and tie-ups to allow for a variety of uses, as well as enable emergency evacuation. The master plan proposes the waterfront esplanade be raised to a passive design flood elevation of +11 feet NAVD88 so that it will be protected from future tidal flooding. However, the shoreline edge must also be designed to be accessible by vessels during today's tidal conditions. The master plan includes a mix of ramps and floating barges to ensure that access from the esplanade remains feasible today and long into the future.

Design Flexible and Expansible Ferry Facilities

The project team met with maritime operators in the study area and studied ferry terminals elsewhere across the world and city, to understand what makes a successful ferry terminal. For example, Pier 79 on the west side of Manhattan is a model of a ferry terminal that provides adequate waiting and queuing areas, a feature that is lacking at Pier 11 today. The master plan locates the passenger waiting area on an expanded pier to allow space for circulation and queuing. The master plan proposes ferry facilities near the floodgates to allow high visibility to pedestrians and provide access for emergency and operational vehicles. The master plan also locates ferry facilities to allow flexibility for future growth of the ferry system and/or changes in technology, such as electric ferries.



Flexible and Expandible Slips (Plan)

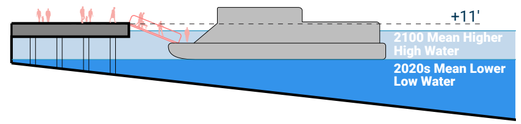


Drive-off Freight / Vehicle Slips (Plan)

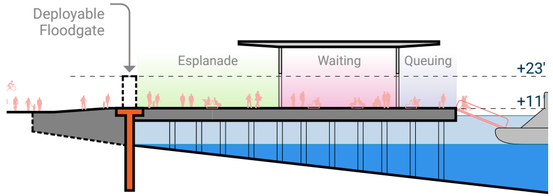
Plan for Future Maritime Freight Access

The master plan provides maritime access for freight that could serve future needs for a variety of services, from construction to last-mile delivery. The master plan locates these piers or slips near floodgates to allow direct vehicle access.

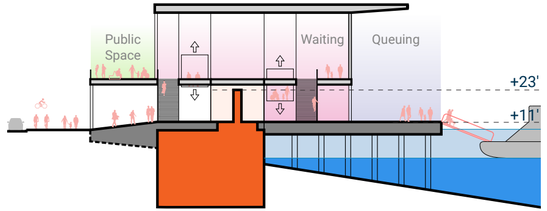
Resilient Maritime Structures Toolkit

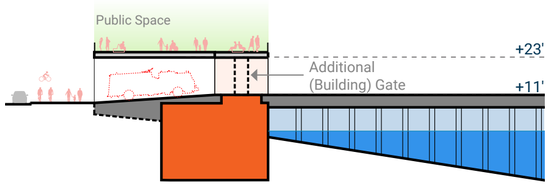


Resilient and Flexible Maritime Edge



Resilient Maritime Structures Outboard of Flood Defense





Resilient Maritime Structures Integrated with Flood Defense

Create Resilient Maritime Structures

Some piers and maritime facilities, like Pier 11, must be elevated to protect against future tidal flooding but will still be subject to flooding during coastal storms. To account for this, the master plan proposes to make them resilient by using flood damage-resistant materials. The master plan also proposes critical mechanical and electrical systems be elevated or hardened.

Integrate Flood Defense into Maritime Facilities

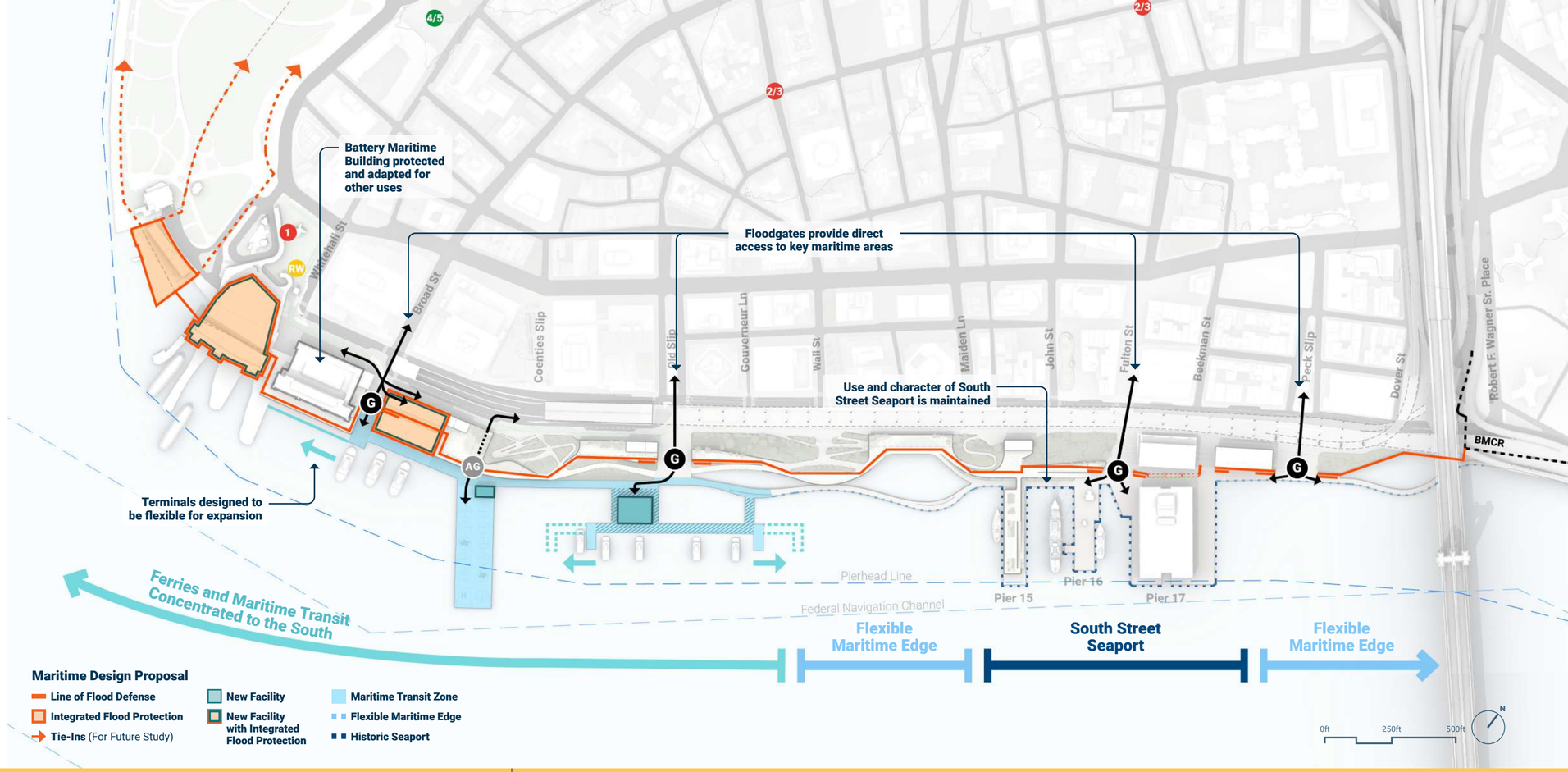
Some maritime facilities located directly on the shoreline, such as Whitehall Ferry Terminal, will need to be redesigned to accommodate the flood defense system through the building. These new and reconstructed facilities will be protected against coastal storms and tidal flooding. Multiple levels are proposed for boarding, similar to how Whitehall Ferry Terminal operates today. Elevators, stairs, and escalators can be used to provide access within these facilities.

Maritime Design Proposal

The master plan aims to preserve the important waterfront functions that currently exist, while ensuring that the ferry terminals and piers themselves are resilient in the face of climate change. In addition to protecting against the impacts of climate change, the master plan also provides flexibility for future potential uses, such as expansion of the ferry system and/or last-mile freight.

This diagram illustrates the proposed plan for maritime uses.

- **Ferry activity is concentrated in the southern portion of the study area.** This ensures more direct access to public transit while preserving flexibility for future maritime uses.
- **Ferry terminals, the heliport, and the South Street Seaport slips** will be directly accessible at gateway entrances via floodgates.
- The historic **Battery Maritime Building** will be protected and the facility itself can be adapted for complementary public uses (e.g., an extended waiting hall, food hall, or other space to support the adjacent ferry terminals). Governors Island Ferry and other services will be relocated to new maritime facilities.
- **All facilities will be located with future expansion in mind.** New ferry terminals will be located to allow for future slip expansion along the waterfront. The Downtown Manhattan Heliport will be designed to be a pier with direct vehicle access, ensuring flexibility for alternative uses in the future.
- **To preserve the historic character around the South Street Seaport, the master plan proposes minimal changes to the nature of Piers 15, 16 and 17.** Pier 15 will be reconstructed to resemble its current appearance, and a bridge will connect the upper level of the pier to the raised shoreline. Pier 16 will be reconstructed to be resilient to future sea levels but will retain the material character that it has today. Finally, Pier 17 will remain as it is today because it is already elevated to prevent inundation from tidal flooding.



Whitehall Ferry Terminal

The master plan proposes the flood protection system be integrated into the Whitehall Ferry Terminal. The terminal will need to be rebuilt, both to accommodate a flood defense system as well as to adapt operations for sea level rise. The City will also explore opportunities to seamlessly integrate the flood protection and resilience components while improving passenger experience.

New Ferry Terminals

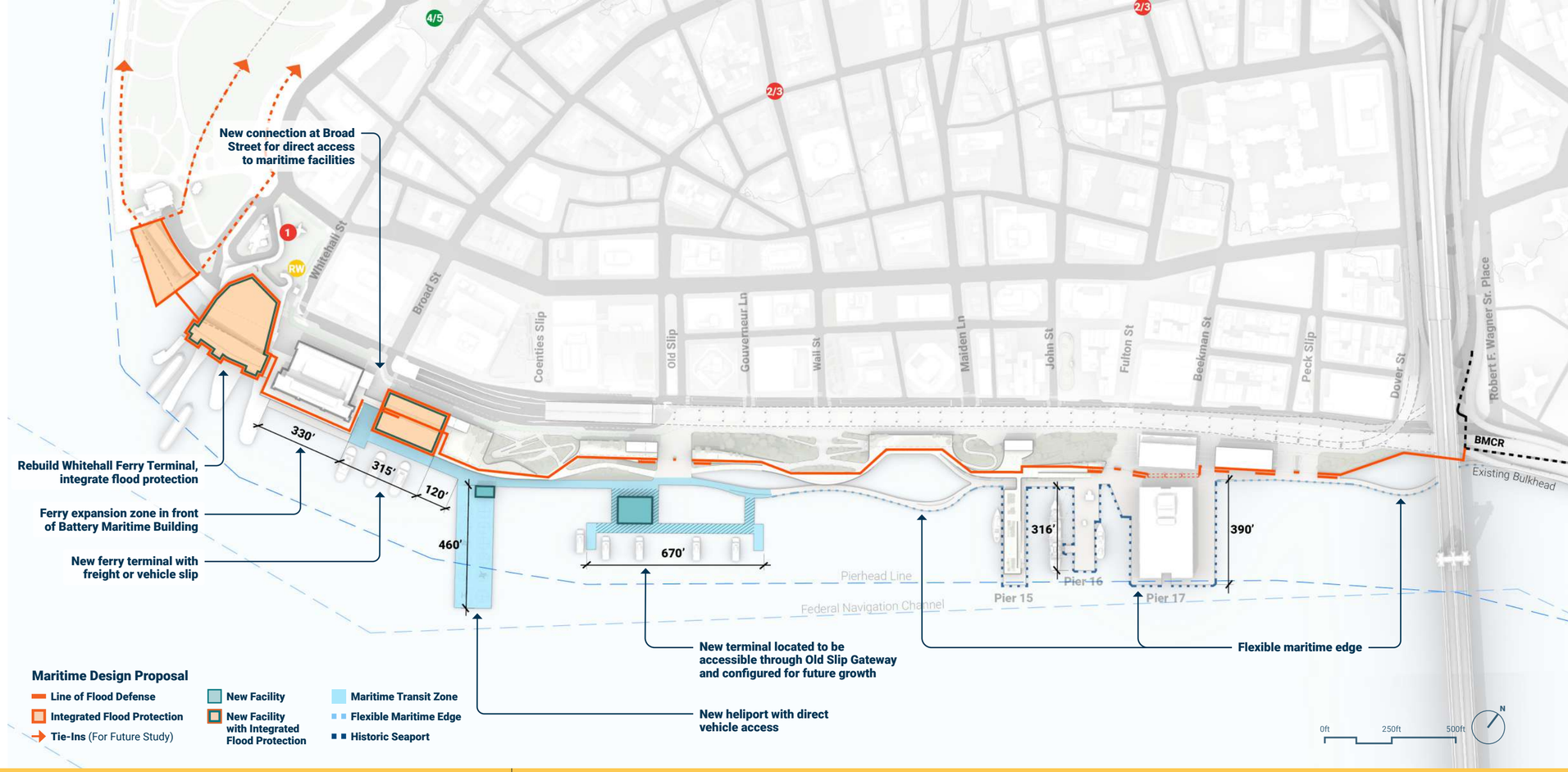
The master plan proposes two new ferry terminals. First, directly to the north of the Battery Maritime Building, a new facility is proposed to provide a resilient gateway to Governors Island and other destinations. Direct vehicle and pedestrian access to the new terminal would be provided by extending the Battery Underpass and creating a new access point at Broad Street. A second terminal is proposed near Old Slip, ensuring direct access to the city via floodgates. The new facility will provide additional space for ticketing and passenger waiting, will be flexible for both front and side loading vessels, and will be configured to allow for expansion over time. All terminals will be designed to accommodate future technologies such as electric ferries, as needed.

Downtown Manhattan Heliport

The master plan proposes the heliport be reconstructed near its current location at a higher elevation. A dedicated loading zone along South Street reduces vehicle-bike conflicts along the greenway. In addition to curbside drop-off, vehicles can access the heliport pier via a small parking facility located behind the flood defense. A floodgate within the parking facility allows service and emergency vehicles access directly onto the pier. The heliport building will be located on the pier, similar to where it is today, and will be designed to be resilient with offices for operators of the heliport on a second floor. The proposed pier provides the same number of helicopter parking locations as today while simplifying the layout.

A Flexible Maritime Edge

North of Old Slip, the master plan proposes a continuous flexible maritime edge. The waterfront esplanade, Pier 15, and Pier 16 will be elevated to protect from future tidal flooding and will be designed to be flexible for vessel mooring. The master plan will maintain space for the historic and commercial vessels that currently use the waterfront today and ensure future expansion can be accommodated.



Ecology

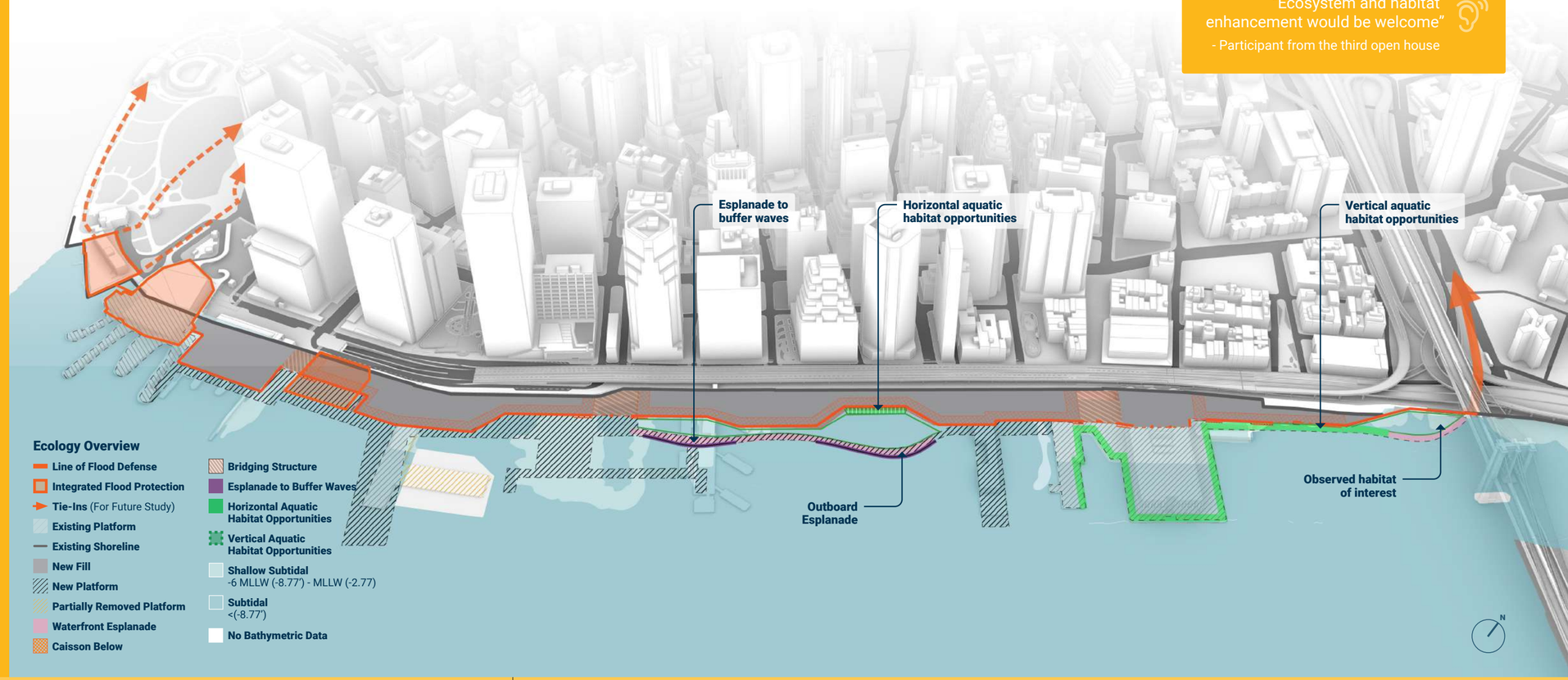
Overview

To build the flood defense infrastructure, the master plan requires extending into the East River along some portions of the shoreline and replacing the bulkhead. This will displace some of the existing river bottom and open water and could affect fish and other aquatic organisms that use these areas. While this extension into the East River presents a challenge, it also provides an opportunity to rebuild the shoreline in a way that integrates habitat enhancements into the flood defense infrastructure. The master plan aims to preserve and enhance East River aquatic habitats wherever possible while ensuring that the Financial District and Seaport neighborhoods are protected from the impacts of climate change.

The project team conducted a year-long sampling study of the habitat conditions in the East River in and around the study area. The sampling took place over four seasons to understand changing habitat conditions and the presence of different kinds of fish and other aquatic organisms throughout the year. The results and findings from this study, coupled with research and input from biologists and community members, have informed the conceptual design of the master plan.

The implementation of the master plan cannot compromise the current use of the East River by fish and other aquatic organisms. Rather, the master plan provides an opportunity to improve the current habitat conditions along most of the new shoreline structure, possibly increasing the number and types of fish and other aquatic organisms in the area. Greater variety of habitats, increased surface complexity (more varied and textured surfaces), and greater porosity (more crevices and porous spaces) generally supports a greater number and variety of organisms.

"Ecosystem and habitat enhancement would be welcome"
- Participant from the third open house



Technical Analysis

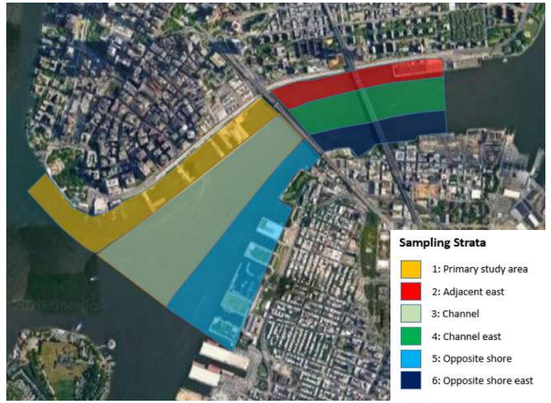
The project team commenced a series of studies and analyses of existing aquatic habitats within the East River, habitat requirements of fish and other aquatic organisms that use these habitats, and opportunities to incorporate enhancements of these habitats into the master plan. The key questions studied included:

1. What are the existing aquatic habitats across the study area and what fish and other aquatic organisms are using them?
2. How can the master plan minimize impacts to existing aquatic habitats?
3. How can the master plan incorporate habitat enhancements?

What are the Existing Aquatic Habitats Across the Study Area and what Fish and Other Aquatic Organisms are Using Them?

The project team completed the first year of a seasonal aquatic sampling program (October 2020 through September 2021) in and around the study area to characterize existing aquatic habitat conditions and identify the fish and other aquatic organisms that use the area.

The project team found that the study area has both intertidal and subtidal zones along the shoreline. Intertidal zones, characterized by water levels between low and high tide, have qualities like those of a beach, whereas subtidal areas are below low tide and are generally permanently submerged, or underwater. Intertidal and subtidal habitats were of particular interest since they are rare along the Lower Manhattan shoreline of the East River. The project team used a variety of nets, traps, and remote sensing instruments to collect samples of aquatic organisms in these different zones, including fish, benthic invertebrates that live on and in the river bottom, and crustaceans, such as crabs.



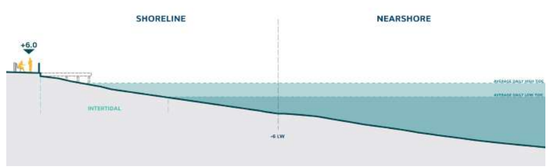
Map of sampling plan strata

Rather than looking separately at individual fish or invertebrate species, the project team analyzed “functional groups” of species that interact with each other and their habitat requirements. These groups were based on the aquatic species collected in the sampling, as well as species that are a focus of regional restoration priorities; are of value to commercial and recreational fisheries; are an important food for other fish; and/or are of interest to regulatory agencies. The project team considered how these species would respond to habitat changes and how in-water components of the master plan might be changed to be of use to them. This informed the identification of habitats to be protected and preserved, and the types of habitat enhancement strategies put forward in the master plan.

Example of Varying Shoreline Conditions Across the Study Area

Subtidal Zones (Vertical Shoreline)

Most of the shoreline in the study area comprises a vertical bulkhead and subtidal habitat. The river bottom is fairly uniform, with areas that have remnant pile fields, piles of debris and sand waves, or ridges in the sand formed by water movement, which add habitat complexity. Platforms shade the entire shoreline along the bulkhead, as do piers, like 11, 15, 16, and 17, limiting the amount of light reaching the aquatic habitats beneath. Light is required by many aquatic organisms to find food, and for algae to conduct photosynthesis, which supports the aquatic food chain.



Intertidal and Shallow Subtidal Zones

North of Pier 17 and around the base of the Brooklyn Bridge, a small beach and gently sloping intertidal and shallow subtidal nearshore habitat has developed along the bulkhead. While portions of this area are shaded by overwater structures, much of it has access to light. This area is of ecological interest as it represents the only beach and intertidal area in the study area not shaded by overwater structures. During the aquatic sampling, high abundances of *Sabellaria vulgaris*, an important reef building worm, were found in this area, though reef structures created by these worms have not been observed to date. There are also some intertidal areas around the Whitehall Ferry Terminal and Battery Maritime Building, but these areas are almost completely covered by the ferry buildings and are highly exposed to boat wake from ferry traffic.

Strategies to Protect and Preserve Aquatic Ecosystems

How can the Master Plan Minimize Impacts to Existing Aquatic Habitats?

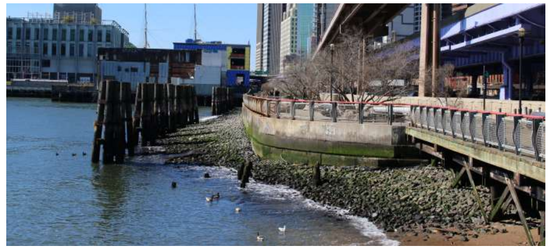
The master plan aims to avoid or minimize impacts to existing aquatic resources by implementing strategies to protect and preserve aquatic ecosystems. While this is one of the City's goals, it is also a necessary approach to obtain the permits and approvals needed to realize the master plan. That is, the City will need to meet the regulatory obligation of avoiding fill in the East River to the maximum extent possible, minimizing fill when avoidance cannot be achieved, and mitigating any impacts from such fill.

Informed by a year of aquatic sampling, the primary ecological goal for integrating flood defense from The Battery to the Brooklyn Bridge is to minimize the in-water footprint while achieving the master plan's goals. The project team worked to minimize the shoreline extension and reduce new platform and piers in all areas along the shoreline. The project team also worked to avoid impacts to existing habitats, prioritizing rare/less common habitat areas. For example, the master plan avoids filling the intertidal beach habitat at the foot of the Brooklyn Bridge to the greatest extent practicable.

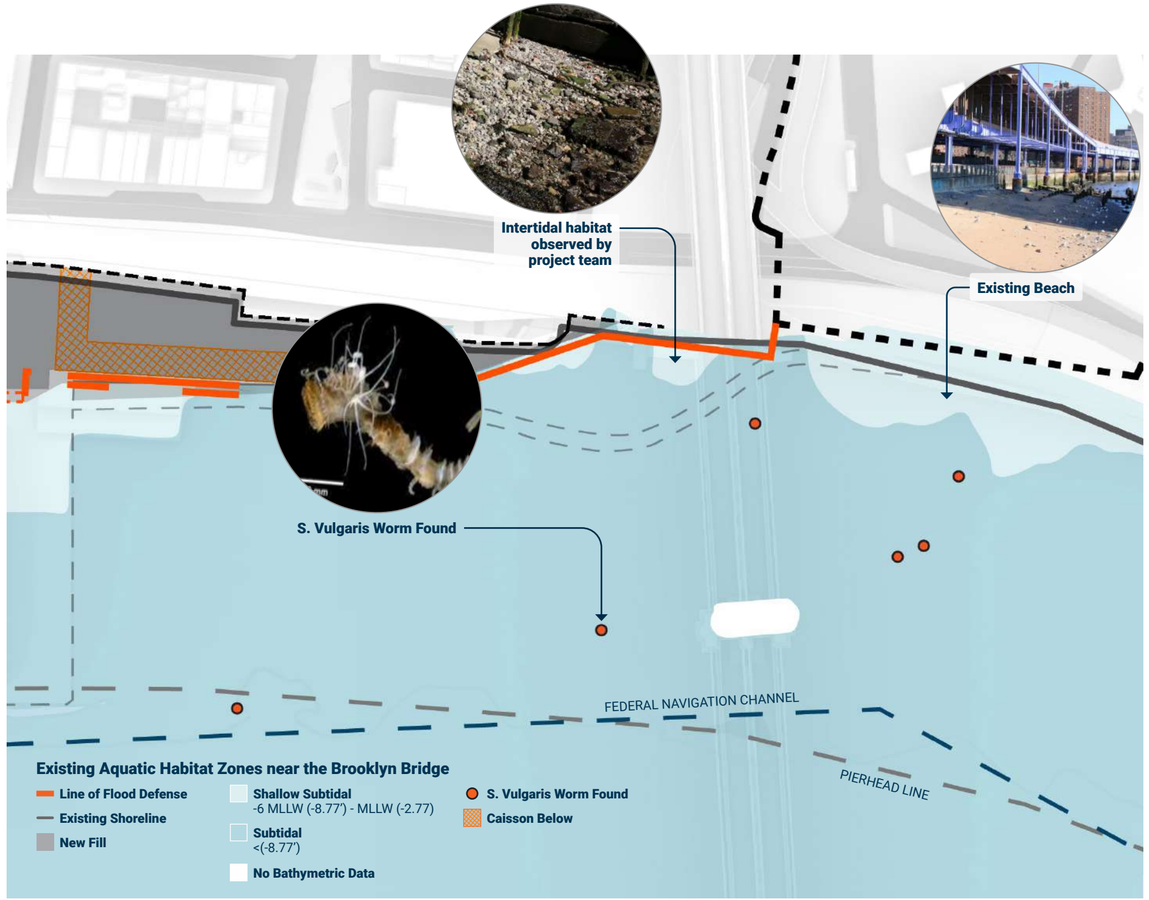
Other strategies to avoid impacts include minimizing disturbance to existing structured habitat, such as debris piles or pile fields, during construction of the master plan. Leaving them in place will help sustain any existing habitat complexity.

Existing rock piles (Photo Credit: Normandeau Associates)

Existing rock piles (Photo Credit: Normandeau Associates)



Observed intertidal habitat near the Brooklyn Bridge (Photo Credit: Normandeau Associates)



Strategies to Enhance Aquatic Ecosystems

How can the Master Plan Incorporate Habitat Enhancements?

The master plan incorporates a suite of strategies to enhance aquatic habitats. These are design modifications and material recommendations that can be integrated into the shoreline and flood defense design to enhance aquatic habitats and possibly increase the number of species within the study area. These strategies can be employed independently of one another but will provide greater ecological benefit if combined.

Introduce Complex Structured Habitat

Increasing the types of habitats available, as well as introducing surface complexity and porosity, can attract a larger number of aquatic species. To accomplish this, the master plan proposes to apply different materials and surface treatments to new in-water structures, such as caissons, bulkheads, and platform pilings. The resulting wider variety of surface conditions – niches and crevices of varying sizes – provide living, foraging, and refuge opportunities for an array of fish and other aquatic species.

Make Space for Shallow Subtidal and Intertidal Habitat

Intertidal and shallow subtidal habitat zones are home to many of the species that are the foundation of the aquatic food chain. However, these habitats are also rare in the East River, particularly along the Lower Manhattan shoreline. The master plan identifies opportunities to support more of these habitats by creating spaces for rocky or planted shelves. These shelves are designed to transition to intertidal or subtidal habitat as sea levels rise but will not increase the proposed footprint in the East River.

Allow Light Penetration to Aquatic Habitats, Especially at the Shoreline

Aquatic habitats need light for algae to perform photosynthesis and for fish and invertebrates to find food. Habitat under platforms can be of limited value when they have too little light, which generally occurs 20 feet in from the platform edge. To overcome this challenge, the project team identified several tactics to limit shading of aquatic habitat by overwater structures. These include separating the waterfront esplanade from the shoreline in strategic locations to create coves. Separating the waterfront esplanade allows light to both reach the surface of the East River under the esplanade and along the shoreline and nearshore zone.

Buffer Nearshore Areas from Wave Action

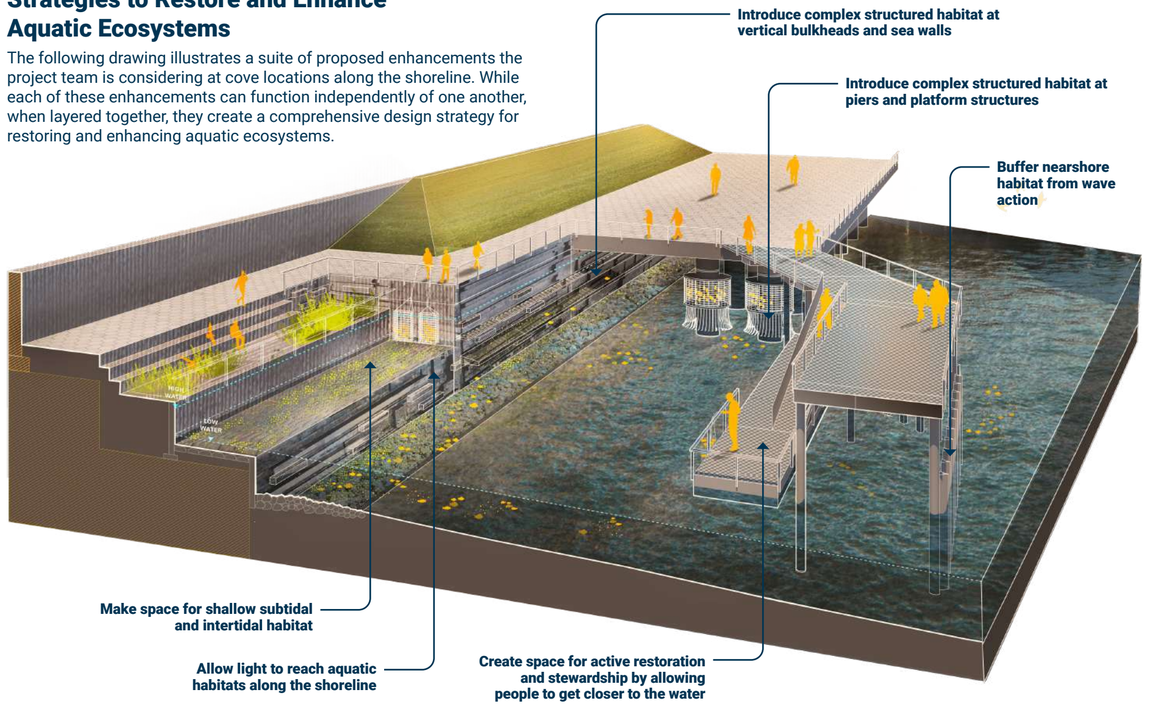
High wave energy that is generated by boat traffic can be disruptive to aquatic habitats and the organisms using them. Wave energy can be dissipated by locating wave attenuating structures that lessen the force of waves and minimize the impacts to habitats. The master plan proposes the use of these wave attenuating features, which could include sills and wave screens, to reduce the force of waves before they reach existing or new habitat along the shoreline.

Create Spaces for Active Restoration and Stewardship

The long-term success of these habitat enhancements will largely depend on the actions taken by individuals and groups to protect and care for them over time. To generate interest in and build capacity for people to steward these aquatic ecosystems, the master plan recommends spaces specifically designed to promote restoration, research, and stewardship. This includes designing accessible shoreline edges and get-downs so that people can get close to the water and see the aquatic habitats. This can build on and tap into the education and stewardship efforts of many existing citywide and neighborhood organizations. Fostering environmental stewardship within the community ultimately encourages continued advocacy for healthy East River ecosystems.

Strategies to Restore and Enhance Aquatic Ecosystems

The following drawing illustrates a suite of proposed enhancements the project team is considering at cove locations along the shoreline. While each of these enhancements can function independently of one another, when layered together, they create a comprehensive design strategy for restoring and enhancing aquatic ecosystems.



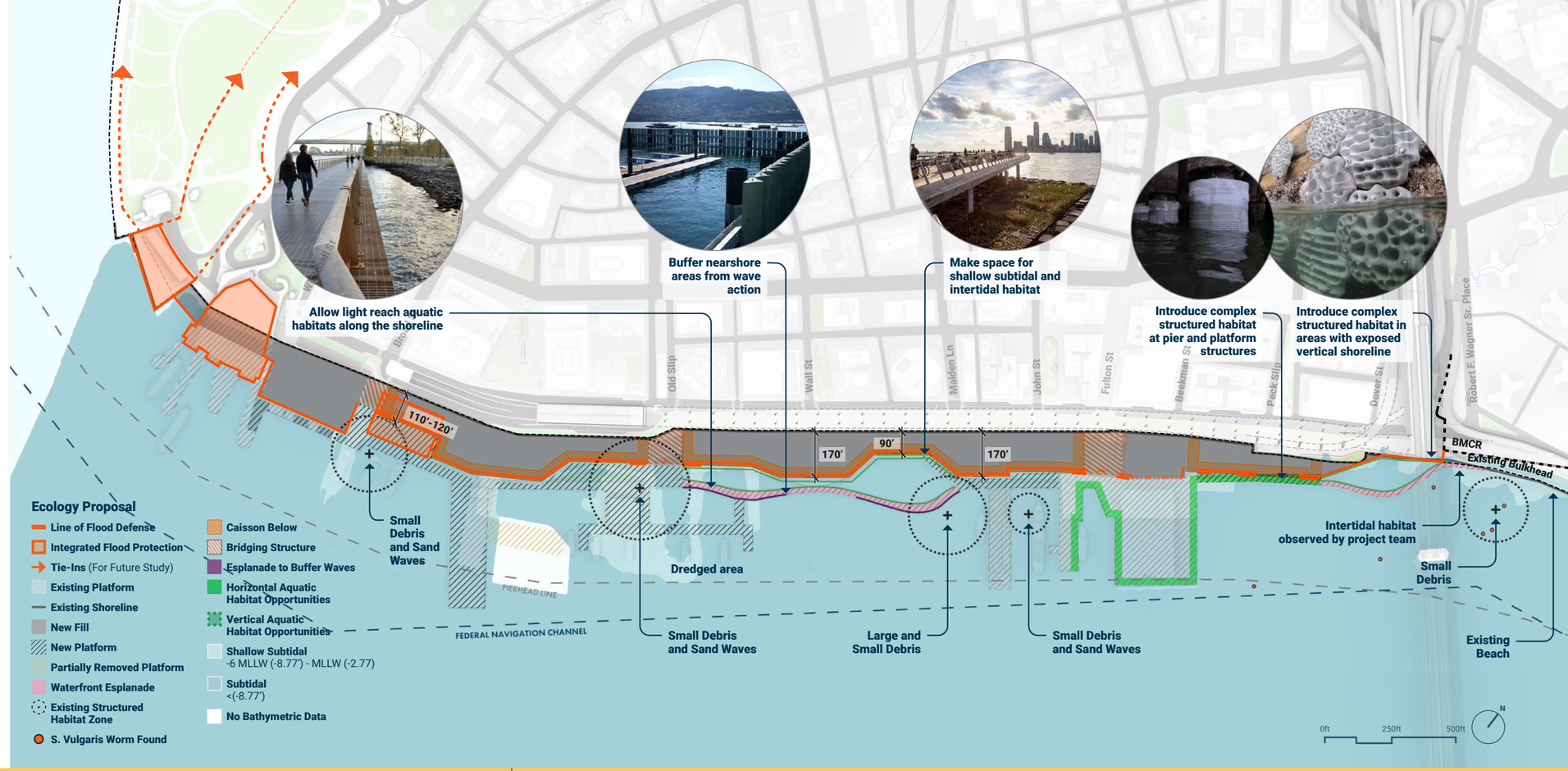
Ecology Proposal

Strategies to Protect and Preserve

- **Avoid or minimize fill**, by ensuring the in-water footprint is driven by the need to construct coastal flood defense and accomplish the goals of the master plan
- **Minimize the in-water footprint**, where there is rare intertidal habitat near the Brooklyn Bridge

Strategies to Enhance

- **Introduce complex structured habitats** in locations with an exposed vertical shoreline provided by new bulkhead, seawall, and caisson edges for fish and other aquatic organisms. On pier and platform structures, pile enhancements or hanging structures can be installed to provide additional structured habit for aquatic species
- **Make space for shallow subtidal and intertidal habitats** in the cove between Wall Street and Maiden Lane by modifying a narrow portion of the caisson edge to create a planted shelf. This provides space and structures for a variety of aquatic habitats to form as sea levels rise
- **Allow light to reach aquatic habitats** along the shoreline by separating the waterfront esplanade from the shoreline
- **Buffer nearshore areas from wave action** by integrating wave screens into the coves. Between Wall Street and Maiden Lane, the buffered area can potentially support other habitat enhancements that would further buffer the shelf from wave energy and provide habitat for aquatic species
- **Create space for active recreation and stewardship** by incorporating get-downs along the waterfront esplanade to bring people closer to the water and enable educational programs adjacent to the coves

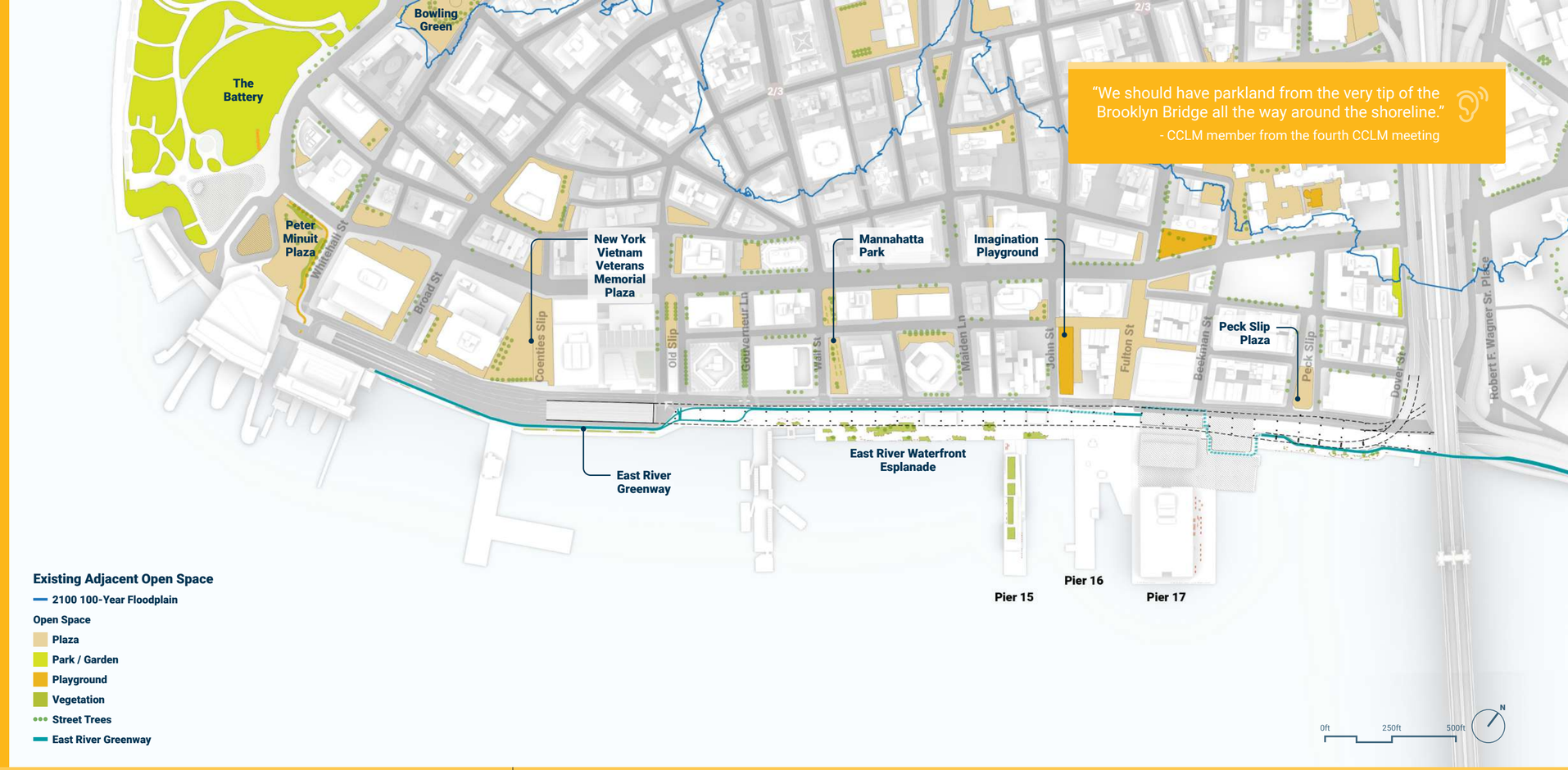


Public Open Spaces and Public-Serving Uses

The master plan creates enough new space along the Financial District and Seaport waterfront to replace and enhance the public destinations people use today with new, additional open spaces and community programming.

Technical Analysis

To inform the design, the project team documented every feature of the existing waterfront and asked community members what they hope to see along the waterfront in the future. Based on these inputs, the project team tested a wide variety of open space typologies and public serving uses to assess what could work in the study area. The project team found that most of the community's ideas—including new open and green spaces, recreational spaces, restaurants, and community centers—can be integrated into the master plan. However, larger recreational opportunities such as full-scale soccer fields are unlikely to fit in the study area. The project team also tested residential and large-scale commercial uses and found that the master plan's footprint significantly limits the viability of these uses.



Design Proposal

The master plan proposes four distinct areas for open spaces and public serving uses. Each area has unique opportunities and limitations, as described below.

1. Uses **inland of the flood defense infrastructure** are most directly accessible to nearby neighborhoods and can be nestled into ramps, stairs, and sloped green spaces.
2. Uses **on the upper level, or above the flood defense**, can take advantage of new elevated views of the East River. However, deep-rooted trees are not feasible here, as they could compromise the effectiveness of the flood defense.
3. The **waterfront esplanade** is designed to withstand temporary flooding from coastal storms. While this limits the types of uses, sturdier elements, like built-in seating and get-downs that bring people closer to the water, can help activate the esplanade.
4. **Piers 15 and 16**, which are well-used today, can provide similar public-serving uses once reconstructed to a higher elevation. **Pier 17's existing esplanade**, open space, and dining and beverage establishments will remain in place since the pier is elevated high enough to avoid future tidal flooding.

The images to the right represent other projects as examples of the types of open space that could be integrated along this waterfront.

Overall, the master plan replaces and enhances the types of public destinations that are available today, including seating with river views, dining and drinking establishments, and a dog run, while incorporating opportunities to introduce new open spaces and public serving uses. It also increases the amount of open and green space compared to today. The master plan does not propose any residential or large-scale commercial development. The City will continue to collaborate with the community to design open space that best meets neighborhood and citywide needs.

City-Facing Uses

Landscaped Walkways example at Brooklyn Botanic Garden (Photo Credit: Barrett Doherty)

Multi-level Playground example at Teardrop Park
(Photo Credit: Michael Van Valkenburgh Associates)

Upper-Level Uses

Elevated Café example at Brooklyn Bridge Park (Photo Credit: William Pevear Architects)

Sloped Lawns example at Hunter's Point South (Photo Credit: NYCEDC)

Esplanade Uses

Separated Esplanade example at East River Park (Photo Credit: Nathan Kensinger)

Oyster Restoration Stations example at Brooklyn Waterfront on East River
(Photo Credit: Billion Oyster Project)

Shaping a Resilient 21st Century Waterfront

What Could This Resilient Waterfront Look and Feel Like?

The master plan reflects the layering and weaving together of multiple goals, the push and pull of numerous trade-offs, and feedback from neighborhood and citywide community members and organizations. This master plan brings seemingly disparate systems—flood defense, drainage infrastructure, resilient maritime assets, access and connectivity, ecology, and public open space—together, and weaves them into a cohesive whole. The proposed flood defense will also improve the waterfront experience by enhancing connections to the water, providing new public amenities and open spaces, bringing people closer to natural systems, and creating new elevated views of the East River.

The master plan proposes a collection of diverse and captivating experiences unlike anywhere else along the City's waterfront. By providing a variety of urban and waterfront experiences, this conceptual design is welcoming to nearby residents, commuters, and visitors alike. While the illustrations that follow depict what the waterfront experience could be like in the future, this master plan does not present a fixed and final design.

Moving south to north, the following illustrations show what walking along the future resilient waterfront from The Battery to the Brooklyn Bridge could look like. From the Vietnam Veterans Memorial Plaza at Broad Street to the South Street Seaport at Peck Slip, people of all ages and abilities can engage with a series of multi-level open spaces, maritime activities, and a waterfront esplanade that brings people close to the water. This waterfront will provide new 360-degree views out towards the East River, as well as back into the Financial District and Seaport neighborhoods.

Waterfront Entrances

Beginning across South Street near the Vietnam Veterans Memorial, the proposed entryway to the waterfront embraces a multi-layered landscape that integrates not only circulation paths up to the ridge, but also indoor and outdoor amenities like kiosks, lawns, and seating. This entryway to the area features gently sloped pathways that are universally accessible, as well as complementary stairs and elevators. By providing a variety of experiences atop the floodwall buried under the landscape, this entryway guides people through a dynamic landscape that welcomes, rather than walls off, people from the water.

Once atop the ridge, people are greeted with expansive views of the East River. These elevated vantage points provide views of the Brooklyn Bridge to the north and a bustling ferry terminal to the south. Along the upper ridge, open spaces include plazas, lawns, and neighborhood-oriented spaces like cafes, restaurants, and comfort stations.

Looking down from the ridge, visitors get a glimpse of the waterfront esplanade, which takes them further out into the East River. This esplanade connects people to piers and ferries, providing unique experiences to get closer to the water. Paths to get down to the esplanade are intentionally located to help visitors clearly see their destination from the ridge and intuitively know which direction to go to get down to destinations along the esplanade.

Site Plan

View Looking North near Vietnam Veterans Memorial Plaza

Accessible slopes and stairs provide ease of access to the waterfront at key corridors

Planting and vegetation increase permeability and help with stormwater management

Small buildings, planted slopes, and a variety of conditions provide an active and dynamic street edge along South Street and the greenway

CAFE

"The master plan should include running, biking, dog walking, and recreational uses."

- Participant from the third open house

View Looking North towards Old Slip

Destinations along the waterfront are clearly visible from the upper level

Open space including lawns, plazas, planting, and seating are integrated into the upper level

New resilient ferry terminals allow for future maritime expansion

"Seating and gym equipment should be facing the water."

- Participant from the third open house

Pine Street Cove Looking North

Site Plan

"Pier 11 steps down and you can put your feet in the water. More connections like this are needed."

- Participant from the third open house

Integration with the Seaport

Moving into the South Street Seaport Historic District, the following renderings illustrate how the master plan seamlessly integrates into the existing fabric of this neighborhood and is easily accessible from the city.

Looking down from the rooftop of Pier 17 facing south, one sees how the deployable floodgate at Fulton Street remains open during normal weather conditions, creating an opening in the ridge for direct visual and physical access to the waterfront. Exiting the waterfront from the Seaport, visitors can cross directly into the upland neighborhood, or meander up accessible ramps that provide access to new upper-level spaces with expansive views of historic ships along the waterfront. Small buildings, plazas, and lawns further activate the open space across the upper level. Even while integrating flood defense along the waterfront, this master plan maintains direct physical and visual access to the waterfront. Such access creates a vibrant and interwoven South Street corridor connecting back to the upland neighborhood.

Near Fulton Street, city-facing spaces behind the flood defense serve the community and are well-suited for placing equipment, one- and two-story buildings, and other amenities. These multi-level spaces within the slopes accommodate community assets such as playgrounds, climbing walls, and gardens while small buildings in this area activate the edge of South Street and provide indoor community spaces, comfort stations, and restaurants or cafes. These indoor and outdoor spaces are interwoven with planted landscapes to increase vegetation and shading across the study area, as well as extend the liveliness and urban character of the Seaport into the city-facing portions of the waterfront.

Site Plan

View Looking South from Pier 17

Docks for historic vessels remain and are integrated into the waterfront experience

Small buildings, plazas, and lawns activate the open space across the upper level

Pathways from the waterfront esplanade and slopes along South Street help visitors navigate to upper-level spaces

Floodgates remain open and provide direct physical and visual access to the water, closing only in the event of a coastal storm

"Play up the maritime character with wharf-like detailing and nautical playgrounds"

- Participant from the third open house

Fulton Street Waterfront Entrance

Site Plan

"This waterfront needs active recreation, green space, parks for different ages, and rest areas for the elderly."

- Participant from the third open house

Peck Slip with FDR Drive Viaduct

"The narrow streets with brick paths in the Financial District and Seaport are great for wayfinding. This adds to the character of the area. We must preserve this."

- Participant from the third open house

Peck Slip with Reimagined FDR Drive Viaduct

Highlights of the Design Proposal

Protect Lower Manhattan from tidal flooding and coastal storms by

Building a primarily passive system of flood defense infrastructure, including two design levels:

- A **raised shoreline** three to five feet higher than the esplanade today to protect against daily tidal flooding
- **Buried and exposed floodwalls** 15 to 18 feet higher than the esplanade today with **floodgates** in select locations to protect against coastal storms

Building new drainage infrastructure to manage stormwater behind the flood defense, including:

- A new **pump station** to push stormwater out against high tides and coastal storm surges
- **Green infrastructure**, such as bioswales and permeable pavement, to help manage stormwater during smaller rain events

Integrate climate resilience infrastructure into the city by

Constructing new resilient maritime facilities to support ferries, historic ships, and other waterfront operations, including:

- Rebuilding the **ferry terminals** and the heliport to higher resiliency standards and with improved operational efficiencies
- Protecting the historic **Battery Maritime Building** while building a **new ferry terminal** directly to the north **for Governors Island ferry and other services**
- Rebuilding **Piers 15 and 16** to higher elevations with similar appearances and uses as today
- Designing the waterfront esplanade as a **flexible maritime edge** for vessel mooring

Ensuring universal accessibility, continuous bike connections, and direct emergency vehicular access, including:

- Creating expansive **gateway and ramped entrances** to the waterfront
- Prioritizing a dedicated two-way **bike path** along South Street to continue the Manhattan Waterfront Greenway
- Providing **emergency vehicles** with enough space to make the waterfront safe while **designing for pedestrian safety**

Limiting impacts to the East River's ecology while enhancing aquatic habitats where possible, including:

- **Avoiding or minimizing fill and platforms** where possible, especially in areas with rare aquatic habitats
- Introducing **opportunities** along the shoreline for protected coves and new aquatic habitats
- Creating space for **active recreation and stewardship** to bring people closer to the water and teach New Yorkers about the East River

Enhance the public waterfront by

Preserving and improving existing public destinations, including:

- Holding space to replace all the **public-serving uses along the waterfront**, like the public esplanade, seating with river views, eating establishments, and a dog run
- **Expanding the amount of public open space and green space** compared to today

Creating multi-level waterfront open spaces, including:

- **Open spaces inland of the flood defense infrastructure** that are directly accessible to nearby neighborhoods and nestled into ramps, stairs, and sloped green spaces
- **Open spaces on the upper level**, above the flood defense infrastructure, with new elevated views of the East River
- A **waterfront esplanade**, designed to safely flood during a coastal storm, brings people close to the water itself and to maritime destinations

Providing community-serving uses, including:

- **Outdoor recreation spaces** like sports courts, gardens, playgrounds, and more
- **Indoor spaces** like comfort stations, community centers, and food establishments

Illustration of how the buried floodwall and floodgates would protect Lower Manhattan during a coastal storm

Illustration of how the master plan could enhance aquatic habitats

Illustration of how the master plan could host new types of public serving uses

Bird's-Eye View Facing South
Illustration of what a resilient waterfront could look like in the future

Sources

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Notes

i. Further south in the study area, near The Battery, the DFE is +26 feet NAVD88 as a result of even greater wave action.

ii. Based on National Oceanic and Atmospheric Administration (NOAA) Atlas 14

iii. All primary paths should be no steeper than 5%.

Chapter Six

Implementation Roadmap

"After learning about how climate change will impact Lower Manhattan, I am most concerned about the rate at which action will be taken versus the rate at which climate change is acting."

- Participant from the first open house

Construction of Belt Parkway Bridge in Gerritsen Beach, Brooklyn (Photo Credit: Arcadis)

Overview

Acting with Urgency

The *Financial District and Seaport Climate Resilience Master Plan* sets forth a bold vision for a 21st-century resilient waterfront that will protect the Financial District and Seaport neighborhoods and the functions they provide for the entire city and region. To realize this master plan, the City needs to advance an extensive regulatory and permitting process with multiple local, state, and federal agencies, secure funding, and construct a project of monumental scale and complexity.

This master plan will take 15 to 20 years to design, secure approvals, and build; the time to act is now. With full funding and alignment with key regulatory agencies, the flood defense could be in place by 2035. With frequent tidal flooding expected as soon as the 2040s, this leaves little room for delay. Without action, infrastructure that serves all New Yorkers will be at risk. Businesses and residents may begin to question the viability of remaining in Lower Manhattan under worsening climate change impacts.

Permitting and Approvals

Securing the required regulatory permits and approvals is a critical milestone for implementing the master plan. After undergoing an environmental impact review, which assesses potential significant environmental impacts and possible alternatives, the master plan will require permits and approvals from local, state, and federal regulatory agencies. Notably, extensions of the shoreline into the East River will require permits from the US Army Corps of Engineers (USACE) and the New York State Department of Environmental Conservation (NYSDEC).

Constructing the Master Plan

Fully building the proposed flood defense infrastructure will involve a complex design, permitting, and construction process. Balancing costs, executing timely construction, and ensuring continuity of critical maritime operations along the waterfront will be essential to implementing the master plan. The plan will also have to remain flexible to different streams of funding which could advance portions of the master plan.

Funding and Financing

Funding the master plan will require significant government investment. As part of the master plan process, the project team looked at a wide range of funding solutions and found that no single source will be sufficient to cover the estimated five to seven billion dollars in capital costs. In addition to considering established sources for resilience projects, such as federal grants and City capital, the project team studied potential new funding opportunities from federal infrastructure legislation to city- or state-level surcharges or fees, and other local sources of funding. Introducing new funding streams could help catalyze citywide resilience investments, but each new opportunity also has unique constraints that could affect its viability.

The City will also need to identify additional sources to cover ongoing operations and maintenance (O&M) costs for the new infrastructure over the long-term—currently estimated as an additional $30 million a year.

Governance

Governance, or the manner in which the new infrastructure will be managed, operated, and maintained, can take many forms depending on specific needs. The master plan could be implemented by existing government agencies or by a new entity.

The entity or entities responsible for implementing the master plan will need to be flexible in responding to changing needs over time. They will have to shepherd the master plan through design, permitting, and construction; identify and secure funding; manage financing; and oversee long-term maintenance and operations. Given the challenges of both obtaining approvals and covering the substantial costs, the entity may also need to advocate for new policies or legislation to facilitate implementation.

Permitting and Approvals

Overview

As the master plan progresses toward implementation, it will undergo several local, state, and federal reviews and approvals. This understanding is based on the current design proposal, existing historic resources, and likely potential environmental impacts. Throughout the review and approvals processes, there will be multiple opportunities for the public to participate, offer feedback, and stay informed.

Technical Analysis

To better understand the regulatory approvals needed to construct the master plan, the project team studied the anticipated approval processes and is coordinating closely with local, state, and federal agencies. The list of actions studied is not exhaustive and further consideration will be needed as the master plan advances towards implementation.

Environmental Review

The proposed master plan will undergo an environmental impact review pursuant to the National Environmental Policy Act (NEPA), State Environmental Quality Review Act (SEQRA), and City Environmental Quality Review (CEQR). The environmental review process will involve analyses of potential environmental impacts, alternatives, and options to mitigate any identified significant adverse impacts.

State and Federal Approvals

As conceived, implementation of the master plan will require several state and federal permits. This includes from USACE, pursuant to Section 10 of the Rivers and Harbors Act of 1899 and Section 404 of the Clean Water Act; from New York State Department of Environmental Conservation (NYSDEC), pursuant to the State's Tidal Wetlands and Protection of Waters Act; and a federal consistency determination in accordance with the federal Coastal Zone Management Act from the New York State Department of State (NYS DOS) Coastal Management Program.

What is the Aquatic Resources Advisory Committee?

Given the complexity associated with implementing a plan of this scale, the City took a proactive approach to permitting and protection of aquatic resources starting early in the master plan process. The USACE, as a key regulator overseeing in-water construction, recognized the importance of the master plan and agreed to convene a series of working sessions with relevant regulatory agencies to advise the project team on permitting considerations for any work proposed in the East River. The USACE Regulatory Branch of the New York District convened and chaired the Aquatic Resources Advisory Committee (ARAC) for the master plan process. The ARAC includes NYSDEC, the NYS DOS, the National Marine Fisheries Service, and the United States Coast Guard.

How did Regulatory Feedback Shape the Master Plan?

By engaging with regulators early and often, the project team worked to ensure that feedback from state and federal agencies helped to shape the master plan.

The City met with the ARAC seven times beginning in 2020 to present various iterations of the master plan conceptual design, incorporating the ARAC's feedback as the design progressed. Topics discussed included:

- Overview of Master Plan Goals ("Purpose & Need")
- Essential Fish Habitat - Sampling & Testing Plan
- Development and Refinement of the Master Plan
- Proposed Conceptual Design

Early in the master plan process, the ARAC recommended that the City embark on one year of sampling and testing in the East River to understand current ecological conditions. This will inform the future assessment of potential adverse environmental impacts of the master plan. Completing this year of sampling and testing was important because there is limited existing information characterizing the species and habitats in the East River and the little information available is dated.

The findings from the sampling and testing program were shared with the ARAC and informed the development of the master plan. The findings will also inform the future assessment of potential adverse environmental impacts of the master plan.

Over the course of multiple meetings, the ARAC emphasized the regulatory obligation of avoiding fill in the East River to the maximum extent practicable, minimizing fill when avoidance cannot be achieved, and mitigating any impacts from such fill. The ARAC also provided additional feedback to help refine the approach and design. **After extensive presentation of materials, the ARAC heard the challenge of constructing the flood defense infrastructure on land and the possible need to extend the shoreline into the East River to construct flood defense infrastructure.** However, the ARAC simultaneously continues to stress the need to reduce fill and over water structures. This challenged the City to think creatively about how to balance the master plan's goals of simultaneously providing flood defense, maintaining maritime and water-dependent uses, and ensuring universal waterfront accessibility, all while minimizing impacts to aquatic ecosystems and navigation of ferries and vessels in the East River. The City is continuing to work collaboratively with ARAC members to further advance and refine the design and develop appropriate mitigation strategies.

City and State Approvals

Numerous City and state agency approvals relating to safety, access, construction, and land use will be required. Throughout the planning process, the City met with agency partners to understand how existing regulations and policies will influence implementation of the plan.

What City and State Approvals need to be Considered as a Part of the Master Plan?

- The study area is subject to the Waterfront Revitalization Program administered by NYC Department of City Planning, which establishes the City's policies for development and use of the waterfront and provides a framework for evaluating activities proposed in the coastal zone.
- Changes to the waterfront will necessitate permits from NYC Department of Small Business Services, which has jurisdiction over all city-owned waterfront property and all structures on private waterfront property dedicated to maritime uses.
- Permits will be required from NYC Department of Sanitation to conduct any fill material operations on underwater land.
- Any changes or impacts to the historic resources in the study area, including the Battery Maritime Building, the South Street Seaport Historic District, and The Battery, will require review and approval by NYC Landmarks Preservation Commission and the State Historic Preservation Office.
- As the City's design review agency, NYC Public Design Commission has jurisdiction over permanent structures, landscape architecture, and art proposed on or over City-owned property. It will therefore review and approve the design of the master plan.
- Several elements of the proposed design may trigger public land use review. These include alterations to the City Map due to changes in street grade, site selection for a pump station, acquisition, landfill, and waterfront zoning.
- There are also complex and interrelated jurisdictional considerations for the properties along this waterfront, which will require ongoing coordination across City, state, and federal agencies.

Recommendation and Next Steps

Ongoing Coordination

Projects that build significantly into the water are rare within the current regulatory environment but are likely to become more common with the increasing threats posed by climate change. Given the complexity associated with implementing a master plan of this scale, the City has been engaging and meeting with key regulatory agencies to identify a viable path for permitting. The City will continue to consult with local, state, and federal agencies on the design, funding, phasing, and permitting of the master plan. Additionally, there will be ongoing jurisdictional coordination between federal, state, and City entities.

Additional Sampling and Testing

To better understand existing aquatic resources within the study area, and to complete the baseline aquatic sampling and testing that will be required for future permit applications, the City recently commenced a second year of aquatic sampling at the time of writing. Two to three years of sampling and testing will be required to develop a baseline understanding of the aquatic environment, ahead of obtaining any necessary permits.

Identification of Mitigation Opportunities

Mitigating potential adverse environmental impacts associated with creating a new resilient waterfront will be an important consideration as the implementation of the master plan moves forward. A mitigation strategy will need to be developed to compensate for impacts on habitat caused by the proposed new landfill and over-water structures in the East River. This will involve looking for opportunities to create or improve habitat in locations around New York Harbor (e.g., restoring tidal wetlands) or removing overwater platforms or fill. The City will collaborate with the relevant regulatory agencies and key stakeholders to identify mitigation opportunities.

A member of the project team rinses a sample collected from the bottom of the East River to look for aquatic invertebrates (Photo Credit: Normandeau Associates)

A sample of sediment from the bottom of the East River
(Photo Credit: Normandeau Associates)

Members of the project team use a beach seine to sample fish along the shoreline
(Photo Credit: Normandeau Associates)

A member of the project team looking for fish as part of the sampling program
(Photo Credit: Normandeau Associates)

A member of the project team preparing fish traps to be set in the East River as part of the sampling program (Photo Credit: Normandeau Associates)

Constructing the Master Plan

Overview

Successfully constructing the proposed infrastructure requires the City to balance construction timelines and obstacles that could slow down implementation with the increasing impacts of climate change. The construction timeline is driven by the core infrastructure components of the master plan, accounting for continuity of critical maritime operations, especially passenger ferry service. The project team also considered how the project may be divided into smaller phases to respond to funding opportunities.

Technical Analysis

To develop a strategy around construction and phasing, the project team asked the following questions:

1. When will climate change impact different parts of the study area?
2. What are the core engineering considerations for construction?
3. How could the master plan be implemented in phases?

When will Climate Change Impact Different Parts of the Study Area?

The pace of climate change requires the City to act now to ensure that flood defense infrastructure is in place before impacts become more frequent. The primary impacts of climate change that the City needs to address include:

- **Sea level rise:** By the 2040s, high tides will begin to frequently flood the waterfront due to sea level rise. By the 2050s tidal flooding will be monthly and, by the 2080s, daily. Passive flood defense will need to be in place by the 2040s to keep this area functional, operational, and safe for New Yorkers.
- **Coastal storms:** Coastal storms are already impacting the waterfront. The sooner the flood defense system is built, the less damage the city and community will incur. By the 2050s, the cost of inaction from coastal flooding combined with sea level rise is estimated to be over one billion dollars per year.[i]
- **Extreme precipitation:** Recent storms, like Tropical Storm Henri and Hurricane Ida, illustrated the potential damage of heavy rainfall. With a larger percentage of precipitation coming in the form of intense single-day events, constructing drainage improvements in earlier phases of the master plan could help minimize flooding and damage.

What are the Core Engineering and Operational Considerations for Construction?

The construction timeline will need to balance the speed of construction with some level of continuity of operations along the waterfront. This includes:

Some parts of the infrastructure need to be built in a particular order. First, the base flood defense infrastructure needs to be built before anything can be built on top. This includes enclosing a portion of the East River with concrete caissons, filling behind the new structures with clean fill, and carefully placing bridging structures over subway tunnels, where necessary. Once the caissons and clean fill are in place, the new ground can be prepared to build floodwalls and floodgates on top. Then new open space, landscaping, seating, and other features can be integrated.

Some materials will take a long time to get to the study area. Given the large quantity of materials needed, like clean fill, and the custom nature of some of the project elements, like the caissons and floodgates, material availability and delivery timelines need to be considered. This may include multiple barge deliveries per week. An off-site staging area will also be needed for materials and equipment, and workers may need to access the study area from the water.

Critical services along the waterfront need to remain viable during construction. Maintaining access to the services offered by the ferry terminals in the area will drive the construction schedule. To minimize disruption to commuters, all ferry terminals cannot be reconstructed and out of service at the same time. This means taking a phased approach to the maritime facilities, including Whitehall Ferry Terminal, Battery Maritime Building, and Pier 11. Either new or temporary facilities need to be constructed before work begins on the Battery Maritime Building and Whitehall Ferry Terminal to ensure some level of continuity of ferry service.

How Can the Proposed Infrastructure be Constructed Sustainably?

Construction is a resource-intensive activity that generates greenhouse gas emissions. The building and construction sectors account for nearly 40-percent of global emissions[1] while construction and demolition debris accounts for over twice as much solid waste created in the U.S. as waste from households and businesses.[2] By prioritizing sustainable construction methodologies, the master plan has the opportunity to set a precedent for how New York City can meet the dual goals of mitigating the causes of climate change while protecting against its impacts. One way of doing this is to assess the greenhouse gases that are emitted during the entire "life-cycle" of the project—including those from materials as well as in construction itself. Construction impacts can be minimized through a variety of strategies:

- Using recycled materials, including post-consumer recycled content and post-industrial recycled content
- Minimizing waste through construction best practices, including guidelines from the NYC Department of Design & Construction
- Using materials that meet standards for life-cycle assessment (or an assessment of the carbon footprint of the production and use of material) from the Leadership in Energy and Environmental Design (LEED) program for structures in the project and from the Envision certification for infrastructure components

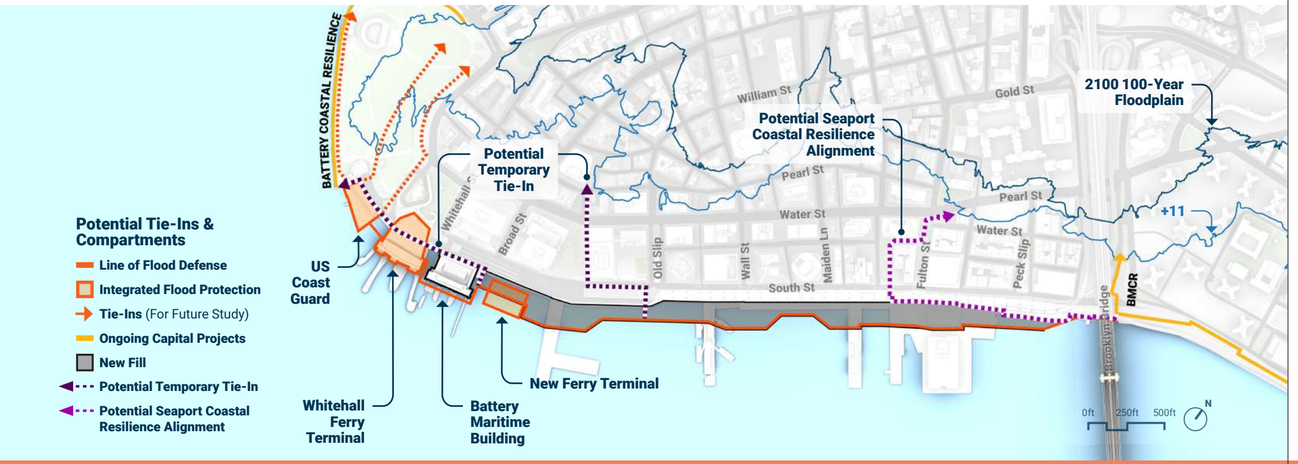
How Could the Master Plan be Implemented in Phases?

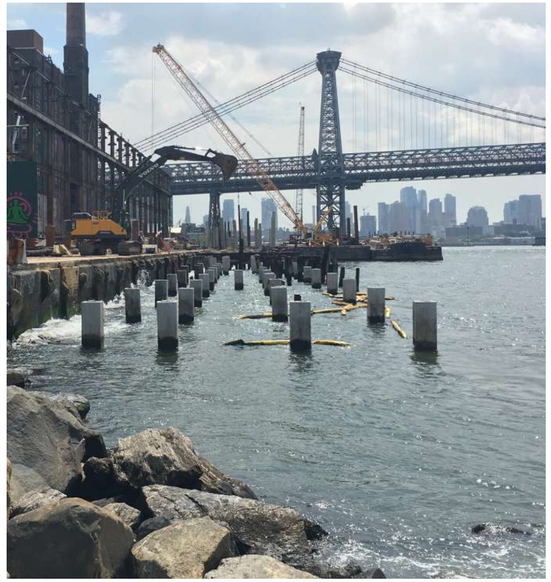
When considering how to divide the master plan into phases for implementation, it was imperative that each phase identified provides some level of protection without relying on another unfinished component. This is known as independent utility.

A key component of independent utility for a flood defense system is constructing tie-ins to high ground, ensuring that flooding does not go around the flood defense system. The overall master plan proposes to tie-in to high ground through The Battery to the south and BMCR to the north. However, with a phased approach to construction, additional temporary tie-ins would be needed to provide independent utility. Since the ground in this area is very low-lying, tying into high ground will be challenging and will require careful consideration of how to integrate this new infrastructure into the existing urban fabric, including streets, plazas, parks, and underground utilities over many blocks.

Although constructing tie-ins is challenging, it could enable the master plan to be realized in phases rather than all at once. For example, if the base infrastructure—the caissons and clean fill—is constructed from the Battery Maritime Building to Pier 17, temporary tie-ins could protect the full study area from future tidal flooding before the complete defense against coastal storms is built out.

Constructing the base infrastructure first would also provide greater flexibility for continuity of maritime operations. For example, a new ferry terminal is proposed just north of the Battery Maritime Building; if the caissons and fill are built earlier in this area, then the new terminal could be constructed and serve as a temporary location for ferry service while other terminals are under construction.





Construction of the Domino waterfront park in Williamsburg, Brooklyn (Photo Credit: Arcadis)

How Quickly Could the Master Plan Infrastructure Be Built?

Assuming full funding and prioritization by key regulatory agencies, the master plan could be completed in 15 to 20 years. This includes the time it takes to complete the final design and environmental review, as well as permitting and construction. To implement the master plan within this timeframe, much of the Financial District and Seaport waterfront would need to be under construction at the same time, and some services will need to be temporarily relocated within the study area. With funding limitations and/or regulatory hurdles, construction could take longer to complete in its entirety.

Recommendations and Next Steps

The critical next step is advancing the design of the master plan to a level sufficient to begin the environmental review and permitting processes. As the master plan advances toward implementation, additional engineering, design, and analysis will be required to develop a phasing and construction plan that balances the speed of construction with continuity of operations along the waterfront. Throughout the process, there will be multiple opportunities for the public to participate, offer feedback, and stay informed.

Funding and Financing

Overview

Implementing this master plan to protect Lower Manhattan will require significant funding to pay for both the upfront capital cost of construction and the ongoing cost of operations and maintenance (O&M). **A combination of multiple funding sources will be needed, including potential new funding approaches and substantial investment of public funds.**

The project team estimated that the capital costs for construction will range from approximately five to seven billion dollars.[ii] The flood defense infrastructure as well as new public amenities, such as increased open space and promenades, will also have new O&M requirements and costs. O&M costs will vary over time as phases of the master plan are built, as elements age and require additional maintenance, and as the increasing frequency of extreme storms requires deployment of floodgates. Today's O&M costs also need to be considered as maintaining existing piers and bulkheads is already factored into the City's budget and will only continue to increase over time with sea level rise and aging infrastructure costs. With this understanding, O&M costs are estimated to be, on average, an additional $30 million annually (in 2021 dollars) above existing waterfront maintenance costs. Cost ranges – for both capital and O&M – are estimated using a combination of information from precedent projects and bottom-up estimating based on quantities of specific master plan elements. This high level of cost estimating provides a useful snapshot to help plan for implementation, but can vary considerably given the early stage of design.[iii]

The magnitude of the master plan calls for a funding strategy that considers a broad mix of local, state, and federal sources. While the City can contribute capital and expense funding, the project team analyzed funding strategies that would limit the need for direct contribution from the City's general fund and identified sources that could make a sizable contribution to the capital and/or O&M costs. The City is actively advocating for new federal funding to support resilience projects across New York City and will continue to explore and pursue additional sources of funding.

What Drives the Costs of the Master Plan?

Implementing this master plan requires construction of large, new infrastructure systems in locations that are challenging for construction. The costs are primarily driven by the core infrastructure needed to construct the flood defense system, including clean fill and structural elements such as caissons, floodwalls, and floodgates. New drainage infrastructure will also be needed, including a pump station, additional sewer pipes and green infrastructure. Another main cost driver is the partial or full reconstruction of multiple maritime facilities across the shoreline to ensure their resiliency and provide integrated flood protection to complete the line of defense.

The project team estimated capital costs using a combination of approaches based on precedents from around the region. For some project elements, such as a new ferry terminal, where the size and design are less certain, the estimates were more approximate than for other elements, such as pier reconstruction, where more detailed cost per square foot estimates were used. *While it will be expensive to implement the master plan, the cost of doing nothing is far greater.*

Technical Analysis

What Are the Potential Funding Sources for the Master Plan?

The project team undertook a four-step process, detailed below, to analyze and identify potential funding sources.

1. Broad survey of potential funding sources
2. Screening of potential sources
3. Shortlist of sources for additional analysis and community outreach
4. Refinement of analysis

The first step was a broad survey of potential funding sources based on national and international precedents for projects of a similar type and scale. This informed a set of key evaluation criteria (see Table 1) that provided a framework for screening potential funding sources.

Table 1. Evaluation Criteria for Potential Funding Sources

Category	Criterion	Questions for Evaluation
Financial Feasibility	Viability	How likely is the City to receive funding from this source if it is pursued?
	Size	Is the amount of funds sufficiently large to justify the associated effort?
	Timing	Would the funds be available when needed?
	Predictability	Are funding streams from this source likely to be stable or volatile over time?
Implementation Feasibility	Legal	Does this source require new processes and/or legislation to establish?
	Other	Will this source be difficult to implement for additional technical reasons?
Equity	Fairness	Does this source avoid placing disproportionate burden on low-income or disadvantaged populations?
	Project Nexus	Is there alignment between those who benefit and those who bear the costs?

Based on the screening exercise, the project team created a shortlist of the most viable funding sources for further analysis (see Table 2) and conducted outreach, which included meetings, workshops, and a panel discussion with community members, as well as thought leaders to solicit feedback. The final part of the process was refining the analysis by testing preliminary scenarios to understand the amount each source could potentially contribute to the proposed master plan.

What Can Each Funding Source Contribute?

Given the scale of the proposed master plan and the investment needed, a broad mix of funding sources will likely be required, each presenting its own opportunities and challenges. For example, state and federal grants may only be applicable to specific elements of the project, such as flood defense or transportation facilities, and some sources can only be used to pay for capital costs, not ongoing O&M.

Furthermore, different funding sources may become available at different times. For example, federal grants will not be immediately available due to the extensive requirements of application processes, which generally necessitate design at the schematic level to perform the required benefit-cost analyses. Similarly, potential new funding sources, such as a resilience assessment, would require legislative action prior to implementation. Where there is a mismatch between when funds are available and when the relevant costs will be incurred, the City may also consider financing a portion of the project based on future streams of revenue. For example, where a funding source provides an annual revenue stream over many years, the City or a governance entity could issue bonds against the expected revenue to produce a larger upfront amount that could be used to pay for capital costs. However, issuing bonds would increase the overall project costs due to interest payments and other financing considerations.

Table 2. Funding Sources Analyzed[iv]

	Funding Source	Opportunities	Challenges	Potential $ Amount[v]	Eligible Costs
Existing Funding Sources	US Army Corps of Engineers (USACE) Civil Works Program	Represents one of the largest sources of funding, with potential to fund **up to 65% of the flood defense infrastructure.**	Requires an extensive process, including congressional approval and appropriations. Will impact local control over design and timing.	Up to $3 billion	Capital
	Federal Emergency Management Agency (FEMA) Programs	There are several grant programs including the Building Resilient Infrastructure Communities (BRIC) and the Hazard Mitigation Grants Program (HMGP).	Grants are highly competitive and have funding caps that are small for a project of this scale.	Typically up to $50 million per grant	Capital
	Capital Investment Grant	Federal Transit Administration grant program that could fund **up to 60 - 80% of eligible transportation costs** related to ferry infrastructure.	Program is highly competitive, with limited precedents for ferry projects.	Up to $200 million	Capital
	Infrastructure for Rebuilding America and Rebuilding American Infrastructure with Sustainability and Equity Grants	Long-standing federal surface transportation grant programs, with a new focus in 2021 to address climate risk and environmental justice.	Both programs are highly competitive. Funding contributions are limited to transportation work.	Up to $160 million	Capital
New Funding Sources Studied	New York State Environmental Bond Act	The Bond Act would introduce a potential **new source of funding for resilience-focused projects.**	Pending voter approval in 2022.	TBD	Capital
	Insurance Surcharge	Size of contribution dependent on the insurance surcharge rate and assessed lines of insurance policies.	A state-level implementation and allocation mechanism needed.	Estimated $31 million annual revenue in 2021 dollars	Capital or O&M
	Resilience Assessment	Size of contribution dependent on the resilience assessment structure and the geographic area in which it is applied.	Many Lower Manhattan commercial property owners already pay special assessments to the local business improvement district; need to consider impact on businesses, particularly locally owned small businesses. Requires state legislation to establish and is untested in U.S.	Estimated $30 million annual revenue in 2021 dollars	Capital or O&M
	Revenue from new development (residential, office)	Not included in the master plan due to public feedback, space constraints, and permitting challenges	Revenue estimates are highly dependent on multiple assumptions, including size and use of buildings, timing, and market demand.	Variable	Capital or O&M

Recommendation and Next Steps

This master plan requires a broad mix of local, state, and federal sources to enable a stream of funds that can cover costs of construction and long-term O&M. As project planning and design advance, the City will continue to monitor and explore new funding sources and further develop the overall funding strategy.

The federal government is a potential major source of funding for the master plan and the City will continue to pursue all avenues to federal funding, including:

- Continuing to engage with USACE regarding potential opportunities through ongoing studies in the region
- Pursuing FEMA grants to provide additional funding for project planning and construction of initial projects
- Continuing to evaluate federal transportation grants as revenue sources for ferry-, bike-, and highway-related project elements with input from state and City transportation agencies
- Advocating for additional federal resilience infrastructure investments to increase the overall funding pool for city- and state-wide resilience needs
- Advocating to increase funding caps for federal and state project awards

Analyzing the Potential Role of Real Estate Development

The width of the proposed shoreline extension is solely driven by the space needed for flood defense infrastructure. Regulatory restrictions on extending the shoreline into the East River, combined with the master plan's goal of maximizing universal accessibility, limit the options for locating buildings on the shoreline extension. In addition, public feedback during the engagement process indicated a desire to limit large-scale development, especially around the South Street Seaport Historic District.

In response, the City is not proposing any residential or large-scale commercial development as a part of the master plan. However, for comprehensiveness, the project team studied whether the inclusion of mid- and high-rise buildings could provide a significant source of funding. Based on preliminary analysis, the project team found that development revenue is unlikely to contribute significantly towards the capital costs but could provide a significant share of annual O&M costs.

Governance

Overview

The master plan requires complex large-scale infrastructure planning over many years to meet different needs across flood resilience planning and engineering, maritime engineering and operations, emergency operations and more. To implement a project of the magnitude proposed, a governance entity needs to be able to manage a capital construction project across these multiple disciplines; secure funding and financing; and shepherd the proposed project through complicated federal, state, and City permitting and approvals. The entity that manages the construction of the project will also need the capacity to plan for and take on long-term operations and maintenance, which could include managing maritime facilities, open space and programming, and emergency operations of flood defense systems.

Existing government agency structures may not be ideally suited to manage a project of this scale and cross-disciplinary nature. Instead, a special-purpose entity could bring these disparate functions together under one roof with specialized staff and a clear mandate.

Technical Analysis

To understand the types of potential governance entities and which ones may be best suited to carry out the master plan, the project team asked the following questions:

1. What would a new governance entity need to do?
2. What types of governance entities may be applicable?
3. What are examples of existing governance entities that achieve similar functions?

What Would a new Governance Entity need to do?

The master plan is unique compared to other infrastructure or construction projects in a few important ways. First, the area in which the proposed project will be built is currently overseen by many different entities. For example, the land near the shoreline and underwater is owned by the City, but the waters are also subject to state and federal regulations. **The entity will need to navigate complex permitting and approval processes over many years to receive the necessary permission to construct the project.** Where challenges arise, the entity may need to advocate for changes to existing regulations or policies, as well as new funding sources.

The entity will need to be able to access a variety of funding and financing sources—particularly those that have the greatest potential to cover the costs of the master plan. For example, the entity should be able to receive City capital and expense funding as well as apply for state and federal grants. The entity should also be able to receive allocations from new revenue streams, such as an insurance surcharge or resilience assessment, that may be used to fund different projects across the city or state. In addition, it may be advantageous for the entity to issue bonds that could provide upfront capital financing. In some cases, securing funding may require significant coordination with government entities like the USACE, which the entity should have the capacity to manage.

The entity may also play a role in managing capital construction and day-to-day operations and maintenance once construction is complete, including emergency activation of the flood defense infrastructure in advance of coastal storms. Staff responsible for overseeing capital construction should have the appropriate engineering and project management expertise. As the proposed project is constructed, staff may need to maintain and operate the specialized flood infrastructure and could be responsible for maintaining the public realm.

Finally, because it will take close to two decades to realize the master plan and it will be built to protect the area into the next century, the master plan needs to be a sustained priority for the entity ultimately charged with realizing the plan. Implementation will call for significant communication and coordination with many different types of entities including local, state, and federal government agencies as well as continued engagement with the community. The entity should have the capacity and authority to conduct this engagement and outreach.

What Types of Governance Entities may be Applicable?

All types of governance entities the project team evaluated would be publicly controlled, either by the City or the state. The first option the project team explored would be governance by a City agency or combination of City agencies. This would not require a new entity to be established, but may call for a non-binding agreement, such as a Memorandum of Understanding (MOU), to define the roles and responsibilities of each agency involved. If roles assigned to a given agency go beyond its typical purview, additional authorization may be required.

Beyond direct City agency management, the project team explored creating a public authority. A public benefit corporation is a public authority chartered through state legislation to support public interests, notably the development and maintenance of infrastructure. The powers and limitations of the authority are set forth in the authorizing legislation and by-laws. A board of directors would oversee a public authority, with the required composition of that board established in the legislation. Other entities, such as local development corporations, do not require special state legislation to establish but may be deemed public authorities and be subject to reporting requirements outlined in the Public Authorities Accounting Act (PAAA).

The entities that the project team explored are detailed in Table 3.

Table 3. Types of Public Authorities Evaluated

Entity Type	Description	Advancing Design & Permitting	Advocacy	Funding & Financing	Capital Construction	Operations & Maintenance
City Agency	Existing City-agency management	Moderate Alignment Can procure and contract a design team. Can conduct community engagement. Has the expertise and ability to coordinate and advance pre-construction processes.	High Alignment Can advocate for legislation / policy.	Moderate Alignment Can access city capital and channel federal or state funding.	Moderate Alignment Have staff with expertise to oversee capital construction, but capacity may be limited for a project of this scale.	Moderate Alignment No existing agency dedicated to managing resilience infrastructure. Organizational capacity would need to be created and could require an amendment of the City Charter for authorization.
Public Benefit Corporation or other public authorities	State-controlled public authorities, with one or more board members appointed by the Governor.	High Alignment Can procure and contract a design team. Can hire staff to coordinate and advance pre-construction processes.	Moderate Alignment Have restrictions around advocacy for legislation / policy.	High Alignment Has bonding authority and can raise private funds. Can also access City capital and channel federal or state funding.	High Alignment Can hire dedicated staff with expertise to oversee capital construction.	High Alignment Can hire appropriate personnel for O&M.
Local Development Corporations (LDC)	A nonprofit corporation that is created or sponsored by a local government.	High Alignment Can procure and contract a design team. Can hire staff to coordinate and advance pre-construction processes.	Low Alignment LDCs cannot advocate for legislation / policy.	High Alignment Has bonding authority and can raise private funds. Can access City capital and channel federal or state funding.	High Alignment Can hire dedicated staff with expertise to oversee capital construction.	High Alignment Can hire appropriate personnel for O&M.

What are Examples of Existing Governance Entities that Achieve Similar Functions?

Table 3 above shows that different types of entities can do similar things. Notably, local development corporations, public benefit corporations, and other public authorities, have similar capabilities. To help understand why one type of entity might be selected over another, the project team looked at examples of existing governance entities and how they typically operate. Examples evaluated include:

Hudson River Park Trust (Public Benefit Corporation)
Hudson River Park Trust was created by the Hudson River Park Act of 1998 to design, build, operate, and maintain a public park and estuarine sanctuary along several miles of the western Manhattan shoreline. Some of this land is owned by the State and some by the City, but it is all jointly leased to the Trust. The Trust is subject to state oversight by board members, a majority of whom are appointed by the Governor. The mayor and borough president of Manhattan also place appointees on the 13-member board of directors. Because the Hudson River Park Act requires the Trust to be financially self-sufficient, the entity needs to channel funding through a variety of sources. O&M for the park and Trust are primarily funded by income generated through park concessions, rents, and donations. Capital projects have historically been funded by various city, state, and federal allocations or grants, but private fundraising, as well as revenue from development rights, are currently playing a larger role. The Trust has staff with diverse expertise to oversee its many responsibilities, from design and construction to operations, programming, and environmental stewardship.

Battery Park City Authority (Public Benefit Corporation)
The Hugh L. Carey Battery Park City Authority (BPCA) was created in 1968 to oversee development of new land that would become the Battery Park City neighborhood. Over much of the following decades, the Authority has focused on creating and maintaining the mixed-use, 92-acre community of commercial, residential, retail, and open space, including 36 acres of public parks, on Manhattan's Lower West Side. BPCA generally operates independently, though it coordinates with City agencies where appropriate. In pursuit of its strategic goal of adapting to a changing climate, it is currently undertaking significant resilience infrastructure projects in concert with the City's efforts and is responsible for securing funding, designing, building, operating, and maintaining, these flood protection systems. Unlike other entities described in this chapter, BPCA owns the land it manages, and most of its current funding comes through revenue from ground leases to residential and commercial developments and, more significantly, payments in lieu of taxes. Because these sources generate surplus revenue, a majority of those funds are given back to the City and used for other public priorities.

Lower Manhattan Development Corporation (Public Authority)
Lower Manhattan Development Corporation (LMDC) was created in December 2001 as a subsidiary of Empire State Development to administer federal funds granted by the US Department of Housing and Urban Development (HUD) to redevelop and revitalize Lower Manhattan after the September 11 attacks. The central effort of this entity is a redevelopment plan for the World Trade Center site, including the September 11 Memorial and new towers, and other programs supporting residential growth, public realm and street life, and waterfront access. LMDC oversees the development and construction of these projects and programs, while other entities handle ongoing O&M.

Brooklyn Navy Yard Development Corporation
(Local Development Corporation)
Brooklyn Navy Yard Development Corporation (BNYDC) is a not-for-profit corporation created by the City of New York as a local development corporation. BNYDC develops, manages, and operates the Brooklyn Navy Yard on behalf of the City. The City retains control of the Brooklyn Navy Yard site through the terms of a long-term lease, the annual City Contract, and the by-laws, which provides that most of the Board of Directors are appointed by the mayor.

Recommendations and Next Steps

The City, working with local, state, and federal partners, will continue to assess the potential options for governance and establish a mechanism to oversee implementation of the master plan design, environmental review, and permitting. Questions that still need to be answered include:

- Who will control the new land created by the shoreline extension?
- What sources of funding will be utilized?
- What role will the state and federal governments play in realizing the proposed project?
- Who will operate and maintain the flood defense infrastructure, public open space, and transportation infrastructure?

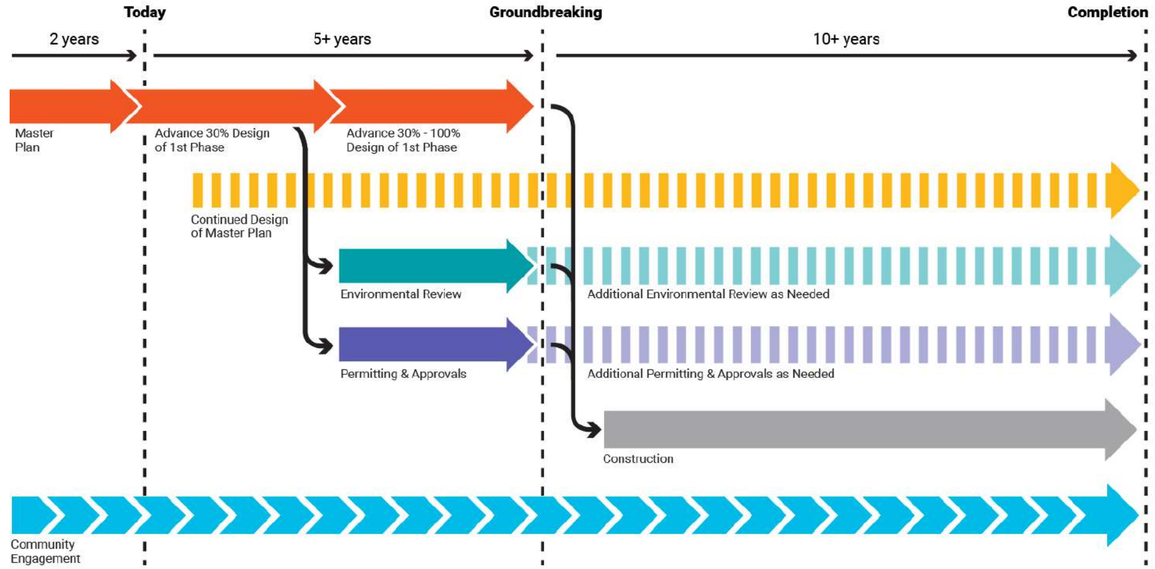
Timeline

To make this master plan into a reality, the City will need to advance an extensive regulatory approval and permitting process with multiple state and federal agencies, secure funding, and construct a project of monumental scale and complexity.

The City will continue to work closely with the community, advocates, and elected officials to identify a construction phasing strategy for the master plan, including the identification of a first phase project. First, the design must be developed to a level sufficient to begin environmental review. Environmental impact review and permitting processes can then commence and advance in parallel as the design continues towards 100 percent. This process, from design through obtaining all necessary approvals, will take a minimum of five years.

Construction of the first phase may begin only after environmental impact review is completed and necessary permits and approvals are obtained. Other phases of the master plan may continue to be designed as the first phase project advances depending on availability of funding. Additional environmental impact review, as well as approvals, may be needed as future phases advance.

Just as the master plan was informed by extensive community feedback, the City will continue to engage with stakeholders to ensure that the refined design and construction process aligns with neighborhood and citywide goals.



Illustrative timeline of master plan implementation

Sources

1. IEA. “Global Status Report for Buildings and Construction 2019 – Analysis.” Accessed December 7, 2021. https://www.iea.org/reports/global-status-report-for-buildings-and-construction-2019.
2. US EPA, OLEM. “Sustainable Management of Construction and Demolition Materials.” Overviews and Factsheets, March 8, 2016. https://www.epa.gov/smm/sustainable-management-construction-and-demolition-materials.

Notes

i. Cost of inaction is presented in 2021 dollars and not discounted over time.

ii. The low end represents the value in 2021 dollars and the high end accounts for the impacts of inflation over a representative construction schedule.

iii. The current estimates are between Association for the Advancement of Cost Engineering International Class 4 (Concept Screening) and Class 5 (Study or Feasibility) estimates and do not include, for example, financing costs. Appropriate unit costs were selected by examining recent bids for similar projects, referencing published or industry accepted unit costs or costs for similar project elements, or estimating costs as a percentage of construction. Markups are based on generally accepted industry practice or derived from recent project experience.

iv. The estimated size of each potential source is based on the facts and circumstances present at the time of this master plan and may change over time as this project, funding programs, and financial markets evolve.

v. Amounts here are escalated to take into account an estimate of the effect of inflation over the duration of the project unless stated otherwise.

Chapter Seven

Next Steps & Call to Action

"I would like to learn more about what we can do as citizens to help make a resilient NYC."
- Participant from the first open house

Overlooking the Financial District and Seaport neighborhoods from the Brooklyn Bridge pedestrian walkway (Photo Credit: Filippo Bacci)

The *Financial District and Seaport Climate Resilience Master Plan* is a bold vision that responds to the impacts of climate change in one of the most low-lying and exposed neighborhoods of New York City.
It proposes to extend the shoreline of Lower Manhattan for the first time in decades to make space for critical flood defense infrastructure. Once fully realized, this waterfront will be universally accessible and serve all New Yorkers better than before with transformed open spaces, community amenities, and resilient ferry terminals and piers.

Much of the new Financial District and South Street Seaport waterfront will be raised nearly two stories higher than it is today to provide passive protection against coastal storms. The proposed conceptual design takes advantage of this topography to create slopes and ridges that foster a unique waterfront experience. Atop these ridges, which are formed by floodwalls that are buried under the landscape, the proposed master plan provides new public open spaces that offer expansive views of the East River. On the water side of the ridges, a raised esplanade brings people close to the water itself and provides easy access to resilient ferry terminals and piers. This seamless integration of flood defense infrastructure into the fabric of a dense urban environment will set a new global precedent for more resilient and livable cities that successfully adapt to the impacts of climate change.

The master plan envisions a resilient waterfront with long-term adaptability to the changing needs and conditions of the city's historic maritime hub. It proposes resilient facilities for ferries and other vessels, space for docking historic ships, and flexibility for emergency operations. Wherever possible, the master plan also proposes sustainable solutions that aim to improve the health of our planet, from integrating renewable energy and green infrastructure to enhancing aquatic habitats in the East River.

While the conceptual design of the master plan is not set in stone, it is a blueprint for how to create a 21st century resilient waterfront. This master plan is:

- Grounded in sound engineering and technical analysis;
- Shaped by extensive collaboration with City agencies; local, state, and federal regulators; and both the local community and citywide organizations; and,
- Flexible, to ensure the master plan can stand the test of time.

The result is a shared City-community vision that responds to the impacts of climate change while transforming the waterfront to better serve all New Yorkers for generations to come.

Climate resilience is the only option.

The Financial District and Seaport ***will*** change dramatically whether the City takes action or not. By the 2040s, high tides will frequently flood the area. This flooding will happen monthly in the 2050s and daily by the 2080s. By 2100, high tides could flood most of the area between Water Street and the current shoreline every day with heights up to four feet above the current esplanade. A coastal storm event in 2100 could cause flooding that reaches inland more than five city blocks, past William Street, with a depth of up to 15 feet. This would have devastating impacts to vital transportation networks, critical public utilities, businesses, residents, and schools. This stark reality raises the question of Lower Manhattan's future viability, to which this master plan is the answer.

It is not simply infrastructure that is affected by climate change. It is the 70,000 daily passengers that currently rely on the Staten Island Ferry; the 290,000 people who work in Lower Manhattan; the 62,000 residents who call it home; the 175,000 vehicles that drive along the FDR Drive and Battery Park Underpass on a daily basis; the 17.7 million annual visitors who come to this area; and many others who rely on and pass through the area. The impacts of climate change in Lower Manhattan will be felt well beyond New York City. As Hurricane Sandy, the September 11 attacks, and other shutdowns of Lower Manhattan have shown, even a few days of impacts result in significant economic reverberations around the entire region, nation, and even the globe.

The shoreline of Lower Manhattan must be extended.

With these high stakes, and imbued with a sense of urgency, the City embarked on an extensive, multidisciplinary planning process to secure the future of the Financial District and Seaport neighborhoods. This began with learning from other cities and countries around the world that are grappling with similar issues before evaluating the broadest range of potential climate resilience solutions within the local context.

The result of technical analysis was clear: to achieve the goals of this master plan, the shoreline of Lower Manhattan ***must*** be extended into the East River to create the space needed to build a flood defense system. Extending the Manhattan shoreline is critical to achieving these goals because the Financial District and Seaport shoreline today simply does not have enough space to build this infrastructure. Further, this space is necessary to ensure that flood defense does not wall off the city from the waterfront but instead provides universally accessible entrances and pathways down to the shoreline edge.

The City did not come to this conclusion lightly. Building in the water is a complex and expensive process that requires approvals from state and federal regulatory agencies. To ensure the master plan is implementable and constructable, the project team conducted extensive technical engineering analyses as well as a detailed review of existing laws, regulations, and permitting requirements. The City worked closely with the state and federal regulators that will ultimately issue permits, reflecting a design that avoids and minimizes the shoreline extension everywhere possible without sacrificing the dual goals of passive flood protection and high-quality, universal public accessibility.

The City acknowledges that any potential environmental impacts to the East River must be mitigated. This work to integrate regulatory feedback into the design from the beginning has resulted in a master plan that the City believes can advance through an extensive permitting process and has a viable pathway to construction. As the master plan advances to later stages of design, applying for and securing these permits will be a major next step.

Attendees at Public Open House #1 explore flood risks through a virtual reality simulation and speak with a member of the project team (Photo Credit: SCAPE)


Attendees at Public Open House #1 learn about New York City's sewer system and how it works today (Photo Credit: SCAPE)

The master plan reflects a shared City-community vision.

The conceptual design of the master plan is the product of two years of extensive public engagement. Community feedback fundamentally shaped the design, reflecting several major themes reinforced by members of the community time and again, including:

- The master plan should **not wall off the city from the water.**
- The community is excited about an opportunity for a **new elevated waterfront experience.**
- The community shares a strong interest in **community-serving amenities**, including green spaces, active recreation, and indoor amenities such as community facilities and cafes.
- The master plan should include a continuous **bike path and waterfront esplanade** to connect the Manhattan Waterfront Greenway.
- The master plan should preserve or enhance the **ferries, ships, and piers** in the area, which add to the character of the waterfront.
- Many people are interested in **replacing the FDR Drive viaduct** with an at-grade boulevard.
- The master plan should preserve and protect the **Historic South Street Seaport.**
- The master plan should design for a **sustainable future** with carbon-neutral and nature-based solutions.
- The master plan should complement the **existing character** of the waterfront and surrounding neighborhoods.
- The master plan should set a new global standard for **design excellence.**

Community feedback and public engagement will continue to shape the future of this waterfront as design advances.

The time to act is now.

Grounded in climate science, engineering, and feasibility testing, the master plan reflects a vision that can ultimately be realized. However, time is not on our side. With a long road to implementation and the impacts of climate change already being felt more frequently and intensely, there is not a moment to spare. Realizing this master plan will require significant funding commitments, political will, and a coalition of community support to carry it forward.

Throughout the master plan process, the project team carefully considered costs and analyzed possible funding sources. The price tag for flood defense infrastructure is high; fully realizing this master plan will require considerable federal support. At present, federal programs commensurate with the scale of this resiliency investment are not yet in place. Creating a resilient waterfront that serves all New Yorkers will require the combined efforts and resources of all levels of government—local, state, and federal.

New York City is part of a coalition of local governments advocating to create new funding pathways for climate adaptation, acknowledging that investing in resilient infrastructure is critical for our collective safety, prosperity, and well-being. It is critical that all partners, particularly the federal government, embrace the role they must play in building a more resilient nation by creating funding opportunities to adapt to the increasingly devastating impacts of climate change.

What do we do next?

A project of this scale will take 15 to 20 years, perhaps even more, to fully implement. If the master plan is fully funded and designated a priority for regulatory agencies, complete flood protection for this area could be in place as early as 2035.

Given this, it is critical that the City act now. As a next step, the City will progress design of the master plan to a level sufficient to begin permitting and environmental review. Advancing design will also unlock additional federal funding opportunities. Beyond design, it will be critical to continue to work closely with the regulatory agencies that will ultimately decide the fate of this plan and continue studies and analysis, including sampling and testing in the East River, to determine a baseline for potential environmental impacts. The City will also explore options for future governance structures to shepherd implementation of the master plan.

Throughout all of this, the City will work closely with the community, advocates, and local, state, and federal elected officials to ensure the master plan continues to represent a shared vision between the community and the City.

A call to action.

This master plan is the first step towards realizing a more resilient Lower Manhattan, but its long-term success will rely on the continued support and advocacy by all who care about this place. It is critical to build an ongoing coalition of support, and your participation matters. For all readers of this report: Whether you are a local resident, worker or student, commute through Lower Manhattan, or simply care about resilience and the future of New York City, you can act ***now*** by:

- Visiting the master plan website (*fidiseaportclimate.nyc*) to sign up for the latest updates;
- Sharing this master plan and website with your colleagues, friends, and family to generate awareness;
- Reaching out to your local, state, and federal elected representatives to share your support and enthusiasm; and
- Reaching out to the project team if you have any additional questions.

Glossary of Terms

100-year Storm
A coastal storm that has a 1 percent probability of occurring in any given year.

Caisson
A large, watertight foundation structure used as part of the flood defense system.

Compartment
An area designed to be enclosed by a flood protection system, including shoreline structures, gates, and tie-ins to high ground.

Conveyance
The process of using gravity to move water from one location to another, like through sewer pipes.

Climate Change
A change in global or regional climate patterns, in particular a change apparent from the mid to late 20th century onwards and attributed largely to the increased levels of atmospheric carbon dioxide produced by the use of fossil fuels.

Combined Sewer Overflow (CSO)
The discharge of a mix of excess stormwater and untreated wastewater into a waterbody caused by heavy rainfall.

Combined Sewer System
A network of sewers that are designed to collect rainwater runoff, domestic sewage, and industrial wastewater in the same pipe.

Datum
A datum is a reference system for consistently measuring sea level across regions, given local variation in tides.

Deployable Floodgate
Temporary flood barrier that can be installed in anticipation of a coastal storm and removed thereafter.

Design Flood Elevation (DFE)
The height of the flood defense measures selected for an area.

Floodwall
A type of flood defense infrastructure made up of a wall that can either be buried or built above ground.

Get-down
A ramp or set of steps to bring people closer to the water.

Heat Wave
A period of three days in a row where temperatures rise above 90°F or two consecutive days over 95°F.

Intertidal Zone
The space where water meets land between high and low tides.

Mean Higher High Water (MHHW)
The average of the highest tide recorded each day during the recording period.

Mean Monthly High Water (MMHW)
A metric that is the average of all monthly maxima in predicted astronomical tide levels.

Mean Lower Low Water (MLLW)
The average of the lowest tide recorded each day during the recording period.

Maritime
Structures relating to the water or sea; can include ferries, ships, vessels, piers, and other water-dependent structures.

New York City Panel on Climate Change (NPCC)
The body of leading climate and social scientists convened by the City and charged with making climate change projections for the metropolitan region.

Nature-based Solutions (NbS)
Measures that work with nature to protect, restore, and manage ecosystems to address and adapt to societal challenges.

Outboard
On the seaward side of the shoreline; in the water.

Passive Protection
Flood defense measures that do not require direct human interaction to activate once constructed.

Piles
Vertical structural elements of a foundation system that are driven deep into the soil or bedrock for stability.

Pumping / Pump Station
Pumping moves water from lower to higher ground. Pumps push water out against high tides and coastal storm surge conditions, ensuring water does not collect behind the flood defense system. A pump station can manage large volumes of combined sewage and stormwater to prevent flooding during heavy rainfall.

Sea Level Rise (SLR)
An increase in sea level caused by a change in the volume of the world's oceans due to temperature increase, melting glaciers, and ice melt.

Shoreline Extension
The process of creating new land in a body of water.

Sill
Submerged structure designed to break waves, made of rock, root wads, or other material.

Storm Surge
During a coastal storm, low atmospheric pressure and strong winds create a temporary increase in ocean levels, called storm surge, which is pushed onshore by winds. The force of the water and associated waves can lead to significant damage and risk to lives.

Stormwater
Water that originates from rain or melting snow that doesn't soak into the ground but runs into the sewer system and waterways.

Stormwater Management System
A series of practices and infrastructure used to collect, convey, detain, and retain stormwater.

Sub-tidal Zone
The area of the river that is below the intertidal zone and always submerged.

Tidal Flooding
Regular, persistent flooding from a higher tide in a coastal area that results from sea level rise.

Urban Heat Island Effect (UHI)
The tendency for higher air temperatures to persist in urban areas due to heat absorbed and emitted by buildings and asphalt, tending to make cities warmer than the surrounding suburban and rural areas.

Universal Access
An environment designed to be usable by all people to the greatest extent possible; design that is focused on providing equitable access and experiences for people with disabilities.

Wastewater
Water that has been used in homes, businesses, industrial, or agricultural locations.

Waterborne Transportation
Transportation that is based on waterways. This includes passenger ferries and commercial vessels that run along the Hudson River, East River, and in the Upper Bay.

Wave Screen
Fence-like in-water wave attenuating structure that can be pile-supported, or attached to a pile-supported structure.

NYC/EDC NYC Mayor's Office of Climate Resiliency

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