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

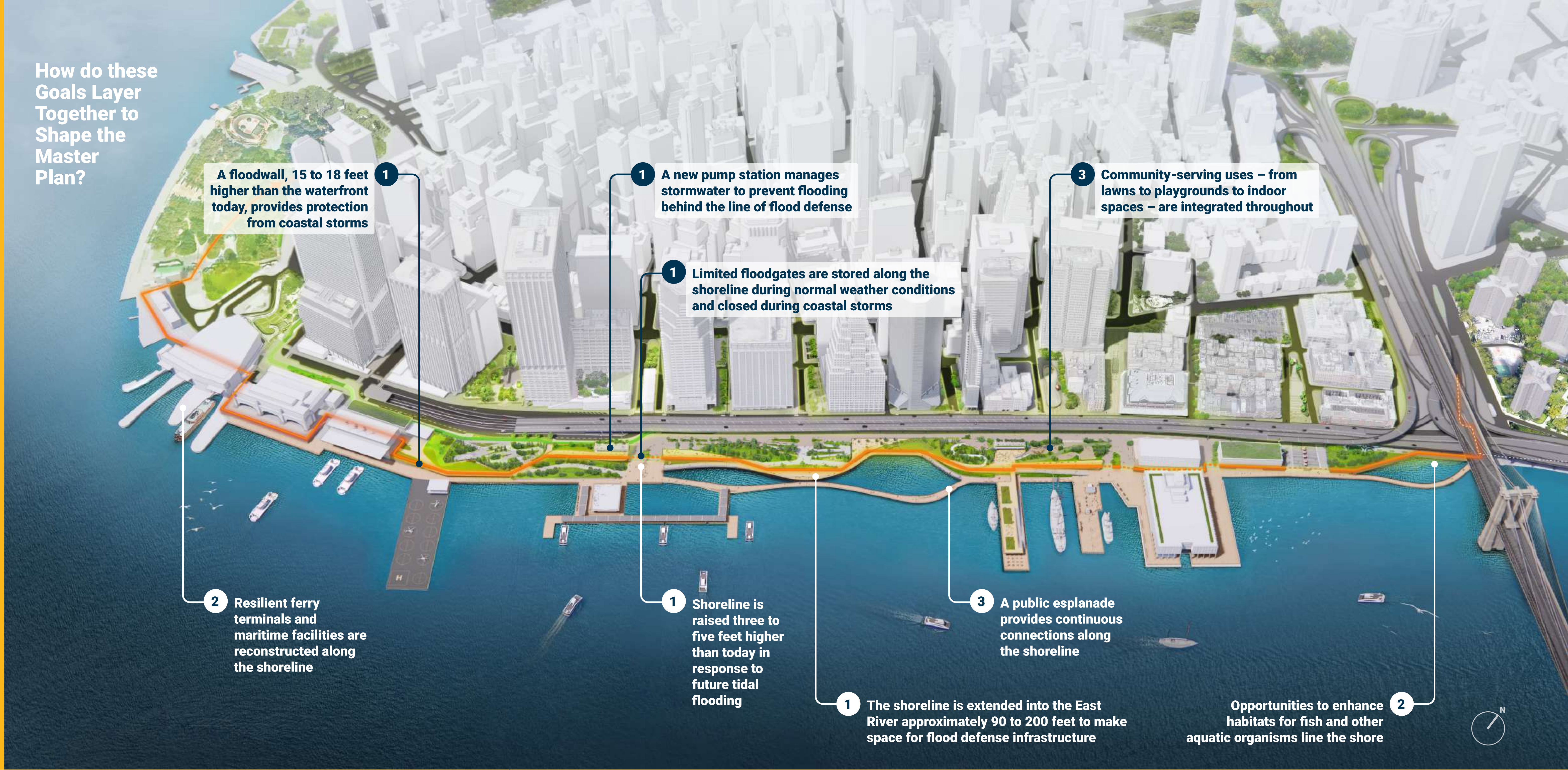
2 Integrate climate resilience infrastructure into the city by

- 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**

How do these Goals Layer Together to Shape the Master Plan?



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.

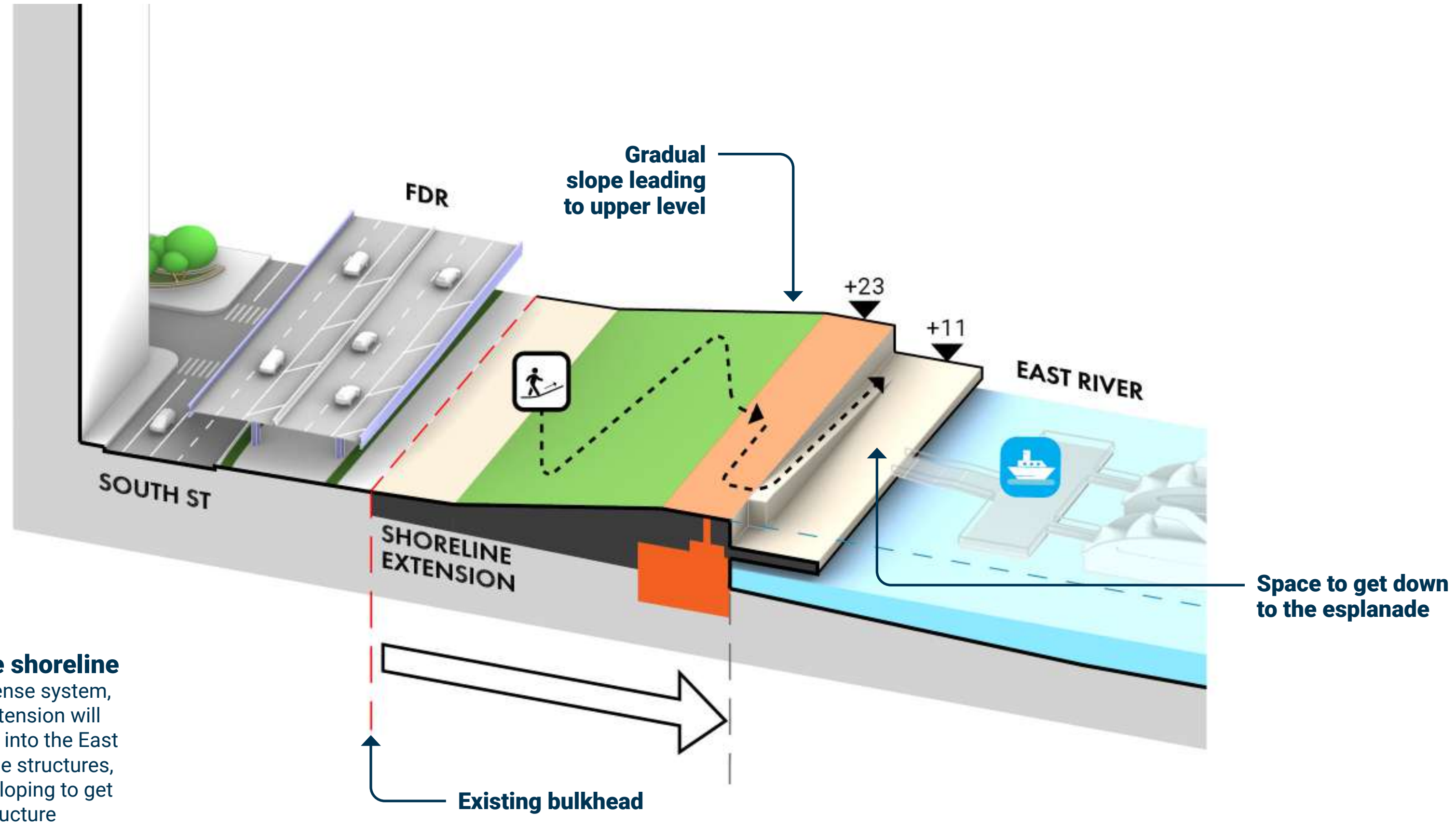
In the Financial District and Seaport, a unique convergence of climate change hazards and physical constraints makes it challenging to construct flood defense infrastructure entirely on land. Building an 18-foot-tall floodwall requires not only vertical space to achieve this height but also extensive 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.

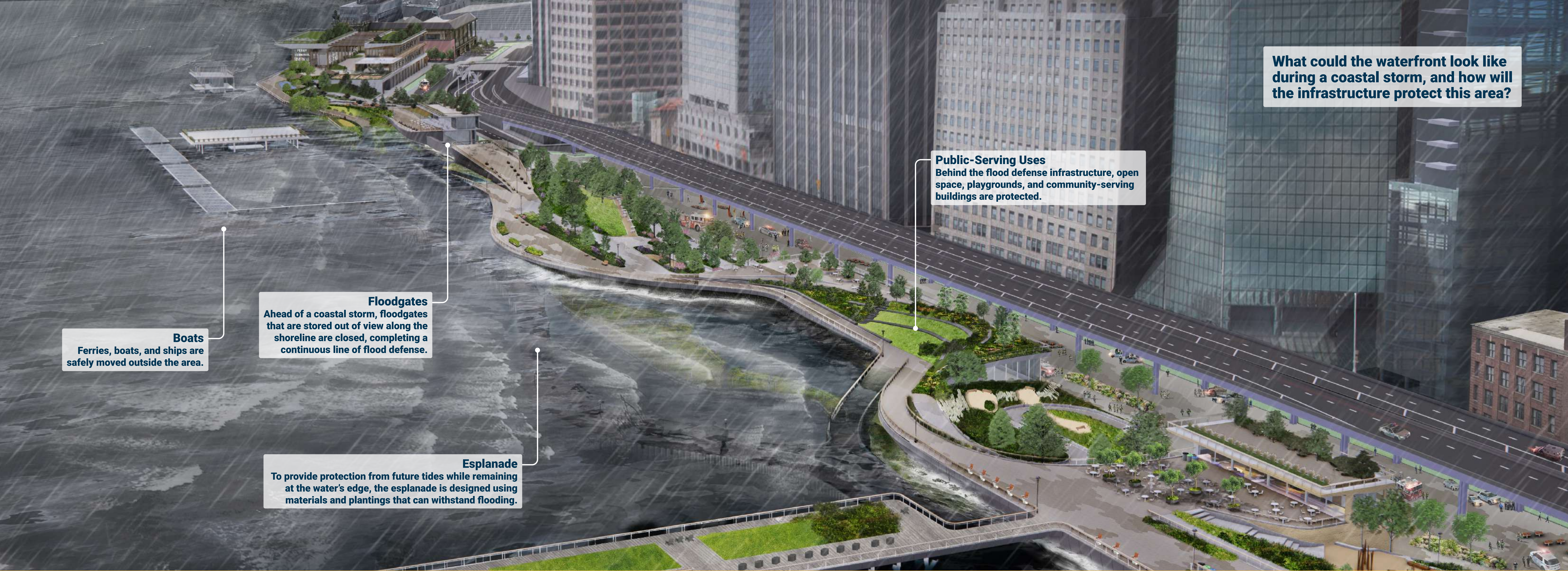
The proposed design has been refined throughout the master plan process and aims to avoid and minimize fill in the East River wherever possible.

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.

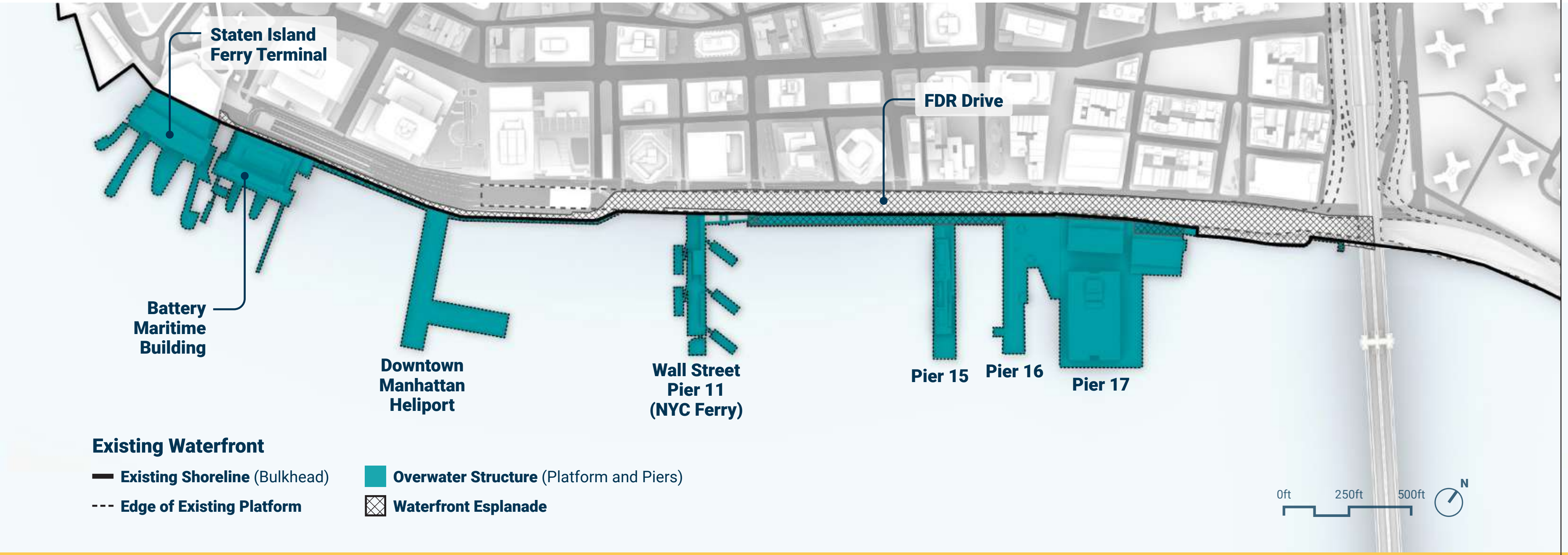

What could the waterfront look like during a coastal storm, and how will the infrastructure protect this area?
Public-Serving Uses
Behind the flood defense infrastructure, open space, playgrounds, and community-serving buildings are protected.
Floodgates
Ahead of a coastal storm, floodgates that are 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.

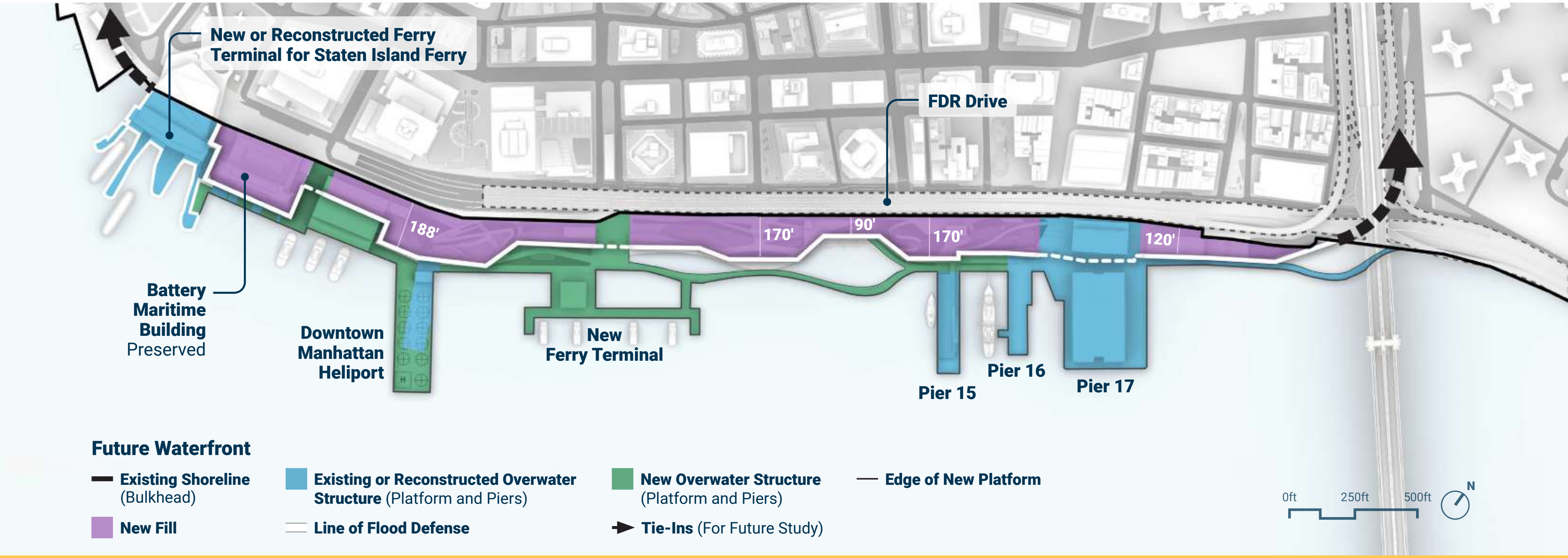
View south from the top of Pier 17 of the Financial District and Seaport waterfront in December 2021 (Photo Credit: ONE Architecture)



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 south 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.

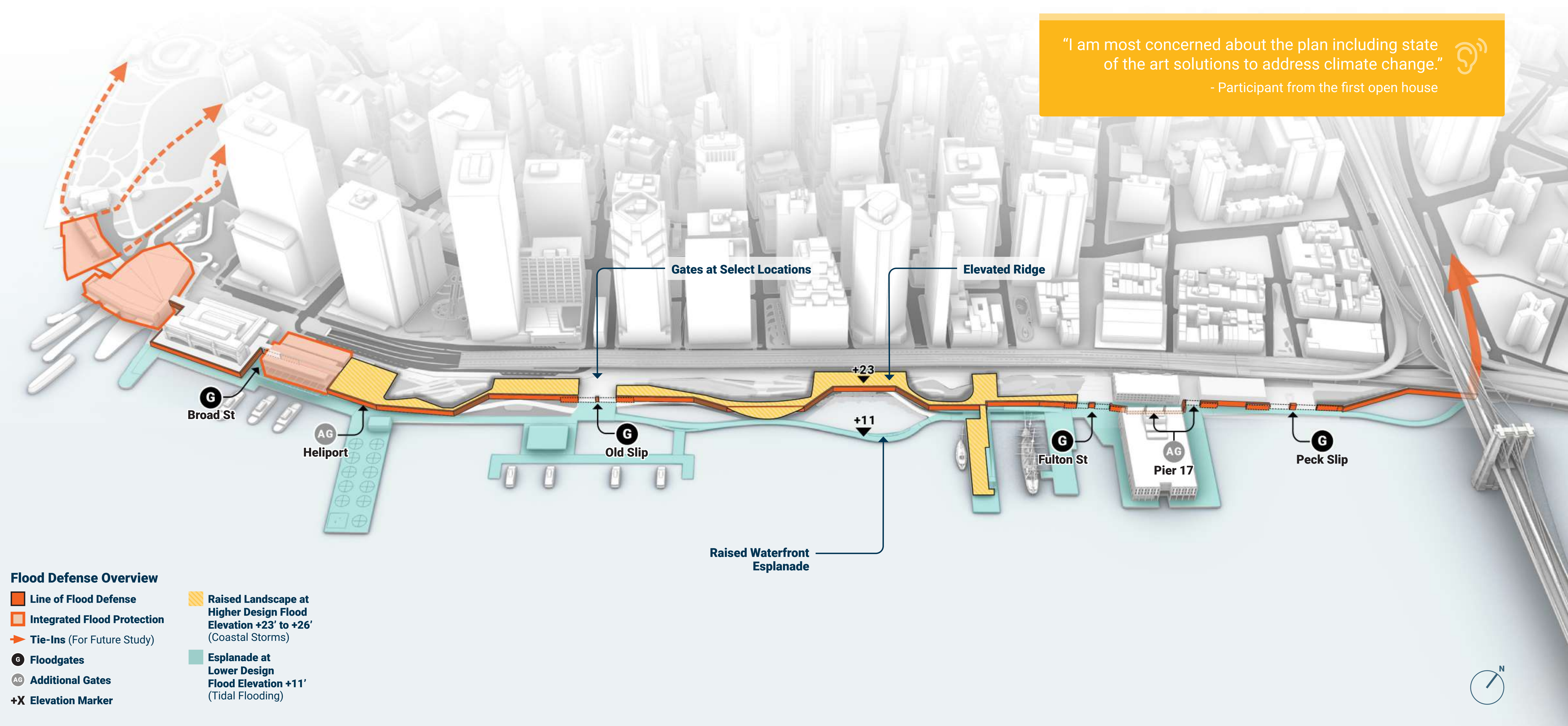
The unique conditions of this area create a complex environment for constructing this infrastructure. With larger waves than nearby areas due to its location in New York Harbor, compounded by low-lying topography and unique above- and below-ground conditions, the City needs to take a bold approach to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

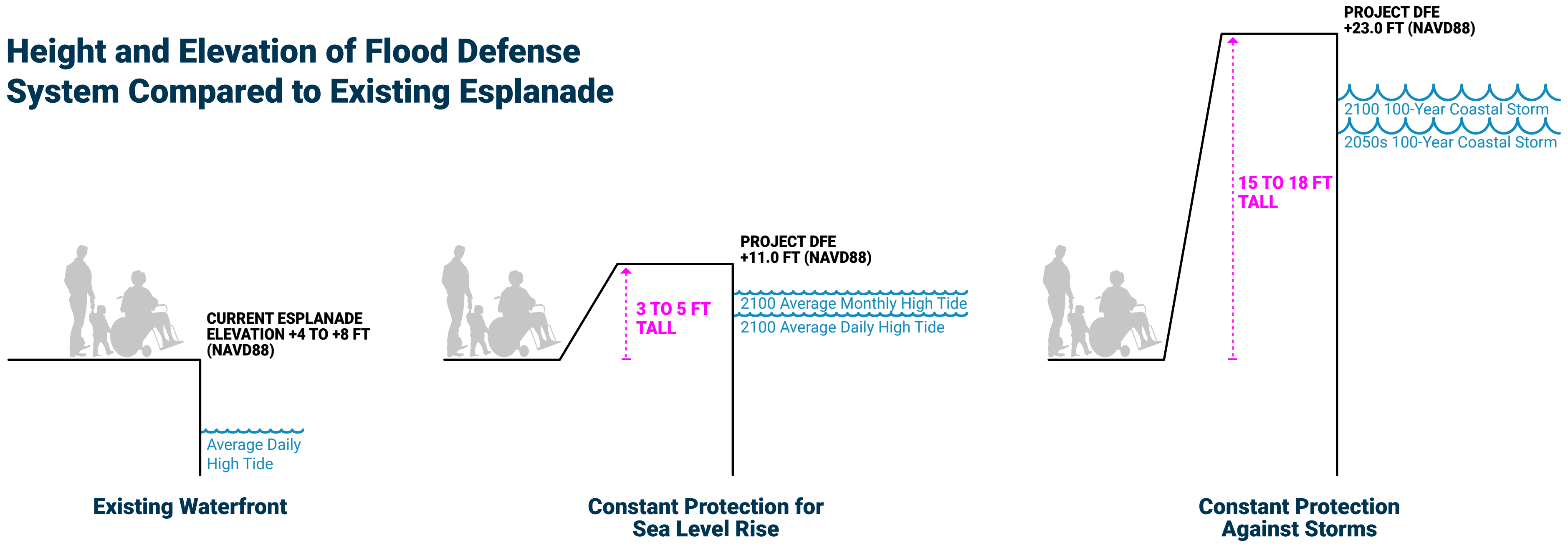
The first component that the project team identified was the stillwater elevation, which is the projected height of floodwaters caused by tides and storm surge (not including waves). FEMA has defined the stillwater elevation for a 100-year flood, or a flood that has a one-percent chance of occurring 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

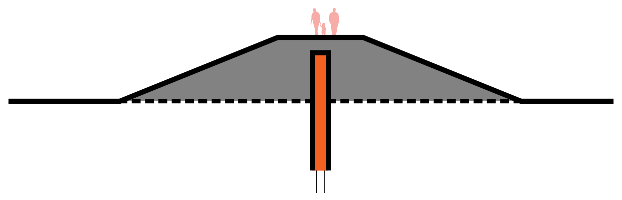
To realize a complete flood defense system while protecting buildings and facilities across the study area, most of the existing maritime buildings along the shoreline will need to be reconstructed to withstand wave forces and pressures from standing water. In these instances, the master plan proposes 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

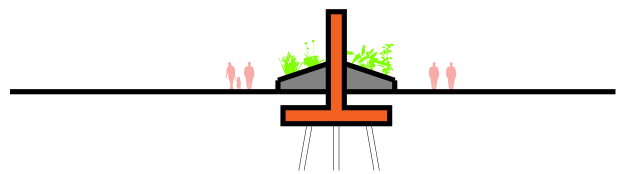
As the flood defense crosses over subway tunnels, the master plan is mindful of the potential additional load, or weight, that is placed on the subway tunnels. In these locations, the master plan proposes bridging structures, which allow the flood protection to be anchored on either side of the subway 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.

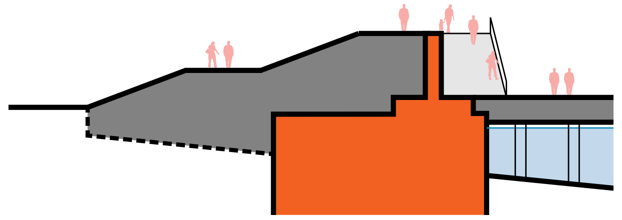
Flood Defense Toolkit



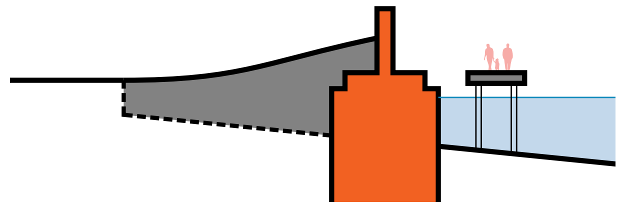
Floodwall (Buried)



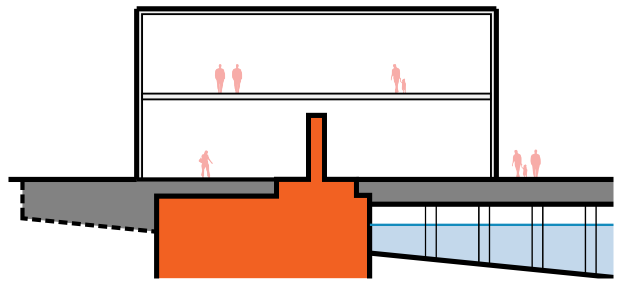
Floodwall (Exposed)



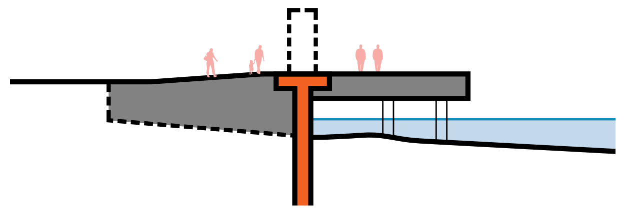
Raised Shoreline (Caissons and Buried Floodwall)



Raised Shoreline (New Bulkhead and Exposed Floodwall)



Integrated Floodwall with New or Reconstructed Buildings

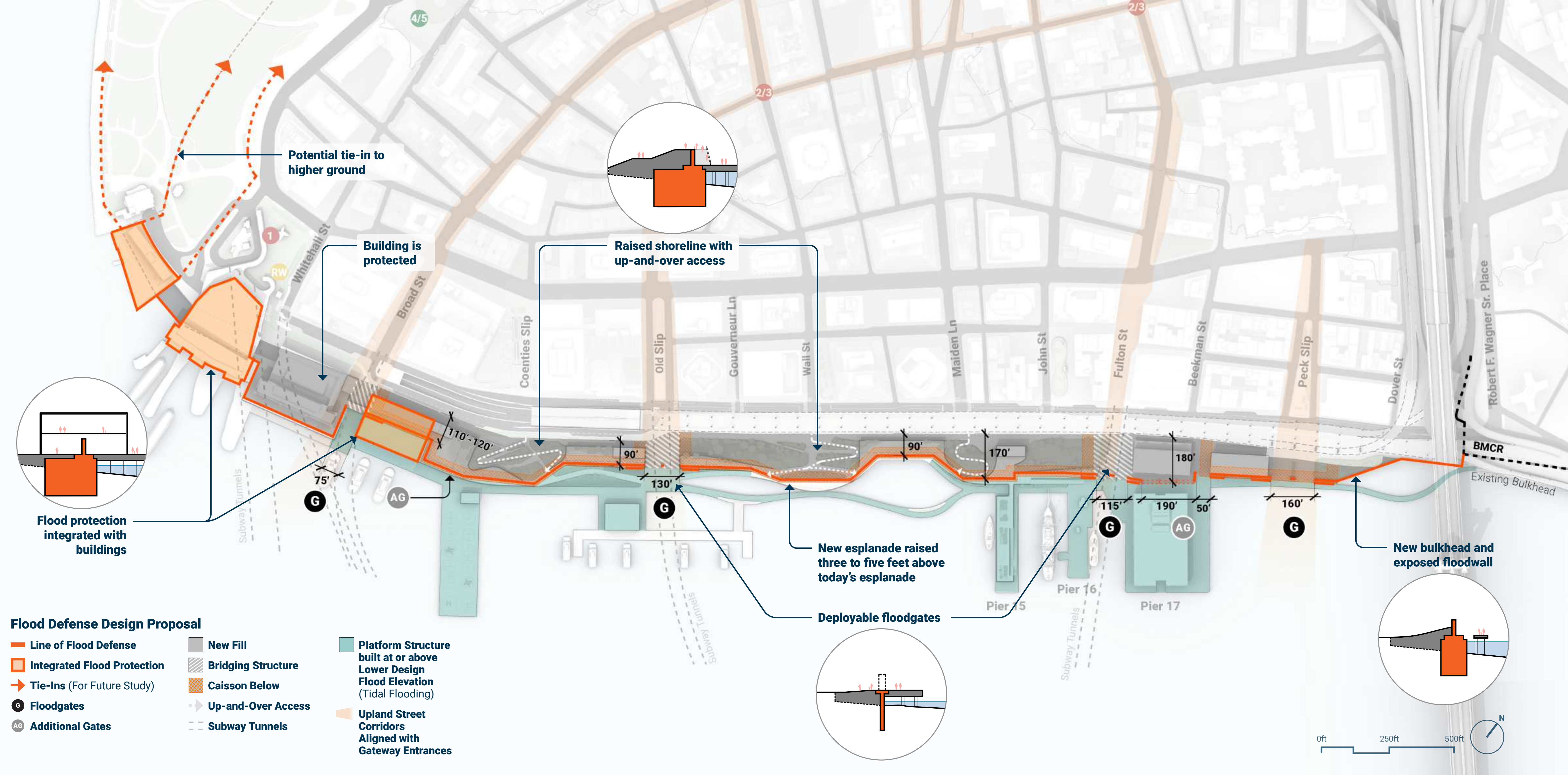


Floodgates

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.



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:

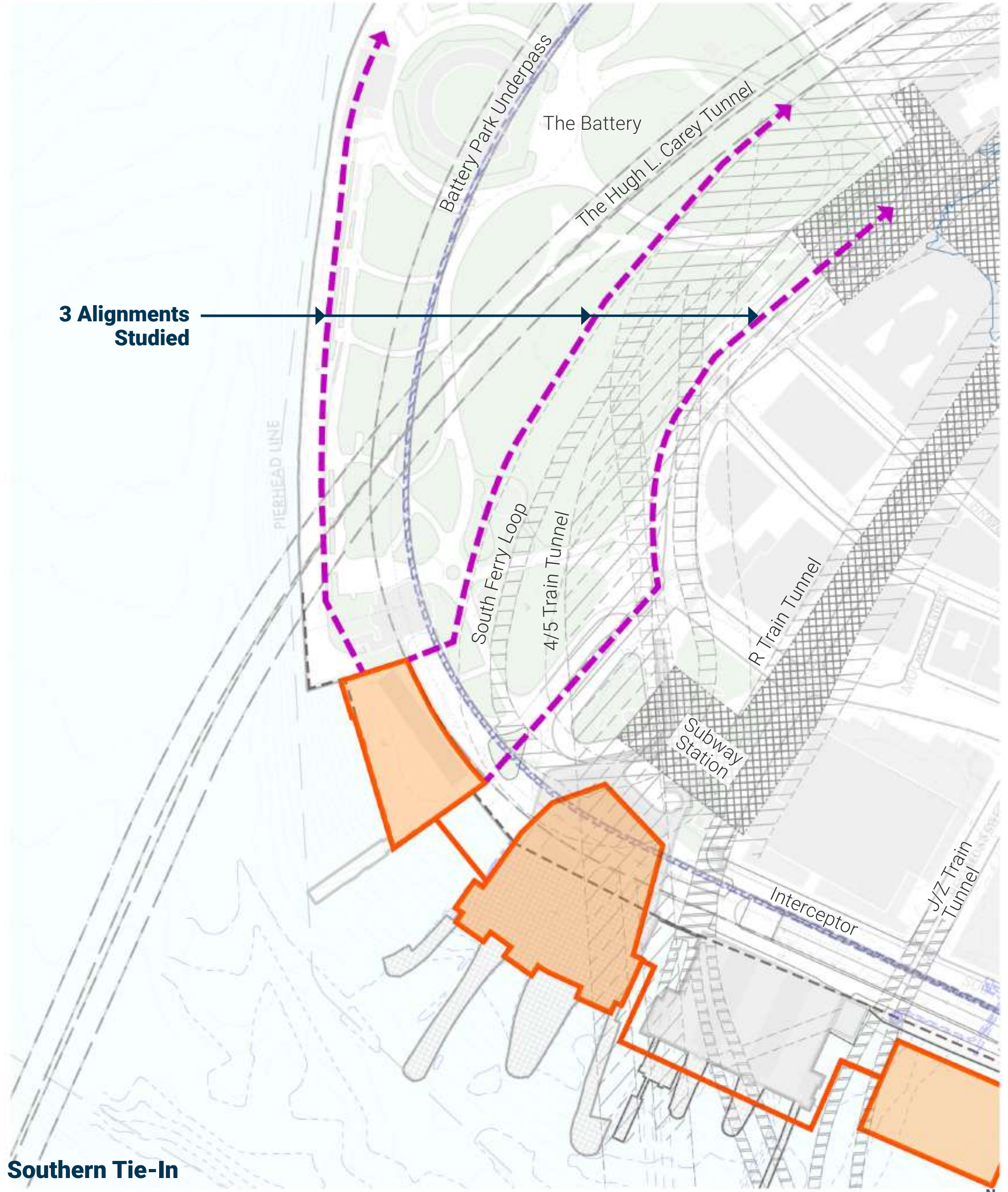
- The 1 and 4/5 subway lines run under State Street and under the back edge of The Battery
- The R subway runs along Whitehall Street and the J/Z tunnel runs beneath Broad Street
- The Battery Park Underpass runs though The Battery, connecting the FDR Drive and West Street, running just upland of Castle 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.

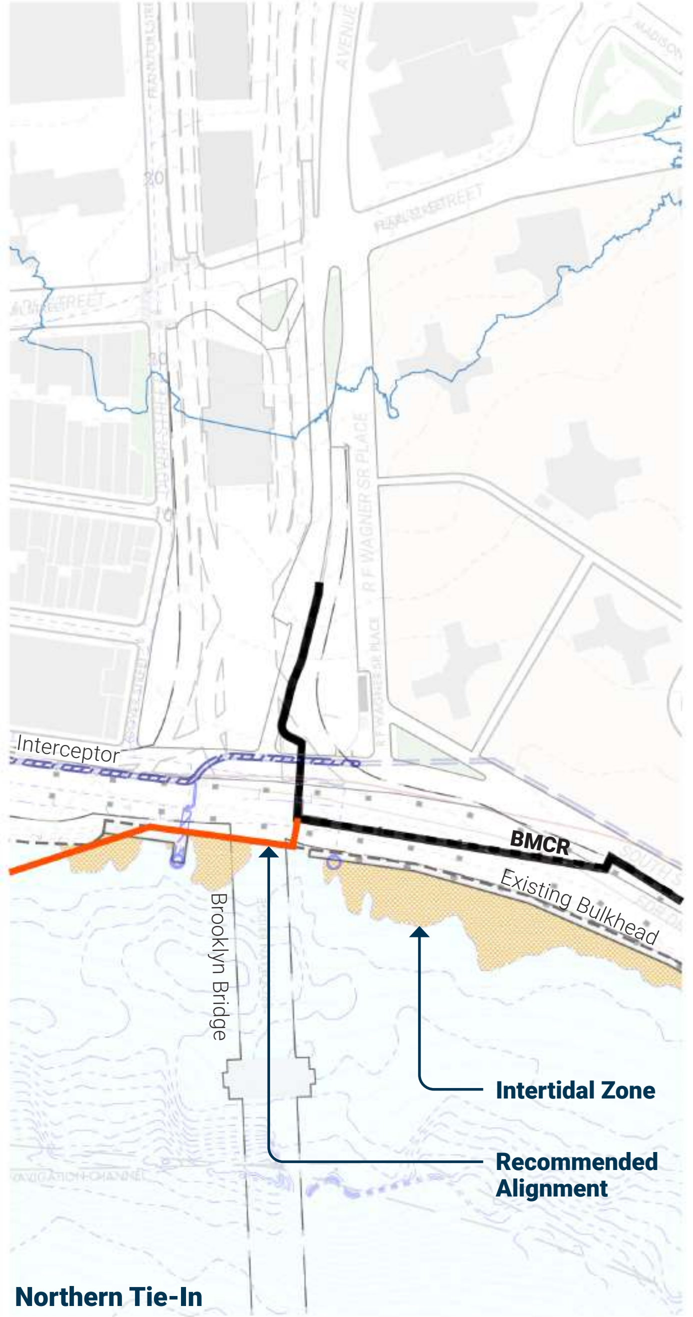
Northern Tie-In

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.



Southern Tie-In



Northern Tie-In

Line of Flood Defense | Integrated Flood Protection | Tie-Ins (For Future Study)

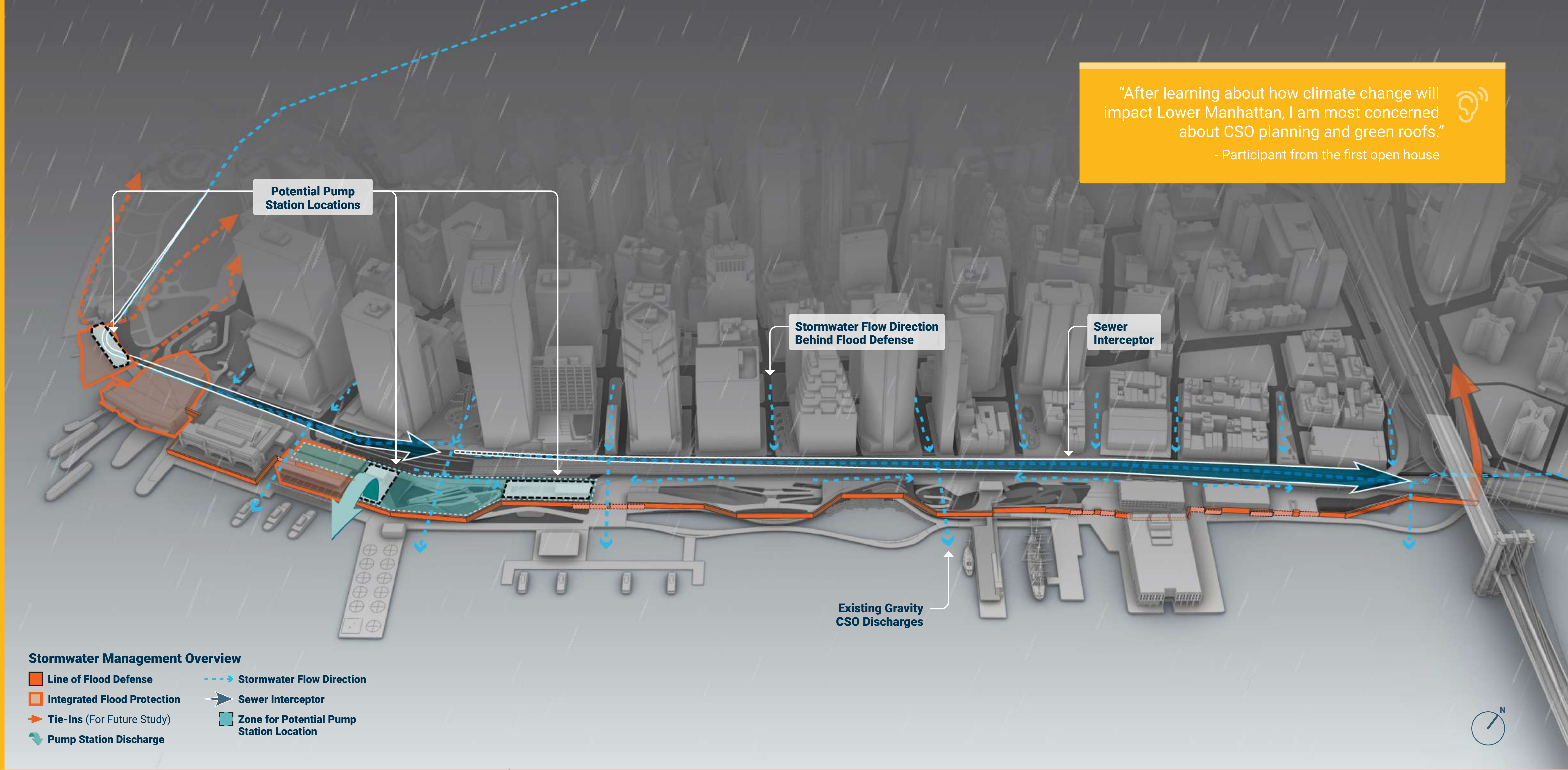
Stormwater Management

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:

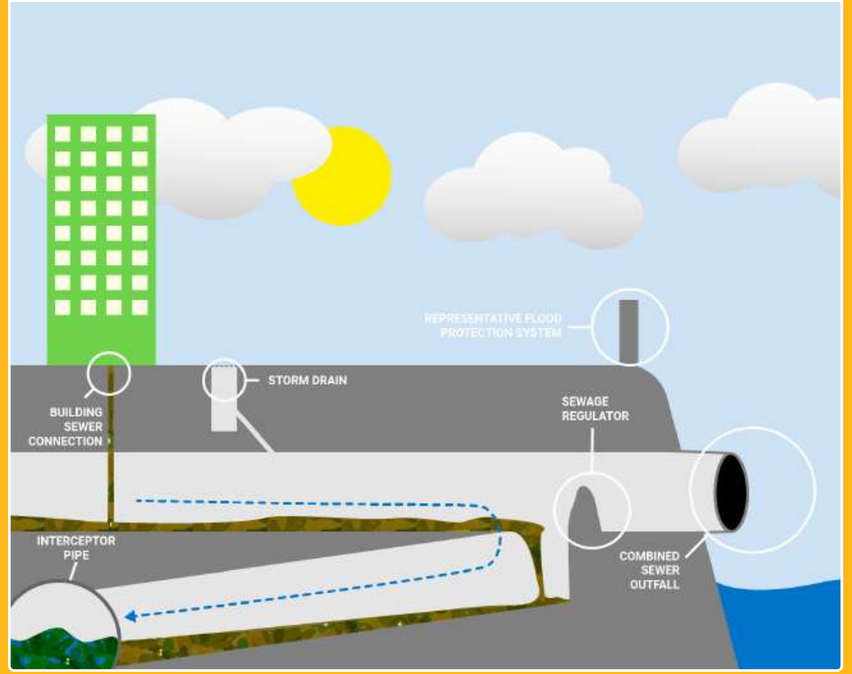
1. How will the sewer system be impacted by climate change?
2. Without drainage improvements, what would the flooding from rainfall look like?
3. What types of drainage infrastructure can be used in the study area to mitigate flooding?

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.

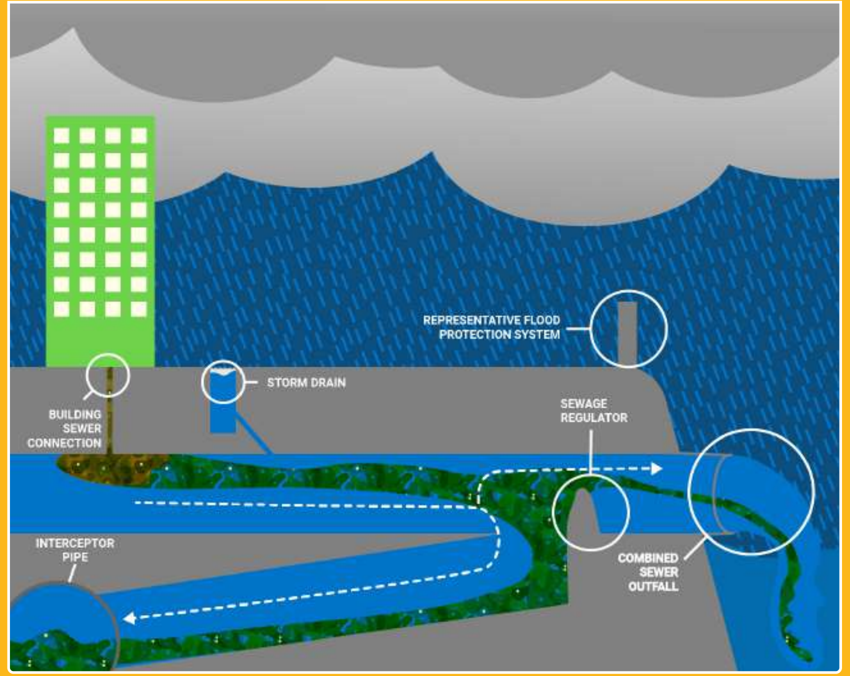
Additionally, the BMCR project, directly north of the study area, will be using an interceptor gate during storms, blocking water from flowing out of the Financial District and Seaport neighborhoods to the wastewater treatment facility in Brooklyn. Therefore, an intervention is needed to move water up 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?



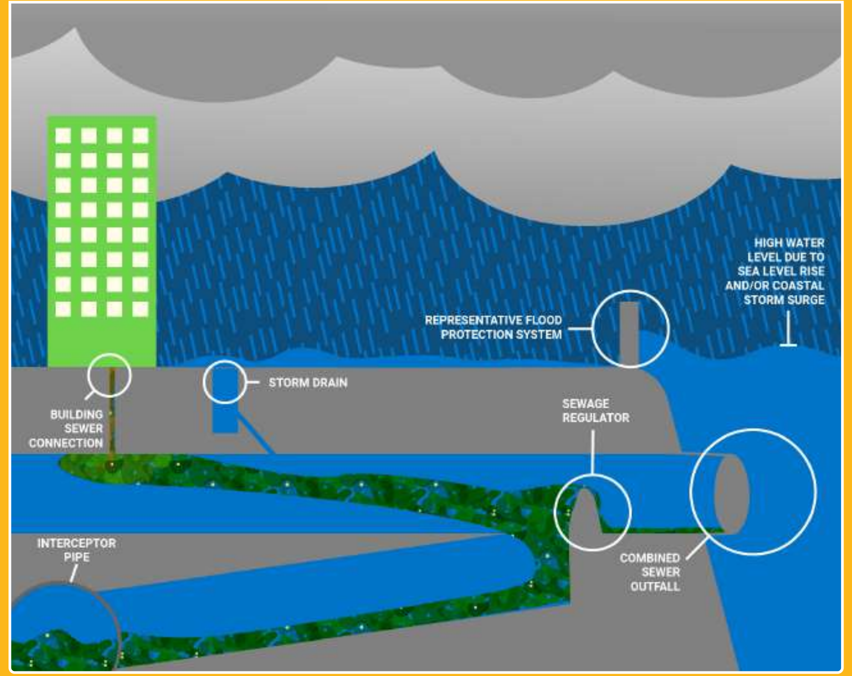
Normal Weather Conditions

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

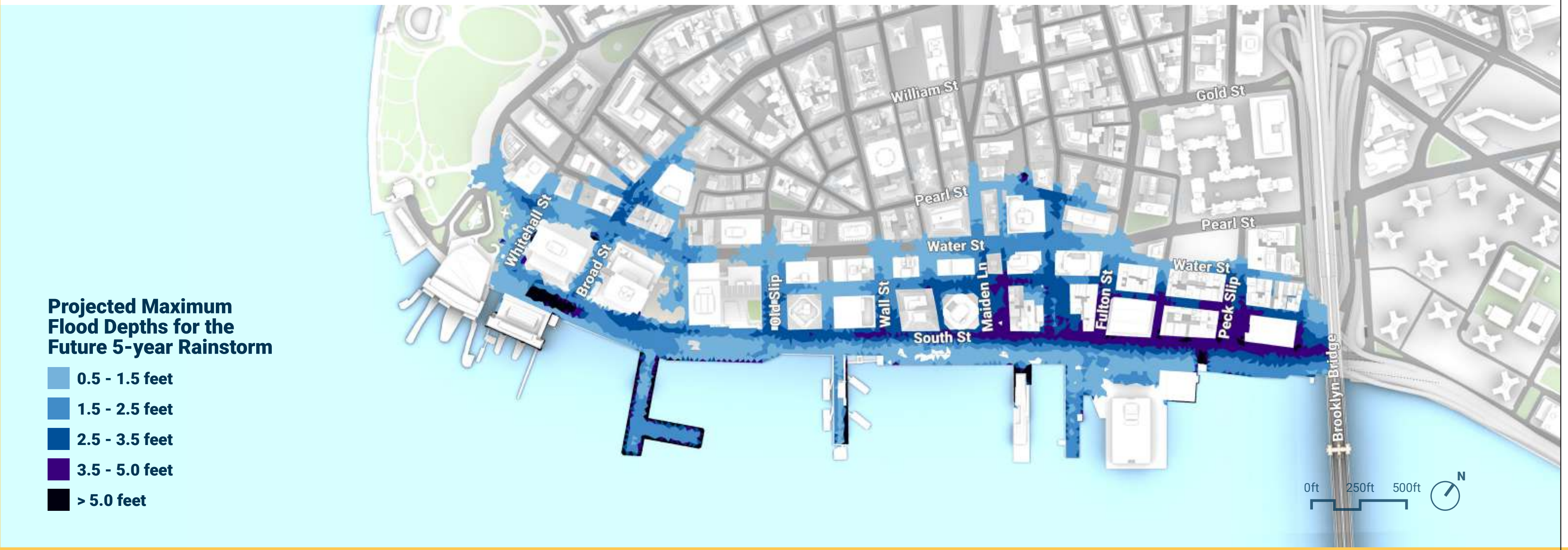
During coastal storms, the sewer system is unable to drain naturally by gravity. The blocking of these outfalls causes the combined stormwater and wastewater flow to back up into streets and basements instead of being discharged into the East River.

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?

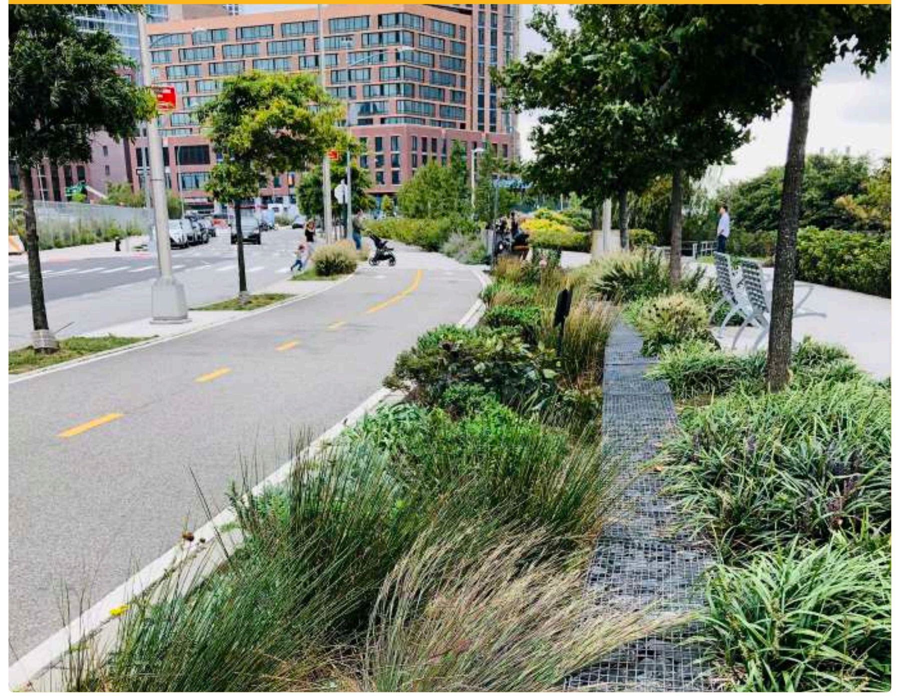
New drainage infrastructure needs to be integrated with the flood defense to manage large volumes of stormwater flooding. The water can either be captured before it enters the sewer system or be managed below ground by upgrading the sewer system so that it does not back up onto the streets.

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)

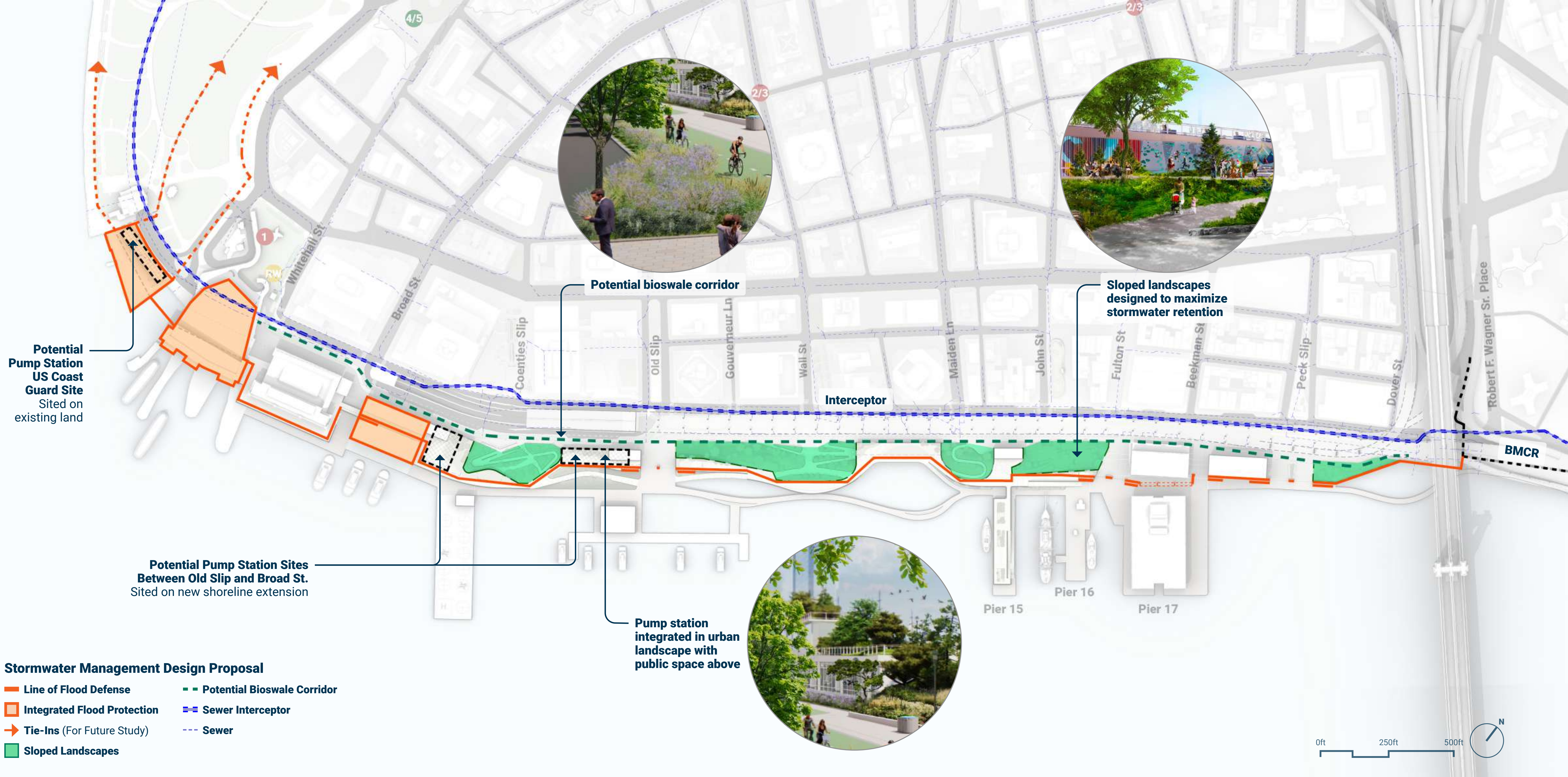
Stormwater Management Design Proposal

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

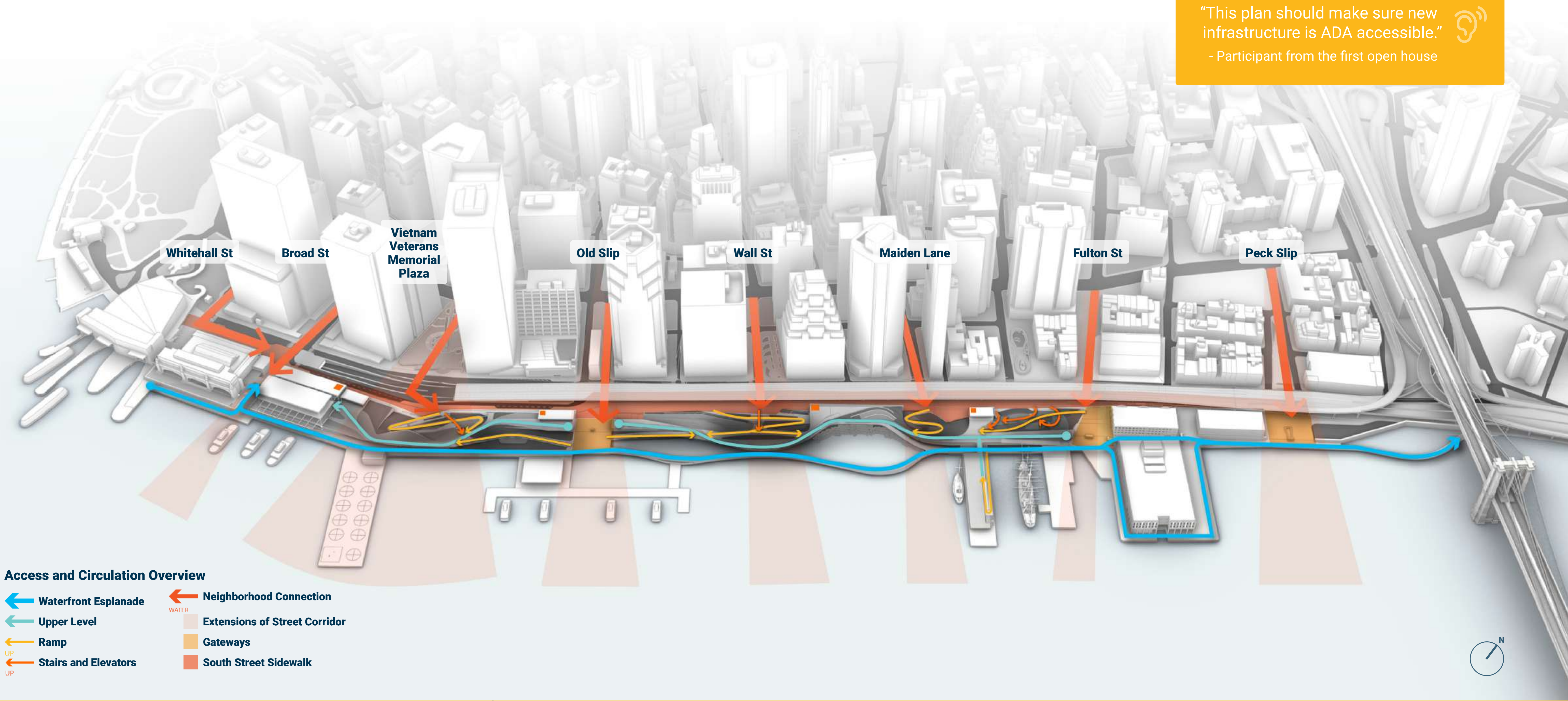
Overview

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



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.

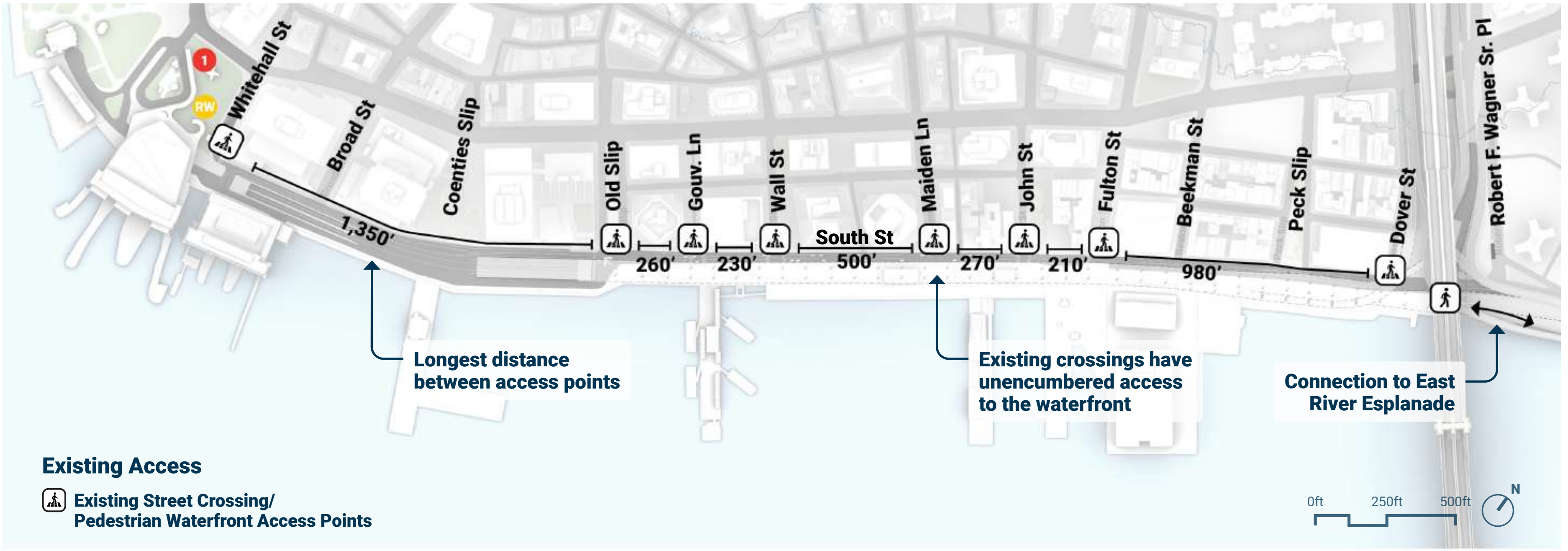
Today, pedestrians can cross South Street at eight locations to reach the shoreline, as shown in the diagram on the top right. While some of these access points are close together (just over 200 feet), existing infrastructure blocks pedestrians from directly reaching the waterfront in other areas. For 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.

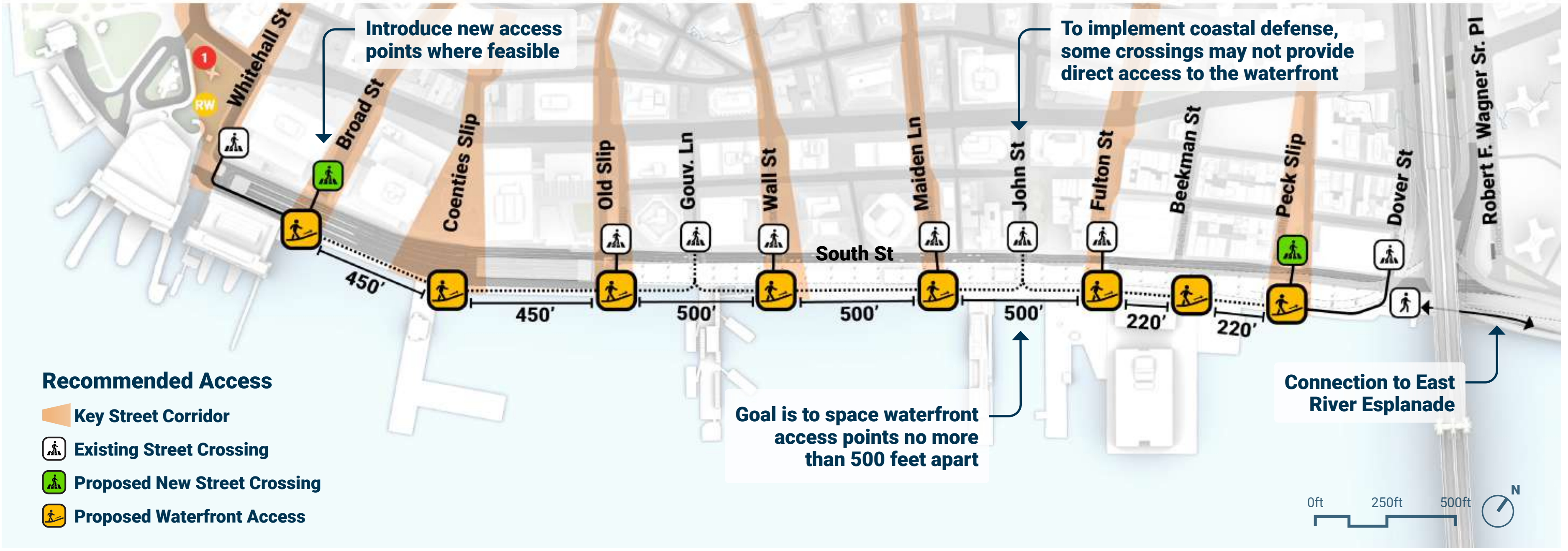
The master plan maintains existing crosswalks. The City is also further exploring the possibility of adding new crosswalks to preserve or reduce the distances people need to travel to cross South Street, where feasible.

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

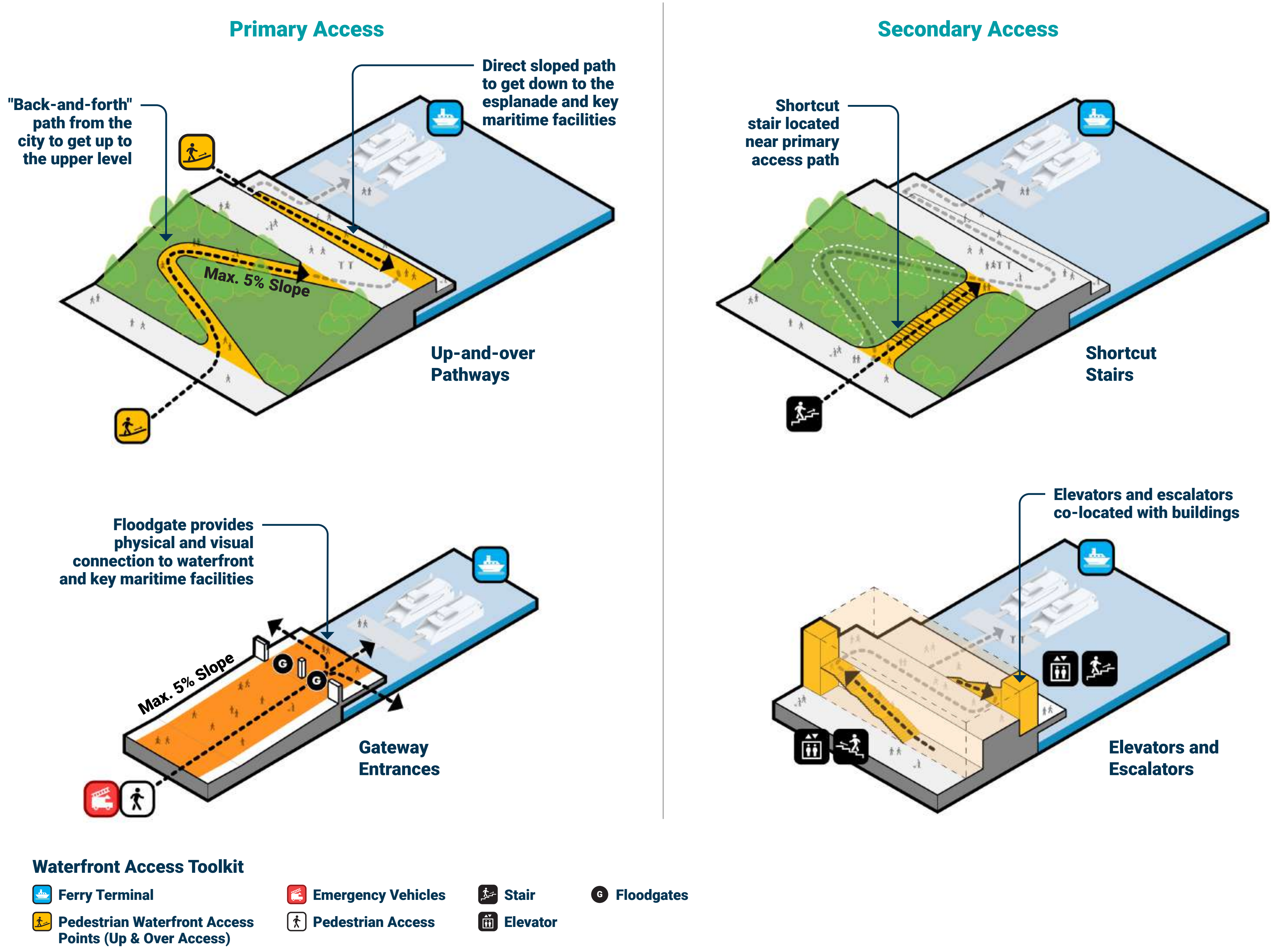
The master plan includes multiple routes to the waterfront. Secondary paths, such as stairs, elevators, and escalators provide options for navigating the waterfront.

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.



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.

Goal 2. Integrate Climate Resilience Infrastructure

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

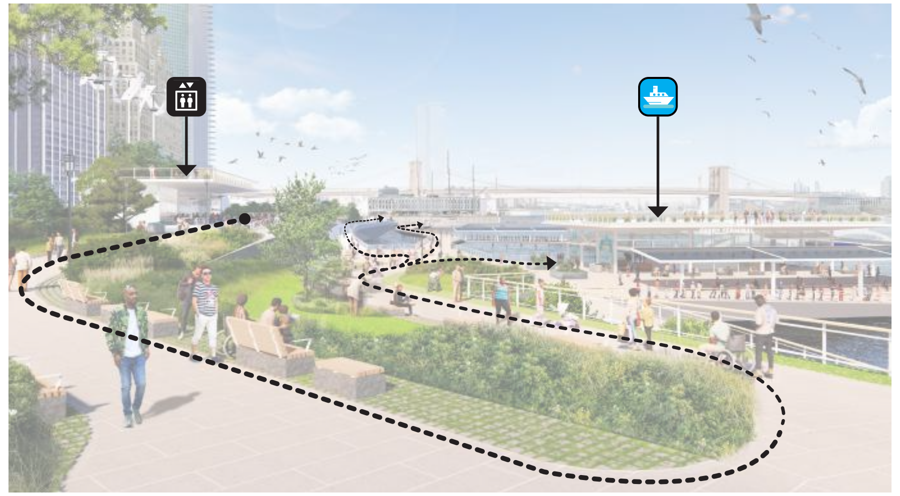
Across the study area, access points are proposed no more than 500 feet apart. From anywhere along South Street, people can visibly see a clear way to get to the waterfront. Gateway entrances are located within street corridors and adjacent to ferry terminals to provide direct visual and physical access 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

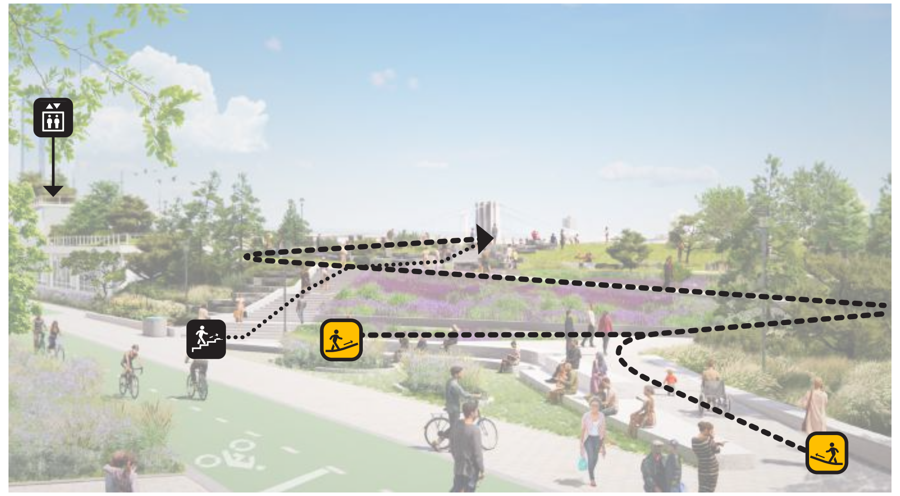
The proposed esplanade provides continuous north-south access along the shoreline edge, providing additional opportunities for people to get down to the water in select locations. In high traffic areas, additional space is provided for circulation and gathering. To minimize conflicts with pedestrians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

Integrating Access

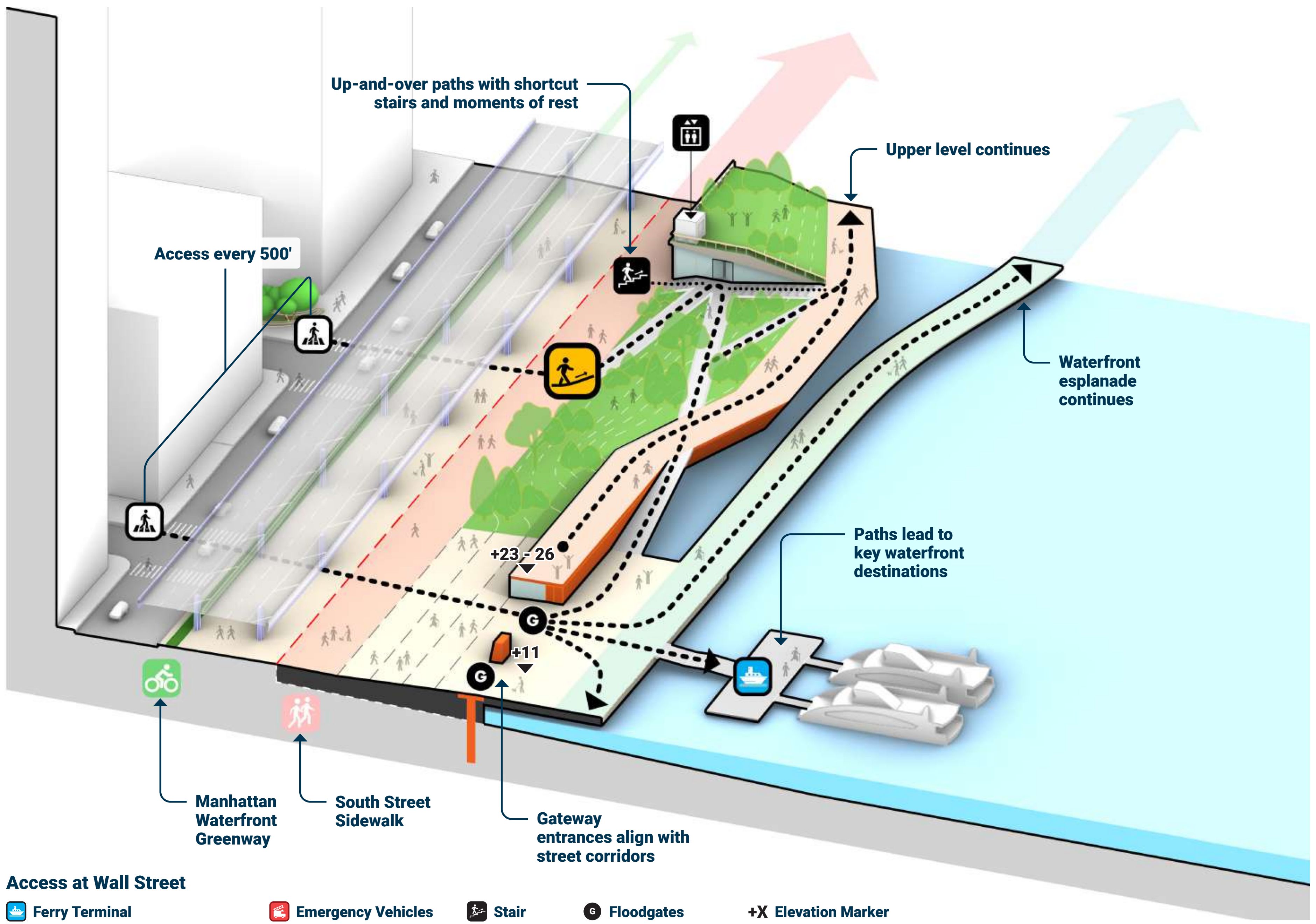
To make the flood defense system a seamless part of the waterfront, proposed access areas also provide opportunities for public space. Grand and inviting paths visually connect back to the many open plazas, parks, and playgrounds that already exist along South Street. Access paths along the waterfront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

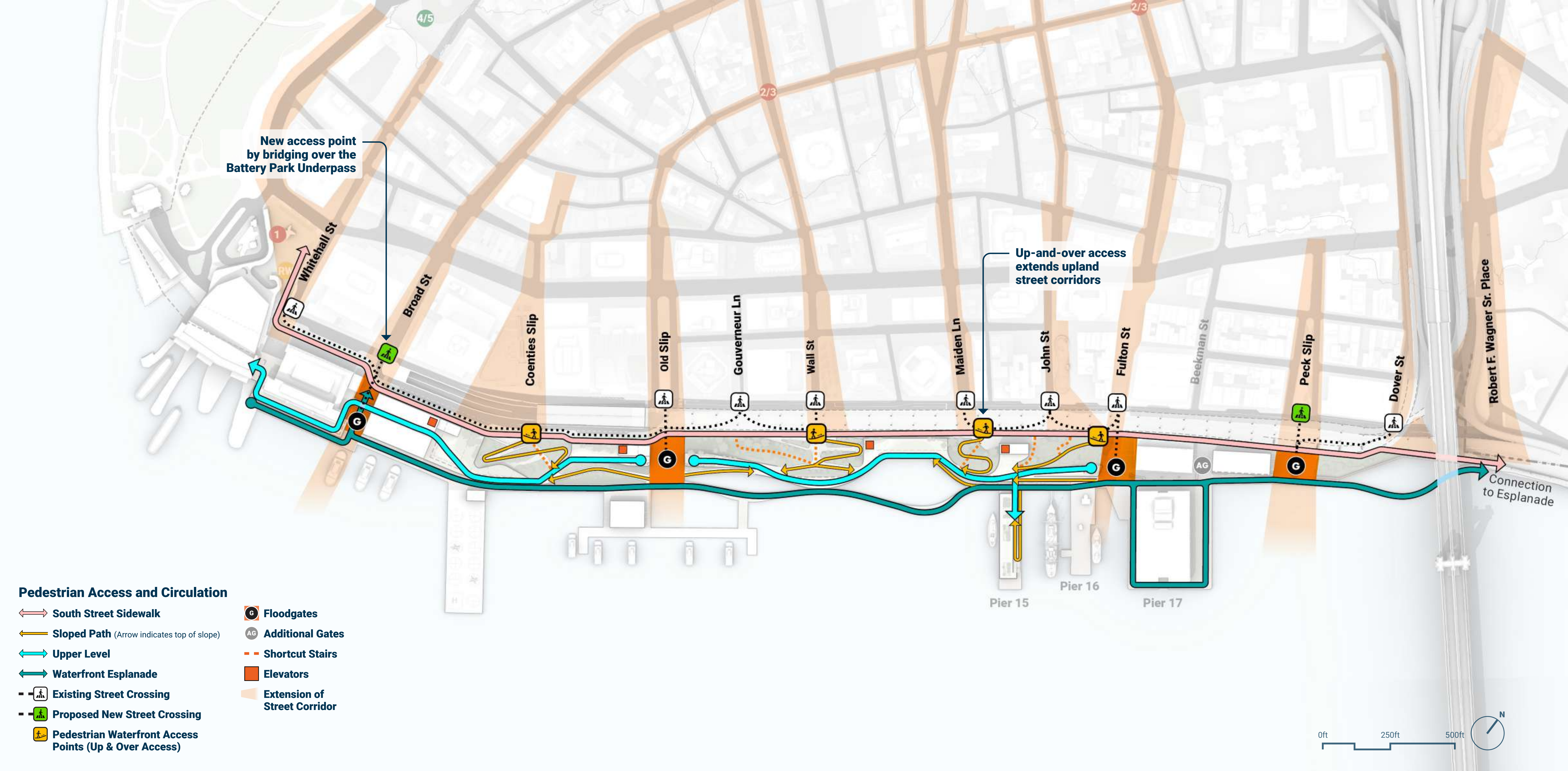
The project team prioritized pedestrian access and circulation in designing the master plan. All proposed primary waterfront access routes are universally accessible paths that are clearly visible from the city and invite the user to the waterfront esplanade. The master plan proposes the following to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



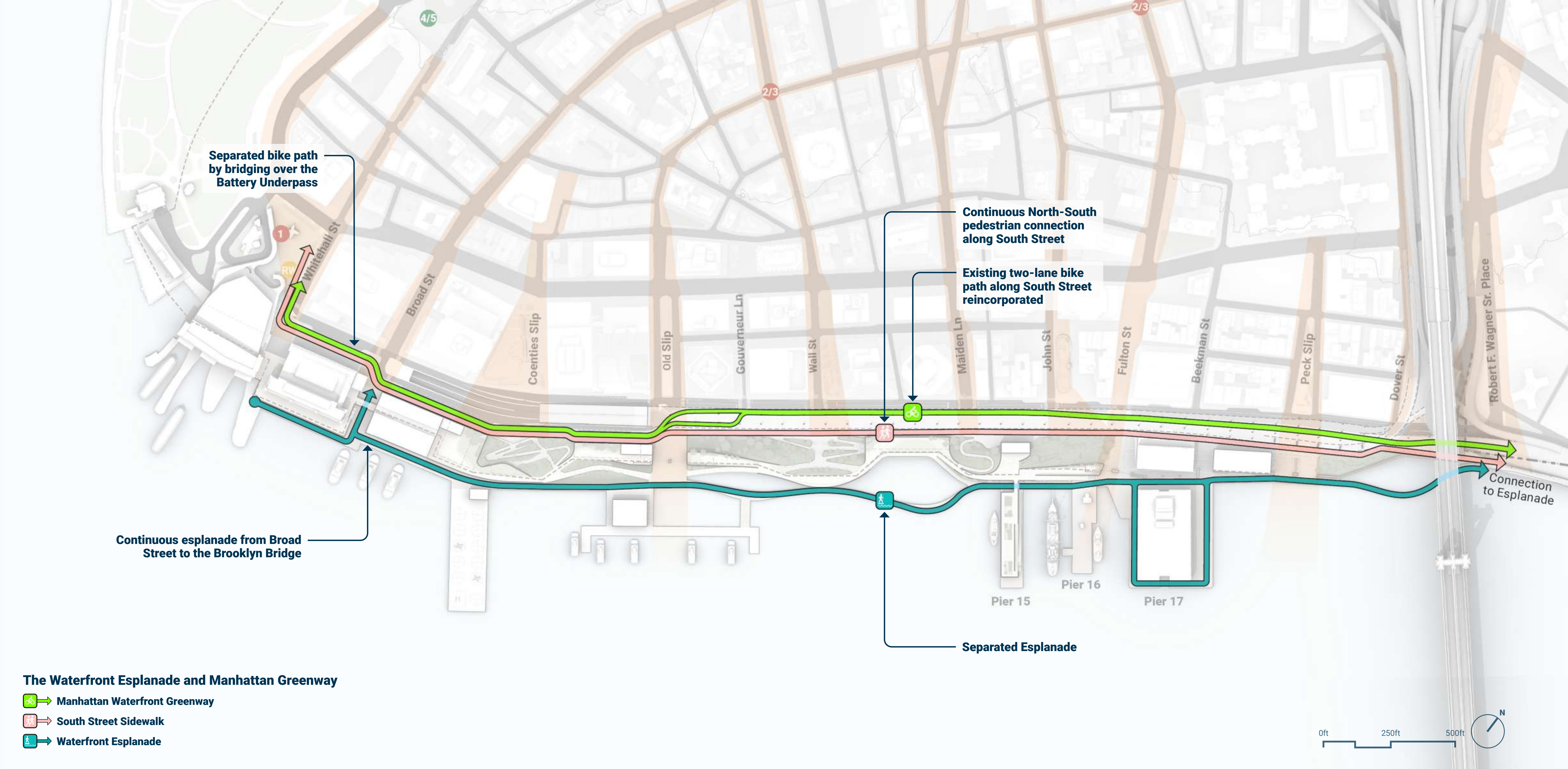
The Esplanade and Manhattan Greenway

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.

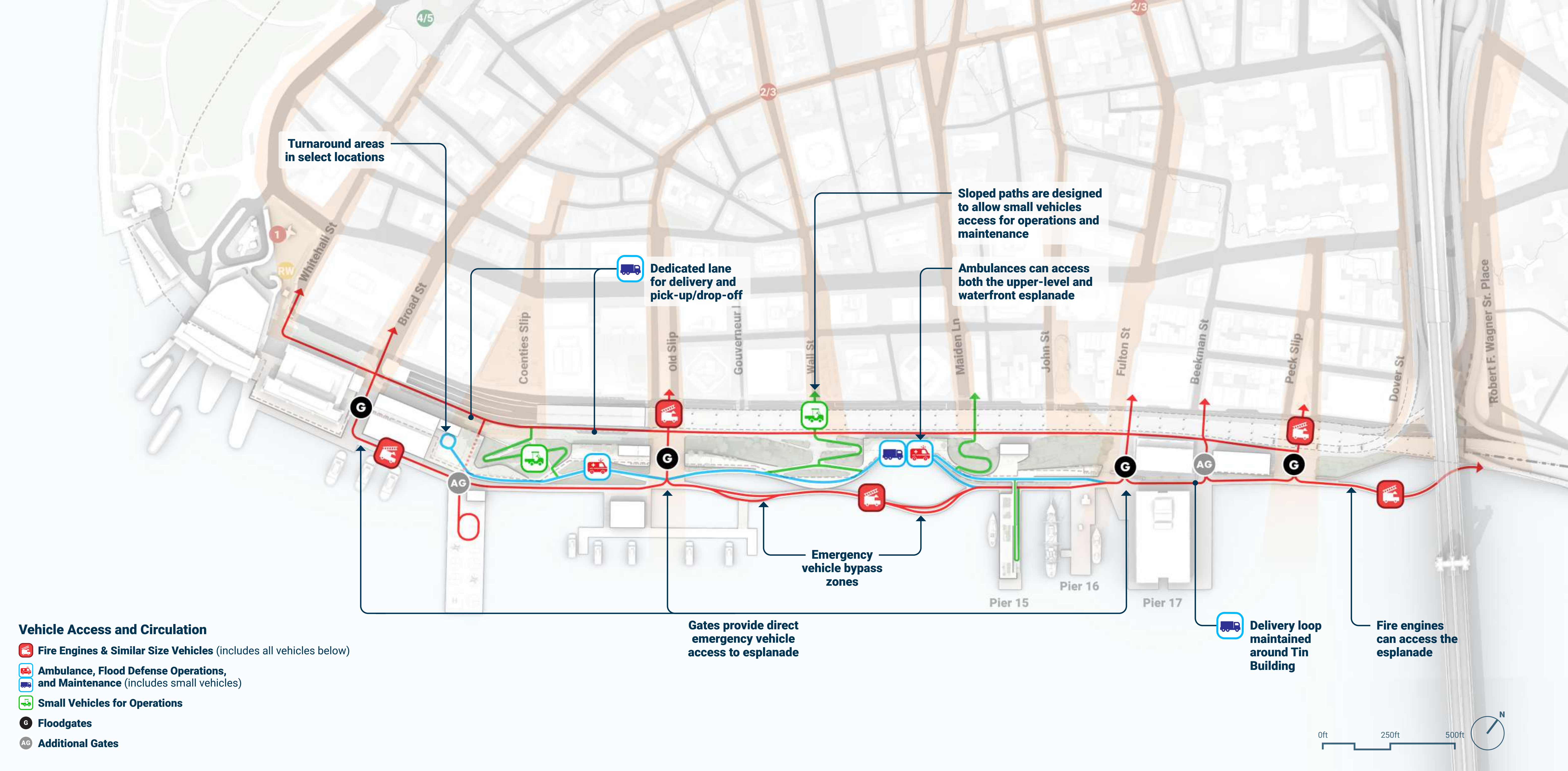
Bike Path

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.



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.



Maritime

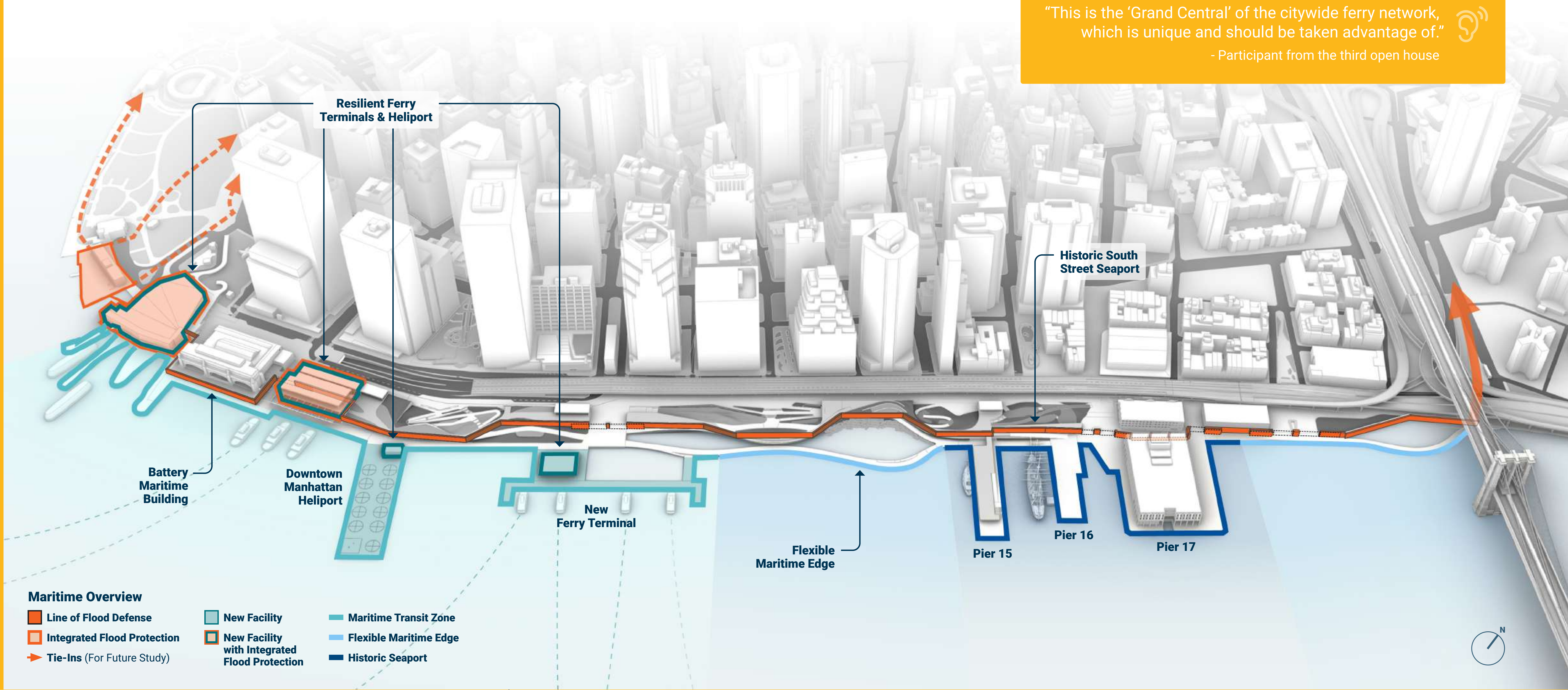
Overview

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.

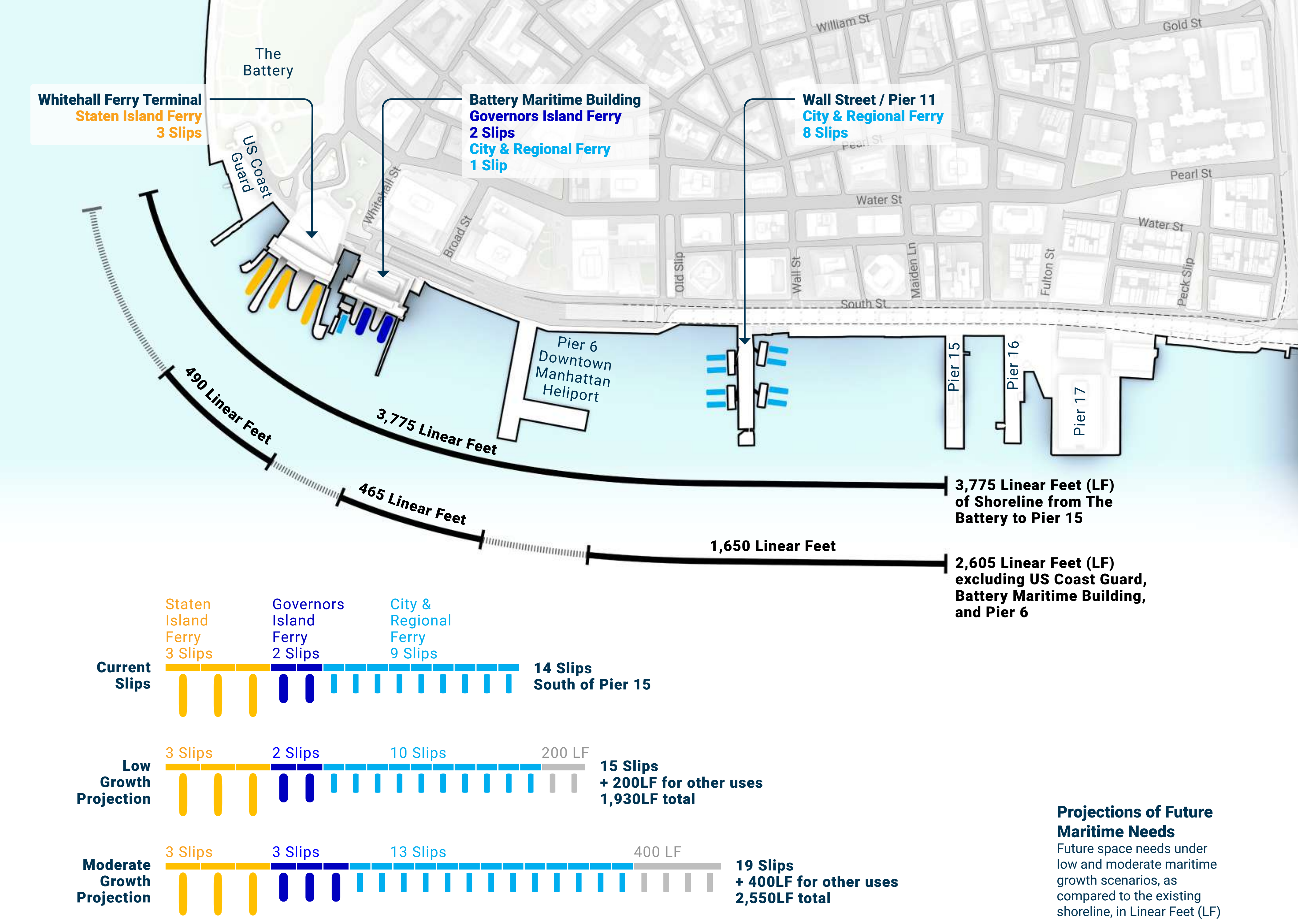
- There are 3,775 linear feet of shoreline from Pier 15 to The Battery. This is the area where current ferry services are located, and the area best positioned for accommodating any additional growth.
- In the low growth scenario, a total of 15 ferry slips would be needed, which would require 1,730 linear 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?

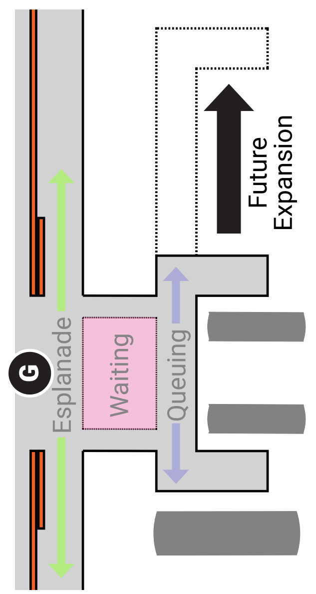
The project team explored a wide range of approaches for how to weave the flood defense system into an active maritime waterfront. This included assessing strategies for adapting existing maritime facilities to be protected from coastal storms and tidal flooding, as well as how to plan for flexibility 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

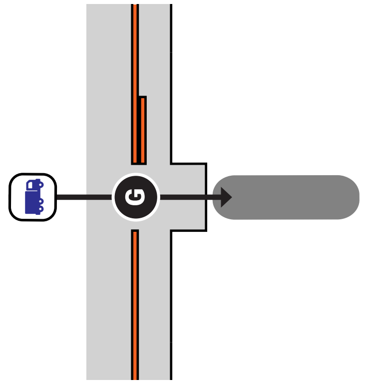
While some places along the waterfront must be set aside for specific maritime uses, like the NYC Ferry or the South Street Seaport museum's historic ships, the master plan proposes the shoreline throughout the study area be designed to accommodate vessel access and tie-ups to allow for a variety of 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)

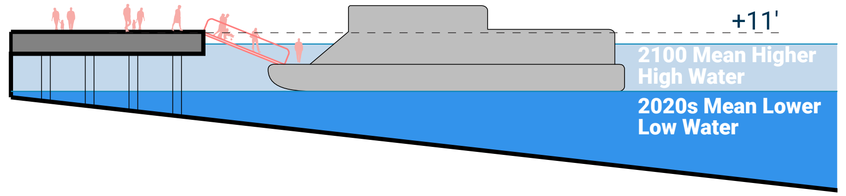


Drive-off Freight / Vehicle Slips (Plan)

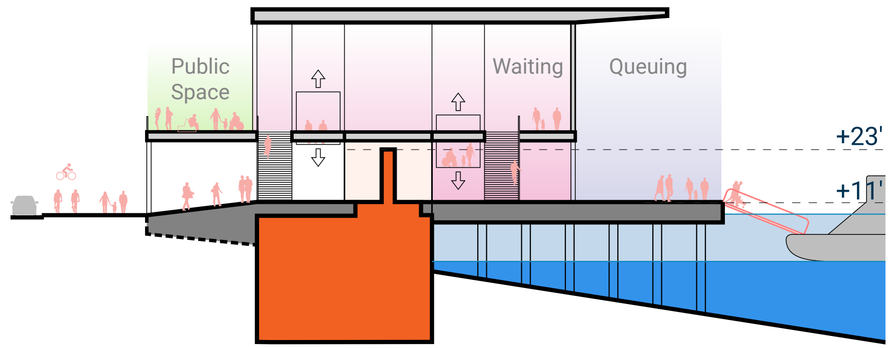
Plan for Future Maritime Freight Access

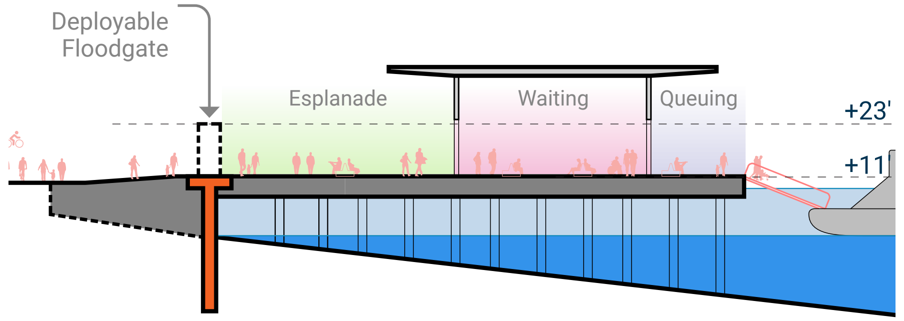
The master plan provides maritime access for freight that could serve future needs for a variety of services, from construction to last-mile delivery. The master plan locates these piers or slips near floodgates to allow direct vehicle access.

Resilient Maritime Structures Toolkit

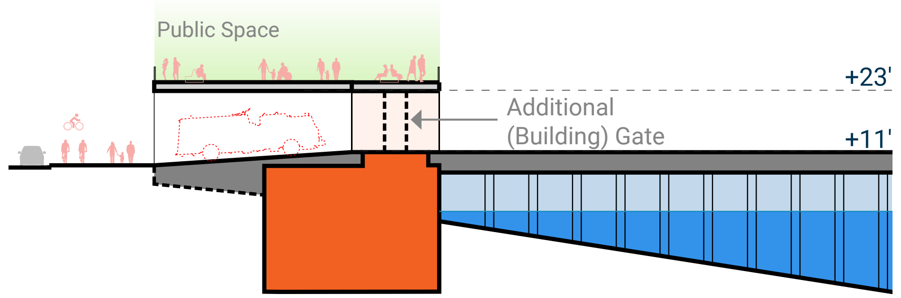


Resilient and Flexible Maritime Edge





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

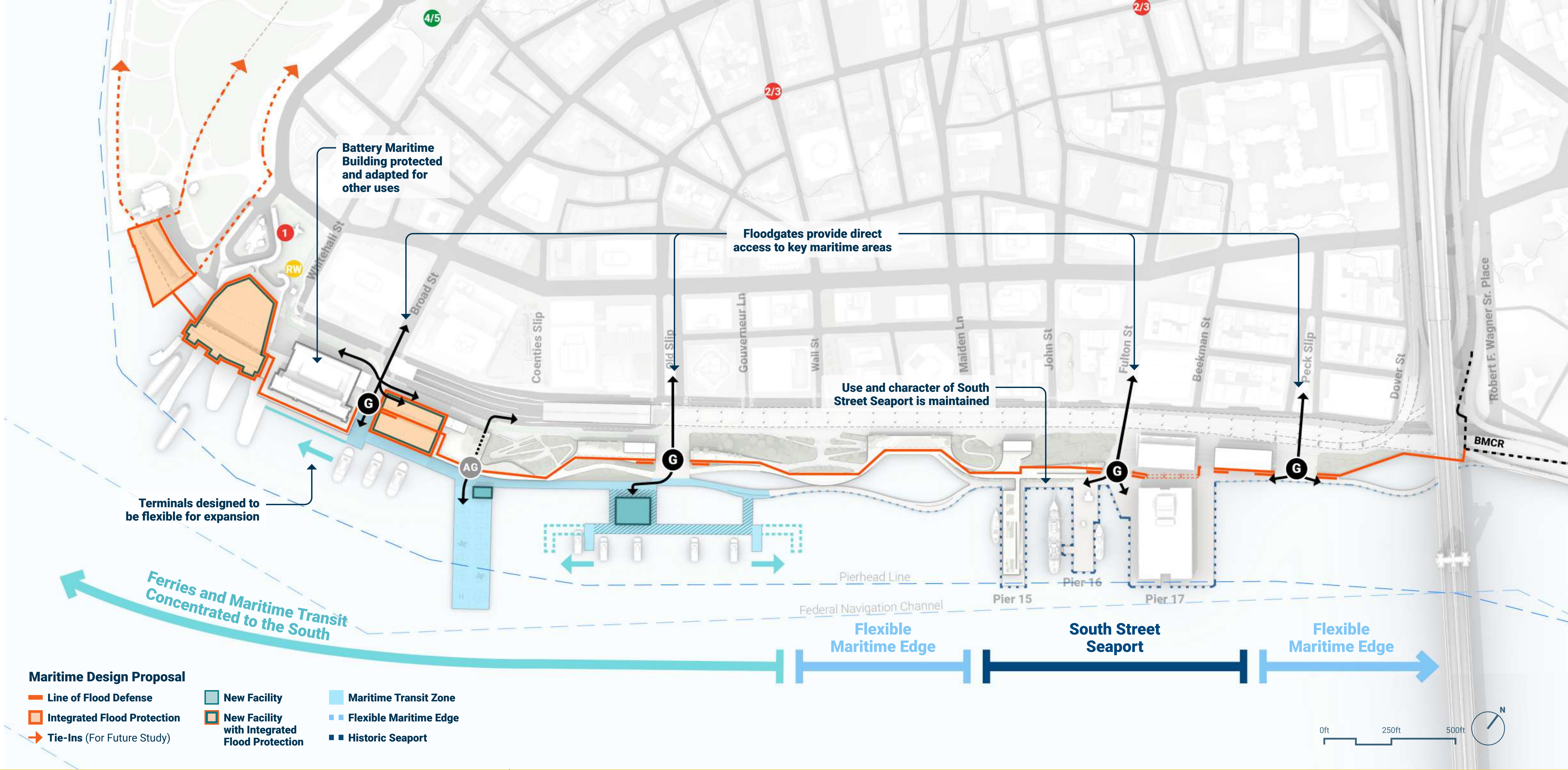
Some maritime facilities located directly on the shoreline, such as Whitehall Ferry Terminal, will need to be redesigned to accommodate the flood defense system through the building. These new and reconstructed facilities will be protected against coastal storms and tidal flooding. Multiple levels are 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

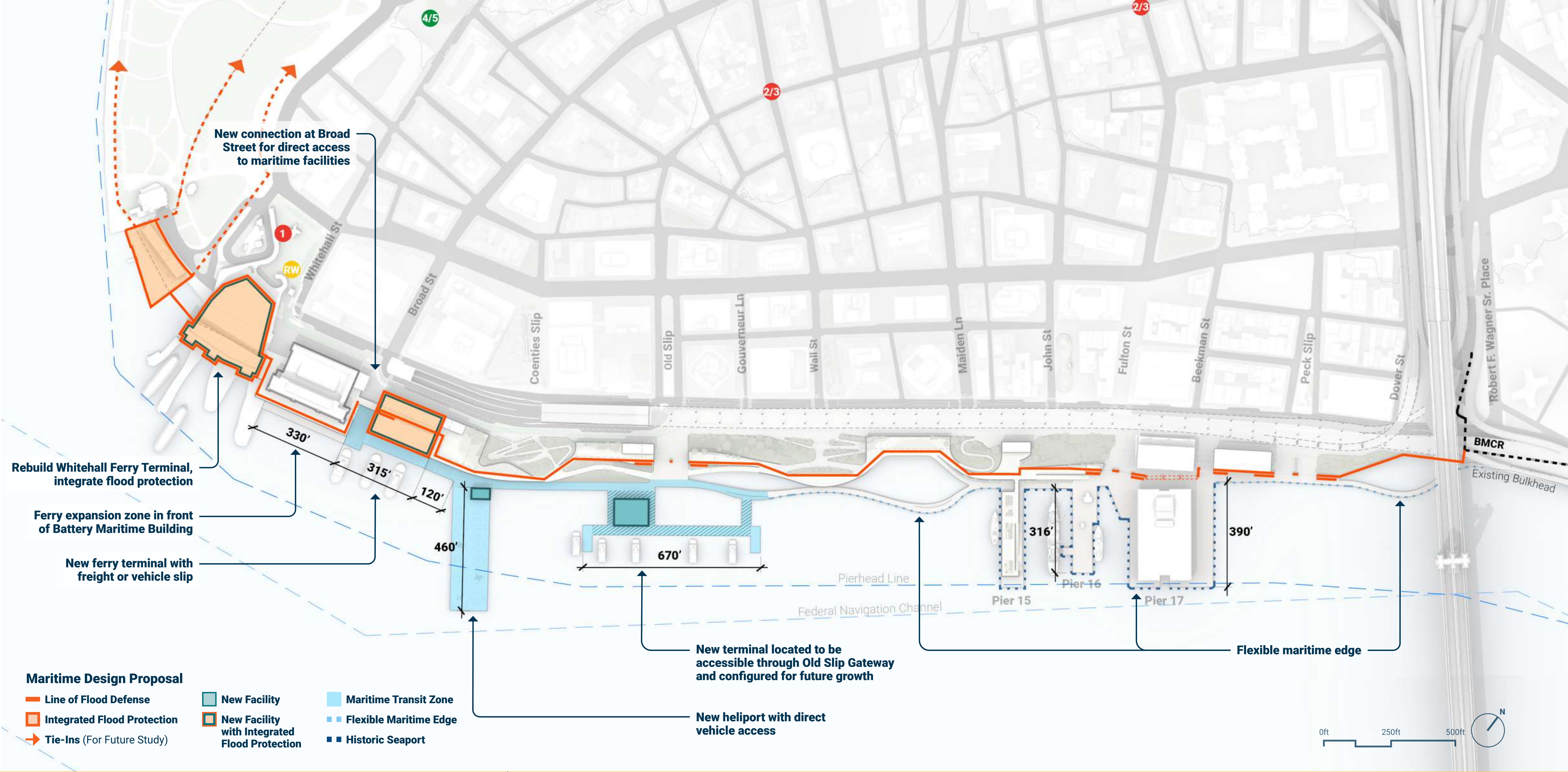
The master plan proposes two new ferry terminals. First, directly to the north of the Battery Maritime Building, a new facility is proposed to provide a resilient gateway to Governors Island and other destinations. Direct vehicle and pedestrian access to the new terminal would be provided by extending 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, 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

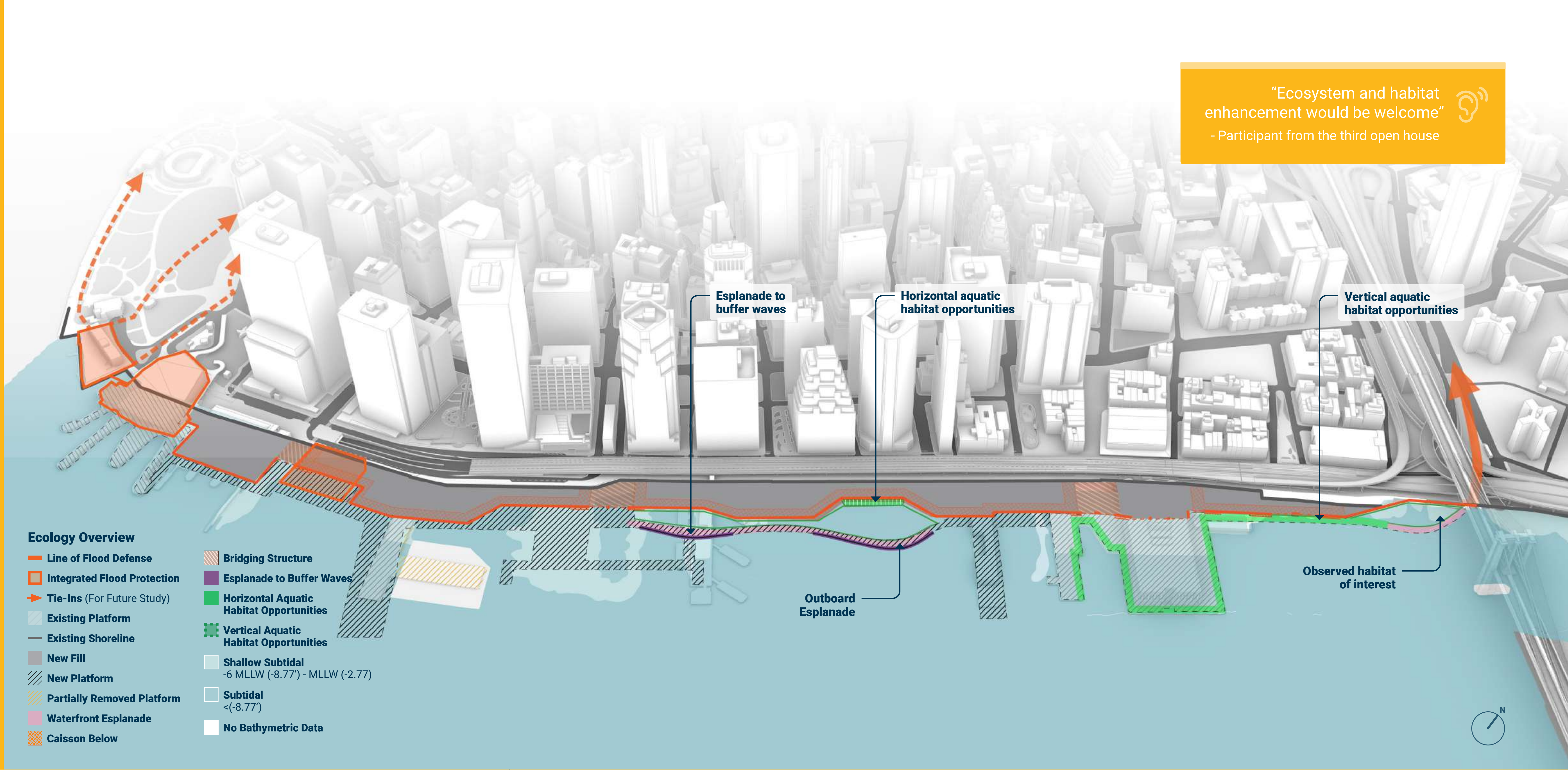
Overview

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

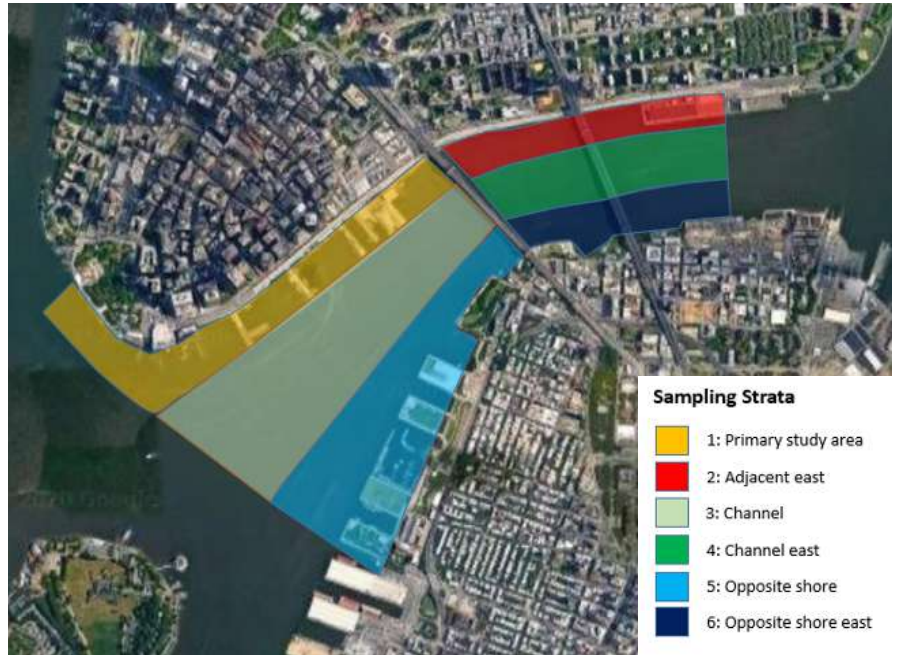
The project team commenced a series of studies and analyses of existing aquatic habitats within the East River, habitat requirements of fish and other aquatic organisms that use these habitats, and opportunities to incorporate enhancements of these habitats into the master plan. The key questions studied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



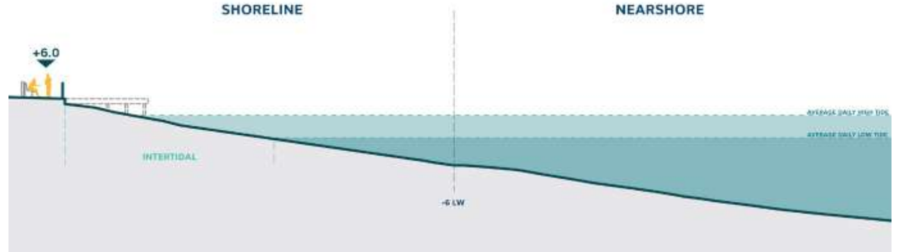
Map of sampling plan strata

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?

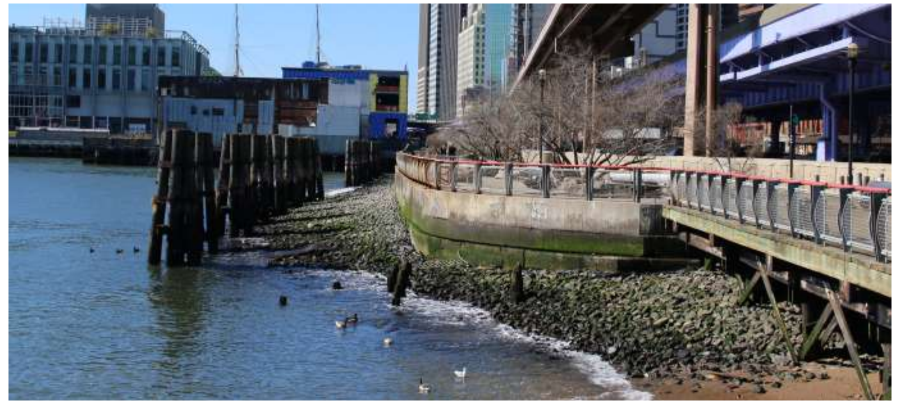
The master plan aims to avoid or minimize impacts to existing aquatic resources by implementing strategies to protect and preserve aquatic ecosystems. While this is one of the City's goals, it is also a necessary approach to obtain the permits and approvals needed to realize the master plan. That is, 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.

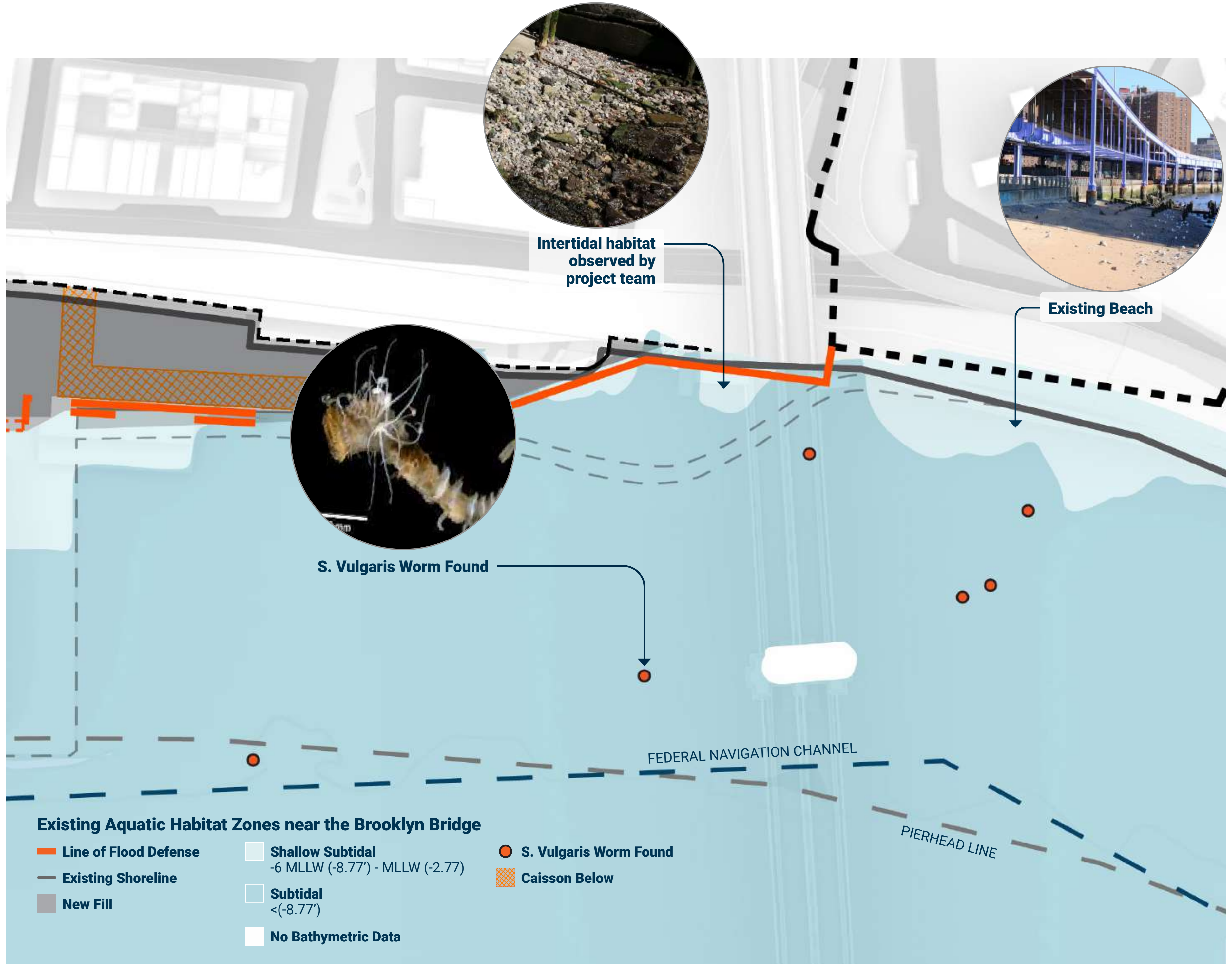
Informed by a year of aquatic sampling, the primary ecological goal for integrating flood defense from The Battery to the Brooklyn Bridge is to minimize the in-water footprint while achieving the master plan's goals. The project team worked to minimize the shoreline extension and reduce new platform 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

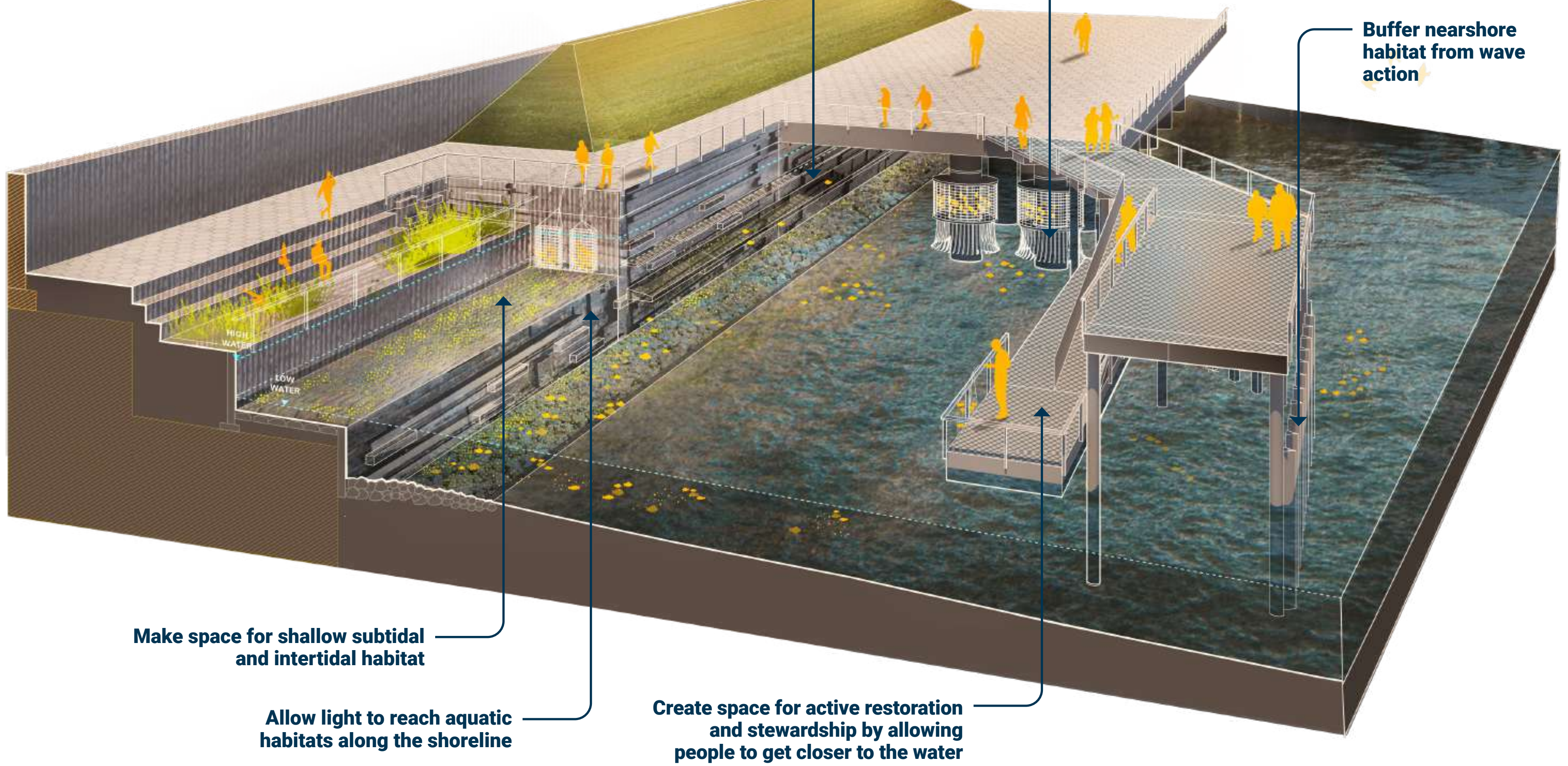
High wave energy that is generated by boat traffic can be disruptive to aquatic habitats and the organisms using them. Wave energy can be dissipated by locating wave attenuating structures that lessen the force of waves and minimize the impacts to habitats. The master plan proposes the use of these wave 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.



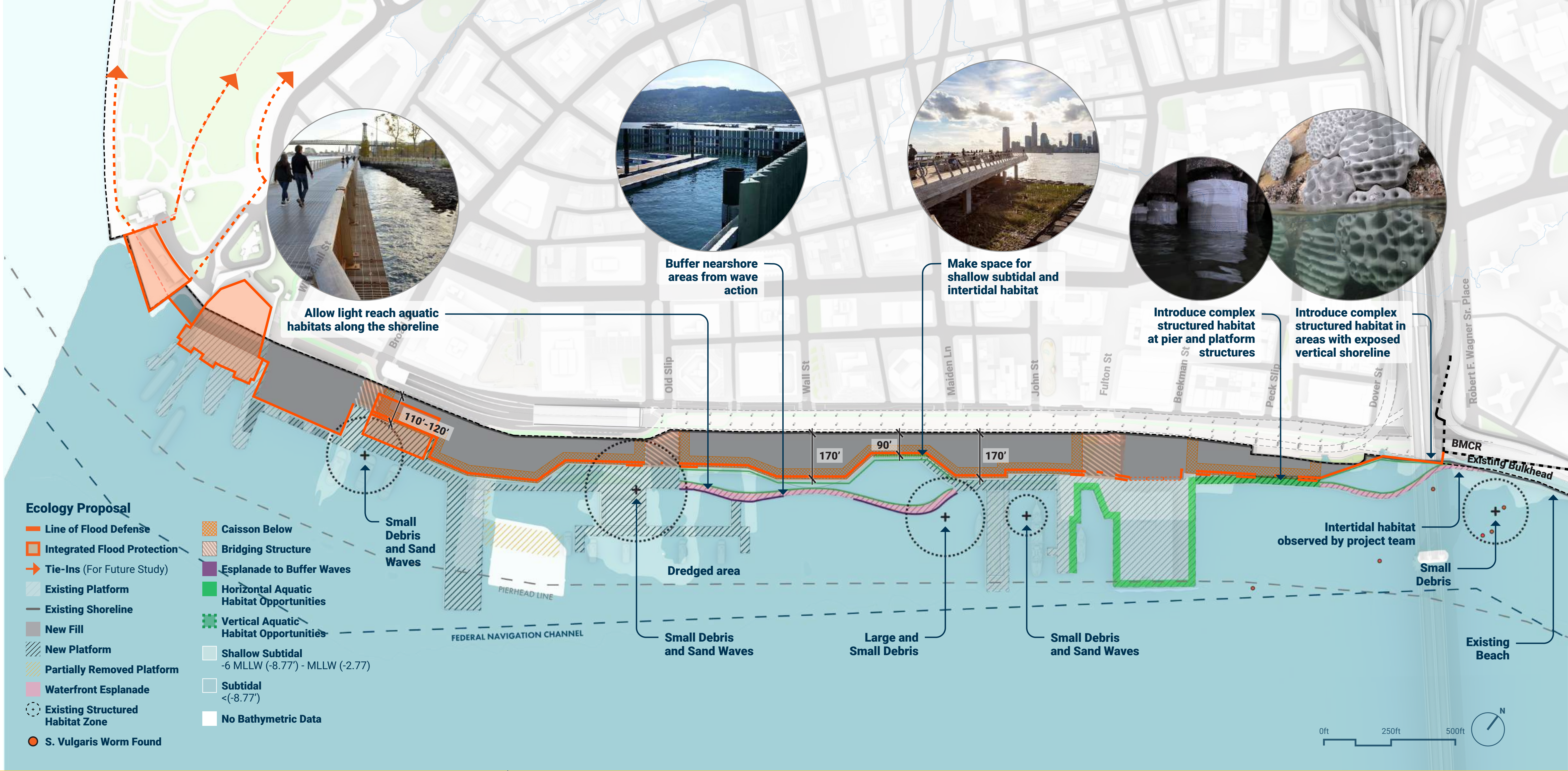
Ecology Proposal

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

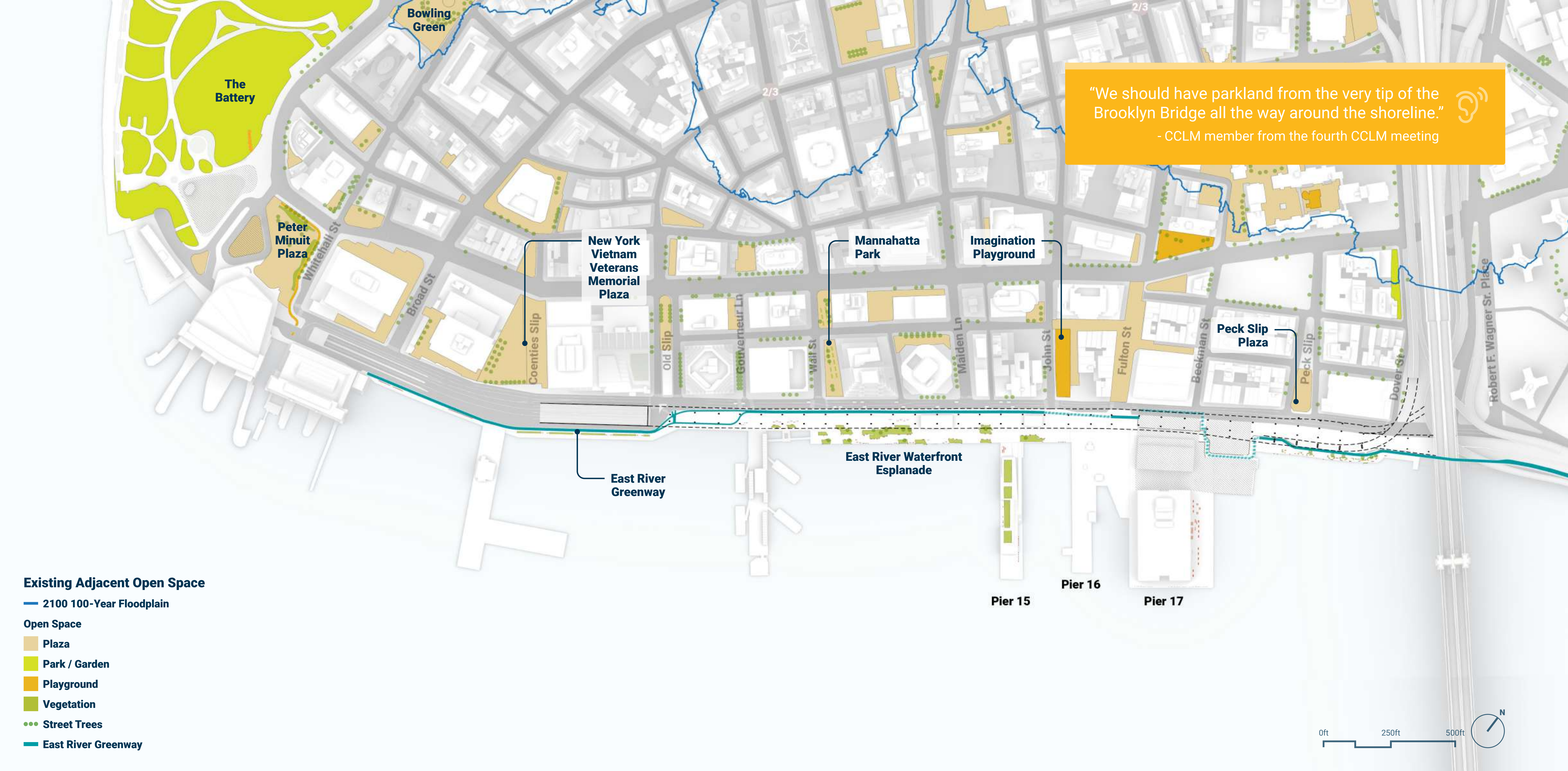


Public Open Spaces and Public-Serving Uses

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.



> "We should have parkland from the very tip of the Brooklyn Bridge all the way around the shoreline."
> - CCLM member from the fourth CCLM meeting

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.

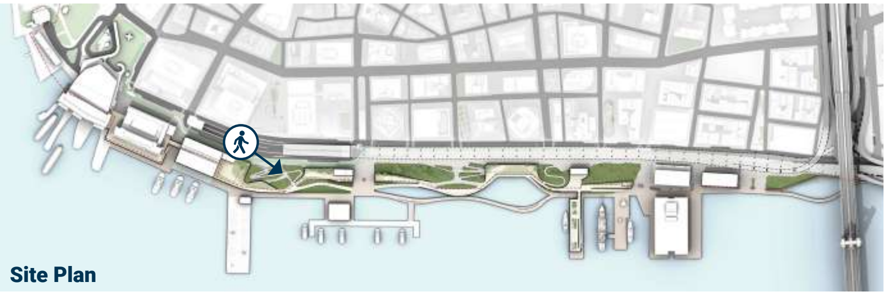
Moving south to north, the following illustrations show what walking along the future resilient waterfront from The Battery to the Brooklyn Bridge could look like. From the Vietnam Veterans Memorial Plaza at Broad Street to the South Street Seaport at Peck Slip, people of all ages and abilities can engage 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 towards Old Slip

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

- Participant from the third open house

Pine Street Cove Looking North

> "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

Fulton Street Waterfront Entrance

"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 Looking towards the East River

"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

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

1. Patrick, Lesley, William Solecki, Vivien Gornitz, Philip Orton, and Alan Blumberg. "New York City Panel on Climate Change 2019 Report Chapter 5: Mapping Climate Risk." The New York Academy of Sciences., March 15, 2019. https://nyaspubs.onlinelibrary.wiley.com/doi/10.1111/nyas.14015#nyas14015-bib-0017.
2. "Datums - NOAA Tides & Currents - NOAA Tides and Currents." Accessed December 7, 2021. https://tidesandcurrents.noaa.gov/datums.html?id=8518750.
3. "Flood Insurance Study." Federal Emergency Management Agency, December 5, 2013.
4. Science in Action: Innovative Research for a Sustainable Future. "Healthy Benefits of Green Infrastructure in Communities." Environmental Protection Agency, August 2017. https://www.epa.gov/sites/default/files/2017-11/documents/greeninfrastructure_healthy_communities_factsheet.pdf.
5. 2010 ADA Standards for Accessible Design, September 15, 2010. https://www.ada.gov/regs2010/201n.d.AStandards/2010ADAstandards.htm.
6. Magazine, Smithsonian, and John Hanc. "On 9/11, a Flotilla of Ferries, Yachts and Tugboats Evacuated 500,000 People Away From Ground Zero." Smithsonian Magazine, September 9, 2021. https://www.smithsonianmag.com/history/911-flotilla-boats-evacuated-500000-new-yorkers-safety-180978614/.
7. "The Staten Island Ferry." Accessed December 7, 2021. https://www.siferry.com/ferry-about.html.
8. New York City Ferry Service. "Reports & Statistics." Accessed December 7, 2021. https://www.ferry.nyc/reports-statistics/.

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%.