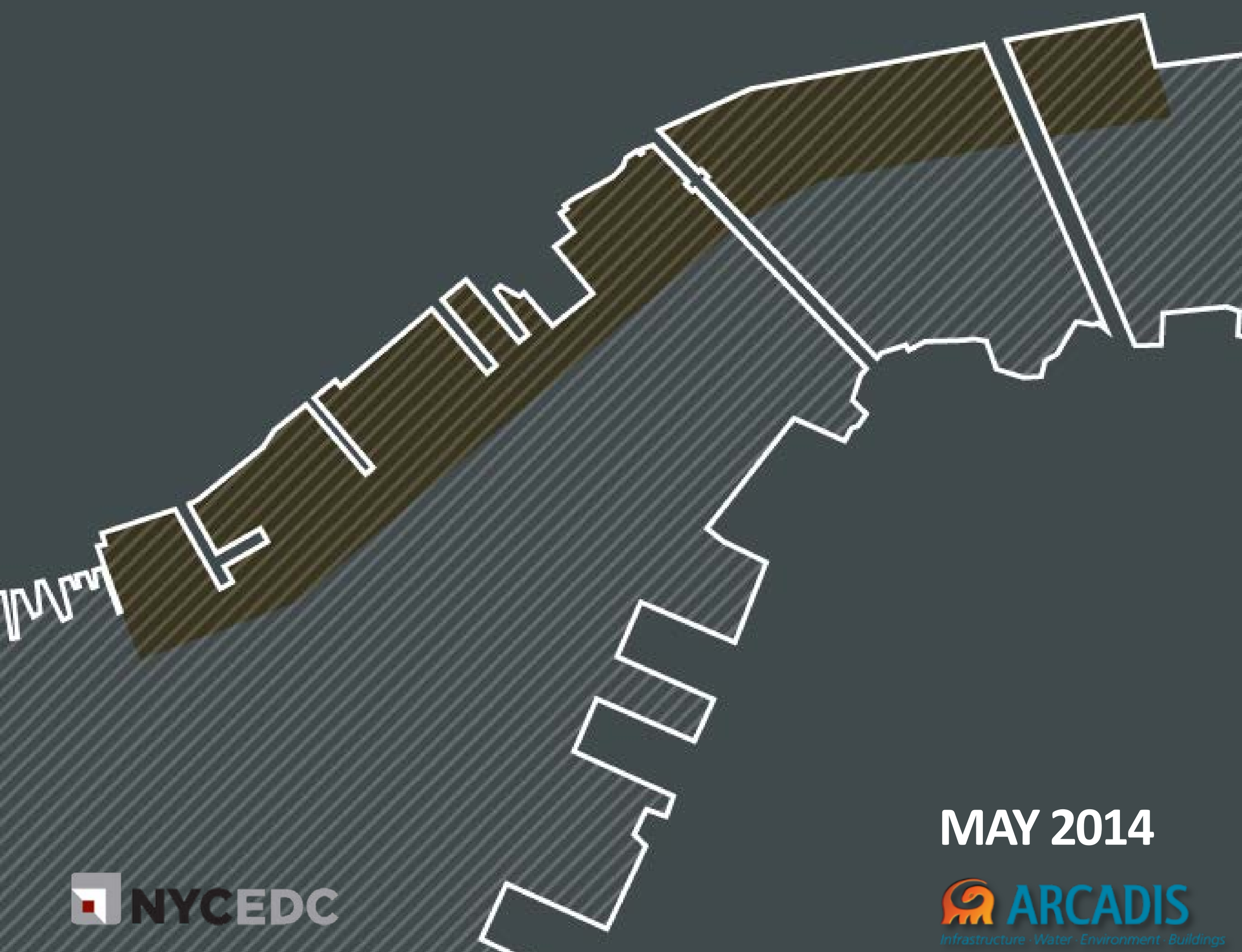
SOUTHERN MANHATTAN COASTAL PROTECTION STUDY: EVALUATING THE FEASIBILITY OF A MULTI-PURPOSE LEVEE (MPL)



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Infrastructure · Water · Environment · Buildings

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Executive Summary

Hurricane Sandy hit New York City in October 2012, highlighting the city's vulnerability to extreme weather events. While Hurricane Sandy is one data point, this single event not only demonstrated but also heightened the awareness around the increasing impacts of climate change, particularly sea level rise ("SLR") and storm surge, in New York City's coastal areas. The resulting discussion has expanded an understanding of the need to adapt to a changing climate and, consequently, of the importance of resiliency investments.

Even before Hurricane Sandy, the City's PlaNYC initiatives established New York as a leader in the efforts to plan better for the impacts of climate change. The City's response to Sandy's impacts has furthered that leadership. In December 2012, the City launched a Special Initiative for Rebuilding and Resiliency ("SIRR") in order to (i) assess the risks faced by New York City's infrastructure, buildings, and communities in connection with climate change and (ii) create a strategy that increases New York City's resiliency to such risks. A comprehensive strategy was ultimately outlined in the June 2013 "A Stronger, More Resilient New York" plan (the "Resiliency Plan"), which recommended 257 specific initiatives to rebuild the neighborhoods that were hardest hit by Sandy and make the city's infrastructure ready for future risks.

One of the 257 initiatives is the further study of a multi-purpose levee ("MPL") concept to protect Southern Manhattan from the risk of coastal flooding. New York City Economic Development Corporation ("NYCEDC") was called to lead this initiative, which evaluates the technical (engineering, environmental), legal, and financial feasibility of developing this type of flood protection infrastructure along a portion of Southern Manhattan's East River waterfront.

The *Southern Manhattan Coastal Protection Study: Evaluating the Feasibility of an MPL* report (the "Feasibility Study") was conducted by a team led by ARCADIS U.S., Inc.. The team also included HR&A Advisors, Inc., FXFOWLE Architects, WXY Studio, Sive, Paget & Riesel P.C., AKRF, Inc., Ocean and Coastal Consultants, and Jesse M. Keenan (the "Study Team"). The Feasibility Study focused on an approximately 1.3-mile span of the eastern edge of Manhattan, from the Battery Maritime Building to Pier 35 (the "Study Area"). The Feasibility Study also analyzed adjacent areas that would be integral to a comprehensive flood protection solution for Southern Manhattan.

The Feasibility Study concluded that:

1) An MPL is technically feasible in the Study Area and will not induce flooding either in adjacent neighborhoods or across the East River.
2) An MPL is legally feasible within the existing regulatory framework. However, the required permitting/approvals processes will be complex and lengthy.
3) An MPL is financially feasible and could not only be self-financing, but could also help finance complementary flood protection investments in Southern Manhattan.

The MPL options and conceptual development programs evaluated within the report were defined for feasibility analysis purposes; the findings within do not comprise a development proposal. The process to articulate, assess, and advance an actual development proposal for an MPL will be long and complex, and will require extensive local stakeholder engagement and coordination. The commitment to effectively address the known climate change risks must remain as the core driver of that process, especially regarding all future work that builds upon and follows up on this Feasibility Study.

1 Introduction

1.1 Context

New York City, like many global waterfront cities, is highly vulnerable to the effects of climate change, including SLR and extreme storm events such as Hurricane Sandy. The city's significant population and valuable assets compound these risks significantly.

A key to New York City's successful long-term resiliency and sustainability lies in creating and maintaining a synergy between urban function, flood protection, and economic development along the waterfront. There is no single solution or approach to climate change adaptation and coastal flood protection. Adaptable, passive, multi-functional approaches to flood protection that contribute to urban quality and potentially generate economic value are preferable solutions, when feasible.

In 2013, the City developed the Resiliency Plan to proactively address the climate change risks that New York City faces today and into the future. One of the 257 recommendations in the plan is to further study an MPL concept that not only protects the eastern edge of Southern Manhattan from the risks of SLR and storm surge, but also creates development opportunities which, over time, accommodate the city's growth and make the MPL infrastructure self-financing. This report documents the work carried out by the Study Team to assess the technical, financial, and legal feasibility of implementing such flood protection elements. Outreach was conducted throughout the course of this Feasibility Study with local elected officials, Community Boards 1 and 3, and certain local, state, and federal agencies (collectively, "Stakeholders").

1.2 Project Goals

Many factors are involved in determining the individual components of a citywide flood protection strategy. While the primary goal of each component is to enhance flood protection and resiliency, additional key factors, or goals, must be taken into account so that each element is successfully integrated into an optimal overall strategy. Project goals can vary by element, depending on the area where the specific flood protection element will be deployed, as well as on the strengths, weaknesses, opportunities, and threats to the overall strategy.

MPLs have been implemented in a variety of urban waterfronts around the world to effectively achieve distinct combinations of project goals. Ultimately, the projects have sought to optimize the coastal resiliency, visual quality, and long-term sustainability of the locations where the MPLs have been deployed. To achieve their distinct purposes, MPLs have taken many forms, combining different physical configurations, land uses, and infrastructure.

This is the context for the Feasibility Study, which analyzes the feasibility of deploying a variety of MPL and other flood protection solutions along the eastern edge of Southern Manhattan. The starting point for this analysis is a discrete set of project goals:

1) Enhanced flood protection for Southern Manhattan;
2) Resiliency program funding source (i.e., the ability to self-finance and/or generate surplus revenue to fund other resiliency efforts); and,
3) Economic and community development (i.e., new economic activity, affordable housing, and open space; integration with Southern Manhattan's urban fabric and character).

The project goals arise from broad strategic and location-specific considerations that derive from both the Resiliency Plan and discussions between the Study Team and NYCEDC over the course of the Feasibility Study. The project goals inform the entire analysis documented in this report and help define the framework for recommendations and proposed next steps. The goals should be not only the guideposts for further stages of project analysis and implementation but also the main conceptual underpinnings of the flood protection solution that is ultimately pursued for the Study Area.

2 Resiliency for Southern Manhattan

2.1 Flood Risk

Current trends in climate change suggest that short- and long-term impacts will amplify the threat of extreme weather events in New York City. When coupled with SLR, this threat will present major physical challenges and risks to the city. While one data point is not a trend, Hurricane Sandy illustrated that it is imperative to reconsider how to protect the city's coasts.

As temperatures continue to rise, so will sea levels, and the increase of both temperature and sea levels will increase the risk of large storm tide events.[1] According to the New York City Panel on Climate Change ("NPCC"), New York City's sea level is expected to rise between 15 inches (low estimate) and 75 inches (high estimate) by the 2100s.[2] Rising seas dramatically increase the odds of damaging floods from storm tide; climate change more than triples the odds of a 100-year or worse flood occurring by 2030 in New York City.[3,4]

Currently, the existing bulkhead at The Battery in Southern Manhattan is approximately 7 feet North American Vertical Datum of 1988 ("NAVD88").[5] High estimates of SLR projections show an approximately 7 foot (10 feet NAVD88) increase at The Battery by the 2100s, with the mean projection showing an increase of approximately 4 feet (7 feet NAVD88) by the 2100s. As sea levels continue to rise, the bulkhead could eventually be underwater unless action is taken.[6]

SLR alone could flood areas behind the bulkhead before the century ends. The potential combined effects of storm tide and SLR could put Southern Manhattan in an especially vulnerable position; for a 100- and a 500-year storm tide event, the storm tide would rise to more than double the elevation of the existing bulkhead.[7] Water surface elevation estimates are approximately 19 feet NAVD88 for the 100-year event and 23 feet NAVD88 for the 500-year event by the 2100s.[8]

[1] Storm tide pushes additional water along the shoreline and is often a major storm's greatest threat to life and property. Storm tide impacts are further amplified when tides enter narrower water bodies (e.g., from an ocean to a river), as is the case in the New York Harbor; a funneling effect causes peak water elevations to rise even further.

[2] 2013 SLR projections from the NPCC. http://www.nyc.gov/html/planyc2030/downloads/pdf/npcc_climate_risk_information_2013_report.pdf

[3] A 100-year flood event is a flood event that has a 1 percent chance of happening in any year.

[4] Climate Central, "New York and the Surging Seas" (2013).

[5] NAVD88 is the national vertical datum standard. A vertical datum is a base measurement point (or set of points) from which all elevations are determined.

[6] While The Battery is not in the Study Area, it is close enough to the Study Area that its data can be used to make meaningful predictions for the Study Area. The Battery is a useful reference point due to the significant hydrologic and hydraulic data that exists for this location.

[7] A 500-year flood event is a flood event that has a 0.2 percent chance of happening in any year.

[8] Based on data from National Oceanic and Atmospheric Administration ("NOAA") and the NPCC.

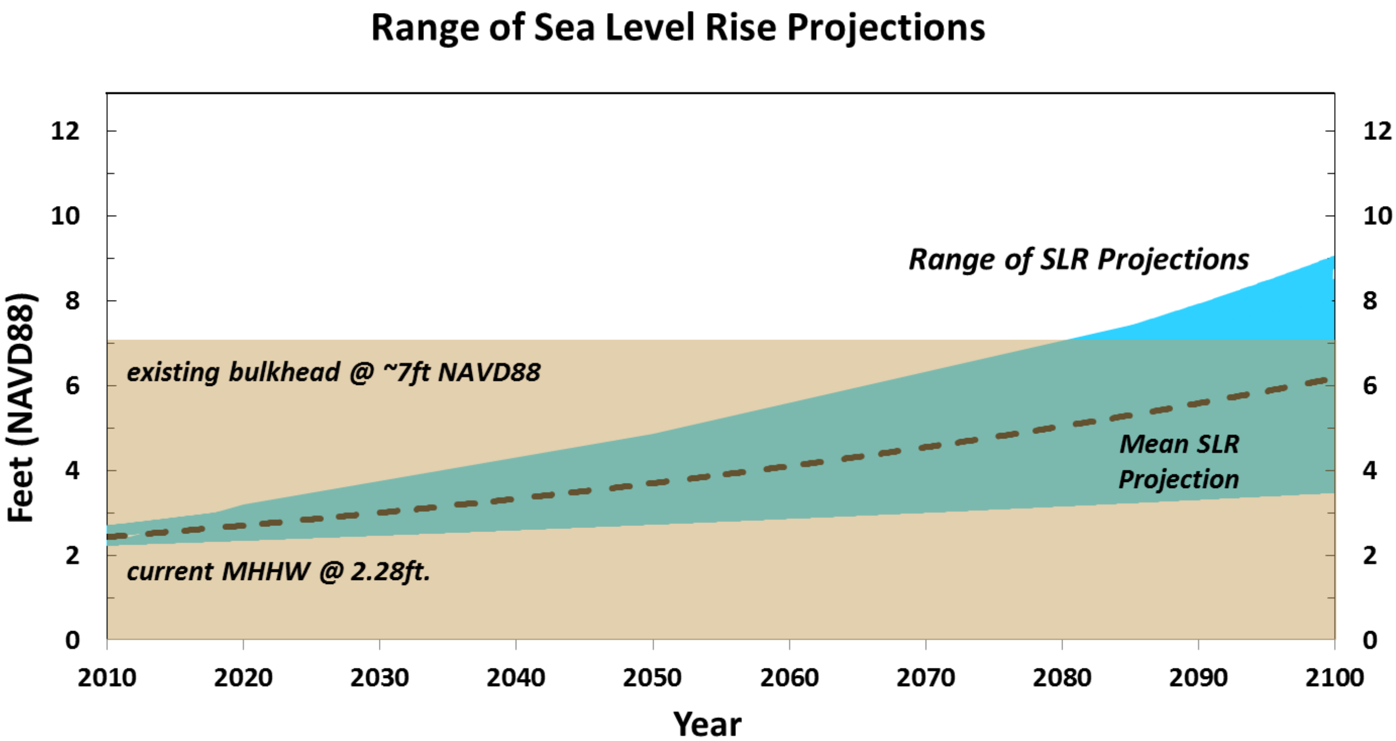


Figure 1: Range of SLR projections over time. Current mean higher high water (MHHW) at 2.28 ft NAVD88. Data Source: NPCC

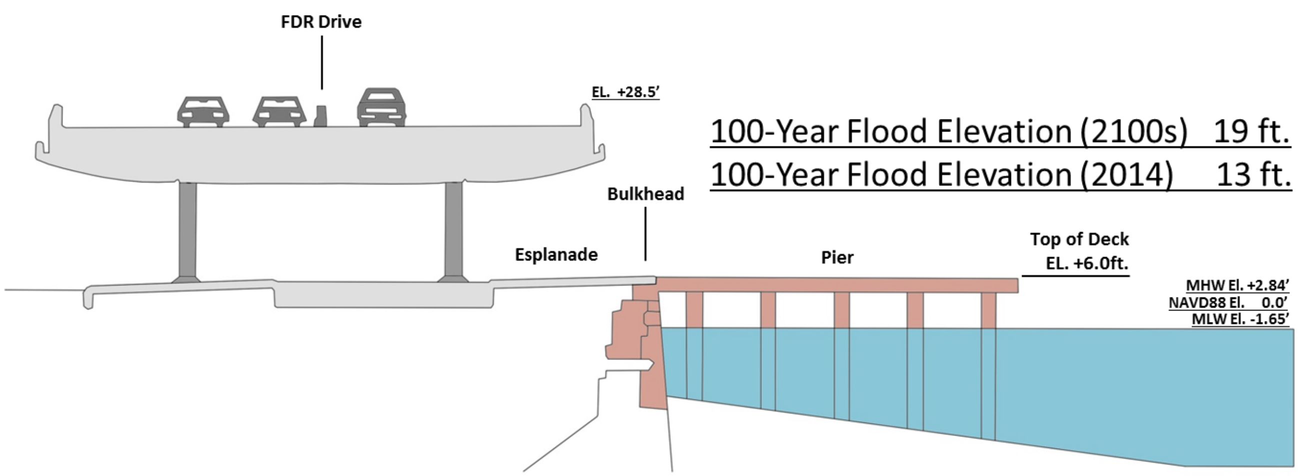


Figure 2: 100-Year Flood elevations with SLR compared to current mean high water (MHW) and mean low water (MLW). Typical FDR Drive section, northbound perspective.

2.2 Vulnerabilities

The potential impacts of climate change in Southern Manhattan, which the Resiliency Plan identifies as the area south of 42nd Street, would be especially disastrous due to the area's high population density, its role as a central business district and global business hub, and the significant amount of vulnerable infrastructure located inside the 100-year floodplain.

For example, approximately 61,000 residents live within the 100-year floodplain in this area; more than half of those residents live in Chinatown and the Lower East Side in low- to moderate-income housing. Approximately 1,600 residential and commercial buildings, historic landmarks, hospitals, telecommunication facilities, subway stations and lines, power stations, and vehicular tunnels are also located within the 100-year floodplain.[9] According to population growth projections from the New York City Department of City Planning ("DCP") and floodplain expansion projections from the Resiliency Plan, the threats will only increase over time as more people reside in the floodplain.

Table 1: Buildings in the 100-Year floodplain (Manhattan south of 42nd Street)[10]

Buildings and units	100-YEAR FLOODPLAIN		
	2013 PFIRMs[11]	2020s	2050s
Residential Buildings	940	1,400	1,650
Residential Units	42,000	60,800	68,000
Commercial and Other Bldgs.	670	910	1,080

2.3 "A Stronger, More Resilient New York"

The Resiliency Plan seeks to address and mitigate the risks of climate change in New York City by laying out 257 specific initiatives in broad strategic areas that include the strengthening of coastal defenses, building upgrades, infrastructure protection, and the creation of safe and vibrant neighborhoods.

In regard to coastal protection, the $3.7 billion plan is structured in phases. The first phase of citywide initiatives focuses on minimizing wave impacts by taking advantage of existing protective features such as natural wetlands and dunes, as well as constructed breakwaters. In this phase, the City will also work to implement measures that mitigate floodwater inundation (e.g., levees, floodwalls, and local storm surge barriers). This phase includes the following four key strategies (as well as 37 accompanying initiatives) to protect vulnerable areas from waves and inundation:

1) Increase coastal edge elevations;
2) Minimize upland wave zones;
3) Protect against storm surge; and
4) Improve coastal design and governance.

[9] Source: City of New York, "A Stronger, More Resilient New York", 2013.

[10] Source: City of New York, "A Stronger, More Resilient New York", 2013.

[11] Preliminary Flood Insurance Rate Maps. These maps are released as a preliminary step towards revising flood hazard maps. These maps document changes in a given study area since the publication of the immediately preceding flood hazard maps.

The Resiliency Plan ultimately calls for the completion of a full-build set of coastal protections that expand on the first-phase strategies over time, as additional resources are identified. In sum, the plan does not propose a one-size-fits-all approach, but rather a more tailored approach that consists of a coordinated set of solutions to increase resiliency. It is within this context that the Resiliency Plan recommended the further study of an MPL to protect the eastern edge of Southern Manhattan.

2.4 Multi-Purpose Levees (MPLs)

Growing challenges associated with climate change, SLR, urbanization, and economic development create opportunities for innovative, long-term flood protection measures. Seizing on such opportunities, cities around the world have implemented projects that integrate flood protection and new development in densely populated areas. A central idea behind those projects is that flood-control infrastructure should be intensively used not only during infrequent large flooding events, but also during normal weather conditions. Often, the projects have consisted of an MPL or a network of MPLs, incorporating commercial and residential real estate development on or behind the MPL.

An MPL is a high and wide standard river embankment, or a wall or bank of earth or stone, that is built to prevent flooding and designed to withstand flood overtopping. In traditional designs, MPLs are passive, earthen levees that are about 30 times as wide as they are high. MPLs are designed to have an extended, gradual slope behind what would otherwise be a traditional levee on the edge of a water body. The extended slope essentially raises the land behind the traditional levee, providing structural reinforcement and a stable region that can be developed. This design allows for overtopping without complete failure because flowing water does not breach the levee but rather flows slowly across its top surface.

As a result of the design, MPLs have a demonstrated ability to achieve coastal resiliency over the long term and are less likely to experience structural failure when compared to a traditional levee, which can be breached if overtopped (i.e., collapse or be washed away). History shows that flood events turn into a disaster if a protective system as a whole fails, as is the case when a levee breaks and large quantities of water flow into urban areas. MPL's are designed to sustain their function under extreme flood conditions. There are no examples known where overtopping of a system or MPL has led to a catastrophic event.

As passive flood protection solutions, MPLs are less likely to experience mechanical failure than active solutions such as integrated flood protection systems ("IFPS") (e.g., gates or deployable floodwalls). While MPLs take longer to construct and may cost more than other alternatives, the level of protection and reliability that they can provide far exceeds the protection and reliability levels of those other alternatives. MPLs are therefore considered large-scale best practices for protecting densely populated areas. In addition, the opportunities that MPLs provide for new public spaces and other uses and the ability of MPLs to seamlessly integrate into the existing urban fabric make MPLs far superior flood protection solutions than traditional levees or IFPS.

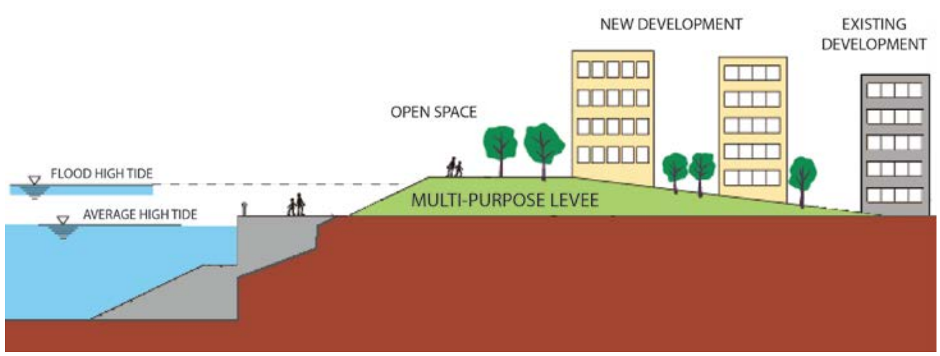


Figure 3: Cross-Section Diagram of a Generic MPL (Not to Scale). Source: Arcadis/FXFOWLE.

MPLs also provide benefits that other flood protection measures lack. For example, MPLs are not typically used to prevent erosion, but they can be combined with seawalls or armored rip-rap (i.e., rock used to protect the shoreline) to resist heavy storm waves. Unlike traditional seawalls, MPLs also allow interaction with the waterfront instead of creating a separation from it.

2.5 Global Precedents

Various waterfront cities around the world have successfully deployed MPLs, also called high-standard levees or "super levees." Notable examples can be found in the Netherlands, Singapore, and Japan.

2.5.1 The Netherlands

One example of an MPL can be found in Scheveningen in the Netherlands, a popular tourist destination on the Dutch coast. During a routine government inspection, the boulevard in Scheveningen was identified as one of eight weak spots in the city's coastal defense zone. The boulevard's scale (it extends approximately 1 mile along the coast with an average width of 260 feet) and its importance to the local community were critical considerations for the Delft Water Board and the local government of The Hague as they worked together to develop the best solution to reinforce Scheveningen's existing coastal defense structure.

Figure 4: Multi-purpose flood protection provides safety to the coastal city of Scheveningen. Source: Mi Modern Architecture.

The project took into account SLR due to climate change and, among other goals, sought to reinforce the coastal defense structure to withstand a storm with an occurrence likelihood of 1-in-10,000 years over the next 100 years. The project also sought to enhance the area by preserving the connection to the seafront and improving the public realm with both traffic reduction measures and new, pedestrian-accessible open space. While several alternatives were initially considered, the project that was ultimately chosen combined a multi-functional space, a covered hard seawall structure, and a beach nourishment initiative. This coastal defense project allowed the Dutch to develop new construction guidelines for hybrid flood defenses, as the dune and seawall combination at the Scheveningen Boulevard required both soft coastal defense measures and heavy construction.

2.5.2 Japan

Super levees are constructed in Japan in conjunction with urban development or redevelopment. They are typically a high standard river embankment that is about 30 times as wide as it is high, similar to MPLs. The wide space on top of the super levee allows for commercial and residential development along a new green corridor that fosters enjoyment of the rivers.

A series of super levee projects began in 1987 along six large rivers in Tokyo and Osaka: the Tonegawa, Edogawa, Arakawa, Tamagawa, Yodogawa and Yamatogawa. Along the lower reaches of Arakawa River, super levee projects have been completed along 13 sites, totaling over three miles, with two more projects in progress. The land uses for these super levees include, but are not limited to, residential and commercial development and public parks. This effort to incorporate residential and commercial development into levee design has become an innovative way of thinking about urban flood protection, especially in densely populated regions, such as Japan.

Figure 5: Example of a super levee in Japan. Source: Asian Network of Major Cities 21

2.5.3 Singapore

Another key precedent is the Marina Bay and Marina Barrage in Singapore. In the 1970s, 890 acres of land were reclaimed in Marina Bay to provide long-term expansion for the growing country. Land uses on the reclaimed land include commercial and residential development, as well as hotels, entertainment, and open space. A new underground transit system and water taxis also provide mass transit opportunities within Marina Bay and to the rest of Singapore. In 2008, the Marina Barrage, a dam built across the Marina Channel, was constructed to form a freshwater reservoir and act as a tidal barrier to prevent low-lying areas in the city from flooding. Additional uses have been incorporated into the Marina Barrage, including a large green roof that also functions as a rooftop garden (see Figure 6) and water dependent uses such as boating and windsurfing.[12]

[12] PUB, Singapore's national water agency, http://www.pub.gov.sg/Marina/Pages/3-in-1-benefits.aspx.

Figure 6: Illustration of design and mix of uses of the Marina Barrage. Source: Government of Singapore

During heavy rain events, the Barrage's nine steel crest gates are activated to release excess stormwater into the sea at low tide. During high tide, drainage pumps capable of displacing a combined total of almost 10,000 cubic feet per second (cfs) of water are used to drain any excess stormwater.[13] Stormwater is also managed through drainage cells on the green roof of the structure's main building.

Although dam infrastructure was not analyzed for this Feasibility Study, the Singapore example is worth noting in that land was reclaimed for development and the unique design of the Marina Barrage, like an MPL, provides space for a mix of uses and not just coastal protection.

[13] Source: Koh Brothers Building & Civil Engineering Contractor Pte Ltd http://www.kohbrothers.com/projects

3 Study Area

In keeping with the boundaries suggested in the Resiliency Plan, the Study Area is generally bounded by: Rutgers Slip/Pier 35 to the north; Broad Street/Battery Maritime Building ("BMB") to the south; the U.S. Pierhead Line and U.S. Bulkhead Line to the east; and South Street to the west. The Study Area roughly comprises a 1.3 mile long section of Southern Manhattan that is highly exposed to the risks of extreme weather events and SLR.

Figure 7: An approximate visualization of the Study Area is highlighted in yellow and outlined in red

The Study Area generally encompasses the waterfront and the upland area adjacent to South Street and under the elevated FDR Drive, as well as portions of the East River Bikeway, the East River Waterfront Esplanade, and areas under the Brooklyn Bridge and the Manhattan Bridge. Piers 6, 11, 15, 16/17, and 35 are also part of the Study Area. The total land and water encompassed by the Study Area amounts to approximately 90.5 acres.

For the purposes of this Feasibility Study, the Study Area was divided into 4 distinct zones (the "Study Area Zones" or "Zones") based primarily on common physical and architectural site characteristics. The four Zones are shown below and include:

- Zone 1 – BMB to Maiden Lane;
- Zone 2 – Maiden Lane to the Brooklyn Bridge;
- Zone 3 – Brooklyn Bridge to the Manhattan Bridge; and
- Zone 4 – Manhattan Bridge to Pier 35.

Figure 8: Study Area Zones and adjacent upland areas

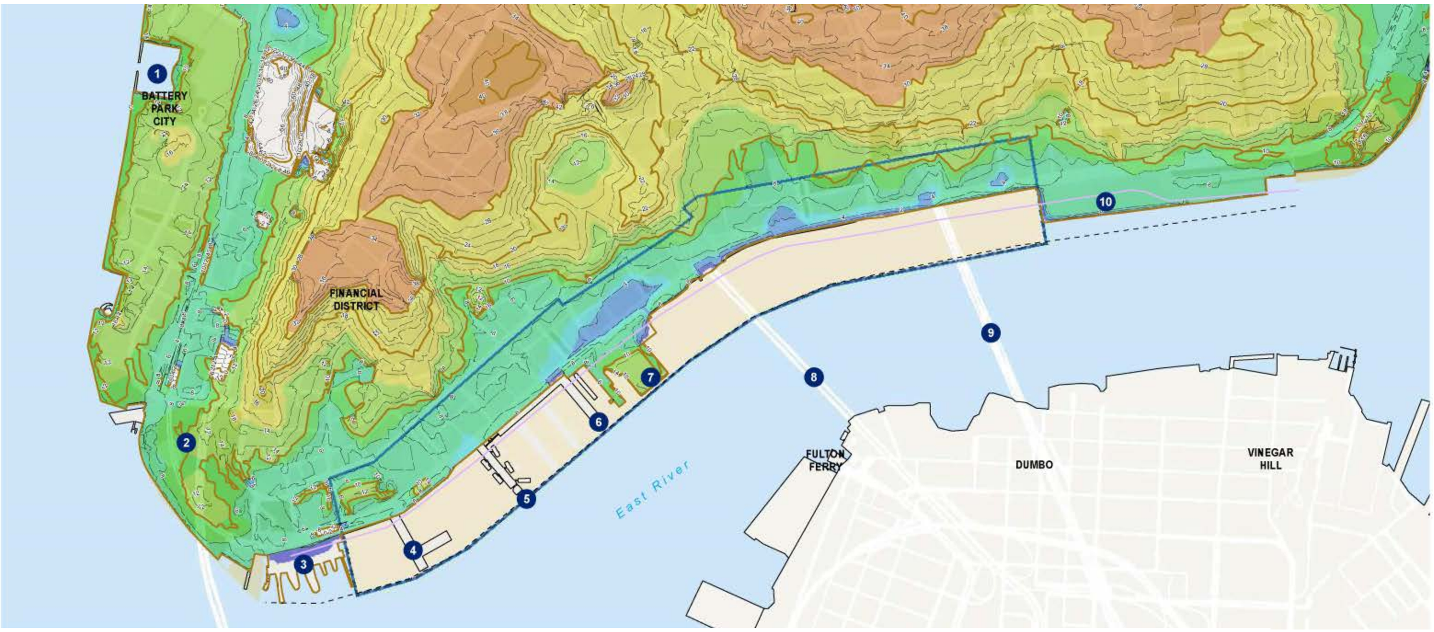
3.1 Physical Characteristics

Since the feasibility of any resiliency measure for Southern Manhattan depends significantly on its integration with the area's current physical characteristics and urban fabric, this Feasibility Study began with a thorough analysis of the Study Area's existing conditions, considering the adjacent upland areas where appropriate.

3.1.1 Topography

The Study Area's topography is generally level and is approximately five to ten feet above mean sea level. The land typically slopes gently upward inland of the Study Area.

Historic maps show that the current shoreline of Southern Manhattan is the result of some 250 years of man-made interventions and is significantly larger than it was in the mid-1600s when European settlers first arrived. Landfill followed a cycle of building shipping piers, then filling in the land between them and extending new piers further into the water. The extension of the Southern Manhattan coastline continued most recently until the early 1980s, when Battery Park City's land mass was completed. One result of most of the earliest man-made land areas is that the edges created to be accessible to maritime shipping activities are also the most susceptible to flooding because they lie at a lower elevation than Manhattan's original, natural topography. Since Battery Park City was constructed in an era that postdates that activity, the edge of that new land mass was at a higher elevation than other portions of Southern Manhattan's coastline.



LEGEND
- U.S. Bulkhead Line
- U.S. Pierhead Line
- Limits of Study
- Study Area
- Parks and Open Access

Elevation (ft)
- 50 - 72
- 30 - 50
- 15 - 30
- 10 - 15
- 8 - 10
- 5 - 8
- 4 - 5
- 2 - 4
- 1 - 2

Landmarks
1. Battery Park City
2. Battery Park
3. Whitehall Ferry Terminal
4. Pier 6 Heliport
5. Pier 11
6. Pier 15
7. Pier 17
8. Brooklyn Bridge
9. Manhattan Bridge
10. Piers 35 - 42

Figure 9: Topography of Southern Manhattan, including the Study Area. Source: 2006-2008 Department of Information Technology and Telecommunications ("DOITT")

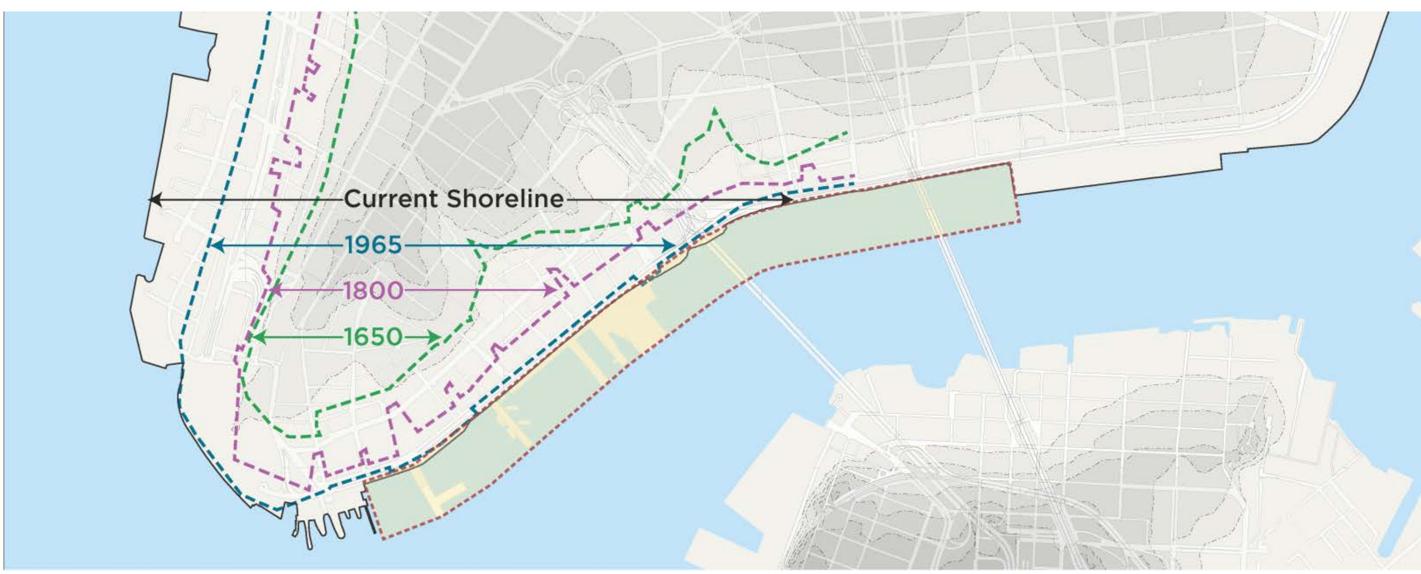


Figure 10: Changes in Southern Manhattan shoreline over time. Source: 1966 Southern Manhattan Framework Plan

3.1.2 Geology

The Study Area is located on the New England Upland physiographic unit known as the Manhattan Prong. The New York Geologic Map classifies the soil in this area as Glacial and Alluvial surficial deposits consisting of till, gravel, sand, and mud. The bedrock within the Study Area is comprised of Manhattan Formation schists.

Many soil tests have been conducted over time in the Study Area. This Feasibility Study analyzed approximately 167 geotechnical borings within the East River. The vast majority of the borings are concentrated near the southern boundary of the Study Area.[14] The boring data reviewed for this Feasibility Study includes the following:

1) East River Waterfront Esplanade and Piers Project; Geotechnical Desk Study and Proposed Marine Borings (March 2007)
2) East River Waterfront Esplanade and Piers Project; Marine Geotechnical Factual Report (September 2007)
3) East River Waterfront Esplanade and Piers Project; Geotechnical Report (February 2008)
4) East River Esplanade and Piers; Archaeological Field Monitoring and Soil Boring Analysis (March 2008)

Almost all of the borings identified varying thickness of river silt within the Study Area (i.e., sand, gravel, shells, or fibrous organic material). Silty sand consisting of fine to medium size grains and, in some cases, gravel (e.g., in Piers 35, 36, and 42) is the next material encountered vertically throughout the Study Area, except in places where there is bed rock at shallow depths. A few boring logs, predominantly near Pier 15, identify very stiff clayey silt beneath the sand and above the bedrock. Bedrock, described as several feet of weathered rock or boulders underlain by sound intact rock, is observed in soil borings throughout the Study Area (except in places where the log terminated at a shallow depth).

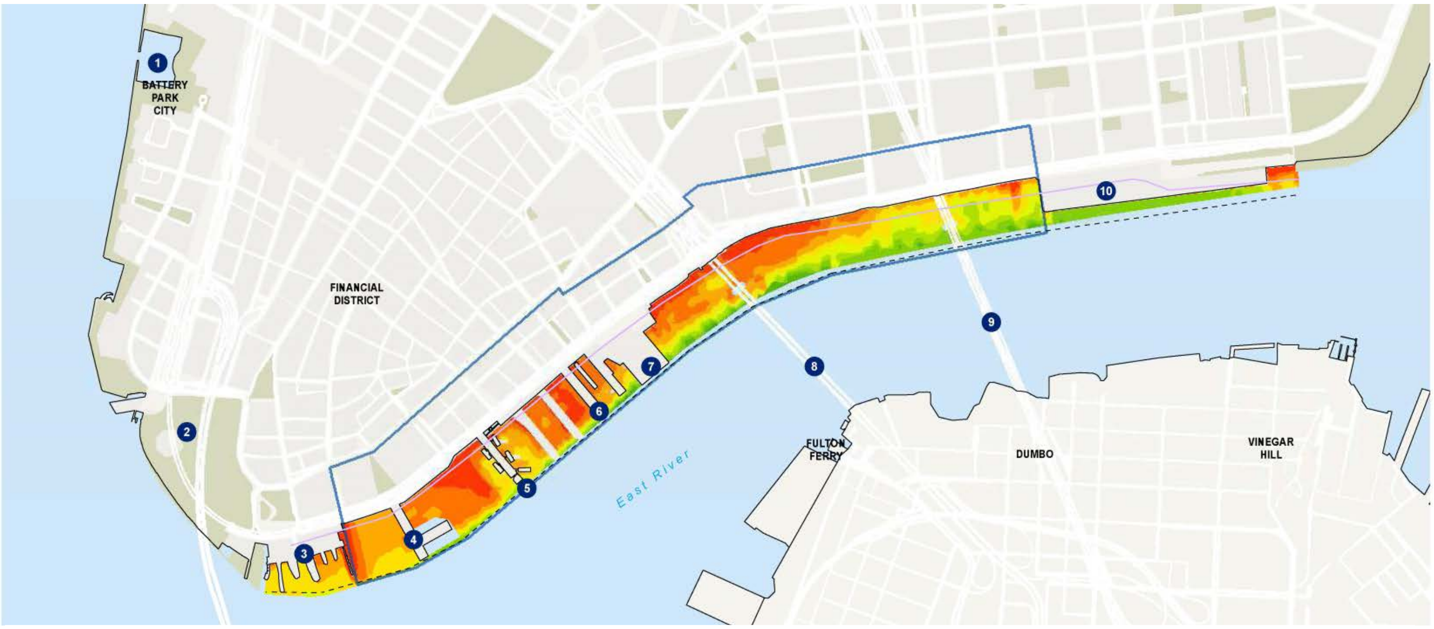
3.1.3 Groundwater

There is groundwater approximately five feet or less below grade within upland portions of the Study Area. While groundwater throughout the Study Area would be expected to flow toward the East River, local variations are possible due to intervening subsurface structures (e.g., tunnels and former or current bulkheads), tidal fluctuations, and past landfilling. Groundwater in Manhattan is not used as a source of drinking water.

3.1.4 Bathymetry

The East River is a tidal strait that connects the western Long Island Sound with the upper New York Harbor. The river is approximately 16 miles long and between 600 to 4,000 feet wide. Generally, a rising tide in the Harbor is accompanied by a flood current that flows north in the river, while a falling tide in the Harbor is accompanied by an ebb current that flows south from the river to the Harbor. Water depths in the river’s main channel vary considerably; some areas are as shallow as 15 feet at mean low water (“MLW”) and others are deeper than 100 feet. Tidal depth fluctuations are around 4 feet in the lower portions of the East River near The Battery.

[14] There is a notable historic boring data gap between the Manhattan and Brooklyn Bridges.



LEGEND
- U.S. Bulkhead Line
- U.S. Pierhead Line
- Limits of Study
- Parks and Open Access

Bathymetry (ft)
- -47.2- -45
- -45- -40
- -40- -35
- -35- -30
- -30 - -25
- -25- -20
- -20- -15
- -15- -10
- -10- -5
- -5- -1

Landmarks
1. Battery Park City
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3. Whitehall Ferry Terminal
4. Pier 6 Heliport
5. Pier 11
6. Pier 15
7. Pier 17
8. Brooklyn Bridge
9. Manhattan Bridge
10. Piers 35 – 42

Figure 11: Bathymetry of the Study Area

3.2 Neighborhoods and Built Environment

3.2.1 Demographics and Real Estate Conditions

The Study Team assessed the demographics and current real estate conditions of the diverse set of Southern Manhattan neighborhoods that are closest to the Study Area. This approach sought to ensure not only that potential flood protection options for the Study Area are compatible with Southern Manhattan's existing neighborhood context and needs, but also that the financial feasibility analysis is based on assumptions that are consistent with real estate market trends. Four sub-districts[15] were evaluated and defined as follows:

1) Chinatown/Lower East Side, defined as the area east of Broadway and Bowery, north of the Brooklyn Bridge, and south of Broome Street and Houston Street;
2) The Financial District, including Southern Manhattan south of the Brooklyn Bridge and Chambers Street and east of West Street;
3) Battery Park City, located west of West Street; and,
4) TriBeCa, including the area south of Canal Street, north of Chambers Street and west of Broadway.

[15] The Study Team outlined these sub-districts solely for the research and analysis purposes of this Feasibility Study. The sub-districts are not intended to coincide with actual New York City neighborhood boundaries.

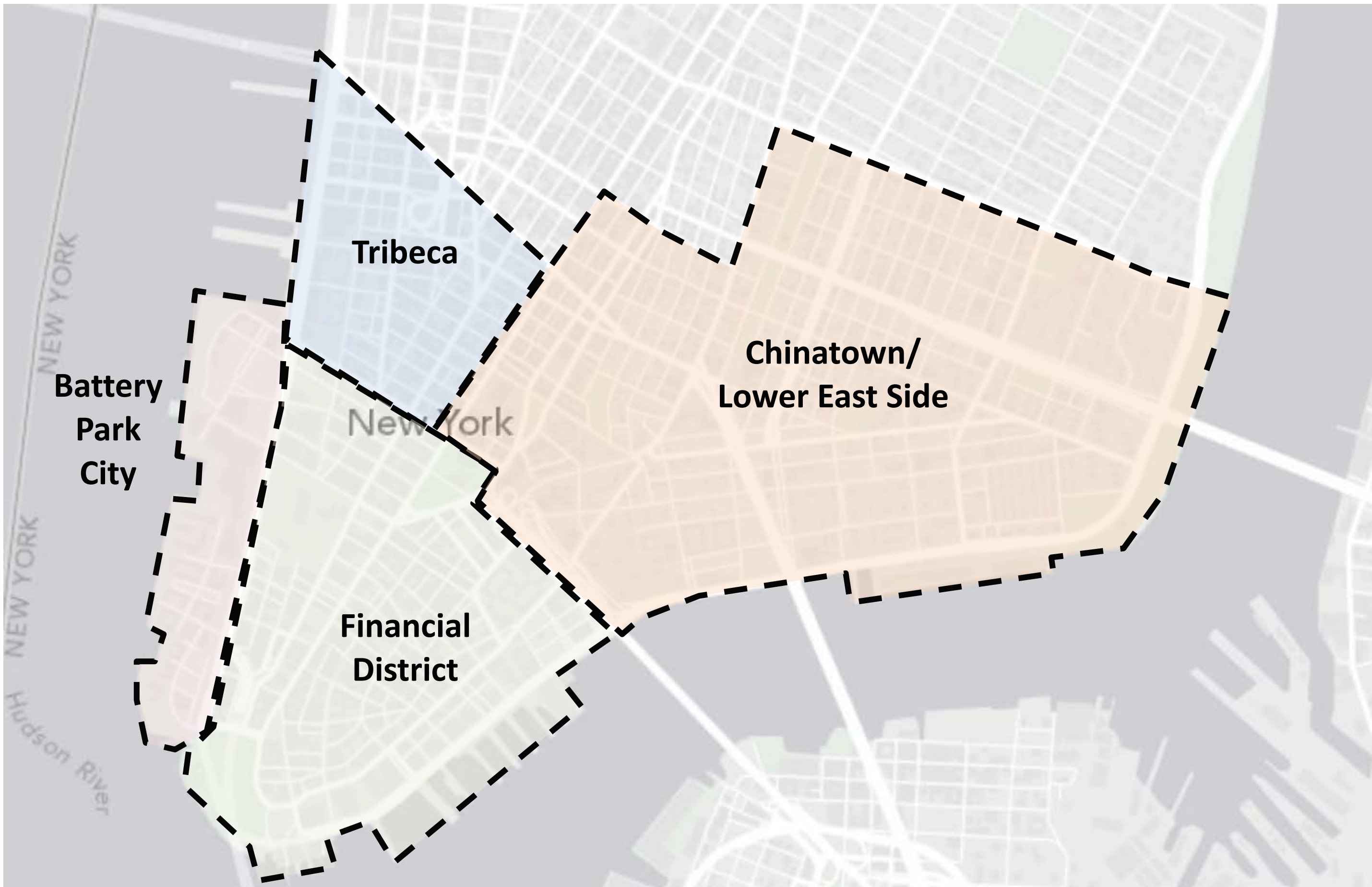


Figure 12: Market Scan – Southern Manhattan Sub-Districts

Chinatown and the Lower East Side contain the majority of Lower Manhattan's population and have a rich history of welcoming successive waves of immigrants to New York City. In recent years, population growth has lagged that of the Financial District, Battery Park City and TriBeCa. Chinatown and the Lower East Side are home to several New York City Housing Authority ("NYCHA") apartment complexes. As shown in Table 2, the neighborhoods have a lower median household income than the other sub-districts and a larger share of residents over the age of 65 (19%).

The **Financial District** is one of the largest central business districts in the United States, as measured by square feet of office space, with over 110 million square feet of rentable space. It is the city's second most important office district, though office space currently rents at a significant discount compared to Midtown levels. The neighborhood has become increasingly residential in recent years, due both to office-to-residential conversions and new residential construction. As shown in the table below, the neighborhood had the highest rate of population growth of any of the sub-districts (142%) between 2000 and 2012.

The Financial District is a popular destination for visitors attracted by Wall Street, the Brooklyn Bridge, the Statue of Liberty, and other tourist destinations. Ticketed attractions in the neighborhood attracted 11.5 million visitors in 2012, with 4.5 million visits to the 9/11 Memorial, 4.0 million passengers on the ferries to the Statue of Liberty and Ellis Island, and 345,000 passengers on the Governor's Island ferry. The South Street Seaport neighborhood also attracts visitors and shoppers; the Seaport Museum had 65,000 visitors in 2012.

Battery Park City, with 92 acres of reclaimed land on the southwestern tip of Southern Manhattan, saw its first vertical development in 1980 and recently achieved full build-out. It has approximately 7 million square feet of office space as well as nearly 7,800 units of high-rise condominiums and apartments and 36 acres of open space. As shown in the table below, the neighborhood has the highest median income among the four sub-districts. The neighborhood had the second highest rate of population growth among the sub-districts between 2000 and 2012 (70%).

TriBeCa, historically a commercial and industrial center, has experienced changes in recent years, as wealthy residents, upscale stores, world-class restaurants and entertainment venues, and boutique hotels have come to occupy the neighborhood's stock of former warehouses and lofts. Home to the TriBeCa Film Festival, the neighborhood has become a destination for the film industry in recent years. As shown in the table below, the neighborhood's median household income is the second highest among the sub-districts.

Table 2: Key Neighborhood Indicators[16]

Category	Financial District	Battery Park City	TriBeCa	Chinatown/ Lower East Side	All Sub-Districts
Population					
Current	33,000	13,000	12,000	103,000	**161,000**
Change since 2000	142%	70%	38%	-4%	**17%**
Workforce (Approx.)	228,000	15,000	69,000	163,000	**475,000**
Education Level					
Bachelors or Higher	66%	75%	72%	16%	**29%**
Assoc./Some College	16%	17%	16%	12%	**13%**
H.S. Degree	10%	5%	8%	17%	**15%**
No H.S. Degree	7%	2%	4%	55%	**43%**
Age Cohort					
Ages 0-24	28%	24%	25%	26%	**26%**
Ages 25-34	37%	26%	21%	17%	**22%**
Ages 35-54	23%	35%	34%	26%	**27%**
Ages 55-64	6%	9%	13%	13%	**11%**
Ages 65+	6%	7%	8%	18%	**14%**
Median Household Income	$96,000	$143,000	$138,000	$27,000	**$63,000**
Race/Ethnicity					
White Alone	71%	73%	83%	30%	**46%**
Black Alone	4%	3%	4%	8%	**7%**
American Indian Alone	0%	0%	0%	0%	**0%**
Asian Alone	20%	19%	9%	49%	**38%**
Pacific Islander Alone	0%	0%	0%	0%	**0%**
Some Other Race Alone	2%	2%	1%	9%	**6%**
Two or More Races	4%	4%	3%	3%	**3%**
Hispanic Origin (Any Race)	7%	8%	6%	23%	**17%**

[16] Source: ESRI

3.2.2 Existing Neighborhood Density and Land Use

Building densities vary considerably in the neighborhoods adjoining the Study Area, with the highest densities located towards the south of the Study Area and significantly lower densities towards the north. Figure 13 illustrates such densities in terms of average built floor area ratios (FARs).[17] Several parcels of land south of Chambers Street have FARs higher than 28, but most have ratios of between 16 and 24. Parcels east of Broad Street/Nassau Street and south of Maiden Lane (Zone 1 uplands) have an average floor area ratio of 18.4. Between Maiden Lane and the Brooklyn Bridge (Zone 2 uplands), this ratio decreases to 8.3. Between the Brooklyn and Manhattan Bridges (Zone 3 uplands) and east of Park Row/East Broadway, the ratio is only 2.9. Above the Manhattan Bridge (Zone 4 uplands), the FAR is 2.7.

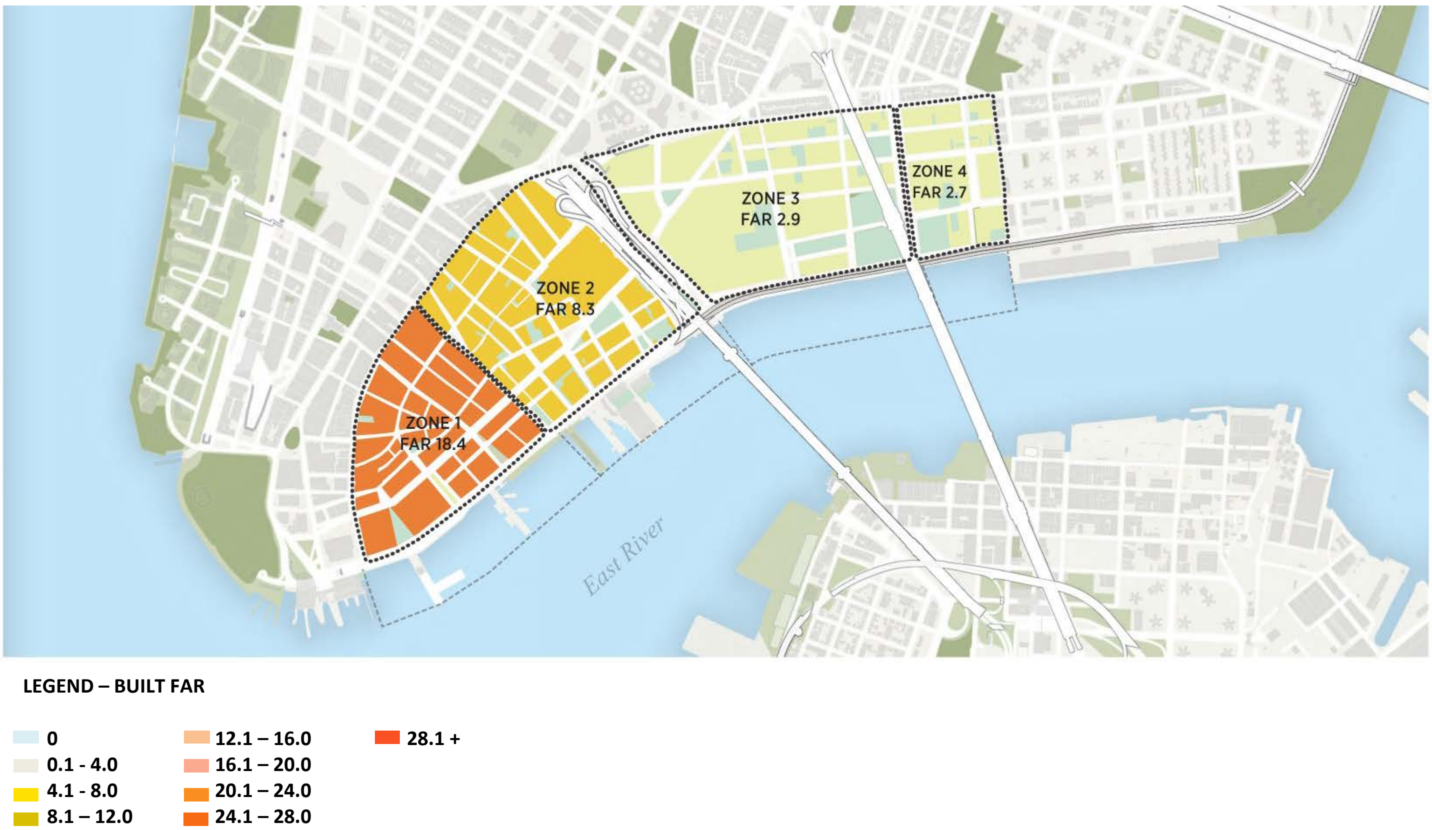


Figure 13: Built FARs in Study Area Zone uplands[18]

Although Southern Manhattan includes a wide range of land uses, these tend to be clustered into predominantly residential or predominantly commercial areas. Over the last 10 years, residential conversions of office buildings and the development of new residential buildings in commercial areas have gradually transformed Southern Manhattan, leading to more mixed use neighborhoods. Farthest south, the Financial District is comprised primarily of commercial office buildings, though recent years have seen a growing number of residential conversions. Meanwhile, Battery Park City has a combination of commercial and residential buildings. In other neighborhoods, including Tribeca and Chinatown/Lower East Side, land uses are fairly mixed, with a variety of

[17] Floor Area Ratio (FAR): The ratio of building square feet to land square feet on a given parcel.

[18] Source: FxFowle, New York City Department of City Planning

residential buildings that includes one and two family buildings, multi-family buildings, and mixed residential and commercial buildings. Office uses are virtually non-existent along the waterfront north of the Brooklyn Bridge.

Public facilities, institutions, and utilities are dispersed throughout all of Southern Manhattan. Open space and outdoor recreation facilities in the area are limited, with the East River Waterfront Esplanade, East River Park, Battery Park, and the Battery Park City Esplanade providing the largest open spaces in the area. There are also significant open spaces near the base of the Manhattan Bridge, as well as among NYCHA developments adjacent to the Brooklyn and Manhattan Bridges.

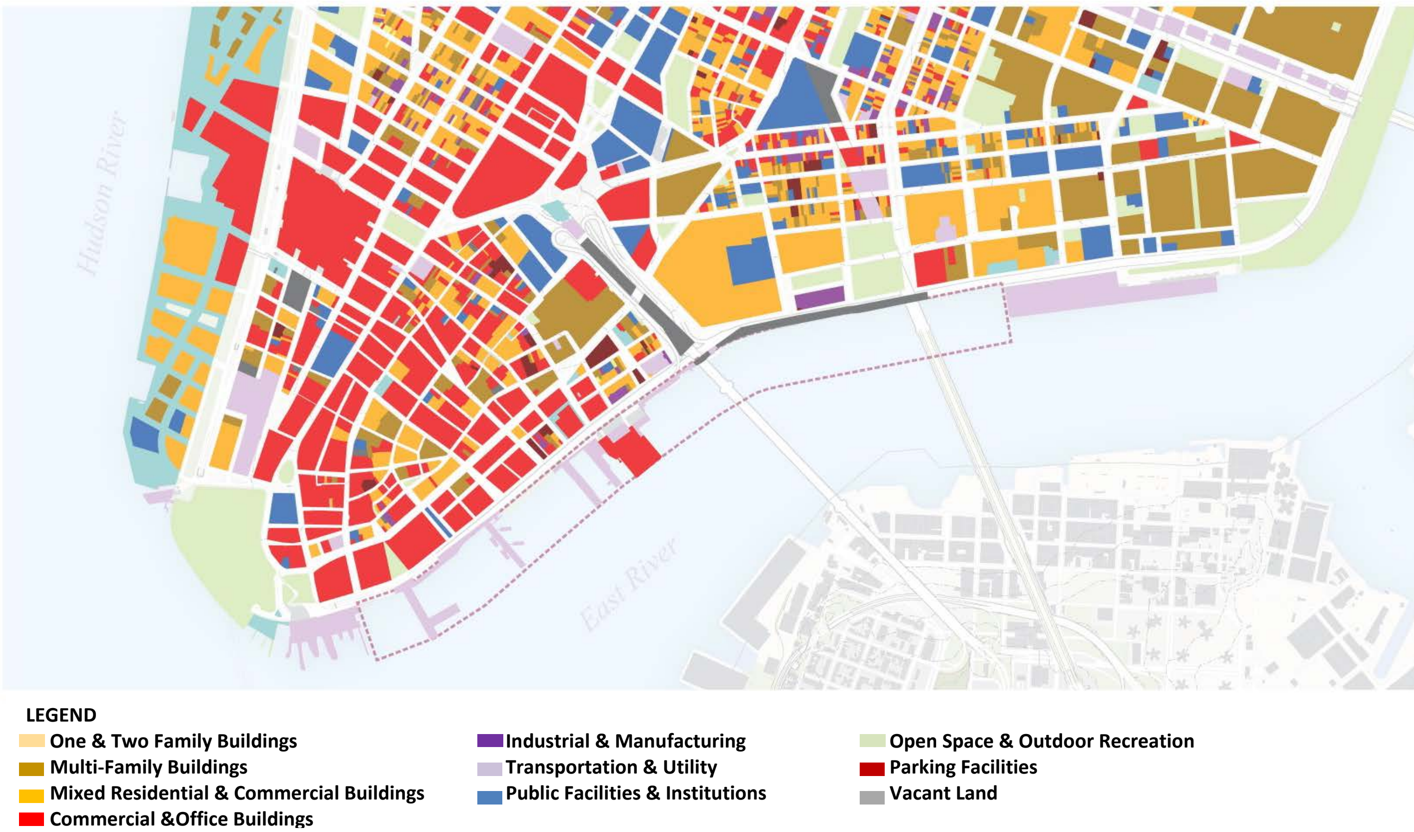
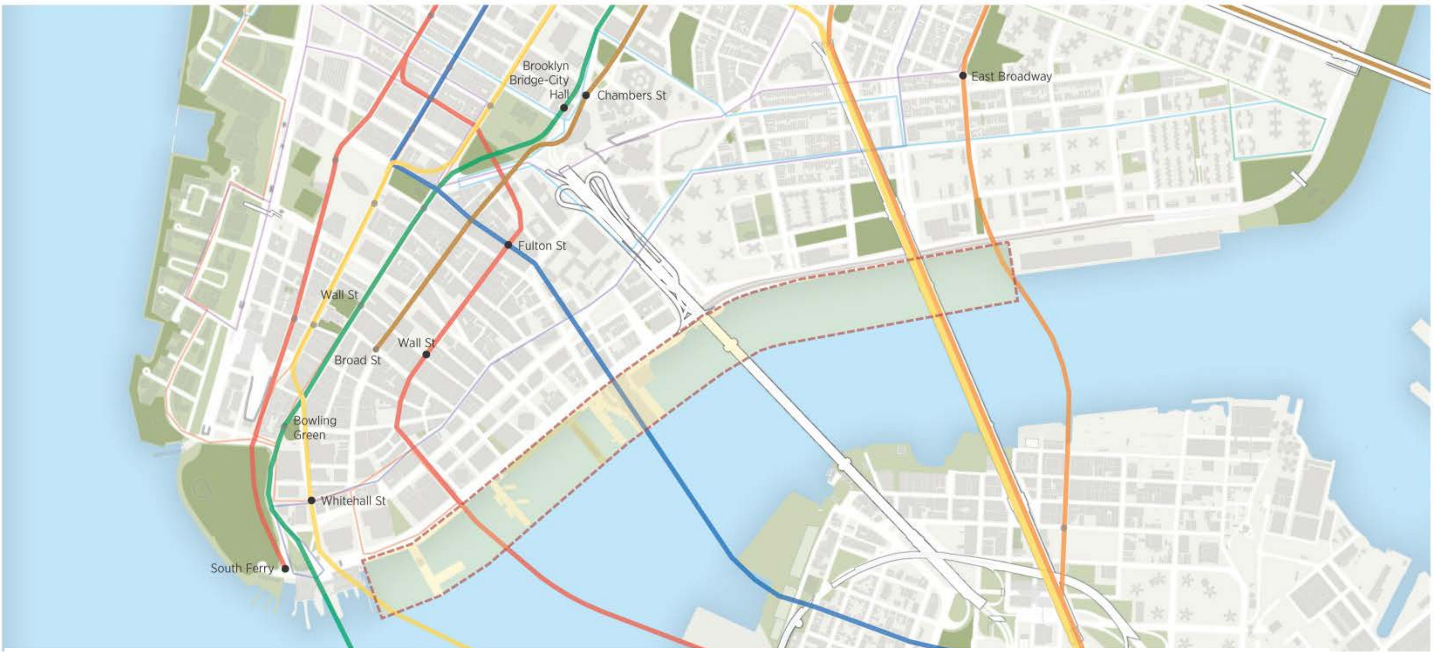


Figure 14: Land uses in and near the Study Area Zones. Source: 2013 DCP Pluto Map Data

3.3 Transportation

There are a number of important transportation assets within or in the immediate vicinity of the Study Area, including subway tunnels and major roadways, pedestrian and bicycle routes, bus routes, and ferry service. The roadways include key links in the regional transportation network such as FDR Drive (an approximately 1.3-mile section falls within the Study Area), the Manhattan Bridge, and the Brooklyn Bridge and its off- and on-ramps in Manhattan. The Study Area also includes the East River Waterfront Esplanade, which incorporates a fully-separated bike lane and pedestrian amenities.

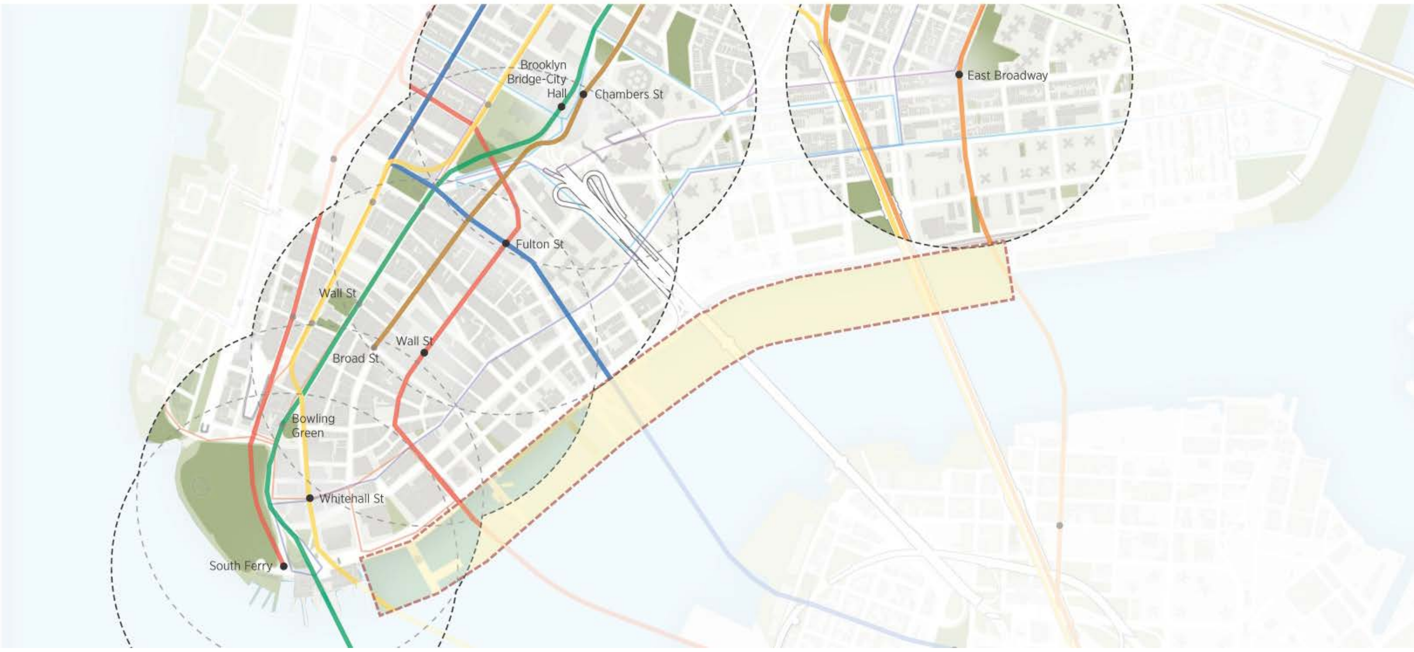
With multiple subway lines and the World Trade Center PATH Station, Southern Manhattan represents a critical hub of the city's transit system. There is greatest transit service density near the southern end of the Study Area. Thirteen subway lines (1, 2, 3, 4, 5, A, B, C, D, F, N, R, and Q) on eight pairs of tracks run across or immediately adjacent to the Study Area, with three additional lines (6, J, Z) within walking distance. Existing subway stops are generally 1/8 to 1/2 mile from the Study Area. Eight of the subway lines slope down to tunnel underneath the East River, while four lines travels across the river on the Manhattan Bridge. One subway line (1) terminates adjacent to the Study Area at the South Ferry station. Bus lines near the Study Area include the M5, M15, M15-SBS, M20, and M22.



LEGEND

- NYC Bus Line M5
- NYC Bus Line M15
- NYC Bus Line M20
- NYC Bus Line M22
- NYC Bus Line M103
- NYC Bus Line X9
- Subway Station
- Subways A, C
- Subways 4, 5, 6
- Subways Q, N, R
- Subways J, Z
- Subways 1, 2, 3
- Subways B, D, F

Figure 15: Subway and bus transit in Southern Manhattan



LEGEND

- NYC Bus Line M5
- NYC Bus Line M15
- NYC Bus Line M20
- NYC Bus Line M22
- NYC Bus Line M103
- NYC Bus Line X9
- Subway Station
- Subways A, C
- Subways 4, 5
- Subways Q, N, R
- Subways J, Z
- Subways 1, 2, 3
- Subways B, D, F
- Study Area
- ¼ of Mile Walking Radius (approximate)

Figure 16: Subway and bus transit in Southern Manhattan – ¼ mile walking radii

3.4 Historical and Cultural Assets

Southern Manhattan is home to many historic landmarks and local, state, and/or federally designated historic resources. Prominent historic resources include, among others, the National Museum of the American Indian, the James Watson House, the Battery Maritime Building, the First Precinct Police Station, and the South Street Seaport Historic District.

In addition, the Brooklyn Bridge and Manhattan Bridge are both city icons and popular destinations for residents and visitors. The Brooklyn Bridge has been designated a National Historic Landmark by the National Park Service and a New York City Landmark by the Landmarks Preservation Commission ("LPC"), and it is listed on the State and National Registers of Historic Places. The Manhattan Bridge was named a National Historic Civil Engineering Landmark by the American Society of Civil Engineers in 2009 during its centennial year.

Lastly, the various piers that are found along the Study Area's waterfront reflect New York's important role as a port city throughout most of its history. Although those piers are no longer used for the shipping of goods, they remain today as important access points to the waterfront.

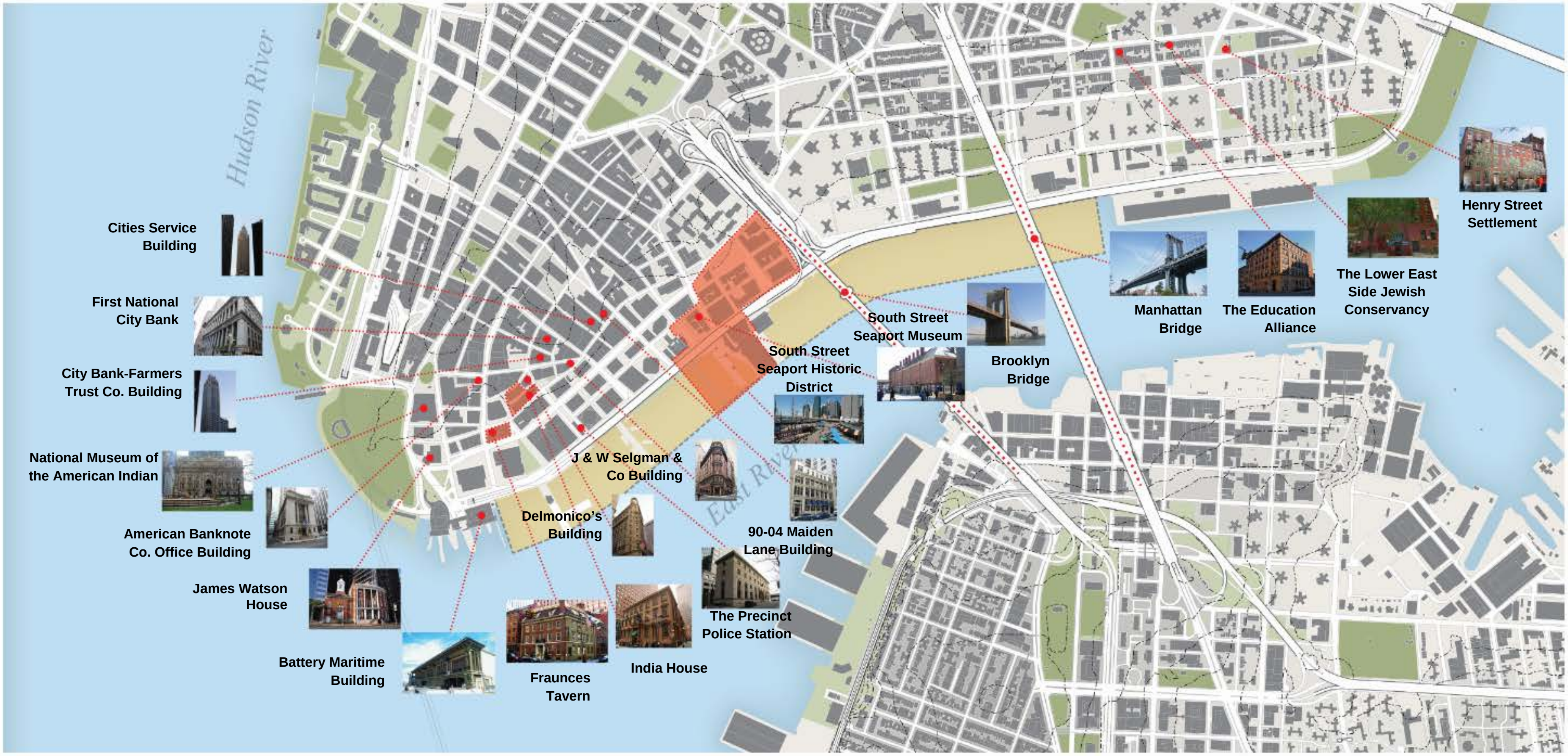


Figure 17: Map of historic resources and districts in the Study Area's vicinity

3.4.1 South Street Seaport Historic District

This district includes portions of eleven upland blocks located between South Street, Dover Street, Pearl Street and Maiden Lane, as well as Piers 15 and 16, and portions of Pier 17. The historic district was designated in 1977 and expanded to its present boundaries in 1989. The district contains tourist destinations such as the South Street Seaport Museum, historic Schermerhorn Row, and the Pier 17 shopping mall, which is currently being redeveloped by The Howard Hughes Corporation.

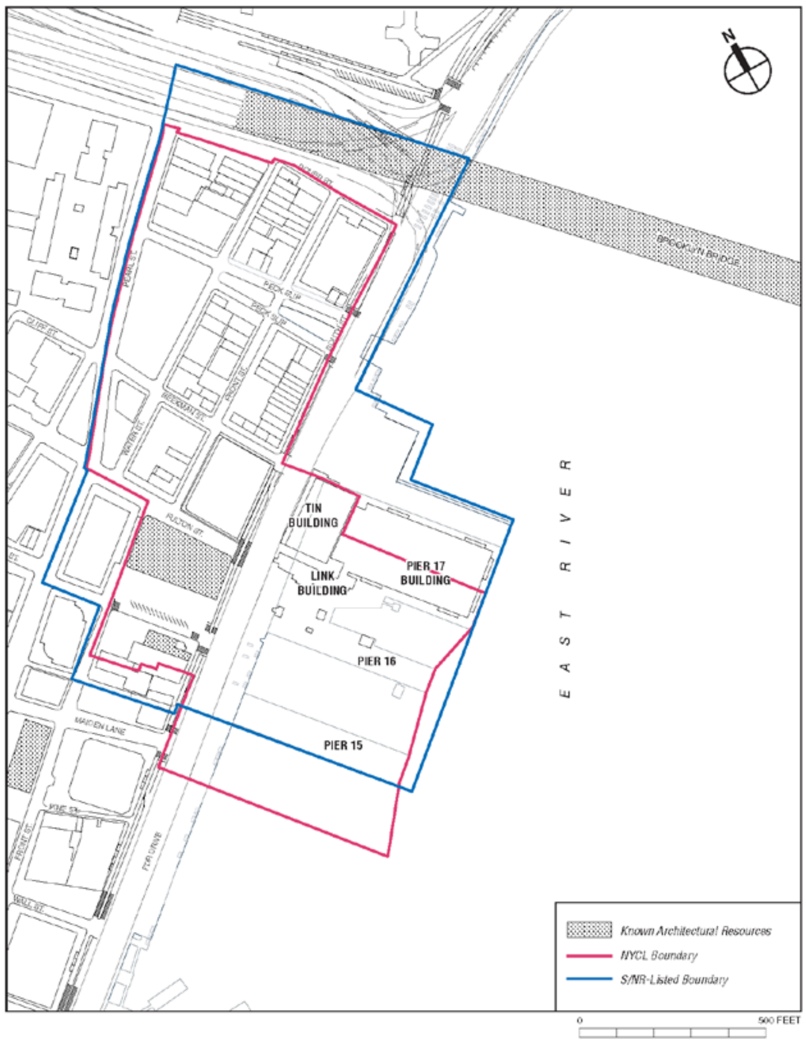


Figure 18: South Street Seaport historic district resources

3.5 Other Related Programs

Proposed as part of the U.S. Department of Housing and Urban Development's ("HUD") Rebuild by Design competition, The Big U is a flood protection system for Manhattan, stretching from West 57th Street south to The Battery and up to East 42th Street. The proposed system would not only shield the city against floods and stormwater but would also provide an improved public realm, among other social and environmental benefits to the community.

The team that developed The Big U concept created separate but coordinated plans for three contiguous regions of the Manhattan waterfront and their associated communities, each dubbed a "compartment." Each compartment comprises a physically separate flood-protection zone that is isolated from flooding in the other zones. The compartments would work in concert to protect and enhance the city, but the proposal for each compartment is designed to stand on its own. Each compartment could be implemented in phases and integrated with existing projects in progress. The Big U could act as an interim flood protection system for a long-term MPL project in the Study Area and as complementary flood protection in Southern Manhattan outside the Study Area. Compartments 2 and 3 are most relevant to the Study Area:

Compartment 2: Two Bridges area, from Montgomery Street to the Brooklyn Bridge
At Two Bridges, the relative lack of space between the residential areas and the waterfront favors a mixed-flood-protection strategy, incorporating limited-height flood protection barriers that would shield the area against most recurrent floods, as well as "swing down" flood gates designed to a height of 10 feet and attached to the underside of the FDR Drive. These configurations would permit views to the waterfront, as well as enhance the urban space with benches, skate parks, etc.

Compartment 3: Battery-Financial District, from the Brooklyn Bridge to The Battery
In the Battery-Financial District, a sequence of attractive urban spaces on the waterfront would protect the city while also serving the millions of visitors and thousands of workers and residents in the area. The northern end of this compartment, at the Brooklyn Bridge, would be anchored by a combination of pavilions that would provide flood protection to a height of 15 feet. Deployable systems would also swing down from the underside of the FDR Drive; furniture sited beneath the FDR would also serve to anchor additional deployable barriers. To the south, these systems would lead to an elevated bikeway/footpath that connects to an elevated plaza at the mezzanine floor of the BMB. Continuing west towards The Battery, a floodwall would align with the FDR Drive at the BMB and connect through the Staten Island Ferry Whitehall Terminal building. Finally, a landscaped berm in Battery Park could be strategically located to create a continuous protective upland landscape.[19]

As of the writing of this report, HUD was expected to make funding decisions on a final selection of Rebuild by Design competition projects.

[19] The BIG U proposal was submitted to the 2014 Rebuild by Design competition by BIG (Bjarke Ingels Group) with One Architecture, Starr Whitehouse, James Lima Planning + Development, Project Projects, Green Shield Ecology, AEA Consulting, Level Agency for Infrastructure, ARCADIS, and the Parsons School of Constructed Environments. For more information on The BIG U proposal, visit http://www.rebuildbydesign.org/project/big-team-final-proposal/.

4 Feasibility Analysis

A full spectrum of engineered defenses can be implemented to prevent coastal flooding and reduce the impact of SLR and storm surge events; however, the various combinations of defenses and their associated implementation strategies are not equally applicable or feasible in all areas. Applicability depends significantly on existing site conditions, including space availability, geology, topography, and hydrology, as well as land use context.

The Study Team first considered different possible engineered flood defenses given the physical constraints of the Study Area. The team employed a screening process to identify the typologies within that spectrum that would best fulfill the project goals. As mentioned before, the goals are this Feasibility Study's main evaluation criteria and consist of the following:

1) Enhanced flood protection for Southern Manhattan;
2) Resiliency program funding source (i.e., the ability to self-finance and/or generate surplus revenue to fund other resiliency efforts); and,
3) Economic and community development (i.e., new economic activity, affordable housing, and open space; integration with Southern Manhattan's urban fabric and character).

After analyzing many typologies, the team selected the following six flood protection options for further consideration:

- Upland Integrated Flood Protection System (IFPS)
- Upland Protection
- 250' Land Reclamation
- 250' Land Reclamation with Secondary Channel
- 250' Land Reclamation-Platform Hybrid
- 500' Land Reclamation

The Study Team analyzed these options as designed to protect to a height of +19.0 feet NAVD88 for a 100-year storm event in the 2100s, evaluating each option against the project goals. The analysis of these six options is described in further detail in the following sections.

4.1 Coastal Protection Options

The coastal protection solutions discussed below would be built in phases over an approximately 65-year period, varying by option. This Feasibility Study assumes that an IFPS would be built first in any section of the Study Area where a passive flood protection solution (e.g., land reclamation or platform MPL) is not initially constructed. As financial resources become available and each phase of a passive solution is built, the corresponding IFPS section would be phased out.

4.1.1 Upland IFPS

This Feasibility Study analyzes IFPS both as a stand-alone intervention and, as mentioned before, as a 'gap' intervention that is integrated/combined with a phased passive flood protection solution. Conceptually, an upland IFPS could consist of a combination of mechanical gates and deployable floodwalls (Figure 19). An IFPS requires minimal site preparation; therefore, it would not be implemented in phases. Footings capable of supporting deployable floodwalls would be installed and would integrate with site-specific conditions along the length of the Study Area. Detailed design processes may identify methods of integrating IFPS with existing infrastructure such as the FDR Drive's elevated road deck.

Figure 19: Example of deployable floodwalls. Source: Flood Control of America (FCA)

4.1.2 Upland Protection

The proposed conceptual design for this option is a waterproof barrier that would be erected on *terra firma* at the existing water's edge along the southern portion of the Study Area (Figures 20 and 21). The flood barrier would be an integrated floodwall capable of supporting building infrastructure and platform structures. Thus, the floodwall could provide opportunities for new development along the waterfront.

The existing seawall would be lined with mixed-use buildings engineered and designed to be storm hardened (i.e., all electrical and telecommunications infrastructure would be above the base flood elevation and the lower two floors of each building would be fortified to resist flood waters).[20] The lot depth would allow for residential buildings with a retail base, but would not accommodate the larger footprints required by office buildings. There would be integrated flood protection barriers in between the buildings; these mechanical devices would be moveable to avoid blocking circulation and street-level waterfront views, and they would be closed prior to storm events.

Under this option, the northern portion of the Study Area would rely on an IFPS.

[20] Base flood elevation is the elevation of surface water resulting from a flood that has a 1 percent chance of equaling or exceeding that level in any given year (FEMA)

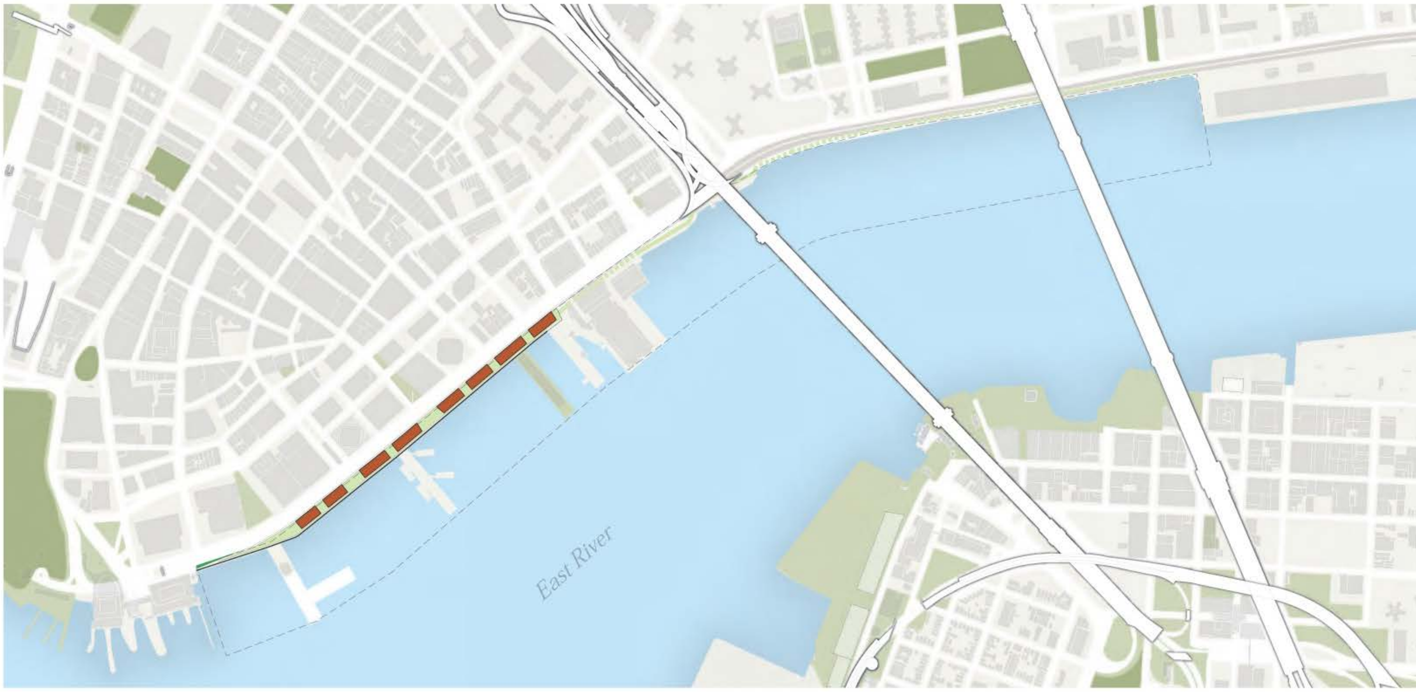


Figure 20: Upland Protection option (full build out): Plan view[21]

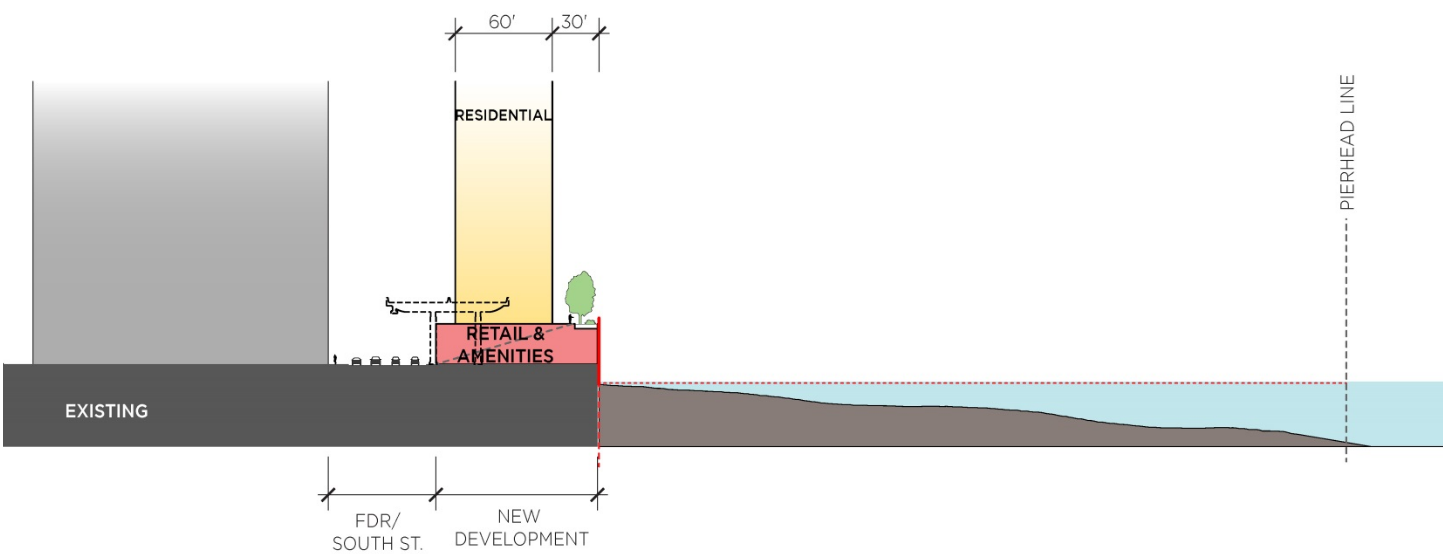


Figure 21: Upland Protection option (full build out): Example section view

[21] Full build out refers to the build out in 2100.

4.1.3 250' Land Reclamation

The proposed conceptual design for this option is 250' of land reclamation in the East River (i.e., placing fill material) (Figures 22 and 23). The 250' Land Reclamation option would allow for one city block of new development, with streets on either side of the block and a waterfront esplanade. The elevation of the leading offshore edge of the levee would be +19.0 feet NAVD88, which would require a 4-5% slope from the existing East River bulkhead elevation to the newly established waterfront. This incline would be gradual enough to avoid considering the levee a ramp, in which case railings and landings along pedestrian routes would be required.

The block depth would allow for residential and commercial development on both frontages of the block with sufficient rear yard separation. Additional open space and waterfront access could be incorporated in the vicinity of the Brooklyn Bridge. Rather than constructing a vertical seawall along the length of the levee, the offshore edge would incorporate a rip-rap revetment. The revetment would provide benefits such as dampening wave energy and creating ecologically-friendly conditions along the East River shoreline.

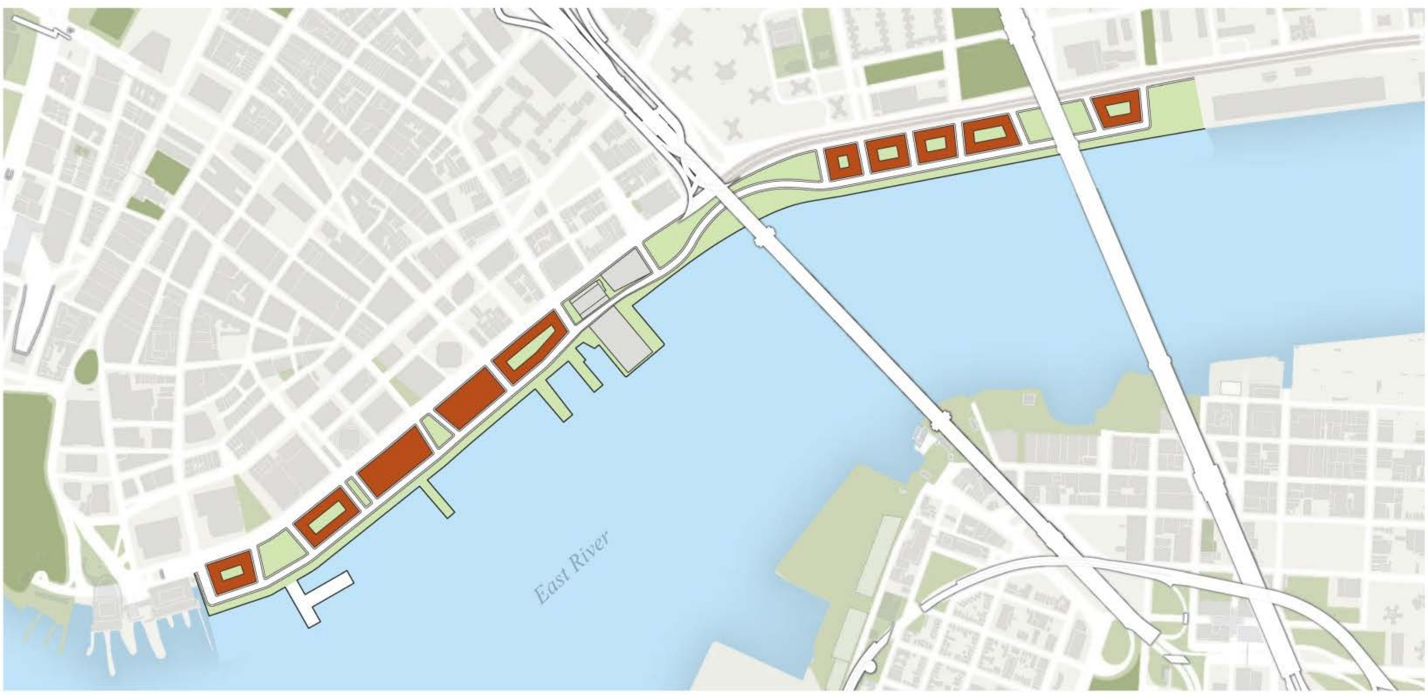


Figure 22: 250' Land Reclamation option (full build out): Plan view[22]
Note: Buildings in grey are excluded from the MPL options' conceptual vertical development programs. See Section 4.4.1.2 for further detail

[22] Full build out refers to the build out in 2100.

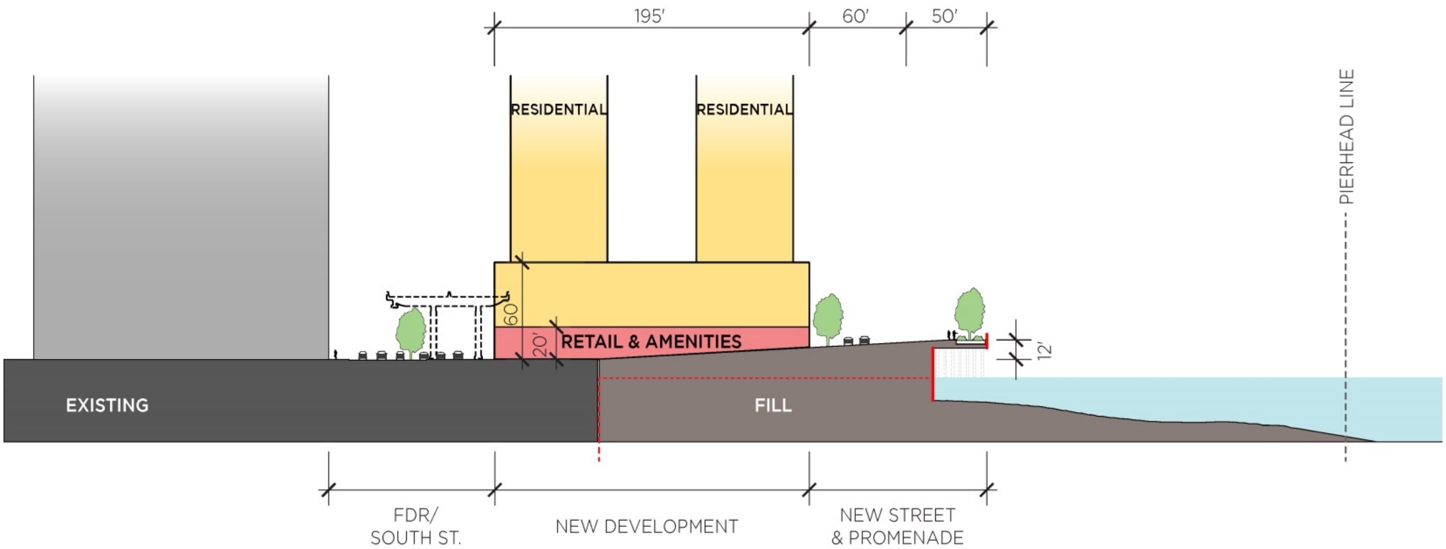


Figure 23: 250' Land Reclamation option (full build out): Example section view[23]

4.1.4 250' Land Reclamation-Platform Hybrid

The proposed conceptual design for this MPL option is a hybrid of the 250' Land Reclamation option and a platform structure (Figures 24 and 25). The levee portion of this MPL design would be similar to the 250' Land Reclamation option, extending 250 feet from the existing shoreline and reaching an elevation of +19.0 feet NAVD88. An additional 250 feet of pile-supported structure would be added to the levee, which would result in a 500-foot wide MPL along the length of the Study Area.

The resulting 500-foot wide surface would accommodate two typical city blocks with a 60-foot right-of-way between them, roads on the upland and waterfront side, and a waterfront promenade. The block depth would allow for residential and/or commercial development on both frontages of the block with sufficient rear yard separation. A 50-foot walking esplanade would be constructed on the platform's edge adjacent to the water.

The 250' Land Reclamation-Platform Hybrid configuration would also allow the creation of narrow inlets in the platform portion of the MPL; water would not stagnate in those inlets because it would flow under the platform. These inlets would create additional water frontage and accommodate boats and other water-dependent uses, but they could not accommodate a continuous waterfront roadway for local circulation. The proposed design also includes green space in the form of a waterfront area in the vicinity of the Brooklyn Bridge. The edges of the MPL under the platform would consist of soft rip-rap revetments (where possible) to dampen wave height and provide ecologically-friendly conditions along the shoreline.

[23] Block would be dimensioned to allow office and/or residential building typologies.

Figure 24: 250' Land Reclamation-Platform Hybrid option (full build out): Plan view[24]
Note: Buildings in grey are excluded from the MPL options' conceptual vertical development programs. See Section 4.4.1.2 for further detail

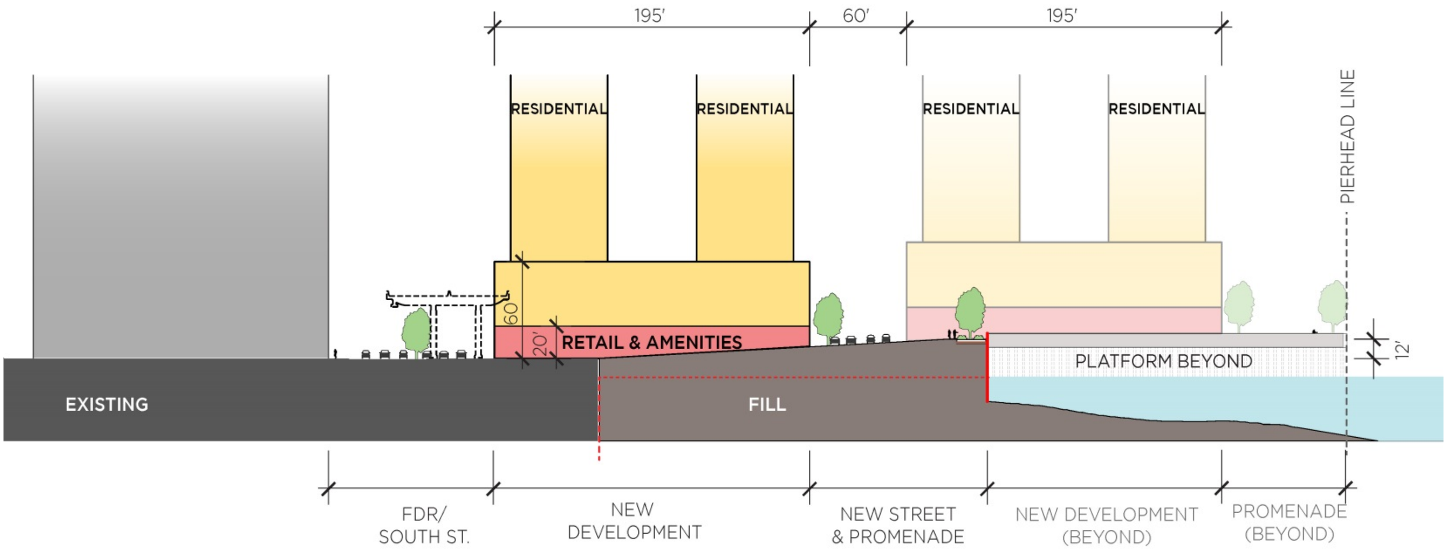


Figure 25: 250' Land Reclamation-Platform Hybrid option (full build out): Example section view[25]

[24] Full build out refers to the build out in 2100.

4.1.5 250' Land Reclamation with Secondary Channel

The proposed conceptual design for this option is a 250- to 300-foot-wide barrier island that would be constructed approximately parallel to the existing shoreline of the Study Area (Figures 26 and 27). Between the new barrier island and the Study Area's existing shoreline would be a channel with a maximum width of no greater than 165 feet. Flood gates on the northern and southern ends of the barrier island would be constructed to allow water flow through the channel in normal weather conditions and to close off the channel in the event of extreme weather conditions (thus protecting the inland areas along the length of the Study Area from flooding).

The width of the island would allow for one city block of new development, with streets on either side of the block, and a waterfront esplanade. Residential and/or commercial buildings could be developed on both frontages of the block with sufficient rear yard separation. In addition, water flow in the inner channel would permit edge plantings and, potentially, small recreational vessels (e.g., kayaks). The inner channel would also provide a storage area for stormwater when the northern and southern flood gates are closed prior to an extreme storm event. In this option, the current East River Waterfront Esplanade could remain intact. All edges of the barrier island would be rip-rap revetments to dampen wave height and provide opportunities for more ecologically-friendly conditions along the shoreline.

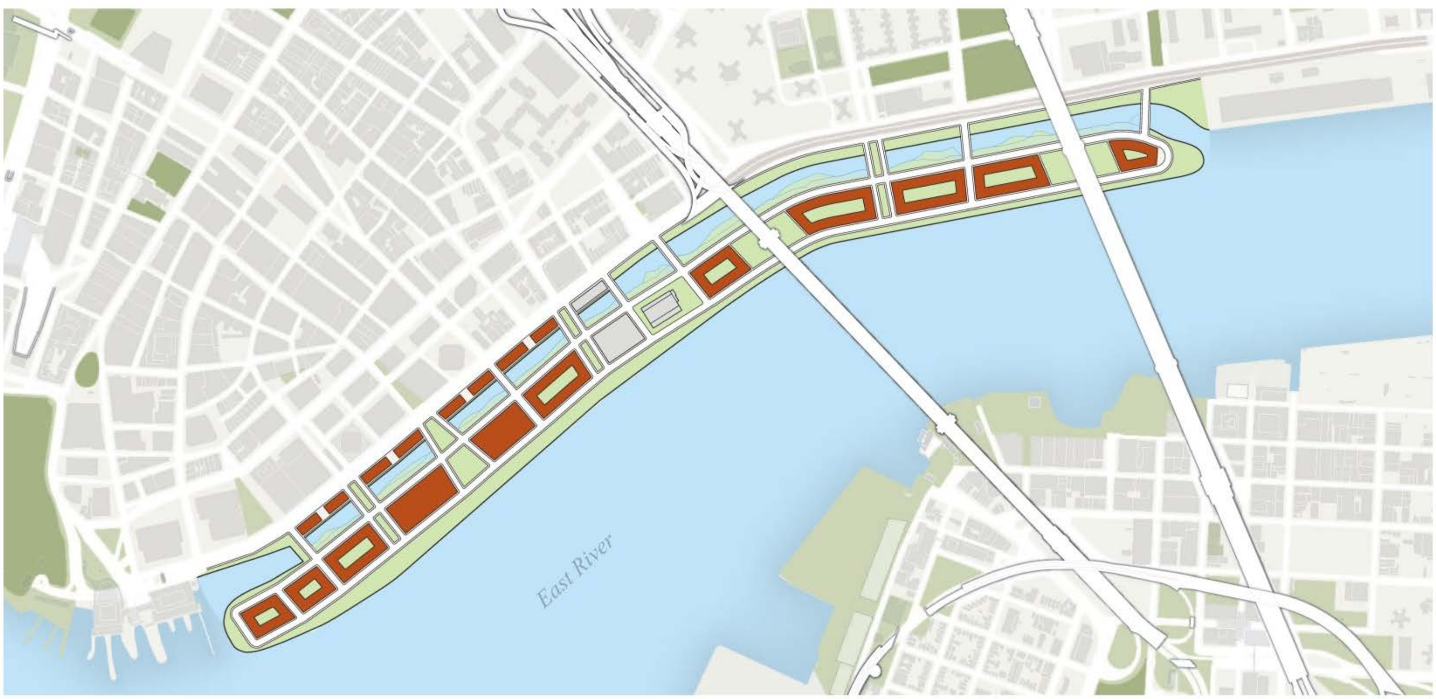


Figure 26: 250' Land Reclamation with Secondary Channel option (full build out): Plan view[26]
Note: Buildings in grey are excluded from the MPL options' conceptual vertical development programs. See Section 4.4.1.2 for further detail

[25] Each block would be dimensioned to allow office and/or residential building typologies.

[26] Full build out refers to the build out in 2100.

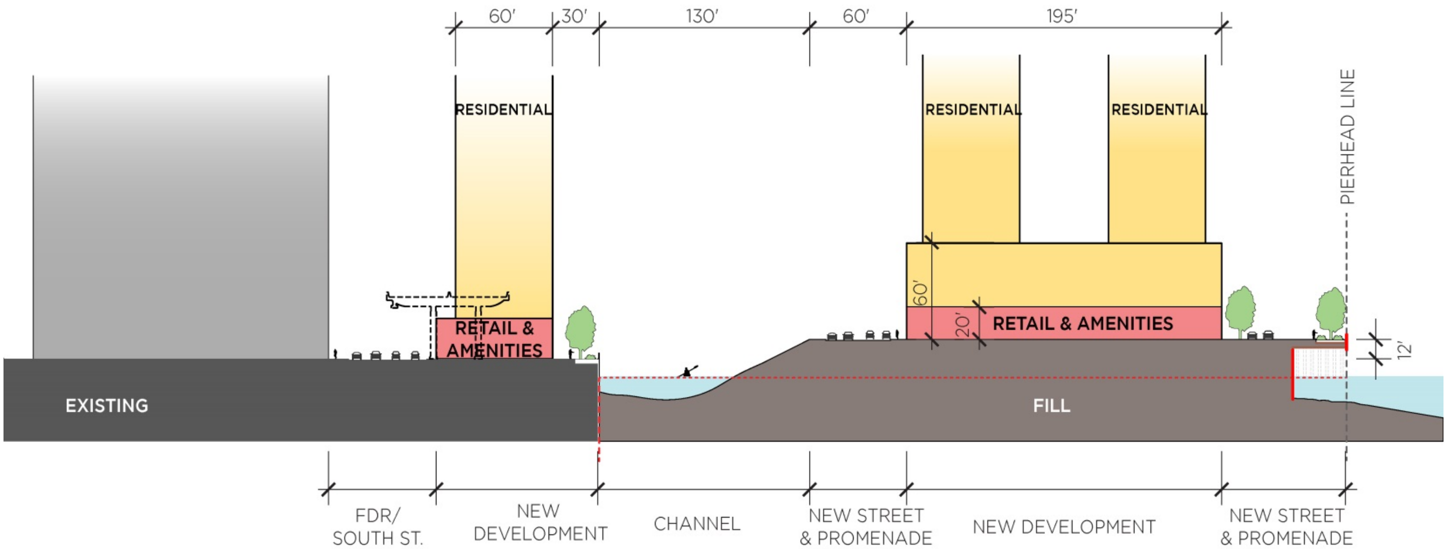


Figure 27: 250' Land Reclamation with Secondary Channel option (full build out): Example section view[27]

4.1.6 500' Land Reclamation

The proposed conceptual design for this option is 500' of land reclamation in the East River (i.e., placing fill) (Figures 28 and 29). A 500-foot wide levee would accommodate two blocks of a typical depth with a 60 foot right-of-way between them, roads on the upland and waterfront sides, and a waterfront promenade. The block depth would allow residential and/or commercial development on both frontages of the block with sufficient rear yard separation. Additional open space and waterfront access could be incorporated in the vicinity of the Brooklyn and Manhattan Bridges. Rather than construct a vertical seawall along the length of the levee, the offshore edge would incorporate a rip-rap revetment to dampen wave energy and create more ecologically-friendly conditions along the shoreline.

[27] Block built on fill would be dimensioned to allow office and/or residential building typologies.

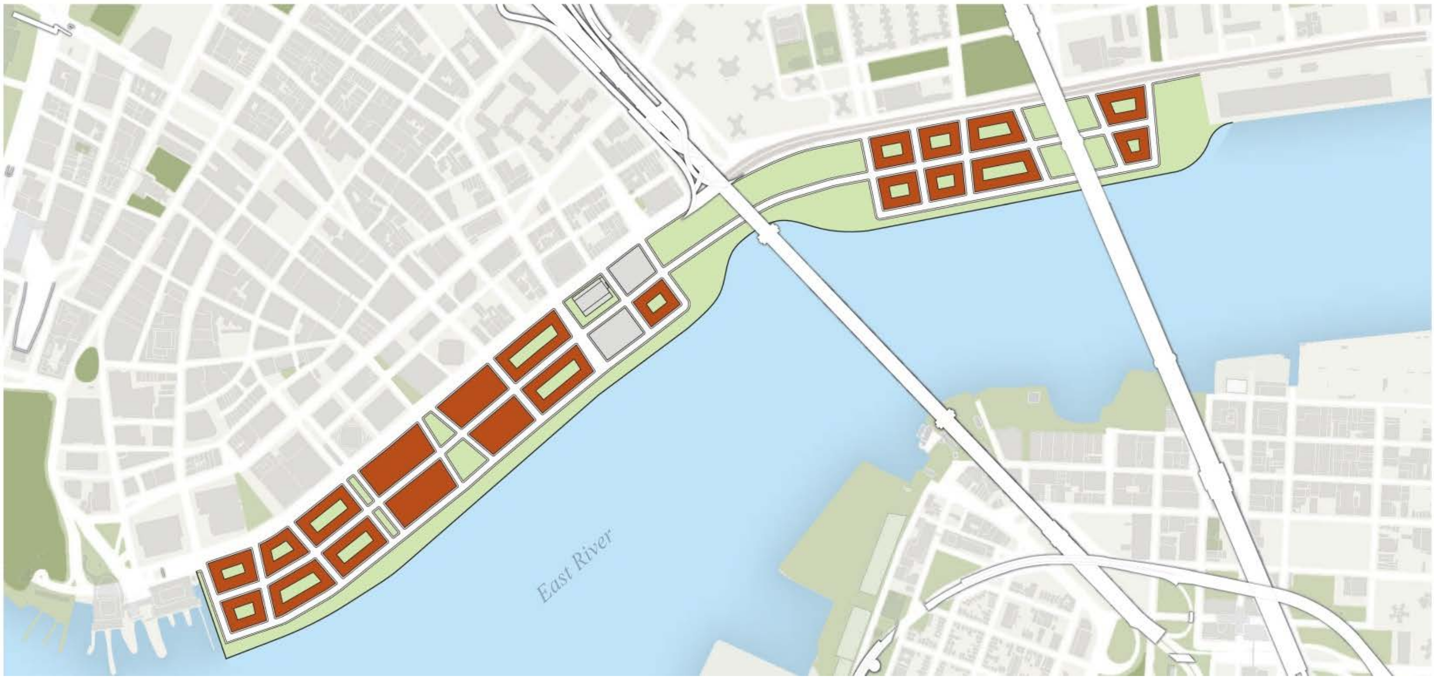


Figure 28: 500' Land Reclamation Option (full build out): Plan view[28]
Note: Buildings in grey are excluded from the MPL options' conceptual vertical development programs. See Section 4.4.1.2 for further detail

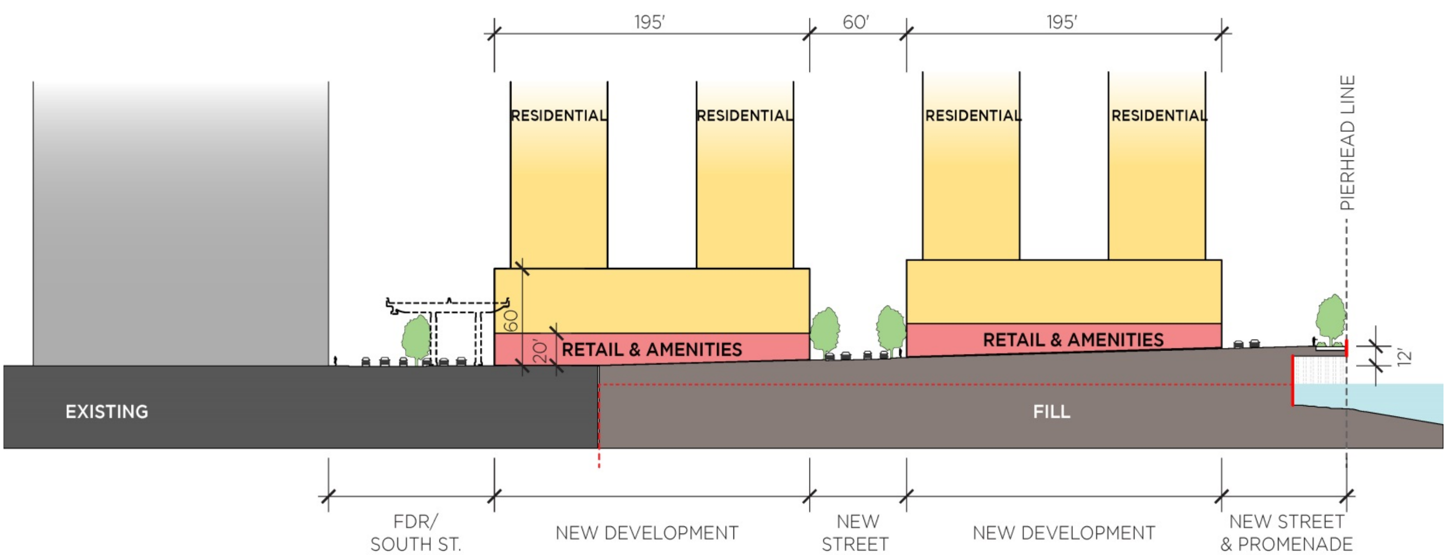


Figure 29: 500' Land Reclamation option (Full Build Out): Example section view[29]

[28] Full build out refers to the build out in 2100.

4.2 Principles and Assumptions

This section discusses the principles and assumptions that informed the technical (engineering, design) and financial analysis of the different options described above. These principles and assumptions cover spatial extent and urban design aspects, transportation planning and structural considerations, as well as broader flood protection issues that extend beyond the Study Area. This Feasibility Study assumes that an IFPS would be built first in any section of the Study Area where a passive flood protection solution (e.g., land reclamation or platform MPL) is not initially constructed. This Feasibility Study assumes that the additional flood protection improvements would be constructed roughly from 14th Street on the east side to 14th Street on the west side (outside the Study Area), as part of the City's broader flood protection strategy.[30]

4.2.1 Preliminary Urban Design Principles

A set of preliminary urban design principles was articulated to guide the conceptual development and analysis of the different options. These principles were intended to provide parity between the options and establish a simple baseline of "good urban design" across all options for the purposes of studying their feasibility within a broad 100-year time frame. More detailed urban design goals and urban design guidelines, as well as the possibility of creative exceptions to these initial principles, would be part of future master planning work. The preliminary urban design principles are:

1) Extend the city grid onto the MPL.
2) Make streets continuous within the MPL, especially those parallel to water.
3) Create long-term flexibility for diverse uses and building types on the MPL.
4) Include a mix of uses on the MPL that supports a robust neighborhood and complements upland uses.
5) Provide the MPL with continuous public access to the water (e.g., a "promenade").
6) Create one or more destination open spaces at the MPL.
7) Maintain primary upland view corridors to the water.
8) Engage the water.
9) Consider modifications to the FDR to improve connections to the waterfront.
10) Integrate existing and future public transportation with any new development on the MPL.
11) Promote sustainable, resilient, and resource-efficient development on the MPL.
12) Celebrate the bridges.

4.2.2 Dimensional and Density Assumptions

Plan dimensions for the land reclamation options in this Feasibility Study were based on typical building and block dimensions in Manhattan. This informed the conceptual site plans, development footprints, and resulting programs that were used in the financial feasibility analysis. The Study Team made these assumptions in order to study the feasibility of each coastal protection typology, relying also on its collective expertise, current development models, and relevant precedents. However, any actual development master plan, building design or development program for an MPL would be determined in future phases of study.

[29] Each block would be dimensioned to allow office and/or residential building typologies.

[30] These additional flood protection improvements could be portions of The BIG U proposal described in Section 3.5.

4.2.2.1 Block, Residential, and Commercial Development Typologies

Blocks were assumed to be 195’ deep, separated by 60’ right-of-ways. The 195-foot block dimension works equally well for residential or office development and provides a great deal of flexibility. This dimension will also be familiar to designers, developers, and builders working in New York City.

Block lengths were largely determined by extending the existing upland cross streets that run perpendicular to the water’s edge, in order to preserve view corridors and promote connectivity to the existing neighborhoods. Land uses were assumed to be predominantly residential, with residential building densities initially set at an FAR of 12, and commercial, with building densities at an FAR of 20. These numbers reflect the highest allowable FARs for Manhattan in each land use category and represent only a starting point from which to investigate the density required to finance the fill, infrastructure, and flood protection costs associated with a given coastal protection typology.

Residential buildings were assumed to be 55-65 feet deep with separations between building facades of 60 feet. These buildings were also assumed to have ground-level retail, with a few (3-5) residential floors above to create a building base.

4.2.2.2 Community Facilities and Open Spaces

A small percentage of total new development was assumed for community facility and cultural uses. These community facilities could include, but are not limited to, schools and libraries that would serve the new population on the MPL. In addition to the aforementioned land uses, open spaces were assumed to be located at the end of certain cross streets to serve as extensions of key upland open spaces and as recreational areas under the bridges and along waterfront esplanades. The open space locations were also assumed to coincide with the location of subway tunnels.

The wedge-shaped open spaces along the water that are the vestiges of boat slips were generally—though not always—kept in order to extend the existing open spaces, sight lines, and view corridors. A larger open space was generally maintained around the Brooklyn Bridge to frame the structure and create a destination park at its base. All options were assumed to maintain open space percentages of approximately 40%, a generous amount appropriate for high density neighborhoods and equivalent to the percentage of open space in Battery Park City.

4.2.2.3 Historic District Context

This Feasibility Study examined several strategies to achieve a high level of flood protection within the South Street Seaport Historic District while preserving the district’s character, reinforcing its cultural assets, and respecting the City’s existing leases with third parties. This meant devising development phasing and densities for each coastal protection option giving special deference to those factors. Thus, density was shifted away from the historic district and new development was not envisioned on the historic district’s waterfront parcels for approximately 50 years (i.e., until the existing leases expire).

Permanent preservation of the waterfront portion of the historic district was explored in the Feasibility Study, as described in detail in Section 4.4.1.

4.2.2.4 Conceptual Development Program

The principles and assumptions described above are the basis for the following development program framework, which also takes into account the road, sidewalk, and open space requirements that any new development on the MPL would have to meet:

- **Identification of Predominant Block Use**:[31] Development areas were divided into two types of blocks: (i) those with predominantly residential uses, including affordable and market-rate housing, rental apartments and condominiums, and (ii) those with predominantly commercial uses, namely office space.
- **Identification of Secondary Uses:** Predominantly residential and commercial blocks were then broken out into more specific uses:
  - **Predominantly Residential Blocks**: Each residential block was assumed to contain several additional uses, including retail in the majority of the ground floors and a small portion for community facilities with lower or no revenue generation potential (e.g., cultural, health care, educational, and other uses).
  - **Predominantly Commercial Blocks**: Each commercial block was assumed to contain the same share of retail and community amenities as the residential blocks. Commercial development was divided between office space and a modest amount of hotel development, catering to Southern Manhattan's dense office core and visitor base.
- **Projection of Preliminary Development Intensity**: FARs of 12 and 20 were applied to residential and commercial development parcels, respectively.[32] These FARs, which represent the upper end of allowable New York City density in each land use category, were selected solely in order to complete a preliminary comparison of development revenues and costs; the FARs are not meant to indicate or prescribe the nature of development on a Southern Manhattan MPL.

Potential development was then redistributed throughout the Study Area to better align with the range of densities and urban fabrics that exist along the adjoining neighborhoods, with significantly higher densities south of Pier 15 and lower densities to the north, which generally corresponds to existing conditions.

Based on the framework described, the Study Team defined development programs for each of the MPL typologies under consideration.[33] Table 3 details the programs, which can summarized as follows:

- The **Upland IFPS** option would not create land for new development because it consists of a series of flood protection mechanisms that would be deployed within the existing urban fabric of the neighborhoods that adjoin the Study Area.
- The **Upland Protection** option would not create new land and would, thus, afford minimal opportunities for new development.
- The **250' Land Reclamation** option would create 3.5 million square feet of commercial development, 6.4 million square feet of mixed-income residential development (corresponding to roughly 6,900 dwelling units), and 0.8 million square feet of community facility space. In addition, 17 acres of parks / open space would be created.
- The **250' Land Reclamation with Secondary Channel** option would create 3.4 million square feet of commercial development, 8.5 million square feet of mixed-income residential development (corresponding to roughly 8,800 dwelling units), and 0.8 million square feet of community facility space. In addition, 17 acres of parks / open space would be created.

[31] The Study Team categorized most parcels on the MPL as predominantly residential, given that new development at Hudson Yards, Manhattan West and the World Trade Center is likely to absorb a significant share of demand for new Manhattan office space in the near and medium term. However, several parcels were reserved for commercial development in most of the flood protection options given the value of creating a mixed-use district on the MPL and of preserving Southern Manhattan as an employment hub.

[32] Office buildings are generally built with larger floor-plates and are allowed higher FAR densities than residential buildings.

[33] Conceptual development programs were defined for analysis purposes only and are not meant to indicate an actual development plan.

- The **250' Land Reclamation-Platform Hybrid** option would create 6.4 million square feet of commercial development, 9.1 million square feet of mixed-income residential development (corresponding to roughly 9,900 dwelling units), and 1.3 million square feet of community facility space. In addition, 29 acres of parks / open space would be created.
- The **500' Land Reclamation** option would create 6.7 million square feet of commercial development, 12.1 million square feet of mixed-income residential development (corresponding to roughly 13,100 dwelling units), and 1.5 million square feet of community facility space. In addition, 30 acres of parks / open space would be created.

Table 3: Summary of Development Program[34]

Category	Upland Protection	250' Land Rec.	250' Land Rec. with Secondary Channel	250' Land Rec.-Platform Hybrid	500' Land Rec.
Commercial	70k SF	3.5M SF	3.4M SF	6.4M SF	6.7M SF
Mixed-Income Residential	1.0M SF (1,000 Units)	6.4M SF (6,900 Units)	8.1M SF (8,800 Units)	9.1 M SF (9,900 Units)	12.1M SF (13,100 Units)
Community Facilities	80k SF	0.8M SF	0.9M SF	1.3M SF	1.5M SF
Total	1.1M SF	10.7M SF	12.4M SF	16.8M SF	20.3M SF
Open Space	2 Acres	17 Acres	27 Acres	29 Acres	30 Acres

4.2.3 Transportation Infrastructure

The high-level, preliminary nature of this Feasibility Study required certain simplifying assumptions regarding the possible treatment of key transportation assets such as the FDR Drive, Pier 11, and the Manhattan Downtown Heliport. The significant complexities associated with the treatment of these assets in the event of an MPL development will require additional study in the future.

4.2.3.1 Subways and Bus Routes

Existing subway stops are generally 1/8 to 1/2 mile from the Study Area. Eight of the subway lines slope down to tunnel underneath the East River, while four lines travels across the river on the Manhattan Bridge. This makes the creation of new stops on these lines virtually impossible within the Study Area; only the 1 line at South Ferry or the J/Z line at Broad Street may offer opportunities to better serve the Study Area because they currently terminate adjacent to the Study Area, although the scope of this Feasibility Study does not cover studying the possibility of this. A better approach may be to modify existing bus routes or create additional routes to serve the Study Area coupled with continued ferry service, although the scope of this Feasibility Study does not examine these options.

4.2.3.2 FDR Drive

In the Study Area, the FDR Drive starts at the ground level on Broad Street to the south, becomes an elevated road deck at Old Slip, and continues north as an elevated deck after the Manhattan Bridge, past the northern boundary of the Study Area at Rutgers Slip/Pier 35.

[34] Total development square footage of comparable projects, for reference: World Trade Center 14.0M SF; Battery Park City 16.5M SF; Hudson Yards 12.7M SF; Seward Park 1.65M SF

This study assumes the reconfiguration of portions the FDR Drive to enable the conceptual design of several of the MPL typologies under review. The exact nature, extent, and feasibility of any such reconfiguration would require further study and discussion. Additional research would include a traffic study that provides a better understanding of current and projected traffic loads in the area, as well as reconfigured FDR geometries and design. Traffic analysis projections would take into account potential future conditions resulting from the implementation of an MPL, including the new development thereon. In addition, cost/benefit analyses would help identify the optimal FDR reconfiguration. Those analyses will have to be mindful of the specific conditions created by each different MPL typology under evaluation at that point.

Based on the knowledge gained from studying past, present, and potential future traffic conditions within the Study Area, the Study Team assumed the following potential FDR configurations as part of its analysis of the different MPL typologies: i) FDR remains as it is currently; ii) elevated portions of the FDR within the Study Area are lowered to grade (i.e., FDR is reconfigured as a boulevard); iii) FDR section within the Study Area is tunneled; and iv) FDR within the Study Area is reconfigured as a combination of at-grade and below-grade sections.

4.2.3.3 Pier 11

Ferry service is a very important part of Southern Manhattan's urban fabric, serving thousands of commuters every day (ferry routes shown in Figure 30). This Feasibility Study assumes that a new ferry landing or multiple landings would be included in the design of a future MPL in order to replace the landing currently located at Pier 11. Access to Southern Manhattan's office core and the constraints posed by the existing U.S. Pierhead Line are among the key factors that would have to be considered in the location and configuration of any new ferry infrastructure.

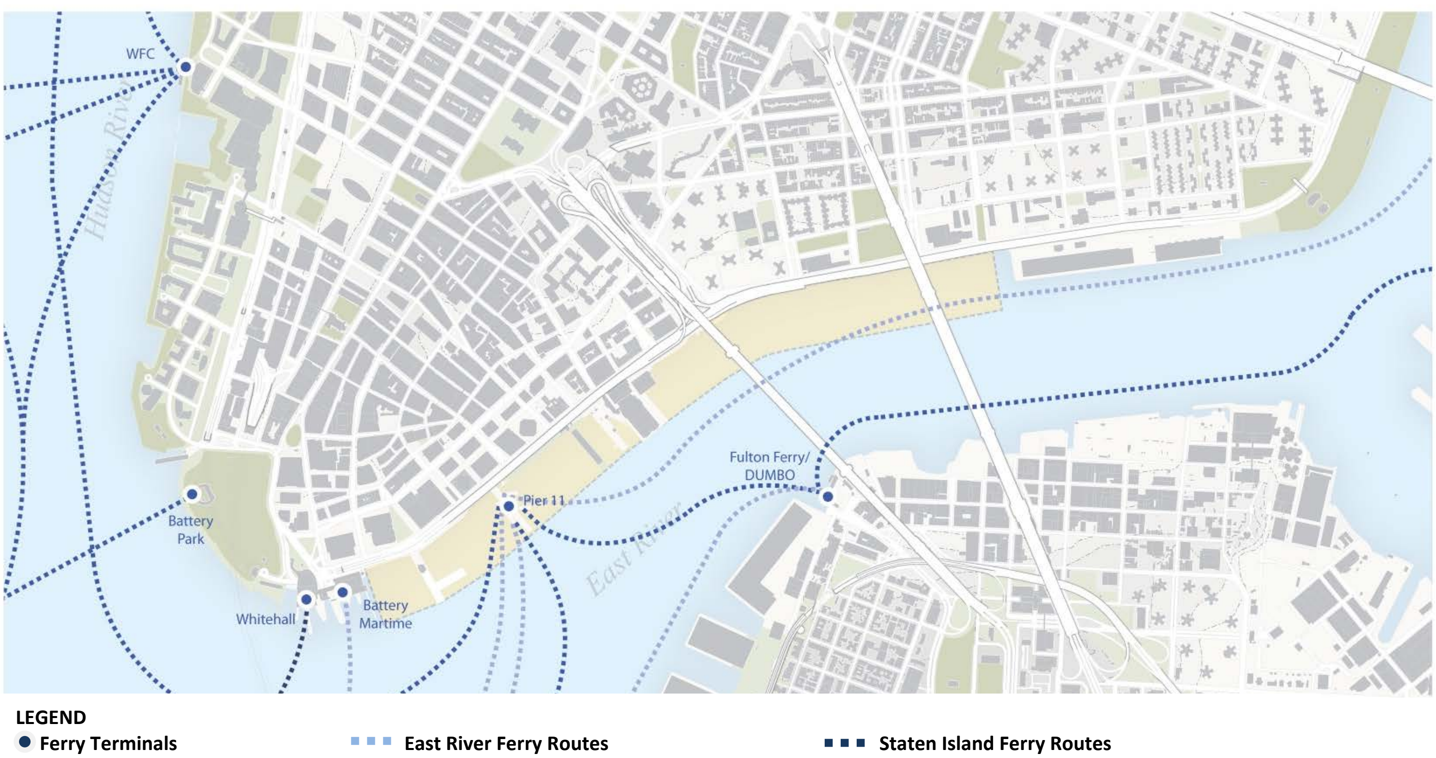


Figure 30: Ferries in Southern Manhattan

4.2.3.4 Heliport

This study assumes that the Downtown Manhattan Heliport would have to be relocated in the event an MPL is developed in the Study Area. The analysis of this potential relocation is outside the scope of this study and would have to be undertaken in future phases of evaluation.

4.2.4 Waterfront Integration

The Study Team examined the potential opportunities that each of the six flood protection typologies would provide to interact with the waterfront. While the higher elevation of an MPL with respect to the water would make direct physical interaction and water-based activities more challenging, the opportunities for waterfront integration could include ferry landings, river bottom habitats, marshland habitats, water-based recreation (swimming, kayaking) and education, and storm water management.

4.2.5 Structural Considerations

The following assumptions predominantly apply to the land reclamation flood protection options. The assumptions regarding rip rap revetment and utilities apply to all flood protection options except for an IFPS. The platform-related assumptions only apply to the 250’ Land Reclamation-Platform Hybrid option.

4.2.5.1 Land Reclamation

This Feasibility Study assumes that, in order to build out from the edge of the City’s existing perimeter, either a steel sheet pile cellular cofferdam system or pre-cast concrete cofferdam sections would be utilized to construct a perimeter wall that retains the proposed infill.[35] Following current engineering practice, the Feasibility Study assumes that the cellular cofferdam system would be comprised of 50 foot diameter main cells, with shorter arc cells in between them. Alternatively, if pre-cast concrete sections were selected to create the new outer perimeter, the soft soil stratum would be excavated to the sand layer and the pre-cast concrete sections would be installed on top of a layer of gravel that is built up to the required elevation. Each section would be floated into position and, with the use of ballasting techniques, would be lowered into the proper position on the river bottom. The pre-cast concrete sections would be connected to form a contiguous barrier.

4.2.5.2 Structural Fill

A suitable foundation would be needed for a new landform that accommodates the anticipated loading associated with the flood protection infrastructure and the new development on top of the MPL. This would require the placement of a structural fill inboard of the proposed perimeter structures. This Feasibility Study assumes that such structural fill would be a clean, well-graded sand fill.

4.2.5.3 Contaminated Soils

The historic use of Manhattan’s shorelines for heavy industrial operations makes it highly likely that a percentage of the material that is dredged within the footprint on a future MPL would be contaminated. This would require post-processing in order to treat the soil before disposal if capping is not an option. The contaminated soil could be treated as follows: 1) excavation, treatment, and disposal; 2) *in-situ* (at the site) treatment; or 3) containment.

[35] A cofferdam is a temporary enclosure that is built within a body of water and is designed to allow the enclosed area to be pumped out in order to create a dry work environment. A cofferdam is thus watertight and is usually made of sheet piling that encloses a given underwater area where engineering work will be performed.

This Feasibility Study assumes that any contaminated soil would be contained via capping techniques, possibly using geomembranes. However, if the non-structural soil stratum needs to be replaced with structural material, the contaminated soils would need to be excavated and transported to a special facility where they would be treated and/or incinerated and disposed of in a confined space.

4.2.5.4 Rip-rap Revetment

This Feasibility Study assumes that a rip-rap revetment would be installed along the outboard face of the waterfront structures proposed for each of the flood protection options except an IFPS. The revetment would help to reduce wave reflection in the harbor, stabilize the cofferdam systems on which the MPLs are constructed, and protect the base of the structures from scour due to river currents. The revetment may not be necessary if the cofferdam systems are constructed as pre-cast concrete sections; in this case, special wave attenuation measures could be constructed within the cofferdam units.

4.2.5.5 Utilities

The Study Team considered quantities and placement of utilities in its analysis of the different flood protection options. This study assumes the following in connection with utilities:

- Water: iron pipes would be used for water supply; utility infrastructure includes water supply regulators, water service lines, manholes, sewage piles, storm drainage piles, pump stations with sewer extensions and regulators, and fire hydrants;
- Lighting, electrical, and steam: utility infrastructure includes electrical ducts, site lighting, steam piping, steam chambers, and service lines; and
- Paving: utility infrastructure includes a concrete base for sidewalk and street/road pavement, concrete sidewalk and curb construction, and asphalt as the material of choice for street paving.

4.2.5.6 Platform

The 250' Land Reclamation-Platform Hybrid option assumes that a high capacity, high level pile-supported platform would be constructed outboard of the 250' land reclamation limit. The design of the platform's pile supports would vary in accordance with future building foundation/footing requirements to accommodate the different anticipated loadings. This Feasibility Study assumes a platform that is comprised of pre-cast, pre-stressed concrete elements.

4.2.5.7 Integrated Flood Protection and Flood Barriers

Integrated flood protection would be required on portions of the Study Area's shoreline that do not have any planned land reclamation, such as in the Upland IFPS option and portions of the Upland Protection option. Flood barriers would include floodwalls and/or flood gates, depending on the alternative.

A floodwall is a vertical barrier implemented to contain the waters of a river or other waterway that rise to higher than normal levels during extreme weather events. A flood gate is an adjustable gate used to control water flow. Flood gates can be used as part of a floodwall or levee system, closing prior to an extreme weather event. The floodwalls are assumed to be tall enough to protect the region from a 100-year storm event in the 2100s, which is an elevation of 19.0 feet NAVD88. Flood barriers of some kind would be required during early phases of many of the flood protection options under evaluation, including the land reclamation options, until the flood protection option has reached full build-out. A detailed geotechnical investigation would be required in order to properly design the foundations of such barriers.

4.2.5.8 Southern Manhattan Flood Protection

This Feasibility Study assumes that an MPL solution for the Study Area will be complemented by additional improvements that protect Southern Manhattan's entire waterfront from the effects of climate change. Section 4.2.7 of this report discusses how the cost of those other improvements (including the cost of interior pumping stations to prevent rainfall accumulation during storm events) is assumed in the financial feasibility analysis of each MPL option.

This Feasibility Study assumes that an IFPS would be built first in any section of the Study Area where a passive flood protection solution (e.g., land reclamation or platform MPL) is not initially constructed. This Feasibility Study assumes that the additional Southern Manhattan flood protection improvements would be constructed roughly from 14th Street on the east side to 14th Street on the west side (outside the Study Area).

4.2.6 Project Phasing

The Study Team made certain assumptions regarding the phasing of infrastructure and "vertical" development for each of the six flood protection options under review. For the land reclamation options, such phasing was based on the four Study Area Zones. The phasing for Zone 2 was mindful of both the South Street Seaport Historic District and the existence of long-term lease agreements between the City and third parties. Given these factors, Zone 2 was further divided into two subsections consisting of: 1) the waterfront parcels of the South Street Seaport Historic District, and 2) the area north of Pier 17. For the options where no land reclamation was proposed, it was assumed that the project was built at once and there was no phasing.

Infrastructure phasing considerations for all six flood protection options included the cost of the different infrastructure elements (e.g., land fill, flood protection, site work, and other upfront costs), the treatment of the FDR Drive, and coordination with other flood protection systems in Southern Manhattan. The table below illustrates the phasing for all flood protection options; "years" are relative to the start of the project rather than pegged to specific calendar years.

Table 4: Site-wide infrastructure phasing for all flood protection options relative to start of development period (years)

Category	Years
IFPS	
Fill & Flood Protection	1 to 5
Other Upfront Costs	6 to 7
Start of Other Southern Manhattan Flood Protection	35
Upland Protection	
FDR	1 to 10
Flood Protection/Building Base	1 to 15
Site Work	16 to 17
Other Upfront Costs	16 to 17
Start of Other Southern Manhattan Flood Protection	35
250' Land Reclamation	
Other Upfront Costs	5 to 6
FDR	5 to 14
Start of Other Southern Manhattan Flood Protection	35
250' Land Rec.-Platform Hybrid	
Other Upfront Costs	6 to 7
FDR	6 to 15
Start of Other Southern Manhattan Flood Protection	35

Category	Years
250’ Land Rec.-Secondary Channel	
Other Upfront Costs	6 to 7
FDR	6 to 15
Start of Other Southern Manhattan Flood Protection	35
500’ Land Reclamation	
Other Upfront Costs	6 to 7
FDR	6 to 15
Start of Other Southern Manhattan Flood Protection	35

Table 5: Infrastructure phasing (years) for land reclamation options, by Study Area Zone

Category	Zone 1	Zone 2 (Historic District)	Zone 2 (North of Pier 17)	Zone 3	Zone 4
250’ Land Reclamation					
Fill/Settling & Flood Protection	1 to 4	52 to 56	10 to 13	11 to 14	14 to 17
Site Work	5 to 6	57 to 58	14 to 15	15 to 16	18 to 19
250’ Land Rec.-Platform Hybrid					
Fill/Settling & Flood Protection	1 to 5	52 to 56	15 to 18	16 to 19	20 to 23
Site Work	6 to 7	57 to 58	19 to 20	20 to 21	24 to 25
250’ Land Rec.-Secondary Channel					
Fill/Settling & Flood Protection	1 to 5	52 to 56	10 to 13	12 to 15	16 to 19
Site Work	6 to 7	57 to 58	14 to 15	16 to 17	20 to 21
500’ Land Reclamation					
Fill/Settling & Flood Protection	1 to 5	52 to 56	17 to 20	18 to 21	23 to 26
Site Work	6 to 7	57 to 58	21 to 22	22 to 23	27 to 28

Phasing of vertical development was considered for all flood protection options under evaluation except the Upland IFPS option, which does not allow for any vertical development. Key vertical development phasing considerations included when land sales would begin and end, as well as when the first and last buildings on the MPL would be delivered.

Table 6: Phasing of vertical development (years)

Category	Zone 1	Zone 2 (Historic District)	Zone 2 (North of Pier 17)	Zone 3	Zone 4
Upland Protection					
Land Sales Begin	18	19			
Land Sales Completed	19	20	-	-	-
First Building Delivery	20	21			
Final Building Delivery	20	21			
250' Land Reclamation					
Land Sales Begin	7	58	14	15	18
Land Sales Completed	14	61	15	18	19
First Building Delivery	9	61	16	17	20
Final Building Delivery	15	62	16	19	20
250' Land Rec.-Platform Hybrid					
Land Sales Begin	8	59	19	20	24
Land Sales Completed	19	60	20	24	26
First Building Delivery	10	61	21	22	26
Final Building Delivery	20	61	21	25	27
250' Land Rec.-Secondary Channel					
Land Sales Begin	8	59	15	16	20
Land Sales Completed	15	61	16	20	21
First Building Delivery	10	61	17	18	22
Final Building Delivery	16	62	17	21	22
500' Land Reclamation					
Land Sales Begin	8	59	21	22	27
Land Sales Completed	21	62	22	27	29
First Building Delivery	10	61	23	24	29
Final Building Delivery	22	63	23	28	30

4.2.7 Financial[36]

4.2.7.1 Project Costs and Revenue

The financial self-sufficiency of an MPL system and its potential to generate excess funds to support other resiliency initiatives depends on the relative magnitude of the "horizontal" costs that will be incurred and the revenues that will accrue over time, as outlined below. "Horizontal" costs include onsite and off-site costs required to achieve flood protection, provide required mitigation, and create and service new development parcels. This Feasibility Study assumes that a future MPL's "master developer"

[36] Program assumptions are for analysis purposes only and are not meant to indicate an actual development program.

would take on these costs.[37] "Vertical" costs include the cost of constructing revenue-generating buildings on an MPL's development parcels. These costs are assumed to be borne by third-party developers who would lease or purchase development rights from the master developer.

In order to test the financial feasibility of the six flood protection options under evaluation, the Study Team projected over a 100-year period both costs and revenues associated with the development of an MPL. The Feasibility Study assumes that such period would commence after the MPL's infrastructure is constructed. The assumptions that were made to generate costs and revenues for each of the six options under study can be summarized as follows:

4.2.7.1.1 Project Costs

These costs comprise horizontal and vertical development costs.

Horizontal Project Costs[38]

- **Onsite Infrastructure Creation Costs:** Include initial planning and permitting costs, land reclamation and/or platform creation costs, "gap" IFPS costs for interim protection, improvements to the storm water system, and site infrastructure costs (including costs to create roads, utilities, sidewalks, and open space).
- **Infrastructure Reconfiguration and Mitigation Costs:** Includes a contingency to account for potential FDR reconfigurations, Downtown Manhattan Heliport relocation, as well as improvements to the Brooklyn and Manhattan Bridges (the bridge improvements would be required specifically in connection with the 250' Land Reclamation with Secondary Channel option). The contingency also covers off-site mitigations that could be required under the New York State Tidal Wetlands regulations as well as a contingency to increase school and library capacity in connection with the new population on a future MPL. This Feasibility Study accounts for all of these costs to conservatively reflect their scale and potential, although the associated projects have not been planned or designed and are subject to further study.
- **Infrastructure and Open Space Operating Costs:** Refers to the costs associated with the flood barriers that would be constructed in connection with the different MPL configurations under review, within different timeframes for each configuration, as well as maintenance costs associated with new open space created within the Study Area.
- **Southern Manhattan Flood Protection:** Refers to the cost of implementing an IFPS roughly from 14th Street on the east side to 14th Street on the west side (outside the Study Area).[39] This cost includes the installation of the IFPS foundations, required improvements to the existing storm water infrastructure, maintenance and storage of materials, and labor to assemble and remove the IFPS before and after a storm.

[37] A master developer would be responsible for overseeing all planning, entitlement processes and infrastructure financing. The master developer would also coordinate with various third parties to manage the construction of horizontal infrastructure such as reclaimed land, other flood protection infrastructure, new utilities, roadways and open space. The master developer would engage with vertical developers seeking to build revenue-generating uses and collect ground lease, land sale and/or other revenues associated with vertical construction. A range of public and private entities could theoretically play the role of master developer, including the City itself, a newly-created public authority similar to the Battery Park City Authority, some form of public-private partnership, or a for-profit entity.

[38] Excludes the costs of building vertical structures for revenue-generating and community uses.

[39] This IFPS could be portions of The BIG U proposal described in Section 3.5.

Vertical Project Costs

In addition to the horizontal costs, the Study Team projected the "vertical" (i.e., building) costs associated with the new commercial and residential development that would be built on the different flood protection options. This Feasibility Study assumes that third-party developers would take on these costs when bidding for the right to develop on the MPL's newly-created parcels. Thus, these costs are not directly included in the cash flows to the MPL's master developer.[40]

4.2.7.1.2 Project Revenues

Master developer revenues were projected from two sources: 1) the phased disposition of the rights to create new residential (market rate and affordable), office, retail, and hotel development on the MPL, in accordance with certain space absorption estimates, and 2) ongoing property tax or equivalent payments in lieu of taxes ("PILOT") from new buildings on the MPL.

Revenues from development rights were estimated by modeling hypothetical vertical development cash flows for each of the uses described above and solving for the amount private developers would be willing to pay per square foot for the right to build each product type. These "residual" values per square foot were multiplied by the projected development program for each development parcel to determine the revenue generation potential of each parcel in each of the different flood protection options under review.

Payments for development rights were assumed to consist of a ground lease, structured either as a lump sum payment or a stream of future cash flows (the latter were calibrated to equal a lump sum payment in net present value terms). The ground lease was assumed to generate a modest reduction in the value of development rights compared to land sale, which is consistent with observed conditions at other local sites subject to a ground lease such as Battery Park City.

This Feasibility Study's financial feasibility analysis relies on a number of assumptions relating to rents, operating expenses, property taxes, tax incentives, tenant improvements and leasing commissions for commercial uses, exit sales for income-generating uses, as well as sale prices for condominiums. These assumptions are based on historic data for Southern Manhattan's neighborhoods, as well as reasonable projections of future conditions. Residential development on the MPL was assumed to be 20% affordable housing and 80% market rate housing.[41]

In addition to the revenues generated through development rights, this Feasibility Study examines the revenues from property taxes or PILOT. The NYC Department of Finance provides detailed estimates of property taxes per square foot, by use and neighborhood, in its "FY 2014 Guidelines for Properties Valued Based on the Income Approach, Including Office Buildings, Retail, Garages, Hotels, and Residential Properties." The Financial Feasibility analysis projects annual property tax revenues for each new development parcel on the MPL based on these estimates, which are weighted to reflect the break-out of each use on each such parcel.[42]

4.2.7.2 Project Financing

Project costs can be financed with a range of different options. Depending on the magnitude of those costs, the availability of funds, and the preferences of decision makers, project costs could be financed:

[40] These costs impact the master developer cash flows indirectly by helping to determine the amount developers would be willing to pay for the right to build at the Study Area.

[41] These are housing affordability assumptions only for baseline analysis purposes; they do not describe an actual development program.

[42] In other words, the development proceeds per square foot associated with a parcel consisting of residential, retail, and community uses would be equal to the product of the parcel's relative use break-out times the property taxes per square foot associated with each use.

- Directly through City, state and/or federal government capital budgets (and those of their component entities);
- With revenue bonds tied to on-site development proceeds and PILOT, with or without a public sector guarantee;
- By a private master developer in exchange for the right to develop on newly created parcels; or,
- By a hybrid of these options.

Given the magnitude of potential MPL project costs and the range of potential new development on the different MPL typologies, a private master developer would likely not be able to independently finance all project costs, even in exchange for the right to all project revenues. At the same time, given the constrained budgets of the City, state and federal governments, public capital grants would likely not be available to cover more than a portion of project costs.

The Feasibility Study assumes that a future MPL project would largely be funded with a combination of General Obligation bonds and revenue bonds. The latter would require public credit enhancement and/or debt service support, at least in the earliest phases of the project (i.e., before a critical mass of revenue-generating uses is completed). Therefore, to compare future costs and revenues, the financial feasibility analysis applies a discount rate associated with publicly-supported infrastructure projects.

Project financing structures are discussed in Section 5.3.

4.3 Evaluation

For each of the six flood protection options under review, the Study Team evaluated a range of factors, including: cost and time to construct, maintenance required to achieve a desired level of flood protection reliability, and impacts to the aquatic environment. The following matrix summarizes such evaluation in a pros and cons format.

Table 7: Pros and cons of each of six flood protection options

Options	Pros	Cons
Upland IFPS	• Faster and easier to construct than other alternatives • Relatively low cost, as compared to earthen levees • Avoids impacts to aquatic environment • Fewer permitting requirements than land reclamation options	• Less reliable option for Study Area than passive flood barrier • Does not produce economic and community development opportunities • Not self-financing; Does not provide funding for other Southern Manhattan flood protection investments
Upland Protection	• Provides some economic and community development opportunities • Avoids impacts to aquatic environment • Fewer permitting requirements than land reclamation options	• Less reliable than passive flood barriers such as levees • Not self-financing; Does not provide funding for other Southern Manhattan flood protection investments • Scale of economic and community development opportunities is constrained
250’ Land Reclamation	• High level of flood protection reliability • Large area for economic and community development; sufficient space to construct a complete city block of civic infrastructure plus waterfront esplanade	• Impacts to aquatic environment • Restriction to a single block of development hinders creation of cohesive neighborhood • Not self-financing; Does not provide funding for other Southern Manhattan flood protection investments

Options	Pros	Cons
250’ Land Reclamation-Platform Hybrid	• Underlying levee would provide high level of flood protection reliability • Potentially large area for economic and community development • Less fill material required than land reclamation alternatives of same size	• Requires land reclamation, but does not allow for design and construction flexibility on the platform over time; any large-scale development must be pre-determined at project outset • Because of shading affects, level of aquatic impacts likely considered comparable to land reclamation of same size • Not self-financing; Doesn’t provide funding for other Southern Manhattan flood protection investments
250’ Land Reclamation with Secondary Channel	• High level of flood protection reliability • Large area for economic and community development; sufficient space to construct a complete city block of civic infrastructure plus waterfront esplanade • Environmentally friendly; triples the available shoreline and waterfront area and could provide aquatic habitat	• Increased cost of protecting additional channel shorelines is carried by less square footage of development compared to 250’ Land Reclamation • Potential operation & maintenance issues associated with surge barriers constructed at north/south end of secondary channel could affect reliability • Restriction to a single block of development hinders creation of cohesive neighborhood; neighborhood could feel isolated from Manhattan • Existing Pier 17, Tin Building and New Market Building structures cannot be incorporated into the MPL • Not self-financing; Does not provide funding for other Southern Manhattan flood protection investments
500’ Land Reclamation	• High level of flood protection reliability • Largest area for economic and community development among the alternatives; sufficient space to construct 2 complete city blocks of civic infrastructure plus waterfront esplanade • Potential to self-fund and provide significant resiliency program funding	• Impacts to aquatic environment

4.3.1 Financial Evaluation

In addition to a qualitative evaluation of the different flood protection options, the Study Team quantified revenues and costs for each of the options in order to determine the net economic benefit each one would yield. The following table illustrates the net present value (“NPV”) of each flood protection option’s associated costs and revenues.

Table 8: Detailed NPV of costs and revenues

Category	Upland IFPS	Upland Protection	250' Land Reclamation	250' Land Rec.-Platform Hybrid	250' Land Rec. with Secondary Channel	500' Land Reclamation
Revenues						
Land Sale Proceeds	$0B	$0.1B	$1.0B	$1.0B	$1.1B	$1.7B
PILOT Revenues	$0B	$0.1B	$1.6B	$2.4B	$1.7B	$2.6B
Total	**$0B**	**$0.2B**	**$2.5B**	**$3.4B**	**$2.8B**	**$4.3B**
Costs						
Onsite Infrastructure Creation[43]	$0.1B	$0.3B	$2.1B	$2.6B	$2.6B	$2.4B
Infrastructure Reconfiguration & Mitigation[44]	$0B	$0.3B	$0.5B	$0.6B	$0.8B	$0.6B
Infrastructure and Open Space Operating Costs[45]	$0.4B	$0.1B	$0.1B	$0.1B	$0.1B	$0.1B
Southern Manhattan Flood Protection[46]	$0.4B	$0.4B	$0.4B	$0.4B	$0.4B	$0.4B
Total	**$0.9B**	**$1.2B**	**$3.1B**	**$3.8B**	**$3.9B**	**$3.6B**
Net Benefit	**($0.9B)**	**($1.0B)**	**($0.6B)**	**($0.4B)**	**($1.1B)**	**$0.7B**

Table 9: Summary of NPV of costs vs. revenues

Option	NPV Revenue	NPV Costs	Net Benefit
Upland IFPS	$0.0B	($0.9B)	**($0.9B)**
Upland Protection	$0.2B	($1.2B)	**($1.0B)**
250' Land Reclamation	$2.5B	($3.1B)	**($0.6B)**
250' Land Reclamation-Platform Hybrid	$3.4B	($3.8B)	**($0.4B)**
250' Land Reclamation with Secondary Channel	$2.8B	($3.9B)	**($1.1B)**
500' Land Reclamation	$4.3B	($3.6B)	**$0.7B**

[43] Includes initial planning work, land reclamation and/or platform creation, temporary flood protection infrastructure within the Study Area, site work and open space capital costs

[44] Includes cost contingencies for modification of FDR, Downtown Heliport, bridge infrastructure, school and library capital costs and off-site mitigation projects, subject to future planning studies

[45] Includes ongoing costs to maintain and operate flood protection infrastructure and open space within the Study Area

[46] Includes cost of extending flood protection infrastructure outside of the Study Area, including upfront capital, maintenance and ancillary improvements to stormwater system

- **Upland IFPS Option:** Since it does not generate any revenues, its net financial impact is equal to the NPV of its costs, which add up to negative $900 million.
- **Upland Protection Option:** The NPV of its horizontal costs exceeds that of its revenues by nearly $1 billion, which indicates that this option would not be self-financing and would require additional funding.
- **250’ Land Reclamation Option:** The NPV of its horizontal costs exceeds that of its revenues by $600 million. Most, but not all, of this option’s infrastructure costs would be covered by project revenues.
- **250’ Land Reclamation-Platform Hybrid Option:** The NPV of its horizontal costs exceeds that of its revenues by $400 million. Most, but not all, of this option’s infrastructure costs would be covered by project revenues.
- **250’ Land Reclamation with Secondary Channel Option:** The NPV of its horizontal costs exceeds that of its revenues by over $1.1 billion, which indicates that this option would not be self-financing and would require significant additional funding.
- **500’ Land Reclamation Option:** The NPV of its project revenues exceeds that of horizontal costs by nearly $700 million. Thus, infrastructure costs could potentially be covered solely by project revenues using conventional public financing. Additional project revenues could help pay for other flood protection investments in the city.

4.4 Findings

After evaluating the six flood protection options, the Study Team further screened and analyzed them based on their ability to achieve the project goals described in Section 1.2 of this report. Key findings are described below.

1) Enhanced Flood Protection for Southern Manhattan

Each of the six options was designed to achieve the same level of flood protection, if properly constructed and regularly maintained.

The options relying on permanently elevated reclaimed land, including the 250’ and 500’ Land Reclamation options, are likely the most reliable as they are passive in nature, consisting of only earthen levee. The Upland IFPS, which relies on temporarily deployable floodwalls, is likely the least reliable option for the specific location of the Study Area. This would be particularly the case once rising sea levels begin to require the construction of higher flood barriers.

2) Resiliency Program Funding Source, including the ability to self-finance and/or provide surplus for other resiliency investments

Two revenue streams were assumed for the payment of the upfront and ongoing costs associated with each flood protection option under evaluation: (i) the phased disposition of development rights, through either outright sale or ground lease, to private developers that would create new residential (market-rate and affordable), office, retail, and hotel development on the MPL, and (ii) ongoing property taxes or PILOTs from development on MPL parcels. Any revenues remaining from these two sources after covering project costs could potentially be directed toward other City resiliency initiatives.

As discussed previously, the Upland IFPS option generates no revenues. The Upland Protection option, 250’ Land Reclamation option, 250’ Land Reclamation with Secondary Channel option, and 250’ Land Reclamation-Platform Hybrid option would be able to fund only a portion of their respective costs and would be unlikely to generate excess revenues to fund other City resiliency initiatives. The 500’ Land Reclamation option would likely generate sufficient revenues to fund all required costs, plus excess revenues that could support other City resiliency investments.

3) Economic and Community Development

Generally, the different flood protection options under review could enhance New York City’s economic and community vitality by creating new residential, commercial, community facility, and public open space, and by attracting the population density that supports such spaces. In addition, the construction of an MPL project could generate construction jobs.

Economic and community development benefits would be smallest for the Upland IFPS option, which involves no new development. Economic benefits would be most significant for the 500’ Land Reclamation and 250’ Land Reclamation-Platform Hybrid options, which would both result in the highest level of permanent job creation and the largest number of new residents, followed by the 250’ Land Reclamation and 250’ Land Reclamation with Secondary Channel options, then the Upland Protection option.

- **Upland IFPS** would not create any new development. In addition, this option could potentially isolate Southern Manhattan’s neighborhoods from the East River waterfront over time, as SLR would continue to demand higher flood walls.
- The line of narrow towers associated with the **Upland Protection** option could also isolate Southern Manhattan from the East River waterfront.
- With one block of new development, including public open space and community facility space, the **250’ Land Reclamation** option would add to the community and economic vitality of Southern Manhattan. This option may not have a critical mass large enough to develop a unique neighborhood fabric; however, the region could integrate into adjacent Southern Manhattan blocks.
- The **250’ Land Reclamation-Platform Hybrid** option offers water inlets as key areas of community activity; however, it presents a significant drawback in terms of phasing and long-term flexibility, due to the infrastructure associated with the platform portion of the option. The lack of flexibility could hinder community vitality in the future if the development is not able to adapt to serve new needs over time.
- The **250’ Land Reclamation with Secondary Channel** option would create a unique waterfront environment that could become a focus for community and economic activity. The option would feel less integrated into adjacent Southern Manhattan blocks, limiting the connections between existing neighborhoods and new development. It does, however, offer environmental benefits and the potential for a greater connection with the waterfront.
- With the largest amount of new development, including public open space and community facility space, as well as the highest level of integration into Southern Manhattan’s existing neighborhood fabric, the greatest critical mass, and the strongest internal connections, the **500’ Land Reclamation** option would likely have the most significant impact on community and economic vitality of Southern Manhattan.

Figure 31 presents the ability of the different flood protection options under review to achieve the project goals. Green shading indicates that a given option best meets the project goal, whereas red indicates that a given option is the least able to meet the project goal.

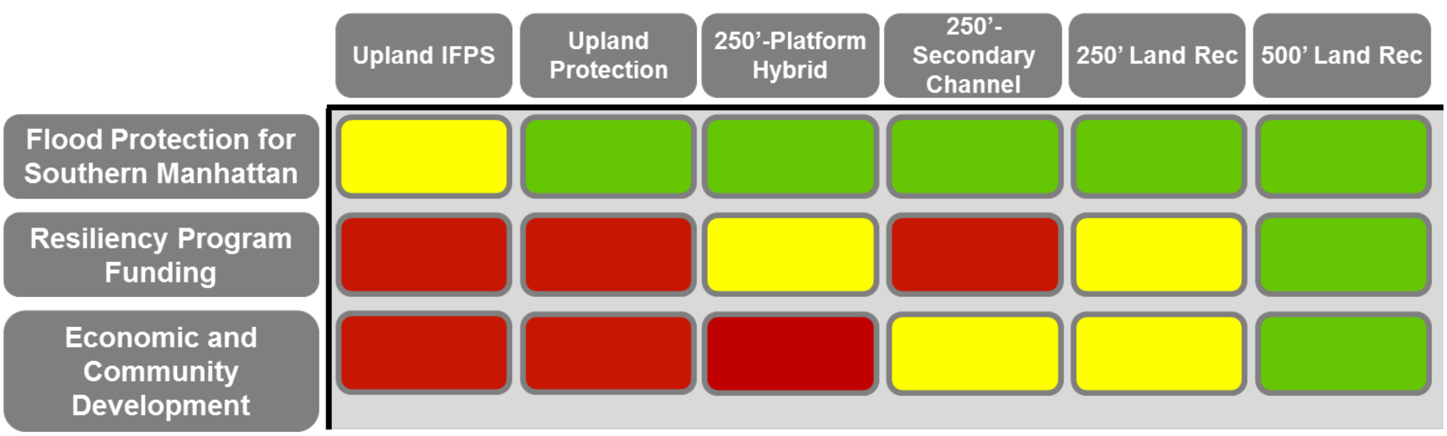


Figure 31: Ability of the six flood protection options to achieve project goals

Based on these findings, the Study Team screened out three of the options due to fatal flaws:

- **Upland IFPS** would not provide the same level of reliability as compared to other flood protection options under review, is unable to self-fund, and has no opportunity for economic or community development.
- **Upland Protection** is not able to self-fund and has little opportunity for economic or community development.
- **250' Land Reclamation-Platform Hybrid** is difficult to phase and limits future opportunities for economic and community development due to lack of flexibility.

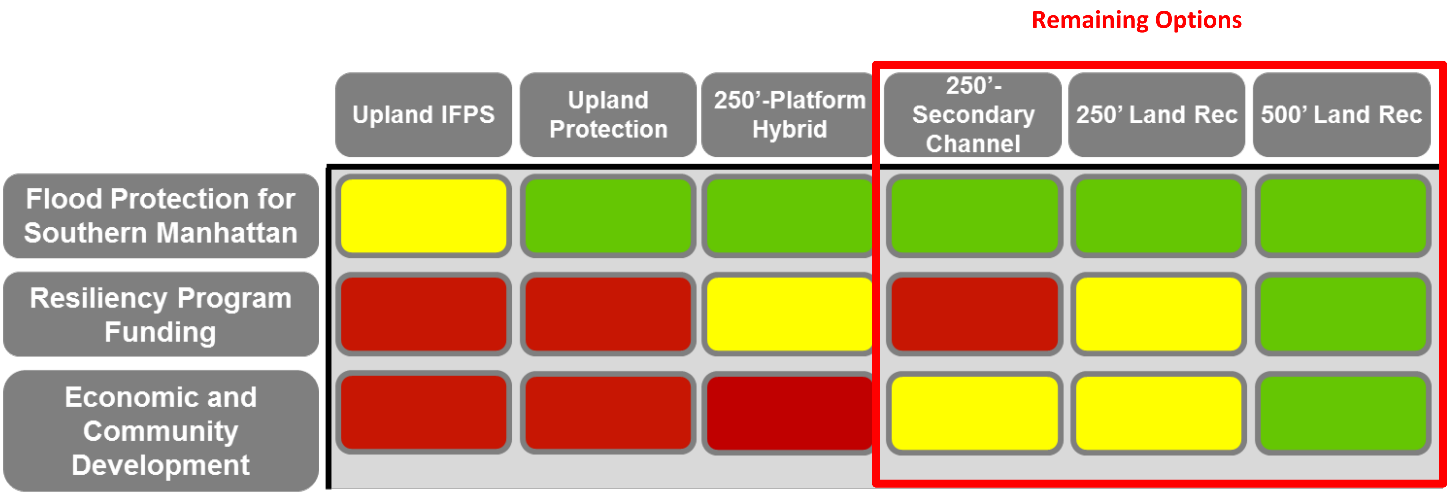


Figure 32: Ability of the six flood protection options to achieve project goals; remaining options for future analysis

As a result of this screening, the Study Team recommends three typologies for future analysis:

- 250' Land Reclamation
- 250' Land Reclamation with Secondary Channel
- 500' Land Reclamation

The 500' Land Reclamation option should be highlighted as the MPL typology that would best achieve all the project goals described in Section 1.2 of this report.

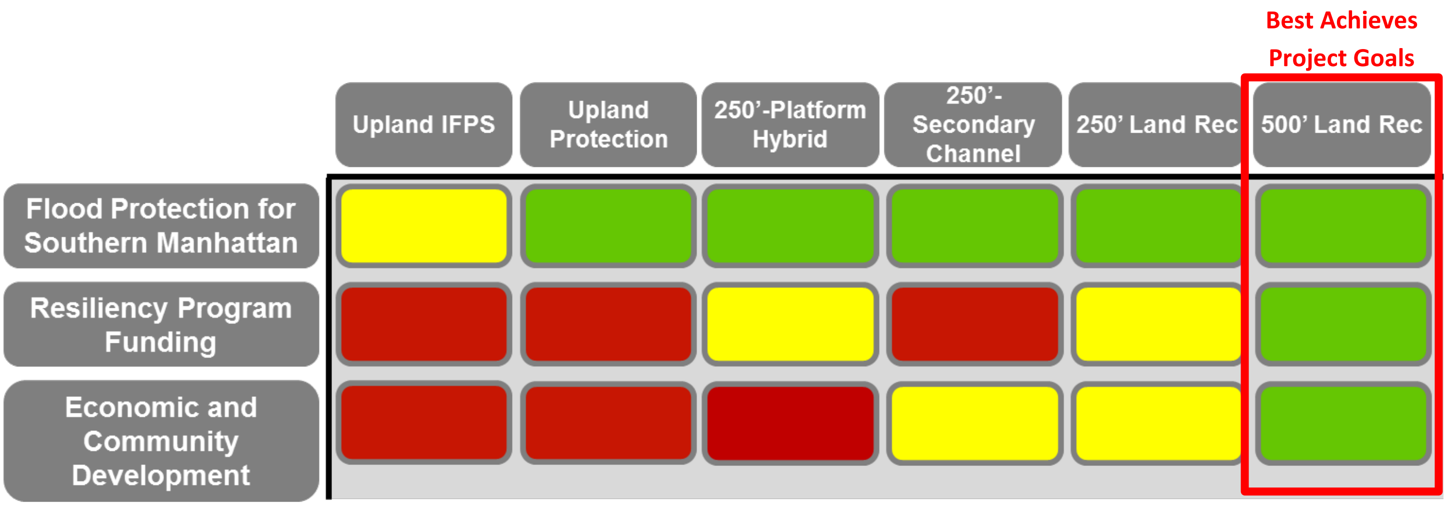


Figure 33: Ability of the six flood protection options to achieve project goals. Heat map illustrates that the 500' Land Reclamation option best achieves project goals.

4.4.1 Optimizing the 500' Land Reclamation Option: Development of the North Park Option

The 500' Land Reclamation option merited further study because it best achieves the project goals. The result of that additional study is an optimized configuration of the 500' Land Reclamation option.

Such resulting variation, labeled the **500' Land Reclamation North Park** option, shifts higher density development toward the southern portion of the Study Area in a manner consistent with the distribution of density in Southern Manhattan. Blocks with predominantly commercial uses would be located between the southern edge of the Study Area and Coenties Slip, with predominantly residential blocks located further north. A "North Park" would be constructed on the MPL between the Brooklyn Bridge and the Manhattan Bridge. The park could consist of wetlands and open spaces that would act both as flood protection elements and as an amenity for the adjoining neighborhoods. Two residential blocks would be constructed north of the Manhattan Bridge.

With the density concentrated south of the Brooklyn Bridge and north of the Manhattan Bridge, the North Park scenario performs well from an urban planning perspective: this distribution of density is contextual with adjacent neighborhoods, concentrates development closest to existing transit assets in the Financial District and the Lower East Side, and allows for the creation of a major open space amenity between the bridges.

4.4.1.1 Zone 1 Conceptual Development Program

In the 500' Land Reclamation North Park option, commercial blocks would reach an FAR of 25 between the southern boundary of the Study Area and Coenties Slip. Predominantly residential blocks would be located further north and would be limited to an FAR of 18, in line with the adjacent density. This alteration would result in a 12% increase in total development in Zone 1 over the amount assumed in the original 500' Land Reclamation option, from 12.4 million square feet to 13.8 million square feet over twelve new blocks. Zone 1 open space would total 5.5 acres.

4.4.1.2 Zone 2 Conceptual Development Program

MPL infrastructure construction would commence within Zone 2 following the completion of infrastructure and vertical development in Zone 1.

- **Zone 2 (Historic District)**
  - In the short term, integrated flood protection elements would be deployed adjacent to the waterfront portion of the South Street Seaport Historic District. These elements would protect the area prior to the development of an earthen levee and could take the form of The Big U concepts described in greater detail in Section 3.5 of this report.
  - After the existing City leases with third parties expire, those waterfront portions would be integrated into the MPL to increase their level of flood protection and enable four new development blocks. The structures on Pier 17 and the Tin Building parcels, which have been excluded from MPL project revenue projections, would ultimately be integrated into the MPL. Further study would be needed determine the best engineering solution to integrate development on these parcels into an MPL project.
- **Zone 2 (North of Pier 17)**
  - In addition, an MPL would be built generally between the waterfront portion of the South Street Seaport Historic District and the Brooklyn Bridge, creating two new development parcels. One of the two parcels would include development adjacent to the site of the current New Market Building, which is located on an existing pier and is presently the subject of a development proposal by The Howard Hughes Corporation to construct a new mixed use project. While the specific outcome of such development proposal will be determined by the applicable public approval processes, it is reasonable to generally assume that the New Market Building parcel will likely be redeveloped in some form prior to the commencement of MPL project infrastructure. Therefore, this parcel has been excluded from MPL revenue projections. Further study would be needed determine the best engineering solution to integrate development on this parcel into an MPL project.

Development in Zone 2 would have an average FAR of 13.6 and total 3.5 million square feet, a 31% increase over the amount of development assumed in the original 500 foot Land Reclamation option. These calculations exclude any current or future development that may or may not occur on Pier 17, the site of the Tin Building or the site of the New Market building. Any development on the last two sites will first require, among other permits/approvals, the relevant environmental and land use/public review processes. Zone 2 in this optimized scenario would include 9.1 acres of open space.

4.4.1.2.1 Analysis of Alternative Permanent Flood Protection Options for the Waterfront Portions of the South Street Seaport Historic District:

The Study Team also analyzed alternative flood protection options to an MPL that would minimize impacts on this area. Each of the options sought to minimize impacts to the character of the historic district while providing robust flood protection (i.e., infrastructure that relies as little as possible on the deployment, installation, and/or preparation of mechanical elements before an extreme weather event). The options that were studied sought to protect the historic district through the 2100s and include:

- **Option 1:** Implementing a longer-term upland IFPS. In concept, an IFPS could be installed below the eastern edge of the FDR viaduct and transition at angles on the south and north to the proposed MPL landforms. The IFPS would be designed to maximize specific view corridors and consist of possibly 6-10 large mechanized elements, possibly integrated into the FDR viaduct structural frame. Such a system would maintain most view corridors to the water and connectivity within the historic district east and west of the FDR viaduct (Infrastructure cost: $25 million in 2014$);
- **Option 2**: Constructing a narrow 19’ high levee structure on a strip of land that would be created by moving the current bulkhead east into the river by approximately 20 feet. The structure would include 1–3 large mechanical elements that would seek to preserve the primary view corridors through the new levee; however there would be adverse impacts to views to and from the historic district due to the levee height. Specific community or commercial programming could be integrated on the

east and west sides of the levee. This option would require the reconstruction of the Tin Building to a new elevation that equals the top of the new levee crown (Infrastructure cost: $150 million in 2014$); and,

- **Option 3:** Constructing a narrow 19' high levee structure on strip of land that would be created by moving the current bulkhead east into the river by approximately 20 feet. This option would also raise to the new levee crown elevation all of the piers and structures located east of the levee/FDR viaduct edge. No mechanized elements would be required in this option. Visitors to the raised areas would experience it as a "plateau" that is aligned with the topography of the MPL to the south and north; however there would be adverse impacts to views to and from the historic district due to the levee height. Similar to Option 2, this option would require reconstructing the Tin Building to a new elevation (Infrastructure cost: $250 million in 2014$).

The Study Team continues to recommend a 500' Land Reclamation MPL solution as the flood protection typology that best meets the project goals in this area. The alternative options that were analyzed are not as reliable, fail from a cost-benefit perspective, and generate significant negative impacts on view corridors and other elements of the historic district's urban fabric.

4.4.1.3 Zones 3 and 4 Conceptual Development Program

No development would occur between the Brooklyn Bridge and the Manhattan Bridge. After the completion of Zone 2's initial infrastructure, the MPL would be extended to Zones 3 and 4 and would become a new public park, with water-dependent recreational uses and various other public amenities. The North Park MPL in Zones 3 and 4 would provide the same level of flood protection as assumed in the original 500' Land Reclamation option; the park itself could be designed to flood during a storm event, but the built-in passive levee element would provide protection equal to the level provided throughout the Study Area.

Development in Zone 4 north of the Manhattan Bridge would total 1.5 million square feet of primarily residential development, assumed to include ground floor retail uses as well as community facility space, with a total FAR of 8.8. Including residential and retail development in Zone 4 would help activate the North Park by extending the street grid and urban fabric to the waterfront on the north side of the Park.

A plan view and rendering are illustrated in Figures 34 and 35, respectively.

Figure 34: 500' Land Reclamation - North Park option (2050 build out): Plan view

Figure 35: Illustrative rendering of 500' Land Reclamation - North Park concept (2050 build out)

4.4.1.4 Phasing

Phasing of infrastructure and vertical development under the North Park Option is provided in the tables below.

Table 10: Infrastructure phasing (in years) for North Park option; Site-Wide

Category	Site-Wide
500' Land Rec.- North Park	
Other Upfront Costs	6 to 7
FDR	6 to 15
Start of Other Southern Manhattan Flood Protection	35

Table 11: Infrastructure phasing for North Park option (in years)

Category	Zone 1	Zone 2 (Historic District)	Zone 2 (North of Pier 17)	Zone 3	Zone 4
Fill/Settling & Flood Protection	1 to 5	52 to 56	17 to 21	22 to 25	26 to 29
Site Work	6 to 7	57 to 58	22 to 23	26 to 27	30 to 31

Table 12: Vertical development phasing for North Park option (in years)

Category	Zone 1	Zone 2 (Historic District)	Zone 2 (North of Pier 17)	Zone 3	Zone 4
Land Sales Begin	8	59	22	N/A	30
Land Sales Completed	22	63	23	N/A	32
First Building Delivery	10	61	24	N/A	32
Final Building Delivery	23	64	24	N/A	33

4.4.1.5 Financial Implications

The North Park scenario would require lower infrastructure costs than the original 500 foot Land Reclamation option, reducing the NPV of required costs from $3.6 billion to $3.3 billion. A 7% reduction in total development, combined with slightly higher revenue generation potential, would result in an overall decline in revenues of $120 million in NPV terms, from $4.3 billion to $4.2 billion. Over a 100-year period, this scenario would generate $875 million in NPV, after covering all required project costs.

The following tables summarize new development, costs, and revenues associated with the 500' Land Reclamation options.

Table 13: 500' Land Reclamation Options – Conceptual development programs
Note: Numbers may not add due to rounding

	500' Land Rec.	500' Land Rec. - North Park
Commercial	6.7M SF	6.3M SF
Mixed-Income Residential	12.1M SF (13,100 Units)	11.1M SF (12,000 Units)
Community Facilities	1.5M SF	1.4M SF
Total	20.3M SF	18.8M SF
Open Space	30 Acres	26 Acres

Table 14: Detailed NPV of costs and revenues

Category	500' Land Reclamation	500' Land Rec. – North Park
Revenues		
Land Sale Proceeds	$1.7B	$1.8B
PILOT Revenues	$2.6B	$2.4B
Total	**$4.3B**	**$4.2B**
Costs		
Onsite Infrastructure Creation[47]	$2.4B	$2.2B
Infrastructure Reconfiguration & Mitigation[48]	$0.6B	$0.6B
Infrastructure and Open Space Operating Costs[49]	$0.2B	$0.1B
Southern Manhattan Flood Protection[50]	$0.4B	$0.4B
Total	**$3.6B**	**$3.3B**
Net Benefit	**$0.7B**	**$0.9B**

[47] Includes initial planning work, land reclamation and/or platform creation, temporary flood protection infrastructure within the Study Area, site work and open space capital costs

[48] Includes cost contingencies for modification of FDR, Downtown Heliport, bridge infrastructure, school and library capital costs and off-site mitigation projects, subject to future planning studies

[49] Includes ongoing costs to maintain and operate flood protection infrastructure and open space within the Study Area

[50] Includes cost of extending flood protection infrastructure outside of the Study Area, including upfront capital, maintenance and ancillary improvements to stormwater system

Table 15: Summary: NPV of 500' Land Reclamation options
Note: Numbers may not add due to rounding

Category	Base 500’ Land Reclamation	500’ Land Rec. - North Park
NPV Revenue	$4.3B	$4.2B
NPV Cost	($3.6B)	($3.3B)
Net Benefit	**$0.7B**	**$0.9B**

4.4.1.6 Alternative Affordable Housing Scenario for the 500’ Land Reclamation North Park Option

An alternative scenario was examined to model the financial impact associated with reserving a higher share of housing units within the project for low- and moderate-income households. The baseline scenario for all options within this study incorporates 20 percent of the housing units reserved for low-income households, with the remaining units rented or sold at market rates. In the North Park option, this adds 2,400 new low-income units at full build-out, while generating a positive net present value of project revenues less costs of $875 million over the next 100 years.

An alternative scenario, in which an additional 30 percent of housing units are reserved for moderate-income households, was also analyzed. This scenario results in a total of 50 percent of units reserved for low- and moderate-income households, holding the overall residential square footage constant. This option results in a total of 6,400 affordable units, while generating a positive net present value of project revenues less costs of $70 million over the next 100 years.

4.5 Additional Considerations

The Study Team took into consideration the additional factors described below as it developed and analyzed the different flood protection options.

4.5.1 Hydrodynamic Modeling

The Advanced CIRCulation model (the “ADCIRC Model”), which simulates movement of water throughout a given domain (in this case, the greater region of the Study Area), was used to model the storm tide with SLR in the region. Modeling was performed for the 500’ Land Reclamation option, as it was the option that—given the amount of land reclamation it would require—was expected to create the largest amount of impacts to the navigation channel. The Study Team designed a preliminary elevation model and landscape configuration using a geographic information system (“GIS”) software based on existing topographic data. The goal of these preliminary modeling efforts was to better understand how the 500’ Land Reclamation option would impact velocities in the East River and whether there would be a rebound effect outside the Study Area (i.e., an increase in water surface elevations in other areas of Southern Manhattan or Brooklyn).

The model inputs for the Feasibility Study were consistent with the ADCIRC Model developed for the Resiliency Plan. This included similar grid cell sizes and resolution, sea surface elevation, data for validation of the model (e.g., tidal constituents, average seasonal water levels, etc.), and hydrologic and hydraulic properties (e.g., Manning’s roughness values). SLR predictions were consistent with those outlined by the NPCC in 2013. In addition, the tidal forcing was assumed to come from a far offshore boundary and the model was run for 18 days to achieve a dynamic steady state. The model was then run for an entire month to examine tidal water levels and currents near the Study Area.

Preliminary modeling efforts done for the present day (2014), as well as for 2050 with SLR, indicate that land reclamation of this scale would not generate measureable wave rebound conditions. These findings suggest that, with the creation of an MPL in Southern Manhattan, there would not be a noticeable increase in water surface elevations in the areas outside the Study Area, such as Southern Manhattan or Brooklyn.

In addition, preliminary modeling efforts conducted for the present day (2014), as well as for 2050 with SLR, indicate with a high level of confidence that an MPL would minimize the effect that storm tide would have on upland areas. A 19.0-foot NAVD88 earthen levee could provide reliable flood protection even as SLR becomes a greater threat to the region over time; the areas upland of the MPL would also be better protected from the effects of storm surge during extreme weather events.

While preliminary modeling efforts have shown that the project is hydrodynamically feasible, future modeling efforts should be undertaken to determine which land reclamation configurations would generate the least likelihood of wave rebound conditions, as well as which configurations could ultimately reduce storm tide by the largest amount. Figures 36 and 37 illustrate an example of the maximum storm tide with and without a 500-foot MPL in the year 2050.

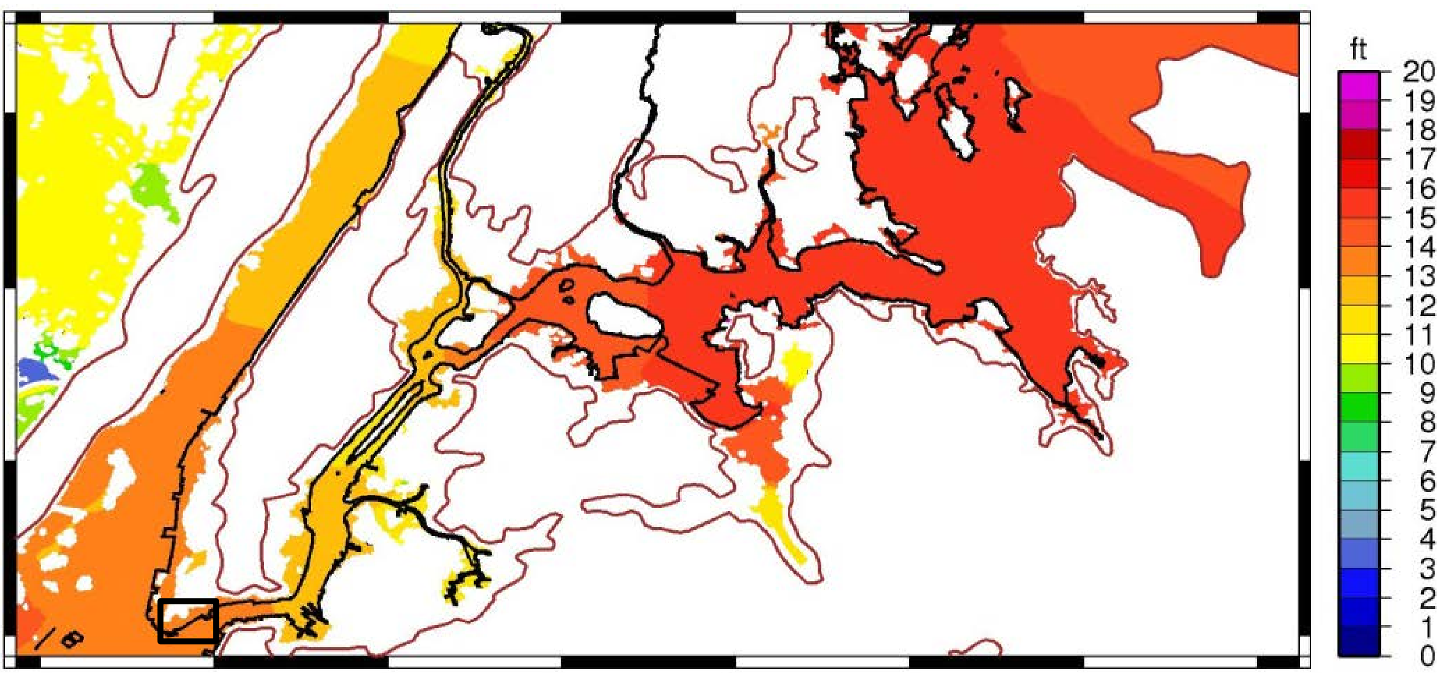


Figure 36: Maximum storm tide without MPL (year 2050). Approximate Study Area indicated by black polygon.

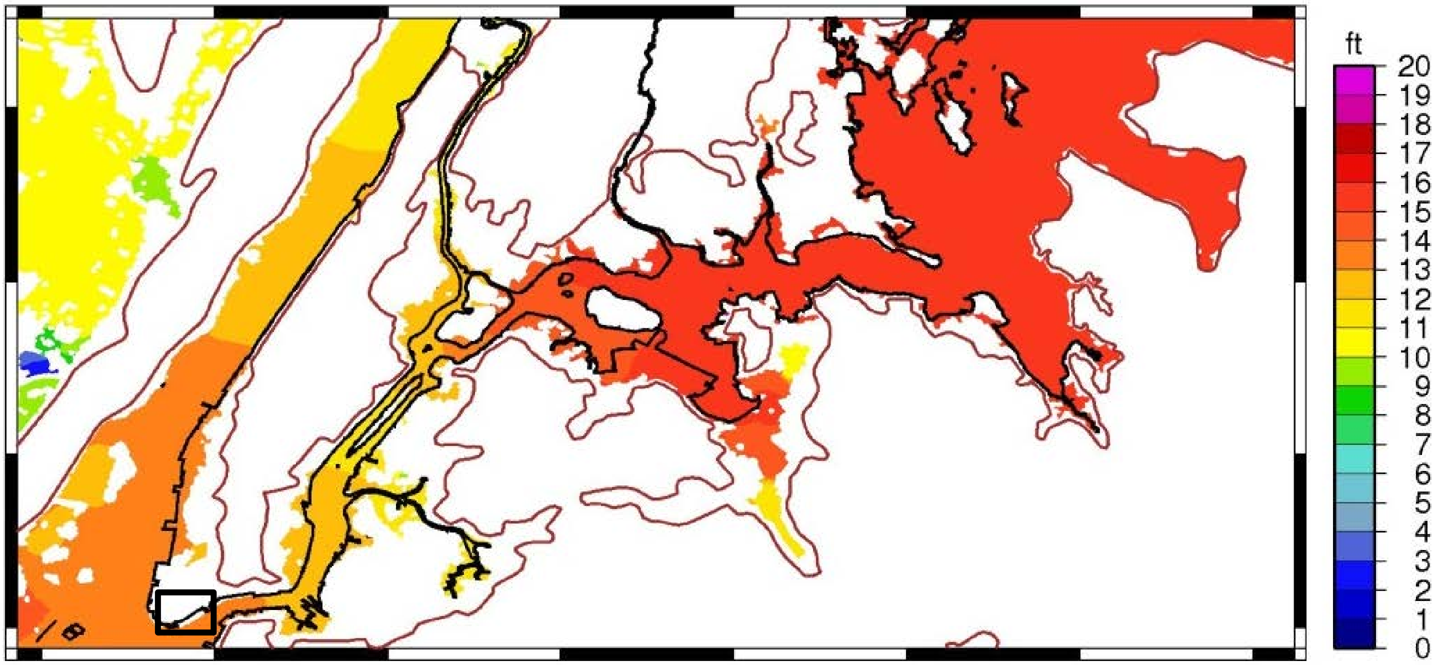


Figure 37: Maximum storm tide with MPL (year 2050). Approximate Study Area indicated by black polygon.

A tidal conditions impact assessment for present day was conducted near the Study Area in the navigation channel. In particular, the Study Team examined time series data on the velocities of water at five points in the East River in order to further understand how a potential MPL project would impact current conditions in the navigation channel. Simulations were run for two months, January 2012 and September 2012, in order to account for seasonal tidal fluctuations and expand the dataset. Both simulations were run under two conditions: (i) with the inclusion of a 500’ Land Reclamation MPL and (ii) without an MPL. The Study Team assumed that SLR will be uniform throughout the region and any changes in sea level would not drastically impact velocities. Therefore, it was acceptable to run the simulation for 2012 and make conclusions based on the data.

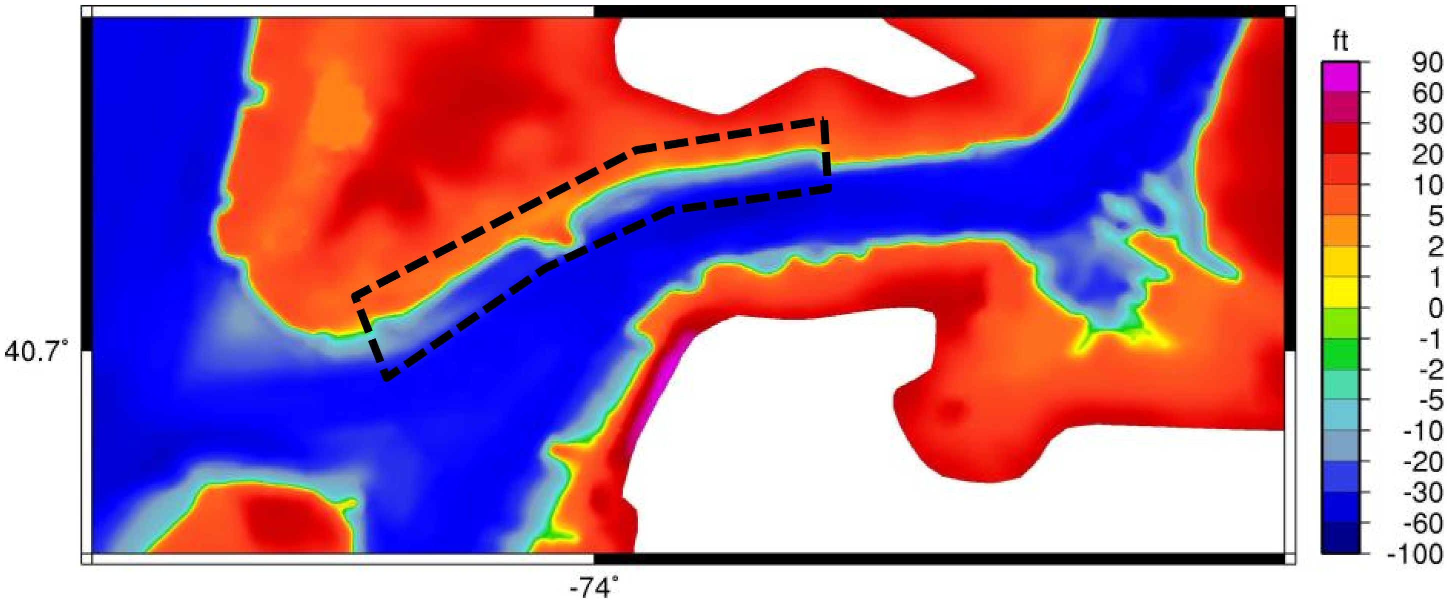


Figure 38: Location of time series gauges for tidal conditions impact assessment. Black box outlines the approximate Study Area.

As the data in Figure 39 shows, velocities decreased in some locations in the navigation channel with the addition of the MPL. In other locations, velocities increased. However, existing velocity profiles would not change substantially throughout the navigation channel. In other words, the modeling exercise did not show an increase in the East River's maximum velocity; the exercise showed only a shift in the locations where velocities take place.

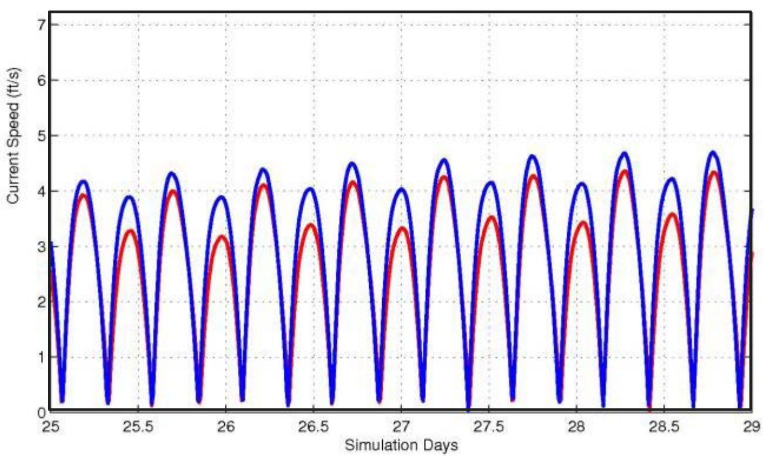


Figure 39: Example of change in East River velocities, with (red) and without (blue) an MPL

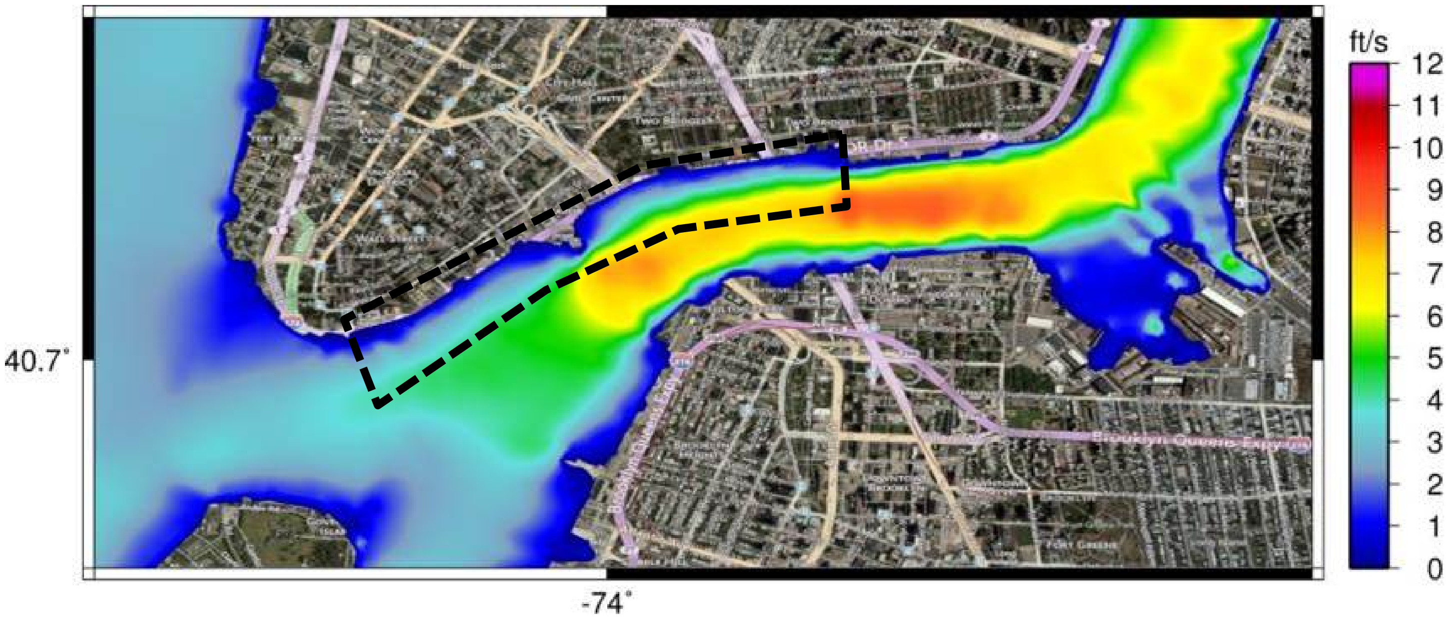


Figure 40: East River velocities without the MPL. Black box outlines the approximate Study Area.

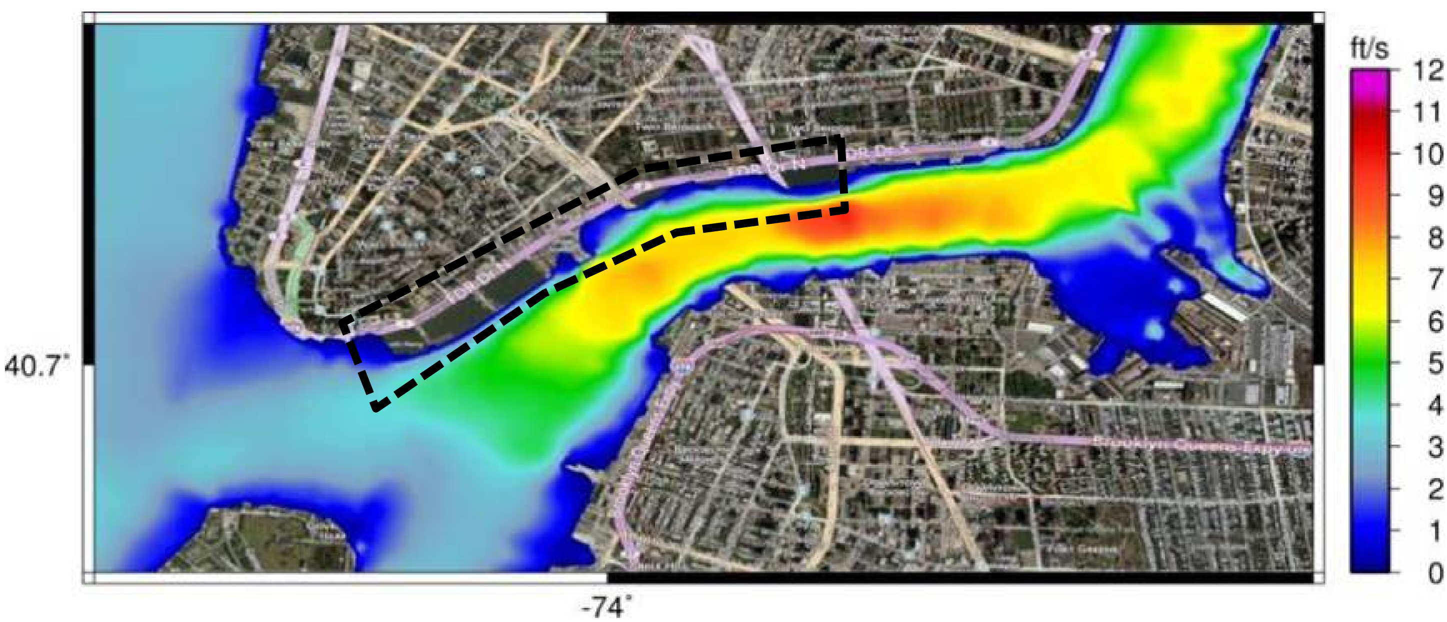


Figure 41: East River velocities with an MPL. Black box outlines the approximate Study Area.

Additional modeling efforts are needed in future studies to better understand these velocities and shifts, as well as whether different land configurations could avoid or mitigate these changes. Future hydrodynamic modeling studies would also further look at potential bridge scour and East River navigation impacts and solutions thereto (even though preliminary modeling efforts suggest no significant impact to navigation in the East River). For example, pre-engineered technologies could be implemented to minimize any potential scour.

4.5.2 Off-site Mitigation

The potential for mitigating potential adverse impacts associated with each of the flood protection options under consideration is a critical component of this study's overall feasibility assessment of an MPL concept. The implementation of an MPL project would require the mitigation of any adverse impacts to natural resources in the open water habitats of the East River. The corresponding offsetting mitigation measures would be identified through an iterative consultation process with local interest groups and federal (e.g., U.S. Army Corps of Engineers, National Marine Fisheries Service, U.S. Fish and Wildlife Service, and U.S. Environmental Protection Agency), state (e.g., New York State Department of Environmental Conservation, New York State Department of State), and City agencies (e.g., DCP). Mitigation for the possible loss of up to 66 acres of open water habitat within the East River could include a suite of measures such as the restoration of open water habitats and/or tidal wetlands.

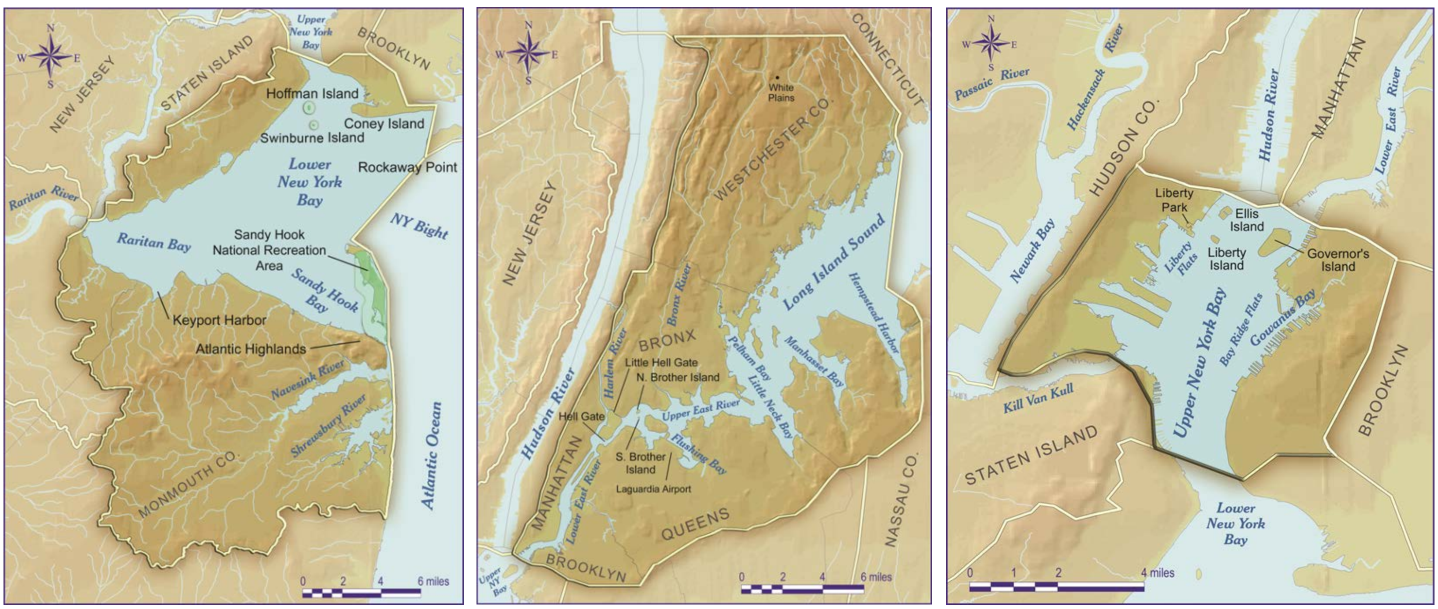


Figure 42: Open water restoration opportunities in the greater New York City area. Source: USACE.

4.5.2.1 Potential Large Scale Mitigation Effort at Jamaica Bay

Generally, larger-scale mitigation projects have a greater chance of success and result in greater habitat value than small, scattered projects. Jamaica Bay would offer at least 66 acres of contiguous area for a large-scale tidal wetlands restoration project that provides enhanced habitat for fish, benthic macro-invertebrates, waterfowl, and wading and grassland birds. Projects can be guided by the Hudson-Raritan Estuary Comprehensive Restoration Plan which provides a blueprint for wetland restoration throughout the Harbor and Jamaica Bay, where the newly formed Jamaica Bay Institute is taking a leadership role in guiding city, state, and federal restoration and resiliency initiatives to help reduce storm surges and absorb wave energy during storm events.

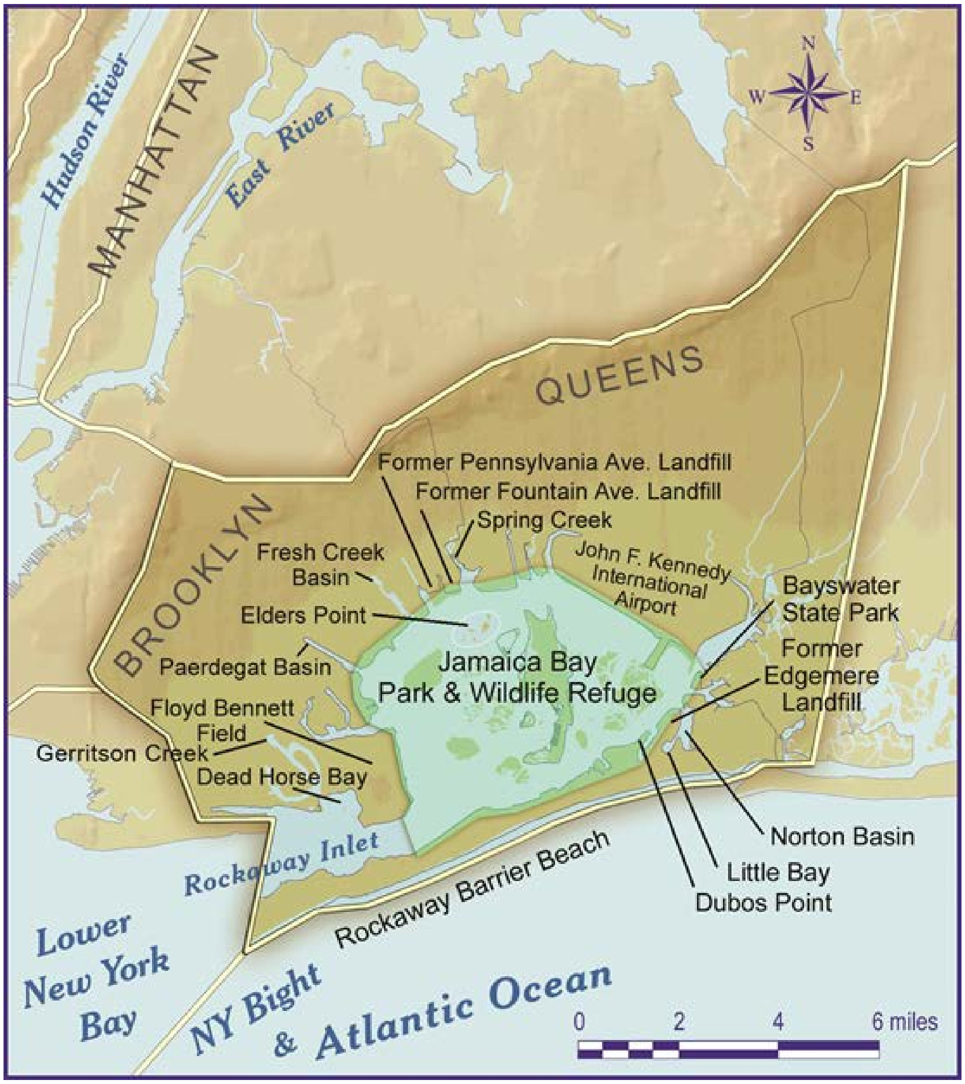


Figure 43: Wetland restoration opportunities in Jamaica Bay. Source: USACE.

5 Implementation Process Framework

Significant additional study, planning, preparation, and approvals would be required before an MPL project could be implemented. Public and Stakeholder outreach will be of critical importance in all stages. The following discussion elaborates on the steps that would need to be taken to build on the findings of this Feasibility Study and advance its recommendations.

5.1 Planning and Design

Before starting an environmental review process for any future MPL project, a number of steps would need to be taken to refine the parameters of the project, identify strategies to minimize its potential adverse impacts, and identify viable off-setting mitigation projects. Those "pre-environmental review" steps can be described as follows:

- **Project Scope:** It will be critically important to articulate a clear scope that provides a framework for, and helps guide, the environmental review process for any future MPL project. Such project scope would reflect the project goals described in Section 1.2 of this report.
- **Planning & Design:** A number of planning and design issues relating to any future MPL project will have to be studied further, including but not limited to:
  - A more defined configuration of an MPL and the extent of its associated land reclamation;
  - The location, nature and density of any development on the MPL, including the timing and nature of the interventions within the waterfront portion of the South Street Seaport Historic District;
  - The nature and extent of infrastructure and other site preparation investments required at an MPL;
  - Potential changes to, or reconfigurations of, the FDR and its associated infrastructure (e.g., on- and off- ramps), as well as the investments to implement such changes or reconfigurations and mitigate potential impacts;
  - Potential impacts and enhancements to subway infrastructure;
  - The impact on, and, as applicable, replacement of, any transportation infrastructure (e.g., Downtown Manhattan Heliport, Pier 11 ferry landings);
  - The nature and extent of open space on an MPL, as well as cultural, academic, and similar facilities that would strengthen the identity and sense of place at a future MPL project;
  - The nature and extent of complementary flood protection measures that would be undertaken in areas of Southern Manhattan outside of the Study Area; and
  - The nature and extent of new technologies and neighborhood-wide "green" infrastructure systems that, much like Battery Park City did in its day, would make an MPL project a pioneer in future generations of sustainable design and city-building.

A significant number of these planning and design issues could be analyzed and addressed through a comprehensive master planning process for a future MPL project.

- **Off-Setting Mitigations:** The City would need to study in detail the potential ecological impacts associated with any future MPL project, including impacts on the aquatic ecosystem and on currents and sediments. The findings of these studies would help not only refine a future MPL project's design to minimize such impacts, but also identify and refine the corresponding off-setting mitigation strategies.

5.2 Review and Permitting

Project counsel has concluded that no legislative or regulatory changes to existing environmental statutes and regulations would be required to implement an MPL project, but that such a project could be designed and implemented in such a way as to meet the currently applicable requirements for the issuance of the necessary permits and approvals. Such a determination was based upon the analyses contained in this Study, the compelling and mounting recognition of the need for resiliency intervention, the significant economic land use and other benefits to be realized from the studied project, the opportunities for effective mitigation of potential environmental impacts, and careful consideration of relevant legal precedents. While federal and state agencies have been hesitant during the past several decades to issue permits for projects of similar scale involving land reclamation, the growing threats of climate change and extreme weather may result in a changed or more flexible approach to resiliency initiatives going forward.

Before permits can be issued, an MPL would need to undergo environmental review, including the preparation of an Environmental Impact Statement ("EIS") and its accompanying stages of public review and comment. The environmental review and permitting processes for such a major project would be lengthy and complex.

- **Preparation of an Environmental Impact Statement**: One of the most critical steps in the permitting process is the environmental review necessary to secure both state and federal permits. Because any future MPL would require federal and state action, the environmental review, including the preparation of an EIS, would need to satisfy both: 1) the National Environmental Policy Act ("NEPA") and 2) the New York State Environmental Quality Review Act ("SEQRA"). An EIS under either Act would consider the environmental impacts of the entire project (i.e., land reclamation and associated development). It would be preferable to prepare an EIS under NEPA, as an EIS prepared under NEPA would be used to satisfy the requirements of SEQRA. State and City agencies would then make the required SEQRA findings on the basis of the NEPA EIS.
- **Selection of a Lead Agency**: A federal agency must be designated as "lead agency" during the NEPA environmental review process. State agencies cannot legally serve as lead agency under NEPA, although they can serve as a "co-lead" agency. If significant federal funding was to be used to implement a future MPL, the federal funding agency would likely serve as lead agency. If no such funding were to be available, the U.S. Army Corps of Engineers (the "USACE") would likely serve as lead agency. The future MPL project's local sponsoring entity could serve as a "co-lead agency" with the lead federal agency, participating in the environmental review process and providing expertise. The sponsoring entity could be a state- or City-sponsored special purpose entity or agency. Other federal, state, and local agencies not acting as lead or co-lead would be involved in the environmental review process.
- **Required Permits**: Following the completion of the NEPA/SEQRA process, the future MPL project would need to receive a number of permits and approvals from federal, state and City agencies. For example, permits would be required from the USACE under Section 10 of the Rivers and Harbors Act of 1899 and under Section 404 of the Clean Water Act. The New York State Department of Environmental Conservation (the "DEC") would need to issue permits under the State's Tidal Wetlands and Protection of Waters Act. It is assumed that while the entire future MPL project would be subject to a general or master plan adopted by the sponsor entity, the unfolding phases of the project would require updated approvals and permits.
- **Key Considerations for Permitting**: The future MPL's permitting process would focus in particular on two analyses: an assessment of potential alternatives that still achieve the project's purpose and an assessment of the project's water-dependency.
    - **Alternatives Analysis**: An examination of reasonable alternatives to the proposed project, and specifically of alternatives that would lessen the amount of fill and associated impacts, will be required under NEPA and SEQRA, as well as the relevant permitting regimes.
    - **Water-Dependency**: The water-dependency of the project will also be the focus of the permitting agencies.

- **Designation as “High Priority”**: Given a future MPL project’s long timeframe and high degree of complexity, as well as limited agency staff and budgets, it would be beneficial to seek designation as a “high priority project” by the federal government. This designation, which expedites the permitting and review processes, has been applied to projects such as the Tappan Zee Bridge replacement.

5.3 Project Financing Structures

The magnitude of project costs, as well as the potentially long gap between the beginning of MPL construction and the first deliveries of revenue-generating uses, suggests that a future MPL project may require some upfront public support to cover infrastructure costs. Depending on the option selected and a range of future decisions by policy makers, this public support requirement may vary. For example, a project with a higher affordable housing requirement or lower density would generate lower revenues and could require a greater financial role for the public sector. This public sector role could include:

- Credit enhancement for initial bond issues, likely a requirement given the perception of risk during the early years of a new project,
- Debt service support prior to the completion of revenue-generating uses in order to minimize capitalized interest costs, and
- Capital grants from federal, state or City agencies to cover certain upfront costs as available.
- Project revenues, consisting largely of land sale or ground-lease payments and PILOT or property tax payments, would become substantial as the project is built out. Over time, these revenues could cover all required interest payments and pay down outstanding principal on infrastructure bonds. The time required to retire infrastructure bonds would depend on the degree of upfront public capital support and the degree to which capitalized interest can be avoided prior to the completion of revenue-generating uses.

5.4 Project Governance Structures

A governance structure controlled by a City- or state-sponsored entity acting as “master developer” of an MPL project would provide access to tax-exempt bond financing, while ensuring that the public’s flood protection, economic development and community development goals are met. Private developers could be engaged under this publicly-controlled governance structure to build phases of infrastructure and vertical development.

5.4.1 Special-Purpose Project Sponsor

In line with major New York City projects, it may be beneficial to create a special purpose sponsoring entity or entities that acts as “master developer” and centralizes project leadership and funding. This entity or entities would be a project of the City and/or state and would be responsible for planning, environmental review, adoption of a master or general plan for a project, application for permits, financing, construction of publicly-developed components, and disposition of rights to construct privately-developed components. While decisions about the lead development entity for horizontal (i.e., land and infrastructure) and vertical (i.e., buildings) components may be made in a number of configurations, a focused entity to manage the public components and serve as the public partner for private components could be highly effective.

5.4.2 Agency-Led Projects

Other New York City projects have been spearheaded by City or state agencies without a dedicated entity to lead the project. This structure works best for projects that are financed predominantly with private funds and include a smaller ratio of public infrastructure improvements to private development. Recent precedents include Atlantic Yards, which was led by the Empire State Development Corporation and Seward Park, which was led by NYCEDC and the New York City Department of Housing Preservation and Development.

5.5 Stakeholder Engagement

In addition to working with the regulatory agencies, the project sponsor must engage in a comprehensive stakeholder engagement process with City, state and federal elected officials, environmental organizations, community organizations, including Community Boards 1 and 3, and other interested parties. This process, which would last for the duration of a future MPL project, is critical to ensure that the project meets the needs of its Stakeholders.

While very preliminary outreach has been undertaken with the USACE and the DEC to describe the scope of this Feasibility Study, additional meetings would be required once a future MPL project is more particularly defined in order to identify and address the agencies' concerns and to understand the scope and content of additional analyses that would be required in order to advance the recommendations of this Feasibility Study. Outreach to other resources agencies (e.g., the National Marine Fisheries Service, the U.S. Fish and Wildlife Service, the U.S. Environmental Protection Agency, and the New York Department of State) should also be conducted to discuss the potential impacts of a future MPL on natural resources, as well as potential mitigation measures, and also to understand the scope and content of additional studies that would be required in connection with the environmental review.

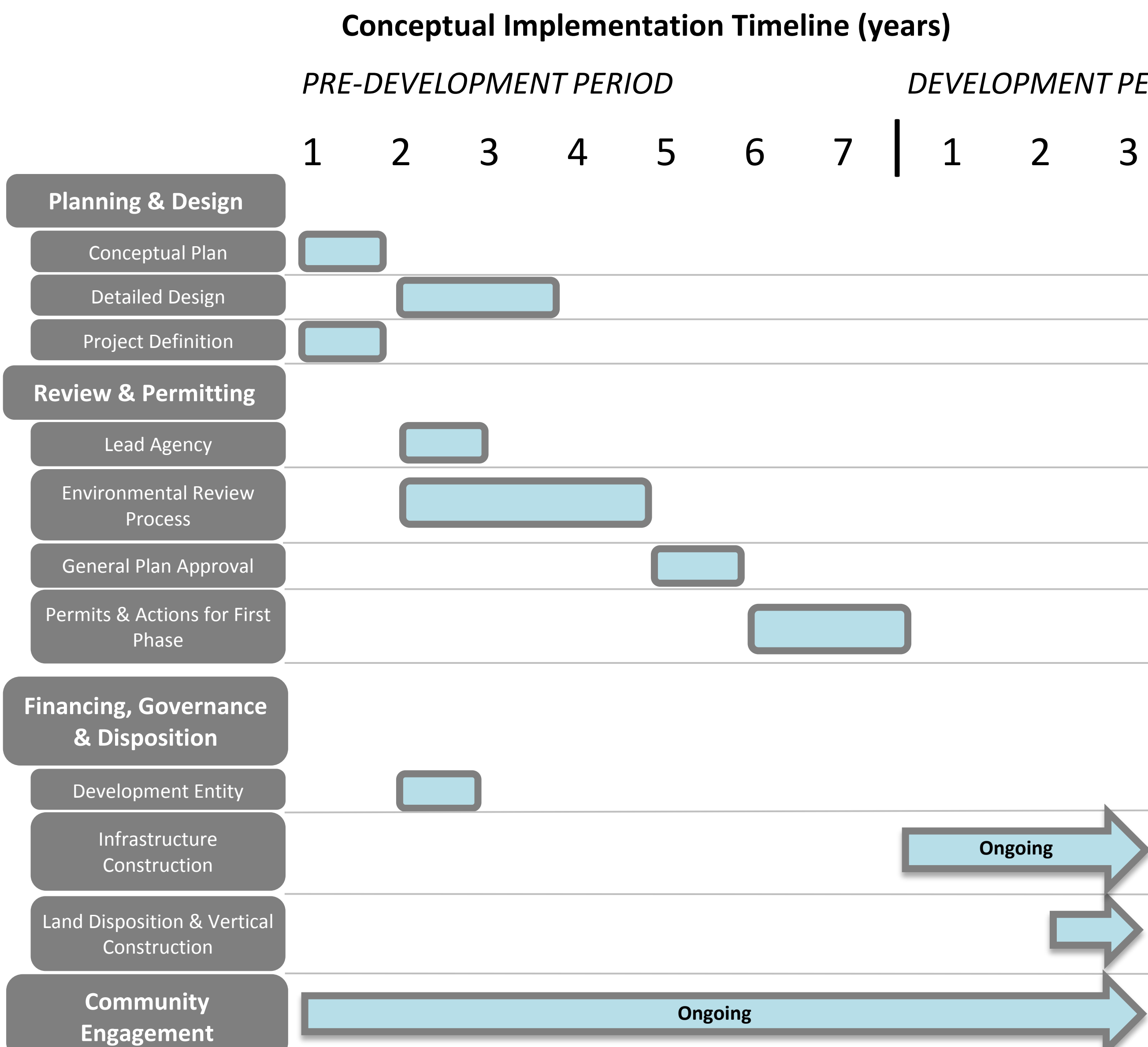


Figure 44: Implementation Timeline with Goal Milestones

6 Conclusions

This Feasibility Study has found that an MPL can be built in the Study Area, can be permitted, and can be self-financing, while effectively reducing the risks of inundation:

- **Technical feasibility:** An MPL is physically feasible in the Study Area. Preliminary hydrodynamic modeling and an initial assessment of tidal conditions impacts show that an MPL would not induce flooding either in adjacent neighborhoods or across the East River. Additional engineering, ecological, and master planning work should be undertaken to determine the layout, phasing and construction methodology of a future MPL in ways that optimize storm tide protection performance and integration with the existing urban fabric of Southern Manhattan, and minimize wave rebound, scour, environmental, and navigation impacts.
- **Legal feasibility:** The permitting and implementation of an MPL is feasible within the existing regulatory framework. The processes associated with such permitting and implementation will be complicated and will take a long time. Those processes will require extensive consultation with the relevant federal, state, and city permitting agencies and local Stakeholders. Central aspects of the discussions will include the mitigation of any adverse impacts to natural resources in the open water habitats of the East River, as well as the assessment of potential alternatives to an MPL and of the water-dependency of any proposed flood protection solution.
- **Financial feasibility:** An MPL is financially feasible. An MPL that protects the Study Area to a height of +19.0 feet NAVD88 for a 100-year storm event in the 2100s could also self-finance and help fund complementary flood protection investments in Southern Manhattan.

The following project goals were set forth at the outset of this study as the basis to evaluate the feasibility of a variety of MPL and other flood protection solutions for the Study Area:

1) Enhanced flood protection for Southern Manhattan;
2) Resiliency program funding source (i.e., the ability to self-finance and/or generate surplus revenue to fund other resiliency efforts); and,
3) Economic and community development (i.e., new economic activity, affordable housing, and open space; integration with Southern Manhattan's urban fabric and character).

Among all of the flood protection solutions evaluated during this Feasibility Study, the 500' Land Reclamation option is the MPL concept that best meets the project goals. Because of this, the 500' Land Reclamation option was refined further to develop the 500' Land Reclamation - North Park option, which concentrates density to the south of the Brooklyn Bridge and to the north of the Manhattan Bridge and creates a major open space between the two bridges.

All of the MPL options evaluated in this Feasibility Study and their respective development programs were defined for feasibility analysis purposes only and do not constitute a development proposal. As noted in detail in Section 5 of this report, significant additional analysis will be required to articulate, assess, and advance an actual development proposal for an MPL.

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