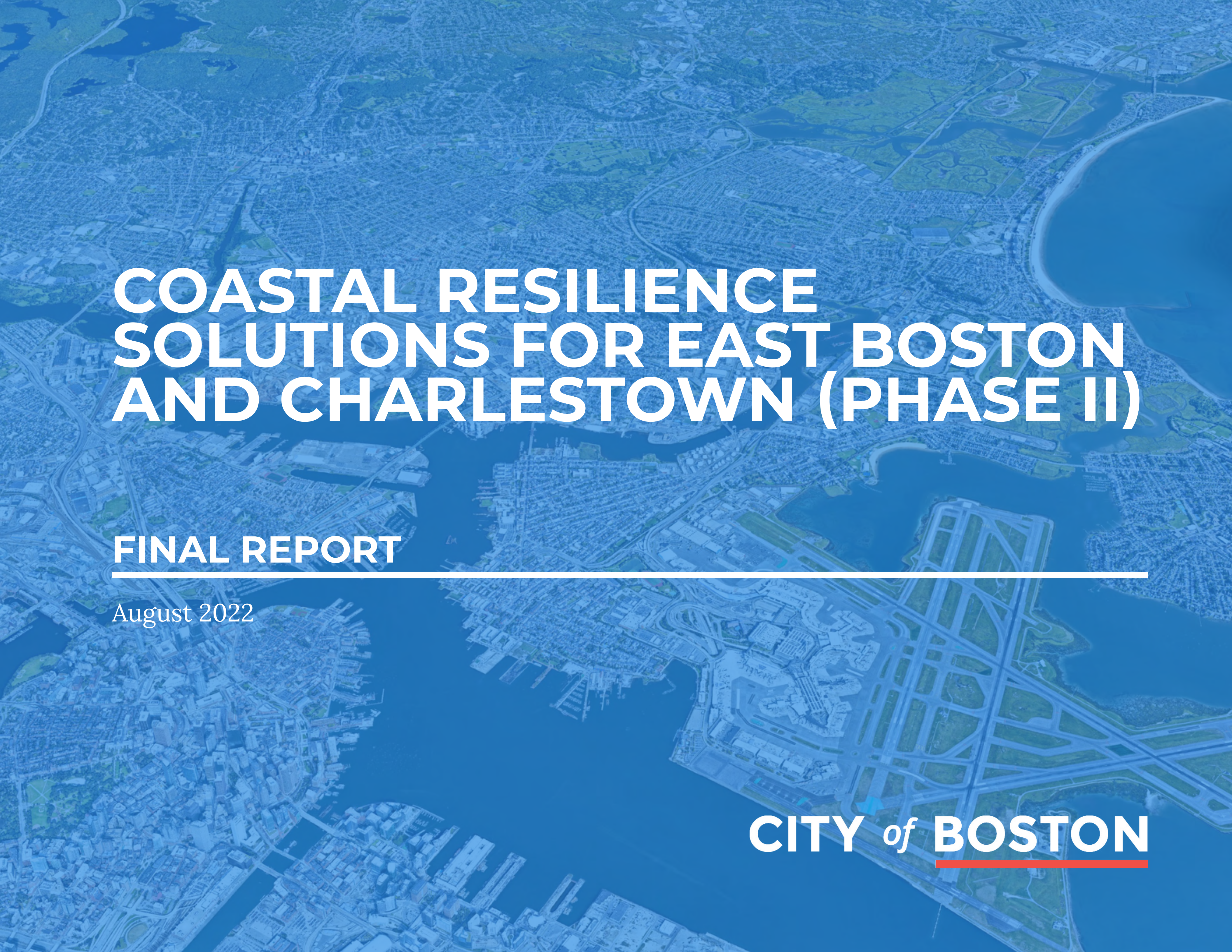

COASTAL RESILIENCE SOLUTIONS FOR EAST BOSTON AND CHARLESTOWN (PHASE II)

FINAL REPORT

August 2022

CITY of BOSTON

AUGUST 12, 2022

Dear Neighbors,

In Boston, we experience the effects of climate change on a daily basis. Rising sea levels, hotter days, and stronger storms all pose serious threats to critical infrastructure and our communities. That's why the City of Boston is taking bold action to create resilient solutions to prepare and protect all of our communities for generations to come.

Coastal neighborhoods with low-lying shorelines—like East Boston and Charlestown—are especially vulnerable to flooding. In the last year alone, Boston experienced seven days of high-tide flooding. Over the next year, NOAA predicts that number will climb to at least 11 days, and possibly as high as 18. Right now, we have a responsibility—and an opportunity—to create a resilient, climate-ready waterfront that also advances our priorities to create more open space, increase mobility, generate affordable housing, achieve social and racial equity, and conserve our natural resources. *Coastal Resilience Solutions for East Boston and Charlestown* (*Phase II*) is an important milestone in our efforts to do just that. With the completion of this report, we have developed coastal resilience solutions that will help us adapt to and prepare for the impacts of climate change along all 47 miles of Boston's coastline.

While climate change impacts all of us, our environmental justice communities are most at risk. When we solve for our most impacted communities, we create plans and policies that benefit all of us. This report—which builds on previous resilience plans, including 2016's *Climate Ready Boston* report and the City's first *Heat Resilience Solutions for Boston* report—will ensure that we're applying an equity lens to our fight against climate change. Taken together, these plans will promote public health, reinforce our infrastructure, and protect our public spaces.

This report is just one of the many steps we're taking to make Boston a Green New Deal City. Because from our coastline to each of our neighborhoods, all our families deserve healthy homes, fresh food, clean air and water, and beautiful parks and open spaces.

Sincerely,

Michelle Wu

Michelle Wu
Mayor of Boston


Condor Street Urban Wild, East Boston

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PHOTO CREDIT

All photos were taken by Project Team members, unless otherwise noted.


Little Mystic Channel, Charlestown

ACKNOWLEDGMENTS

Coastal Resilience Solutions for East Boston and Charlestown (Phase II) was made possible by the contributions of many agencies, organizations, and individuals. The City of Boston wishes to acknowledge and thank the many partners and community members who supported this project, and many more City staff, community members, and non-profit, public, and private sector organizations and individuals who contributed their time and effort to help shape this plan.

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INTRODUCTION

Through Climate Ready Boston, the City of Boston is taking action to protect its communities, neighborhoods, and economic and cultural assets in the face of a changing climate to ensure that they will continue to thrive in the coming decades.

Climate Ready Boston is the City of Boston's initiative to prepare for the effects of climate change and is an integral part of the City's planning efforts. Released in 2016, the *Climate Ready Boston* report assessed Boston's climate vulnerabilities, including increased precipitation from more frequent and intense storms, sea-level rise, and extreme heat. Additionally, the report provided projections of climate change impacts in Boston and outlined principles and strategies to build climate resilience across all of Boston's neighborhoods, which set the foundation for the City's ongoing climate resilience efforts.

Following the release of the *Climate Ready Boston* report, the City conducted neighborhood-level coastal resilience plans for Boston's waterfront communities to take a closer look at the localized impacts and specific interventions that could be undertaken to mitigate coastal flood risk. Since 2016, the City has completed coastal resilience plans for each of these neighborhoods, including East Boston and Charlestown (Phase I) in 2017, South Boston in 2018, Downtown and North End in 2020, and Dorchester in 2020. *Coastal Resilience Solutions for East Boston and Charlestown (Phase II)* assesses parts of each neighborhood that were not included in the 2017 Phase I study area.

The study areas for Phase II include:

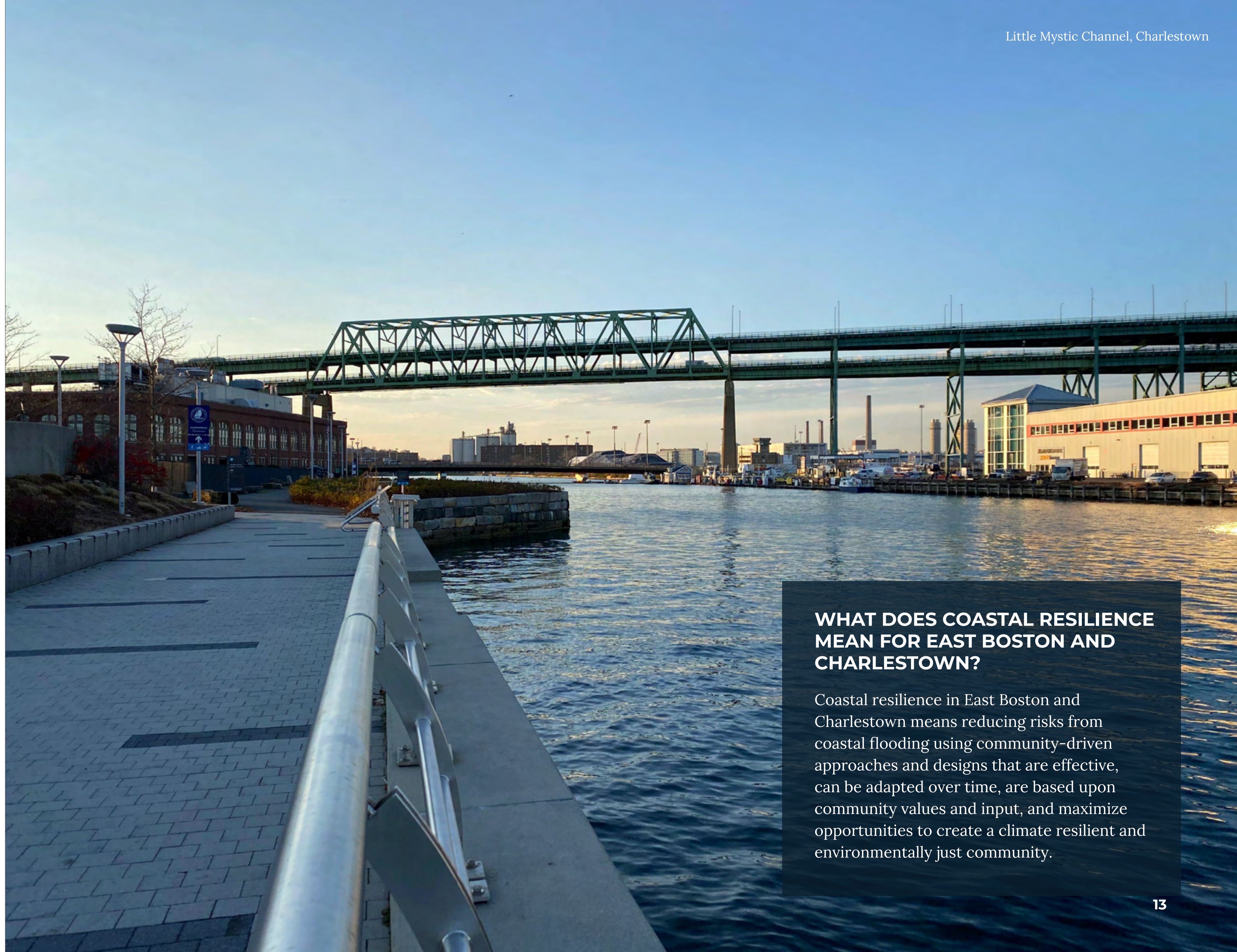
» East Boston's coastline along Chelsea Creek, Belle Isle Marsh, Orient Heights Rail Yard, Constitution Beach, and Wood Island Marsh; and

» Charlestown's coastline along the Navy Yard, Little Mystic Channel, and Terminal Street and the Boston Autoport.

This report presents a summary of the planning process, an assessment of coastal flood risk, design concepts and strategies, and next steps for promoting coastal resilience in the Phase II study area for East Boston and Charlestown. Developed in partnership with community leaders and stakeholders, it highlights the importance of coordination across sectors and municipalities for the implementation of near- to long-term flood protection strategies, and establishes an implementation roadmap for continued planning, design, and climate action.

With the completion of *Coastal Resilience Solutions for East Boston and Charlestown (Phase II)*, the City will have developed coastal resilience solutions plans for all of Boston's 47-mile coastline. Additionally, the City will have a comprehensive understanding of coastal flood risk in each waterfront neighborhood, options for coastal resilience strategies, and timelines for implementation of each solution along the entire Boston coastline.

Together, these plans present a framework for adapting to the impacts of climate change while putting Boston on a path to become a Green New Deal city and improving the quality of life for Boston residents and visitors, today and in the future.



Little Mystic Channel, Charlestown

WHAT DOES COASTAL RESILIENCE MEAN FOR EAST BOSTON AND CHARLESTOWN?

Coastal resilience in East Boston and Charlestown means reducing risks from coastal flooding using community-driven approaches and designs that are effective, can be adapted over time, are based upon community values and input, and maximize opportunities to create a climate resilient and environmentally just community.

PURPOSE, INTENTION, AND PROCESS

Coastal Resilience Solutions for East Boston and Charlestown (Phase II) evaluated coastal flood risk in the neighborhoods and identified flood protection strategies that will effectively reduce this risk. While other climate hazards such as increased precipitation and extreme heat were considered throughout the planning process, this plan focused specifically on how to adapt to the effects of coastal flooding from sea-level rise and storm surge.

The plan also sought to identify strategies that preserve the essential functions and historic character of the East Boston and Charlestown waterfronts, and undo the harm of historic planning that unjustly placed certain communities at risk of environmental hazards.

Since the initiation of *Coastal Resilience Solutions for East Boston and Charlestown (Phase II)*, the project team worked with a group of residents who served on Community Advisory Boards (CABs) for each neighborhood, as well as other stakeholders, to develop an intention statement. This statement captured the mission and guided the work throughout the planning process.

INTENTION STATEMENT

The City of Boston will work closely with the community to co-develop a series of layered flood defense and coastal adaptation approaches that provide protection from rising sea levels and storm surge. Together, we will draw on prior planning and local knowledge to propose buildable projects and responsive policies and programs with lasting social, environmental, and economic benefits realized by those most in need. We will seek to produce a coastal resilience roadmap that protects and creates value for the East Boston and Charlestown communities and all who share in the health of the City and Boston Harbor.

Coastal Resilience Solutions for East Boston and Charlestown (Phase II) included three key steps with community and stakeholder engagement spanning the entire duration of the planning process. The steps included:

» **STEP 1 -** Gather data, analyze existing conditions and projected coastal flood risk, and coordinate with previous and ongoing planning efforts;

» **STEP 2 -** Assess constraints and opportunities, identify a range of preliminary coastal resilience design options, conduct technical feasibility analyses for each, and seek community and regulatory feedback; and

» **STEP 3 -** Develop preferred coastal resilience design options and a roadmap towards implementation.

The planning process began in Fall 2020 and lasted for nearly two years. The project team consisted of City staff, public agency partners, and an interdisciplinary consultant team led by the Dutch engineering firm, Arcadis, with design, engagement, and technical support from Sasaki, Woods Hole Group, ONE Architecture, and community partner, Neighborhood of Affordable Housing (NOAH).

STAKEHOLDER ENGAGEMENT DURING THE COVID-19 PANDEMIC

Planning for coastal resilience is complex and requires coordination with a wide range of stakeholders. Throughout the process, the team met with multiple city, state, and federal agencies, private and institutional stakeholders, non-profit organizations, community-based organizations, residents, neighborhood associations, and the broader East Boston and Charlestown communities.

As a result of the engagement process, stakeholders helped shape the development of coastal resilience solutions in East Boston and Charlestown that have additional benefits for each community.

The realities of the COVID-19 pandemic informed the approach to engagement regarding the types of strategies used and the way that conversations were facilitated. The project team approached engagement during the COVID-19 pandemic with mindfulness of the time and resources asked of the East Boston and Charlestown communities, consciousness of the technical limitations that many residents experience, and a commitment to have compassion for the burdens that the COVID-19 pandemic placed on so many people. Engagement sessions were also used as opportunities to distribute information about existing community and City resources related to COVID-19.

COMMUNITY ADVISORY BOARDS (CABs)

Early in the planning process, a CAB was formed for each neighborhood, with 12 members in East Boston and 10 members in Charlestown. Each CAB consisted of a group of individuals with ties to and knowledge of their neighborhood, including representatives from community-based organizations. Applications to participate on a CAB were open to the public, and compensation was provided on an as-needed basis. *Coastal Resilience Solutions for East Boston and Charlestown* (Phase II) was the first *Climate Ready Boston* planning effort to involve CABs.

The CABs convened five times throughout the planning process: virtually four times during between January 2021 and June 2022, as well as in-person in July 2021 for socially-distanced site walks in their respective neighborhood. The primary focus of the CABs was to provide feedback and insight into preliminary engagement and climate resilience strategies as they were being developed. CAB members helped lead engagement by participating in community events to gather feedback, sharing information, and distributing flyers and surveys to friends, neighbors, and colleagues in East Boston and Charlestown.

STEERING COMMITTEE

The Steering Committee consisted of representatives from city and state agencies. The committee met virtually as a group four times to define goals and desired outcomes, discuss feedback received from each community, and frame guidance on design proposals and next steps. In addition to group meetings, the project team hosted multiple rounds of focused interviews and working sessions with individual Steering Committee members and their teams to build partnerships and develop and refine the coastal resilience solutions. The focus for the Steering Committee was to ensure technical practicality and integrate coastal resilience solutions in East Boston and Charlestown with city and state policy, planning, and capital investment objectives.

COMMUNITY ENGAGEMENT

The project team established multiple channels of engagement for East Boston and Charlestown residents to share the latest study findings, provide feedback and input, and participate in developing coastal resilience solutions throughout the planning process.

The project team directly engaged with more than 550 community members, which includes open house participants, survey respondents, and attendees at presentations to neighborhood associations and community groups.

OPEN HOUSES

The project team hosted two open houses to listen to the community's concerns and priorities. Approximately 60 participants joined for each virtual open house, and Spanish and Chinese interpretation were provided at each. The first open house was held in April 2021 and served as an introduction to the planning process and to the coastal risks facing East Boston and Charlestown. Participants identified flood-related issues and important places to protect in their community as a part of an interactive mapping activity. The second open house was held in August 2021 for community members to discuss conceptual coastal resilience options and inform revisions.

ONLINE SURVEYS

The project team created online surveys following each open house to enable residents to identify the impacts of existing coastal flooding and convey their priorities for the coastal resilience solutions. The surveys included information that was shared at the open houses and provided space for input from community members. The first survey included an interactive mapping exercise that invited residents to pinpoint areas of importance and concern, which received 50 responses. The second survey presented potential approaches to coastal resilience solutions for different parts of the study area, which received 33 responses.

COMMUNITY PRESENTATIONS

Following the open houses in April and August 2021, the project team virtually presented to numerous neighborhood associations, community groups, and other stakeholders to have smaller, more focused conversations. These meetings helped expand the reach of the open houses to include community members who were unable to attend or wanted to continue the conversation.

STAKEHOLDER INTERVIEWS

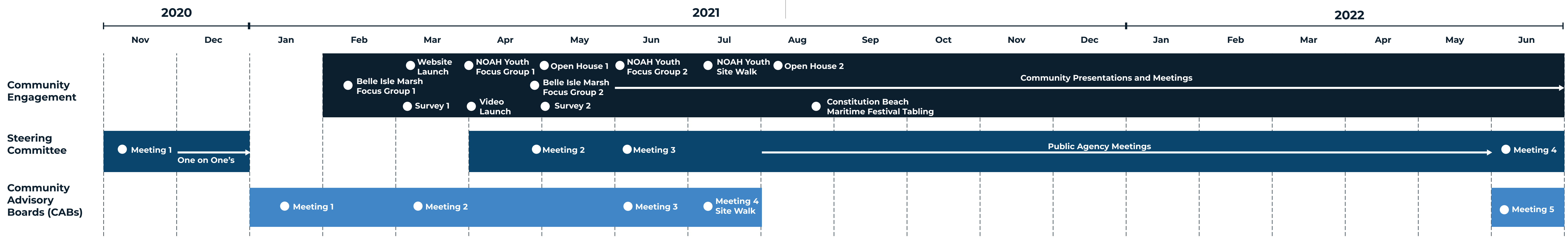
In addition to the community presentations, one-on-one interviews were held with diverse stakeholders at key points in the process. The project team had over 25 meetings with community-based organizations, local non-profits, and neighborhood associations to collect feedback that shaped the coastal resilience solutions. The project team also held or participated in 64 meetings with members of public agencies to refine and develop the coastal resilience solutions further.

OUTDOOR POSTINGS

Flyers with a QR code linked to the project website and survey were posted in 16 locations throughout the East Boston and Charlestown neighborhoods that presented open-ended questions for people to respond to online. The flyers prompted people to think about questions related to coastal resilience while standing at different locations along the waterfront. 53 residents responded with their ideas and concerns via the flyers.

ONLINE ENGAGEMENT

The project website provided general information about the planning process and engagement opportunities. In addition, the project team developed informational videos to increase awareness and understanding of current and future flood risk in each neighborhood that were distributed through the project website, social media, and email lists.



COMMUNITY PRIORITIES FOR COASTAL RESILIENCE

Coastal Resilience Solutions for East Boston and Charlestown (Phase II) organized conversations with the community into three stages of engagement. Each stage involved a combination of engagement strategies that centered around the same core theme.

Building Connections: The focus of the first stage of engagement was to understand how people experience flooding today, identify primary concerns related to coastal flood impacts, and gain a sense of broader neighborhood priorities.

Co-Creating Risk and Vulnerability Assessment Criteria: After a baseline understanding of community priorities was established, the following stage of engagement focused on sharing the latest information on projected coastal flood risks and developing and refining evaluation criteria for possible flood protection strategies.

Exploring "What If" Stories: This stage of engagement focused on identifying possible coastal resilience solutions that are informed by and reflective of community values and priorities. It sought to gather feedback and ideas around what type of designs and approaches to flood mitigation were most supported by community members and aligned best with broader goals for their neighborhood.

Based on the feedback received, the key community-supported priorities that informed this plan include:

- A desire for **urgent action to protect the places people love and the services they depend on**.
- The need for coastal resilience solutions that are **effective and provide multiple benefits**, including public access to and along the waterfront.
- The importance of **preserving housing affordability and neighborhood character**.
- The desire to **improve access to the waterfront** as a shared community amenity and defining identity for the neighborhood more broadly.
- The importance of **protecting homes and essential infrastructure**, such as public transportation and evacuation routes.
- The desire to **restore natural habitats** for plants and animals.
- The desire to **address environmental and climate injustices, burdens, and hazards**.

Community engagement and these key priorities helped shape the coastal resilience solutions for East Boston and Charlestown. This includes guiding decisions about the preferred coastal resilience approaches and amenities or co-benefits that might be incorporated as part of the design and implementation process.

Chapter 4, *Coastal Resilience Solutions for East Boston and Charlestown*, provides further detail as to how community priorities and preferences informed the development of coastal resilience solutions for both neighborhoods.

The Project team, CAB members, and NOAH Youth Crew participated in site walks in July 2021 to discuss preliminary coastal resilience strategies.

INVOLVED STAKEHOLDERS

CITY AGENCIES AND ENTITIES

- Boston Conservation Commission
- Boston Environment Department
- Boston Parks and Recreation Department
- Boston Planning and Development Agency
- Boston Public Works Department
- Boston Transportation Department
- Boston Water and Sewer Commission
- Mayor's Office of Policy
- Office of Emergency Management
- Office of Neighborhood Services

STATE AGENCIES

- Massachusetts Bay Transportation Authority
- Massachusetts Department of Conservation and Recreation
- Massachusetts Department of Transportation
- Massachusetts Office of Coastal Zone Management
- Massachusetts Port Authority

REGIONAL PARTNERS

- City of Chelsea
- City of Revere
- Town of Winthrop
- North Suffolk Office of Resilience and Sustainability

FEDERAL AGENCIES

- National Parks Service
- U.S. Navy

NON-PROFIT ORGANIZATIONS / COMMUNITY-BASED ORGANIZATIONS / RESIDENT GROUPS

- Boston Harbor Now
- CharlesNewtown Co-op Board
- Charlestown Lacrosse & Learning Center
- Eagle Hill Civic Association
- East Boston Climate Coalition
- Friends of Belle Isle Marsh
- Friends of the Charlestown Navy Yard
- Greenroots
- Green Ribbon Commission
- Harborkeepers
- Harbor View Neighborhood Association
- Jeffries Point Neighborhood Association
- Mystic River Watershed Association
- Neighborhood of Affordable Housing
- Orient Heights Neighborhood Association
- Save the Harbor / Save the Bay
- Multiple Charlestown Navy Yard Condo Association Boards

550+ RESIDENTS OF EAST BOSTON AND CHARLESTOWN

EVALUATION CRITERIA

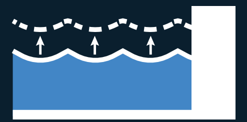
Coastal Resilience Solutions for East Boston and Charlestown (Phase II) used a set of evaluation criteria to assess proposed coastal resilience strategies that are consistent with the previous plans for East Boston and Charlestown (Phase I), Dorchester, South Boston, and Downtown and the North End. These criteria help to compare the benefits and trade-offs between identified design options for the East Boston and Charlestown waterfronts within the Phase II study area. The complete set of evaluation criteria includes:

EFFECTIVENESS

Is the design option effective at reducing coastal flood risk to ensure the protection of people, homes, businesses, critical infrastructure, and community assets?

FEASIBILITY

Can the design option be implemented based on community support, engineering, design and construction considerations, costs, and permissibility under existing regulations?



DESIGN LIFE & ADAPTABILITY

Can the design option effectively address coastal flood risk over the long term or be adapted over time as sea levels continue to rise?

ENVIRONMENTAL & PUBLIC HEALTH BENEFITS

Can the design option include other benefits that help improve the health of people and nature, enhance water and air quality, and create or restore wildlife habitat?

SOCIAL EQUITY & QUALITY OF LIFE

Can the design option include other benefits that help advance social equity, promote racial and environmental justice, and improve community well-being by providing new recreational and cultural amenities?

Belle Isle Marsh, East Boston

WHAT'S NEXT?

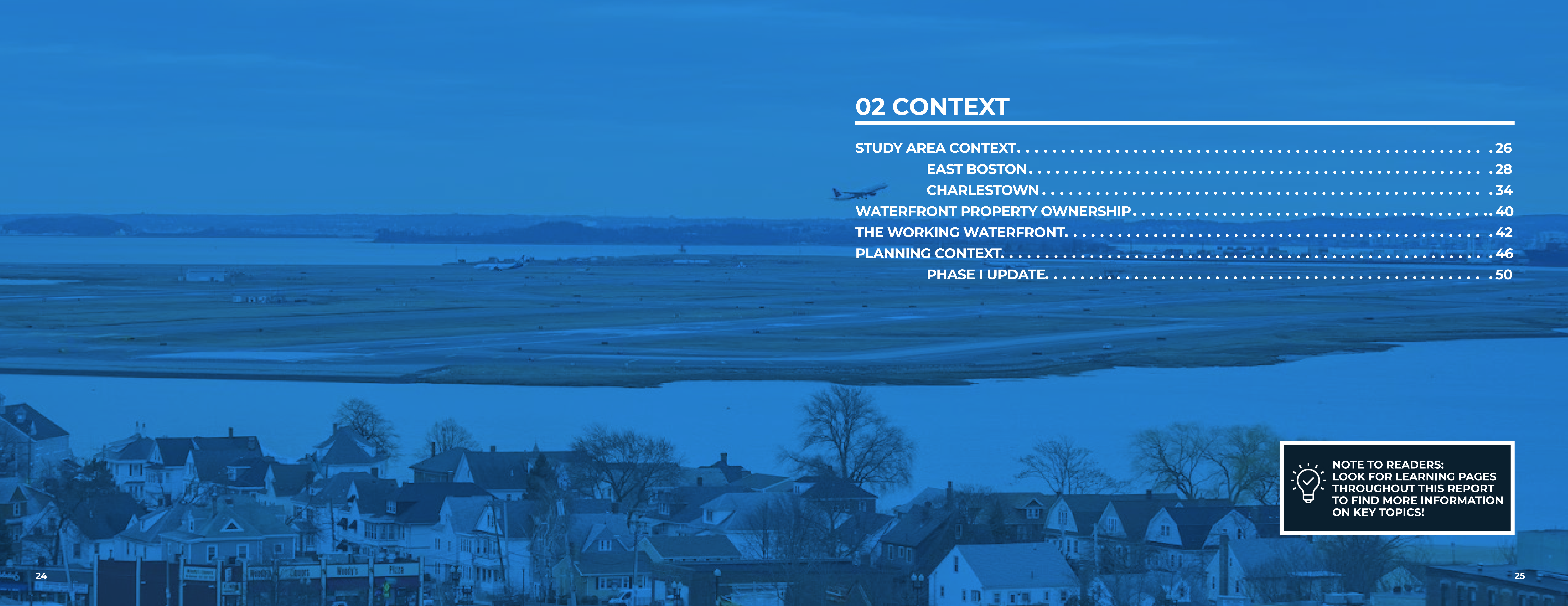
This plan serves as a starting point for addressing coastal flood risk in East Boston and Charlestown. The design strategies provided in this *Coastal Resilience Solutions for East Boston and Charlestown (Phase II)* report are conceptual and serve as the first step of a longer design process. The long-term success of this plan depends on continued coordination and support from the East Boston and Charlestown communities as well as both public and private stakeholders.

The City will continue to work with public agencies, private property owners, and the community to advance the design and engineering for each coastal resilience solution. Community input will be sought through subsequent steps to advance the design of each coastal resilience solution.

Specific next steps for each near- and long-term coastal resilience strategy are discussed in Chapter 4, *Coastal Resilience Solutions for East Boston and Charlestown*, and Chapter 5, *Implementation Roadmap*. Chapter 5, *Implementation Roadmap*, includes additional information on how the solutions outlined in this plan will progress in the decades ahead.

Please join us in strengthening Boston's coastal resilience by participating in this conversation going forward. Your continued collaboration will help us create a more equitable and resilient Boston for all.

Please check our website for updates, events, and opportunities related to Climate Ready Boston: boston.gov/climate-ready



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NOTE TO READERS:
LOOK FOR LEARNING PAGES THROUGHOUT THIS REPORT TO FIND MORE INFORMATION ON KEY TOPICS!

STUDY AREA CONTEXT

Boston's historic coastline was once located much further inland than the currently existing coastline. Many areas of the current landform of the city were historically below high tide levels. With human settlement and the growth of Boston as an economic center, these low-lying areas were filled to create space for new buildings and waterfront structures, such as wharves, piers, and warehouses that were designed to support water-dependent industries.

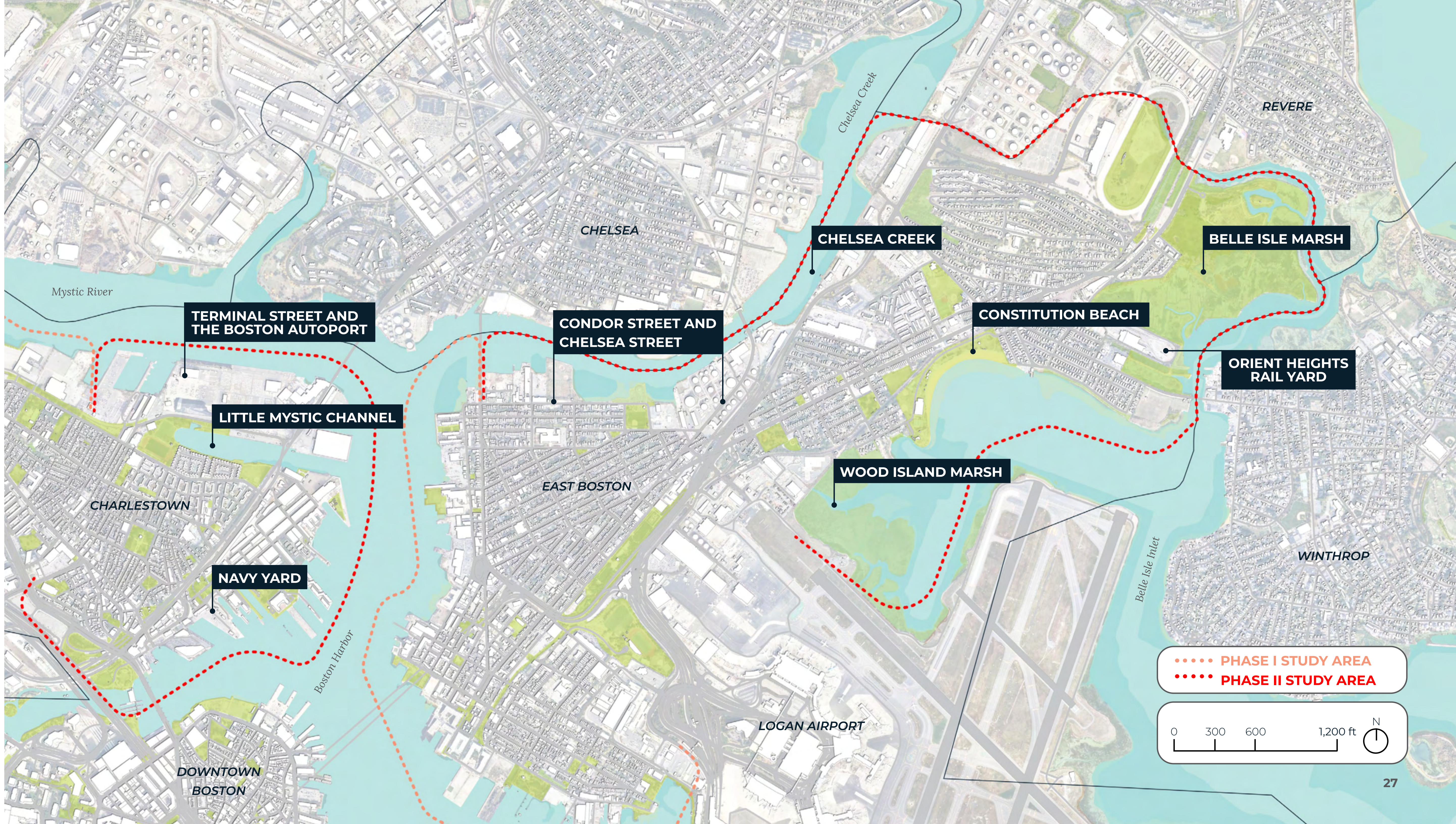
In the neighborhoods of East Boston and Charlestown, much of the land that was created through this fill is now vulnerable to coastal flooding. This is because the filled land exists at a lower elevation than the surrounding areas that were once islands or upland areas. When coastal storms and extreme high tides occur, the water naturally flows to the lowest-lying areas. These are referred to as flood pathways, as described in Chapter 3, *Coastal Flood Risk*.

The study areas for Phase II include:

- East Boston's coastline along Condor Street and Chelsea Street, Chelsea Creek, Belle Isle Marsh, Orient Heights Rail Yard, Constitution Beach, and Wood Island Marsh; and
- Charlestown's coastline along the Navy Yard, Little Mystic Channel, and Terminal Street and the Boston Autoport.

The following sections describe the historic and existing conditions within the study area for East Boston and Charlestown, as well as Boston's broader climate resilience planning context.

Boston's present and historic coastline.
Source: Climate Ready Boston, 2016



EAST BOSTON

East Boston (or “Eastie”) is a neighborhood of Boston surrounded by water bodies, including Boston Harbor, Chelsea Creek, and Belle Isle Inlet. East Boston was once a collection of small islands that have been joined together into one landmass by filling tidal areas over time. East Boston was connected to the mainland in the late nineteenth century when Crooked Creek, the historic waterway and tidal estuary between Noddles Island and Hog Island (later called Breed’s Island), was filled.

Over time, fill was added to the southern portion of the neighborhood to form what is today Jeffries Point and Logan International Airport ("Logan Airport"), which opened in East Boston in 1923.[1] Today, the area where Crooked Creek once flowed is one of the lowest-lying and most vulnerable parts of the study area. East Boston’s history is marked by industries that thrived and catalyzed the rapid growth of the neighborhood in the early 20th century due to its location along the waterfront, specifically the shipbuilding industry.

THE COMMUNITY

East Boston was once the second-largest point of immigration in the United States after Ellis Island. During the 1980s, many Italian immigrants moved to Eastie, establishing businesses and cultural organizations that continue to be a presence in the neighborhood.

Today, East Boston is home to approximately 46,000 people, more than 50% of whom are immigrants.[2] The neighborhood has the highest percentage of immigrants of any neighborhood in Boston.[3] The majority of East Boston residents who immigrated to Boston came from Spanish-speaking countries, such as El Salvador, Columbia, Guatemala, and the Dominican Republic. More than half of East Boston’s households speak Spanish at home. Most East Boston residents hold occupations in the service and hospitality sector (26%), followed by the educational and healthcare (16%) and professional industries (16%).[4]

Boston has experienced unprecedented growth during the last decade and East Boston is one of the fastest-growing neighborhoods in the city. As East Boston has grown, a number of changes have accompanied this growth. Between 2000-2017, there was a 22% increase in population (twice the citywide average), a 42% increase in average rents, and an annual growth rate of 1.3% for weekday boarding of the MBTA Blue Line in all East Boston stations.[5]

While population growth and new development have transformed parts of the neighborhood in recent years, the benefits of growth have not been distributed equitably across the East Boston community. Gentrification caused by rapid growth, particularly along the waterfront, threatens the stability of long-term residents in the neighborhood.

Despite these changes, the residents of East Boston have maintained a strong sense of community over the years through a robust history of organizing and activism in defense of community assets and quality of life. Starting in the 1960s, local activism focused on noise and air pollution generated by industrial and transportation activities in the neighborhood.

Today, that activism has expanded to include a wide range of environmental concerns in East Boston, which is a designated Environmental Justice Community.[6] Local advocacy has focused on promoting community health and safety in the face of anticipated impacts associated with climate change. Community-based organizations in East Boston have been helping lead efforts to organize, educate, advocate, and plan for climate adaptation and climate justice in the neighborhood and surrounding communities. Work by these organizations and others has shaped visions for key waterfront locations, highlighted concerns regarding air and water quality and public health, identified the community’s vulnerability to flooding, and engaged youth and other community leaders in conversations about what it means to be a climate-resilient community.

The proposed coastal resilience solutions for East Boston in this plan are built upon the values and goals of these local efforts and will continue to be shaped in collaboration with the community.

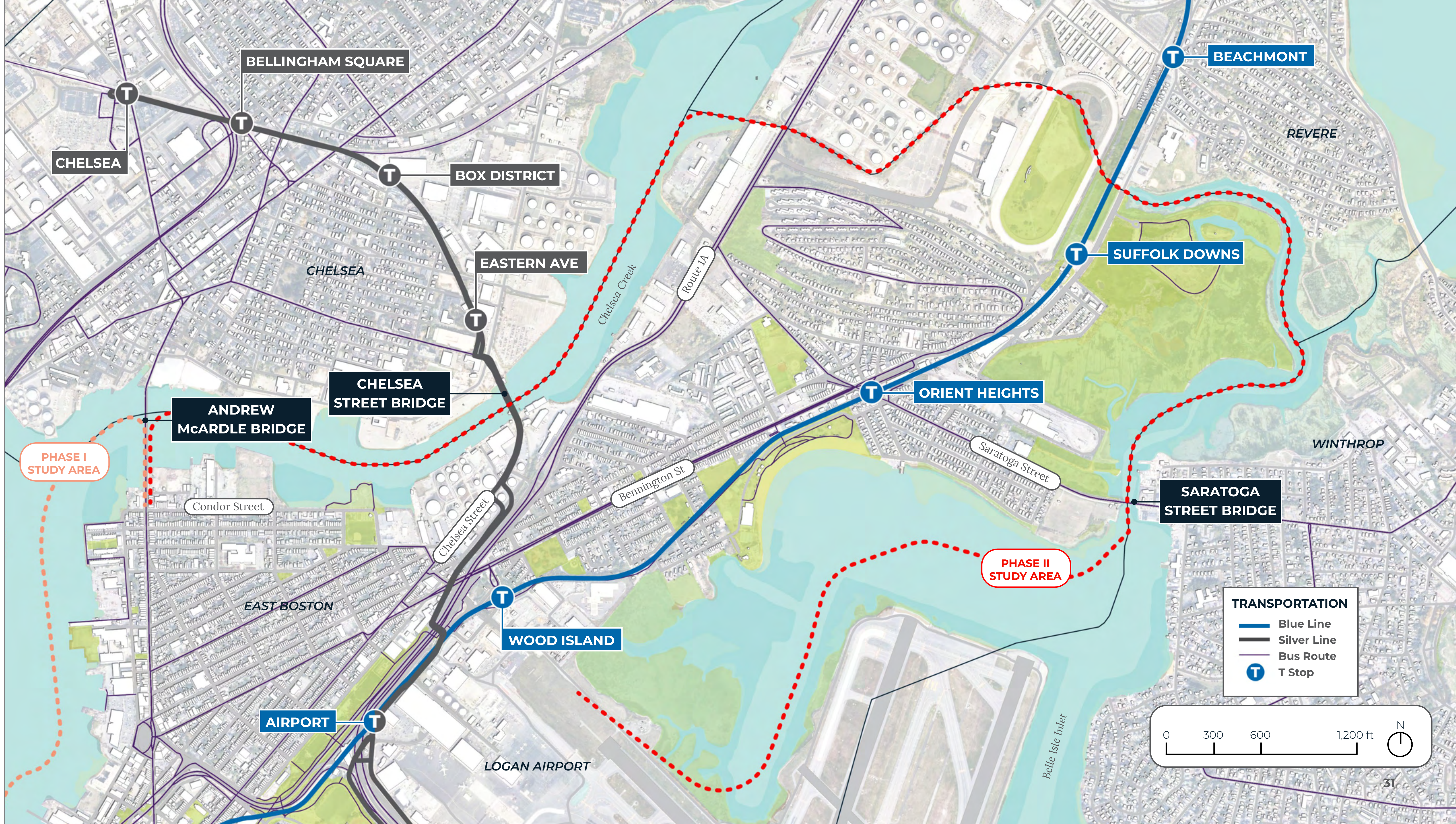
Right: *Mural "Rising Tides" by Sophie Tuttle on the Mary Ellen Welsh Greenway in East Boston raises awareness about the relationship between rising temperatures and sea-level rise.*

LOCAL AND REGIONAL TRANSPORTATION

Many key state and local roadways, bus routes, and railways travel through East Boston. This transportation infrastructure system serves the local community and connects to the rest of Boston, Chelsea, Revere, Winthrop, and the larger region. The MBTA Blue Line connects East Boston and Revere, as well as Logan Airport, to the rest of the city. The MBTA Blue Line has five stations across the neighborhood. The Silver Line (SL3) provides additional connectivity between Logan Airport, Downtown Boston, and the City of Chelsea. The neighborhood is served by a number of bus routes, including the 112, 114, 116, 117, 120, and 121.

East Boston is also connected to surrounding areas by city and state roads, including Massachusetts Route 1A and Bennington Street, which serve as evacuation routes and primary roadways providing access to and from East Boston. Interstate 90 (the Massachusetts Turnpike) enters East Boston from the south before transitioning into Route 1A (also known as the William F. McClellan Highway), which provides vehicular access to north shore communities, such as Revere. These highways serve as connectors between East Boston and its neighbors. Bennington Street (also known as Route 45) serves as a major roadway that carries bus traffic from Eagle Hill through to Orient Heights and beyond.

Three tunnels and three bridges connect East Boston to neighboring municipalities. The Sumner Tunnel and the Lieutenant William F. Callahan Tunnel (the "Callahan Tunnel") connect East Boston to Downtown Boston. The Sumner Tunnel provides one-way travel from East Boston to Downtown Boston while the Callahan Tunnel provides one-way travel from Downtown Boston to East Boston. The Williams Tunnel provides two-way travel between East Boston and South Boston. The Andrew McArdle Bridge and Chelsea Street bridge cross Chelsea Creek to the north, and the Saratoga Street/Main Street Bridge connects to Winthrop in the west.



OPEN SPACE AND COASTAL EDGES

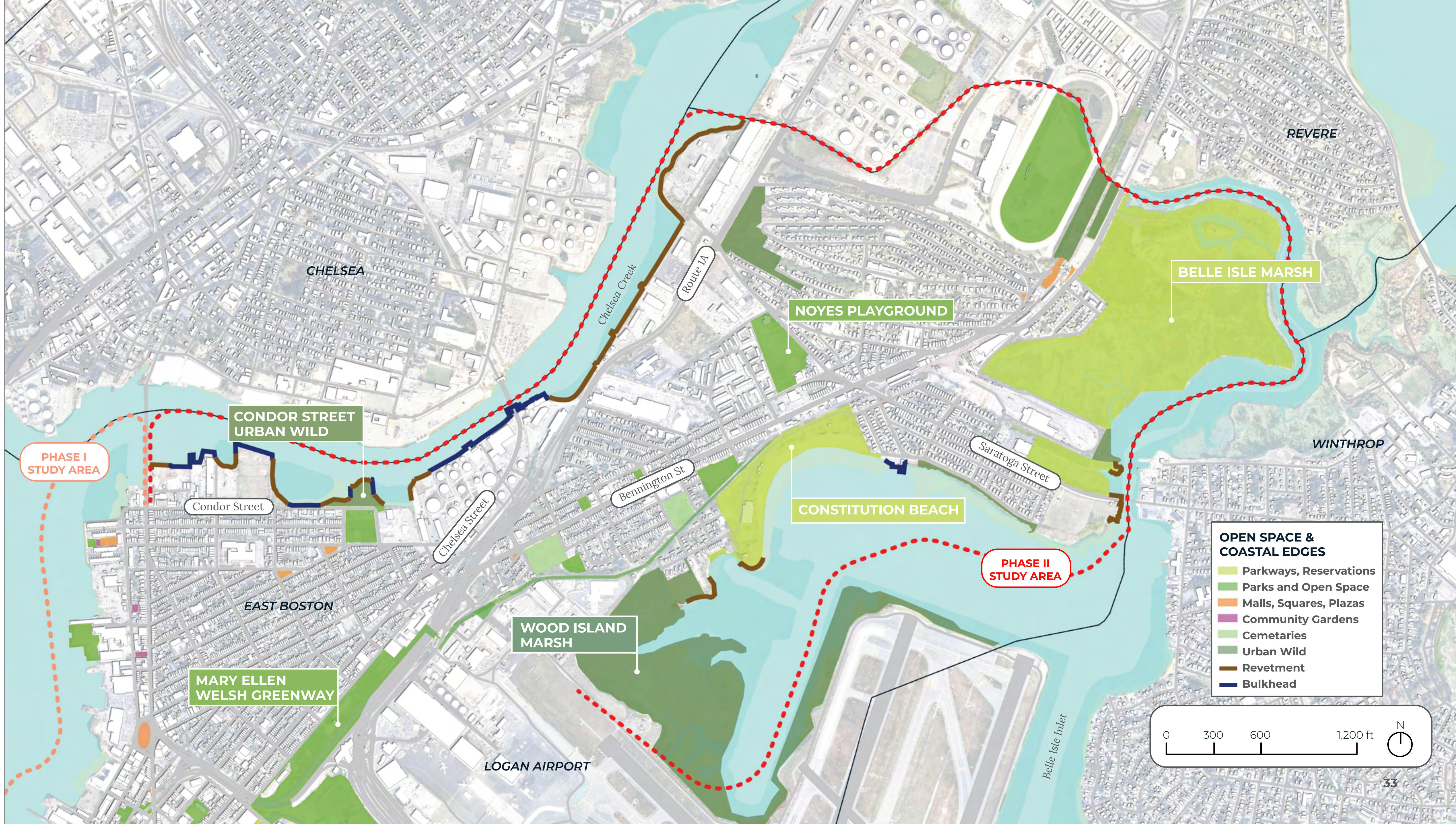
The East Boston waterfront consists of a mix of infrastructure, such as bulkheads and rock armoring in areas that have historically supported water-dependent industrial uses, and softer edges that create habitat for plants, animals, fish, and birds. These softer edges include tidal flats, shallow marsh meadows, salt marshes, intertidal shores, coastal banks, and a coastal beach.

In the study area, much of this open space is concentrated on the waterfront, especially at Constitution Beach and Belle Isle Marsh. Belle Isle Marsh is a 28-acre salt marsh, which is a reservation open to the public with trails, fields, and viewing platforms. Constitution Beach Park is also accessible to the public and includes athletic fields, playgrounds, an ice rink, and a large beach for swimming and recreation. Additional tidal flats and salt marshes border Logan Airport at the Wood Island Marsh but are not accessible to the public.

The existing Mary Ellen Welch Greenway, which connects Piers Park to Constitution Beach, is an important connection for pedestrian and bicycle traffic. Along Chelsea Creek, open space is more limited. The Condor Street Urban Wild is a City-owned public park located along Condor Street on a site that was once used for industrial purposes but has been converted into a recreational setting with trails and sweeping views of Chelsea Creek. Throughout East Boston, there are a number of smaller pocket parks, plazas, malls, and squares.

Access to and from some of these open spaces and parks is a challenge in East Boston. The coastline along Chelsea Creek lacks waterfront access with the exception of the Condor Street Urban Wild. **Community members have expressed a desire to increase access to and connectivity along the waterfront in East Boston.**

The *Coastal Resilience Solutions for East Boston and Charlestown (Phase I)* plan prompted improvements and adaptations to parks in the Phase I study area. Since most of the waterfront recreational parks and open spaces in the Phase II study area of East Boston are vulnerable to flooding, steps will need to be taken to preserve and enhance these valuable community and ecological resources, as well as seek opportunities to use them as naturalized buffers to protect inland areas from flooding.



CHARLESTOWN

Like East Boston, Charlestown is also a neighborhood surrounded by water, including the Boston Harbor and the Mystic River. Charlestown was once a peninsula connected to the mainland in what is now Somerville by a narrow land bridge. Over time, significant portions along the coastline were filled to connect the neighborhood to the mainland and to create more land for urban uses along the waterfront. Much of the Charlestown Navy Yard (the "Navy Yard") and all of the land now surrounding Little Mystic Channel, including the Boston Autoport, is filled land. Like East Boston and other areas of the city, these filled areas are now the most vulnerable to coastal flooding.

THE COMMUNITY

Historically, the Charlestown neighborhood has been particularly welcoming to Irish Catholic communities who settled there in the 1820s. Today, Charlestown is home to approximately 19,890 people and the neighborhood remains 74% white, but racial and cultural diversity has increased over the last 20 years as Black, Asian, and Latinx residents have moved into the neighborhood.[7,8]

Additionally, Charlestown is home to many families with young children. In fact, over 9% of Charlestown's population is under 5 years old, compared to 5% of Boston as a whole.[9] Charlestown also has a high concentration of residents who are highly educated and are employed by anchor industries related to research and healthcare.[10]

Charlestown residents are experiencing growth in their community. While the median income has increased, the gap between the highest median income and the lowest median income is approximately $90,000.[11] The highest concentration of income-restricted housing in Charlestown is located in the area around the Little Mystic Channel, including the Bunker Hill Housing Development (owned by the Boston Housing Authority) and the CharlesNewtown Co-Op (a private income-restricted co-operative housing development). On the blocks surrounding the Bunker Hill Monument, for example, between zero and 7% of residents are coping with factors related to living with an income below the poverty level.[12] In contrast, on the blocks around the Little Mystic Channel, between 33% and 80% of residents are impacted by the needs and stressors of living with an income below the poverty level.[13] **Since the Bunker Hill Housing Development and CharlesNewtown Co-Op are located near the waterfront, much of Charlestown's affordable housing is vulnerable to flooding.**

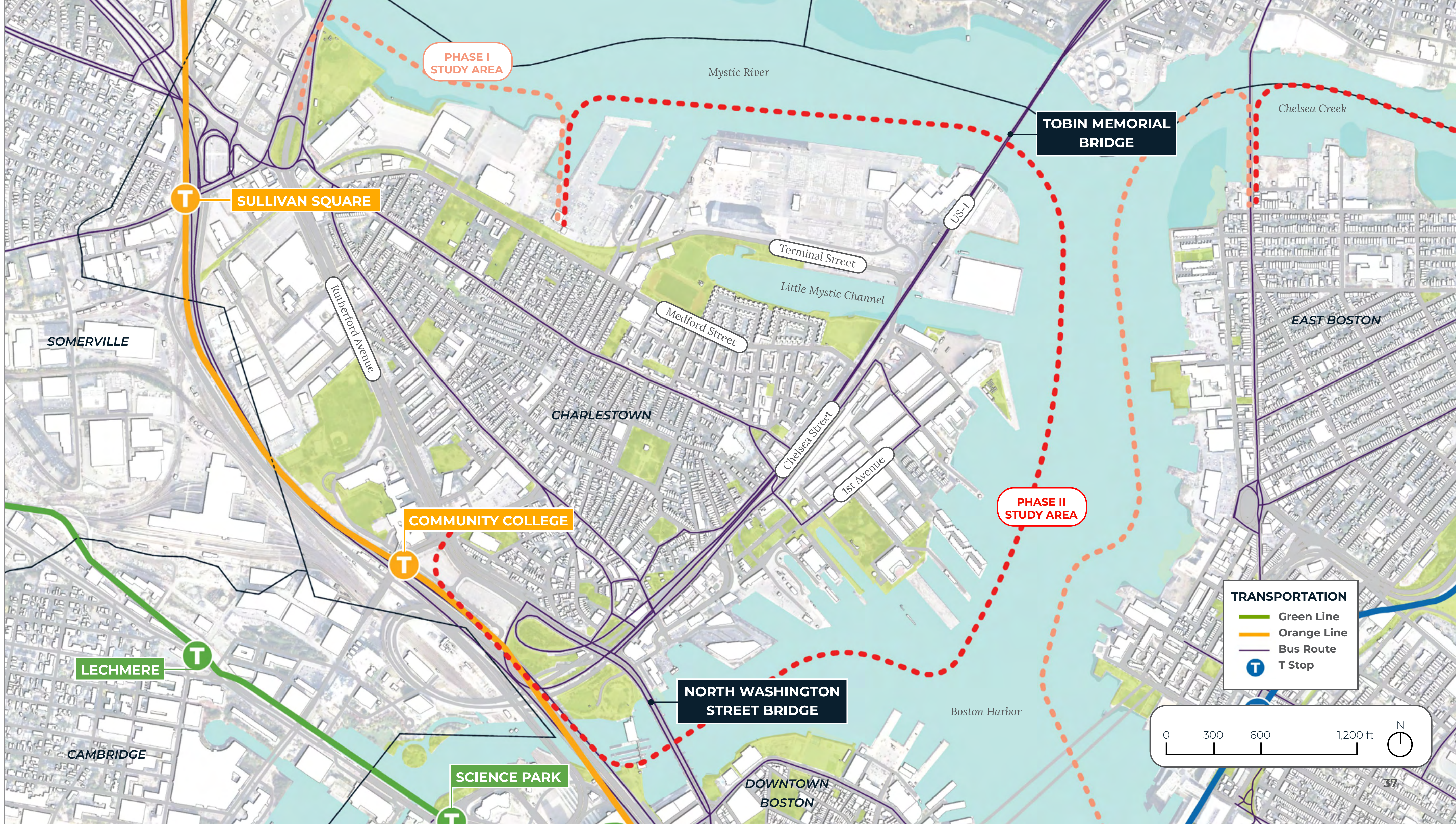
In the face of neighborhood change, economic disparities, and the increasing threat of climate change, residents of Charlestown have expressed concern for the future of the historic Charlestown waterfront as well as the safety and well-being of their neighbors.

Navy Yard Harbowalk, Charlestown

LOCAL AND REGIONAL TRANSPORTATION

Charlestown is primarily served by State and local roads and bus routes, as well as the MBTA Orange Line, which connects Somerville and Malden to the north with downtown Boston to the south. In the study area, I-93 runs along the western edge of Charlestown. US-1 runs east to west through the neighborhood as an elevated highway along Chelsea Street and leads to the Maurice J. Tobin Memorial Bridge, which connects to Chelsea and the North Shore. Charlestown is connected to Downtown Boston by the North Washington Street Bridge.

In the Navy Yard, 1st Avenue is the primary roadway and provides access both to surrounding commercial buildings and to the several residential buildings located along the waterfront, including Flagship Wharf and Constellation Wharf. Medford Street and Terminal Street are the primary roadways providing access along Little Mystic Channel and the Mystic River.



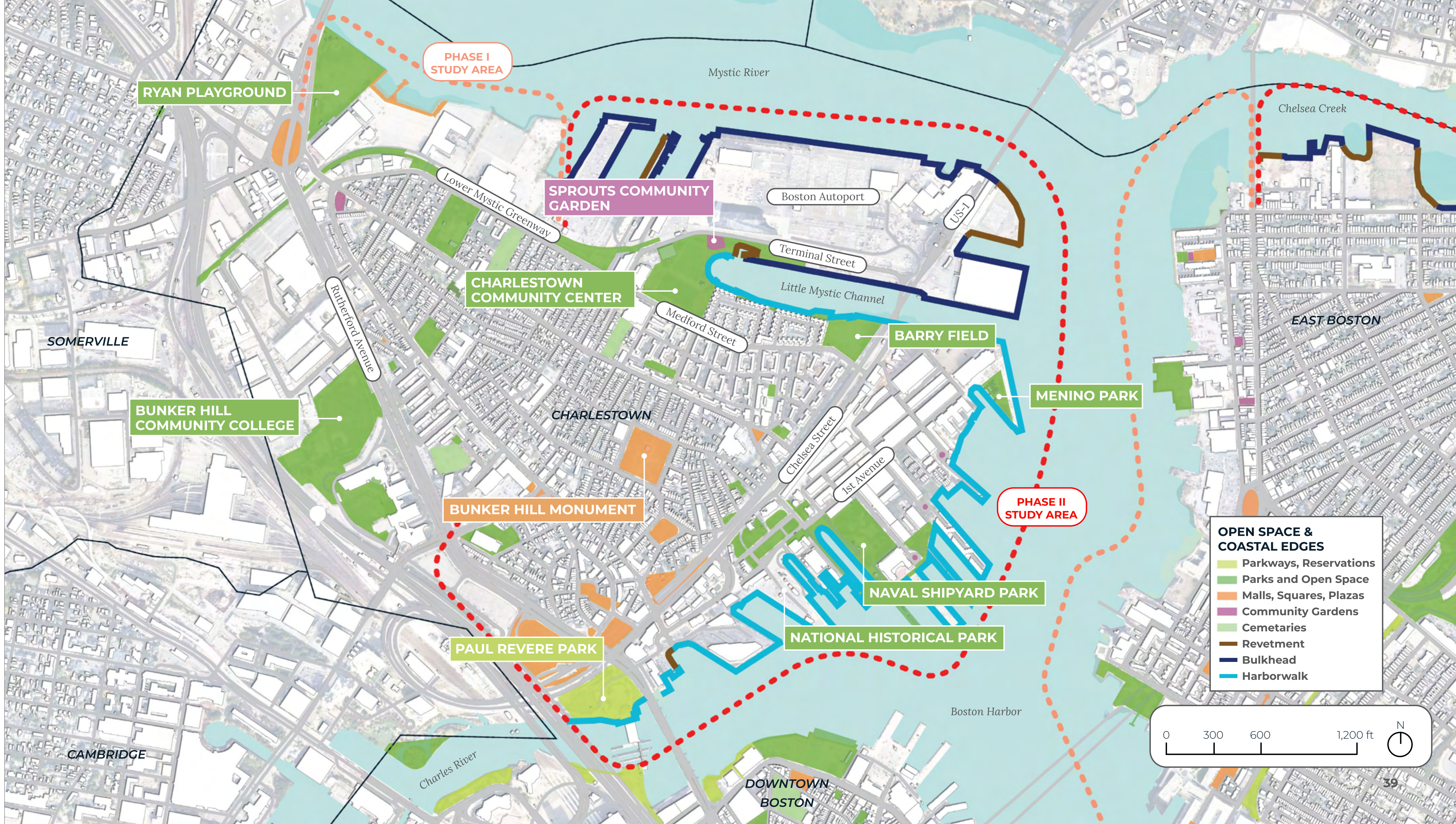
OPEN SPACE AND COASTAL EDGES

Much of the coastline in Charlestown has been developed or hardened with bulkheads, seawalls, and other types of waterfront structures, such as piers. These structures were created to enable the growth of waterfront industries that required docking, and off-loading and repair facilities for ships. They also were intended to stabilize the coastline so that buildings could be erected close to the water's edge. Due to the nature of the Navy Yard's development and use over time, many structures were built very close to the coastline. Because of this, there is often a narrow distance between the developed property and the water, limiting the on-land space for future coastal protection strategies.

Within the study area, key public parks in the neighborhood include City Square Park, the Boston National Historical Park, Thomas M. Menino Park, Barry Field, and the Charlestown Community Center athletic fields.

Additionally, the Haborwalk extends along much of the waterfront, providing a continuous public pathway through the Navy Yard and along Little Mystic Channel. The Little Mystic Channel is home to the Charlestown High School & Community Center and the Sprouts Community Garden. Further inland, public squares provide additional public open space.

Much of Charlestown's open space is concentrated around the waterfront, and consequently these areas are inherently vulnerable to flooding. However, along with that vulnerability comes the opportunity to improve public space while incorporating flood protection measures.

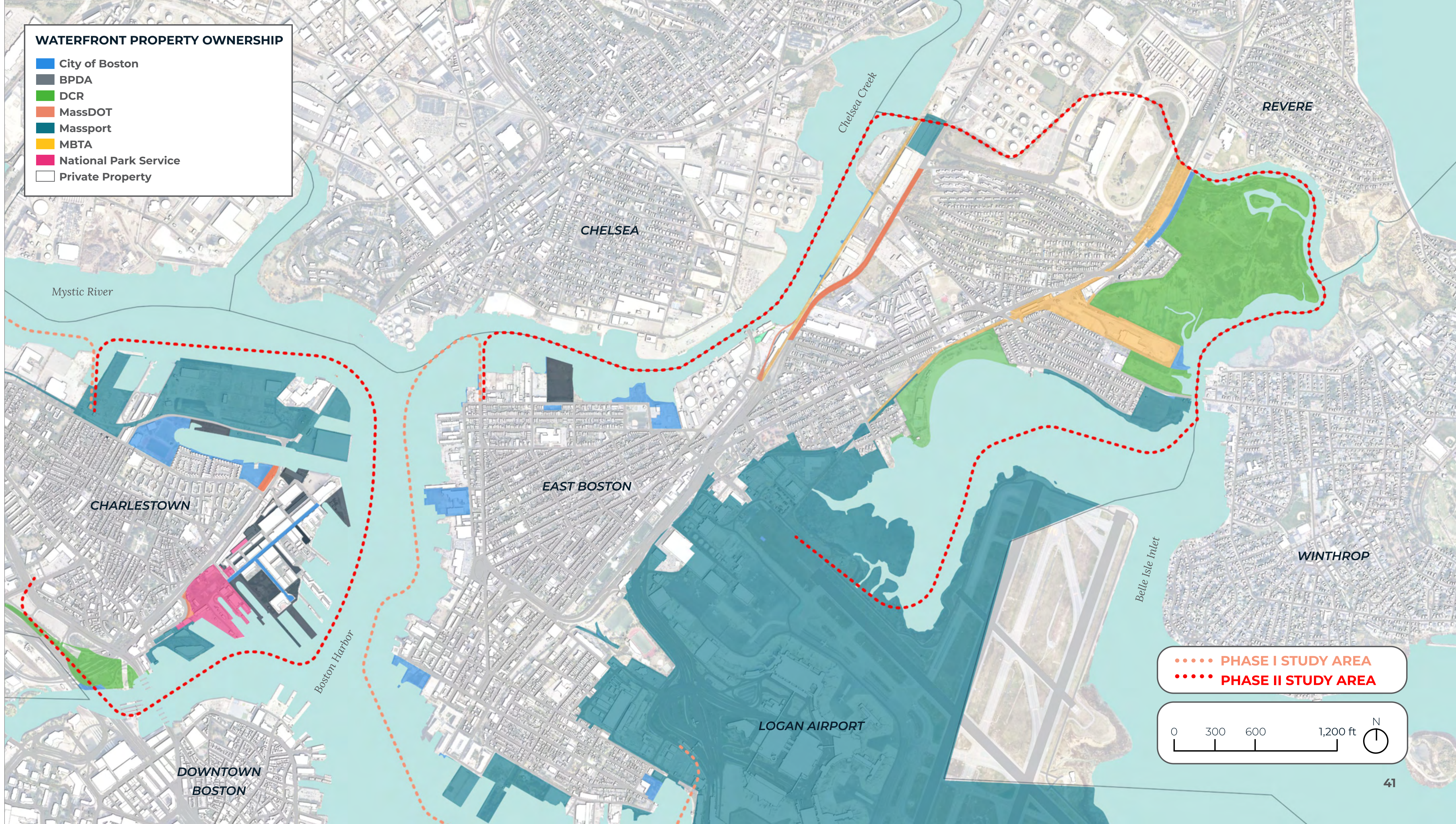


WATERFRONT PROPERTY OWNERSHIP

A mixture of private and public entities own property along the coastline in the East Boston and Charlestown study areas. Much of the coastline in the East Boston study area is owned or under the jurisdiction of public agencies, including the City of Boston, Massachusetts Bay Transportation Authority (MBTA), Department of Conservation and Recreation (DCR), Massachusetts Port Authority (Massport), or Massachusetts Department of Transportation (MassDOT). Public ownership of the coastline offers strategic opportunities to plan coastal resilience infrastructure that protects and enhances public facilities, while protecting private properties further inland. These opportunities include the DCR-owned reservations at Belle Isle Marsh and Constitution Beach, the MBTA-owned Orient Heights Rail Yard and an unused rail corridor along Chelsea Creek, as well as roadways, such as Route 1A, Bennington Street, and Condor Street, which are under the jurisdiction of the City or MassDOT.

In Charlestown, land owners include the City of Boston, Massport, the Federal government (National Park Service and Department of Defense), and private property owners. Many waterfront private property owners have granted public easements for access along the Harborwalk. The coastline surrounding Little Mystic Channel and the Boston Autoport is primarily owned by Massport and the City, although some of this land is under long-term lease agreements with private tenants who operate within the Boston Autoport. Publicly-owned parks, Harborwalks, boat launches, and sports fields surrounding the Little Mystic offer opportunities to reimagine and reinvigorate these public spaces while incorporating coastal resilience infrastructure.

While the coastal resilience strategies included in this plan prioritize implementation on land owned or controlled by public agencies, there will nevertheless be a need for ongoing coordination between the City, public agencies at the State and Federal level, and private property owners as resilience strategies are refined and constructed.



THE WORKING WATERFRONT

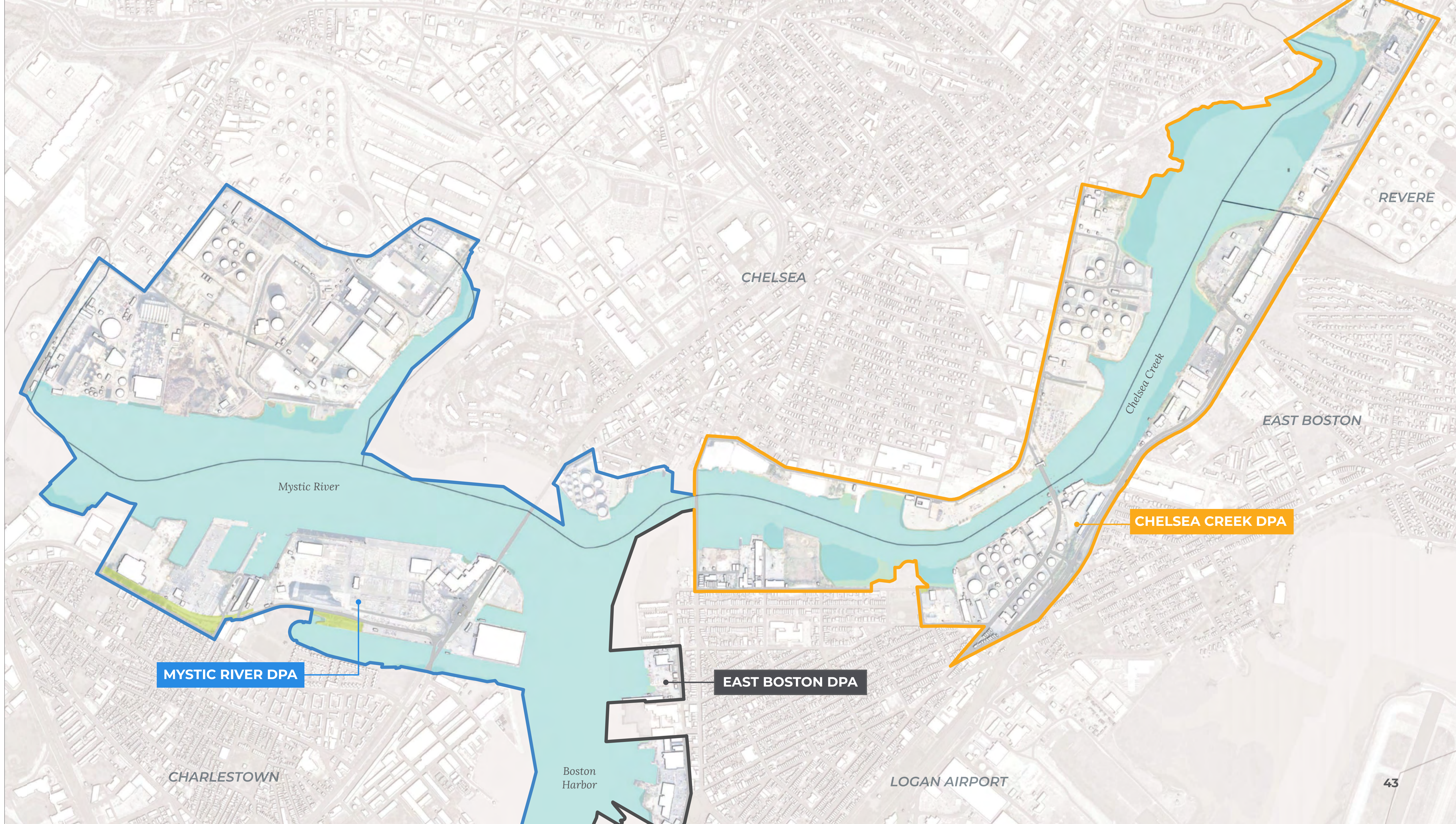
DESIGNATED PORT AREAS (DPAs)

Both Charlestown and East Boston have infrastructure that supports water-dependent industrial uses. These industrial areas are concentrated in the Designated Port Area (DPA) along Chelsea Creek in East Boston (the "Chelsea Creek DPA") and in the DPA along the Mystic River in Charlestown (the "Mystic River DPA"). Properties within DPAs have the necessary physical and operational features needed to support businesses that require close proximity to the ocean, such as commercial fishing, shipping, and other vessel-related activities. The DPA policy is implemented by the Massachusetts Department of Coastal Zone Management (CZM). There are currently 10 DPAs in Massachusetts, four of which lie within the Boston Harbor and two of which lie within the Phase II study area.

While water-dependent industrial uses have been located along Chelsea Creek and the Mystic River for many decades, the nature of these uses has changed over time. Today, a range of industrial uses exist in the DPAs, including some that do not rely on maritime transportation or infrastructure. Climate change presents new challenges for water-dependent industrial uses that are not currently addressed through the DPA policy. As sea-level rise increases and storms become more frequent and more intense, many water-dependent industrial uses within DPAs will need to adapt to these changing conditions and may no longer be able to function as they do today.

Some strategies that have been identified as effective and desirable solutions to address coastal flood risk currently are not permissible within DPAs because they may not be consistent with future water-dependent industrial uses. These strategies include parks and nature-based solutions, such as living shorelines or earthen berms, that would be built in or along the waterfront. Consequently, DPAs present an important regulatory consideration for the implementation of coastal resilience strategies that reflect community priorities for nature-based solutions and access to the waterfront.

It is important to plan for multiple scenarios in both East Boston and Charlestown that take into account the DPAs as they exist today and revisions that may allow for new waterfront uses in the future. The coastal resilience strategies described in Chapter 4, *Coastal Resilience Solutions for East Boston and Charlestown*, focus on near-term design options that are allowed under current regulations, but this study also explores longer-term opportunities that may be permissible in the future.



BOSTON AUTOPORT

The Massachusetts Port Authority (Massport) owns and operates several properties throughout the Boston Harbor that host maritime industrial uses. In some locations, Massport leases its land to maritime industries, one of which is Diversified Automotive Inc., which operates the Boston Autoport (the "Autoport") in Charlestown. Located on a peninsula at the confluence of the Mystic River and the inner Boston Harbor, the Autoport is an approximately 80-acre property that supports a variety of maritime industrial activities, including the export and import of new and pre-owned vehicles, salt storage and mixing, vehicle and marine vehicle fueling, and truck repair. The Autoport lies within the Mystic River DPA and is subject to the DPA policy.

The site is primarily used as parking lot that currently operates as a shipping and outdoor storage facility for approximately 90,000 vehicles that are shipped to Boston annually. Vehicles are imported and exported by shipping vessels, and imports are stored at the Autoport and distributed by truck across the northeastern U.S.

In addition to the Autoport parking lot, there is a six-story building on-site known as the Administration Building that houses the offices of Diversified Automotive and two businesses, a maintenance building and an observation tower and a salt pile and salt and sand mixing shed, which is used to melt snow and ice on roads during the winter. Additionally, a portion of the property has a state-of-the-art building that is occupied by the Massachusetts Clean Energy Center's (MassCEC) Wind Technology Testing Center (WTTC), which was built to encourage the testing of large-scale blades for wind turbines.

Massport has been working with its tenants at the Autoport to ensure that they are aware of the climate-related risks that exist across Massport-owned properties and that they are prepared for the impacts of climate change, including coastal flooding. Massport will continue to analyze the potential risks, mitigation options, and timing of interventions, as well as regularly evaluating industry best practices regarding the safe storage of materials, such as road salt.

View of the Boston Autoport and the Tobin Memorial Bridge, facing northwest. Source: City of Boston Digital Team

BOSTON NATIONAL HISTORICAL PARK

The Boston National Historical Park area in the Navy Yard is a 30-acre Historic Landmark District. The National Park Service (NPS), in partnership with the U.S. Navy and the USS Constitution Museum, preserves the naval heritage that spans some 174 years. In 1798, Charlestown became one of six naval shipyards in the United States.

Through 1974, the landscape of the Navy Yard evolved and shaped the way naval vessels were built, how new technologies were adapted, and how the workforce diversified during wartime.

The Navy Yard reflects remnants from the early 19th century through today where visitors can witness a working shipyard, as the U.S. Navy still maintains and preserves America's "Ship of State," the USS Constitution. Nearly 1.5 million people visit Charlestown annually to explore the workings of the Yard, the USS Constitution, as well as the USS Cassin Young, a World War II destroyer.

The Navy Yard and the U.S.S. Constitution Museum are important neighborhood amenities and sites of regional and national importance.

The NPS and U.S. Navy are working collaboratively to evaluate potential future coastal flooding impacts to Navy Yard assets and the visitor experience. The complexity in planning and designing mitigation measures within a nationally significant working shipyard, while protecting the historic landscape and structures is challenging, but the NPS is committed to working with the City of Boston to develop a coordinated approach within the larger context of the Charlestown community.

View of the Boston National Historical Park, facing northwest. Source: National Park Service

PLANNING CONTEXT

This section details the key initiatives, studies, and plans that address the City's climate resilience goals building on the Climate Ready Boston initiative. Collectively, the plans, policies, and programs detailed below have provided a foundation for building coastal resilience in Boston.

IMAGINE BOSTON 2030

Released in July 2017, *Imagine Boston 2030* is Boston's first citywide comprehensive plan in 50 years. *Imagine Boston 2030* provides a direction for the City's long-term planning and development, bringing together plans for housing, education, transportation, racial equity, climate preparedness, and more. This plan highlights challenges and opportunities related to climate change, as the City assesses future policy, zoning, and other requirements in response to Boston's changing needs.

SOCIAL AND RACIAL RESILIENCE

In July 2017, the Mayor's Office of Resilience and Racial Equity released the *Resilient Boston* plan, which focuses on racial equity, social cohesion, and social and climate resilience strategies. The report outlines visions, goals, and actions that support climate change adaptation measures and solutions, prioritizing the most underserved residents and neighborhoods in the city.

RESILIENT PUBLIC RIGHTS-OF-WAY

In November 2018, the Boston Public Works Department (PWD) published the *Climate Resilient Design Standards and Guidelines* that provide the design process and best practices for evaluating flood barriers to protect Boston's public right-of-way, such as City-owned streets and sidewalks. Subsequently, in February 2020, the Public Improvement Commission (PIC) adopted *A Policy for Climate Resilience* that requires all projects that come under the jurisdiction of the PIC to complete an evaluation to determine the risk of sea-level rise and storm surge flooding on the adjacent right-of-way. This requires that projects that lie within an area identified as being vulnerable to sea-level rise and coastal flooding must take adequate measures to protect the public right-of-way.

RESILIENT BOSTON HARBOR VISION

In October 2018, the City of Boston announced a comprehensive vision to invest in Boston's waterfront to protect the city's residents, homes, jobs, and infrastructure against the impacts of rising sea levels and climate change. *Resilient Boston Harbor* builds off of *Imagine Boston* 2030 and uses the City's *Climate Ready Boston* 2070 flood maps and coastal resilience neighborhood studies to focus on Boston's most vulnerable flood pathways. The strategies laid out in the vision include elevated landscapes, enhanced waterfront parks, flood resilient buildings, and revitalized and increased connections and access to the waterfront.

WETLANDS PROTECTION ORDINANCE

In December 2019, the City of Boston enacted the Wetlands Protection Ordinance (the "Ordinance"), which gives the City greater authority to protect its wetlands. The Ordinance also directs the Boston Conservation Commission to consider future climate impacts in all applications. Since 2019, the City has taken a phased approach to develop additional regulations and standards to formally codify the authorities described in the Ordinance. Going forward, the Conservation Commission will adopt regulations that address climate resilience as well as equity and environmental justice as they relate to development within a wetland resource area.

COASTAL STORMWATER DISCHARGE ANALYSIS

In August 2020, the Boston Water and Sewer Commission (BWSC) launched a project to conduct a coastal stormwater discharge analysis. This analysis will assess the performance of Boston's drainage system under different scenarios of storms, precipitation amounts, and sea-level rise. The project boundary of BWSC's analysis includes tidally influenced coastlines from the Neponset River Dam to downstream of the Charles River Dam and the coast of East Boston and Charlestown. The analysis will develop specific plans for investments in stormwater management infrastructure. The project will also consider facilities and barriers proposed in the *Climate Ready Boston* coastal defense strategy and seek to incorporate them into the BWSC plans for structures, pumping facilities, and barriers. Additionally, the previously-created The Inundation Model will enable BWSC to delineate where and to what extent coastal and upland flooding could occur under different scenarios, the projected depth and duration of inundation.

RESILIENCE REVIEW IN THE COASTAL FLOOD RESILIENCE OVERLAY DISTRICT

In October 2021, the City's Zoning Commission fulfilled the steps outlined in the 2016 *Climate Ready Boston* report by adopting the Coastal Flood Resilience Zoning Overlay District (the "Overlay District"). The Overlay District applies to areas of the city anticipated to be flooded with a 1% chance storm event with 40-inches of sea-level rise through the year 2070 and is administered by BPDA staff for the review of proposed development projects within the Overlay District. It also formalized the implementation of the *Coastal Flood Resilience Design Guidelines* (the "Guidelines") and established new definitions and standards for building dimensions and uses. All development projects subject to BPDA's Article 80 Large and Small Project review will be required to undergo Resilience Review with BPDA staff to ensure compliance with the Guidelines. See page 91 for more information.

NEIGHBORHOOD PLANNING INITIATIVES

The City has been advancing several other neighborhood-wide and citywide initiatives in parallel with this study. In partnership with multiple City agencies, the BPDA is leading neighborhood-wide planning initiatives in both East Boston and Charlestown, known as PLAN: East Boston and PLAN: Charlestown. Both plans will update neighborhood zoning, establish neighborhood design guidelines, and propose new capital improvements to public space, including near- and long-term improvements to the neighborhood's transportation network and park system. The City and the BPDA have been in close coordination throughout these processes. Consequently, PLAN: East Boston and PLAN: Charlestown have informed this project and vice versa, and the *Coastal Resilience Solutions for East Boston and Charlestown (Phase II)* study serves as the climate adaptation plan for both of these studies.

PROJECT SPOTLIGHT: HEAT RESILIENCE SOLUTIONS FOR BOSTON

In April 2022, the Climate Ready Boston initiative released Heat Resilience Solutions for Boston (the "Heat Plan"), a citywide plan to address the current and future impacts of extreme heat.

Alongside the impacts of coastal flooding, Boston also faces increasing impacts of extreme heat. Some residents and communities experience greater risk to the impacts of extreme heat due to environmental factors, the legacy of past investment decisions, health factors, and age.

Over the century, annual temperatures and the number of very hot days are projected to increase. Under a business-as-usual greenhouse gas emissions scenario, it is likely that temperatures in Boston could exceed 90°F for more than 60 days by the 2070s. If aggressive action is taken to reduce greenhouse gas emissions, Boston could instead see approximately 40 days over 90°F each year by the 2070s. While all of Boston experiences extreme heat, there are temperature hotspots throughout the city.

The Heat Plan identified community-driven solutions to reduce extreme temperatures in hot spots across the city and increase access to cooling resources. These strategies aim to reduce exposure to extreme heat by: enhancing the built environment; expanding programs and information to access cooling; and integrating existing preparedness, public health, and racial equity initiatives to inform citywide heat resilience.

To develop strategies that center the experience of disproportionately impacted residents, the Heat Plan focused on detailed extreme temperatures analysis and strategy development in areas where temperature hot spots overlap with historically underserved environmental justice communities. The five neighborhood focus areas for the study include Chinatown, Dorchester, Mattapan, Roxbury, and East Boston. The study revealed that these neighborhoods can experience the longest heat duration at over 30 hours with some areas experiencing up to 37 hours of extreme heat conditions.

Additionally, a redlining analysis was conducted to understand the lingering impacts of historical development practices. The study found a strong correlation between the areas of the city that experience the highest temperatures and the areas that were subjected to redlining practices in the past. These neighborhoods also tend to have less tree canopy and green open space, and more concrete, asphalt, and infrastructure, such as highways, than wealthier neighborhoods where homeownership tends to be higher.

Following the release of the Heat Plan, the City took immediate steps to advance heat resilience during Summer 2022. These projects and programs focused on providing heat relief in Boston's hottest neighborhoods and building awareness around heat resilience strategies.

CLICK ON THE REPORT COVERS TO LEARN MORE ABOUT BOSTON'S CLIMATE WORK!

EAST BOSTON AND CHARLESTOWN PHASE I - PROGRESS ON NEAR-TERM ACTIONS

Over 400 residents from East Boston and Charlestown participated in the Phase I planning process in 2017 through meetings, community events, open houses, and an online survey. East Boston and Charlestown residents, businesses, and organizations shared their desire for effective and long-lasting solutions to keep them safe from coastal flooding while also enhancing their neighborhoods.

EAST BOSTON

The *Coastal Resilience Solutions for East Boston and Charlestown (Phase I)* report from 2017 studied the East Boston waterfront from Porzio Park to Central Square, including the sub-neighborhoods of Jeffries Point, Maverick, Central Square, and Lower Eagle Hill. This plan included strategies such as a deployable floodwall in the East Boston Greenway, new elevated open spaces at the Greenway entrance and Piers Park II, and building-scale adaptations to ongoing development projects.

Implementing all near-term actions would protect over 10,800 residents, at least 250 businesses, and infrastructure, up to the 1% annual chance flood with nine inches of sea level rise (anticipated by the 2030s), plus 1 foot of freeboard (see Chapter 3, *Coastal Flood Risk*, for more information). At this level of protection, from a single event these measures would prevent an estimated $620 million in losses.

MARY ELLEN WELSH GREENWAY DEPLOYABLE FLOODWALL

Following the release of the Coastal Resilience Solutions for East Boston and Charlestown (Phase I) final report, the City purchased a seven-foot high deployable floodwall to be installed along the Mary Ellen Welsh Greenway (the "Greenway") under Sumner Street in advance of a storm. This deployable floodwall would block the current 1% annual chance flood and provide immediate protection to almost 4,300 residents, at least 70 businesses, and critical infrastructure. The deployable floodwall serves as an interim measure to prevent existing flood pathways that enter at low elevations along the East Boston waterfront from extending further into the neighborhood via the Greenway.

EAST BOSTON RESILIENT WATERFRONT PROJECT

Led by the Boston Planning and Development Agency (BPDA), this project advanced the design from the 2017 report at Lewis Mall and Carlton Wharf, which are two critical near-term flood pathways for the East Boston neighborhood. This project further analyzed existing site conditions and developed implementable design options to protect the East Boston waterfront and community from future sea level rise and coastal storm events. Additionally, the proposed designs will strengthen the connection to the waterfront and protect environmental justice communities in East Boston from flooding.

BORDER STREET

The City of Boston plans to conduct a design study looking at the potential strategies for addressing coastal resilience along Border Street, which will evaluate options for outboard and inland flood protection strategies.

CHARLESTOWN

The Phase I report from 2017 studied the Charlestown waterfront from Sullivan Square, the Neck, Rutherford Avenue, and areas of Somerville and Cambridge. This plan included strategies such as elevating Main Street, redesigning Ryan Playground, and integrating coastal resilience solutions along the Schrafft's Center waterfront.

Implementing all near-term actions would protect over 330 residents and at least 60 businesses, and transportation infrastructure up to the 1% annual chance flood with nine inches of sea level rise (anticipated by the 2030s), plus 1 foot of freeboard. At this level of protection, these measures would prevent an estimated $390 million in losses from a single storm event.

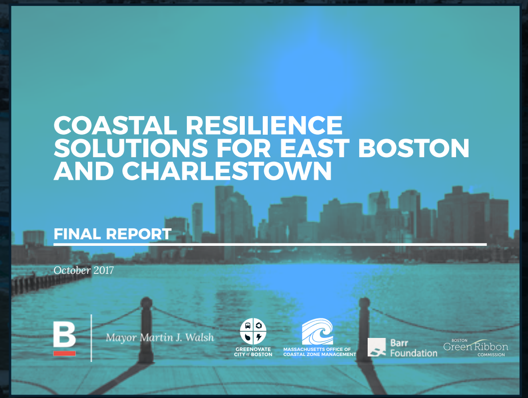
RYAN PLAYGROUND

Led by the Department of Parks and Recreation (BPRD), Ryan Playground began preliminary design investigations in the Fall 2020. Since then, the design of Ryan Playground was developed with input from three community meetings, starting in fall 2021 and culminating in March 2022. With flood resilience as a primary goal, the project aimed to incorporate programmatic elements sought by the community.

The new design will provide flood protection in the form of a large wall built landward of the existing seawall, hidden from park view below a berm. Since elevating sports fields is costly, the flood barrier will be limited to the coastal portion of the park. The berm will create the setting for a new playground with a vantage point overlooking the Mystic River and provides the backdrop for viewing the many sports fields in the heart of the park. The project aims to begin construction in Spring 2023.

ELEVATION OF MAIN STREET

A critical flood pathway in the Charlestown study area leads through a narrow, low-lying section of Main Street before spreading across the community. This section is located in front of the Schrafft's Center driveway, between Bunker Hill Street and Alford Street. The Boston Transportation Department (BTD) continues to work with the MBTA to include elevating Main Street in the redesign of Sullivan Square to protect residents from sea-level rise and storm surge. Elevating Main Street by an average of two feet in front of the Schrafft's Center driveway would block the main flood pathway through Charlestown up to a 1% annual chance flood with nine inches of sea level rise (2030s), plus 1 foot of freeboard. This would protect over 250 residents, at least 60 businesses, first responder facilities, and the Rutherford Avenue underpass.



The Phase I plan for East Boston and Charlestown was completed in 2017

Rendering of the East Boston Resilient Waterfront Project at Lewis Mall

Site plan for the redesign of Ryan Playground in Charlestown

CHAPTER ENDNOTES

1. East Boston Today: An Interim Report of PLAN: East Boston. City of Boston. http://www.bostonplans.org/planning/planning-initiatives/plan-east-boston

2. Population total for 02128 zip code, American Community Survey 2019, 5-Year Estimates.

3.East Boston Today: An Interim Report of PLAN: East Boston. City of Boston. http://www.bostonplans.org/planning/planning-initiatives/plan-east-boston

4. ACS 2019 (5-Year Estimates).

5. East Boston Today: An Interim Report of PLAN: East Boston. City of Boston. http://www.bostonplans.org/planning/planning-initiatives/plan-east-boston

6. https://mass-eoeea.maps.arcgis.com/apps/webappviewer/index.html?id=1d6f63e7762a48e5930de84ed4849212

7. Population total for 02129 zip code, American Community Survey 2019, 5-Year Estimates.

8. Based on population data from 2010 American Community Survey, 5-Year Estimates and 2019 American Community Survey, 5-Year Estimates.

9. 9.45% of the population in the 02129 zip code is under the age of five, and 5% of the Boston (Census Place) population is under the age of five; 2019 American Community Survey, 5-Year Estimates.

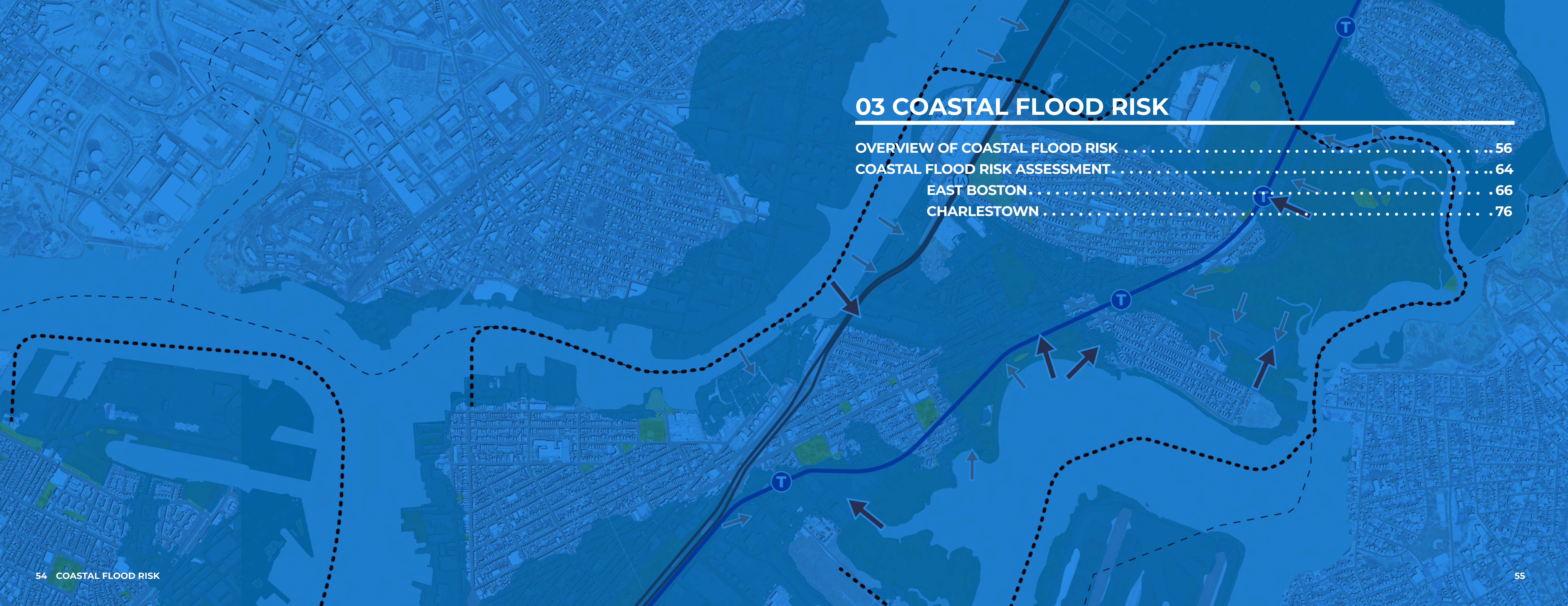
10. 78% of the population in the 02129 zip code over 25, and 68% of the Boston (Census Place) population over 25 have some college or more education; 2019 American Community Survey, 5-Year Estimates.

11. The census block with the highest median income had a median of $142,563, and the census block with the lowest had a median income of $52,917; 2019 American Community Survey, 5-Year Estimates

12. For the 02129 zip code, white household median income was $145,081, and Black household median income was $22,725; 2019 American Community Survey, 5-Year Estimates.

13. Blocks around the Bunker Hill Memorial includes: Block Group 1, Census Tracts 401; Block Group 2, Census Tracts 401, 402, 403. (2019 American Community Survey, 5-Year Estimates).

14. Blocks around Little Mystic, north of Route 1 includes: Block Group 1, Census Tracts 402, 403, 408.1; Block Group 2, Census Tract 408.1. (2019 American Community Survey, 5-Year Estimates).



03 COASTAL FLOOD RISK

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COASTAL FLOOD RISK

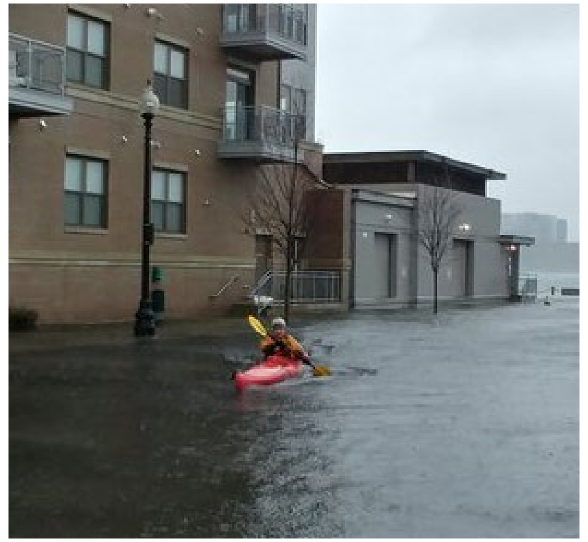
Climate change will increase the risk of coastal flooding along Boston's waterfront. Large areas of East Boston and Charlestown will be exposed to more frequent and widespread coastal flooding, which will affect people, community assets, buildings, infrastructure, and ecological resources.

Coastal flooding occurs when low-lying land is inundated by seawater. This includes flooding that is caused by rising tide levels on a daily and monthly basis, and flooding that is caused by the increasing intensity of storms such as hurricanes and nor'easters, which cause storm surge. While coastal flooding already affects communities in Boston, rising sea levels will result in daily tides that will reach increasingly higher levels. A storm will cause higher water levels and greater flooding than it would today.

Over the coming decades, damaging floods will shift from being a rare occurrence to a monthly reality.

In the near-term with 9 inches of sea-level rise anticipated around the 2030s, a flood event inundating five percent of the city will have a 1% chance of occurring in a given year. Around the 2050s, such a flood will be ten times more likely each year. In the long-term with 40 inches of sea-level rise anticipated by the 2070s, that magnitude of flooding will likely occur at least once per month. It is crucial that the City acts now to ensure that Boston's residents and physical infrastructure are prepared.

Flooding along the Mary Ellen Welsh Greenway in East Boston. Source: Lisa A. DiFrisco



Man kayaks along surface streets near Lewis Mall in East Boston. Source: Steve Holt

Chelsea Creek flood along Border Street in East Boston. Source: NOAH

WHAT ARE THE TYPES OF COASTAL FLOOD RISK?

SEA-LEVEL RISE
Chronic flooding

Sea-level rise is one of the most certain and potentially destructive impacts of climate change. Sea-level rise will impact beaches, harbors, bays, estuaries, and tidal rivers across Massachusetts. As the average tide rises, low areas along the coastline that were once dry will be flooded more often. Initially, flooding at high tide may happen a few times a year. Eventually, it will likely occur monthly or even daily. In some cases, current low-elevation areas along the coastline may be submerged daily. When the sea level rises, this also affects the ability of upstream water to flow from lakes, ponds, rivers, streams, and pipes that drain into coastal water bodies. This can result in increases in inland flooding during rain events as water is unable to drain and can even cause "sunny day flooding" in particularly low-lying areas.

STORM SURGE
Episodic flooding

Coastal storms typically produce strong winds that push ocean water towards the land, creating a storm surge. Storm surge is an increase in the water elevation above the normal everyday tide. The maximum water level reached during a storm event, which is the combination of the storm surge and high tide, is called a storm tide. Different types of storms can generate different types of storm-induced flooding. In the Northeast, the most common storm types are extratropical cyclones (nor'easters) and tropical cyclones (hurricanes). Due to sea-level rise that is projected to happen over the next 50 years, the risk of damaging storm surge will increase in Boston and across Massachusetts over the coming decades.

WAVE ACTION & EROSION
Ongoing and episodic

Coastal erosion is the process by which sea-level rise, wave action, and coastal flooding wear down or carry away rocks, soils, and sand along the coast. This can result in greater flooding, increased sedimentation in rivers and streams, loss of soil nutrients, and soil degradation. Boston Harbor is relatively protected from Atlantic Ocean waves by the Boston Harbor Islands and the towns of Hull and Winthrop. However, during significant storm events, energy from the Atlantic Ocean and locally-generated wind can cause erosion of the coastline. This can impact the stability and safety of coastal structures in the area. Additionally, as the sea level rises, deeper water may allow for the generation of higher and more powerful waves, particularly during storm events.

Graphics and description by SCAPE Landscape Architecture for Coastal Resilience Solutions for Dorchester (2020)

WHERE DOES FLOODING OCCUR?

Depending on the physical features of coastal areas, flooding from high tides and storm surge can occur as either fringe flooding or as flooding through flood pathways. The elevation of the coastline influences how and where coastal flooding can happen in East Boston and Charlestown.

- **Fringe flooding** impacts low-lying areas directly along the waterfront, including parks, industrial uses, and, in some cases, homes and businesses. This creates coastal flooding across the neighborhood as water levels rise above the ground elevation.
- **Flood pathways** impact low-lying waterfront areas and inland areas when water enters through a particularly low-lying location on the waterfront, such as over a bulkhead or roadway, and flows inland along streets and other pathways to create widespread impacts to homes, businesses, and infrastructure.

HOW DO WE ESTIMATE FUTURE COASTAL FLOOD RISK?

SEA-LEVEL RISE PROJECTIONS

The sea-level rise projections used in this plan are the same as those used for all past *Climate Ready Boston* plans. Projections indicate that Boston's sea level is likely to rise by 9 inches around the 2030s and 36 inches around the 2070s if emissions continue at their current pace. An additional 4 inches of land subsidence, which is the gradual sinking of land, will also occur around 2070. **Consequently, the City anticipates approximately 40 inches of relative sea-level rise across the city (or approximately 3 feet) around the 2070s, and storms of greater magnitudes will become more frequent than they have been in the past.** The City of Boston revisits sea-level rise projections frequently and updates plans as needed based on changes to those projections.

STORM SURGE PROJECTIONS

This plan uses the same flood modeling results as all previous *Climate Ready Boston* neighborhood plans. The results are based on the Boston Harbor Flood Risk Model (BH-FRM), developed by Woods Hole Group and the University of Massachusetts Boston. This is a computer model that simulates the physical flow of water for thousands of coastal storm events of varying intensities, types, and durations under changing climate conditions.[1] The model dynamically simulates tides, waves, and storm surges to predict the location and timing of future flood risk, including flood entry points and pathways. The results can help to predict potential flooding impacts, assess the location and timing of flood entry points and pathways, and inform climate resilience planning. In this plan, the model is also used to test the performance of the proposed solutions by re-running the model with the planned coastal resilience strategies in place.

An updated version of the BH-FRM, the Massachusetts Coast Flood Risk Model (MC-FRM), is being developed for the entire Commonwealth of Massachusetts. The MC-FRM will provide the best available data on coastal flood risk for Boston Harbor using the most recent climate projections. While BH-FRM results were utilized, results from the MC-FRM were also evaluated in this study to guide planning and ensure flexible and adaptable design approaches. This means that as sea-level rise projections continue to be updated in the future, planned coastal resilience strategies for Boston's coastlines can easily be adjusted to address higher future risks.

WHEN AND HOW OFTEN WILL COASTAL FLOODING HAPPEN?

Coastal flooding impacts depend on the size and severity of the storm that causes the flooding, as well as the timing of when that storm arrives along the coast. **Storms with high probabilities are likely to happen more frequently but result in less flooding, whereas low probability storms are likely to happen less often but can result in severe flooding.**

For example, smaller storms, such as nor'easters, have a higher probability of occurring in any given year. By contrast, large, catastrophic floods have a very low probability of occurring each year. Coastal flooding from storms and high tides will also increase over time due to sea-level rise.

Data from past storm events and projections of future climate conditions can be used to estimate the likelihood that a flood of a certain magnitude will occur. The table to the right shows how the frequency of a storm is related to the severity of flooding. It also shows how the chance that a flood might happen in any given year in a specific location relates to the cumulative risk of flooding in that location over time. Storms that have a low chance of happening in any given year today will have a higher likelihood of happening when considered over longer time periods. This is because the annual chance of a flood adds up over time, resulting in a higher overall likelihood of a flood happening. Projected sea-level rise will also increase this cumulative risk. Over nearly a lifetime (~70 years), the risk of even low probability flood events can be quite high, so it is important to prepare even if the risk seems low today.

This plan evaluates flooding impacts from a variety of storm scenarios and the flooding that would be associated with each over time. Based on this evaluation, this plan provides coastal resilience solutions that offer protection against a flood with a 0.1% annual chance of happening with 40 inches of sea-level rise.

ANNUAL CHANCE OF FLOOD	CHANCE OF EXPERIENCING A FLOOD IN A 70 YEAR PERIOD	SEVERITY OF STORM EVENT
5% Annual Chance	97.2%	A severe winter storm / Nor'easter
2% Annual Chance	75.7%	Memorable winter storm / Nor'easter
1% Annual Chance	50.5%	Major Nor'easter / Hurricane Example: January Bomb Cyclone, 2018
0.2% Annual Chance	13.1%	Very significant Nor'easter or Hurricane Example: Hurricane Sandy, 2012
0.1% Annual Chance	6.8%	Extreme superstorm Example: Hurricane Katrina, 2005, or more severe

WHAT IS THE DESIGN FLOOD ELEVATION?

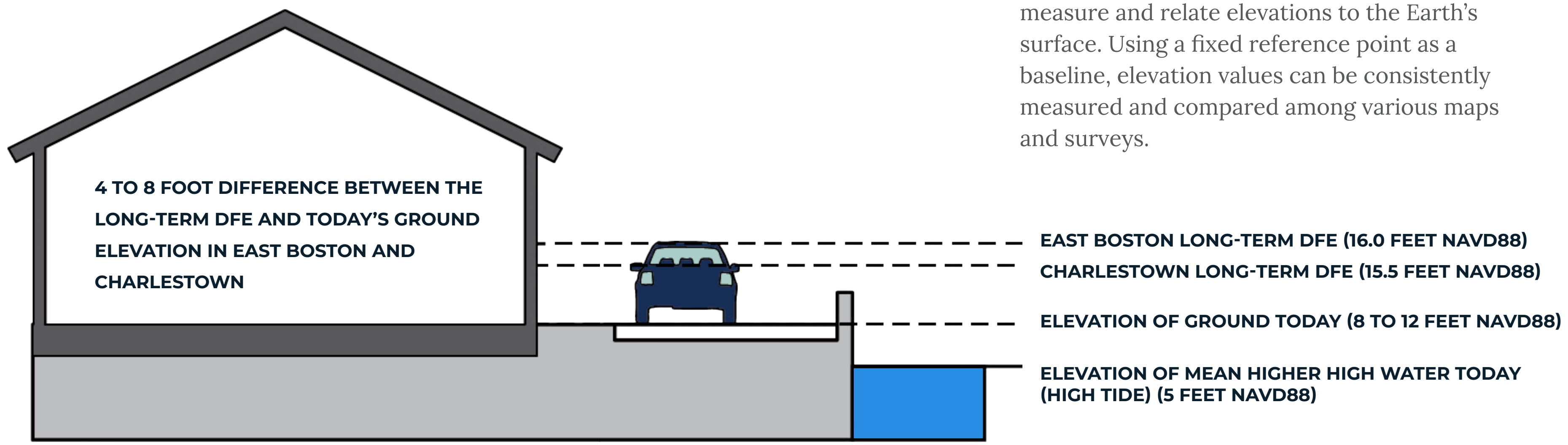
The design flood elevation (DFE) is defined as the recommended elevation required to protect an area from a specific level of coastal flooding including water levels and waves. The DFEs for East Boston and Charlestown were identified using data from the BH-FRM and are based on the 0.1% annual chance flood rather than the 1% annual chance flood used in earlier *Climate Ready Boston* projects.

In prior Climate Ready Boston projects, the 0.1% annual chance was included in planning as a higher "modular" flood elevation that could be attained, if sea-level rise projections increased. Recent studies by the Commonwealth of Massachusetts project a faster rate of sea-level rise in Boston. Under the State's sea-level rise draft projections, 40 inches of sea-level rise is expected to occur sooner than 2070.

As a result of the State's projections for an increased pace of sea level rise, the "modular" elevation used in prior studies was the basis of the DFEs for this study. Even with this change in projections, the DFEs used for this study are consistent with the 1% annual chance flood expected in the 2070s using the State's most recent projections (MC-FRM).

DFEs range across the City of Boston due to locally-specific factors, such as distance from the ocean, exposure to waves, currents, existing coastline infrastructure, and the presence of natural resources like wetlands. Some neighborhoods of Boston require coastal resilience solutions that are designed to a higher DFE than others since some areas experience greater coastal flood risk.

The DFEs are measured relative to a fixed datum called North American Vertical Datum of 1988 (NAVD88). A vertical datum is a reference system used by surveyors, engineers, and mapping professionals to measure and relate elevations to the Earth's surface. Using a fixed reference point as a baseline, elevation values can be consistently measured and compared among various maps and surveys.



** North American Vertical Datum of 1988 (NAVD88): a base measurement created by the National Geodetic Survey and used to calculate or compare elevations. NAVD88 can be converted to Boston City Base (BCB) by using a conversion factor of NAVD88 + 6.46 feet.*

The DFE is 16.0 feet (NAVD88) for East Boston and 15.5 feet (NAVD88) for Charlestown. The DFE for the study areas in each neighborhood evaluated in this plan includes wave action information and an additional foot of freeboard to account for climate uncertainties and to be consistent with previous *Climate Ready Boston* projects. In some cases, this plan provides near-term DFEs in targeted areas where near-term coastal resilience strategies are necessary. Projects built to near-term DFEs can be adapted to higher DFEs over time to address longer-term risks.

It is important to understand that the elevation of the DFE is not above the ground surface. In most areas along the East Boston and Charlestown waterfront, the lowest-lying locations are currently at approximately 8 to 12 feet (NAVD88). Therefore, coastal resilience solutions need to be designed at 4 to 8 feet above the current ground elevation to reach the DFE of 16 feet (NAVD88) in East Boston and 15.5 feet (NAVD88) in Charlestown.

WHAT IS GROUNDWATER FLOODING?

The Boston Groundwater Trust was established in 1986. Through this and other efforts, including the Groundwater Conservation Overlay District and partnerships with the State, the City has helped maintain and conserve groundwater levels, with particular focus on neighborhoods built atop created or filled lands where buildings depend on consistent groundwater levels to maintain the stability of their building foundations, i.e. wood pile-supported structures. While groundwater conservation will continue to be a priority, there are additional efforts required to anticipate and prepare for the effects of groundwater table changes on Boston's residents and infrastructure as a result of climate change.

In addition to contributing to an increased risk of overland flooding from high tides and storm surge, sea-level rise may also increase the level of the water table below the ground, especially along the coast. Rising groundwater has distinct characteristics that set it apart from other types of flooding. While storm surges are fast and temporary, groundwater flooding tends to be slow and chronic. When sea-level rise lifts the coastal water table, impacts can include higher corrosion rates of buried infrastructure, increased basement flooding, reduced stormwater and wastewater sewer capacity, soil contaminant movement, soil instability, and eventually, the creation of wetlands as groundwater emerges to the surface.

Not only does groundwater flooding have impacts distinct from coastal flooding, it also has unique solutions. While floodwalls and berms are effective against temporary storm surge, they do not substantially impact the long-term movement of groundwater. Instead, the types of solutions employed for a rising water table tend to fall into the categories of groundwater drainage and pumping, raising structures, or gradual relocation away from chronic flooding. The viability of each option is highly dependent upon local conditions. While a detailed study of groundwater impacts is not a part of this study, some low-lying areas of both East Boston and Charlestown may experience the effects of increased levels of groundwater in the future due to sea-level rise.

WHAT IS STORMWATER FLOODING AND MANAGEMENT?

Stormwater flooding occurs when the stormwater runoff from rainfall overwhelms the capacity of the drainage and sewer network, resulting in the inundation of land and property. Most drainage systems in cities like Boston are "gravity-based" with water flowing from higher elevations to lower elevations. Underground sewers direct these flows towards the coastline (or Charles River). However, the current gravity-based stormwater system will be challenged as sea-level rises and storms become more intense. Sea-level rise and storm surge will contribute to the stormwater collection and discharge system being unable to drain naturally by gravity during some storm events. In some locations, stormwater discharge from pipes and drains may not be possible at all during extreme storm events. This could lead to stormwater backups and street-level or basement flooding throughout the city in low-lying areas.

Stormwater outfalls that are not protected by tide gates could also become flood pathways in low-lying areas. Tide gates can be installed at outfalls to prevent water from the ocean from entering the stormwater system and causing flooding inland. During a 1% chance storm with 40 inches of sea-level rise, 18 stormwater outfalls will be submerged in the East Boston study area, including one that is already located underwater. Five of these outfalls already have tide gates installed. 23 stormwater outfalls will be submerged in the Charlestown study area with 13 already protected by tide gates. BWSC is in the process of assessing the vulnerability of all outfalls and installing new tide gates where necessary. In addition, property owners should evaluate the potential to install backflow preventers to stop stormwater and/or sewage from surcharging into homes and businesses through drainage pipes.

Green infrastructure can help manage stormwater and is an important component of the overall drainage strategy. Green infrastructure includes solutions such as permeable pavement, bioswales, and tree plantings, which can provide multiple benefits beyond stormwater management, including heat reduction, air and water quality improvement, and public realm enhancements. However, even an extensive green infrastructure system would likely not be capable of managing all of the volume of stormwater flooding that Boston will experience in the future. Furthermore, green infrastructure has certain long-term maintenance requirements for proper performance. In most cases, a combination of both traditional or "gray" infrastructure and green infrastructure will be necessary to help Boston manage stormwater runoff.

The siting and design of coastal resilience infrastructure, such as berms, floodwalls, and raised roadways, must account for the presence of underground utilities. Additionally, to minimize residual risk accruing from the stormwater flooding on the landside of the barrier, coastal resilience infrastructure designs must account for drainage needs associated with the barrier. During a coastal storm surge, stormwater from rainfall will not discharge and will become backed up. Once the capacity of the underground drainage network is exceeded, stormwater will pool above the surface until the storm surge recedes and stormwater can discharge by gravity. This can lead to flooding of property, structures, and infrastructure.

While this report focuses on coastal resilience solutions, key considerations and opportunities for future detailed study of stormwater drainage needs are summarized for each focus area in *Appendix B, Potential Drainage Solutions for East Boston and Charlestown.*

For this study, the project team worked with the Boston Water and Sewer Commission (BWSC) to simulate stormwater flooding that could occur even if coastal resilience strategies are implemented. The simulations utilized a dynamic 100-year tropical rain event that BWSC previously developed resulting in 9.58 inches of rain over a 48-hour period. The simulations also included coastal boundary conditions representative of a 100-year tropical storm with storm surge and 4.3 feet of sea-level rise.

The results help generally estimate the magnitude of stormwater flooding that could result from a major rainfall event in the future. This showed an estimated 130 million gallons of residual flooding in East Boston and 30 million gallons in Charlestown, leading to stormwater flooding in streets and properties in low-lying areas of both neighborhoods. Stormwater flooding in the future will be exacerbated not only by increasingly intense rainfall but also by higher sea levels that interfere with gravity-based coastal stormwater discharge. As such, it is critical to the success of Boston's resilience efforts that strategies to reduce this type of stormwater flooding are developed alongside coastal defense measures that protect against sea-level rise and storm surge.

INSURING YOUR PROPERTY AGAINST FLOOD DAMAGE

It is important for East Boston and Charlestown residents to protect their investments by insuring their home or business and belongings. Most standard home and business insurance policies do not cover flood damage. Property owners in both neighborhoods are encouraged to learn more about flood insurance and explore options for insuring their buildings and possessions against flood risks.

Flood insurance is required for all properties in the Special Flood Hazard Area, or high-risk flood zone, that have a federally-backed mortgage. The Special Flood Hazard Area (SFHA) is shown on the City of Boston's adopted Flood Insurance Rate Maps (FIRMs) created by FEMA. These maps represent present-day flood risk based on historical floods for the purposes of insurance rating. The FIRMs do not include projected sea-level rise, like the flood maps used for this study do, and care should be taken when trying to compare these different types of flood maps. All property owners in areas at risk of flooding in the future should consider purchasing flood insurance, either through the National Flood Insurance Program (NFIP) or a private insurer. Though there are coverage limits under the NFIP, additional coverage may be available through private insurance. The Small Business Administration encourages business owners to consider purchasing a flood insurance policy that will reimburse for business disruptions in addition to physical loss.

According to FEMA, over 25% of flood insurance claims come from properties outside of the high-risk area.[3] So, even if your property has not experienced a flood in the past, or is not located right along the coastline, it may still be at risk of flooding.

Flood insurance policies do not automatically renew and must be renewed every year. We recommend setting an annual reminder to renew flood insurance policies.

For more information on the NFIP, visit: www.boston.gov/departments/environment/understanding-flood-insurance

COASTAL FLOOD RISK ASSESSMENT

Coastal flooding has the potential to cause physical damage, emotional stress from anxiety, trauma, lost productivity, temporary or permanent displacement, and financial losses due to business interruption. It also can disrupt the critical infrastructure systems that people in East Boston and Charlestown need, as well as have long-term impacts on natural resources.

Risk is defined as the potential for a hazard, such as coastal flooding, to have negative impacts on the places that people depend on and care about. The overarching goal of the coastal flood risk assessment is to quantify and understand the risk to people, buildings, infrastructure, community assets and services, and natural resources under a scenario in which no actions are taken to reduce coastal flood risk. By assessing a no-action scenario, we can determine where the risk is the greatest. This allows us to prioritize areas that have the greatest need for coastal flood protection and measure the benefits of planned coastal resilience measures.

Understanding and communicating the frequency and intensity of coastal floods and the risk they pose will help the City and the East Boston and Charlestown communities take intentional and proactive steps toward climate resilience.

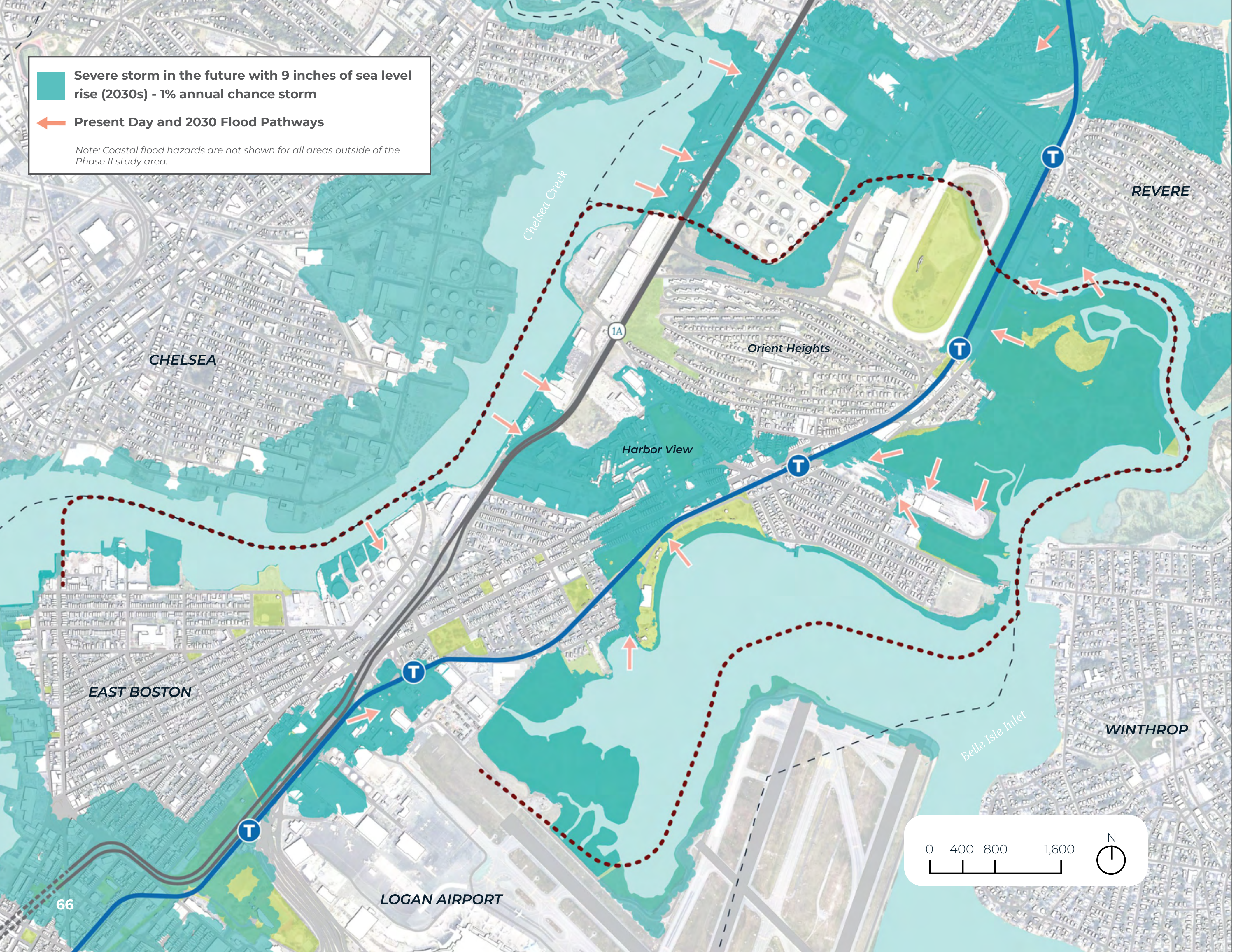
Navy Yard Harborwalk, Charlestown

OCEAN WATER DISPLACEMENT

People sometimes wonder if preventing coastal flooding in one location will increase the chances of coastal flooding in other locations by displacing ocean water onto unprotected coastlines.

While the displacement of water along inland rivers and streams is a concern when these water bodies flood, it is not a significant concern in coastal areas. This is because the physical processes of flooding are different between river and coastal environments, and encroachments (such as the elevation of land within or into the floodplain) affect the processes in different ways.

For the coastal environment, displacement volumes are extremely small compared to the total surge volume and areas removed from the floodplain are very small compared to the overall coastal area. As such, in most instances coastal flood impacts on adjacent properties are very limited. Nevertheless, as coastline resilience infrastructure is designed, it is incumbent on the engineers and other specialists to show that adjacent properties will not be negatively impacted and that can be accomplished through the use of hydraulic and hydrodynamic modeling.



COASTAL FLOOD RISK IN EAST BOSTON

The study area in East Boston is projected to experience significant impacts from coastal flooding over time. These impacts will increase with sea-level rise and threaten places and services that are vital to community safety and wellbeing, including homes and businesses, evacuation routes, community centers, public parks, and natural areas.

PRESENT DAY

Some areas along the East Boston coastline are already affected by coastal flooding, including Belle Isle Marsh, low-lying areas adjacent to Constitution Beach, and fringe flooding on waterfront sites along Chelsea Creek.

The most significant flood pathway in East Boston today originates from Lewis Mall along the waterfront near the MBTA Blue Line Maverick Station and flows inland via the East Boston Greenway. This flood pathway was included in the Phase I study area. See page 50 for an update on the implementation of coastal resilience solutions that were identified through the Phase I study.

9 INCHES OF SEA-LEVEL RISE (2030s)

With 9 inches of sea-level rise, flooding will increase along Chelsea Creek, Belle Isle Marsh, and Coleridge Street near Constitution Beach. During a severe coastal storm (with a 1% annual chance of occurring), new flood pathways from Chelsea Creek, Constitution Beach, and the Belle Isle Marsh will begin to merge across the neighborhood.

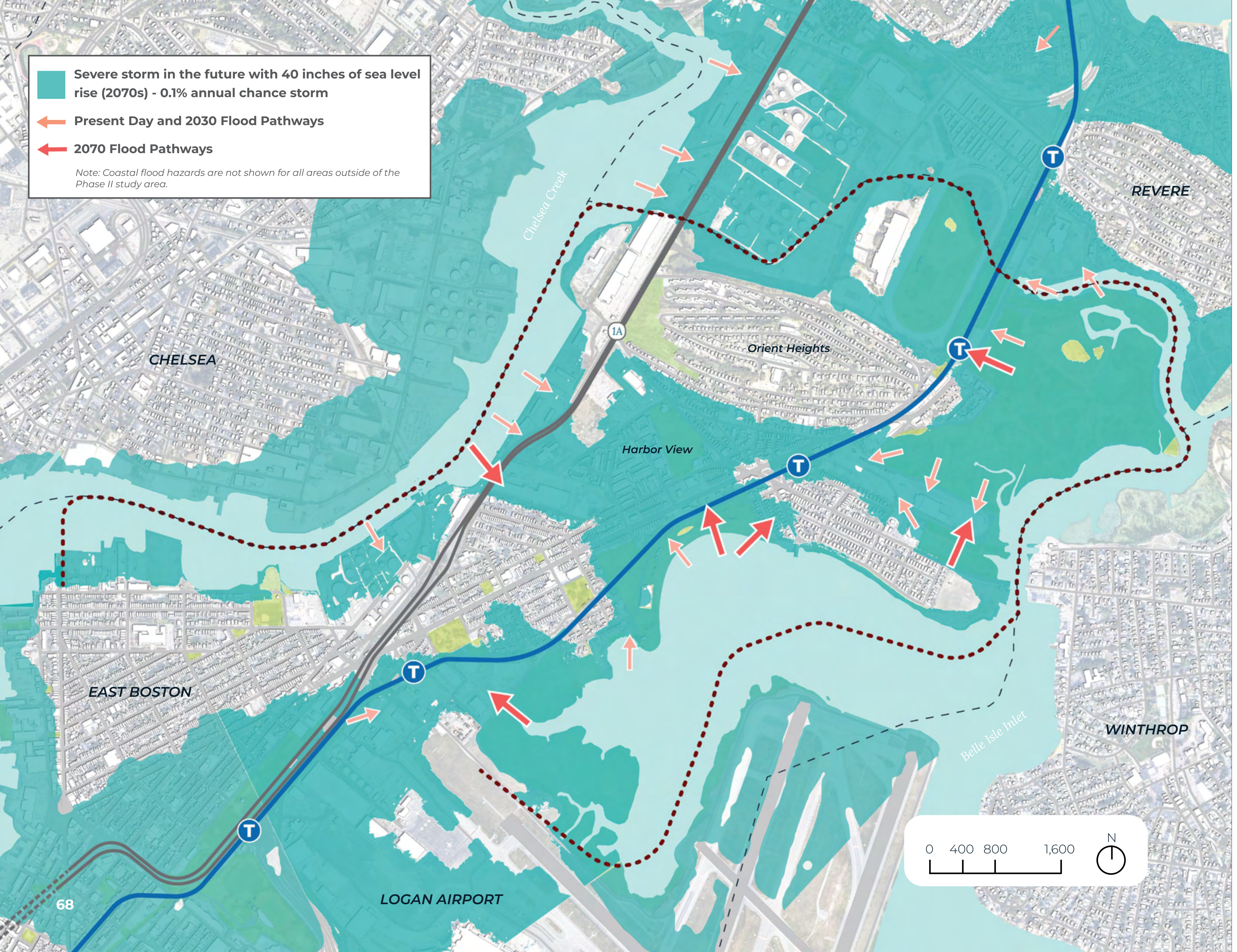
Coastal flooding also becomes more frequent and severe in and around Belle Isle Marsh, with portions of Bennington Street projected to have up to a 50% annual chance of being submerged during a storm. Overall, this will lead to widespread flooding in the low-lying area of homes, businesses, roadways, rail lines, and parks in the lower Orient Heights and Harbor View sub-neighborhoods.

The connection of flood pathways from separate water bodies means that coastal resilience solutions will need to be planned and implemented at all potential flood entry points to effectively address the long-term coastal flood risk for the entire neighborhood.

CHELSEA CREEK AND ROUTE 1A

CONSTITUTION BEACH AND COLERIDGE STREET

BELLE ISLE MARSH AND ORIENT HEIGHTS RAIL YARD



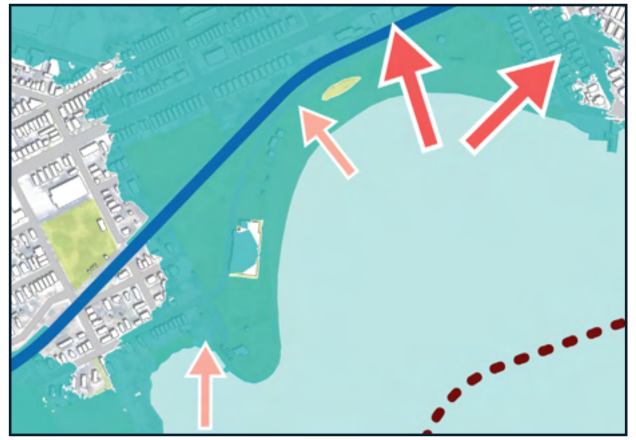
40 INCHES OF SEA-LEVEL RISE (2070s OR SOONER)

With 40 inches of sea-level rise, fringe flooding will continue to expand along Chelsea Creek, Belle Isle Marsh, and Constitution Beach, further affecting waterfront properties, critical infrastructure, and natural resources. Flooding also becomes more likely and more severe in the interior of the neighborhood as flood pathways from Chelsea Creek, Constitution Beach, and Orient Heights converge, leading to widespread risk to the low-lying area of homes, businesses, roadways, rail lines, and parks in lower Orients Heights and Harbor View. Around 2070, these areas have up to a 50% annual chance of experiencing a coastal flood.

REGIONAL FLOOD RISK

Flood pathways that originate in Revere and Winthrop will connect with flood pathways that originate in East Boston. Creating coastal resilience solutions that effectively address coastal flooding requires collaboration between these neighboring municipalities. This is especially true for the area surrounding Belle Isle Marsh and the Suffolk Downs site, where coastal flooding from areas to the north in Revere connects and creates a widespread risk to homes, businesses, industrial properties, and regional transportation infrastructure. The coastal resilience solutions developed through this plan are a first step toward building a regional coastal flood resilience strategy, and the City will continue to work with partners to plan for regional solutions.

CHELSEA CREEK AND ROUTE 1A


CONSTITUTION BEACH AND COLERIDGE STREET


BELLE ISLE MARSH AND ORIENT HEIGHTS RAIL YARD

WHAT DOES COASTAL FLOODING MEAN FOR EAST BOSTON?

RISK TO HOMES AND BUSINESSES

In the near-term within the study area, with 9 inches of sea-level rise, up to 160 structures are at risk of flooding from a 1% annual chance flood, with the potential to impact the homes of approximately 1,200 East Boston residents.[2] This flooding could result in approximately $5.5 million in annual losses through the 2030s.

With 40 inches of relative sea-level rise, up to 430 structures are at risk of flooding from a 1% annual chance flood, with the potential to impact the homes of approximately 3,500 East Boston residents. This flooding could result in approximately $790 million in annual losses through the 2070s. The total cumulative risk with 40 inches of sea-level rise could result in over $2.9 billion in estimated losses.

RISK TO TRANSPORTATION INFRASTRUCTURE

Transportation infrastructure includes roads, sidewalks, bike lanes, greenways, bus routes, and trains. This infrastructure is especially important for the East Boston community's ability to evacuate in advance of or during a storm.

Many public rights-of-way, such as roadways and sidewalks, are low-lying and vulnerable to flooding. Some roadways serve as flood pathways for water as it flows from the coast to inland areas of the neighborhood. Today, Bennington Street is at the highest risk with portions adjacent to Belle Isle Marsh having a 5% annual chance of flooding. In the near term, with 9 inches of sea-level rise, Route 1A will have the same 5% annual chance of flooding. Both evacuation routes could experience monthly disruptions in service due to sunny day tidal flooding in the 2050s or before. In the long term with 40 inches of sea-level rise, nearly nine miles of roadway in the study area could lose service during a 1% annual chance storm, including both Bennington Street and Route 1A. Important roadways must be protected from flooding so that people who cannot shelter in place during a storm can safely leave the neighborhood and access emergency services elsewhere.

Three MBTA Blue Line stations in or adjacent to the East Boston study area, as well as the Orient Heights Rail Yard and large segments of the rail network, are or will be exposed to flooding. Today, portions of the rail network in the study area are exposed to flooding

	NUMBER OF RESIDENTS EXPOSED*	NUMBER OF BUILDINGS EXPOSED	EXPECTED ANNUAL LOSSES
1 percent annual chance flood with 9 inches of sea-level rise (2030s)	1,200	160	$5.5 million
1 percent annual chance flood with 40 inches sea-level rise (2070s)	3,500	430	$790 million
Total Cumulative Risk with 40 inches of sea-level rise (0% discount rate)			$2.9 billion

** Risk to residents based on 2019 population estimates and not projected future population*

from a 1% annual chance flood. With 9 inches of sea-level rise, the risk to the MBTA Blue Line and the Orient Heights Rail Yard, where Blue Line trains are stored for maintenance, will be exposed to flooding from a 5% annual chance flood. Flooding of these facilities would have significant regional effects on the MBTA Blue Line's ability to operate unless steps are taken to reduce this risk.

Flooding of the Rail Yard and Blue Line tracks could lead to lengthy disruptions in service system-wide, leaving the approximately 68,000 daily riders on the Blue Line with reduced access to their jobs and other places they need to go.[3]

Furthermore, during the COVID-19 pandemic, the MBTA Blue Line retained the highest percentage of the ridership of all the MBTA rapid transit lines, which illustrates the East Boston community's dependency on the MBTA Blue Line to reach other parts of Boston.[4]

RISK TO COMMUNITY ASSETS

Some of the buildings in East Boston that are vulnerable to flooding host services that residents rely on for affordable housing, health care, education, childcare, worship, and community and public safety. These places are considered community assets because they not only improve everyday life for residents but also can aid in recovery after a storm or other disaster. During and after a flood, these places can provide shelter, food, power, and other resources that are important to the neighborhood's ability to recover quickly.

Available data suggest that, in the long term, a number of important community assets could be affected by flooding. This includes a public school (the Curtis Guild Elementary School), three childcare locations, three houses of worship, and two community centers. With 9 inches of sea-level rise, coastal flooding threatens places such as the Marty Pino Center and East Boston YMCA (54 Ashley Street location), potentially impacting the many valuable services provided including after-school care, adult education, recreation, and fitness programs for residents. With 40 inches of sea-level rise, more than half of the existing income-restricted housing units in East Boston could be exposed to a 1% annual chance flood.

RISK TO PARKS AND NATURAL RESOURCES

Parks, open spaces, and ecological areas like wetlands are important places where family and friends gather for recreation, learning, and socializing, and where plants and animals live. These places can provide a haven from the city and also provide resilience benefits by reducing heat, storing rainfall, and serving as buffers against coastal flooding. The study area has a number of important waterfront public open spaces that are exposed to coastal flooding today and in the future.

In the long-term, with 40 inches of sea-level rise, up to 274 acres of open space could be affected by a 1% annual chance flood. This includes large waterfront parks like Constitution Beach and Belle Isle Marsh Reservation and smaller neighborhood parks like the Condor Street Urban Wild and Noyes Playground. Damage and disruption to these parks and open spaces threaten community health and wellbeing on a day-to-day basis and also reduce the benefits that these open spaces provide in mitigating heat and reducing flooding.

WHAT DOES COASTAL FLOODING MEAN FOR THE BELLE ISLE MARSH?

The Belle Isle Marsh is composed of 275 acres of salt marsh, salt meadow, tidal flats, and other habitats, and is the largest remaining salt marsh in Boston.

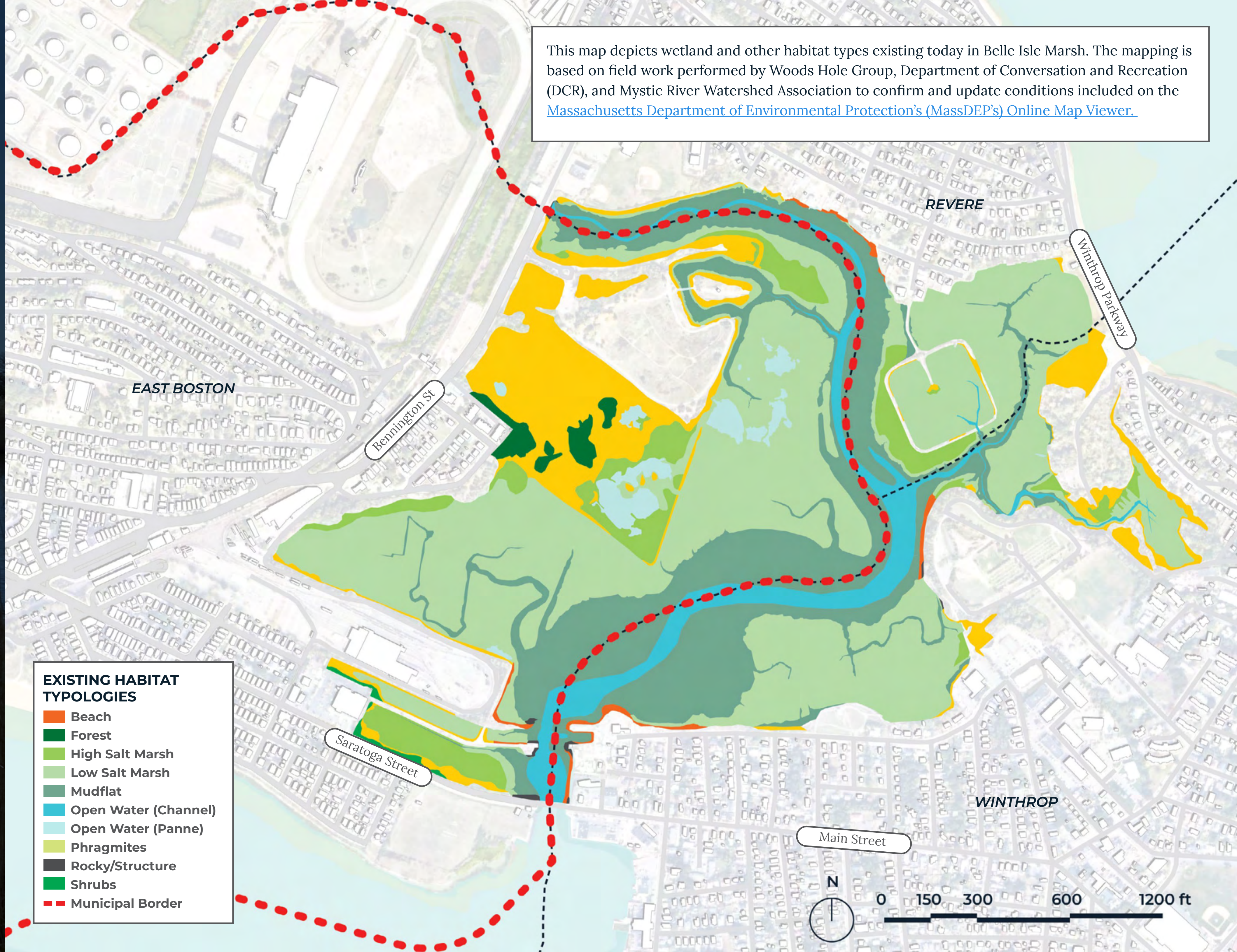
Portions of the marsh also extend into the neighboring municipalities of Winthrop and Revere. Owned and managed by the Massachusetts Department of Conservation and Recreation (DCR), the marsh is an important natural resource and recreation space for East Boston and surrounding communities. It is part of the State-designated Rumney Marshes Area of Critical Environmental Concerns (ACEC), which means there are specific regulations and management requirements that apply to any actions that could affect the marsh.

Additionally, priority and estimated habitats have been delineated by the Natural Heritage and Endangered Species Program (NHESP) of the Massachusetts Division of Fisheries and Wildlife. Belle Isle Marsh falls within this designation. Of particular concern is the Saltmarsh Sparrow, which is currently facing population decline and is listed by the State as a special concern under the Massachusetts Endangered Species Act (MESA). The U.S. Fish and Wildlife Service will assess whether the Saltmarsh Sparrow should be federally listed under the Endangered Species Act (ESA) in 2023. Consequently, Belle Isle Marsh is identified as a prioritization habitat in the State and Federal action plan for protecting the Saltmarsh Sparrow, which has regulatory implications for areas that provide habitat for the species. Furthermore, there are 16 other state-listed endangered species that use Belle Isle Marsh for breeding habitat.

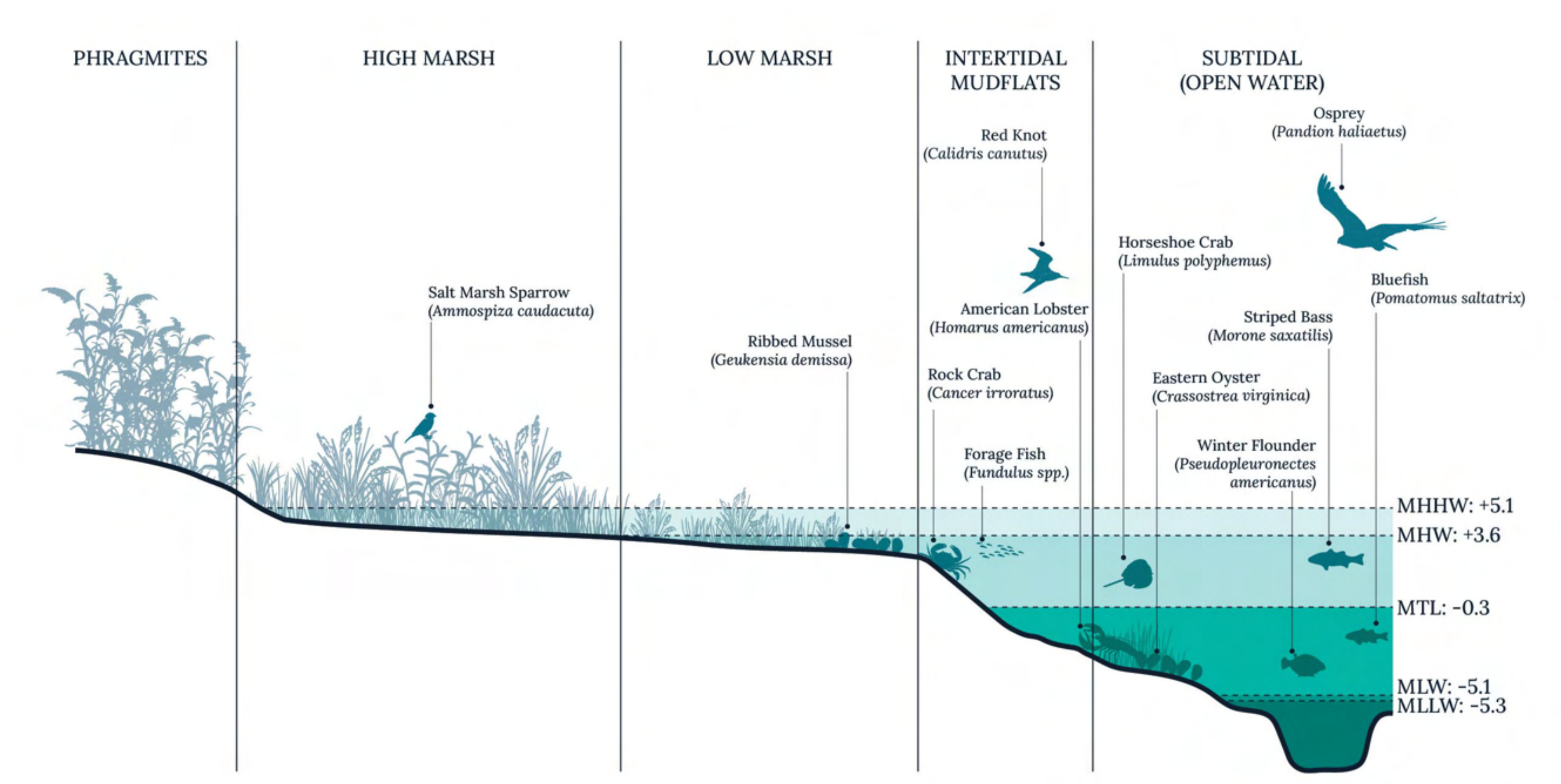
The marsh was once part of a much larger system of coastal wetlands that were filled over time due to urban development and the expansion of Logan International Airport in Boston. Human activity has changed Belle Isle Marsh from its natural state over time. These changes include multiple instances of filling and ditching that have altered the natural flow of tidal waters, as well as the placement of urban infrastructure, such as pipes, roads, buildings, tide gates, and piers. While efforts to evaluate and restore the marsh are ongoing, the remnants of past human alternations are visible in many areas today and are important to consider as part of the future restoration of the marsh.

The preservation and restoration of Belle Isle Marsh are of critical importance for multiple reasons. Natural resources like Belle Isle Marsh have many benefits, including:

» Serving as natural buffers that stabilize coastlines and protect coastal areas from flood damage and sea-level rise.
» Improving water quality in urban settings by filtering out water and soil pollutants.
» Supporting the health of commercial and recreational fisheries.
» Providing critical habitat for nesting and foraging for migratory birds.
» Offering access to natural amenities and associated recreational opportunities.
» Having historic and cultural significance to the community.



This map depicts wetland and other habitat types existing today in Belle Isle Marsh. The mapping is based on field work performed by Woods Hole Group, Department of Conversation and Recreation (DCR), and Mystic River Watershed Association to confirm and update conditions included on the Massachusetts Department of Environmental Protection's (MassDEP's) Online Map Viewer.



A range of habitats exist within Belle Isle Marsh as depicted here. These habitat types are dependent on their elevation relative to regular tidal conditions. Numerous species of plants, animals, fish, and other aquatic creatures rely on these habitats for food and shelter. This is an example of why it is important to pay careful attention to the health of different habitat types in the marsh.

MHHW: Mean Higher Water
MHW: Mean High Water
MTL: Mean Tide Level
MLW: Mean Low Water
MLLW: Mean Lower Low Water
**All elevations presented in NAVD88.

The health of Belle Isle Marsh is threatened today and will be under increasing threat in the future. In the near term, a range of issues can harm the ecological function in the marsh, including the presence of invasive species, such as phragmites; erosion impacts to critical high and low marsh habitats; reduction in water quality caused by stormwater runoff; increasing temperature; and the constraints resulting from urban infrastructure surrounding the marsh. Addressing these near-term concerns is important to preserve the marsh in the future.

In the long-term, through the 2070s and beyond, ensuring the marsh's health will also mean addressing the threats posed by climate change. Coastal wetlands like the Belle Isle Marsh are among the most susceptible ecosystems to sea-level rise and marsh drowning. The Belle Isle Marsh's natural resilience and ability to adapt to sea-level rise will be shaped by the pace of sea-level rise, surrounding urban land uses, sediment flow into the marsh, and plant productivity.

While the ways in which marsh ecosystems will respond to sea-level rise is an area of ongoing scientific research, analysis using the Massachusetts Sea Level Affecting Marshes Model (SLAMM), developed by the Massachusetts Office of Coastal Zone Management (CZM), suggests how sea-level rise might affect Belle Isle Marsh over time. Based on preliminary assessments, as sea levels rise, existing intertidal mudflats will be submerged as the main channel widens until it abuts the existing low marsh platform. This is expected to create additional open water habitats in existing marsh ecosystems.

At the same time, the zone of salt marsh habitat, which includes low marsh and high marsh, is expected to be reduced by more frequent submergence. The result is the conversion of high marsh to low marsh and a reduction in the overall presence of high marsh habitat. High marsh serves as habitat for numerous species, including the Salt Marsh Sparrow, and acts as the transitional zone between low marsh areas and the upland.

The steepness of the slope between the marsh and surrounding upland areas of Boston, such as along Bennington Street and the Orient Heights Rail Yard, and presence of roadways, public transportation infrastructure, and housing, prevents high marsh zones from migrating inland with sea-level rise.

With 40 inches of sea-level rise, there could be a 57% loss of high marsh (by acreage) in Belle Isle Marsh.

Given the threat imposed by climate change and sea-level rise, interventions to restore the Belle Isle Marsh will be necessary to preserve the health of the marsh and the benefits it provides to the region. The goals of such restoration are many, but focus on the valuable ecological functions offered by the Belle Isle Marsh, such as its rare habitat and species diversity, water quality enhancement capability, storm surge and wave attenuation benefits to surrounding communities, and carbon sequestration, as well as the socio-economic services created through recreation, education, and more.

Chapter 4, *Coastal Resilience Solutions for East Boston and Charlestown*, describes some of the approaches that DCR, the City, and other partners can use to preserve and adaptively manage the long-term health of the marsh as the sea level rises.

COASTAL FLOOD RISK IN CHARLESTOWN

The study area in Charlestown is projected to experience significant impacts from coastal flooding over time. These impacts will increase with sea-level rise and threaten places and services that are vital to community safety and wellbeing, including homes and businesses, community centers, historic landmarks, the Harborwalk, and public parks.

PRESENT DAY

Several areas along the Charlestown coastline are already at risk of coastal flooding. In the study area, low-lying areas in the Navy Yard surrounding Constitution Wharf, the Boston National Historical Park, and the 1st Avenue corridor, as well as the Boston Autoport are exposed to flooding from severe storms today. The risks in these areas include flooded roadways, damage to homes and businesses, and disrupted operations for industrial uses at the Autoport. Fringe flooding also affects buildings, roadways, and the Harborwalk along the Navy Yard waterfront and along Little Mystic Channel.

A significant source of flooding in Charlestown today enters the neighborhood near Ryan Playground and the Schrafft's Center, which was included in the Phase I study area. See page 51 for an update on the implementation of coastal resilience solutions that were identified through the Phase I study.

9 INCHES OF SEA-LEVEL RISE (2030s)

With 9 inches of sea-level rise, flooding from a severe storm with a 1% annual chance of occurring will expand risk across the Navy Yard waterfront. Water would enter at low-lying street ends and flow inland, impacting transportation, homes, and businesses. Both the Boston National Historical Park and areas adjacent to Constitution Wharf will also experience more extensive flooding than under present-day conditions. This level of flooding will also further impact the Boston Autoport, particularly on the eastern side of the facility.

LITTLE MYSTIC CHANNEL AND BOSTON AUTOPORT

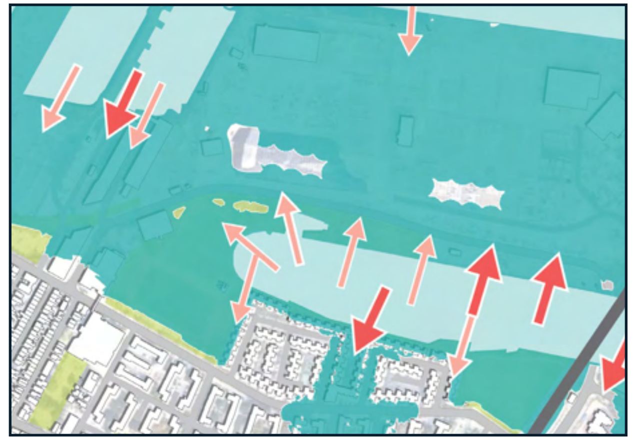
CHARLESTOWN NAVY YARD

CONSTITUTION WHARF AND BOSTON NATIONAL HISTORICAL PARK

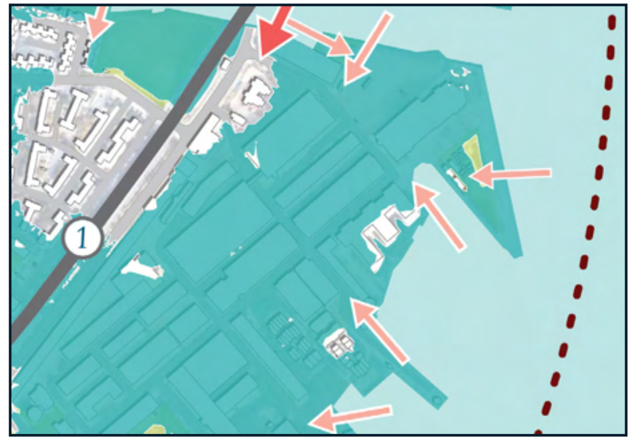
40 INCHES OF SEA-LEVEL RISE (2070s OR SOONER)

With 40 inches of sea-level rise, coastal flooding will occur across the entirety of the Navy Yard waterfront, affecting most homes and businesses east of Chelsea Street. During a severe coastal storm with a 1% annual chance or less of occurring, new flood pathways from the Little Mystic Channel will merge with flood pathways entering from the Navy Yard. This will result in flood pathways connecting through the low-lying area of homes, businesses, community landmarks, and the CharlesNewtown and Bunker Hill affordable housing developments.

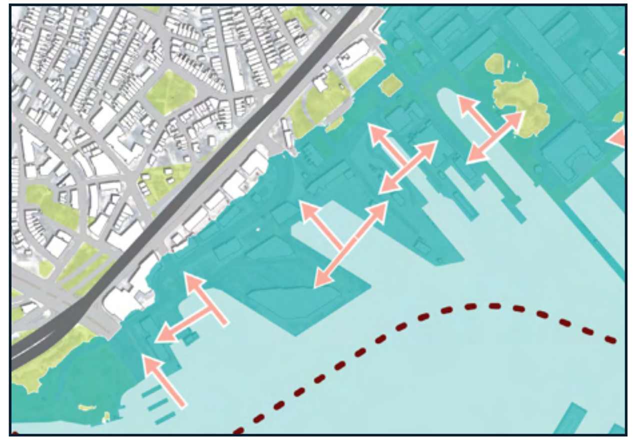
The connection of flood pathways from separate water bodies means that, in the long term, coastal resilience solutions will need to be planned and implemented at all potential flood entry points along the coast to effectively address the flood risk.



LITTLE MYSTIC CHANNEL AND BOSTON AUTOPORT



CHARLESTOWN NAVY YARD



CONSTITUTION WHARF AND BOSTON NATIONAL HISTORICAL PARK

WHAT DOES COASTAL FLOODING MEAN FOR CHARLESTOWN?

RISK TO HOMES AND BUSINESSES

In the near term, with 9 inches of sea-level rise, up to 30 structures are at risk of flooding from a 1% annual chance flood, with the potential to impact the homes of approximately 150 Charlestown residents. This flooding could result in approximately $15 million in annual losses through the 2030s.

With 40 inches of sea-level rise, up to 110 structures are at risk of flooding from a 1% annual chance flood, with the potential to impact the homes of approximately 1,700 Charlestown residents. This flooding could result in approximately $1.3 billion in losses through the 2070s. The total cumulative risk with 40 inches of sea-level rise could result in over $4.4 billion in estimated losses.

RISK TO TRANSPORTATION INFRASTRUCTURE

Transportation infrastructure in Charlestown is at-risk from coastal flooding, today and in the future. While Charlestown is served by the MBTA Orange Line, there are no train stations or rail networks that are at risk from flooding originating within the study area.

Many public rights-of-way in Charlestown are low-lying and vulnerable to flooding. Some roadways even serve as flood pathways for water as it flows from the coast to inland areas of the neighborhood, especially in the Navy Yard. In the long term, with 40 inches of sea-level rise, nearly eight miles of roadway in the study area could lose service during a 1% annual chance storm. This includes almost all streets in the Navy Yard and sections of Terminal Street and Medford Street. Some MBTA buses, such as the 92 and 93, follow roadways that will be exposed to flooding in the future. These impacts could be felt sooner, with portions of 1st Avenue and Terminal Street exposed to flooding from severe storms today.

Flooding could disrupt MBTA ferry service from Charlestown, which connects up to 500 daily riders to Downtown and other areas of Boston. Unless the coastline is raised, potential docking locations for the ferry along the Navy Yard waterfront could experience monthly inundation with 40 inches of sea-level rise.

	NUMBER OF RESIDENTS EXPOSED*	NUMBER OF BUILDINGS EXPOSED	EXPECTED ANNUAL LOSSES
1 percent annual chance flood with 9 inches of sea-level rise (2030s)	150	30	$15 million
1 percent annual chance flood with 40 inches sea-level rise (2070s)	1,700	110	$1.3 billion
Total Cumulative Risk with 40 inches of sea-level rise (0% discount rate)			$4.4 billion

** Risk to residents based on 2019 population estimates and not projected future population*

RISK TO COMMUNITY ASSETS

In the long-term with 40 inches of sea-level rise, a number of important community assets could be affected by flooding. This includes a public school (the Harvard Kent Elementary School), seven childcare centers, two healthcare facilities, and two community centers. NEW Charlestown Community Health would be exposed to a severe flood with a 1% annual chance of occurring with 40 inches of sea-level rise, threatening the range of community-based health services that are provided to the community. The Charlestown Community Center is exposed to flooding during severe storms with 9 inches of sea-level rise, which threatens to disrupt recreational opportunities and community services. Additionally, with 40 inches of sea-level rise, more than 60% of the existing income-restricted housing units in Charlestown could be exposed to a 1% annual chance flood.

RISK TO PARKS AND NATURAL RESOURCES

The Charlestown study area has a number of important waterfront public open spaces that are exposed to coastal flooding, particularly the Harborwalk. The Harborwalk in Charlestown extends along the coastline in the Navy Yard and along Little Mystic Channel and is a valued amenity for the community. While the Harborwalk itself is relatively safe from damage due to flooding, frequent flooding threatens to limit waterfront access for the public.

Portions of the Harborwalk along the Boston National Historical Park are vulnerable to flooding today. With 9 inches of sea-level rise, the Harborwalk along the Navy Yard will have a 10% annual chance of flooding. In the long-term, with 40 inches of sea-level rise, up to 31 acres of open space could be affected by a 1% annual chance flood. This includes all of the Harborwalk in Charlestown and waterfront parks such as Barry Field, Menino Park, Naval Shipyard Park, and Paul Revere Park, as well as the Little Mystic Boat Launch and the ballfields at the Charlestown Community Center.

CHAPTER ENDNOTES

1. Both the BH-FRM and MC-FRM are probabilistic models, which evaluate a statistically robust set of viable storm conditions to produce both spatial and temporal probabilities of flooding. Thousands of storms are dynamically simulated to produce flood exceedance probabilities at high resolution.

2. Based on 2019 population figures, not projected future population

3. Information is based on average weekday Blue Line ridership for 2019. 2019 represents the last full year prior to the impacts of the COVID-19 pandemic on subway ridership. Source: www.mbtabackontrack.com

4. Source: https://massdottracker.com/datablog/?p=343

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COASTAL RESILIENCE SOLUTIONS FOR EAST BOSTON AND CHARLESTOWN

This report provides a roadmap for strategic flood protection interventions at key flood pathways to reduce risks from coastal flooding. These interventions also offer opportunities for community amenities such as public waterfront access, recreation, and ecological restoration to sustain and enhance coastal communities and habitats.

Boston's path to become a Green New Deal city includes efforts to develop different types of flood protection approaches that can help accomplish multiple goals, including landscaped berms, waterfront parks, an elevated Harborwalk, elevated roadways, floodwalls, and site-scale adaptations to buildings and landscapes.

This chapter describes details of the proposed coastal resilience solutions for the East Boston and Charlestown study areas, why they were chosen, how they perform in reducing coastal flood risk, and next steps for implementation.

HOW WERE SOLUTIONS DEVELOPED?

Coastal flooding will affect East Boston and Charlestown in different ways, depending on existing conditions above and below the surface, uses along the coastline, and the elevation of land at key flood pathways. The types of approaches and designs that can effectively reduce coastal flood risk also depend on these factors, as well as others, such as cost, regulations, and potential impacts on the health and wellbeing of the community.

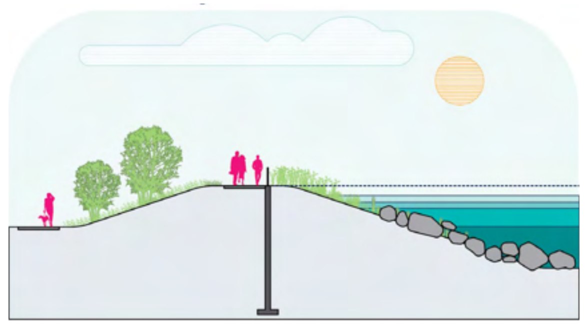
The overall coastal resilience strategy in both neighborhoods includes a series of connected flood protection options informed by a detailed analysis of these conditions and engagement with the community. Together, the strategies form a cohesive district-scale approach to coastal resilience. The process of developing coastal resilience solutions involves bringing together a technical analysis of coastal flood risk with community and stakeholder input to identify solutions that effectively reduce coastal flood risk and create additional benefits for the community. While multiple options are considered during the planning process for each specific location, the Evaluation Criteria described in Chapter 1, *Introduction*, were used to help narrow the range of options to a preferred option or set of options that can be advanced to the next stage of implementation.

As the project team evaluated options, they considered three technical elements that combined to form the coastal flood protection strategy, which include the coastal resilience **alignment**, the **approach**, and the **design**, as described on the next page. The relationship between these three elements aims to provide long-term protection from rising sea levels and create social, environmental, and economic benefits for the communities of East Boston and Charlestown.

COASTAL RESILIENCE ALIGNMENTS

An "alignment" is the placement of the coastal flood protection or where it may be located in space. Considering the location of the flood protection is important because it influences the types of approaches that may be feasible, as well as the degree of flood risk reduction provided. The project team considered multiple alignment options for each flood pathway, including options located along the coastline and further inland, before determining the preferred alignment option or options. Alignments on publicly-owned rights-of-way are often preferable because coastal resilience solutions can be implemented more efficiently on land under singular ownership by a public entity.

COASTAL RESILIENCE APPROACHES



After considering the alignment of the coastal resilience strategy, the project team evaluated the types of resilience approaches that are possible in each location. **The approach is the type of coastal resilience strategy, including berms, floodwalls, raised roadways, and more.** Considerations such as available space, existing infrastructure, community input, and regulations that govern what can be built and where all help to determine the coastal resilience approaches that are best suited at each location. It is important to recognize that not every approach is possible in every location. The next several pages provide a summary of the coastal resilience approach toolkit that was drawn upon for this study.

COASTAL RESILIENCE DESIGNS

The next step in the coastal resilience planning process is to explore potential designs. **Design relates to the look, feel, and experience of the strategy or concept.** This planning study explores conceptual designs for key locations based on community input during this planning process. However, the designs for the coastal resilience approaches are not finalized in this study and will continue to evolve through the ongoing community engagement and detailed engineering and design processes that will take place prior to a given strategy's construction.

COASTAL RESILIENCE TOOLKIT

The coastal resilience approaches developed for the East Boston and Charlestown study areas draw on an existing toolkit of options used for other areas of Boston that have been studied through past planning efforts, including South Boston, Dorchester, Downtown and North End, and other areas along the East Boston and Charlestown coastlines.

These approaches can be applied conceptually to evaluate the feasibility, cost, and community support, and then further developed as designs for implementation. While the approaches described here all reduce coastal flood risk, there are key differences that help determine where they might best apply.

RAISED HARBORWALK / RAISED PARK SPACE


Langone Park & Puopolo Playground, Boston

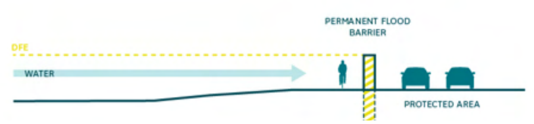
Raised waterfront parks and pathways, like the Harborwalk, block critical flood pathways by increasing the minimum elevation within the park or along the pathway to keep water from flowing inland. They also provide public open spaces for recreation, education, and cultural programming, and can incorporate new infrastructure to mitigate other impacts of climate change, such as extreme heat and rainfall.

RAISED BERMS AND DUNES


Hunters Point South, New York

Berms and dunes are mounds of sand or earthen material extending along the coastline that slope up and down over a short distance. They are built where available space is wide enough for the base of the berm or dune but not wide enough for an entire waterfront park because of existing infrastructure, buildings, or privately-owned properties. In some cases, the top of berms or dunes can be wide enough to provide public access to and along the waterfront, creating places for communities to gather while simultaneously providing flood protection.

VERTICAL FLOODWALLS




Sunbury, Pennsylvania

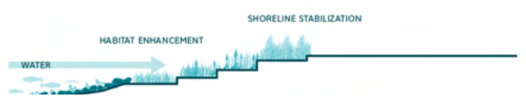
Floodwalls are specially engineered walls made of concrete, steel sheet piles, or other materials designed to protect inland areas from flooding. These approaches are usually used in locations where space is very limited and other options cannot be implemented due to existing buildings and other infrastructure that are close to the coastline. In some cases, where there is sufficient space, floodwalls can be buried or contained in other types of infrastructure, such as in raised berms or roadways. This helps integrate the wall into the landscape and can mean the wall serves multiple functions.

RAISED ROADWAYS / MEDIAN FLOODWALLS


Raised Median

Raising roadways and roadway medians for flood protection means elevating the roadway or median from its existing grade to a new grade above anticipated flood levels. Depending on the specific design and location, this approach can serve multiple benefits such as keeping transportation infrastructure dry during floods, maintaining evacuation routes and access to emergency services, and serving as coastal flood protection for inland communities.

NATURE-BASED SOLUTIONS

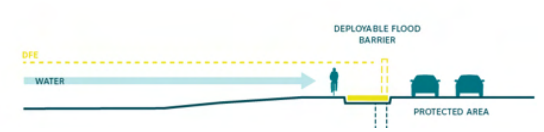



Living Shoreline

Nature-based solutions refer to a range of solutions that use natural systems, or features that mimic them, to reduce flood risk and provide other environmental and social benefits. These can include actions to restore or enhance existing ecosystems, such as wetlands and salt marshes, or installing new features such as waterfront parks and living coastlines. Nature-based solutions are not feasible or appropriate in all locations and often must be paired with other physical approaches like berms and walls in order to provide the desired level of coastal flood protection.

Coastal Resilience Toolkit section graphics created by SCAPE Landscape Architecture for Coastal Resilience Solutions for Dorchester (2020)

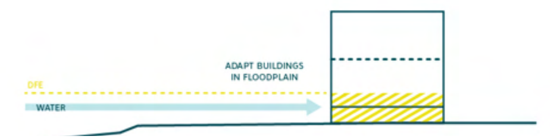
DEPLOYABLE FLOOD GATES / BARRIERS




Deployable Barriers

Deployable barriers are approaches that serve as floodwalls but must be installed in preparation for an upcoming flood, either manually or using automatic controls. These types of approaches are not preferred because they sometimes result in operational challenges and can be complicated to operate, maintain, and store.

ADAPTED BUILDINGS AND STRUCTURES




Elevated homes in Queens, New York

Some areas require independent adaptation measures at the building or site scale, such as utilizing deployable perimeter or entrance flood barriers, filling in basements, and elevating the site or building. Buildings and sites that need to be floodproofed require engineering evaluation for structural soundness and must meet the Commonwealth of Massachusetts' building code requirements. Adapted buildings and structures can also provide an additional layer of resilience in areas protected by coastal resilience infrastructure.

STRATEGIC ACQUISITION OR RETREAT


Edgemere, Queens, NY

Strategic acquisition is the voluntary acquisition of parcels to reduce long-term flood damage and implement targeted flood protection projects at key flood pathway locations. Strategic retreat is a phased process of removing or relocating existing buildings and infrastructure, and preventing future development in vulnerable areas. These strategies can be selectively considered where perimeter protection or adaptation are not feasible, too costly, or detract from other essential aspects of resilience.

COASTAL FLOOD RESILIENCE DESIGN GUIDELINES

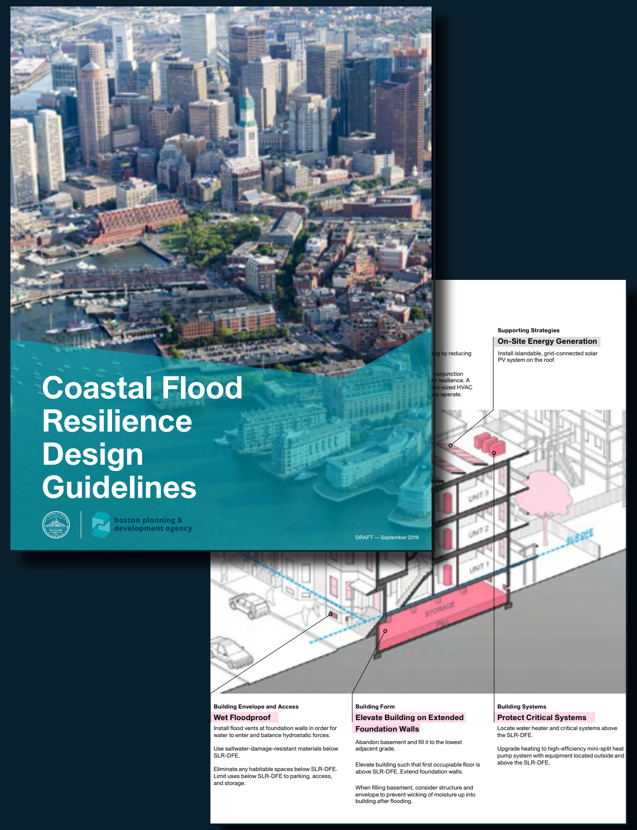
As described in Chapter 2, *Context*, the BPDA has developed and adopted *Coastal Flood Resilience Design Guidelines* for new construction and building retrofits, as well as a new Coastal Flood Resilience Zoning Overlay District (the "Overlay District"). The Guidelines provide best practices for flood-resistant design and are intended to be administered by BPDA staff for the review of projects within the Overlay District, as well as serve as a resource for Bostonians interested in taking action to protect their homes and businesses from flooding.

A building- or site-level flood resilience strategy can be informed by asking the following questions:

- What is the appropriate timeline for implementing different resilience approaches? Do the approaches need to be implemented today or in the future?
- What is the appropriate scale for implementing each approach?
- Can the selected resilience approaches complement or build on each other?
- Do the approaches have budgetary or other constraints? What is the most beneficial approach within budget constraints?
- Do any of the approaches have a limited useful life? For instance, elevating utilities within a building may be effective in preventing flood damage until 2050 but, after that, elevating the building may be necessary given increased risk of flooding.
- Can resilience approaches be integrated into other planned improvements at the building or site, such as renovations, new equipment and systems, or structural additions?

These questions can help guide the selection of protection measures for your home or business but each resident or business will need to determine the most effective approaches based on their unique structure type, needs, level of vulnerability, and circumstances unique to each situation and may require input from a licensed professional.

For more information on steps you can take to make your home or business safer, review the Guidelines by clicking on the report cover to the right.



For more information on a property's flood risk and other planning considerations, visit:

maps.bostonredevelopmentauthority.org/zoningviewer/

DESIGN FOR EQUITY, ADAPTABILITY, AND ECOLOGICAL RESTORATION

In addition to the core criteria of effectiveness in reducing coastal flood risk, there are several additional principles used in this study to help guide the conceptual design process. These include Design for Equity, Design for Adaptability, and Design for Ecological Restoration.

DESIGN FOR EQUITY

In addition to reducing coastal flood risk, the design solutions aim to address issues of equitable access to the waterfront, ecosystem health, and safe transportation into, out of, and around the neighborhoods. Through this study and in subsequent stages of engineering and design, the development of solutions incorporate the community's top priorities expressed in the community engagement process.

Community engagement will continue throughout the process of designing and implementing the proposed solutions in future phases of this work. This will give community members ongoing opportunities to help identify issues, proactively identify and mitigate potential burdens on socially vulnerable communities, and ensure that the benefits of these solutions are felt by all.

DESIGN FOR ADAPTABILITY

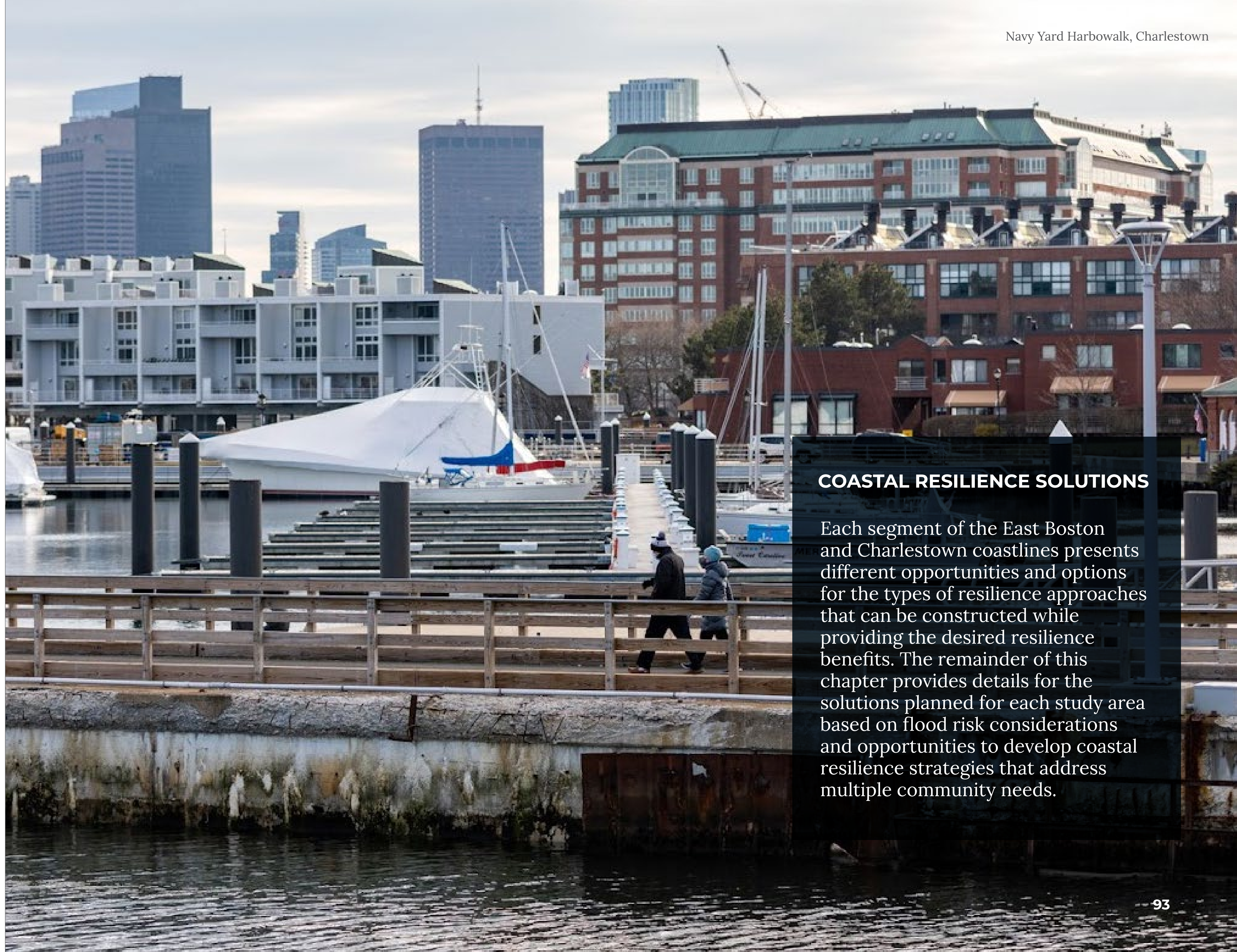
Since sea-level rise and climate change projections may change over time due to the evolving science, coastal resilience solutions need to be flexible and adaptable. Solutions proposed through this study account for coastal risks with a 1% annual chance flood with 40 inches of sea-level rise, but must also address the needs of future unknown conditions including potentially greater levels of sea-level rise that may result if global greenhouse gas emissions are not sufficiently reduced.

Boston's projections for approximately 40 inches of sea-level rise around 2070 is consistent with new sea-level rise projections from the Federal government associated with a high emissions scenario. The coastal resilience approaches proposed in this study intentionally provide for long-term adaptation in response to changing coastal flood risk projections.

DESIGN FOR ECOLOGICAL RESTORATION

Much of the coastline in East Boston and Charlestown has been hardened with bulkheads, sea walls, and stone over time to accommodate urban uses and industry. While some of this coastline hardening is necessary to protect the city from flooding and erosion, there are also opportunities to restore the coastline to more natural conditions.

Where appropriate, restoring natural ecological conditions can have multiple benefits, including providing habitat for fish, birds, and other animals, improving water quality, allowing public access, and, in some cases, reducing the effects of waves and coastal flooding. Ecological restoration approaches require detailed study before implementation. This study has pursued nature-based approaches that serve to restore natural systems wherever possible.



Navy Yard Harbowalk, Charlestown

COASTAL RESILIENCE SOLUTIONS

Each segment of the East Boston and Charlestown coastlines presents different opportunities and options for the types of resilience approaches that can be constructed while providing the desired resilience benefits. The remainder of this chapter provides details for the solutions planned for each study area based on flood risk considerations and opportunities to develop coastal resilience strategies that address multiple community needs.

NAVIGATING THE COASTAL RESILIENCE SOLUTIONS CHAPTER

This chapter includes coastal resilience solutions in the Phase II study area for six identified focus areas in East Boston and four identified focus areas in Charlestown. For each neighborhood, the chapter includes information on:

FOCUS AREAS

An overview of the location of each focus area and preferred long-term neighborhood-wide resilience strategy.

COASTAL FLOOD RISK

An overview of near- and long-term coastal flood risk within each focus area.

COASTAL RESILIENCE DESIGN STRATEGIES

A description and illustrations of the preferred coastal resilience design strategy (Option A). Depending on the complexity of the preferred design strategy, some focus areas include alternative options (Options B or C).

Option A is the preferred strategy because it is informed by the community's key priorities and input, meets evaluation criteria, and presents opportunities for equity, adaptability, and ecological restoration.

Option B or C is a less preferable option that protects critical infrastructure but may leave some waterfront properties exposed to flooding, provides fewer additional benefits, or may be less desirable for the community.

IMPLEMENTATION PHASING

The implementation phasing of the proposed solutions is organized by the degree of coastal flood risk and the timeframe by which the coastal resilience design strategy needs to be constructed. Some focus areas include both near- and long-term projects.

Near-Term projects should be constructed by approximately 2030 in order to protect a given focus area from 9 inches of sea-level rise during a 1% annual chance flood at a minimum.

Long-Term projects should be constructed between 2050 and 2070 in order to protect a given focus area from 40 inches of sea-level rise during a 1% annual chance flood.

COST ESTIMATES

Cost estimate information for planned coastal resilience strategies. This study used information from prior studies and construction projects around the United States to develop preliminary cost estimates for planned coastal resilience strategies. These costs are based on readily available data and do not reflect detailed design-level considerations for the study areas, such as outfall conditions, site surveys, underground utilities, or geotechnical information. The cost estimation methodology includes allowances for project elements such as drainage, utility and site work, demolition, insurance, general conditions, and public amenities. Contingency factors of 30% [low] and 50% [high] are added to base costs to account for uncertainties at this level of conceptual project design. Costs are provided in 2022 prices.

Cost estimates are provided by focus area in this chapter, along with project-specific notes and assumptions. Additional details on the overall cost estimation results and potential causes of cost variation are provided in Chapter 5, *Implementation Roadmap*.

BENEFIT-COST ANALYSIS

Benefit-cost information for planned coastal resilience strategies. In accordance with prior Climate Ready Boston plans, the methodology for the benefit-cost analysis (BCA) includes estimating project costs and monetizing select project benefits to generate a preliminary benefit-cost ratio (BCR). A BCA was conducted for each focus area (where sufficient data was available) and for each study area overall.

BCRs are preliminary in nature and focus on monetized benefits from the avoidance of building-related damages, including direct physical damage and social and economic impacts. BCRs also include loss of service for open space and rail service, where applicable. Coastal modeling performed for this study was used to distribute or confirm benefits by focus area based on the overall volumetric reduction in coastal flooding provided by the strategy in each focus area. Nevertheless, there are many types of physical, social, and environmental benefits not included in this analysis. The addition of these benefits in future planning and design efforts would be expected to add significant additional benefits to the BCR for each project.

Additional details on the overall BCA results and methodology are included in Chapter 5, *Implementation Roadmap*.

STORMWATER MANAGEMENT

An overview of focus area-specific stormwater management and drainage considerations.

COMMUNITY INPUT AND PRIORITIES

As described in Chapter 1, *Introduction*, community engagement spanned the entire planning process. The East Boston and Charlestown communities helped shape the development of coastal resilience solutions. Specifically, the design strategies outlined in this section incorporate the following preferences expressed by residents and other stakeholders for the Phase II study areas:

Provide passive flood protection through berms, dunes, or floodwalls, raising the Harborwalk or roadways, or building elevated waterfront parks. These strategies lower operations and maintenance costs and do not require deployable barriers to be effective. The only exception is for gates that may be necessary at road crossings and to access waterfront uses such as marinas.

Protect critical infrastructure. In East Boston, this includes MBTA Blue Line train stations and train tracks, the MBTA Orient Heights Rail Yard, evacuation routes along Bennington Street and Route 1A, and Logan Airport. In Charlestown, this includes Spaulding Rehabilitation Hospital, and water-dependent uses at the Boston National Historical Park and the Boston Autoport.

Incorporate opportunities to for additional community benefits, including increasing mobility through new multi-use pathways, preserving and enhancing public access to the waterfront, and improving existing open spaces with new recreational amenities.

Prioritize nature-based solutions that promote ecological restoration, marsh migration, and long-term habitat resilience for plants and wildlife.

COASTAL RESILIENCE SOLUTIONS FOR EAST BOSTON

East Boston's diverse coastline will be affected by coastal flood risk in different ways. Each segment of the coastline presents unique opportunities and options for the resilience approaches that can be constructed. The strategies presented in this chapter address coastal flood risk across the entire East Boston study area through a variety of flood resilience strategies.

The East Boston study area is divided into six focus areas. The focus areas are key locations along the East Boston coastline where flood pathways connect and lead to widespread flooding in the neighborhood. Consequently, resilience solutions in the focus areas depend on each other to successfully reduce long-term coastal flood risk across East Boston.

BENNINGTON STREET AND BELLE ISLE MARSH

This focus area extends along Bennington Street from Walley Street, to the border with the City of Revere, and around the Belle Isle Marsh. Resilience solutions in this focus area include near- and long-term options for roadway elevation, berms, open space and ecosystem enhancements, and building- and site-level adaptations.

CHELSEA CREEK AND ROUTE 1A

This focus area extends along Chelsea Creek from the Chelsea Street Bridge to Boston's border with the City of Revere, including portions of the Chelsea Creek Designated Port Area. Resilience solutions in this focus area include near- and long-term options for coastline elevation and restoration, roadway elevation, and building-level adaptations.

CONSTITUTION BEACH

This focus area extends from Bayswater Street to Constitution Beach Reservation with connections into the residential neighborhood on Coleridge Street. Resilience solutions in this focus area include options for elevated berms and dunes that could be integrated into Constitution Beach, floodwalls in public rights-of-way, and building-level adaptations.

ORIENT HEIGHTS RAIL YARD

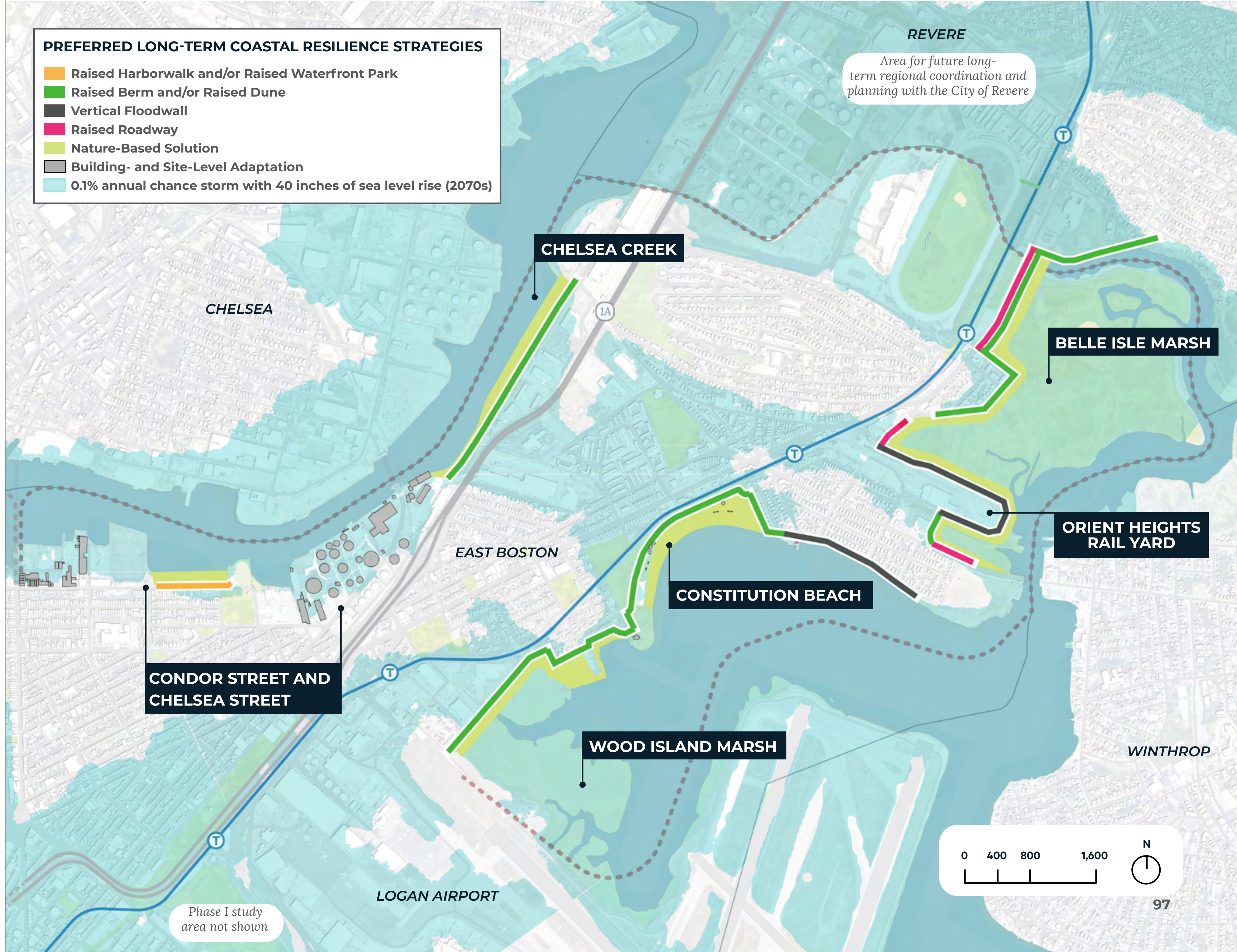
This focus area extends around the Orient Heights Rail Yard located adjacent to the Belle Isle Marsh between Saratoga Street and Bennington Street adjacent to the Orient Heights MBTA Blue Line station. Resilience solutions in this area include options for floodwalls and restoration around the perimeter of the Orient Heights Rail Yard, elevated roadways and pathways along Austin Avenue, and building-level adaptations.

CONDOR STREET AND CHELSEA STREET

This focus area extends along Condor Street and Chelsea Street and includes properties in the Chelsea Creek Designated Port Area. Resilience solutions in this area include options for elevating the coastline along Condor Street, creating new Harborwalk connections, and building- and site-level adaptations for waterfront industrial properties.

WOOD ISLAND MARSH

This focus area includes the Wood Island Marsh extending from the Wood Island Bay Edge Park to Logan Airport. Resilience solutions in this area include the implementation of planned resilience measures in the Phase I study area and options for elevating the coastal edge between Logan International Airport and Wood Island Marsh.



BENNINGTON STREET AND BELLE ISLE MARSH

This focus area extends along Bennington Street from Walley Street to the border with the City of Revere. It also includes the Belle Isle Marsh Reservation, which is a DCR-owned public reservation and salt marsh that extends across municipal boundaries into Boston, Revere, and Winthrop. The strategy in this area focuses on reducing the risk of coastal storm surge to essential transportation routes, including Bennington Street and the MBTA Blue Line, and upland sites, such as Suffolk Downs. It also includes adaptation strategies for the Belle Isle Marsh to provide additional risk reduction to the neighborhood while restoring and preserving marsh habitat for the future. The strategy is intended to lay the groundwork for future regional planning to develop and implement comprehensive coastal resilience solutions for East Boston, Revere, and Winthrop.

COASTAL FLOOD RISK

Coastal flooding from the Belle Isle Marsh presents a risk to East Boston today and this risk is likely to increase substantially over time. Flood pathways in this focus area are not connected to flood pathways in other areas of East Boston due to the Orient Heights neighborhood's higher elevation that separates it from other areas of flooding in the study area. However, flooding from the Belle Isle Marsh is highly connected to coastal flood pathways entering from the City of Revere. These flood pathways from Boston and Revere connect in low-lying areas, contributing to widespread flood risk.

By the 2030s, with 9 inches of sea-level rise, coastal flooding puts access along Bennington Street and the MBTA Blue Line at risk, even during frequent storms, such as those with a 10% annual chance of happening in a given year. In the longer term, with sea-level rise projected to occur between 2030 and 2070, flood pathways from the Belle Isle Marsh will interact with flood pathways from the Atlantic Ocean and Chelsea Creek in Revere, contributing to widespread flooding in Suffolk Downs and residential, commercial, and industrial areas of Revere.

Long-term sea-level rise will also result in changes to wetland habitats in Belle Isle Marsh, including the loss of vital high marsh zones. Comprehensively addressing the regional flood risk along Bennington Street and in Belle Isle Marsh will require further planning and investment in both Boston and Revere.

COASTAL RESILIENCE DESIGN STRATEGY

The coastal resilience strategy for this focus area is intended to provide a regional approach to effective flood risk reduction for essential transportation infrastructure, homes, businesses, and other facilities and services. The strategy for Boston combines coastal flood protection with planning efforts led by the BPDA and Boston Transportation Department to reconfigure Bennington Street as a boulevard with fewer traffic lanes and increase pedestrian and bike access. This solution is complemented by strategies to manage and enhance the resilience of the Belle Isle Marsh as a habitat and a public reservation.

COASTAL RESILIENCE STRATEGY: RAISED BENNINGTON STREET AND BERM TO SUPPORT MARSH MIGRATION

NEAR-TERM: The proposed near-term approach would raise a portion of the Bennington Street right-of-way from its current elevation to reach +16.0 feet (NAVD88) forming a line of coastal flood protection between the Belle Isle Marsh and inland areas. The raised portion would extend for approximately 1,600 linear feet from at least the Revere border to just beyond the intersection with Leverett Street. The right-of-way would be raised approximately 5 feet above the existing grade, with lower changes of 2-3 feet as the roadway reaches the high ground at the intersection with Leverett Street. A 2.5- to 3-foot floodwall on the shoulder of the roadway provides flood protection to +16.0 feet (NAVD88) and has the additional benefit of sheltering pedestrians and cyclists from traffic along new multi-use pathways integrated into the design.

Since the Bennington Street right-of-way is under City of Boston ownership and has significant width with limited side street connections, it offers an opportunity to bring coastal resilience protection to construction within the existing footprint of the roadway more quickly than other options. If completed in coordination with similar actions in Revere, the strategy also would help maintain a dry route for emergency responders and evacuation on Bennington Street.

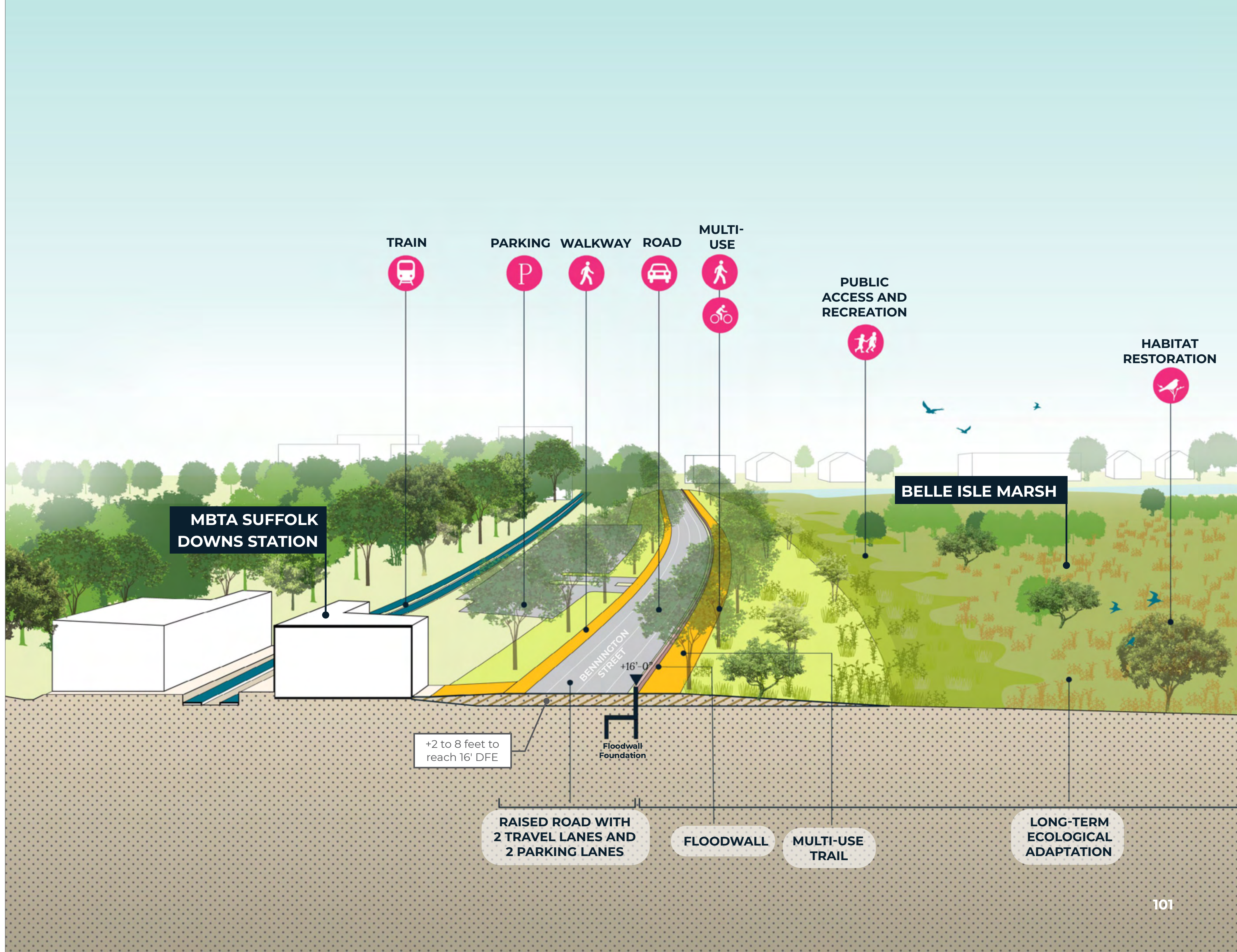
As currently designed, Bennington Street has four traffic lanes, street parking in both directions, and sidewalks. The long-term roadway raising strategy is an opportunity to incorporate new protected multi-use pathways along the roadway and additional pedestrian crossings at other key locations identified through the PLAN: East Boston process. This strategy will require careful study for impacts on access to adjacent private properties and cross streets, such as Leverett Street, and access to the Suffolk Downs MBTA station and the Belle Isle Marsh Reservation. These impacts can be mitigated by re-thinking access points and by introducing sloped driveways and cross streets.

LONG-TERM: Raising Bennington Street also provides opportunities to explore investments in public access, habitat creation, and long-term wetland adaptation within the Belle Isle Marsh Reservation. While potentially challenging to permit under current regulations, the addition of a sloped berm, living levee, or pile-supported walkway along the marsh to the east of the raised Bennington Street would provide opportunities for additional public access, enhanced habitat, and ecological adaptation.

The potential for a berm or living levee extending with a gradual slope from the raised roadway into Belle Isle Marsh will help soften the edge between the marsh and upland urban areas, and provide a space for certain types of marsh habitat, such as high marsh, to migrate upland over time as sea-level rise threatens the habitat zones that currently exist in the marsh.

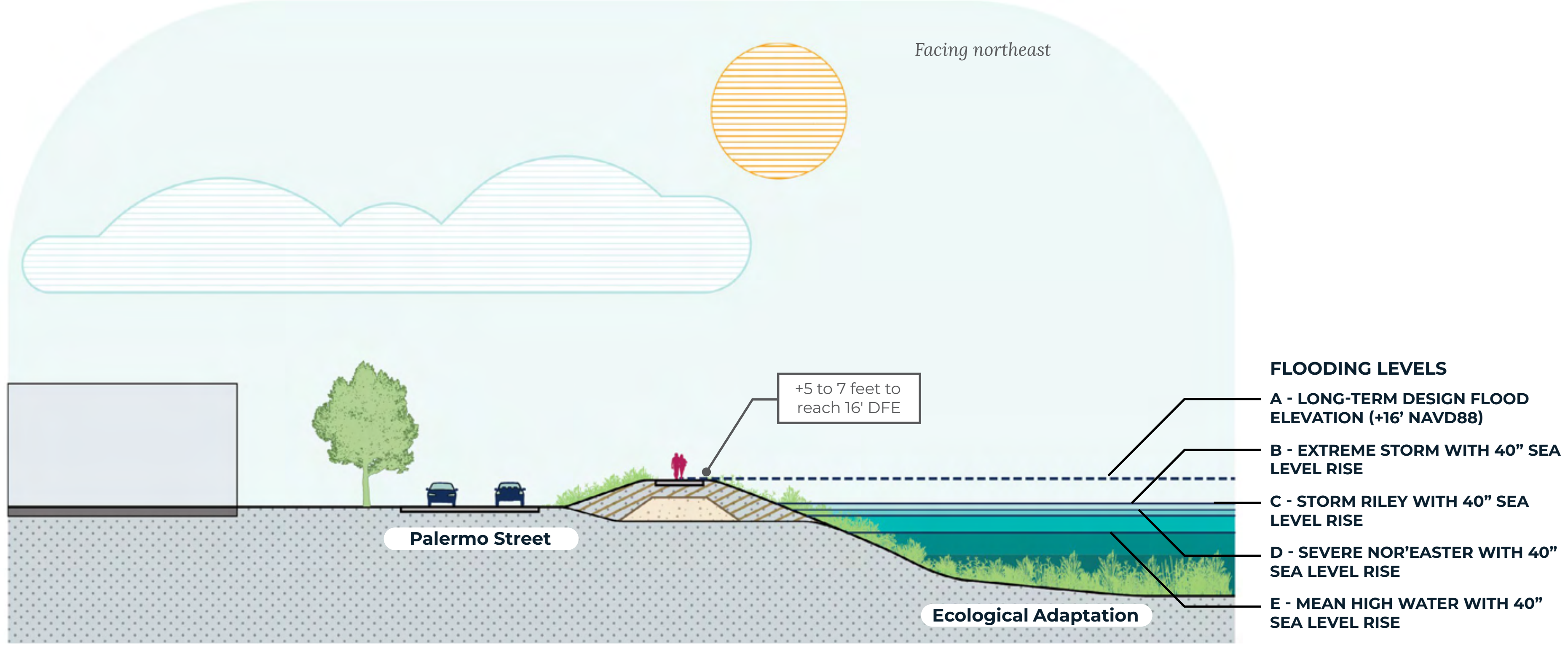
These long-term ecological adaptation strategies are only explored conceptually in this study and require further evaluation and coordination with DCR and other stakeholders to determine the appropriate next steps. See page 107 for more information about potential ecological adaptation strategies for Belle Isle Marsh.

Beyond Boston's borders, a raised berm could be extended into Revere along Revere's Frederick's Park to address flood pathways that enter through the park. The transition of the raised roadway to a solution in Revere will require further evaluation and coordinated study.



LONG-TERM COASTAL RESILIENCE STRATEGY FOR PALERMO STREET AND LAWN AVENUE

Twenty-three residential structures are located in a residential neighborhood on Leverett Street, Lawn Avenue, and Swan Avenue adjacent to the Belle Isle Marsh. These structures will require building-level adaptation to address near-term flood risk, such as elevation of buildings and mechanical systems, floodproofing of vulnerable spaces, or use of flood-resistant materials below the DFE. In the long-term, a separate perimeter coastal resilience solution around this neighborhood, such as a berm (as visualized below), can be studied in coordination with DCR and other regulatory agencies.



Belle Isle Marsh, East Boston

SALT MARSH SPARROW

Salt marsh sparrow is an indicator species for current and future threats to the marsh, including habitat loss and degradation. Action is needed today to protect native high marsh habitats against habitat loss due to current threats. Action is also needed to address long-term threats, such as sea-level rise, that will threaten habitat in the future.

Salt Marsh Sparrow Photo Credit: National Fish and Wildlife Service

REGIONAL PLANNING FOR COASTAL RESILIENCE AND MARSH RESTORATION

As described in Chapter 3, *Coastal Flood Risk*, the Belle Isle Marsh is the largest and one of the last remaining contiguous salt marshes in the City of Boston. The marsh is an important natural resource for East Boston and surrounding communities.

The Belle Isle Marsh's long-term health and resilience is influenced by direct human impacts, both historical and present-day, and by the anticipated effects of climate change. Addressing the long-term resilience challenges in the Belle Isle Marsh will require specific attention to each of these factors that impair the healthy function of the marsh as a habitat for plants, animals, and fish, and as a place for community recreation.

In July 2020, the Mystic River Watershed Association (MyRWA) was awarded a Healthy Estuaries Grant to conduct an inventory of environmental conditions in Belle Isle Marsh in partnership with DCR, Friends of Belle Isle Marsh, and The Nature Conservancy.

Conducting this inventory served as the first step in developing restoration and adaptation strategies for one of the last remaining salt marshes in Boston. As a part of this effort, the City of Boston, the City of Revere, and the Town of Winthrop, as well as MassDOT and the MBTA, have met regularly with the aforementioned organizations to coordinate regional planning for coastal resilience and marsh restoration.

The regional nature of flood risk on Bennington Street and around Belle Isle Marsh requires a regional approach and additional design work. Ongoing regional planning efforts will continue in order to facilitate a comprehensive coastal resilience solution for the Bennington Street focus area and surrounding locations in Revere and Winthrop, as well as develop approaches for the long-term planning and restoration of Belle Isle Marsh.

Preliminary resilience approaches for the Belle Isle Marsh include both restoration and adaptation measures, drawing on a conceptual suite of options that will be further refined and built upon through the ongoing study led by DCR and MyRWA.

RESTORATION AND ADAPTATION APPROACHES FOR THE BELLE ISLE MARSH

As shown in the map (left), there are several identified concerns and considerations that need to be addressed to restore and adapt the Belle Isle Marsh. The strategies listed below represent wetland restoration techniques that can be used to promote ecological restoration in the Belle Isle Marsh today as well as promote ecological adaptation over the long term. There is no "one size fits all" approach for Belle Isle Marsh; distinct areas and habitats within the marsh will require actions tailored to those areas' conditions. However, a suite of natural and nature-based approaches is being considered across these areas by DCR, as summarized below.

STRATEGIES FOR RESTORING MARSH HEALTH TODAY

The strategies listed below represent wetland restoration techniques that can be used today to promote ecological restoration in the Belle Isle Marsh. Implementation of these strategies is necessary to protect and enhance the existing ecosystem with or without long-term resilience measures.

Restoration of natural hydrological and hydraulic dynamics to restore the natural flow of tides:

- Focused ditch remediation includes removing or reconfiguring existing ditches to restore natural flows.
- Salt panne edge stabilization includes reducing the risk of further salt panne expansion due to erosion.
- Focused removal of anthropogenic fill that restricts or limits natural flows with the potential for beneficial reuse of anthropogenic fill in suitable locations.

Habitat restoration and enhancement to improve the ecosystem:

- Phragmites control intended to limit the spread of this invasive species and establish native species.
- Meadow enhancement and preservation focused on preserving public amenities and access while limiting harmful effects to the ecosystem.

STRATEGIES FOR PROMOTING LONG-TERM MARSH RESILIENCE

The strategies listed below are techniques that may be appropriate for encouraging long-term wetland resilience and ecological adaptation to future sea-level rise. Selection of specific strategies should build on the updated Sea Level Affecting Marshes Model (SLAMM), analysis of wetland accretion rates, anticipated ecological changes, the expected rate of sea-level rise, and other factors.

- **Thin-layer deposition** to incrementally raise the marsh platform with sea-level rise to facilitate preservation and creation of critical habitat such as high and low salt marsh.
- **Management and redistribution** of sediment within the wetland system to enhance and encourage natural processes (i.e., accretion) that may not be able to keep up with sea-level rise.
- **Vegetation enhancement** to increase sediment capture within the system.
- **Continue to evaluate marsh migration corridors** for inland movement of the marsh with sea-level rise.
- **Implementation of nature-based features** between the marsh and upland development to provide habitat, soften the transition from open space to urban space, and provide flood protection benefits. This approach could be combined with the road-raising strategy described as part of the coastal resilience strategy for Bennington Street.

STORMWATER MANAGEMENT AND DRAINAGE CONSIDERATIONS

Coastal resilience infrastructure along Bennington Street should be designed to avoid or minimize impacts to underground utilities and pipes. Underground utilities and pipes may also be relocated, where feasible, to allow for the siting of coastal resilience infrastructure, if avoidance is not possible. For example, a 30-inch storm drain is located below Bennington Street, which discharges to the Belle Isle Marsh at the border with the City of Revere. The exact location of this drain will need to be confirmed during the design process to avoid conflicts between the pipe and the coastal flood protection.

The design of the raised roadway should orient stormwater collection systems toward the west, away from Belle Isle Marsh, to avoid the need for the placement of stormwater outfalls or drainage openings in the floodwall.

Where not already present, tide gates should be installed on all public and private stormwater outfalls that discharge into Belle Isle Marsh to prevent ocean water from traveling through the drainage system under the coastal resilience infrastructure.

A range of regional approaches can be explored to manage interior drainage and reduce residual risk from stormwater flooding. Planned upgrades to the DCR-owned Alfred H. Long Pumping Station should incorporate stormwater management needs associated with coastal resilience infrastructure in the area. Additional measures beyond pump station upgrades, such as green infrastructure and conveyance improvements, may be necessary to help manage stormwater.

COST ESTIMATES AND BENEFIT-COST ANALYSIS

While this study provides estimated project costs for coastal resilience solutions in Boston for the Bennington Street focus area, this estimate does not reflect the full cost of actions necessary to comprehensively address flood risk in the region. For example, additional coastal resilience measures would be necessary in Revere along Ocean Avenue to prevent flooding from the Atlantic Ocean and along Route 1A to prevent flooding from Chelsea Creek. Flood pathways from these locations in Revere connect to flood pathways from Bennington Street and Belle Isle Marsh and thus actions are necessary at each location to realize an effective long-term coastal resilience solution.

Additionally, project-specific benefits are not quantified for this focus area, since the building-level benefits in Boston are limited and do not accurately reflect the long-term benefits that will accrue from a comprehensive coastal resilience strategy. Benefits of near- and long-term actions in this focus area include reduced disruption of service along Bennington Street and the Blue Line, maintenance of service on regional evacuation routes, and volumetric reductions to flooding in both Revere and Winthrop through 2050, which would reduce risk to numerous homes, businesses, and community services in Revere.

LONG-TERM COASTAL RESILIENCE STRATEGY: RAISED BENNINGTON STREET	
Estimated Cost	$51 - 57 million
Estimated Annual Operations & Maintenance	$480 thousand

Notes:
*Includes costs for planning, engineering, permitting, construction
*Includes cost estimate includes both near- and long-term strategy, including Palermo Street and Lawn Avenue berm
*Cost estimate does not include detailed estimates for a “living levee” strategy
*See cost estimation methodology (pg. 186-191) for more information
*Annual operations and maintenance costs are expected to be 1.0 percent of the implementation costs

CHELSEA CREEK AND ROUTE 1A

This focus area extends along Chelsea Creek from the Chelsea Street Bridge to Boston's border with the City of Revere, including portions of the Chelsea Creek DPA. The coastal resilience strategy in this area provides multiple near-term options for reducing risks to essential transportation routes, including Route 1A, and a significant portion of the neighborhood by addressing flood pathways that originate from Chelsea Creek and flow inland to lower Orient Heights. In the long-term, the strategy includes options to reduce flood risk and create new public access with ecological restoration along Chelsea Creek.

COASTAL FLOOD RISK

The coastline of Chelsea Creek is one of the lowest-lying areas of the East Boston study area. Once the outlet of a tidal creek named Crooked Creek, the area was filled in the early 20th century for urban and industrial development. This filled land is at a lower elevation than the historic coastlines and is thus more vulnerable to flooding. Flood pathways originating from Chelsea Creek contribute to the most extensive and significant future coastal flooding in the study area. By the 2030s, flood pathways resulting from a 1% annual chance storm are projected to overtop the coastline, cross Route 1A, and flow into the central portions of the neighborhood. This includes residential properties in Brandywyne Village, lower Orient Heights, and Harbor View, as well as along Saratoga, Bennington, and Boardman Streets. This flooding will also affect community assets such as the Martin Pino Community Center and Noyes Playground.

In the longer term, with sea-level rise projected to occur between 2030 and 2070, flood pathways from Chelsea Creek will connect with pathways surrounding Constitution Beach and Orient Heights Rail Yard during severe storm events. This means an effective coastal resilience solution for the Chelsea Creek focus area will in part depend on resilience solutions implemented elsewhere in the study area. Flooding under non-storm conditions is also a concern along Chelsea Creek. While high tides do not lead to flooding in the area today, with projected sea-level rise, future high tides could affect waterfront sites and lead to flooding of Route 1A on a monthly basis.

COASTAL RESILIENCE DESIGN STRATEGY

The coastal resilience solution for this focus area is intended to provide effective flood risk reduction for the area in the near- and long-term. The near-term solutions can be implemented within the parameters of existing regulations and city and state property ownership, while longer-term options will likely require changes to regulations and coordination between multiple public and private property owners.

The preferred long-term approach seeks to reduce coastal risks while maximizing opportunities to provide multiple benefits to the East Boston community, including new and enhanced public access and ecological restoration of habitats along Chelsea Creek. The process of determining which option can be implemented will require continued engagement between the City, East Boston residents, and public and private property owners, including MassDOT, the MBTA, and regulators at the city and state level.

CUMULATIVE BENEFITS OF THE RESILIENCE DESIGN STRATEGY THROUGH 2070*	
Residents protected**	1,490
Number of buildings protected**	198
Damages avoided***	$390 million

*calculated based on preferred long-term coastal resilience strategy
**based on 2019 residential population and buildings
***Loss avoidance based on damages quantified for this study using a 3% discount rate

NEAR-TERM COASTAL RESILIENCE STRATEGY: CONSTRUCT A FLOODWALL TO REDUCE NEAR-TERM RISKS

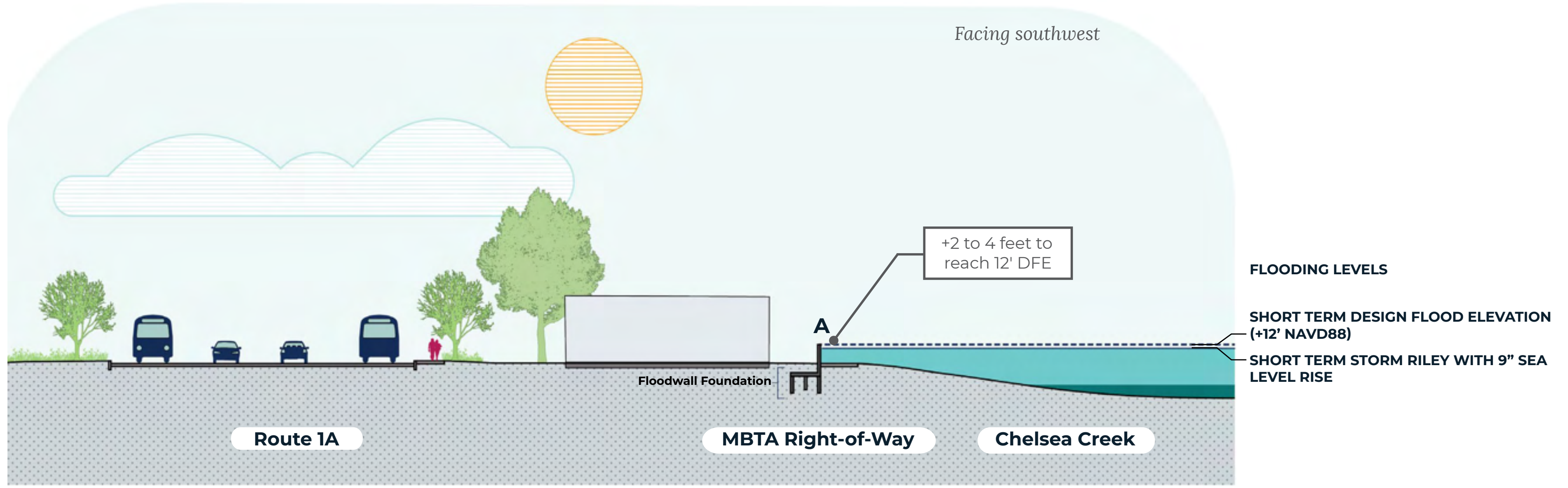
The near-term strategy includes three options for reducing near-term coastal flood risks. The options include implementing a floodwall within an unutilized rail right-of-way located between Route 1A (also called the William F. McClellan Highway) and Chelsea Creek owned by the MBTA, in the median of Route 1A, or along the southbound sidewalk. Near-term options will need to be studied in collaboration with MassDOT and the MBTA to determine technical feasibility and ensure consistency with long-term plans for transit and transportation improvement in the area.

OPTION A (PREFERRED): This option includes implementing a passive floodwall and multi-use pathway along Chelsea Creek. Properties along Chelsea Creek are under a mix of private and public ownership. Uses along the coastline are primarily for industrial and storage facilities related to Logan International Airport. A currently unused rail right-of-way owned by the MBTA runs parallel to Chelsea Creek between the water and the adjacent facilities. Land uses in this area are regulated by the DPA policy, as described in Chapter 2, *Context*. The proposed floodwall would be located in the MBTA right-of-way to utilize the public land ownership to expedite the process of implementation of the new infrastructure.

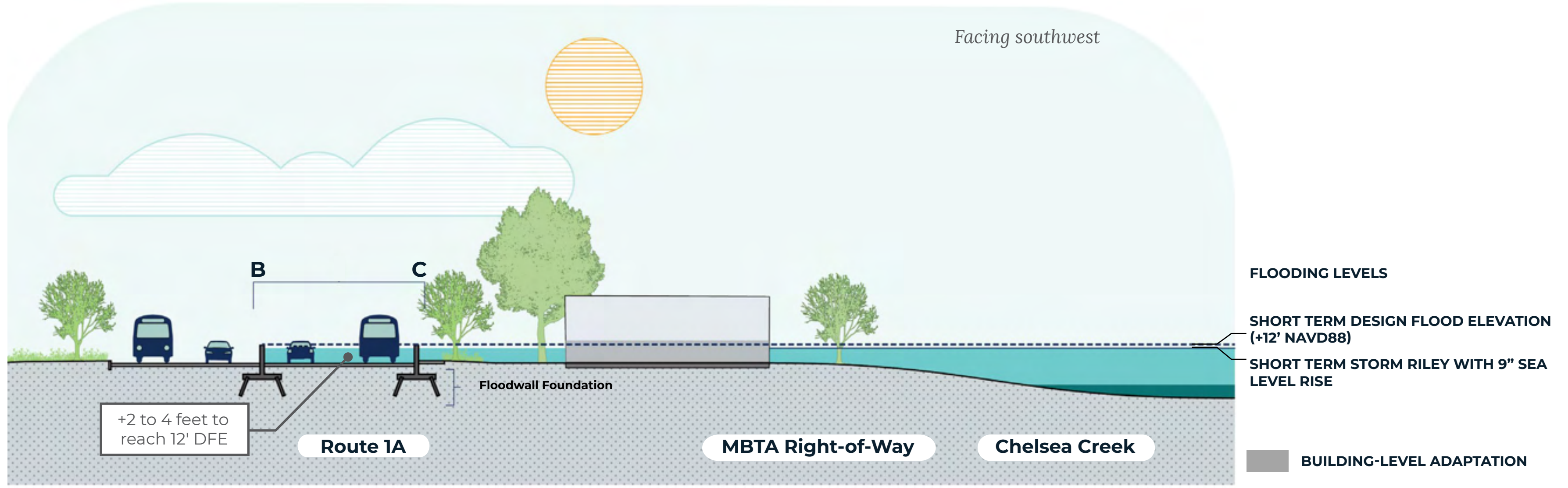
The floodwall would be designed to a height of at least 12.0 feet (NAVD88) to provide protection against the 1% annual chance flood through at least 2030, which would extend approximately 2 to 4 feet above the existing grade along the water's edge. The design of the wall could be integrated into a new multi-use pathway to provide new public access along the coastline. The pathway would be located on the waterside of the floodwall and should also be elevated above the height of future monthly high tides at 10 feet (NAVD88) to ensure long-term resilience against frequent flooding, which is 2 to 3 feet above the existing grade. Coordination with CZM will be necessary regarding the opportunity to add public access within the Chelsea Creek DPA.

OPTION B: This option includes implementing a passive floodwall in the median of Route 1A. The floodwall would be designed to a height of at least 12.0 feet (NAVD88) to provide protection against the 1% annual chance flood through at least 2030 and would be approximately 2 to 4 feet above the existing grade. This length would be approximately 900 feet. The floodwall would be located in the existing median of the roadway so that no gates are necessary, protecting the northbound travel lanes for emergency access during a flood. This increases the effectiveness of the strategy and reduces the overall cost; however, the southbound side of the roadway and seaward properties would remain vulnerable to flooding. Therefore, Option A is preferred.

OPTION C: This option includes implementing a passive floodwall along the southbound sidewalk that runs adjacent to the private properties located between Route 1A and the Chelsea Creek. The floodwall would be designed to a height of at least 12.0 feet (NAVD88) to provide protection against the 1% annual chance flood through at least 2030 and would be approximately 2 to 4 feet above the existing grade. This length will be approximately 900 feet. Placing a floodwall in this location would protect the northbound and southbound travel lanes for emergency access during a flood. However, placing a floodwall in this location would require deployable floodgates to allow for continued access to the private properties that have entry points along Route 1A and therefore Option A is preferred.



CHELSEA CREEK NEAR-TERM COASTAL RESILIENCE DESIGN STRATEGY, OPTION A (PREFERRED)



CHELSEA CREEK NEAR-TERM COASTAL RESILIENCE DESIGN STRATEGY, OPTIONS B OR C

LONG-TERM COASTAL RESILIENCE STRATEGY: RAISE THE CHELSEA CREEK EDGE OR RAISE ROUTE 1A

The long-term strategy includes two options for reducing long-term coastal flood risks by adapting one of the near-term options to a higher elevation and adding additional measures to promote community resilience. The options include heightening the floodwall and expanding public access and coastal restoration along the Chelsea Creek coastline or raising Route 1A. These options can be evaluated for long-term implementation based on ongoing coordination with property owners, regulatory authorities, and the East Boston community.

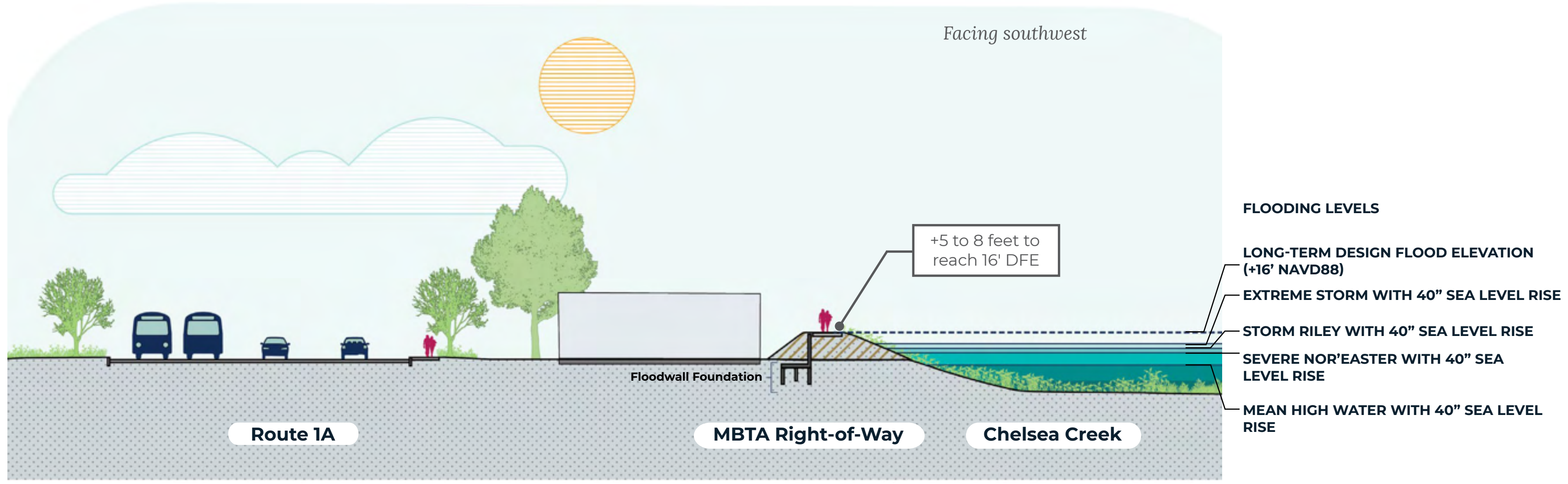
OPTION A (PREFERRED): This preferred option entails re-envisioning the waterfront along Chelsea Creek to increase the height of coastal flood protection against long-term flood risks while adding new public access and advancing ecological restoration of the coastline. This strategy entails constructing an approximately 2,800-foot-long landscaped berm at the water's edge, extending from existing land into the tidal wetland area that is parallel to the current coastline. The berm would be raised to a DFE of 16.0 feet (NAVD88), approximately 5 to 8 feet above the existing grade. This approach would create a new waterfront open space along Chelsea Creek with integrated flood protection that reduces the risk of flooding in the neighborhood from the 1% annual chance storm with 40 inches of sea-level rise.

The new open space could include a number of new community amenities, as well as ecological restoration measures to improve currently degraded wetlands and increase resilience through nature-based approaches. This strategy would require adding fill to existing waters and wetlands, which makes permitting a challenge. Any adverse impacts could be mitigated through the restoration of the existing degraded wetlands and the creation of additional coastal habitat.

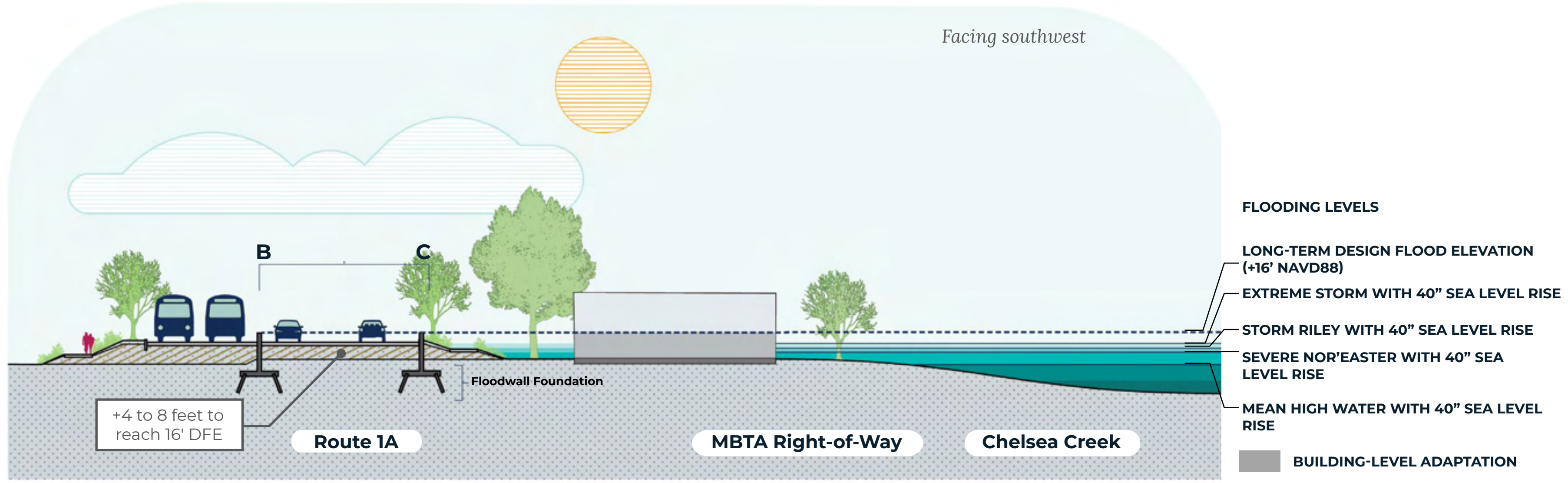
OPTION B OR C: This option would raise the elevation of the roadway to 16.0 feet (NAVD88) and form a line of coastal flood protection along Chelsea Creek. This option could integrate and build on the floodwall implemented as part of near-term Option B or C. The linear extent would be approximately 1,700 feet. In the lowest-lying segment of Route 1A, this would require increasing the elevation by approximately 8 feet above the existing grade for approximately 150 linear feet. This strategy would reduce the risk of flooding in the neighborhood from the 1% annual chance storm with 40 inches of sea-level rise and maintain a safe route for emergency responders and public evacuation. Elevating Route 1A presents an opportunity to bring coastal resilience protection to construction more efficiently since Route 1A is under public ownership by MassDOT.

Presently, Route 1A restricts public access to the Chelsea Creek waterfront due to high traffic volumes and limited pedestrian crossings. As part of any roadway elevation, the roadway design should be evaluated for opportunities to incorporate protected multi-use pathways for bicycles and pedestrians along the roadway, as well as new dedicated lanes for MBTA buses. This strategy would require a careful study of how elevating a portion of Route 1A may impact access to private properties and cross streets. These impacts can be mitigated by redesigning access points and by introducing sloped driveways and cross streets.

Structures on the water side of the Chelsea Creek coastline will require building- and site-level adaptation to address near- and long-term flood risk. See page 91 for information about the BPDA's *Coastal Flood Resilience Design Guidelines*.

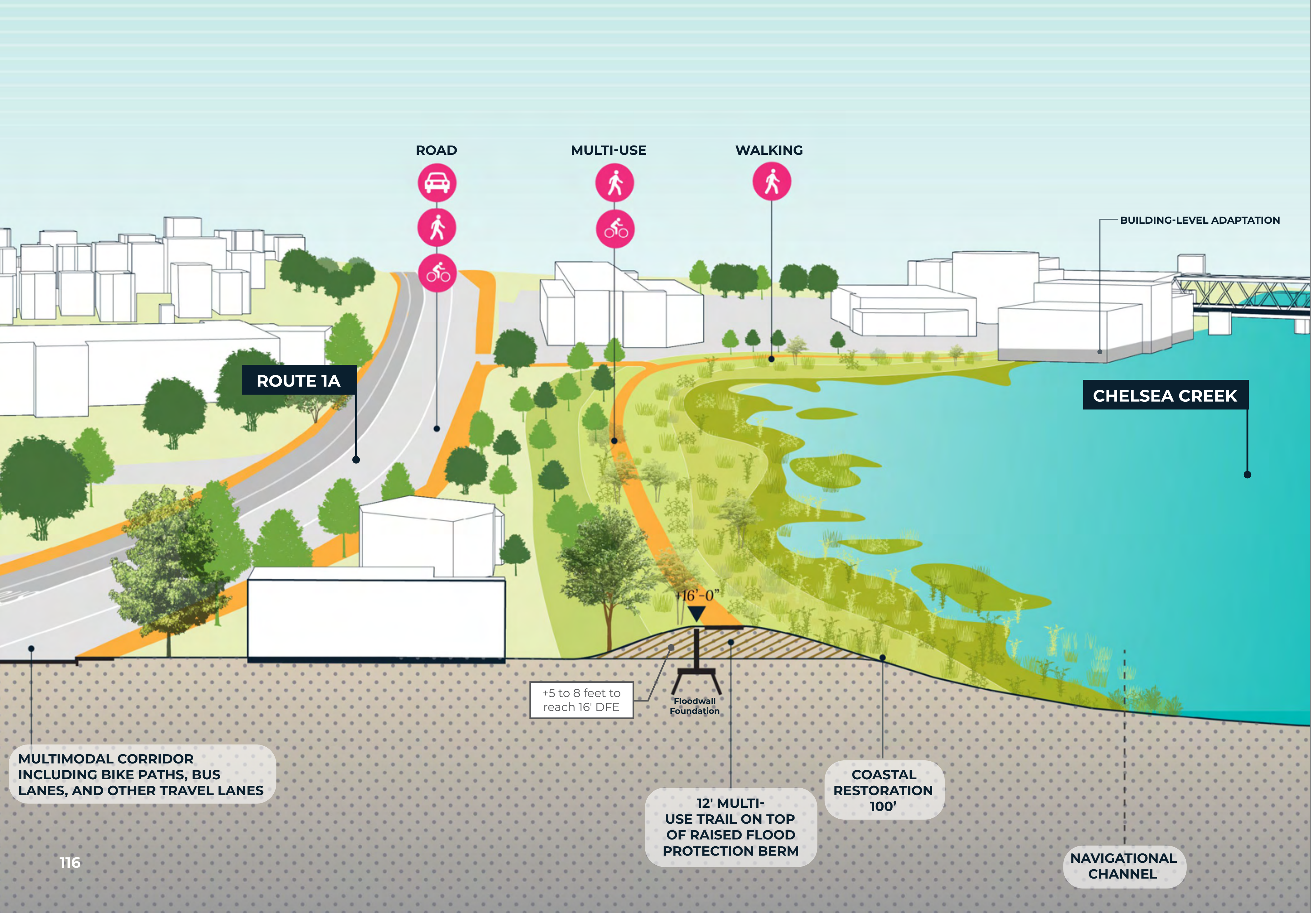


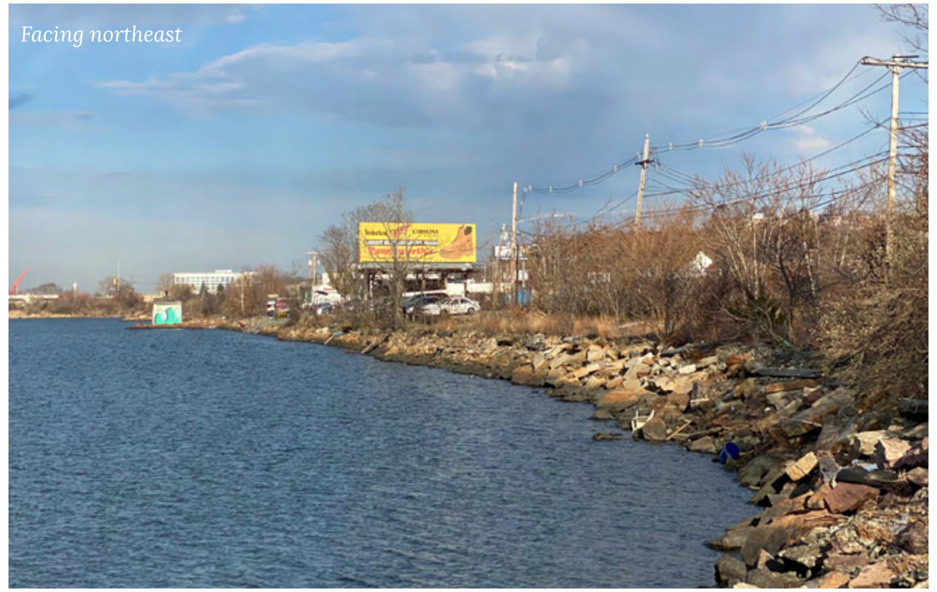
CHELSEA CREEK LONG-TERM COASTAL RESILIENCE DESIGN STRATEGY, OPTION A (PREFERRED), FACING SOUTH



CHELSEA CREEK LONG-TERM COASTAL RESILIENCE DESIGN STRATEGY, OPTION B OR C. FACING SOUTH

CHELSEA CREEK AND ROUTE 1A PREFERRED LONG-TERM COASTAL RESILIENCE STRATEGY





Existing conditions along Chelsea Creek's coastline.

ROUTE 1A CORRIDOR STUDY

Led by MassDOT, the ongoing Route 1A Corridor Study is assessing the potential uses of the MassDOT and MBTA rail parcels located between Route 1A and the Chelsea Creek, and evaluating the Route 1A corridor between Bell Circle in Revere and Day Square in East Boston. The study will identify opportunities to improve connections for walking, biking, and public transit, address safety issues, and mitigate the potential impacts of climate change. The recommendations from this study will be considered in the Route 1A Corridor Study as alternatives are developed. The Route 1A Corridor Study began in the Fall of 2021 and is anticipated to conclude in the Fall of 2022.

STORMWATER MANAGEMENT AND DRAINAGE CONSIDERATIONS

All options for this focus area should be designed to avoid or minimize impacts to underground utilities and pipes. Underground utilities and pipes may also be relocated, where feasible, to allow for the siting of coastal resilience infrastructure, if avoidance is not possible. A stormwater drain is located along Addison Street and discharges to Chelsea Creek at the intersection of Addison and Route 1A. Evaluation of existing tide gates or installation of a new tide gate will be necessary to avoid entry of ocean water into the storm drain during storm surge events.

If Option B or C is advanced, stormwater collection systems should orient toward the east away from Chelsea Creek to avoid placing outfalls or drainage openings in the floodwall to avoid the need for the placement of stormwater outfalls or drainage openings in the floodwall.

Where not already present, tide gates should be installed on all public and private stormwater outfalls that discharge into Chelsea Creek to prevent ocean water from traveling through the drainage system under the coastal resilience infrastructure.

Areas adjacent to Route 1A within the Addison-McClellan EDA are among the lowest-lying inland areas in the East Boston study area. This means the risk of future flooding from stormwater is highest in these locations if drainage solutions are not implemented to help discharge stormwater when outfalls are submerged. A range of regional approaches can be explored to manage interior drainage and reduce residual risk from stormwater flooding. One or more new pumping stations will likely need to be installed in the focus area to help manage stormwater. Additional measures beyond pump stations, such as green infrastructure and conveyance improvements, may also be necessary to help manage stormwater.

Chelsea Creek, East Boston

CARUSO PUMP STATION

Located at the intersection of Addison and Chelsea Streets, adjacent to the Chelsea Creek Bridge, the East Boston Caruso Pump Station connects the sewer network for portions of East Boston to the Deer Island Wastewater Treatment Facility. These facilities, owned and operated by the Massachusetts Water Resource Authority (MWRA), are critical water infrastructure that ensure safe and sanitary conditions for residents and protect water quality throughout Boston Harbor.

The Caruso Pump Station is not exposed to coastal flooding in the near term but may experience flooding during severe and extreme storms in the future with 40 inches of sea-level rise. Given this risk and the regional importance of the pump station, the MWRA will need to study and implement strategies to harden the facility and protect vulnerable equipment from damage and disruption due to future flooding.

COST ESTIMATES AND BENEFIT-COST ANALYSIS

NEAR-TERM COASTAL RESILIENCE STRATEGY: OPTION A FLOODWALL AT CHELSEA CREEK EDGE	
Estimated Cost	$34 - 39 million
Estimated Annual Operations & Maintenance	$320 thousand

LONG-TERM COASTAL RESILIENCE STRATEGY: OPTION A RAISE THE CHELSEA CREEK EDGE	
Estimated Cost	$150 - 170 million
Estimated Annual Operations & Maintenance	$1.4 million

NEAR-TERM COASTAL RESILIENCE STRATEGY: OPTION B FLOODWALL IN ROUTE 1A	
Estimated Cost	$16 - 18 million
Estimated Annual Operations & Maintenance	$150 thousand

LONG-TERM COASTAL RESILIENCE STRATEGY: OPTION B RAISE ROUTE 1A	
Estimated Cost	$45 - 51 million
Estimated Annual Operations & Maintenance	$420 thousand

Notes:
*Includes costs for planning, engineering, permitting, and construction
*See cost estimation methodology (pg. 186-191) for more information
*Annual operations and maintenance costs are expected to be 1.0 percent of the implementation cost.

STRATEGY	BENEFIT COST RATIO	
	HIGH	LOW
Near-Term	9.4	4.1
Long-Term	6.7	1.8

Notes:
*Benefit Cost Ratio includes a 3% discount rate for avoided losses
*High BCR uses low cost estimate for near- and long-term strategy; low BCR uses high cost estimate for near- and long-term strategy
*Both benefits and costs have been applied incrementally over time based on an estimated project completion schedule and sea level rise changes over time, assuming 9 inches around 2030 and 40 inches around 2070.

CONSTITUTION BEACH

This focus area extends from Bayswater Street through Constitution Beach Reservation with connections into the residential neighborhood on Coleridge Street. The strategy in this area focuses on reducing near-term flood pathways along Coleridge Street at the southern entrance to Constitution Beach. It also reduces long-term risk to the neighborhood and essential transportation infrastructure by addressing flood pathways that overtop the beach and lead to neighborhood-wide flooding.

COASTAL FLOOD RISK

Constitution Beach and the surrounding areas were once part of a network of tidal estuaries between the islands in Boston Harbor. This filled land is at a lower elevation than the historic coastline and is more vulnerable to flooding. During coastal storm events, flooding will enter low-lying portions of Constitution Beach and adjacent private properties. Constitution Beach will experience fringe flooding in the near term, while flood pathways at Constitution Beach are a long-term risk.

In the long term, with sea-level rise projected to occur around 2070, flood pathways from Constitution Beach will connect with pathways originating from the areas surrounding Constitution Beach at Coleridge Street, the Orient Heights Rail Yard, and Chelsea Creek during the 1% annual chance storm, leading to more frequent and severe flood impacts. This will put the public beach, homes, businesses, and essential facilities throughout the neighborhood at risk, including the MBTA Blue Line and Bennington Street. This means an effective coastal resilience solution for the Constitution Beach focus area will depend on resilience solutions implemented in the surrounding areas.

The Coleridge Street area to the west of Constitution Beach is considered as part of the Constitution Beach focus area given its proximity to the beach. Near-term flood pathways resulting from a 1% annual chance storm are projected to overtop the coastline along Coleridge Street by the 2030s, flooding nearby properties and impacting the public beach.

COASTAL RESILIENCE DESIGN STRATEGY

The coastal resilience solutions for this focus area are intended to provide effective flood risk reduction for the area in the near- and long-term within the parameters of existing regulations and property ownership. The preferred strategy combines coastal flood protection with efforts to enhance public amenities and community benefits. Long-term efforts to redesign the beach to incorporate flood resilience approaches and new amenities to serve local residents will need to be led by DCR in coordination with the City and the East Boston community. A secondary approach to provide coastal flood risk reduction can also be explored within the MBTA Blue Line rail right-of-way if other options are not advanced.

CUMULATIVE BENEFITS OF THE RESILIENCE DESIGN STRATEGY THROUGH 2070*	
Residents protected**	1,851
Number of buildings protected**	238
Damages avoided***	$390 million

*calculated based on preferred long-term coastal resilience strategy
**based on 2019 residential population and buildings
***Loss avoidance based on damages quantified for this study using a 3% discount rate

LONG-TERM COASTAL RESILIENCE STRATEGY: INTEGRATED FLOOD RESILIENCE AT CONSTITUTION BEACH

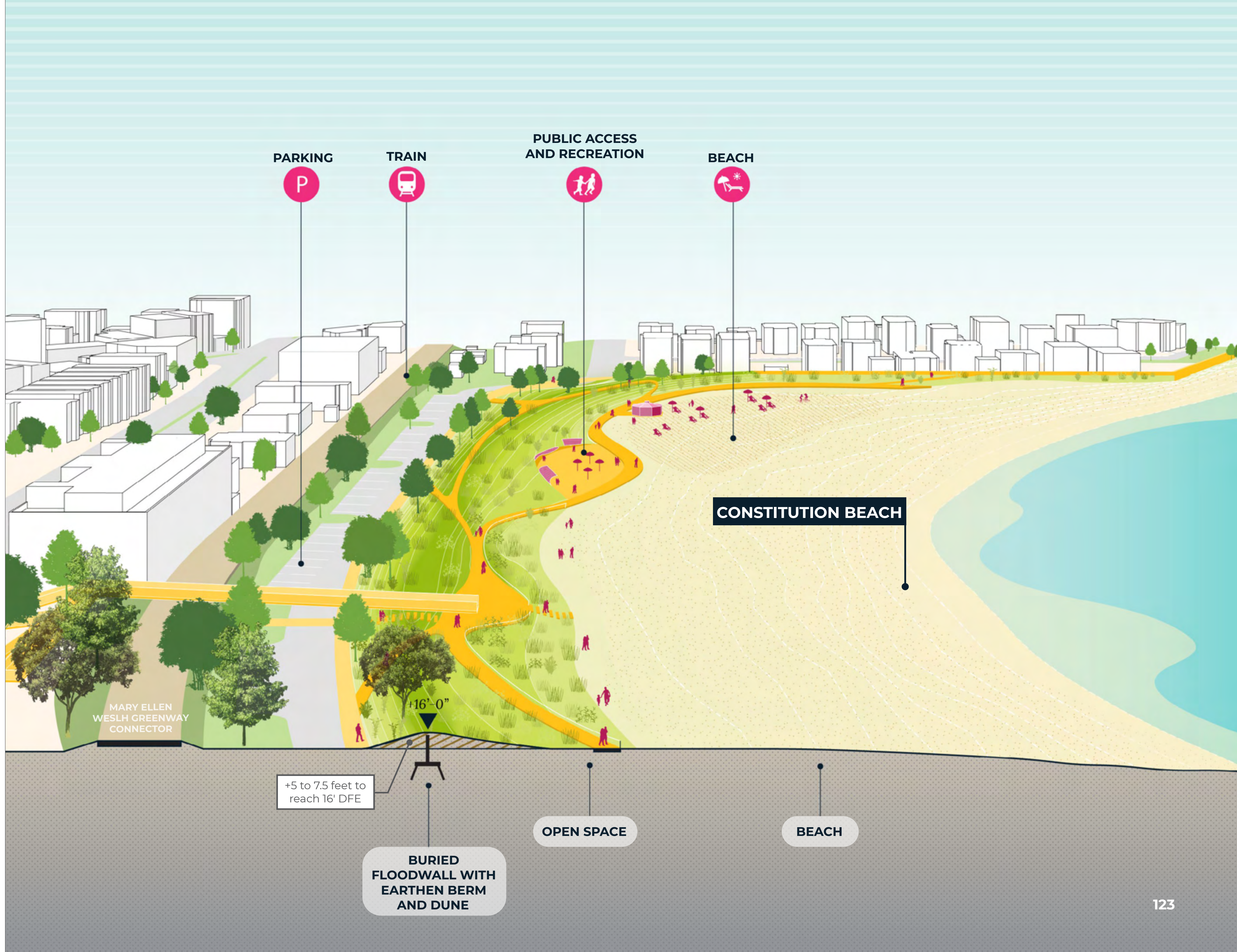
Over the long term, coastal flooding in the Constitution Beach focus area is projected to become widespread. Mitigating this flooding will require constructing a comprehensive coastal resilience solution for Constitution Beach and surrounding areas.

At Constitution Beach, that strategy includes an elevated system of constructed dunes, berms, and integrated open space enhancements to create a more resilient recreational landscape and public amenity that also prevents floodwaters from entering the neighborhood. **The elevated dune and berm system preserves the sandy beach character of the park while providing opportunities to add and improve amenities, including additional trees, seating, play areas, and shade structures.** Preserving the sandy beach is also important for maintaining habitat for certain wildlife, such as Piping Plovers, which are protected under the Endangered Species Act.

Reaching an elevation of +16.0 feet (NAVD88), the coastal resilience approach would be approximately 5 to 7.5 feet above the existing grade. To further extend the life of the beach as the sea levels rise in the future and manage erosion, the beach and dune system may require stabilization measures, such as plantings and sand fences, as well as the replacement of sand (also known as beach nourishment) at regular intervals.

On the eastern end of Constitution Beach, the elevated dune system would tie into a berm and floodwall that protects adjacent residences and streets from flooding. The floodwall must extend along Bayswater Street to the Orient Heights Yacht Club to provide effective flood protection to the DFE. An optional low (1.5 to 3 feet high) floodwall can be extended along Bayswater Street to Shawsheen Road to reduce flooding on Bayswater Street during extreme storms in the long term.

If the preferred resilience strategy for Constitution Beach cannot be implemented, the City may work with the MBTA to explore an alternative strategy for constructing coastal flood protection located in the MBTA Blue Line rail right-of-way. This option is not preferred because it provides fewer opportunities for enhanced public amenities but is a potential location to provide effective protection for the neighborhood from coastal flooding. A floodwall could be constructed in place of the existing chain-link fence that runs parallel to the Blue Line tracks and could offer co-benefits such as noise reduction and opportunities for public art.



NEAR-TERM COASTAL RESILIENCE STRATEGY AT COLERIDGE STREET

The new park amenities and coastal resilience infrastructure that are part of the long-term resilience strategy will need to connect to other resilience solutions at the southern entrance to the park, near the DCR-owned Porrazzo Ice Rink, and extend along or adjacent to Coleridge Street. This area is the location of a near-term flood pathway for flooding during severe storms with 9 inches of sea-level rise.

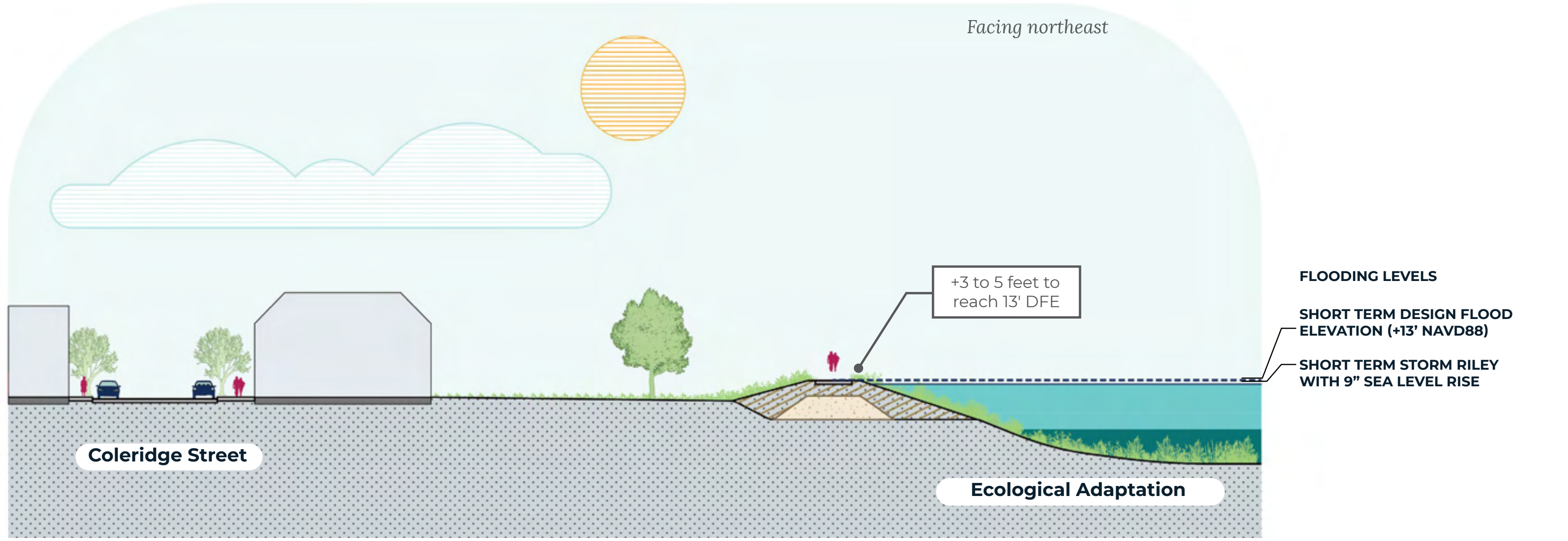
There are two options for addressing this flood pathway in the near term, which can be further explored through the next phase of design and community engagement. Both options can be implemented to near-term DFEs of +13.0 feet (NAVD88) to provide protection through the 2030s or be adapted to the long-term DFE of +16.0 feet (NAVD88) to provide protection against severe storms with 40 inches of sea-level rise. Additionally, both options can be connected to the longer-term strategy for Constitution Beach.

OPTION A (PREFERRED): The first option is constructing a raised berm along the coastline between open water and upland residences connecting to the Massport-owned Wood Island Bay Edge Park. This option provides the greatest level of protection and is preferred, but would require adding some fill to existing waters and wetlands and would be challenging to permit. However, any adverse impacts could be mitigated through the conversion of one wetland resource area to another and the creation of additional coastal habitat. **This option can be considered as part of a strategy for public access and ecological restoration along the coastline in this location.**

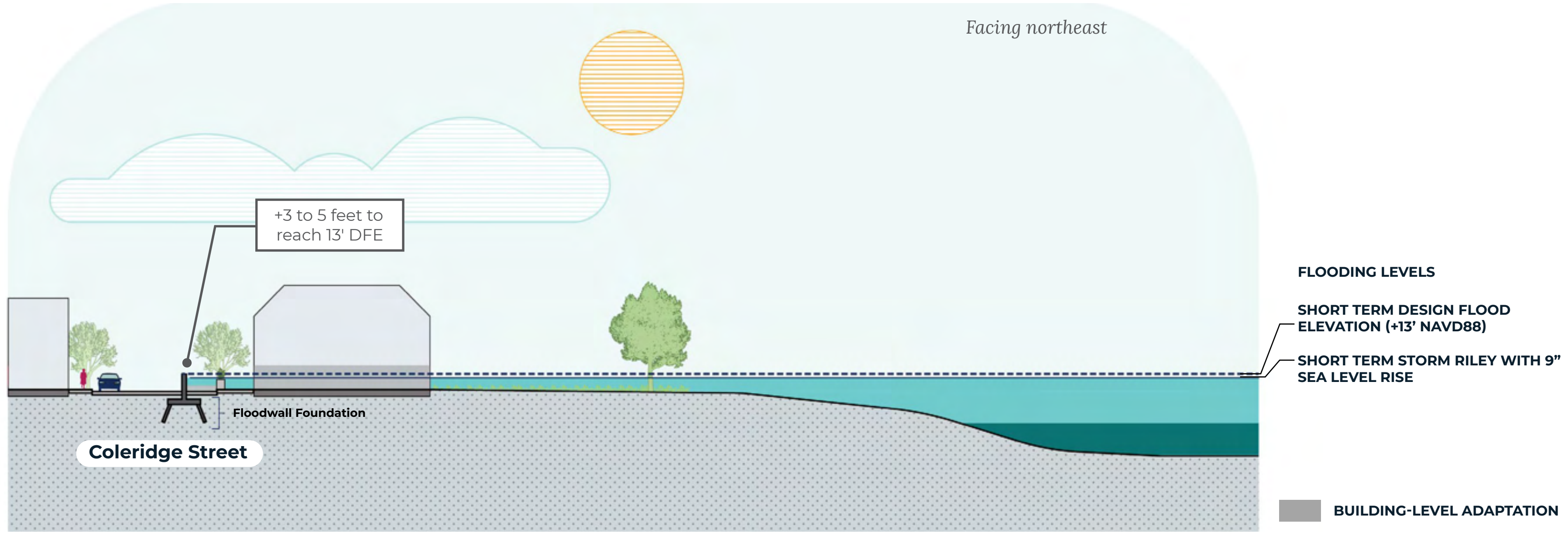
This option would also require coordination with multiple private property owners along the waterfront, as this solution would likely need to be located partially on private land and may obstruct access to the water for property owners whose backyards face the waterfront.

OPTION B: While less preferable, a second option involves a floodwall along Coleridge Street that would tie into high ground along Wordsworth Street. Since this roadway is under single public ownership, it offers an opportunity to bring coastal resilience protection to construction more quickly than other locations under private ownership. The floodwall should reach elevation +16.0 feet (NAVD88) to provide long-term protection, approximately 6 to 8 feet above the existing grade or +13.0 feet (NAVD88) to provide near-term protection, approximately 3 to 5 feet above existing grade.

Under this option, private residences along Coleridge Street and the East Boston Yacht Club will need to implement building-level adaptation measures because they remain on the waterside of the floodwall. This strategy would require reimagining Coleridge Street through a careful study by the City with consideration of access to residences; pedestrian and vehicular crossing; traffic flow; and ADA accessibility.



COLERIDGE STREET NEAR-TERM COASTAL RESILIENCE DESIGN STRATEGY, OPTION A (PREFERRED), FACING NORTHEAST



COLERIDGE STREET NEAR-TERM COASTAL RESILIENCE DESIGN STRATEGY, OPTION B, FACING NORTHEAST

STORMWATER MANAGEMENT AND DRAINAGE CONSIDERATIONS

Coastal resilience infrastructure at Constitution Beach and along Coleridge Street should be designed to avoid or minimize impacts to underground utilities and pipes. Underground utilities and pipes may also be relocated, where feasible, to allow for the siting of coastal resilience infrastructure, if avoidance is not possible. The exact location of all underground utilities will need to be confirmed based on field investigations but depending on the location of the barriers, action will be needed to protect a number of storm drains and sewers located on the non-protected side of the barrier. This includes sealing manholes and installing backflow prevention where ocean water may enter catch basins at Constitution Beach or along Coleridge Street. For this reason, alignments at the water's edge at Constitution Beach and near Coleridge Street are preferred.

Where not already present, tide gates should be installed on all public and private stormwater outfalls that discharge in the focus area to prevent ocean water from traveling through the drainage system under the coastal resilience infrastructure.

A range of approaches can be explored to manage interior drainage and reduce residual risk from stormwater flooding. Drainage for the Constitution Beach focus area should be planned in conjunction with drainage needs for the larger region including the Orient Heights Rail Yard, Wood Island Marsh, and Chelsea Creek/Route 1A focus areas. Pump stations will likely be necessary but the need for pumping can be consolidated across focus areas. Additional measures beyond pump station upgrades, such as green infrastructure and conveyance improvements, may also be necessary to help manage stormwater.

COST ESTIMATES AND BENEFIT-COST ANALYSIS

NEAR-TERM COASTAL RESILIENCE STRATEGY: OPTION A COLERIDGE STREET BERM	
Estimated Cost	$2.4 - 2.7 million
Estimated Annual Operations & Maintenance	$23 thousand

NEAR-TERM COASTAL RESILIENCE STRATEGY: OPTION B COLERIDGE STREET FLOODWALL	
Estimated Cost	$6.7 - 7.5 million
Estimated Annual Operations & Maintenance	$63 thousand

LONG-TERM COASTAL RESILIENCE STRATEGY: INTEGRATED FLOOD RESILIENCE AT CONSTITUTION BEACH	
Estimated Cost	$64 - 85 million
Estimated Annual Operations & Maintenance	$700 thousand

Notes:
*Includes costs for planning, engineering, permitting, construction
*See cost estimation methodology (pg. 186-191) for more information
*Annual operations and maintenance costs are expected to be 1.0 percent of the implementation costs

STRATEGY	BENEFIT COST RATIO	
	HIGH	LOW
Near-Term	4.1	1.4
Long-Term	4.8	3.7

Notes:
*Benefit Cost Ratio includes a 3% discount rate for avoided losses
*High BCR uses low cost estimate for near- and long-term strategy; low BCR uses high cost estimate for near- and long-term strategy
*Both benefits and costs have been applied incrementally over time based on an estimated project completion schedule and sea level rise changes over time, assuming 9 inches around 2030 and 40 inches around 2070.

ORIENT HEIGHTS RAIL YARD

Orient Heights Rail Yard is located along the Belle Isle Marsh between Saratoga Street and Bennington Street adjacent to the Orient Heights MBTA Blue Line station. Owned and operated by the MBTA, the rail yard serves as the primary maintenance facility for the Blue Line. The Blue Line, which has five stations in East Boston, provides rapid public transit and connects East Boston residents to jobs, services, and other needs throughout the city and region. The MBTA is currently in the process of studying and implementing approaches to reduce risk to the Blue Line.

Building on this work, the coastal resilience strategy for the rail yard and adjacent locations focuses on approaches to link the protection of the rail yard with neighborhood-wide resilience and flood protection. The strategy is intended to lay the groundwork for ongoing collaboration between the City of Boston, the MBTA, and other stakeholders as conceptual strategies are refined for implementation.

COASTAL FLOOD RISK

Coastal flooding from the Belle Isle Marsh through the Orient Heights Rail Yard and adjacent sites presents a near-term risk to East Boston and this risk is likely to increase substantially over time. During severe storms (storms with a 1% annual chance or less of happening), flood pathways in this area are projected to overtop the coastline with 9 inches of sea-level rise anticipated around the 2030s. This flooding puts the rail yard facilities at risk, as well as the train service along the entire Blue Line.

In the longer term, with 40 inches of sea-level rise, the rail yard and Blue Line will flood with increasing frequency, potentially leading to greater disruptions in service. With 40 inches of sea-level rise during storms with a 10% or less annual chance of happening, flood pathways originating from the rail yard and surrounding sites may interact with flood pathways from the Chelsea Creek and Constitution Beach focus areas, contributing to widespread flooding in lower Orient Heights and Harbor View. This means an effective coastal resilience solution for Orient Heights Rail Yard will in part depend on resilience solutions implemented elsewhere in the study area.

RESILIENCE DESIGN STRATEGY

The coastal resilience strategy for this area is intended to provide effective coastal flood risk reduction for essential transportation infrastructure, homes, businesses, and other facilities and services across the East Boston study area. The strategy builds on-site and system-scale assessments pursued by the MBTA and was developed in coordination with MBTA staff and adjacent property owners. Refinement and implementation of the strategy will require further coordination with the MBTA.

CUMULATIVE BENEFITS OF THE RESILIENCE DESIGN STRATEGY THROUGH 2070*	
Residents protected**	669
Number of buildings protected**	92
Damages avoided***	$260 million

*calculated based on preferred long-term coastal resilience strategy
**based on 2019 residential population and buildings
***Loss avoidance based on damages quantified for this study using a 3% discount rate

COASTAL RESILIENCE STRATEGY: PERIMETER PROTECTION OF ORIENT HEIGHTS RAIL YARD

NEAR-TERM: The preferred strategy is to construct a perimeter floodwall around the rail yard that builds on the MBTA's current approaches to the site- and asset-level hardening to provide additional layers of coastal flood resilience that contribute to neighborhood-wide protection. In the near term, a segment of the perimeter flood protection can be constructed on the north side of the rail yard. The near-term segment can be designed to the interim DFE of +12.0 feet (NAVD88), which is 3 to 5 feet above the existing grade), protecting against flooding from the 1% annual chance storm with 9 inches of sea-level rise. This approach would be located on the outside of the approximately 20- to 25-foot-wide access road that currently surrounds the facility.

A floodwall is preferred due to the limited space available for other approaches with wider footprints, such as berms. The floodwall strategy effectively reduces the risk of coastal flooding while limiting disruptions to rail yard operations and encroachment in the Belle Isle Marsh.

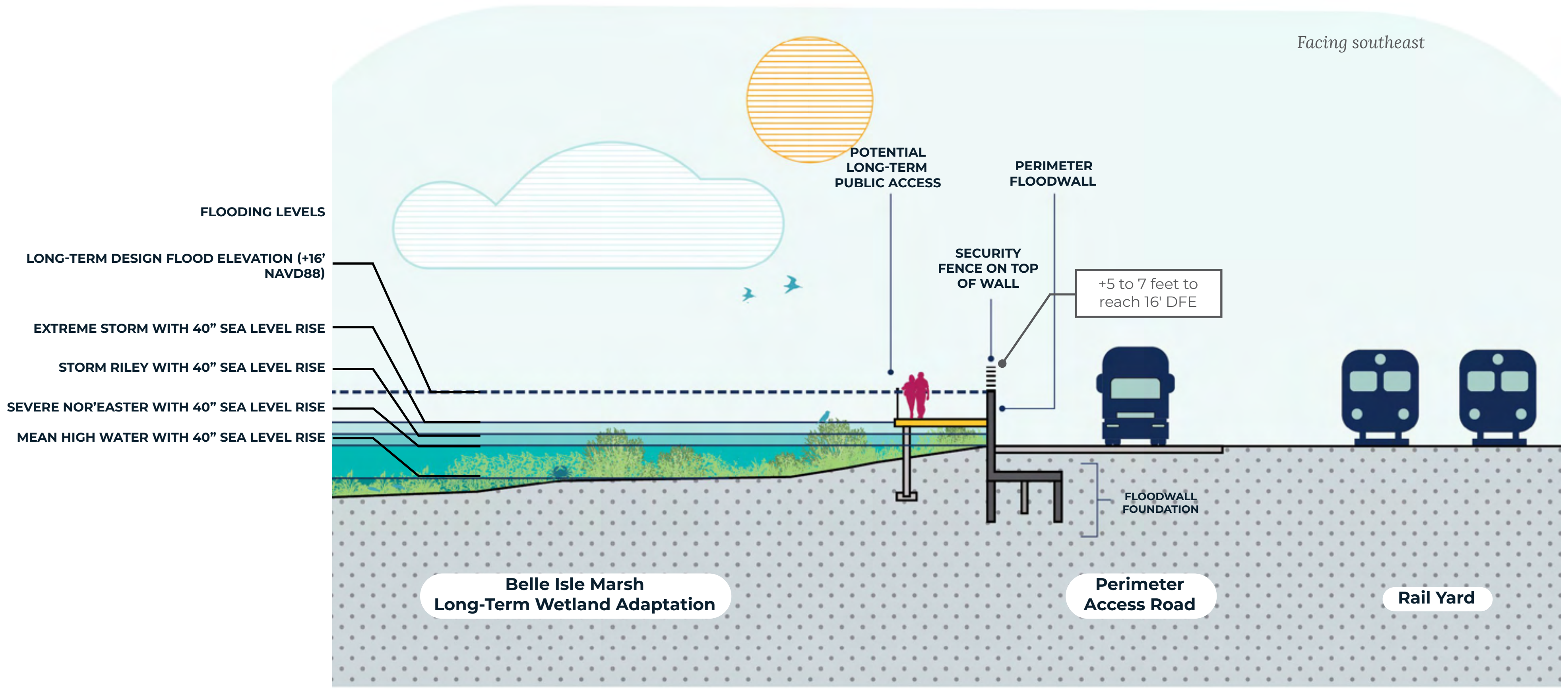
Final designs for the strategy will need to comply with MBTA design standards and operational requirements for rail yard access and security. Over time, the near-term strategy should be adapted and expanded to the long-term coastal resilience strategy to provide comprehensive coastal flood risk reduction for the facility.

LONG-TERM: In the long-term, the perimeter floodwall would be built around the full perimeter of the rail yard to the DFE of +16.0 feet (NAVD88), forming a line of coastal flood protection around the yard. The wall would extend 5 to 7 feet above the existing grade.

Pending further study, the solution could be combined with options for new public access around the rail yard or with wetland resilience approaches for the Belle Isle Marsh. Ongoing study of the Belle Isle Marsh resilience approaches may result in recommended nature-based approaches that could reduce coastal flood risk to upland areas surrounding the marsh, potentially lowering the necessary DFE for the rail yard.

The floodwall must connect to other solutions on adjacent properties to fully address the flood risk. To the north, the floodwall connects to flood protection along Austin Avenue. The approach for Austin Avenue combines raising the road and floodwalls to achieve an elevation of 16.0 feet (NAVD88) while preserving at-grade access to the rail yard. The approach along Austin Avenue is combined with multi-use pathways to provide views and access to the Belle Isle Marsh.

To the south, the floodwall would continue from the rail yard, connecting to high ground along private properties on Shawsheen Road or extending around the edge of the Belle Isle Marsh before tying into to high ground along Saratoga Street. The approaches for both north and south of the rail yard may be implemented in coordination with long-term strategies to elevate Saratoga Street and the Saratoga Street bridge to preserve access along this evacuation route for Winthrop. Depending on the tie-in option selected in this location, building-scale adaptation may be necessary for two commercial structures on Saratoga Street located outside of the floodwall.



STORMWATER MANAGEMENT AND DRAINAGE CONSIDERATIONS

The presence and exact location of underground drainage infrastructure within the Orient Heights Rail Yard should be surveyed and confirmed as part of the design for the recommended coastal resilience infrastructure. This includes a buried sewer line owned by the Massachusetts Water Resource Authority (MWRA) that extends along the southern edge of the Rail Yard conveying wastewater from East Boston to the Deer Island Waste Water Treatment Plant in Winthrop.

Where not already present, tide gates should be installed on all public and private stormwater outfalls that discharge into Belle Isle Marsh from the Rail Yard to prevent ocean water from traveling through the drainage system under the coastal resilience infrastructure.

The location of the recommended floodwall on the perimeter of the Rail Yard protects any existing drainage infrastructure and reduces the potential for coastal flooding to enter the drainage network through catch basins, manholes, and other parts of the collection system.

A range of approaches can be explored to manage interior drainage and reduce residual risk from stormwater flooding in the Rail Yard and MBTA rights-of-way. Drainage for the Orient Heights Rail Yard focus area should be planned in conjunction with drainage needs for the larger region including the Constitution Beach, Wood Island Marsh, and Chelsea Creek/Route 1A focus areas. Pump stations will likely be necessary but the need for pumping can be consolidated across focus areas. Additional measures beyond pump station upgrades, such as green infrastructure and conveyance improvements, may also be necessary to help manage stormwater.

COST ESTIMATES AND BENEFIT-COST ANALYSIS

NEAR-TERM COASTAL RESILIENCE STRATEGY: PERIMETER PROTECTION ON NORTH SIDE OF ORIENT HEIGHTS RAIL YARD	
Estimated Cost	$30 - 33 million
Estimated Annual Operations & Maintenance	$280 thousand

LONG-TERM COASTAL RESILIENCE STRATEGY: PERIMETER PROTECTION FOR ORIENT HEIGHTS RAIL YARD	
Estimated Cost	$110 - 130 million
Estimated Annual Operations & Maintenance	$1.1 million

Notes:
*Includes costs for planning, engineering, permitting, construction
*See cost estimation methodology (pg. 186-191) for information
*Annual operations and maintenance costs are expected to be 1.0 percent of the implementation cost

STRATEGY	BENEFIT COST RATIO	
	HIGH	LOW
Near-Term	3.0	2.8
Long-Term	1.8	1.6

Notes:
*Benefit Cost Ratio includes a 3% discount rate for avoided losses
*High BCR uses low cost estimate for near- and long-term strategy; low BCR uses high cost estimate for near- and long-term strategy
*Both benefits and costs have been applied incrementally over time based on an estimated project completion schedule and sea level rise changes over time, assuming 9 inches around 2030 and 40 inches around 2070.
*BCR for Orient Heights Rail Yard includes benefits associated with maintenance of service for the MBTA Blue Line. Methodology assumes loss of service for Blue Line due to coastal flood exposure through 2070 based on preliminary assessment. Further refinement of the BCA will be necessary based on a more detailed assessment of the rail yard and MBTA operations. Assumptions for loss of service used for this study are as follows: Flood depths less than 0.5 feet = 2 days loss of service; flood depths 1-2.9 feet = 90 days loss of service; flood depths 3-5.9 feet = 160 days loss of service; flood depths greater than 6 feet = 180 days of service. Loss of service values based on publicly-available data for MBTA operating cost per ride and 2019 Blue Line ridership.

CONDOR STREET AND CHELSEA STREET ALONG CHELSEA CREEK

Properties fronting Chelsea Creek from the Andrew McArdle Bridge to the Chelsea Street Bridge are at risk of fringe flooding today and will be increasingly vulnerable in the future. While this flooding is not expected to extend into the neighborhood due to the higher elevation inland from the coastline, waterfront properties in the DPA and the streets that serve these sites are at risk.

The coastal resilience strategy for this area focuses on reducing flood risks along Condor Street while adding new Harborwalk connections and encouraging the adoption of building- and site-scale adaptation approaches for water-dependent industrial uses along Chelsea Creek.

COASTAL FLOOD RISK

Coastal fringe flooding from Chelsea Creek presents a near-term risk to waterfront properties, including water-dependent uses such as the Boston Bay Marina, Channel Fish Company, and Sunoco Oil Terminal. During severe storms (storms with a 1% annual chance or less of happening), water could overtop existing bulkheads, disrupt operations at these sites, and damage buildings and assets.

Over time, with projected sea-level rise, flooding of these sites is expected to increase in depth and frequency. With 40 inches of sea-level rise, flooding from severe storms (storms with a 1% annual chance or less of happening) is projected to overtop Condor Street and Chelsea Street, threatening access along these corridors and putting adjacent buildings at risk.

RESILIENCE DESIGN STRATEGY

The coastal resilience solution for this area is intended to reduce the long-term risk of flooding to Condor Street while expanding public access along Chelsea Creek. The preferred strategy includes multiple adaptation approaches that need to be pursued together. The first option elevates the coastline along Condor Street to reduce the long-term risk of flooding on the street and to adjacent homes and businesses. For water-dependent uses located along Chelsea Creek, building- and site-scale adaptation approaches are recommended. While the DFE for this location is 16.0 feet (NAVD88), a lower DFE may be appropriate for building- and site-scale measures. A structure with a shorter expected useful life requires a lower level of protection compared to one with a longer expected useful life.

CUMULATIVE BENEFITS OF THE RESILIENCE DESIGN STRATEGY THROUGH 2070*	
Residents protected**	105
Number of buildings protected**	11
Damages avoided***	$50 million

*calculated based on preferred long-term coastal resilience strategy
**based on 2019 residential population and buildings
***Loss avoidance based on damages quantified for this study using a 3% discount rate

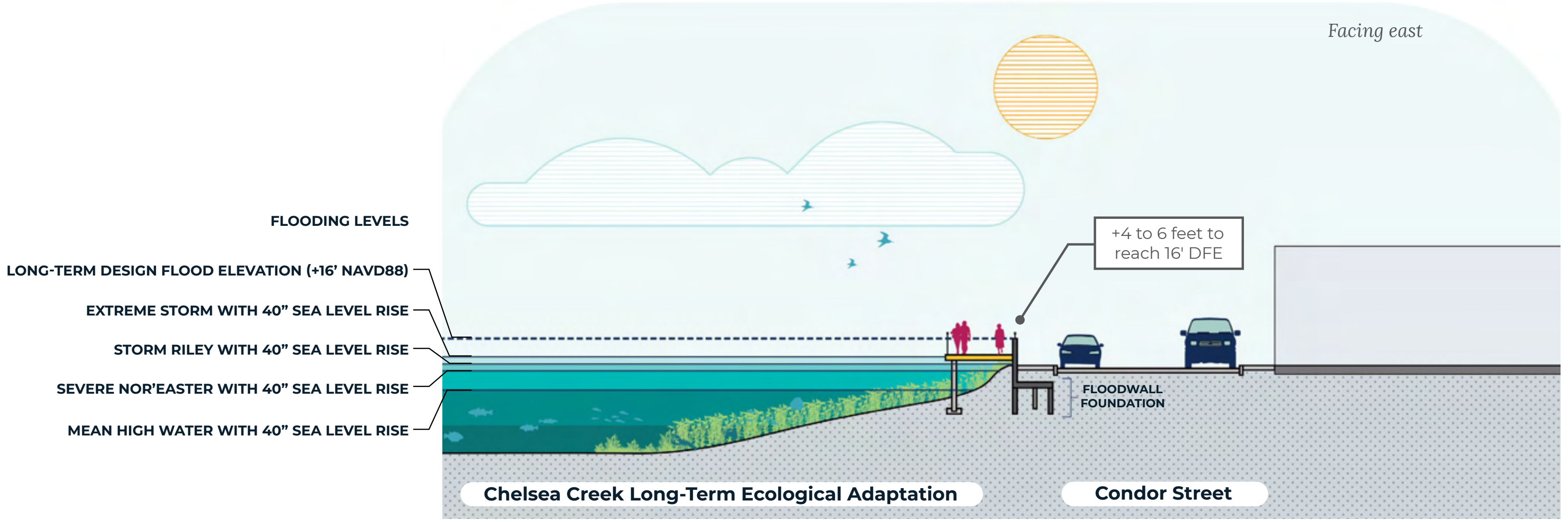
LONG-TERM COASTAL RESILIENCE STRATEGY: FLOODWALL AND HARBORWALK ALONG CONDOR STREET

Condor Street adjacent to the Condor Street Urban Wild will be at risk of fringe flooding during severe storms by the 2070s with 40 inches of sea-level rise. The coastal resilience strategy for this location raises the coastline edge along the Condor Street right-of-way by constructing a new bulkhead and floodwall in combination with a new elevated multi-use Haborwalk.

This public access pathway can serve as an extension of and connection to the open space network within Condor Street Urban Wild and, in the long term, could connect to future uses on adjacent City-owned parcels, such as the Hess site. The floodwall should reach elevation +16.0 feet (NAVD88) to provide long-term protection, which is approximately 4 to 6 feet above the existing grade.

This area is currently within the Chelsea Creek DPA, which restricts certain uses and activities along the waterfront. In the long term, the design could be combined with ecological restoration approaches in adjacent wetland areas within Chelsea Creek to improve habitat and provide additional coastal resilience benefits.

The strategy may require adding limited fill or supporting structures, such as piles, to existing waters and wetlands. Any adverse impacts can be mitigated by on-site habitat restoration. Similar wetland restoration approaches were implemented as part of the Condor Street Urban Wild and serve as a model for other areas of Chelsea Creek.



Condor Street Urban Wild. Source: City of Boston Digital Team

LONG-TERM COASTAL RESILIENCE STRATEGY: BUILDING AND SITE-SCALE ADAPTATION FOR WATER-DEPENDENT INDUSTRIAL USES IN THE CHELSEA CREEK DPA

A number of water-dependent industrial uses are located in the Chelsea Creek DPA overseen by CZM. As described in Chapter 2, *Context*, DPAs have the physical and operational features needed to support businesses that require proximity to the ocean, such as commercial fishing, shipping, marinas, and other water-related activities. Operation of these facilities often depends on unobstructed access to the water for the mooring of ships, loading and unloading of goods, and other logistics.

Given these considerations, building- and site-scale adaptation approaches are recommended for water-dependent uses along this portion of Chelsea Creek. A district-scale coastal resilience solution is not appropriate because fringe flooding along Chelsea Creek is limited to waterfront sites. Building- and site-scale approaches can be tailored to each property owner or business's specific operational and design criteria, based on site-scale risk assessments. These approaches are intended to guide businesses and property owners in developing a tailored resilience strategy for their facilities.

Recommended actions for increasing the coastal resilience of water-dependent properties and businesses include:

» Develop a detailed flood preparedness and business continuity plan that includes evacuation procedures, preparation of emergency supply kits and protocols to protect hazardous materials, and key operational actions that can be taken to reduce flood risk before a storm.

» In advance of a storm, relocate moveable assets, such as vehicles and boats, to higher elevation and/or less flood-prone areas to reduce the likelihood of damage. These assets can be moved immediately before a flood event and moved back after the flood to minimize disruption.

» Install backup systems, such as emergency generators, to provide redundant power and other critical services in case of loss of these services due to flooding.

» Where feasible, elevate mechanical systems and other assets above projected flood elevations or relocate them outside of the floodplain on the site.

» Consider capital investments, such as elevating bulkheads and seawalls around the site, elevating the overall site grade, and relocating vulnerable structures and assets out of the floodplain.

» Consider installing deployable flood barriers at doors, windows, vents, louvers, and other points where water may flow into a structure. Structures housing critical systems, equipment, and hazardous materials that cannot be relocated to a higher elevation should be prioritized for such investment.

» Install tide gates at private outfalls and consider pumps in basements and other low-lying areas to remove flood waters and manage stormwater.

» Maintain equipment and assets in a good state of repair, including coastline structures such as bulkheads and docks, and ensure hazardous materials are stored away from vulnerable areas. By practicing routine maintenance, sites will be more prepared for day-to-day challenges and have more capacity to build resilience during emergency situations.

Chelsea Creek, East Boston

STORMWATER MANAGEMENT AND DRAINAGE CONSIDERATIONS

Coastal resilience infrastructure along Condor Street should be designed to avoid or minimize impacts to underground utilities and pipes. Underground utilities and pipes may also be relocated, where feasible, to allow for the siting of coastal resilience infrastructure, if avoidance is not possible.

A storm drain outfall discharges along Condor Street next to the Condor Street Urban Wild. Evaluation of this tide gate and/or installation of a new tide gate will be necessary to avoid entry of ocean water into the storm drain during storm surge events.

A range of regional approaches can be explored to manage interior drainage and reduce residual risk from stormwater flooding along Condor Street. The recommended strategy on Condor Street can be designed to incorporate green infrastructure, such as bioswales, to reduce stormwater runoff into the drainage system. Evaluation of the need for additional pump station capacity and conveyance improvements may be necessary to help manage stormwater. Appendix B includes a summary of drainage solutions.

COST ESTIMATES AND BENEFIT-COST ANALYSIS

LONG-TERM COASTAL RESILIENCE STRATEGY: FLOODWALL AND HARBORWALK ALONG CONDOR STREET	
Estimated Cost	$69 - 77 million
Estimated Annual Operations & Maintenance	$650 thousand

Notes:
*Includes costs for planning, engineering, permitting, construction
*See cost estimation methodology (pg. 186-191) for information
*Annual operations and maintenance costs are expected to be 1.0 percent of the implementation costs

STRATEGY	BENEFIT COST RATIO	
	HIGH	LOW
Long-Term	0.7	0.6

Notes:
*Benefit Cost Ratio includes a 3% discount rate.
*High BCR uses low cost estimate for near- and long-term strategy; low BCR uses high cost estimate for near- and long-term strategy.
*Both benefits and costs have been applied incrementally over time based on an estimated project completion schedule and sea level rise changes, assuming 9 inches around 2030 and 40 inches around 2070.
*BCR results for this focus area include the avoided cost of implementing improvements to the existing bulkhead in this focus area, which would be necessary to maintain a state of good repair with or without the addition of flood protection measures or other amenities
*BCR results for this focus area reflect the long-term implementation timeline for this strategy. The addition of other benefits and extension of the project performance beyond 2070 would be expected to increase the value of monetized benefits for this focus area.
*While the BCA in this focus area is less than 1.0 as calculated, this site was indentified as an area where public realm improvements are a community priority.

WOOD ISLAND MARSH

Future coastal flooding from Wood Island Marsh will flow onto Logan International Airport and adjacent residential areas in Harbor View. This long-term flood risk is projected to occur during future storms with 40 inches of sea-level rise. While coastal flooding is not expected to extend into the neighborhood from Wood Island Marsh in the near-term, flood pathways near Maverick Square currently threaten Logan International Airport and surrounding areas. In the long term, these flood pathways can connect to flooding at Wood Island Marsh.

While not as urgently needed as in other areas of East Boston, the coastal resilience strategy for Wood Island Marsh must be completed as part of a comprehensive flood resilience plan. The strategy focuses on raising the coastline adjacent to the marsh to prevent coastal flooding from entering the airport and adjacent residential neighborhoods.

COASTAL FLOOD RISK

With 40 inches of sea-level rise, flooding during higher frequency storms (storms with a 10% annual chance or less of happening) is projected to overtop the coastline adjacent to Wood Island Marsh. While the primary source of the flood risk to Logan International Airport is Maverick Square flood pathways and other pathways from Boston Harbor, addressing the flooding from Wood Island Marsh is integral to a comprehensive, effective coastal resilience solution for the neighborhood. This strategy also reduces the long-term coastal flood risk to residences in Harbor View along Moore and Horace Streets.

RESILIENCE DESIGN STRATEGY

The coastal resilience strategy for this area is a raised berm that will reduce the long-term risk of flooding to Logan International Airport facilities and the Harbor View neighborhood. Nature-based approaches provide opportunities for additional layers of resilience through ecological restoration and adaptation within Wood Island Marsh.

CUMULATIVE BENEFITS OF THE RESILIENCE DESIGN STRATEGY THROUGH 2070*	
Residents protected**	273
Number of buildings protected**	58
Damages avoided***	$220 thousand

*calculated based on preferred long-term coastal resilience strategy
**based on 2019 residential population and buildings
***Loss avoidance based on damages quantified for this study using a 3% discount rate. Figure does not include losses avoided associated with Wood Island Marsh coastal resilience strategy in Phase 1 study area.

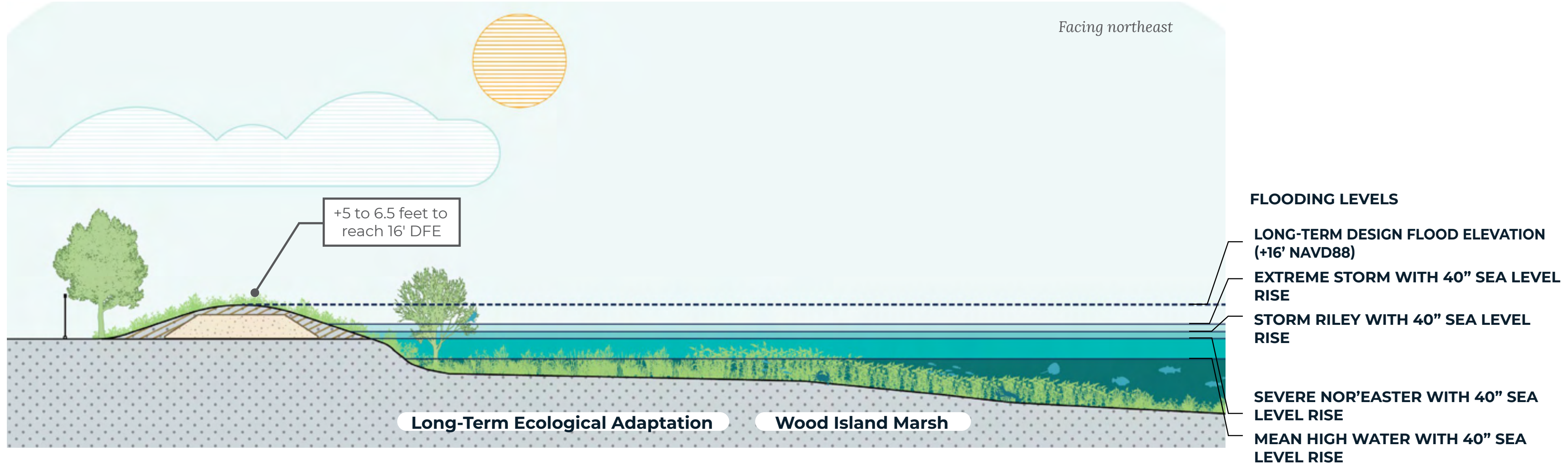
LONG-TERM COASTAL RESILIENCE STRATEGY: RAISED BERM AND ECOLOGICAL ADAPTATION IN WOOD ISLAND MARSH

The proposed coastal resilience strategy for this location includes a raised berm on the existing upland area along Wood Island Marsh to prevent the coastline from being overtopped during storms. The raised berm would connect to the high ground on Massport-owned land within the airport to the southwest and to a Massport-owned open space along Coleridge Street to the northeast. The raised berm should reach elevation +16.0 feet (NAVD88) to provide long-term protection, which is approximately 5 to 6.5 feet above the existing grade.

Due to security and safety concerns related to the airport, public access is not recommended along portions of this berm, although the berm could include opportunities for design improvements and enhanced public access along the Greenway Connector. This greenway offers alternative public access to Wood Island Marsh and connections to nearby parks, including Constitution Beach. This raised berm strategy can be combined with ecological adaptation approaches in Wood Island Marsh.

Ecological adaptation approaches can improve habitats for wildlife, promote the adaptive capacity of the marsh as sea levels rise, and provide additional coastal resilience benefits to the community by mitigating waves and erosion. The strategy may require adding fill to existing waters and wetlands, but adverse impacts can be mitigated by on-site habitat restoration.

This approach requires further study in coordination with Massport regarding appropriate adaptation measures in proximity to the airport to be mindful of Federal Airport Administration regulations and to prevent attracting certain wildlife that could pose a hazard to airport operations.



Wood Island Marsh, East Boston

STORMWATER MANAGEMENT AND DRAINAGE CONSIDERATIONS

At least two outfalls are located in the Wood Island Marsh focus area. Where not already present, tide gates should be installed on these and any other private or Massport-owned stormwater outfalls that discharge into Belle Isle Marsh to prevent ocean water from traveling through the drainage system under the coastal resilience infrastructure.

A range of regional approaches can be explored to manage interior drainage and reduce residual risk from stormwater flooding in the Wood Island Marsh focus area, including Logan Airport. Drainage for this focus area should be planned in conjunction with drainage needs for the larger region including the Constitution Beach, Wood Island Marsh, and Chelsea Creek/Route 1A focus areas. Coordination with Massport will be necessary to further evaluate the need for additional drainage measures to mitigate stormwater flooding within the airport. Pump stations will likely be necessary but the need for pumping can be consolidated across focus areas. Additional measures beyond pump station upgrades, such as green infrastructure and conveyance improvements, may also be necessary to help manage stormwater.

COST ESTIMATES AND BENEFIT-COST ANALYSIS

While this study provides estimated project costs for coastal resilience solutions for the Wood Island Marsh strategy, project-specific benefits are not estimated for this focus area, since the majority of the benefits accruing from the strategy are located outside of the study area. Non-quantified benefits of long-term actions in this focus area include protection of airport facilities, maintenance of airport operations, and volumetric reductions to flooding in East Boston, which would reduce risk to numerous homes, businesses, and community services located from Day Square to Maverick Square.

LONG-TERM COASTAL RESILIENCE STRATEGY: RAISED BERM AND ECOLOGICAL ADAPTATION IN WOOD ISLAND MARSH	
Estimated Cost	$10 - 11 million
Estimated Annual Operations & Maintenance	$94 thousand

Notes:
*Includes costs for planning, engineering, permitting, construction
*See cost estimation methodology (pg. 186-191) for more information
*Annual operations and maintenance costs are expected to be 1.0 percent of the implementation costs

COASTAL RESILIENCE SOLUTIONS FOR CHARLESTOWN

Charlestown's diverse coastline will be affected by coastal flood risk in different ways. Each segment of the coastline presents unique opportunities and options for the resilience approaches that can be constructed. The solutions presented in this chapter address coastal flood risk across the entire Charlestown study area through a variety of flood resilience strategies.

The Charlestown study area is divided into four focus areas. The focus areas are key locations along the Charlestown coastline where flood pathways connect and lead to widespread flooding in the neighborhood. Consequently, resilience solutions in the focus areas depend on each other to successfully reduce long-term coastal flood risk across Charlestown.

BOSTON NATIONAL HISTORICAL PARK AND CONSTITUTION WHARF

This focus area extends along the southwestern portion of the Navy Yard waterfront from the National Park Service's (NPS) Boston National Historical Park to the DCR-owned and operated Paul Revere Park and the new Charles River Dam. Resilience solutions here include options for floodwalls combined with walkways and a raised Harborwalk. The strategy will be developed iteratively with the NPS to implement resilience measures for the National Historical Park.

CHARLESTOWN NAVY YARD

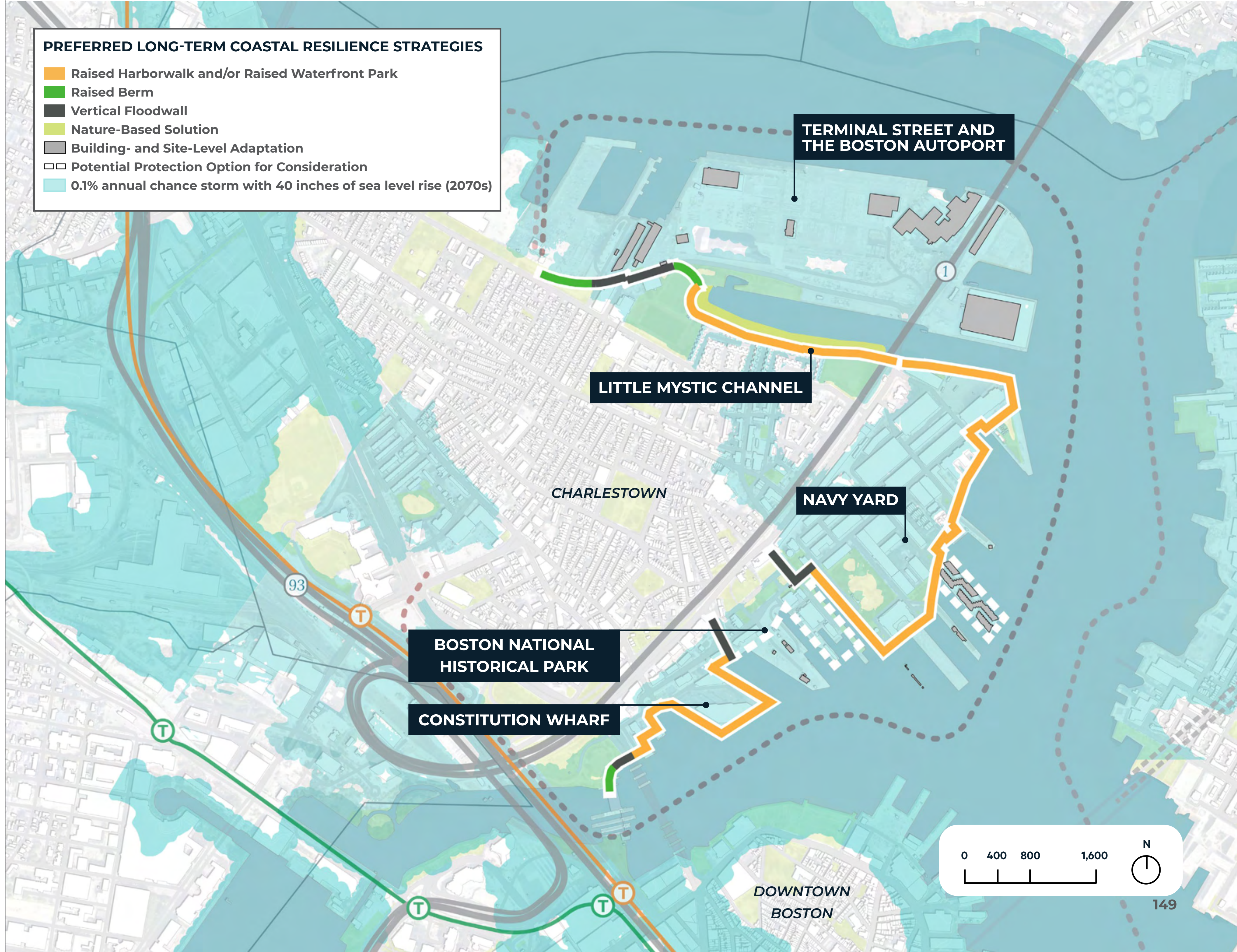
This focus area extends along the waterfront from the Chelsea Street bridge at the northeastern edge of the Navy Yard to 5th Street at the southwestern edge of the Navy Yard. Resilience solutions here include options for elevating the Harborwalk or raising 1st Avenue in conjunction with building-level adaptation along the waterfront.

LITTLE MYSTIC CHANNEL

This focus area extends along the Little Mystic Channel waterfront from Barry Field and the Tobin Memorial Bridge, past the Charlestown Community Center and Little Mystic Boat Ramp, to high ground on the Lower Mystic Greenway. Resilience solutions here include options for a redesigned coastline and raised Harborwalk with improved public spaces to protect affordable housing developments and local amenities.

TERMINAL STREET AND THE BOSTON AUTOPORT

This focus area includes the waterfront along Terminal Street and the Autoport. Resilience solutions here focus on building- and site-level adaptations for water-dependent industrial uses. Options for perimeter protection at the Autoport are also suggested but will require further coordination between the City, Massport, and Autoport businesses.



BOSTON NATIONAL HISTORICAL PARK AND CONSTITUTION WHARF

This focus area extends along the southwestern portion of the Navy Yard waterfront from the Boston National Historical Park to the DCR-owned and operated Paul Revere Park and the new Charles River Dam. The focus area includes a mix of offices, institutions, and parks, along with several piers and marinas.
Much of the waterfront in this focus area consists of hardened bulkhead structures that were erected to enable ship mooring and protect the coastline from erosion. The Boston National Historical Park is a major landmark and destination, including the USS Constitution Museum, the USS Cassin Young, and a historic park dedicated to the history of Naval shipbuilding.

The coastal resilience strategy in this area includes multiple options for elevating the coastline in different locations while enhancing the Harborwalk. It also includes recommendations for further planning for coastal resilience for the Boston National Historical Park.

COASTAL FLOOD RISK

The elevation of land between the water and Chelsea Street is low-lying and relatively flat, except for Constitution Wharf, which has a ground elevation that is generally 2 to 3 feet higher than the surrounding ground. The Boston National Historical Park property is particularly low-lying. Several flood pathways that exist today enter Charlestown at this location and contribute to flooding elsewhere in the neighborhood.

By the 2030s, fringe flooding resulting from a 1% annual chance storm is projected to overtop the coastline, which will cause inundation across the focus area. This flooding could affect access along Constitution Road and 1st Avenue, as well as adjacent buildings. All buildings in the Boston National Historical Park would be at risk of flooding.

In the longer term, the threat of coastal flooding becomes more pronounced. Flooding from frequent storms and annual high tides will overtop the Harborwalk and flow along Constitution Road and 1st Avenue. During more severe storms with a 1% annual chance or less of occurring, coastal flooding will connect between the northern and southern portions of the Navy Yard, leading to widespread flood risk in the future.

RESILIENCE DESIGN STRATEGY

Due to the complexity and cost of constructing coastal resilience solutions in the Navy Yard and at Constitution Wharf, two strategic options are presented in this study. Implementation of either option will mitigate impacts from a 1% annual chance flood with 40 inches of sea-level rise; however, each will require different levels of investment in building scale adaptation. The process of determining which option can be implemented will require continued engagement between the City, the NPS, Massport, residents of the Navy Yard, and other property owners. Although flood pathways from this area connect over time with flood pathways from the northern portion of the Navy Yard, solutions for both areas are designed to be independently effective of each other.

CUMULATIVE BENEFITS OF THE RESILIENCE DESIGN STRATEGY THROUGH 2070*	
Number of buildings protected**	33
Damages avoided***	$97 million

*calculated based on preferred long-term coastal resilience strategy
**based on 2019 residential population and buildings, including buildings within the Boston National Historical Park
***Loss avoidance based on damages quantified for this study using a 3% discount rate. Does not include avoided losses for structures within the Boston National Historical Park

LONG-TERM COASTAL RESILIENCE STRATEGY: RAISED HARBORWALK INLAND OR AT WATER'S EDGE

OPTION A (PREFERRED): The preferred approach for Constitution Wharf and adjacent areas extends the strategy from the Navy Yard focus area by integrating flood protection into the Harborwalk to the long-term DFE of 15.5 feet NAVD88. This forms a continuous line of coastal flood protection along the waterfront from the new Charles River Dam and Paul Revere Park, under the North Washington Street bridge, and to the Boston National Historical Park. This long-term strategy involves increasing the elevation of the Harborwalk by approximately 4 to 7.5 feet above the existing grade, including the connection of the dam to Paul Revere Park and the district-level resilience strategy for Charlestown.

The design of the raised Harborwalk can help mitigate visual impacts by incorporating accessible sloped ramps, terraced seating, new park space, gates for waterside access, and other amenities to integrate the raised edge with the surrounding landscape.

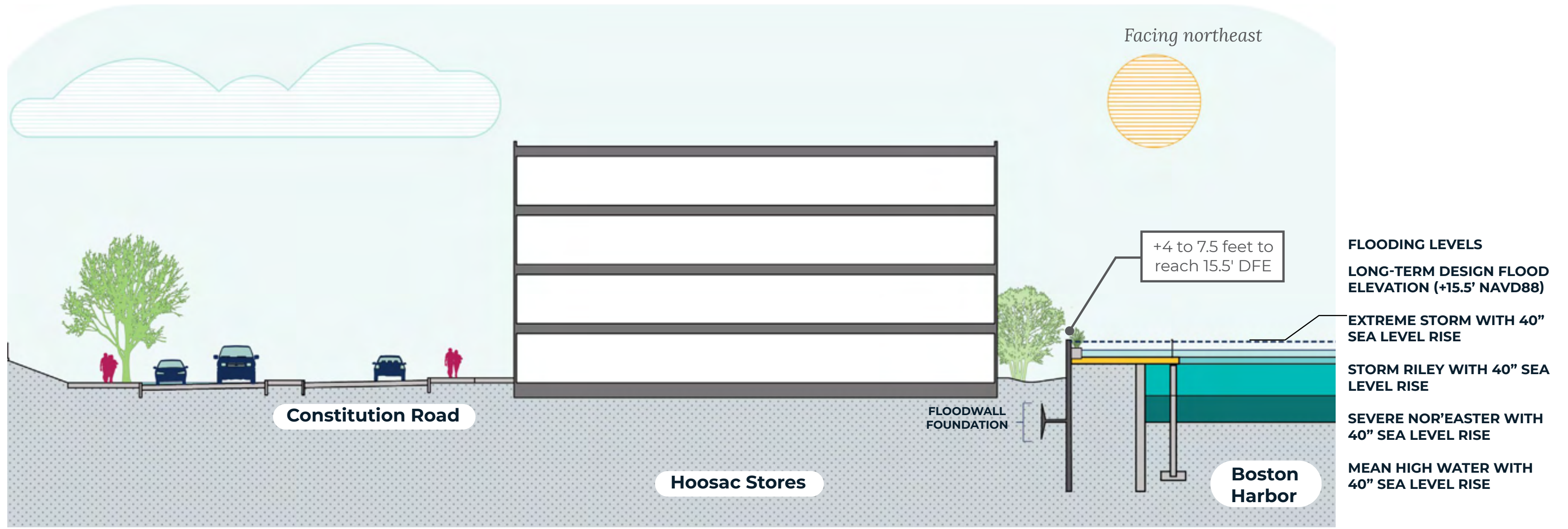
Piers and water-dependent uses that are located over-water outside of the Harborwalk, such as marinas, will need to implement adaptation measures at the building and site scale to reduce coastal flood risks. Vehicular gates and ADA-accessible up-and-over ramps can provide access over the raised Harborwalk to uses located on the waterside.

While technical considerations may make raising the Harborwalk costly and challenging, the consequences of not doing so would mean implementing an alternative option that provides less protection to buildings and infrastructure. Abutting property owners will need to play a leading role in developing and implementing this strategy.

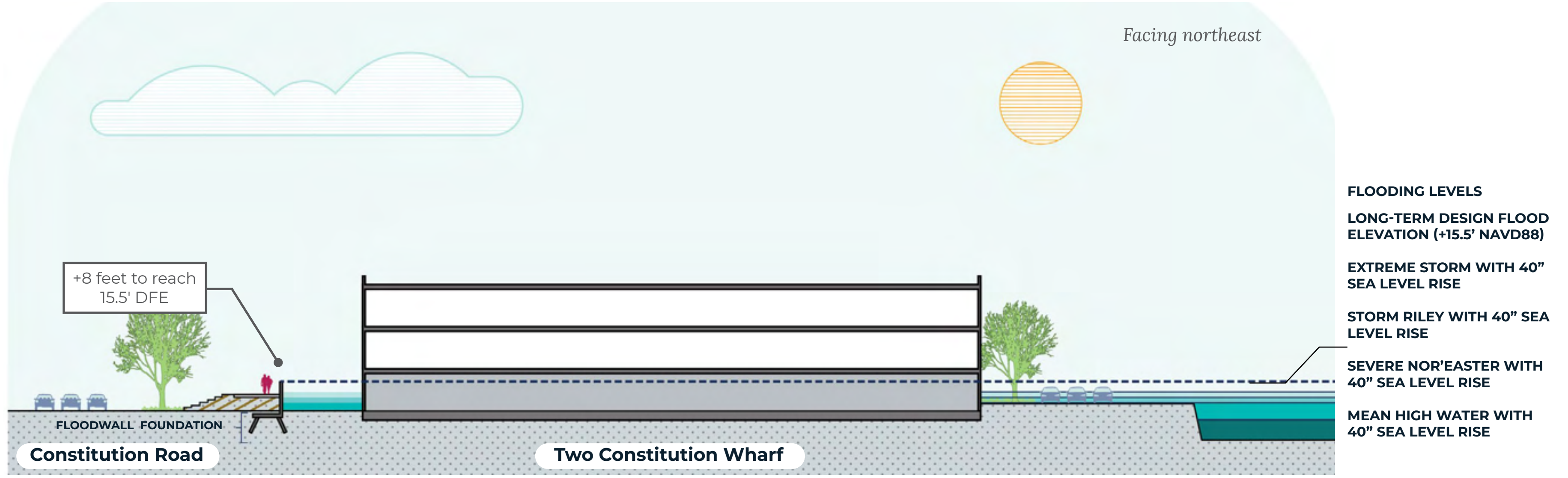
The connection of this strategy with the Boston National Historical Park property will require further study and coordination with the NPS and the U.S. Department of Defense. Ongoing master planning for the park by these federal agencies provides an opportunity to incorporate flood resilience into the design of the Boston National Historic Park and to align with the City's plans for coastal resilience infrastructure in the Navy Yard. NPS planning efforts are considering marine infrastructure improvements, near-term use of deployable flood barriers, concepts to connect to an elevated Harborwalk, and sustainable design for any new buildings.

OPTION B: An alternative option follows a similar approach but along a different alignment by extending a raised floodwall and walkway at the base of Constitution Wharf. This approach would form a line of protection from the Boston National Historical Park to the Harborwalk at Constitution Road. This alternative option would address long-term flooding that is projected to cross Chelsea Street and reach more inland portions of Charlestown with 40 inches of sea-level rise estimated around 2070. This floodwall could be placed at the water's edge or along Constitution Road. The floodwall is raised to 15.5 feet (NAVD88), which is approximately 8 feet above the current grade. The appearance of floodwalls can be improved with planters, public art, seating, and other aesthetic strategies.

If this option is advanced, structures located on Constitution Wharf will require building-level adaptation to address long-term flood risk. A range of options for building-level adaptation is provided by the BPDA's *Coastal Flood Resilience Design Guidelines*, including temporary walls surrounding buildings; deployable gates at entryways, windows, and other entry points; and the elevation of critical utilities and systems above flood levels.



CONSTITUTION WHARF PREFERRED COASTAL RESILIENCE DESIGN STRATEGY, SHOWING LONG-TERM DFE OPTION A (PREFERED), FACING NORTHEAST



CONSTITUTION WHARF OPTIONAL COASTAL RESILIENCE DESIGN STRATEGY, SHOWING LONG-TERM DFE OPTION B, FACING NORTHEAST

BUILDING-LEVEL ADAPTATION

STORMWATER MANAGEMENT AND DRAINAGE CONSIDERATIONS

Stormwater and sanitary sewers on Constitution Wharf are conveyed toward Constitution Road before being released to the ocean via outfalls located to the south of the wharf. If Option B is advanced, catch basins and manhole covers east of the road could allow ocean water to travel under the barrier during storm surge events. This makes implementation of the Constitution Road alignment more complex and less preferable due to the need to mitigate these drainage pathways through backflow prevention and sealing manholes.

The foundations for coastal resilience infrastructure, whether located on the Harborwalk or inland, must be designed to avoid or minimize impacts to underground utilities and pipes. Underground utilities and pipes may also be relocated, where feasible, to allow for the siting of coastal resilience infrastructure, if avoidance is not possible.

Tide gates should be installed on all public and private stormwater outfalls that discharge into the Harbor to prevent ocean water from traveling through the drainage system under the coastal resilience infrastructure.

A range of regional approaches can be explored to manage interior drainage and reduce residual risk from stormwater flooding in the Navy Yard. One or more new pumping stations may need to be installed in the focus area to help manage stormwater. Additional measures beyond pump stations, such as green infrastructure and conveyance improvements, may also be necessary to help manage stormwater.

COST ESTIMATES AND BENEFIT-COST ANALYSIS

OPTION A RAISED HARBORWALK	
Estimated Cost	$130 - 140 million
Estimated Annual Operations & Maintenance	$1.2 million

OPTION B FLOODWALL IN MEDIAN OR AT WATER'S EDGES	
Estimated Cost	$78 - 88 million
Estimated Annual Operations & Maintenance	$730 thousand

Notes:
*Includes costs for planning, engineering, permitting, construction
*See cost estimation methodology (pg. 186-191) for more information
*Annual operations and maintenance costs are expected to be 1.0 percent of the implementation costs

STRATEGY	BENEFIT COST RATIO	
	HIGH	LOW
Near- and Long-Term	1.0	0.5

Notes:
*Benefit Cost Ratio includes a 3% discount rate for avoided losses
*High BCR uses low cost estimate for near- and long-term strategy; low BCR uses high cost estimate for near- and long-term strategy
*Both benefits and costs have been applied incrementally over time based on an estimated project completion schedule and sea-level rise changes over time, assuming 9 inches around 2030 and 40 inches around 2070.

CHARLESTOWN NAVY YARD

This focus area extends along the waterfront from the Chelsea Street bridge at the northeastern edge of the Navy Yard to 5th Street at the southwestern edge of the Navy Yard. The area includes a mix of private residential buildings, offices, medical institutions, and parks as well as several piers and marinas that extend into the Boston Harbor. A central feature of the Navy Yard is the Harborwalk, which provides continuous public access along the entire Navy Yard waterfront. The coastal resilience strategy in this area focuses on reducing risk to a significant portion of the neighborhood by addressing several flood pathways from Boston Harbor while enhancing public access along the waterfront.

COASTAL FLOOD RISK

Once home to an active naval shipyard, much of the waterfront in the Navy Yard consists of hardened bulkhead structures that were erected to enable ship mooring and protect the coastline from erosion. The elevation of land along the waterfront in the Navy Yard is relatively flat. As sea levels rise, this creates challenges because once floodwaters overtop the existing coastline edge, they flow inland and affect a large portion of the area.

The Navy Yard is exposed to fringe flooding today along the Harborwalk from severe coastal storms with a 1% annual chance of happening. With 9 inches of sea-level rise, flood pathways resulting from a 1% annual chance storm are projected to overtop the coastline in several locations along the waterfront and flow along low-lying streets into the neighborhood. This flooding will affect access along 8th, 9th, 13th, and 16th Streets, as well as 1st Avenue. Buildings along these streets could experience flooding on the first floors and in basements.

In the long-term, with sea-level rise projected to occur around 2070, flooding from frequent storms will overtop the Harborwalk and flow throughout the Navy Yard. During severe storms in the future, flood pathways from the Navy Yard flow inland across Chelsea Street and could connect with flooding from Little Mystic Channel along Bunker Hill Street and Tufts Streets. This means an effective coastal resilience solution for the Navy Yard focus area will in part depend on resilience solutions implemented along Little Mystic Channel.

RESILIENCE DESIGN STRATEGY

The coastal resilience solution for this focus area is intended to provide effective flood risk reduction in the near- and long-term while enhancing public access and providing opportunities for new waterfront amenities. As a result of the complexity of constructing coastal resilience solutions in the Navy Yard, two strategic options are presented. Implementation of either option will mitigate impacts from a 1% annual chance flood with 40 inches of sea-level rise; however, each will require different types and scales of investment. Implementation will require continued engagement between the City and Navy Yard property owners.

CUMULATIVE BENEFITS OF THE RESILIENCE DESIGN STRATEGY THROUGH 2070*	
Residents protected**	3,134
Number of buildings protected**	110
Damages avoided***	$550 million

* calculated based on preferred long-term coastal resilience strategy
**based on 2019 residential population and buildings
***Loss avoidance based on damages quantified for this study using a 3% discount rate

LONG-TERM COASTAL RESILIENCE STRATEGY: RAISED HARBORWALK

The Harborwalk is a cherished community amenity that extends along the Charlestown Navy Yard waterfront and provides public access between several public parks and water-borne transportation facilities, businesses, residences, and marinas. As a public right-of-way located at the water's edge, the Harborwalk is both highly exposed to the impacts of sea-level rise and presents an opportunity to create a resilient coastal edge.

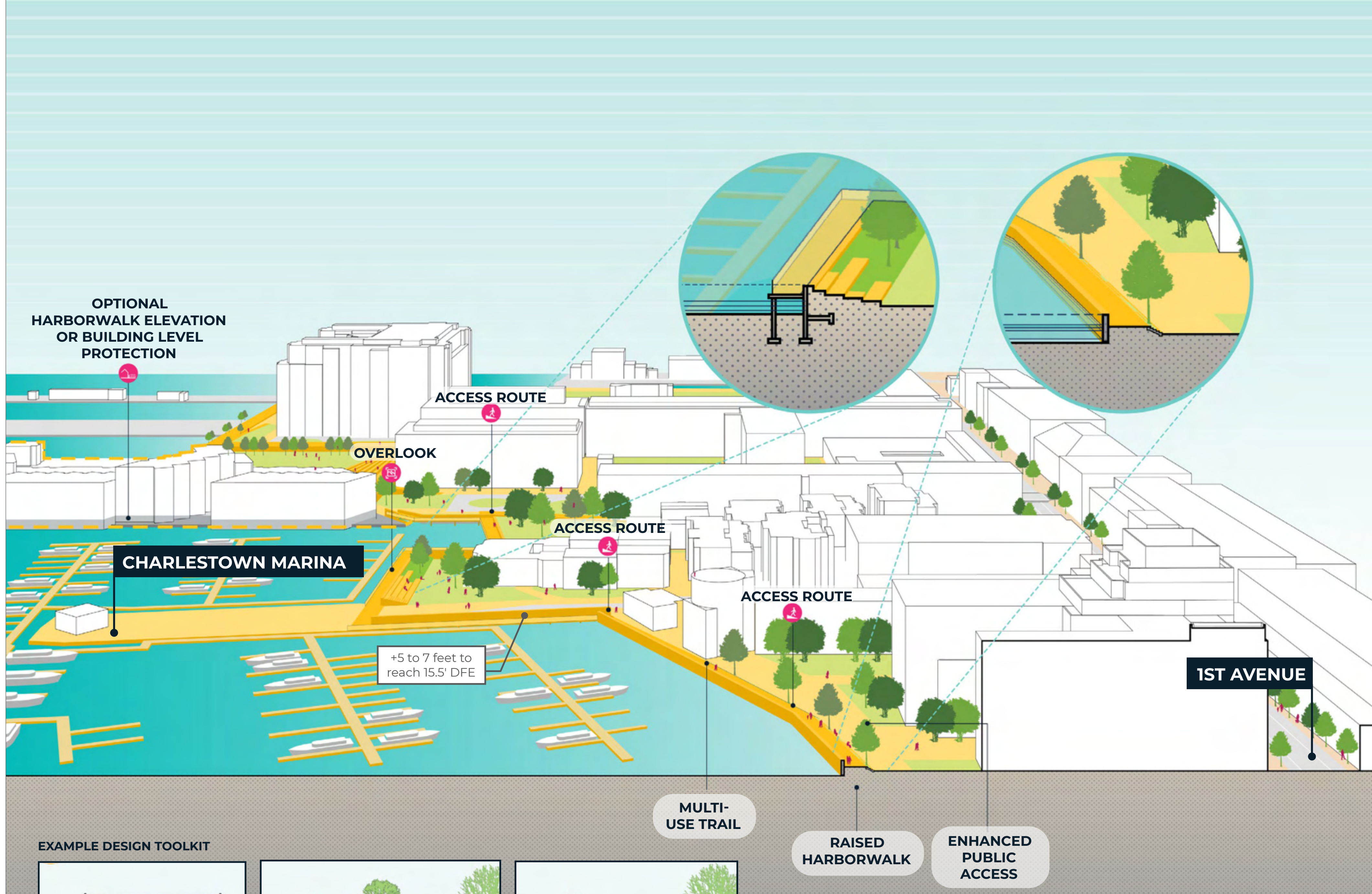
OPTION A (PREFERRED): The preferred coastal resilience strategy for the Navy Yard is to raise the Harborwalk from its current elevation to the DFE of 15.5 feet (NAVD88) to form a continuous line of coastal flood protection along the waterfront from the Chelsea Street Bridge beneath the Tobin Memorial Bridge to the Boston National Historical Park. This involves raising the elevation of the Harborwalk by approximately 5 to 7 feet above the existing grade along the waterfront. Maintaining access to water-side uses is critical so vehicular gates and Americans with Disabilities Act (ADA)-accessible ramps would be installed at key locations, such as the access to residences on Constellation Wharf (Pier 7) and marinas. The approach would reduce the risk of coastal flooding throughout the Navy Yard from a 1% annual chance storm with 40 inches of sea-level rise.

Raising the Harborwalk helps reduce the risk of coastal flooding in Charlestown and ensures the Harborwalk remains accessible into the future but will also alter views of the water from the existing ground level in the Navy Yard. **The design of the raised Harborwalk can help mitigate visual impacts by incorporating accessible sloped ramps and steps, terraced seating, new park space, shade structures, gates for waterside access, play structures for children, and other amenities to integrate the raised edge with the surrounding landscape** (examples illustrated in the design toolkit to the right). Addressing potentially undesirable visual impacts of the raised Harborwalk will require innovative design that incorporates new amenities that the community needs and wants.

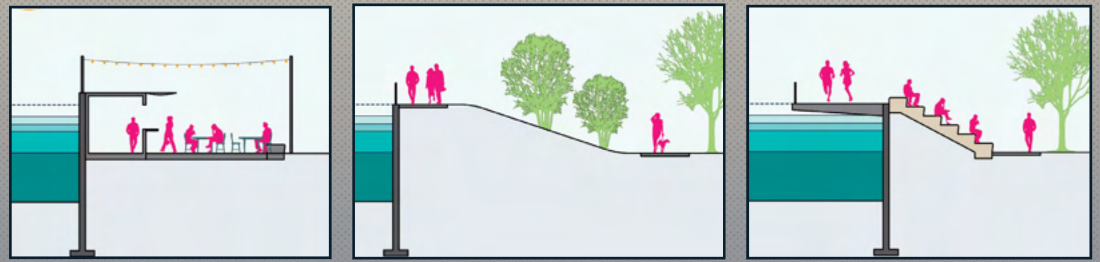
In some portions of the Harborwalk, there is limited space between existing buildings and the water, restricting the ability to design a new pathway to serve as flood protection. In these locations, raising the Harborwalk may require constructing a new bulkhead just outside of the existing bulkhead or extending the Harborwalk over the water on piles. Future phases of work will need to include site surveys and technical assessments of the conditions of the existing bulkheads to determine where structural upgrades and improvements may be necessary and feasible.

Implementing this option will also require collaboration between the City and waterfront property owners. More than half of the area is under private ownership. As property owners and beneficiaries of the project, these private property owners will need to play a leading role, in coordination with city and state agencies, to further develop this coastal resilience solution.

Raising the Harborwalk is a substantial project that will take many years to plan, design, and construct. Since coastal flooding is a near-term risk for the Navy Yard, certain segments of the Harborwalk may be advanced to implementation sooner than others because they can help close near-term flood pathways. **In particular, sections of the Harborwalk fronting Charlestown Naval Shipyard Park, at the ends of 13th and 16th Streets, and adjacent to the property at 114 16th Street, would need to be implemented by 2030.** Raising these sections of the Harborwalk in the near term will help reduce the risk of coastal flooding from severe storms with 9 inches of sea-level rise while other sections of the Harborwalk are being planned and designed.



EXAMPLE DESIGN TOOLKIT



TERRACED SEATING AND BOARDWALK SLOPED BERM WITH ELEVATED PATHWAY PATIO SPACE WITH FLOODWALL

LONG-TERM COASTAL RESILIENCE STRATEGY: 1ST AVENUE MEDIAN FLOODWALL

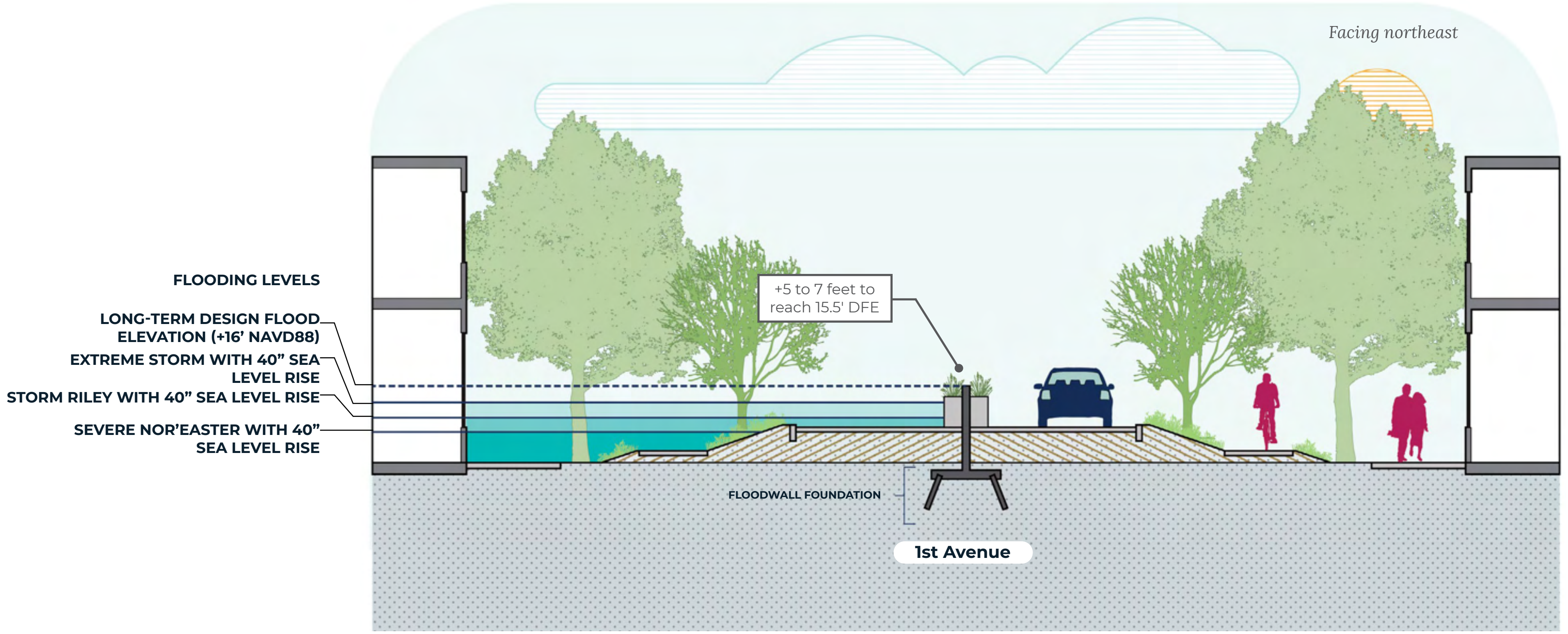
OPTION B: Raising the Harborwalk is the preferred solution for the Navy Yard because of the significant flood risk reduction and other public benefits it offers. However, the cost and complexity of this option will require ongoing study and stakeholder engagement. Similar to Atlantic Avenue in *Coastal Resilience Solutions for Downtown and the North End*, 1st Avenue is the next closest publicly-owned right-of-way to the Navy Yard waterfront (after the Harborwalk) and is another location where a district-scale flood protection strategy could be implemented. If elevating the Harborwalk is not pursued, an alternative option along 1st Avenue would address long-term flooding that is projected to cross Chelsea Street and reach more inland portions of Charlestown with 40 inches of sea-level rise anticipated by the 2070s.

A strategy in this location could include a median floodwall combined with a raised roadway and protected bike lanes that would form a line of protection extending from 16th Street to 5th Street (approximately 2,000 feet long). The median floodwall would reach 15.5 feet (NAVD88), which is approximately 5 to 7 feet above the current grade of 1st Avenue, depending on the location. By elevating the road in conjunction with the median floodwall, the height of the median floodwall would appear much lower when viewed from the ground level while creating a new public realm experience with separated pathways for pedestrians and bicycles. Locating the flood wall in the roadway median would reduce the need for gates and other active elements at intersections and allow the barrier to be integrated seamlessly into the roadway design.

This strategy would require reimagining 1st Avenue through a careful study by the City with consideration of access to businesses, institutions, and residences in the Navy Yard; pedestrian and vehicular crossing; traffic flow; parking; and ADA accessibility. The need to maintain vehicular circulation within the area will require rethinking traffic patterns and access points, as well as evaluating the future of the existing parking lanes that line both sides of 1st Avenue to potentially create more space for grade changes, protected bike lanes, green infrastructure for stormwater management, and other public realm enhancements. The appearance of the median floodwall can be improved with planters, public art, and other aesthetic strategies.

The approach would connect to a raised Harborwalk protecting Spaulding Rehabilitation Hospital on the east and to the high ground adjacent to the NPS's Boston National Historical Park on the west. This long-term option reduces the risk of coastal flooding to portions of the Navy Yard and the Charlestown neighborhood from a 1% annual chance storm with 40 inches of sea-level rise but does not provide the same level of district-scale protection as raising the Harborwalk.

Under this option, structures located south and east of 1st Avenue will require separate building-level adaptation to address near- and long-term flood risk. A range of options for building-level adaptation is provided by the BPDA's *Coastal Flood Resilience Design Guidelines*, including temporary walls surrounding buildings, deployable gates at entryways, windows, and other entry points, and elevation of critical utilities and systems above flood levels. See page 91 for more information.



COASTAL RESILIENCE FOR PIERS, MARINAS, AND WATER-DEPENDENT USES

While the raised Harborwalk approach protects the majority of the buildings and infrastructure in the Navy Yard, buildings on piers and water-dependent uses, such as marinas, that may be located outside of the Harborwalk, will need to implement separate measures at the building- and site-scale to reduce coastal flood risks.

Constellation Wharf (also known as Pier 7) is unique among the piers lining the Navy Yard waterfront because it includes approximately 63 residences. Built in 1958 for repairing ships, Constellation Wharf is constructed over water and is supported by over 950 steel and concrete piles. The site includes six, three-story buildings, added to the pier in 1986, with parking located on the concrete deck. The Constellation Wharf Condominium Association has taken numerous steps to assess the resilience of the wharf and maintain the structure in a good state of repair.

The design of the wharf includes features that reduce the risk of flood damage in the near term, including residences that are located at least 3 to 4 feet above the elevation of the wharf deck, with other units located even higher. While some essential utilities are located at lower elevations near the deck, the Constellation Wharf Condominium Association has carefully mapped these locations and is studying options for protecting them.

The risk from near-term flooding is comparatively low for Constellation Wharf, but in the long term, these risks may increase with sea-level rise. Due to the regulatory and technical constraints of adapting an over-water structure like Constellation Wharf, the range of possible resilience solutions will be different from those proposed for other on-land areas of Charlestown.

The Constellation Wharf Condominium Association is beginning the process of developing a climate adaptation plan based on a detailed evaluation of technical approaches, which may draw on a range of options including perimeter floodwalls and floodproofing of vulnerable spaces or, in the long-term, elevation or relocation of some uses. Implementing the solution will require continued engagement with Navy Yard property owners.

CHAPTER 91: THE MASSACHUSETTS PUBLIC WATERFRONT ACT

Chapter 91 protects the public's right to access and use the Commonwealth's tidelands and waterways. The Public Waterfront Act was the driving force for the development of the Boston Harborwalk extending around much of the city's coastline and a hallmark of the Charlestown Navy Yard waterfront. Chapter 91 and the regulations present in 310 CMR 9.00 identify the State of Massachusetts as the regulating body for the construction, dredging, and filling of coastal and inland waterways.

These activities in waterways require a license from MassDEP and, in some cases, review under the Massachusetts Environmental Policy Act (MEPA). Projects that do not meet the standards for approval under the regulations can seek a variance under 310 CMR 9.21. Changes to alter the Harborwalk in Charlestown for flood resilience will require new or amended Chapter 91 licenses.

STORMWATER MANAGEMENT AND DRAINAGE CONSIDERATIONS

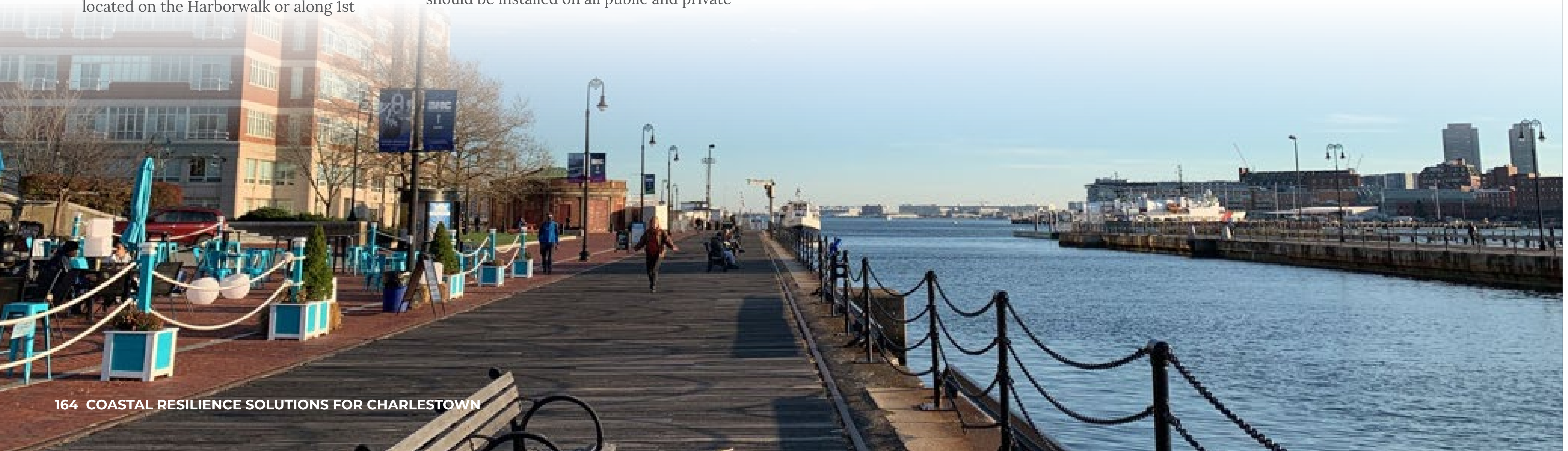
Stormwater throughout the Navy Yard is conveyed to a large drainage pipe under 1st Avenue before being released to the ocean via outfalls located on the northern and southern ends of 1st Avenue. If Option B is advanced, catch basins and manhole covers east of 1st Avenue could allow ocean water to travel under the barrier during storm surge events. This makes implementation of the 1st Avenue alignment more complex and less preferable due to the need to mitigate these drainage pathways through backflow prevention and sealing manholes.

Coastal resilience infrastructure, whether located on the Harborwalk or along 1st Avenue, must be designed to avoid or minimize impacts to underground utilities and pipes. Underground utilities and pipes may also be relocated, where feasible, to allow for the siting of coastal resilience infrastructure, if avoidance is not possible.

If applicable, the design of the raised 1st Avenue should focus on stormwater collection systems toward the west, away from the Harbor, to avoid the need for the placement of stormwater outfalls or drainage openings in the median floodwall.

Where not already present, tide gates should be installed on all public and private stormwater outfalls that discharge into the Harbor to prevent ocean water from traveling through the drainage system under the coastal resilience infrastructure.

A range of regional approaches can be explored to manage interior drainage and reduce residual risk from stormwater flooding in the Navy Yard. One or more new pumping stations may need to be installed in the focus area to help manage stormwater. Additional measures beyond pump stations, such as green infrastructure and conveyance improvements, may also be necessary to help manage stormwater.



COST ESTIMATES AND BENEFIT-COST ANALYSIS

NEAR-TERM COASTAL RESILIENCE STRATEGY: RAISED HARBORWALK AT PRIORITY LOCATIONS	
Estimated Cost	$95 - 110 million
Estimated Annual Operations & Maintenance	$890 thousand

LONG-TERM COASTAL RESILIENCE STRATEGY: RAISED HARBORWALK (OPTION A)	
Estimated Cost	$230 - 260 million
Estimated Annual Operations & Maintenance	$2.2 million

LONG-TERM COASTAL RESILIENCE STRATEGY: RAISED 1ST AVENUE (OPTION B)	
Estimated Cost	$130 - 150 million
Estimated Annual Operations & Maintenance	$1.2 million

Notes:
*Includes costs for planning, engineering, permitting, construction
*See cost estimation methodology (pg. 186-191) for more information
*Annual operations and maintenance costs are expected to be 1.0 percent of the implementation costs

STRATEGY	BENEFIT COST RATIO	
	HIGH	LOW
Near-Term	1.4	1.3
Long-Term	2.0	1.7

Notes:
*Benefit Cost Ratio includes a 3% discount rate for avoided losses
*High BCR uses low cost estimate for near- and long-term strategy; low BCR uses high cost estimate for near- and long-term strategy
*Both benefits and costs have been applied incrementally over time based on an estimated project completion schedule and sea level rise changes over time, assuming 9 inches around 2030 and 40 inches around 2070.

LITTLE MYSTIC CHANNEL

This focus area extends along the Little Mystic Channel waterfront from Barry Field and the Chelsea Street bridge, past the Charlestown Community Center and Little Mystic boat ramp, to high ground on the Lower Mystic Greenway. The waterway is a unique urban waterway that extends inland approximately 3,000 feet from the Boston Harbor. The channel is lined by hardened bulkheads with public access along the Harborwalk, which extends around the Little Mystic Channel to the Little Mystic boat ramp. The coastline around Little Mystic Channel consists of several parks, athletic fields, and the Sprouts Community Garden, as well as residences at the Cooperatives of CharlesNewtown. The Little Mystic boat ramp provides recreational boating access to the water. As described in Chapter 2, *Context*, the waterway is regulated under the DPA policy.

The coastal resilience strategy in this area focuses on reducing long-term flood risks to the Harborwalk, public parks, nearby residences, and the Charlestown Community Center. Over time, the strategy will be integrated with solutions for the Navy Yard, preventing connected flooding from Little Mystic Channel and the Boston Harbor.

The coastal resilience strategy for this focus area is designed to reduce flood risk to the Charlestown community independently of the strategy for the Boston Autoport and Mystic River DPA.

COASTAL FLOOD RISK

The Terminal Street side of the Little Mystic Channel is higher in elevation than the south side, which influences the timing and degree of coastal flood risks on each side of the waterway. This section focuses on the flood risk to the south and west sides of the Little Mystic Channel.

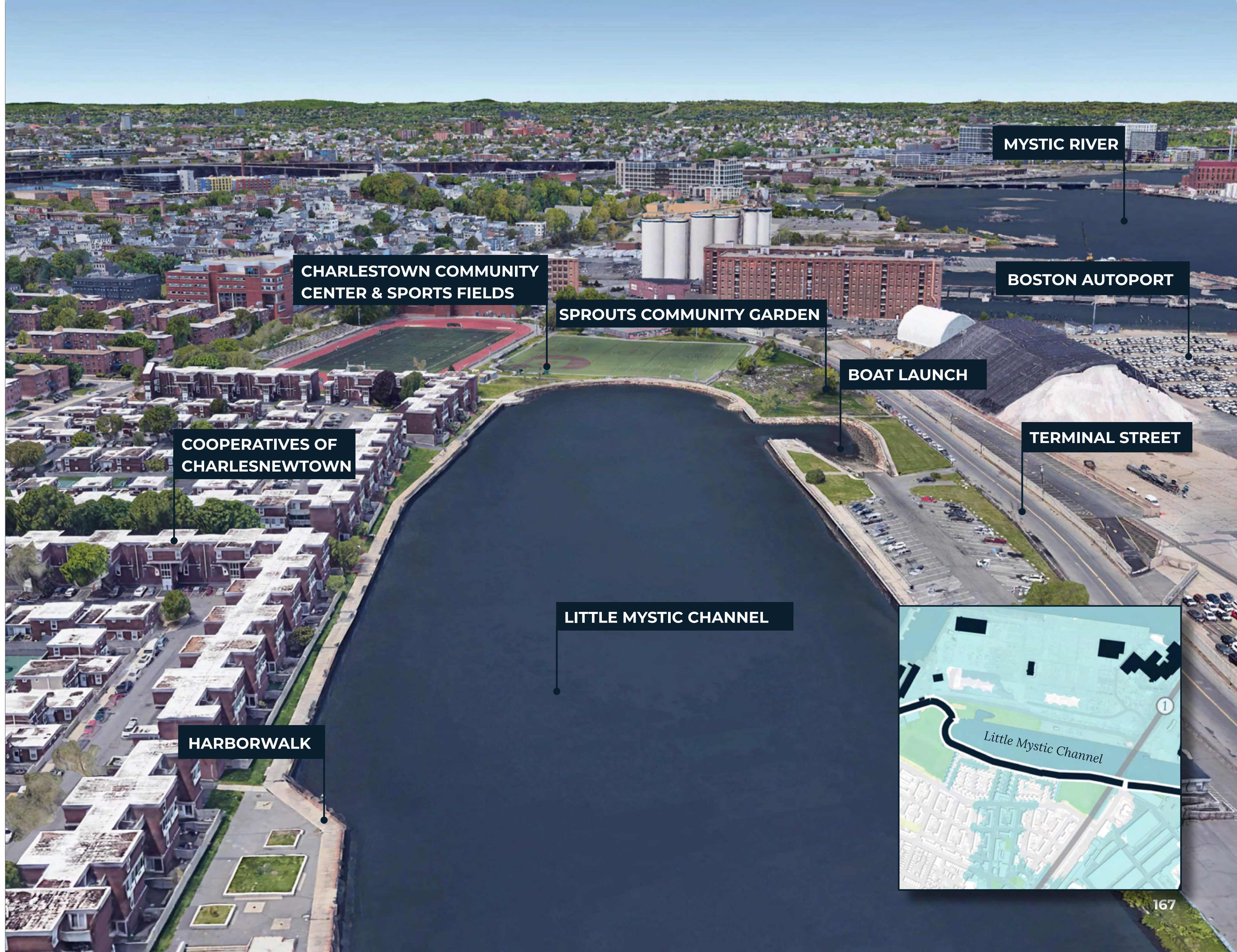
The Harborwalk and waterfront properties along the south and west sides of the Little Mystic Channel are exposed to fringe flooding from severe coastal storms with a 1% annual chance of happening in the 2030s. Sea-level rise projected to occur between 2030 and 2070 will increase the threat of coastal flooding in this area. With 40 inches of sea-level rise anticipated around 2070, severe storms with a 1% or less annual chance of occurring will cause flooding from the south side of the Channel. This flooding is projected to flow inland across Medford Street and connect with flooding from the Navy Yard. Homes and businesses along Medford, Tufts, and Bunker Hill Streets, and the Cooperatives of CharlesNewtown will be at risk.

RESILIENCE DESIGN STRATEGY

The coastal resilience solution for this focus area is intended to provide effective flood risk reduction in the long term while enhancing public access and providing opportunities for new waterfront amenities and long-term ecological restoration. Constructing coastal resilience solutions along the Little Mystic waterfront is complicated because the Cooperatives at CharlesNewtown are located close to the water's edge, with approximately 12 feet of space between the property and the water. Due to this complexity, two strategic options are presented. Both options provide flood resilience benefits and can be pursued to mitigate impacts from a 1% annual chance flood with 40 inches of sea-level rise.

CUMULATIVE BENEFITS OF THE RESILIENCE DESIGN STRATEGY THROUGH 2070*	
Residents protected**	710
Number of buildings protected**	19
Damages avoided	$75 million

*calculated based on preferred long-term coastal resilience strategy
**based on 2019 residential population and buildings
***Loss avoidance based on damages quantified for this study using a 3% discount rate. Calculation includes costs avoided for necessary repairs and improvements to seawall along Little Mystic Channel.



LONG-TERM COASTAL RESILIENCE STRATEGY: NEW ELEVATED PARK WITH ECOLOGICAL RESTORATION

OPTION A (PREFERRED): The Harborwalk surrounding Little Mystic Channel offers the community access to the waterfront but is currently in need of repairs. As a public right-of-way located at the water's edge, the Harborwalk is both highly vulnerable to the impacts of sea-level rise and presents an opportunity to create a resilient coastal edge. Redesigning the Harborwalk along the Little Mystic to incorporate coastal resilience infrastructures provides opportunities not only to reduce risks from flooding but also to enhance the benefits this amenity provides.

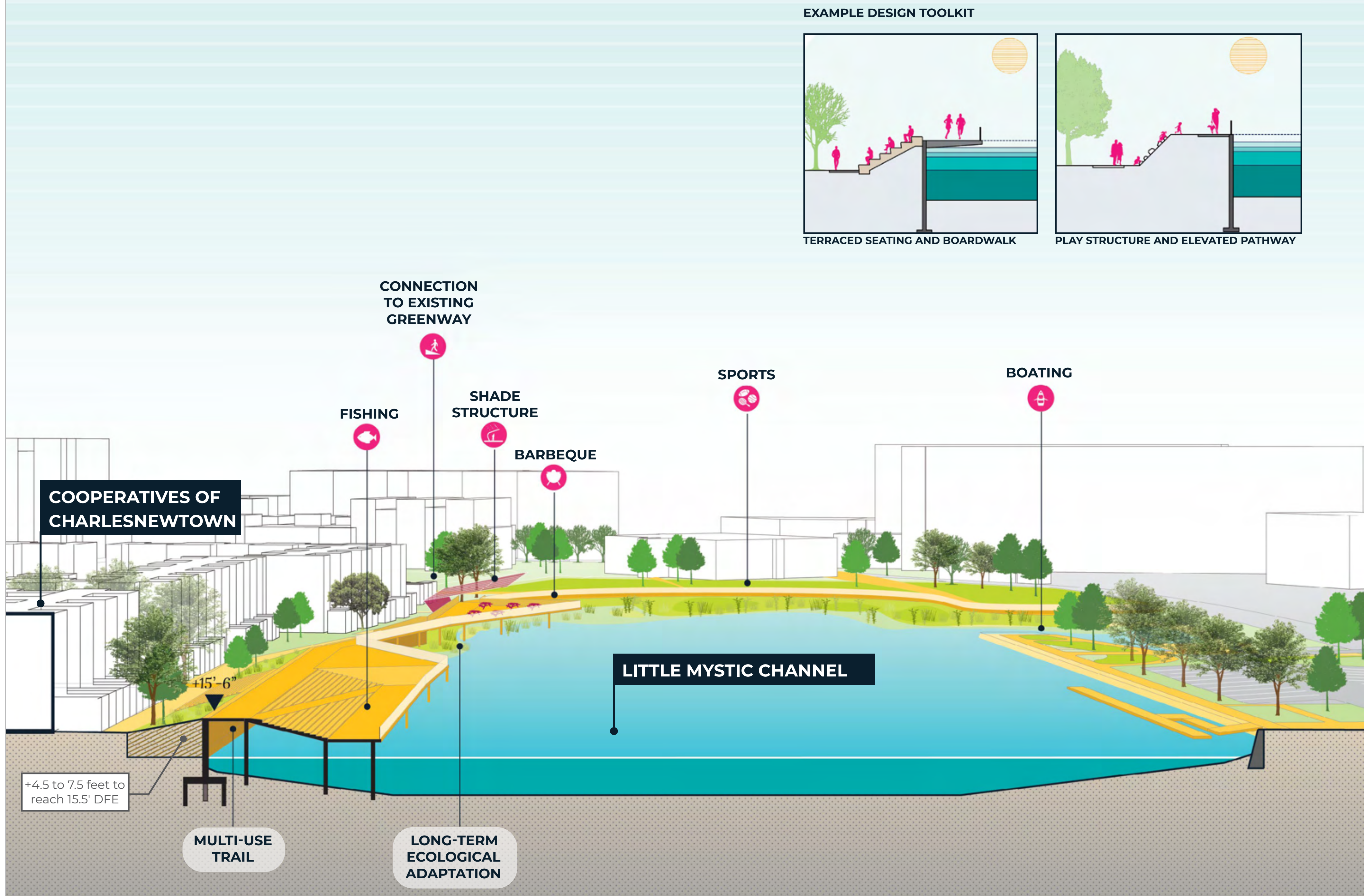
This strategy is a long-term aspirational approach that entails re-envisioning the appearance, function, and use of the Little Mystic Channel. This includes extending the southern and eastern edges of the Channel outward into the water as part of a new elevated park with integrated coastal flood protection. This coastline extension would provide opportunities to introduce ecological restoration projects, such as constructed wetlands that provide new wetland habitat, coastal resilience, and improved water quality. The provision of new aquatic and wetland habitats could mitigate the impacts of placing fill in the waterway. Additionally, the preferred solution presents opportunities for new community amenities along the Little Mystic, including multi-use pathways, play areas, seating, educational programming, shade structures, and fishing access (examples illustrated in the design toolkit to the right).

The extent of the expansion will ultimately be determined based on technical considerations, permitting requirements, and other factors, but can be limited to enable continued recreational boating access within the channel. The elevation of the flood protection in Option A should be designed to the DFE of 15.5 feet (NAVD88). Option A is challenging to permit under today's regulations and could require updates to existing regulations. These regulations, including the DPA policy, Chapter 91, the Wetlands Protection Act, and the local Wetlands Protection Ordinance, presently aim to preserve water-dependent industrial uses, enhance public access to and use of the water, and protect wetland resource areas.

Implementation of this approach, therefore, depends on coordination between city and state agencies, including the CZM, MassDEP, and the Boston Conservation Commission, to assess opportunities to facilitate these types of investments.

OPTION B: Option B entails raising the Harborwalk from its current elevation to 15.5 feet (NAVD88), which is approximately 4.5 to 7.5 feet above the existing grade. This strategy would form a continuous line of coastal flood protection along the waterfront from high ground at the Charles Street Bridge to the Little Mystic boat ramp. Under this approach, the segment of the Harborwalk next to the Cooperatives of CharlesNewtown would need to be reconstructed. Due to spatial limitations, the Harborwalk could be extended over water on pile structures. In other locations, such as Barry Field and the athletic fields at the Charlestown Community Center, the raised Harborwalk could be constructed on land.

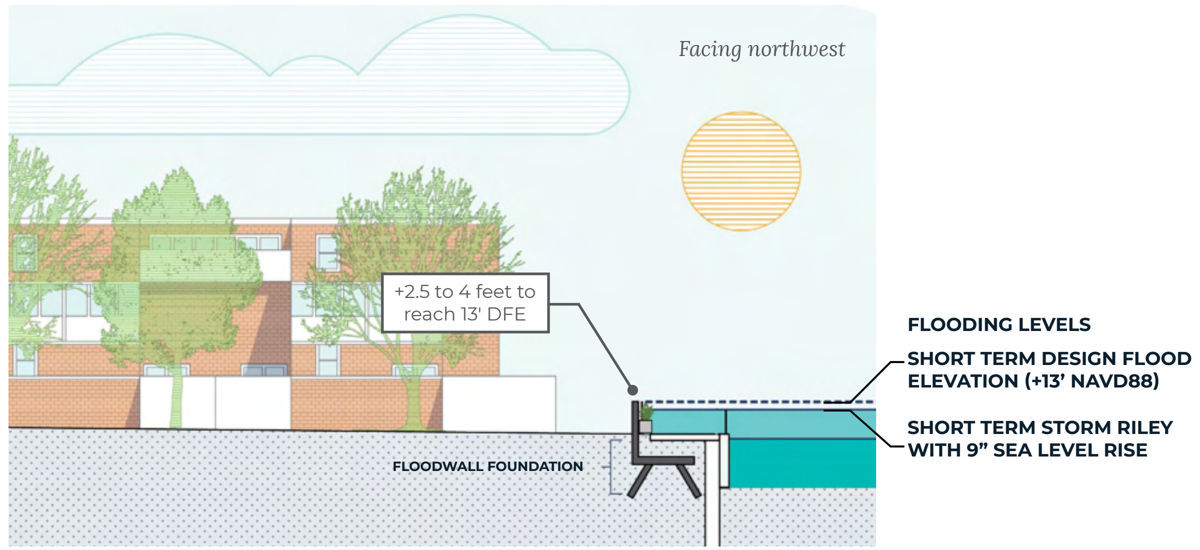
This approach would reduce the risk of coastal flooding along the Harborwalk and throughout the neighborhood from a 1% annual chance storm with 40 inches of sea-level rise. Additionally, the approach ensures that the Harborwalk remains accessible in the future. While the raised Harborwalk will reduce views of the water from the street level, the design of the raised Harborwalk can help mitigate these visual impacts by incorporating accessible sloped ramps, terraced seating, new park space, and other amenities to integrate the raised edge with the surrounding landscape.



As with Option A, this strategy will require careful study to determine the technical requirements for raising the Harborwalk. Future phases of work will need to include site surveys and technical assessments of the conditions of the existing bulkheads to determine where structural upgrades and improvements may be necessary. Implementing this option will also require collaboration between public agencies that own and maintain the Harborwalk along the Little Mystic Channel, as well as adjacent private property owners.

OPTIONAL NEAR-TERM STRATEGY FOR COOPERATIVES OF CHARLESNEWTOWN

Through the 2030s, properties immediately adjacent to the south side of Little Mystic Channel may experience fringe flooding during severe storms (storms with less than a 2% annual chance of occurring). While this near-term flooding does not pose a risk to the broader neighborhood, it may affect the residences at the Cooperatives of CharlesNewtown. To reduce this risk, a near-term strategy can be pursued to implement protective measures for the Cooperatives of CharlesNewtown. This strategy could include the construction of a floodwall located along the inner edge of the Harborwalk, which could be integrated with new seating and other amenities, as well as general improvements to the Harborwalk and public spaces surrounding the Little Mystic Channel. Designed to 13.0 feet (NAVD88), which is 2.5 to 4 feet above the current grade, this approach would reduce the risk of coastal flooding from a 1% annual chance storm with 9 inches of sea-level rise.



Little Mystic Channel, Charlestown

LITTLE MYSTIC CHANNEL HARBORWALK

While the Harborwalk extends along the Little Mystic Channel, this segment has fallen into a state of disrepair and there is a lack of open space amenities. This area is also susceptible to increasing surface temperatures in the summer. Opportunities to improve this segment of the Harborwalk should be explored with the Charlestown community.

STORMWATER MANAGEMENT AND DRAINAGE CONSIDERATIONS

The foundations for coastal resilience infrastructure along the Harborwalk must be designed to avoid or minimize impacts to underground utilities and pipes. Underground utilities and pipes may also be relocated, where feasible, to allow for the siting of coastal resilience infrastructure, if avoidance is not possible.

There are eight outfalls that discharge into Little Mystic Channel within this focus area. Where not already present, tide gates should be installed on all public and private stormwater outfalls to prevent ocean water from traveling through the drainage system under the coastal resilience infrastructure.

As part of the long-term flood resilience approach for this focus area, a range of regional approaches can be explored to manage interior drainage and reduce residual risk from stormwater flooding around Little Mystic Channel. One or more new pumping stations may need to be installed in the focus area to help manage stormwater. Additional measures beyond pump stations, such as green infrastructure and conveyance improvements, may also be necessary to help manage stormwater.

COST ESTIMATES AND BENEFIT-COST ANALYSIS

LONG-TERM COASTAL RESILIENCE STRATEGY OPTION A RAISED HARBORWALK AND NEW PARK WITH ECOLOGICAL RESTORATION	
Estimated Cost	$160 - 180 million
Estimated Annual Operations & Maintenance	$1.5 million

LONG-TERM COASTAL RESILIENCE STRATEGY OPTION B RAISED HARBORWALK	
Estimated Cost	$140 - 150 million
Estimated Annual Operations & Maintenance	$1.3 million

Notes:
*Includes costs for planning, engineering, permitting, construction
*See cost estimation methodology (pg. 186-191) for more information
*Annual operations and maintenance costs are expected to be 1.0 percent of the implementation costs

STRATEGY	BENEFIT COST RATIO	
	HIGH	LOW
Long-Term	0.6	0.4

Notes:
*Benefit Cost Ratio includes a 3% discount rate for avoided losses
*High BCR uses low cost estimate for near- and long-term strategy; low BCR uses high cost estimate for near- and long-term strategy
*Both benefits and costs have been applied incrementally over time based on an estimated project completion schedule and sea level rise changes over time, assuming 9 inches around 2030 and 40 inches around 2070. Benefits include costs avoided for necessary repairs and improvements
to seawall along Little Mystic Channel.
*BCR results for this focus area reflect the long-term implementation timeline for this strategy. The addition of other benefits and extension of the project performance beyond 2070 would be expected to increase the value of monetized benefits for this focus area.
*While the BCA in this focus area is less than 1.0 as calculated, this site was indentified as an area where public realm improvements are a community priority.

TERMINAL STREET AND THE BOSTON AUTOPORT

This focus area includes the Boston Autoport and the Terminal Street waterfront and houses a mix of water-dependent and non-water-dependent industrial uses, including a large terminal with deep-water vessel berthing used for shipping and storing automobiles. Uses here are within the Mystic River DPA and are subject to DPA policy, which encourages water-dependent industrial uses and limits options for public access.

The coastal resilience strategy in this area focuses on building- and site-scale adaptation approaches for water-dependent industrial uses along the waterfront. The resilience strategy for the Boston Autoport and other properties in this focus area is intended to be entirely independent of the resilience strategy for Little Mystic Channel. Separate strategies are presented for the south and west side of Little Mystic Channel on pages 166-173. These strategies provide long-term resilience benefits to the residential portions of the neighborhood regardless of actions taken within the Autoport facility.

COASTAL FLOOD RISK

Coastal flooding from the Mystic River and the Little Mystic Channel presents a near-term risk to the Autoport and Terminal Street. During severe storms with a 1% annual chance or less of occurring, water will overtop existing bulkheads on both sides of the Autoport and could disrupt operations for businesses and damage buildings and assets. Over time, with projected sea-level rise, flooding of these sites is expected to increase in depth and frequency. With 40 inches of sea-level rise anticipated around 2070, flooding during annual high tides and frequent storms with a 30% annual chance of occurring will overtop the coastline and inundate the site. This would lead to significant and recurring disruption for businesses, particularly on the eastern side of the facility, which is lower lying than the rest of the facility. Future flooding from severe storms with a 1% annual chance or less of occurring is projected to be widespread, impacting all buildings and assets in the focus area.

RESILIENCE DESIGN STRATEGY

The coastal resilience solution for this area is intended to reduce the long-term risks from flooding in the Autoport and industrial uses on Terminal Street while limiting interference with the operations of water-dependent industrial users. Future coastal resilience investments in the Autoport will need to be refined in coordination with Massport, which owns the majority of the facility, and with the private tenants operating businesses on the site under lease agreements with Massport. The DFE for this location is 15.5 feet (NAVD88), though lower DFEs may be appropriate for building- and site-scale adaptation approaches depending on the expected useful life of a given structure. A structure with a shorter expected useful life requires a lower level of protection compared to one with a longer expected useful life.

COASTAL RESILIENCE STRATEGY: BUILDING AND SITE-SCALE ADAPTATION AT THE BOSTON AUTOPORT

Massport is taking proactive steps to ensure that its properties and tenants are in compliance with Massport's Sustainability and Resiliency Design Standards and Guidelines (SRDSGs) that were established in 2018. The SRDSGs require that all Massport projects must incorporate floodproofing strategies, such as structural elevation, dry or wet floodproofing to a projected flood elevation, and providing backup power systems to ensure that power is not lost during a storm.

Given the multiple water-dependent industrial uses that currently exist and operate at the Autoport, there are many complexities when it comes to planning for a climate-resilient future at this location. Massport has been studying the Autoport to assess the existing conditions of its assets, the assets of its tenants, potential solutions for adapting the structures on-site, and identifying opportunities to mitigate other risks associated with climate change.

Elevating the entire Autoport site or constructing a flood protection strategy around the perimeter of the Autoport would disrupt the functionality of the industries that currently depend on access to the water. This means that site- and building-scale adaptation measures are appropriate in the near term to enable business owners to flexibly integrate resilience into sites in ways that preserve business continuity. These approaches can be tailored to each property owner or business's specific operational and design criteria, based upon site-scale risk assessments, with special attention given to protecting or relocating hazardous substances stored on Massport and other industrial properties that could cause contamination and public health impacts during a flood.

As a result of this approach to the Autoport, coastal resilience solutions for other areas of Charlestown are designed to be effective independently of the Autoport.

In the long-term, some water-dependent uses currently located at the Autoport may need to be relocated elsewhere as sea-level rise increases. Should this be the case, it is recommended that Massport evaluate options for coastal resilience strategies that provide perimeter protection of the Autoport.

OPPORTUNITIES FOR THE NORTH SIDE OF LITTLE MYSTIC CHANNEL

In partnership with the Charlestown community, the BPDA, Massport, and MyRWA are collaborating as partners to create a vision for how the Little Mystic Access Area could be enhanced to provide better opportunities for recreation, access to nature, social gatherings and climate resilience.

While improvements and enhancements to the Harborwalk and other waterfront access may be combined with the district-scale coastal resilience strategy for the south side of Little Mystic Channel, improvements on the north side of the channel would be implemented outside of the planned line of coastal flood protection.

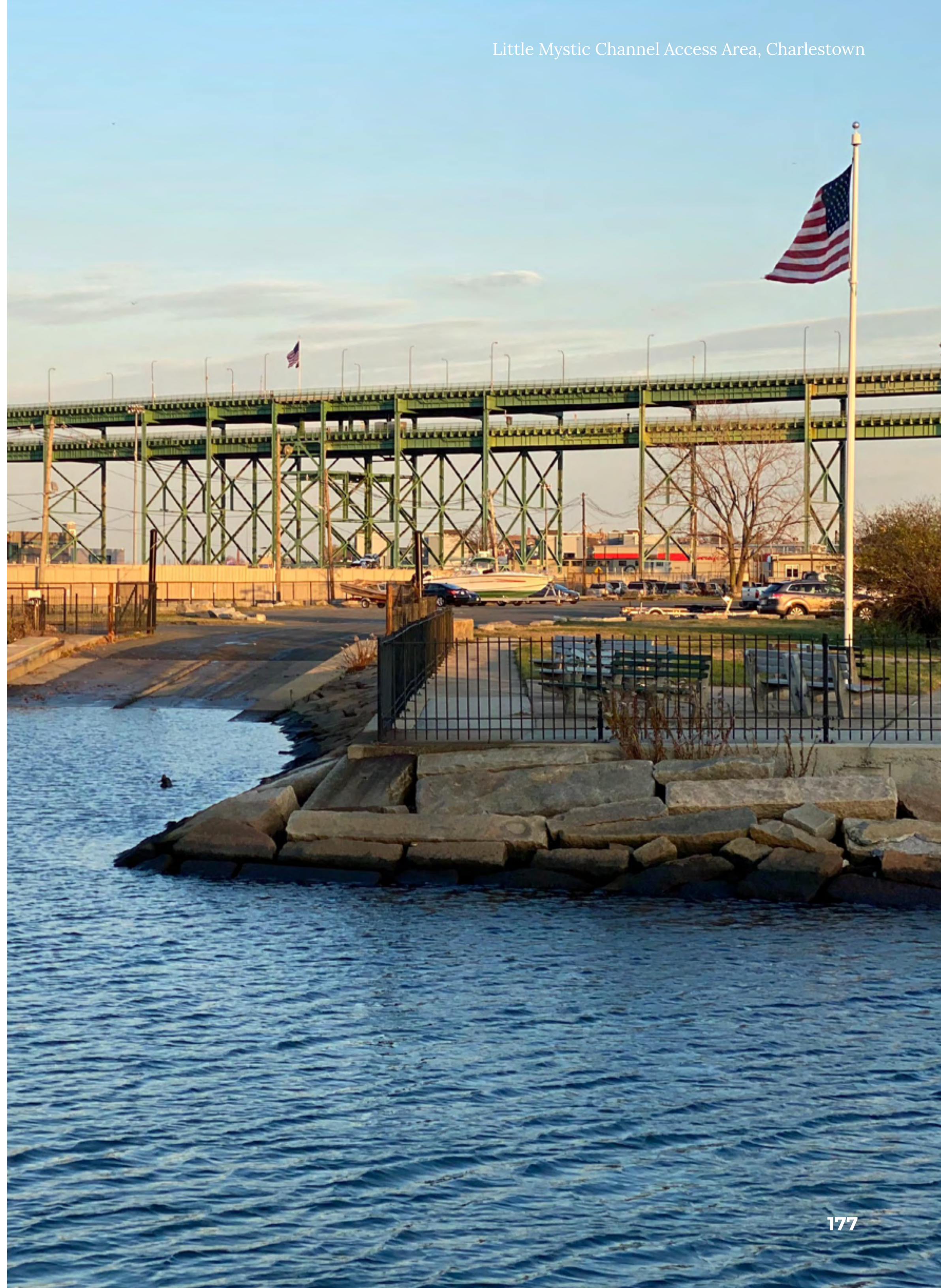
Any new major capital improvements along the north side of Little Mystic Channel should be elevated to at least +11.0 feet (NAVD88), which is 1 to 2 feet above the current grade and would reduce flood risks from annual high tides and frequent storms with 40 inches of sea-level rise. Together these measures help reduce the risk of storm damage and inaccessibility during future high tides and decrease the time necessary to restore the open space to full function after severe storms.

STORMWATER MANAGEMENT AND DRAINAGE CONSIDERATIONS

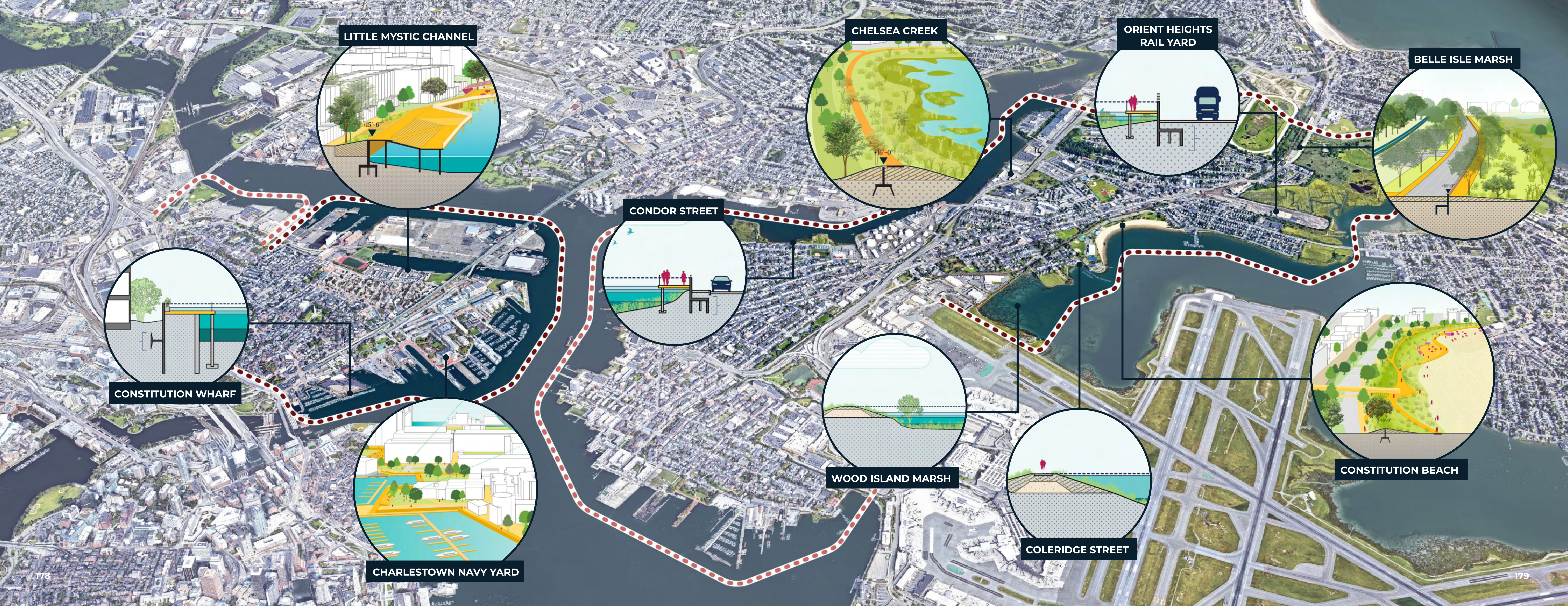
Building and site-scale adaptation measures in the Mystic River Designated Port Area should account for stormwater drainage requirements and, where feasible, include steps to improve drainage, including new or adapted green and grey infrastructure. Pumps may be necessary behind temporary floodwalls to address flooding from rain that may accumulate behind the wall. The foundations for passive and deployable coastal resilience infrastructure at the building- and site-scale must be designed to avoid or minimize impacts to underground utilities and pipes.

On the north side of Little Mystic Channel, open space enhancements should evaluate opportunities to integrate stormwater best management practices (BMPs), such as rain gardens or bioswales, to help build resilience to stormwater flooding.

Where not already present, tide gates should be installed on all public and private stormwater outfalls to prevent ocean water from traveling through the drainage system under the coastal resilience infrastructure. Routine maintenance of the drainage system, such as sediment removal from catch basins, is important to ensure the proper function of the stormwater collection and conveyance system.



Little Mystic Channel Access Area, Charlestown


LITTLE MYSTIC CHANNEL
CHELSEA CREEK
ORIENT HEIGHTS RAIL YARD
BELLE ISLE MARSH
CONDOR STREET
CONSTITUTION WHARF
CHARLESTOWN NAVY YARD
WOOD ISLAND MARSH
COLERIDGE STREET
CONSTITUTION BEACH

05 IMPLEMENTATION ROADMAP

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IMPLEMENTATION ROADMAP

The implementation process for coastal resilience infrastructure is complex and takes time. Each solution and project type will require a different timeline for bringing the solution from concept, through design and development, to construction.

The implementation roadmap guides coastal resilience actions in East Boston and Charlestown. The roadmap draws on risk-based prioritization of projects, strategic opportunities to benefit the community, benefit-cost analyses, and regulatory considerations. As a result of the interconnected nature of coastal flooding in both neighborhoods, the implementation of the solutions must proceed in a coordinated manner over time to achieve comprehensive coastal resilience. Together, these solutions will reduce coastal flood risk and create a more equitable and more resilient East Boston and Charlestown.

IMPLEMENTATION PROCESS

Implementation of all coastal resilience solutions includes ongoing engagement with the community and other stakeholders, including those who will need to play a role in the implementation of the project and those who will be affected by the outcomes of the project. Stakeholders that should be involved throughout the implementation process may include City departments, state capital agencies, regulators at multiple levels of government, funders, private property owners, renters, businesses, non-profit advocacy and conservation organizations, and more.

Strategic partnerships between public, private, and non-profit stakeholders will play a key role in advancing the implementation of coastal resilience strategies in East Boston and Charlestown. The City of Boston will continue to collaborate with all stakeholders as projects progress from planning to design to ensure outcomes are consistent with community goals and values, as described in this plan, and refined through ongoing conversations.

DESIGN AND CONSTRUCTION

While the details related to the implementation of each project will depend on a variety of location- and project-specific factors, there are elements of the implementation process that apply generally across projects.

The process of planning coastal resilience solutions is followed by an extended design, engineering, and permitting process before the project can be built. For projects that are ready to advance from planning to technical design, there is an established set of stages through which a project advances to transition from conceptual design to final design and construction.

The following are typical next steps for the technical design of the coastal resilience solutions presented in this report. The timing for each of these steps depends upon the scale, complexity, and available funding for a project, as well as the urgency of the flood risk. Permitting coordination and ongoing community and stakeholder engagement is a core part of the process, particularly through preliminary design.

CONCEPTUAL PLANNING creates the broad vision for the strategy and outlines key design criteria to be refined during later phases of work.

PRELIMINARY DESIGN refines the conceptual design through additional engagement with stakeholders and more detailed site investigations including site survey and geotechnical assessment.

FINAL DESIGN includes the development of detailed engineering drawings and other information necessary for construction, as well as permitting of the proposed project.

CONSTRUCTION delivers the design as a finished project.

OPERATIONS AND MAINTENANCE includes the community's use of and benefit from the project, and ongoing maintenance and operational effort necessary to maintain a state of good repair.

Once the project is complete, its benefits can be enjoyed by the community over the course of the project's design life, which is the period of time over which the project is designed to perform its intended function. The design life will vary depending on the project type. Regardless of the intended design life, ongoing maintenance and upkeep is critical to the effectiveness of the project and must be accounted for in budgeting for all major structural projects.

OVERALL BENEFIT-COST RATIO AND COST ESTIMATES

BENEFIT-COST RATIO

Chapter 4, *Coastal Resilience Solutions for East Boston and Charlestown*, provides descriptions of estimated project costs and benefit-cost ratios (BCR) associated with each focus area. The benefits and costs of each project were assessed using a methodology consistent with prior *Climate Ready Boston* plans.

Loss estimates are based on a building and asset inventory developed for this study using City of Boston GIS, assessor's data, digital elevation models, and industry-standard methodologies from the Federal Emergency Management Agency (FEMA) and U.S. Army Corps of Engineers (USACE).

The monetized benefits include direct physical damages to buildings and their contents, displacement and relocation costs, effects on mental stress and lost productivity, economic output loss, and loss of service for public and essential facilities (i.e., fire and police stations).

Loss of service benefits were quantified for public parks and open spaces and for affected MBTA transit lines, including the Orient Heights Rail Yard. The benefit-cost analysis does not include many benefits, such as:

- Avoided business interruption costs.
- Avoided impacts on the regional economy.
- Avoided direct physical damages to anything but buildings, their contents, and public parks (i.e., linear transportation, communications, and power infrastructure).
- Avoided emergency response costs.
- Avoided disruption of utilities and public services as a result of protected infrastructure.
- Future development, property values, and population density.
- Other social, economic, and environmental value added.

The addition of these components in future phases of planning and design would be expected to add significant additional benefits to the benefit-cost ratio for each project.

COST ESTIMATES

This study used information from prior studies and construction projects around the United States to develop preliminary cost estimates for waterfront parks, berms, and other coastline protection features. These costs are based on readily available data and do not reflect detailed design-level considerations for the study areas.

The cost estimation methodology includes allowances for project elements such as drainage, utility and site work, demolition, insurance, general conditions, and public amenities. Contingency factors of 30% [low] and 50% [high] are added to base costs to account for uncertainties at this level of conceptual project design. Costs are provided in 2022 prices.

Principal causes of potential cost variation include:

- Whether the flood protection alignment occurs on existing land or within the water.
- Whether the structure is a wall or earthen feature, as well as the height of the structure.
- The number of penetrations in the protection feature (for example, requiring flap gates or surface openings with closeable flood gates).

Current unknowns include:

- The type and condition of existing outfalls.
- The number, type, and condition of buried subsurface utilities (electric, gas, stormwater, wastewater, fiber, etc.).
- Subsurface soil permeability conditions and the necessity for seepage cutoff measures such as sheeting, grout walls, or other treatments.
- Ability to permit in-water construction and the presence of contaminated soils.
- Availability of materials, and labor and material costs.

Navy Yard Harborwalk, Charlestown

PREFERRED COASTAL RESILIENCE STRATEGY COST ESTIMATES FOR EAST BOSTON

Coastal resilience actions in East Boston are expected to cost between approximately $424 million and $639 million between now and 2070, not including necessary building- and site-scale adaptation measures. Together, these actions could protect approximately 4,600 people and over 620 structures, and prevent up to approximately $1.1 billion in direct physical damage to structures, displacement costs, mental stress, anxiety, lost productivity, and loss of service of transit and public parks associated with long-term coastal flood risk with 40 inches of sea-level rise.[1]

FOCUS AREA	ESTIMATED COST**	
BENNINGTON STREET	**LOW**	**HIGH**
Raised Bennington Street and Berm (2030-2050)	$65 million	$71 million
Belle Isle Marsh Resilience (today)*	N/A	N/A
CHELSEA CREEK		
Chelsea Creek or Route 1A Floodwall (2030)	$22 million	$51 million
Chelsea Creek Coastline Raising or Raised Route 1A (2050)	$58 million	$210 million
Chelsea Creek DPA Site- and Building-Scale Adaptation (2030-2050)*	N/A	N/A
ORIENT HEIGHTS RAIL YARD		
Perimeter Protection on North Side of Orient Heights Rail Yard (2030)	$41 million	$44 million
Perimeter Protection for Orient Heights Rail Yard (2050)	$140 million	$160 million

FOCUS AREA	ESTIMATED COST**	
CONSTITUTION BEACH	**LOW**	**HIGH**
Coleridge Street Berm or Floodwall (2030)	$3.3 million	$10 million
Integrated Flood Resilience at Constitution Beach (2050)	$82 million	$110 million
Optional MBTA Blue Line Right-of-Way Floodwall (2050) - *not included in total cost estimate*	$100 million	$110 million
CONDOR STREET		
Floodwall and Harborwalk along Condor Street (2070)	$69 million	$77 million
WOOD ISLAND MARSH		
Raised Berm at Wood Island Marsh (2070)	$10 million	$11 million
TOTAL* **	**$424 MILLION**	**$639 MILLION**

*Cost estimates beyond the scope of this study.
**Includes costs for planning, engineering, permitting, construction, and operations and maintenance from year of implementation to 2070. Annual operations and maintenance costs are expected to be 1.0 percent of the implementation costs.
***Totals based on lowest and highest cost estimates for preferred and optional long-term coastal resilience strategies for each focus area, which are inclusive of near-term strategy costs.

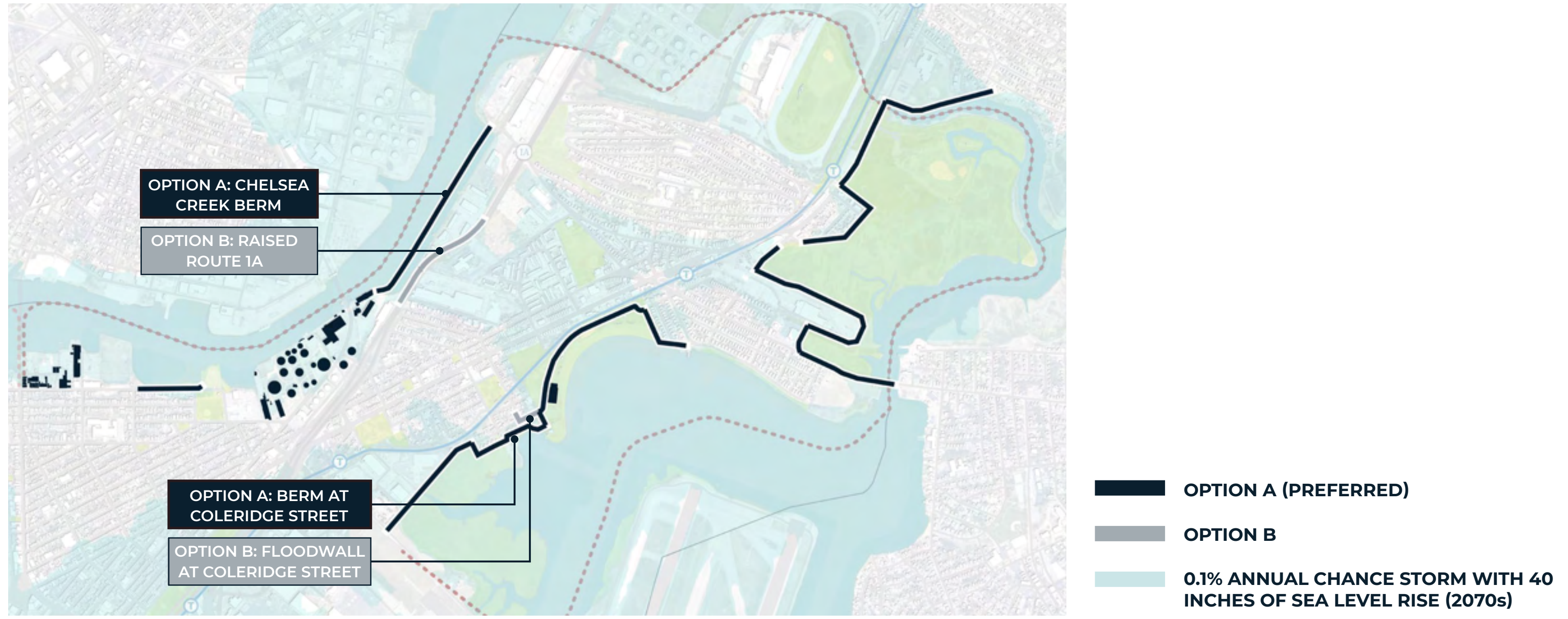
1 Exposed population and structures are based on the 2019 population. No projected growth is considered.

ESTIMATED BENEFITS AND COSTS OF COASTAL RESILIENCE STRATEGIES IN EAST BOSTON

OPTION A (PREFERRED)		OPTION B	
Estimated Capital Cost*	$460 million - $510 million	Estimated Capital Cost*	$360 million to $410 million
Estimated Annual Maintenance Cost	$4.3 million	Estimated Annual Maintenance Cost	$3.4 million
Net Project Benefit**	$460 million - $510 million	Net Project Benefit**	$590 million - $640 million
Benefit-Cost Ratio	1.7 - 1.9	Benefit-Cost Ratio	2.1 - 2.4

Notes:
* Includes costs for planning, engineering, permitting, and construction.
** Net project benefit refers to the benefits minus costs including operations and maintenance through 2070 using a discount rate of 3 percent. Both benefits and costs have been applied incrementally over time based on an estimated project completion schedule and sea level rise changes over time, assuming 9 inches around 2030 and 40 inches around 2070.

Chapter 4, Coastal Resilience Solutions for East Boston and Charlestown provide additional information on project-specific assumptions and methodologies for BCA estimation in each focus area.



PREFERRED COASTAL RESILIENCE STRATEGY COST ESTIMATES FOR CHARLESTOWN

Coastal resilience actions in Charlestown are expected to cost between approximately $410 million and $690 million between now and 2070, not including necessary building- and site-scale adaptation measures. Together, these actions could protect approximately 3,850 people and over 140 structures, and prevent up to approximately $950 million in direct physical damage to structures, displacement costs, mental stress, anxiety, lost productivity, and loss of service of transit and public parks associated with long-term coastal flood risk with 40 inches of sea-level rise.[1]

FOCUS AREA	ESTIMATED COST**	
CHARLESTOWN NAVY YARD	**LOW**	**HIGH**
Raised Harborwalk at Priority Locations (2030)	$130 million	$140 million
Raised Harborwalk or Raised 1st Avenue (2040)	$170 million	$330 million
Navy Yard National Historical Park Resilience* (2030)	N/A	N/A
CONSTITUTION WHARF		
Raised Harborwalk or Floodwall in Median/Water's Edge (2040)	$100 million	$180 million
MYSTIC RIVER DESIGNATED PORT AREA		
Mystic River DPA Site- and Building-Scale Adaptation (2030)*	N/A	N/A
Optional Perimeter Protection for Boston Autoport (2050) - *not included in total cost estimate*	$380 million	$410 million
LITTLE MYSTIC CHANNEL		
Raised Harborwalk or Raised Harborwalk with New Park (2070) - *not including near-term protection on south side of channel needed by 2030*	$140 million	$180 million
TOTAL* **	**$410 MILLION**	**$690 MILLION**

*Cost estimates beyond the scope of this study.
**Includes costs for planning, engineering, permitting, construction, and operations and maintenance from year of implementation to 2070. Annual operations and maintenance costs are expected to be 1.0 percent of the implementation costs.
***Totals based on lowest and highest cost estimates for preferred and optional long-term coastal resilience strategies for each focus area, which are inclusive of near-term strategy costs.

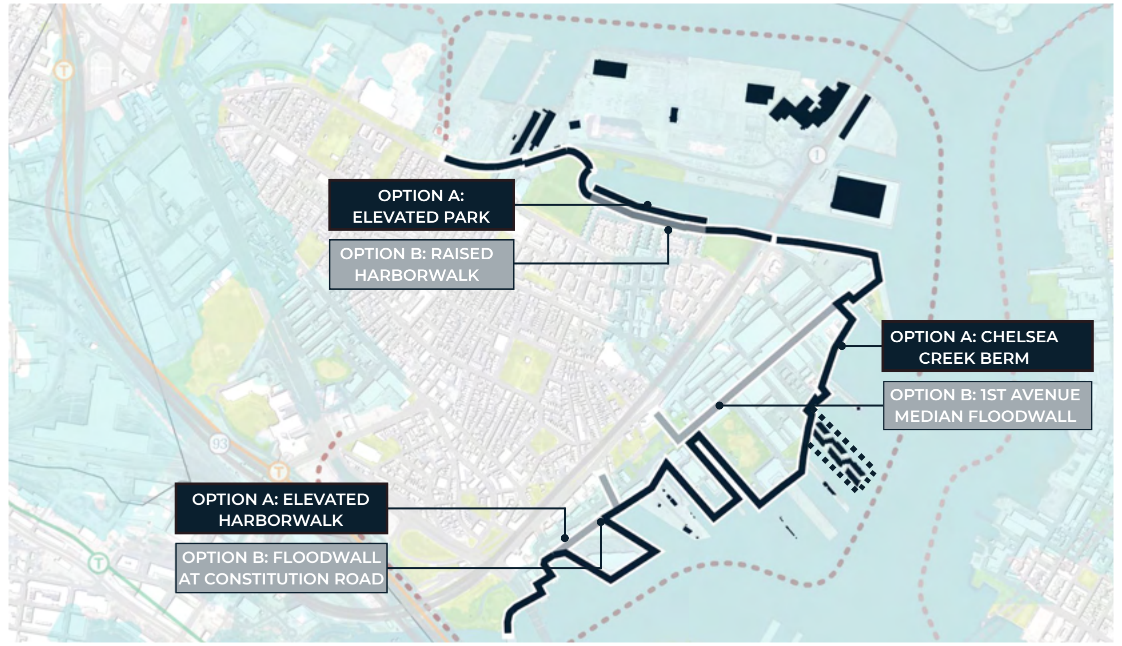
1 Exposed population and structures are based on the 2019 population. No projected growth is considered.

ESTIMATED BENEFITS AND COSTS OF COASTAL RESILIENCE STRATEGIES IN CHARLESTOWN

OPTION A (PREFERRED)		OPTION B	
Estimated Capital Cost*	$520 million - $580 million	Estimated Capital Cost*	$350 million to $390 million
Estimated Annual Maintenance Cost	$4.8 million	Estimated Annual Maintenance Cost	$3.2 million
Net Project Benefit**	$220 million - $290 million	Net Project Benefit**	$20 million - $70 million
Benefit-Cost Ratio	1.3 - 1.4	Benefit-Cost Ratio	1.0 - 1.1

Notes:
* Includes costs for planning, engineering, permitting, and construction.
** Net project benefit refers to the benefits minus costs including operations and maintenance through 2070 using a discount rate of 3 percent. Both benefits and costs have been applied incrementally over time based on an estimated project completion schedule and sea level rise changes over time, assuming 9 inches around 2030 and 40 inches around 2070.

Chapter 4, Coastal Resilience Solutions for East Boston and Charlestown, provide additional information on project-specific assumptions and methodologies for BCA estimation in each focus area.



OPTION A (PREFERRED)
OPTION B
0.1% ANNUAL CHANCE STORM WITH 40 INCHES OF SEA LEVEL RISE (2070s)

PHASING STRATEGY

The implementation phasing strategy for the preferred coastal resilience options provided here is based primarily on the timing of coastal flood risk, but also includes consideration of the complexity and cost of the solution and opportunities for co-benefits. A phased approach will help direct resources to high-priority projects that offer significant benefits in terms of flood risk reduction and community amenities.

The coastal resilience strategy phasing presented in this report reflects the current understanding of how flood risk will evolve over time, foreseeable funding cycles, and the amount of time that will be necessary to complete different actions. However, this timeline may be adjusted based on new information and data acquired over time.

Project priority is based on the estimated size and frequency of expected flood impacts. Actual timing will be affected by funding availability, opportunities for partnerships, complementary infrastructure improvements, and social, environmental, economic, and recreational needs that may be met through coastal resilience investments. Most actions in East Boston and Charlestown should be complete by the 2050s based on current sea-level rise projections. Opportunities to implement solutions sooner should be taken wherever possible, especially where resilience strategies provide opportunities for other benefits for each community.

Many projects will require immediate ongoing planning and coordination as part of the implementation process. Planning and coordination actions are prioritized as foundational next steps to advance implementation of the near-term coastal resilience strategies. There are three time horizons by which certain solutions must be implemented to protect against projected coastal flooding, including:

Projects targeted for completion by 2030 reduce risk in areas exposed to coastal flooding during flood events up to the 1% annual chance flood with 9 inches of sea-level rise.

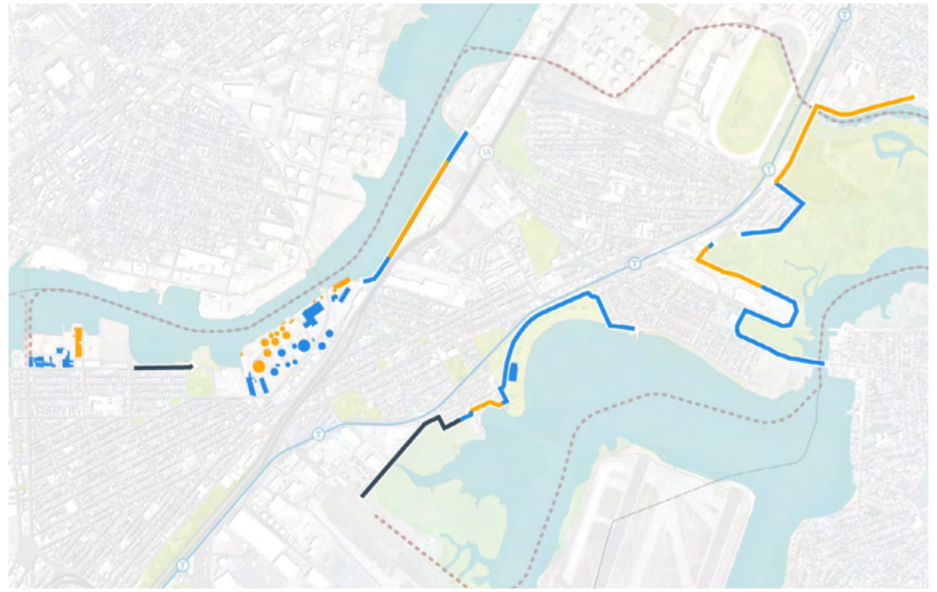
» These projects are near-term steps that will need to be adapted to higher design flood elevations or expanded in extent to address increased risk with future sea-level rise.

Projects targeted for completion by 2050 reduce risk in areas exposed to coastal flooding from 2050 through at least 2070.

» These projects are designed to the long-term design flood elevation to reduce risk up to the 1% annual chance flood with 40 inches of sea-level rise. The schedule should be accelerated if the rate of sea-level rise occurs faster than currently projected.

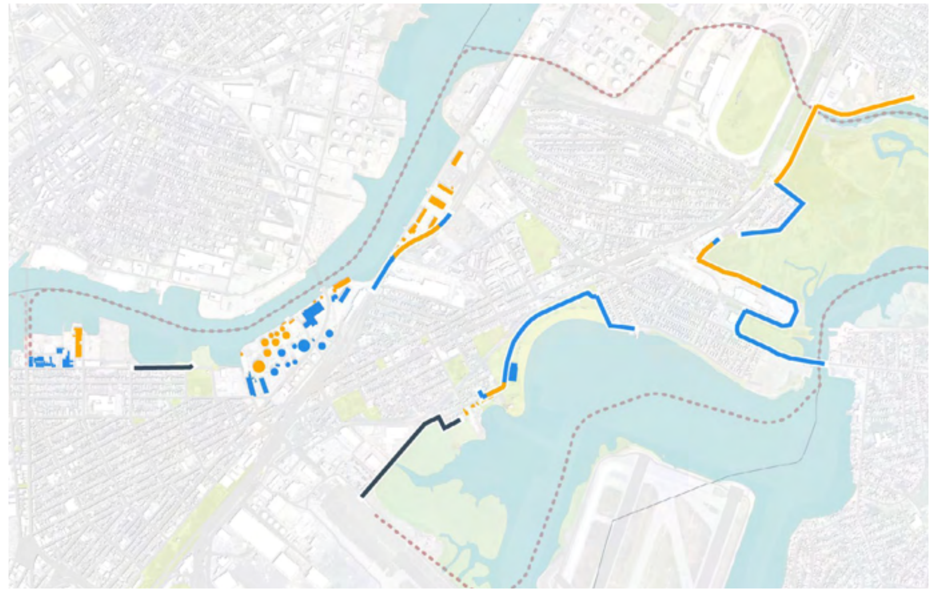
Projects targeted for completion by 2070 reduce risk in areas exposed to coastal flooding from 2070 and beyond.

» These projects are designed to the long-term design flood elevation to reduce risk up to the 1% annual chance flood with 40 inches of sea-level rise. Potential sea-level rise later in the century is less certain. The timeframe for long-term actions should be re-evaluated periodically.



EAST BOSTON IMPLEMENTATION PHASING, OPTION A (PREFERRED)

CHARLESTOWN IMPLEMENTATION PHASING, OPTION A (PREFERRED)



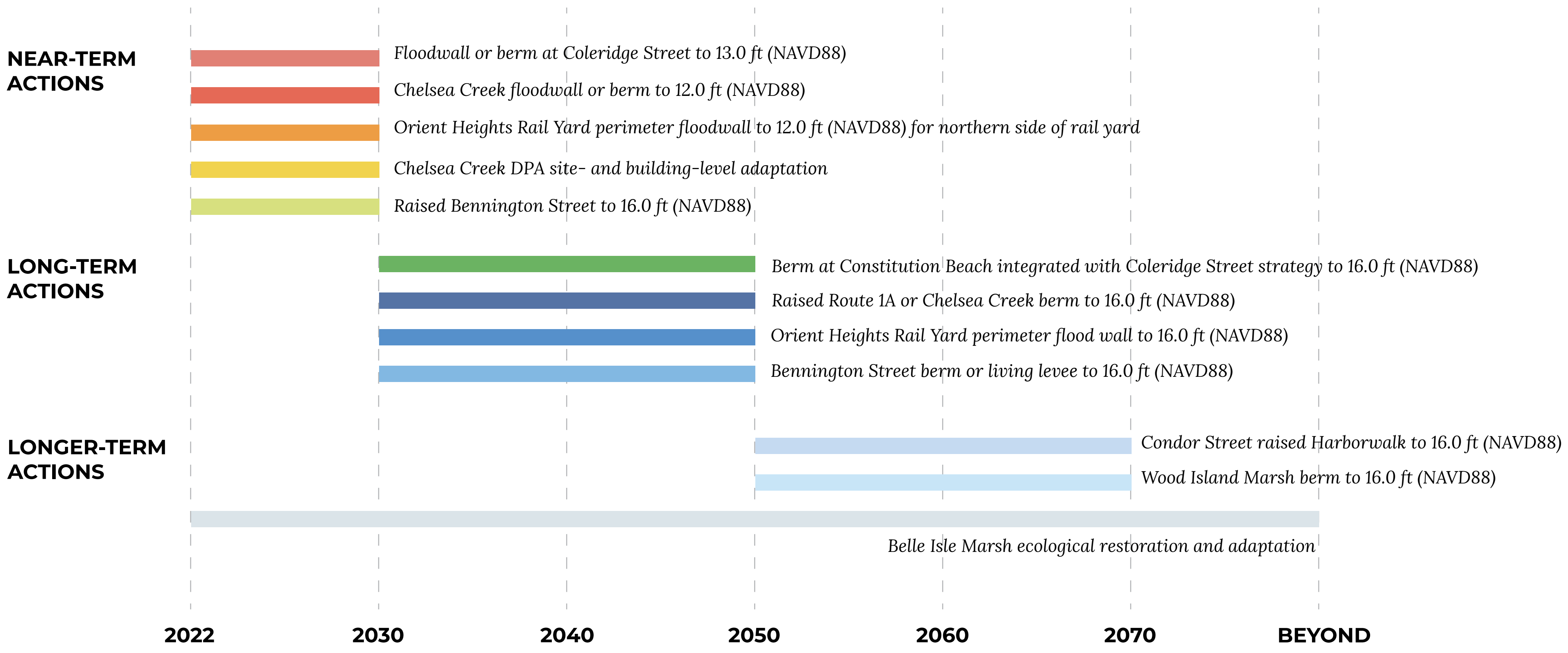
EAST BOSTON IMPLEMENTATION PHASING, OPTION B

CHARLESTOWN IMPLEMENTATION PHASING, OPTION B

PROJECTS TARGETED FOR COMPLETION IN 2030
PROJECTS TARGETED FOR COMPLETION IN 2050
PROJECTS TARGETED FOR COMPLETION IN 2070
POTENTIAL PROTECTION OPTION

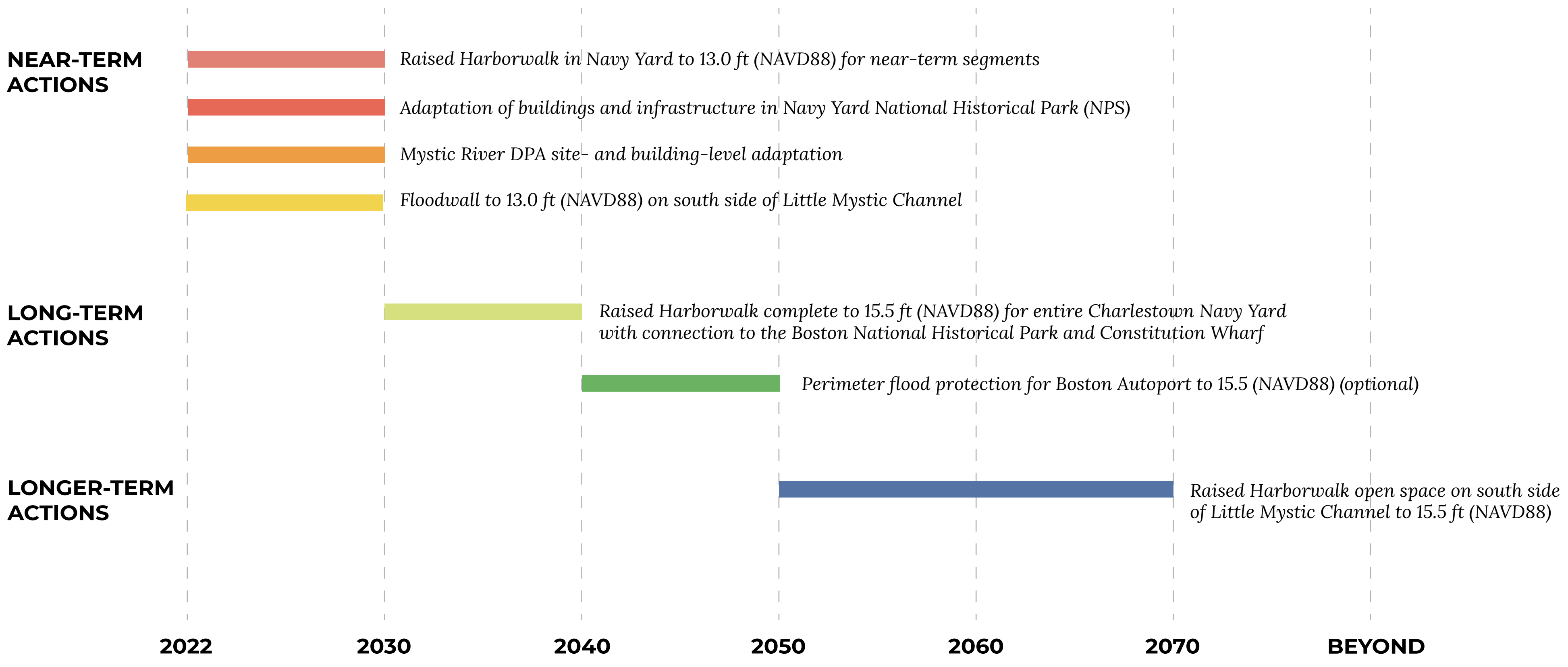
PHASING STRATEGY FOR EAST BOSTON

Recommended phasing plan for coastal resilience solutions in the East Boston Phase II study area. Both costs and phasing plans are estimates and should not be used for detailed planning.



PHASING STRATEGY FOR CHARLESTOWN

Recommended phasing plan for coastal resilience solutions in the East Boston Phase II study area. Both costs and phasing plans are estimates and should not be used for detailed planning.



REGULATORY CONSIDERATIONS

Coastal resilience strategies for East Boston and Charleston must follow city, state, and federal regulations and policies. Many environmental regulations were implemented by federal and state agencies decades ago to protect important natural resources and prevent or minimize the unintended consequences of growth. These regulations were not always designed to consider flood protection or the consequences of climate change, including sea-level rise, more frequent and severe flood damages, and flood-related pollution.

As the understanding of sea-level rise evolves, some regulations will need to be updated to facilitate resilience at all scales of policy and development while maintaining the original mission of these regulations. Flood protection and environmental protection are not mutually exclusive. Thoughtful collaboration with city, state, and federal partners to update existing regulations could enable ecological restoration and in-water adaptation approaches that also provide flood protection and enhance people's quality of life.

Near-term projects will most likely need to be implemented within current regulatory frameworks. Some of these are already undergoing changes to increase the compatibility of regulations to protect sensitive natural resources while enabling the implementation of necessary and beneficial coastal resilience projects. Near-term projects have been designed at the conceptual level for compliance with applicable city, state, and federal regulations in order to expedite regulatory review and permitting.

For all strategies, it is critical to understand the context, constraints, and opportunities that these regulations pose for these projects. Projects may require private property agreements and contracts, as appropriate, and will require permitting from regulatory entities, depending on the area.

Prior *Climate Ready Boston* reports, specifically the report for South Boston, have described permitting considerations and strategies related to the need for targeted regulatory updates. See *Coastal Resilience Solutions for South Boston*, "*Chapter 4: Regulatory Resilience Strategies*" for a detailed discussion of current regulations and challenges for coastal resilience projects as well as a comprehensive description of potential courses of action for implementing solutions through existing permitting pathways or improving regulations to support the implementation of the identified coastal resilience solutions.

NEXT STEPS

Advancing the implementation of the coastal resilience strategies identified in this report is important to ensure the resilience of the East Boston and Charlestown communities. Implementation will depend on action by public and private property owners and businesses, supported by key public agencies and in coordination with the City of Boston and other partners.

The City will work with state and federal partners to optimize long-term resilient infrastructure investments and continue to explore funding and financing options for public-private partnerships to construct district-scale coastal resilience solutions across public and private properties. Immediate next steps will include:

FURTHERING COMMUNITY ENGAGEMENT

Implementation of several coastal resilience strategies presented in this study will require further engagement by the City and partners with residents, business owners, property owners, and community groups to refine concept strategies and designs.

TECHNICAL EVALUATION

To advance to the next phase of design, all coastal resilience projects require further technical evaluation of waterfront structures such as bulkheads and piers to assess existing structural conditions and feasibility.

COLLABORATION WITH STATE AND FEDERAL PARTNERS

The City will continue ongoing collaboration with DCR for the development of an adaptation, restoration, and long-term resilience strategy for the Belle Isle Marsh and Constitution Beach.

The City will continue ongoing collaboration with MassDOT and MBTA in the design of Chelsea Creek and Route 1A resilience strategies and perimeter flood protection at the Orient Heights Rail Yard, which is important to ensure the long-term resilience of the MBTA Blue Line.

The City will collaborate with Massport, CZM, and community partners to advance the implementation of objectives for enhanced public access along the Little Mystic Channel within the Mystic River DPA and the Chelsea Creek waterfront within the Chelsea Creek DPA. The City will also collaborate with Massport to assess the feasibility and advance implementation of a raised berm on Massport property as part of the coastal resilience solution for Wood Island Marsh, which is needed to reduce the risk to residences in Harbor View and Logan Airport.

The City will continue participating in a working group with NPS and the U.S. Department of Defense regarding the integration of the Navy Yard coastal resilience solution with the adaptation strategy for the Boston National Historical Park and U.S. Constitution Museum.

CONCLUSION

Together, Phase I and II of *Coastal Resilience Solutions for East Boston and Charlestown* present actionable roadmaps for the future of the East Boston and Charlestown coastlines. This plan identifies strategies for the Phase II study area to reduce the risk of flooding in the near- and long-term, enabling more resilient communities by pairing flood protection infrastructure with other benefits such as new public waterfront access and restoring ecological areas previously harmed by urban growth and industrialization.

Near-term projects identified by this plan target areas and critical flood pathways that are at risk today or will be within the next decade due to anticipated sea-level rise. Longer-term steps complete the coastal resilience strategy in both neighborhoods by expanding on near-term steps and adding additional projects in locations at risk of flooding between 2030 and 2070. All solutions are designed to build upon one another and be adaptable over time to a range of future conditions.

The coastal resilience solutions and conceptual designs provided by this plan are a vital step in the process of building resilience in East Boston and Charlestown. Intended to build on prior community-based planning, they were developed based on nearly two years of extensive community and stakeholder engagement, technical analysis, and preliminary design.

The coastal resilience projects will be advanced over the coming decades in East Boston and Charlestown starting with near-term steps in the areas most at risk of flooding.

The City of Boston will continue to work closely with city, state, and federal agencies, property owners, businesses, community groups, and residents in each neighborhood to advance the design and implementation process and seek funding for near-term priority projects. This will present many more opportunities for residents of both neighborhoods to learn about and inform the final outcome for each coastal resilience solution, and move Boston one step closer toward creating a resilient, equitable, and accessible waterfront for all.


Navy Yard Harborwalk, Charlestown

APPENDICES

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APPENDIX B - DRAINAGE SOLUTION TOOLKIT 206

APPENDIX A - GLOSSARY OF KEY TERMS

GUIDING TERMS

ADAPTATION
Adaptation refers to changes that respond to anticipated environmental risks.

CLIMATE RESILIENCE
Climate resilience is the ability of a community to adapt and respond to the chronic stresses and acute shocks resulting from climate change, while proactively meeting the needs of and improving the quality of life for all citizens. Resilience is the ability of a system to prepare for, withstand, and recover quickly from a disaster. Ideally, resilient systems should recover from an event by becoming stronger than they were prior to the stress.

ECOLOGICAL ADAPTATION
The traits of an organism or system that improve the fitness of the organism or system to survive and reproduce in a habitat or ecosystem. Ecological adaptation is a biological mechanism by which an organism or system gradually becomes more acclimated to its surroundings. In the context of wetland ecology, this includes long-term changes that enable a wetland system to adjust to and change with the anticipated effects of climate change, including sea-level rise.

ENVIRONMENTAL JUSTICE
Environmental Justice is based on the principle that all people have a right to be protected from environmental hazards and to live in and enjoy a clean and healthful environment regardless of race, color, national origin, income, or English language proficiency. Environmental justice is the equal protection and meaningful involvement of all people and communities with respect to the development, implementation, and enforcement of energy, climate change, and environmental laws, regulations, and policies and the equitable distribution of energy and environmental benefits and burdens. (Source: Massachusetts Environmental Policy Act Office)

EQUITY
Equity is the respectful treatment and fair involvement of all people in a society. It is the state in which everyone has the opportunity to reach their full potential. Additionally, the National Academy of Public Administration, which has been studying the use of equity as a means of evaluating public policy describes equity as the "fair, just, and equitable management of all institutions serving the public directly or by contract; the fair, just, and equitable distribution of public services and implementation of public policy; and the commitment to promote fairness, justice, and equity in the formation of public policy." (Source: Resilient Boston, 2018)

FLOODING/COASTAL HAZARDS

100-YEAR FLOODPLAIN
This is the extent of a flood that has a 1% annual chance of occurring or being exceeded. Also referred to as Special Flood Hazard Areas (SFHA) on FEMA Flood Insurance Rate Maps.

COASTAL EROSION
Coastal erosion is the process by which local sea level rise, strong wave action, and coastal flooding wear down or carry away rocks, soils, and/or sands along the coast. All coastlines are affected by storms and other natural events that cause erosion; the combination of storm surge at high tide with effects from strong waves—conditions commonly associated with landfalling tropical storms—creates the most damaging conditions. (Source: NOAA)

EXTREME WEATHER EVENT
Weather at the extremes of the historical distribution lying in the outermost ten percent (10%) of city of Boston weather history, including but not limited to heat and humidity, droughts, winds and microbursts, blizzards and ice storms, rain and hail, fire, tornadoes, thunderstorms, hurricanes and tides affected by the weather.

LAND SUBSIDENCE
Land subsidence is a gradual settling or sudden sinking of the Earth's surface due to the removal or displacement of subsurface earth materials. The principal causes include aquifer-system compaction associated with groundwater withdrawals, drainage of organic soils, underground mining, natural compaction or collapse, such as with sinkholes or thawing permafrost. (Source: USGS)

SEA-LEVEL RISE (SLR)
Sea-Level Rise refers to the rise in sea level over time relative to the land at a given location. The warming of Earth is primarily due to the accumulation of heat-trapping greenhouse gases, and more than 90 percent of this trapped heat is absorbed by the oceans. As this heat is absorbed, ocean temperatures rise, polar ice melts, and water expands, which contributes to an increase in global sea level. Other factors such as land subsidence may also contribute to relative sea-level rise in some locations. (Source: NASA)

STORM SURGE
Storm surge is the abnormal rise in seawater level during a storm, measured as the height of the water above the normal predicted astronomical tide. The surge is caused primarily by a storm's winds pushing water onshore. The amplitude of the storm surge at any given location depends on the orientation of the coastline with the storm track; the intensity, size, and speed of the storm; and the local submarine topography. (Source: NOAA)

SUNNY-DAY FLOODING
High-tide flooding, often referred to as "nuisance" or "sunny day" flooding, is increasingly common due to years of relative sea level increases. It occurs when tides reach anywhere from 1.75 to 2 feet above the daily average high tide and start spilling onto streets or bubbling up from storm drains. As sea level rise continues, damaging floods that decades ago happened only during a storm now happen more regularly, such as during a full-moon tide or with a change in prevailing winds or currents. (Source: NOAA)

FLOOD PROTECTION

FLOOD RESILIENCE INFRASTRUCTURE
Infrastructure designed for the prevention or reduction of flooding and flood damage, both as currently expected to occur and as projected to occur based on the best available data regarding the impacts of climate change.

FLOODPROOFING
Floodproofing is defined by FEMA as structural or non-structural interventions that reduce flood damage to a space or a building.

DRY FLOODPROOFING
Dry floodproofing is the practice of sealing a space or a building up to the level of the Design Flood Elevation (DFE) or higher, in order to keep water from entering. When dry floodproofing, property owners must strengthen structural members in anticipation of the hydrostatic and hydrodynamic pressure caused by floodwaters.

WET FLOODPROOFING
Wet floodproofing designs for the movement of water through a space or a building, which equalizes hydrostatic pressure and helps prevent structural failure. Wet floodproofing is only allowed for parking, access, crawl space, and storage.

GREEN INFRASTRUCTURE
Projects and practices incorporating the natural environment or engineered systems that provide or supplement natural processes or work in concert with natural systems to provide flood, fire, or drought risk reduction, or clean water or air benefits. Green infrastructure practices protect, restore, augment, or mimic ecological processes. (Source: Boston Wetlands Protection Ordinance)

NATURE-BASED SOLUTIONS
Nature-based solutions are sustainable planning, design, environmental management, and engineering practices that weave natural features or processes into the built environment to promote adaptation and resilience. (Source: FEMA)

STRATEGIC RELOCATION
Strategic relocation (also referred to as managed retreat) involves adapting to coastline change, generally by either preventing construction in a vulnerable area or removing structures already in the vulnerable area, rather than attempting to prevent it when site-specific conditions indicate that perimeter protection or adaptation is not favorable. Strategic relocation is one of three possible responses to sea-level rise; the other two responses are various methods of shore protection or floodproofing. Retreat scenarios may include assisted relocation to high ground and outside of the flood risk area, required setbacks from the coastline, or voluntary buy-out programs. (Source: EPA)

LEVELS OF FLOOD PROTECTION

BASE FLOOD ELEVATION (BFE)

Base Flood Elevation (BFE) is the elevation of the 100-year flood (1% Annual Chance Flood). The BFE is determined by statistical analysis for each local area and is designated on the Flood Insurance Rate Maps (FIRMs). This elevation is the basis of the insurance and floodplain management requirements of the National Flood Insurance Program (NFIP).

DESIGN FLOOD ELEVATION (DFE)

Design Flood Elevation (DFE) is the elevation of the highest flood that a retrofitting method is designed to protect against. Also referred to as Flood Protection Elevation. In Boston, it is the minimum elevation required to protect the neighborhood in a 1% annual chance flood with 40 inches of sea-level rise (2070s). The DFE is separated from the BFE by freeboard.

FREEBOARD

Freeboard is a factor of safety usually expressed in feet above a flood level for purposes of floodplain management. It is a buffer between predicted flood levels and a building's lowest occupiable floor. Freebord is defined as the distance between the SLR-BFE and the SLR-DFE.

DATUMS

NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88)

A base measurement created by the National Geodetic Survey and used to calculate or compare elevations.

BOSTON CITY BASE (BCB)

BCB is the vertical control datum established for the City of Boston. BCB can be converted to NAVD88 by using a conversion factor of BCB - 6.46 feet.

TIDAL DATUMS (SOURCE: NOAA)

- **MEAN HIGHER HIGH WATER (MHHW):** The average of the higher high water height of each tidal day observed over the National Tidal Datum Epoch.
- **MEAN HIGH WATER (MHW):** The average of all the high water heights observed over the National Tidal Datum Epoch.
- **MEAN TIDE LEVEL (MTL):** The arithmetic mean of mean high water and mean low water.
- **MEAN LOW WATER (MLW):** The average of all the low water heights observed over the National Tidal Datum Epoch
- **MEAN LOWER LOW WATER (MLLW):** The average of the lower low water height of each tidal day observed over the National Tidal Datum Epoch

WETLANDS

COASTAL WETLANDS

Any bank, marsh, swamp, meadow, flat or other lowland subject to tidal action or coastal storm flowage. (Source: Boston Wetlands Protection Ordinance)

FILL

To deposit any material so as to raise the elevation of land surface or ground, either temporarily or permanently or to deposit any material in any resource area covered by the Boston Wetlands Ordinance so as to impair the resource values of the area. (Source: Boston Wetlands Protection Ordinance)

MARSH

The types of freshwater wetlands are wet meadows, marshes, swamps, bogs, and vernal pools. These include bordering vegetated wetlands (i.e., bordering freshwater bodies such as on creeks, rivers, streams, ponds, and lakes), and isolated vegetated wetlands which do not border on any permanent water body. Freshwater vegetated wetlands are areas where soils are saturated and/or inundated such that they support wetland indicator plants.

HIGH MARSH

The part of a marsh that lies between the low marsh and the marsh's upland border; this area can be expansive, extending hundreds of yards inland from the low marsh area; soils here are mostly saturated but only flooded during higher-than-average astronomical tides. (Source: EPA)

LOW MARSH

The seaward edge of a salt marsh, usually a narrow band along a creek or ditch which is flooded at every high tide and exposed at low tide. (Source: EPA)

MARSH MIGRATION

A process by which tidal wetlands adjust to rising sea levels by advancing inland into areas previously above the ebb and flow of the tides. (Source: EPA)

Navy Yard Harborwalk, Charlestown

APPENDIX B - DRAINAGE SOLUTION TOOLKIT

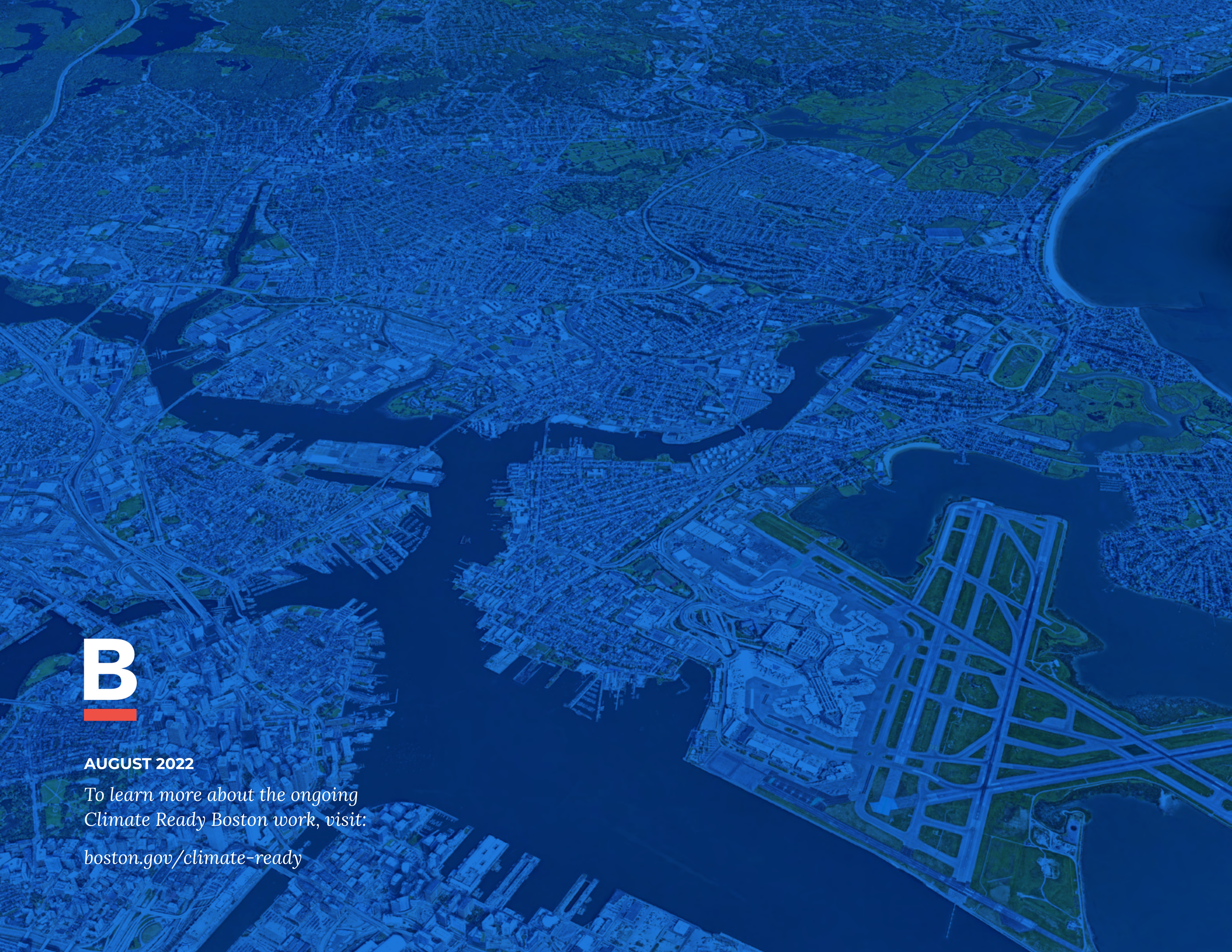
The volume of stormwater that will need to be managed in the future will be significant due to increasingly intense rain events that have the potential to generate greater runoff volumes. Coastal resilience solutions need to be planned in coordination with drainage and discharge improvements to address flood risk that does not originate from overland coastal flooding. During a coastal storm surge, stormwater from rainfall will not discharge and may become backed up. Once the capacity of the underground drainage network is exceeded, stormwater will pool above the surface until the storm surge recedes and stormwater can discharge by gravity. This can lead to flooding of property, structures, and infrastructure.

A range of stormwater management systems will be necessary to handle the volume of stormwater flooding that will occur across the East Boston and Charlestown neighborhoods, even if coastal flood risk is mitigated. This includes constructing additional green infrastructure, stormwater pumping, storage, and tide gates, as well as increasing the capacity of the existing drainage system overall. While this report focuses on coastal resilience solutions, key considerations and opportunities for future detailed study of stormwater drainage needs are summarized for each focus area in this appendix.

APPROACH	DESCRIPTION	FINDINGS/APPLICABILITY
GREEN INFRASTRUCTURE	Green infrastructure replicates the natural processes of capturing and infiltrating water into the ground before it enters the sewer system. These strategies serve two primary purposes: slowing and/or reducing the amount of stormwater that reaches the sewer system and filtering pollutants out of the water along the way. While it can be implemented at a smaller scale wherever possible to support larger-scale strategies, it cannot manage large volumes of stormwater associated with heavy rainfall.	Since a large quantity of water needs to be managed in the study areas, green infrastructure as a standalone solution likely cannot mitigate the design event flooding due to space constraints and the limited capacity of green infrastructure within the study areas. Green infrastructure can complement other approaches described below and offers a range of co-benefits including opportunities to mitigate urban heat island effect, enhance open space networks, and improve the appearance of streetscapes. To have the greatest benefit, green infrastructure should be implemented across a drainage area in locations best suited to reducing runoff into the stormwater system.
UNDERGROUND STORAGE	Underground storage collects water during storms. The stormwater is then pumped back to the stormwater system after the storm ends and stormwater system capacity is available. This strategy is effective when no space is available above ground, but it requires a lot of space underground.	Underground storage facilities are effective for avoiding above-ground conflicts but would require a significant amount of space underground. This is challenging in urban areas like East Boston and Charlestown given the complex existing network of underground infrastructure and limited redevelopment opportunity, particularly in Charlestown. Underground storage is also very costly and complex. Due to design constraints, the potential for storage is likely insufficient to manage the amount of stormwater. Moreover, increasing capacity in a storage facility after construction is challenging because it is underground and would require significant geotechnical and structural work, making storage facilities less adaptable to changing future conditions.

APPROACH	DESCRIPTION	FINDINGS/APPLICABILITY
PUMPING	Pumping moves water from lower to higher ground. Pumps push water out against high tides and coastal storm surge conditions, ensuring water does not collect behind the flood defense system. A pump station can manage a large volume of stormwater within a relatively small footprint. New pipes would be needed to convey water to a pump station.	Pump stations require space both above and below ground to collect water and pump it out from behind the flood defense during storm events. Preliminary modeling estimated pumping station(s) managing a capacity of 127 million gallons per day (MGD) would be required in East Boston. Similarly, pumping stations managing 90 MGD would be required in Charlestown. Multiple pump stations may be necessary in different locations, depending on the drainage network, to manage this volume of water. Further study can evaluate the appropriate level of service/design storm for purposes of interior drainage as well as the siting for pumps. A budgetary construction cost estimate for the East Boston pump station to manage the volume cited here is between $36M - $63M and for Charlestown pump station is between $25M - $45M.[1] Additional cost would be necessary for site acquisition and pipelines to bring water to the pump station.
CONVEYANCE	Conveyance refers to using gravity to move stormwater from one location to another, often through underground stormwater pipes. While conveyance is a useful strategy it must be paired with other drainage strategies to ensure the water is discharged to a safe location.	Managing increased volumes of stormwater also necessitates evaluating the ability of existing pipes to convey water to outfalls and pump stations. Conveyance improvements can be paired with pump stations to rapidly discharge storm water from inland to the coast. The degree of conveyance improvement necessary in East Boston and Charlestown is unknown and would need to be studied in conjunction with any discharge analysis. Conveyance upgrades should be minimized to only where necessary to avoid lengthy and disruptive construction. Conveyance upgrades providing additional conveyance capacity may also provide additional temporary underground storage for smaller storms.
SEWER SEPARATION	Sewer separation is one form of conveyance and involves separating stormwater and sewage flows by constructing additional sewers in each street, one to carry stormwater and one to carry sewage.	BWSC is engaged in ongoing efforts to separate sewers across the city. These projects help increase conveyance capacity for stormwater, in addition having multiple benefits for water quality and public health. As with other conveyance upgrades, sewer separation still needs to be managed at the downstream end of the new sewers.
TIDE GATES	Tide gates prevent water from flowing from the ocean through outfalls into the drainage network during storm surges and extreme high tides. Gates may be operated passively through gravity or manually opened and closed.	BWSC has installed tide gates at many low-lying outfalls across the city and is engaged in ongoing efforts to install others. As part of the design phase for any coastal resilience infrastructure, the need for tide gates will need to be evaluated. Additional attention should be paid to account for stormwater outfalls not owned by BWSC.
REGULATORY	Stormwater and land use regulations encourage or require private developments to reduce their runoff and contributions to the stormwater system. Requirements can range but often include reduction of impervious area on a site, storage on site, and installation of GSI to allow infiltration on site.	The City of Boston has a stormwater permit that requires management of stormwater on site for new developments, Requirements vary by the size of the development. Updates to these regulations may be warranted to account for future increases in rainfall or special considerations for areas protected by coastal barriers.

1 These estimates reflect an AACE Class 4 estimate (-15%/+50%) with an ENR Cost Indices of 17,383 (February 2022) and do not include location site or pipeline (storm drains/force main) infrastructure. Reference: Pumping Station Cost Curves, Pumping Station Design, Robert Sanks, Ph.D., PE



AUGUST 2022

To learn more about the ongoing Climate Ready Boston work, visit:

boston.gov/climate-ready