

# Wharf District Council Conceptual District Protection & Resiliency Plan

## Basis of Design Report

July 19, 2022



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# Introduction

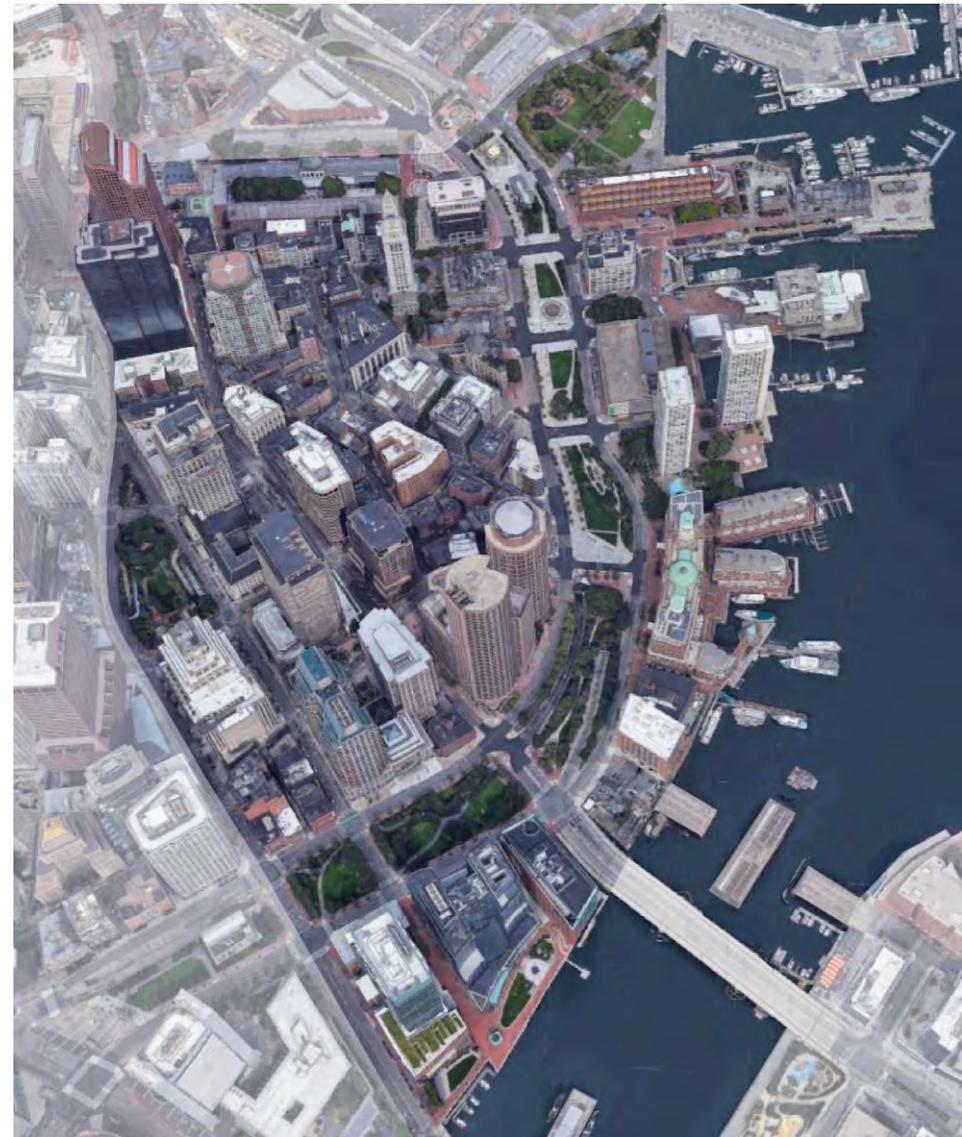
## The Project

This Project will provide an engineering assessment to advance prior flood resiliency planning initiatives by the City of Boston. This assessment will identify a set of preferred flood resiliency strategies for each waterfront property that will go beyond protecting individual buildings – protecting all the Wharf District from current and future flooding. The strategies to be identified by this project are not intended to protect individual properties or the district own their own, but will serve as integral components of a larger contiguous flood protection system extending beyond the borders of the Wharf District.

## Basis of Design Report Intent

The intent of this Basis of Design Report is to:

- Summarize the Project's approach and intended deliverables
- Share the findings of the engineering due diligence assessments, and solicit feedback on the key findings and considerations for each waterfront property
- Solicit feedback on our initial review of Community priorities and preferences
- Solicit feedback on the key design assumptions we propose to use to assess and identify preferred resiliency strategies



*Wharf District Boundaries*

## Project Team

Wharf District Council Climate Resilience Taskforce (CRTF) and Management Team (CRTF MT) members have volunteered many hours of their time and a wealth of invaluable knowledge to this effort.

The CRTF and CRTF MT members include:

Aaron Michlewitz – MA House of Representatives, Chair Ways & Means  
 Alice Brown – Boston Harbor Now  
 Andrew Dankwerth – Pembroke  
 Anne Rogan – Capital Properties  
 Ann Lagasse – Ocean Havens  
 Andrew Brown – US Coast Guard  
 BJ Moriarty – Moriarty Partners, Hook Wharf Project  
 Bill Zielinski – SKW Partners , Hook Wharf Project  
 Bob Gordon – Harbor Towers Resident - WDC Member  
 Bob Gowdy – Harbor Towers Board - WDC Member  
 Brian Abramson, Servidyne – for Rowes Wharf  
 Brian Koop – Boston Properties  
 Bud Ris – Green Ribbon Commission  
 Cheryl Delgreco – North End Waterfront Residents Association (NEWRA)  
 Chris Bush – BPDA  
 Chris Cook – Greenway Conservancy  
 Chris Fincham – Harbor Towers, WDC Treasurer  
 Doug Gribbel -- Folio Condominium, WDC Executive Committee  
**Don Chiofaro Jr. – Chiofaro Company - WDC Member\***  
 Fernando Bent- Mulling - Rasta Rootz - WDC Member  
 Heidi Wolf – InterContinental Residences - WDC Member  
 Jack Clark – Pembroke  
 Joanne Hayes Rines – Friends of Christopher Columbus Park & Harbor Tower Board

Joe Christo – Stone Living Lab  
 John Rogers – MA House of Representative  
 John Larivee – Rowes Wharf Residences - WDC Member  
 John Cleveland – Green Ribbon Commission  
 Kara Dominguez, Cushman Wakefield – for 400 and 470 Atlantic Ave  
 Kathy Abbott – Boston Harbor Now  
 Kelly Roche – Broadluxe Condominium, WDC Clerk  
**Kristan McLaughlin – Pembroke\***  
 Larry Coe – InterContinental Residences  
**Marc Margulies – Wharf District Council President, Rowes Wharf Residences\***  
**Matt Rubin – Harbor Towers Board - WDC Member\***  
 Matthew Murphy – Boston Harbor City Cruises, WDC Vice President  
**Norman Meisner – Harbor Towers Board - WDC Member\***  
**Rick Musiol – New England Aquarium, WDC Executive Committee\***  
 Ray Green InterContinental Residences - WDC Member  
 Rachel Lake – Greenway Conservancy  
 Rich McGuinness – BPDA  
 Sanjay Seth – Office of Environment City of Boston  
**Susanne Lavoie – WDC Executive Director\***  
**Steve Mitchell – Chiofaro Company - WDC Member\***  
 Stephen Johnston – Boston Harbor Hotel, WDC Executive Committee  
 Shelia Willard – InterContinental Residences, WDC Executive Committee  
**Wes Simpson – Harbor Towers Board - WDC Member\***

**\*CRTF MT Members**

## Consultant Team

This project is in collaboration with the following engineering and consulting firms:



ARUP

Resilience Engineering, Civil  
Engineering, Coastal Structures  
Engineering, Stakeholder Engagement  
& Outreach, Cost Estimating



HALVORSON  
Tighe&Bond STUDIO

Landscape Architecture and  
Urban Design



vhb

Permitting Consulting



HALEY  
ALDRICH

Geotechnical Engineering



WOODS HOLE  
GROUP FOR EARTH,  
FROM SPACE  
A CLS COMPANY

Coastal Flood Modeling

## Definitions and Abbreviations

**The Project** – The Wharf District Council Conceptual District Protection & Resiliency Plan.

**Wharf District Council (WDC)** - The Wharf District Council is a non-profit neighborhood organization recognized by the City of Boston as representing the Wharf District community – including residents, hotels, non-profit organizations, small businesses, and A Better City – on matters relating to planning, development, construction, programming events and transportation.

**WDC Stakeholders** - those who live, work, or own property in the Wharf District.

**The Community** – Commonwealth of Massachusetts residents, those who may visit the Wharf District, and those who may be impacted by or benefit from the Wharf District and the Project.

**EDI Partners** - Social equity, diversity, & inclusion (EDI) organizations and/or champions participating in the Project, identified in close coordination with the City of Boston.

**Waterfront Properties** – The waterfront properties of the Wharf District, from Christopher Columbus Park to Congress Street at the Fort Point Channel, as indicated in the blue dashed line in image on the right.

**Inland Properties** – All properties of the Wharf District exclusive of the Waterfront Properties.

**Climate Resilience Task Force (CRTF)** – A task force of volunteers within the Wharf District Council working to address issues of climate resiliency within the district.

**Climate Resilience Task Force Management Team (CRTF MT)** – A group of Climate Resilience Task Force members overseeing the management of the Project.



*Waterfront Properties*

## Definitions and Abbreviations

**Vertical Datum** – a surface elevation to which heights of various points are referenced.

**North American Vertical Datum of 1988 (NAVD88)** – The current vertical datum for the contiguous United States and Alaska used by the National Oceanic and Atmospheric Administration.

**Boston City Base (BCB)** – a Boston city-wide datum that can be converted to NAVD88 by using a conversion factor of:  $\text{NAVD88} = \text{BCB} - 6.46$  feet.

**Boston Harbor Flood Risk Model (BH-FRM)** – A flood model developed by Woods Hole Group and academic partners with funding from MassDOT and Federal Highway Administration to evaluate coastal flooding risks from sea level rise and increased storm surge to the Central Artery Tunnel system caused by climate change. The BH-FRM flooding simulations were developed for three time horizons: Present, 2030, and 2070. The 2070 results include approximately 40 inches (3.3 ft) of relative sea level rise and a late 21st century climatology with more intense tropical cyclones.

**Massachusetts Coast Flood Risk Model (MC-FRM)** – The MC-FRM is an expanded version of the BH-FRM covering the entirety of coastal Massachusetts and including updated elevation and historical storm data, statistical methods, physical processes (wave run-up and overtopping), and sea level rise projections. The MC-FRM includes simulations and results for Present, 2030, 2050, and 2070 time horizons. The 2050 and 2070 results include approximately 3.1 and 4.29 feet of relative sea level rise, respectively, compared to 2000 baseline year, and a late 21st century climatology with more intense tropical cyclones.

**Sea Level Rise (SLR)** – an increase in ocean levels due to effects of global warming.

**SLR 2070 (MC-FRM)** – Rise projected through 2070 by MC-FRM (51.5 inches)

**National Tidal Datum Epoch** – The specific 19-year period adopted by the National Ocean Service as the official time segment over which tide observations are taken and reduced to obtain mean values for tidal datums. It is necessary for standardization because of periodic and apparent secular trends in sea level.

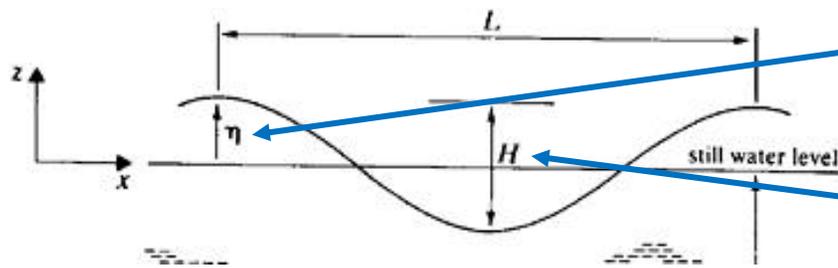
## Definitions and Abbreviations

**Base Flood Elevation (BFE)** – the height floodwaters are expected to reach during a design storm. Depending on the model and source, BFE values may include wave height.

**Design Flood Elevation (DFE)** – the flood elevation that assets should be designed in order to reduce flood risk. DFEs often account for considerations including freeboard, projections of sea level rise for a specific time horizon, and wave height.

**Freeboard** – an additional amount of height above the BFE used as a factor of safety.

**Stillwater Elevation** is the water surface elevation that considers tides, Sea Level Rise (SLR), storm surge and wave set-up. Stillwater elevation does not include wave crest (or wave height) influence. See diagram below:



**Wave height** – FEMA studies: wave height + still water level and a transect-based modeling approach

**Wave crest** – BH-FRM and MC-FRM methods include wave crest + still water level and a hydrodynamic approach

**2070 Mean Higher High Water (MHHW)** – The average of the higher high water height of each tidal day observed over the National Tidal Datum Epoch.

**2070 Highest Astronomical Tide (HAT) elevations** – The elevation of the highest predicted astronomical tide expected to occur at a specific tide station over the time period of 40 years. The 40 years period will include 2 National Tidal Datum Epoch periods.

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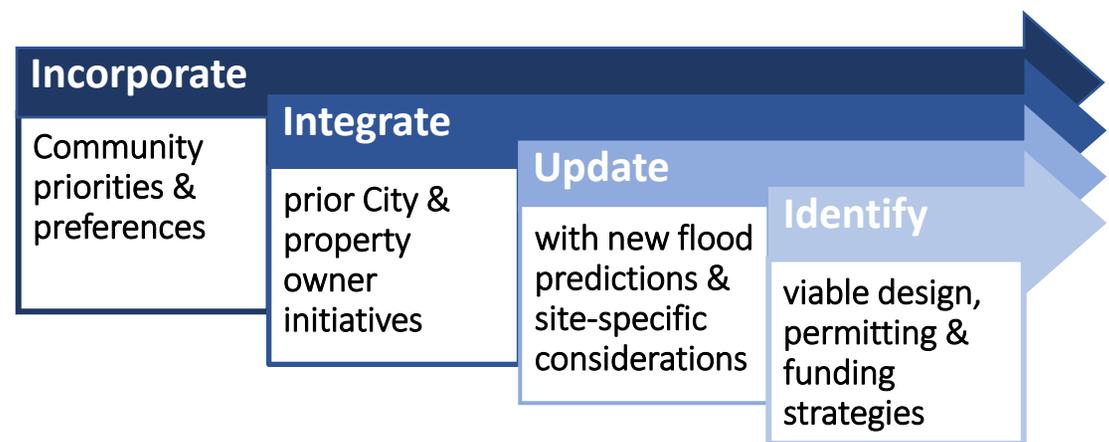
# Project Overview

# Project Overview

## Project Summary

With funding from the **Commonwealth of Massachusetts**, the Wharf District Council is collaborating with the **City of Boston** and **Wharf District Stakeholders** to provide an **engineering assessment** to advance prior flood resiliency planning initiatives by the City of Boston for **protecting all the Wharf District (not just individual buildings)** from present and anticipated future floods. This assessment will:

- Incorporate Community priorities & preferences
- Integrate prior flood resilience initiatives by the City and Wharf District property owners
- Update prior flood resilience plans to reflect advancements in flood predictions, site-specific considerations, and regulatory and City of Boston requirements for the redevelopment of specific parcels
- Identify viable resiliency design, permitting, and funding strategies to deliver district-wide flood protection



A range of flood resiliency strategies will be assessed for engineering viability, resulting in the **identification of preferred strategies for each waterfront property**. Where preferred strategies would require regulatory modification(s), alternative strategies will also be identified.

# Project Overview

## Project Summary (Continued)

While the strategies identified by this Project will not protect individual properties or the Wharf District on their own, they will serve as **integral components of a larger contiguous flood protection system** extending beyond the borders of the Wharf District, identified in Boston’s Coastal Resilience Solutions for Downtown Boston and North End, and Coastal Resilience Solutions for South Boston reports.

As a component of this larger city-wide flood protection system, the following design and permitting considerations identified in the Coastal Resilience Solutions for Downtown Boston and North End report and the Article 25A Coastal Flood Resilience Overlay District zoning and Chapter 91 regulation will be used to guide the assessment and identification of resiliency strategies for the Project:

- **Coordination with bordering districts** to construct a cohesive resiliency system will be required
- Resiliency strategies will be **designed to no less than the Target DFE** identified in the Coastal Resilience Solutions for Downtown Boston and North End report
- Resiliency strategies may need to be **sited on land with public interest** to allow for public-private partnerships and to secure public funding sources
- Resiliency strategies should **tie into work being done by private development sites**
- Building-scale measures should be completed **in addition to** implementation of district scale systems
- Resilience measures should maintain access and egress – **including emergency access** – between buildings and the public realm during flood conditions **for people of all abilities**.
- To the greatest extent possible, resilience measures should be **designed to support pedestrian connections**.
- Enhancements at parcel level should **not worsen risk at adjacent parcels** or restrict implementation of district resilience system.
- Maintaining a **contiguous Harborwalk** throughout the district at an elevation that minimizes tidal “sunny-day” flooding will be required.
- Preserving **access or sight lines to the water** will be required for non-water dependent uses.

# Project Overview

## Project Approach

We will perform **engineering due diligence assessments** that will support the identification of a range of viable strategies for each waterfront property. We will **engage with Wharf District Stakeholders and EDI Partners** to assess the impacts of these flood resiliency strategies and identify a set of preferred resiliency strategies for each waterfront property. Where preferred strategies would require regulatory modifications, alternative strategies will also be identified. We will develop **concept designs** of these preferred and alternative strategies.

### Engineering Due Diligence Assessments:

We have collected, catalogued, and reviewed relevant technical and regulatory information for assessing and identifying constructable flood resiliency strategies. This assessment includes a review of access considerations – including for **emergency access, accessibility, and waterfront transportation**. The findings of the due diligence assessments are summarized in this **Basis of Design Report**.

### Stakeholder and EDI Partner Engagement:

**EDI Partners:** Refer to the [Project Approach to Community Engagement](#) section of this report.

### **Wharf District Stakeholders (including Waterfront Property Owners):**

- We will **seek feedback on Wharf District Stakeholder preferences and priorities** identified in prior engagement processes including the **2019 Wharf District Council Visioning Workshop** and the **Climate Ready Boston and Coastal Resiliency Solutions for North End and Downtown Boston** reports. Feedback will be used to develop evaluation criteria for assessing and identifying preferred resiliency strategies.
- We will **provide presentations of the project deliverables and seek feedback** from Wharf District Stakeholders to be incorporated into the project approach and assessment and identification of strategies.

### **Waterfront Property Owners:**

- We will collect site specific conditions information and resiliency plans from Waterfront Property owners.
- We will engage Waterfront Property owners in a **series of workshops** to incorporate their knowledge, priorities, and preferences into the assessment and identification of preferred resiliency strategies.

# Project Overview

## Project Approach (continued)

### Concept Design:

We will develop a series of concept design deliverables that will form a foundation for coordinating, funding, and implementing subsequent detailed design of district flood protection strategies. These deliverables will include:

- **For Waterfront Properties:** Property-Specific Draft Resiliency Plans, Permitting Considerations, and Cost Benefit Analyses
- **For Inland Properties:** Inland Flood Resiliency Guidelines
- **For the Wharf District:** Preliminary and Final Resiliency Plans, Cross-Sections, and a Concept Report including Cost Estimates, Implementation Timeline, and a List of Funding Sources & Creative Financing Opportunities

Examples of each Concept Design deliverable is provided in the [Project Deliverables](#) section of this report.

# Project Overview

## Project Approach to Community Engagement

We note that planning and design of the public and private land improvements required to ultimately implement the flood resiliency strategies identified by this engineering assessment is not included in this Project. As such, we acknowledge that the associated comprehensive Community engagement initiatives necessary to effectively incorporate the critical issues of waterfront access and social equity, diversity, and inclusion (EDI) in waterfront planning and design, cannot be fully addressed by this Project alone.

We also recognize that any assessment of district-wide flood resiliency strategies must consider impacts on waterfront access and the associated issues of EDI.

Therefore, this Project will:

- Review Community preferences and priorities previously expressed in the comprehensive community engagement processes summarized by the City of Boston's **Climate Ready Boston** and **Coastal Resiliency Solutions for North End and Downtown Boston** reports.
- **In close collaboration with the City of Boston, identify EDI organizations and/or champions (EDI Partners)** to include in the development of a summary of Community preferences and priorities that will be used to develop evaluation criteria for assessing and identifying preferred resiliency strategies.
- **Seek and incorporate feedback** on project deliverables from the EDI Partners and the City of Boston.

Through this process, we strive to incorporate Community priorities and preferences in the assessment and identification of viable flood resiliency strategies. It is our hope that by defining the engineering performance criteria of viable resiliency strategies, this engineering assessment will also facilitate meaningful conversations about waterfront access and EDI in subsequent resiliency and land improvement planning and design efforts.

# Project Overview

## Project Approach to Community Engagement

The diagram below summarizes how we will identify and incorporate Community priorities and preferences directly into the decision-making process for the Project through engagement with EDI Partners and Wharf District Stakeholders.





# Understanding of Community Considerations

# Understanding of Community Considerations

Several open and comprehensive community engagement initiatives addressing flood resiliency for the Wharf District and surrounding communities have been completed in recent years. These initiatives – listed below – provide a wealth of information provided by the Community about their priorities and preferences for flood resiliency. In respect of the time and effort put in by the Community to engage in these prior initiatives, **the following pages of this report summarize our initial review of the Community’s preferences and priorities as documented in the reports and materials produced by these initiatives.**

Additionally, we have included a summary of key considerations for access through the Wharf District and to the Waterfront based on a review of site specific information provided by the Wharf District Stakeholders, publicly available topographic and site layout information, and site visits by our Project team

## Prior Community Engagement Initiatives:

[2016 City of Boston’s Climate Ready Boston](#) – The City’s ongoing initiative to examine vulnerabilities in the City’s neighborhoods and solutions to protect people throughout the City. The resulting report and published open house materials document the community engagement findings.

[2019 Wharf District Public Realm Visioning Study](#) – In 2019, the Wharf District Council, supported by Halvorson, engaged with Wharf District Stakeholders to define community preferences associated with Enhancing Quality of Life, Connections & Access, and Resiliency & Planning for Change. The Study culminated in the Wharf District Council’s video entitled ‘A Vision for the Future’.

[2020 Coastal Resiliency Solutions for North End and Downtown Boston](#) – The City’s neighborhood-specific resiliency initiative builds upon the findings of Climate Ready Boston through a multi-stakeholder planning process. The resulting report and associated published open house materials document the community engagement findings.

We will seek feedback from the Wharf District Stakeholders, City of Boston, and EDI Partners on this initial review to create an updated list of Community preferences and priorities which will be used to develop evaluation criteria for assessing and identifying preferred resiliency strategies.

## 2016 Climate Ready Boston Report

The following Community priorities and preferences relevant to identifying, assessing, prioritizing, and designing district-wide flood resiliency strategies are stated in the 2016 Climate Ready Boston Report.

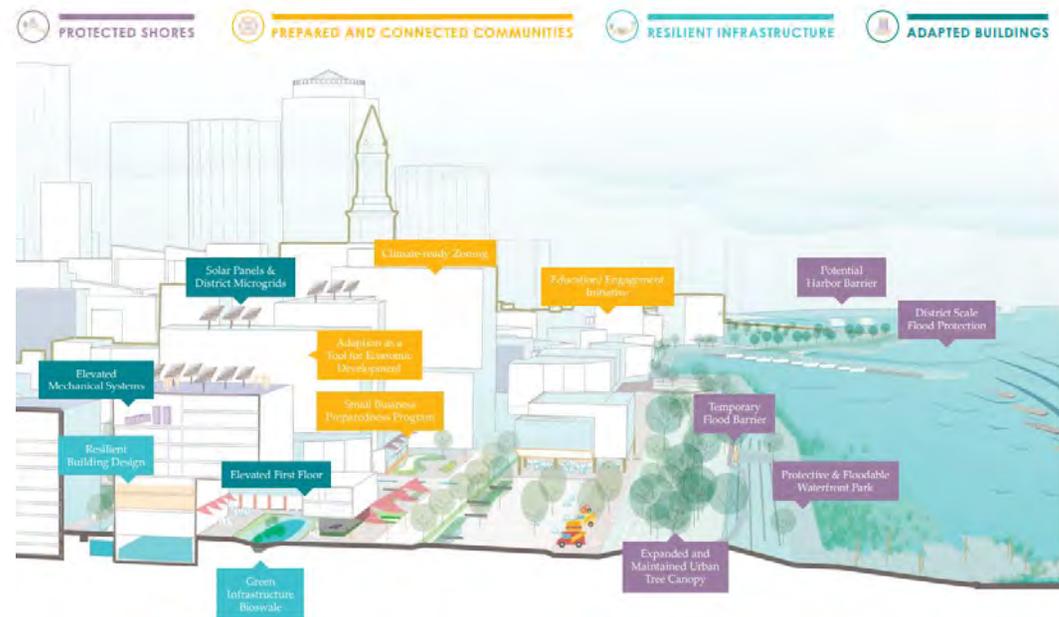
These will be reviewed with Wharf District Stakeholders, EDI Partners, and the City of Boston to inform the selection of evaluation criteria for the Project.

### Evaluation Criteria for Resiliency Strategies:

- Timing of Flood Risk
- Consequences for People and Economy
- Social Equity
- Financial Feasibility
- Potential for Additional Benefits
- Residual Risk (risk remaining after a strategy is implemented)
- Induced Risk (potential impacts of a flood strategy on adjacent sites)

### Resiliency Strategy Design Considerations:

- Resilience Principles: Generate Multiple benefits, Incorporate Local Involvement in Design and Design Making, Create Layers of Protection at Multiple Scales, Design In Flexibility and Adaptability, & Leverage Building Cycles
- Implementation Timeline prioritization factors: who and what are most at risk now; existing efforts that can be built upon; resources available to undertake the work; precursor initiatives; risk or cost of delay; who has to take action; existing community support; and difficulty of implementation.
- Expand the use of green & natural infrastructure
- Consider priority evacuation and service road infrastructure including Interstate 93, Atlantic Avenue, and Congress Street, public transportation systems, and access to medical services



Reference: Climate Ready Boston Executive Report – Creating Layers of Protection at Multiple Scales

# 2020 Coastal Resilience Solutions for Downtown Boston and North End Report

The following summarizes our understanding of Community priorities and preferences relevant to identifying, assessing, prioritizing, and designing district-wide flood resiliency strategies, as stated in the 2020 Coastal Resilience Solutions for Downtown Boston and North End Report. **These will be reviewed with Wharf District Stakeholders, EDI Partners, and the City of Boston to inform the selection of evaluation criteria for the Project.**

## Evaluation Criteria for Resiliency Strategies:

- Effectiveness
- Design Life + Adaptability
- Environmental Impact
- Equity
- Feasibility
- Social Impact
- Value Creation

## Resiliency Strategy General Design Considerations:

- Building-scale measures should be completed in addition to implementation of district scale systems
- *Public-Private Partnerships*: In some cases, in order to secure public funding sources, the flood barrier will need to be managed and maintained by a public agency and potentially sited on land with public interest
- Resiliency strategies should tie into work being done by private developments, including at the Harbor Garage site, Harbor Towers, Boston Harbor Cruises, and by Pembroke

## Resiliency Strategy Parcel-Specific Design Considerations:

- *Christopher Columbus Park*: enhance the relationship of the park to the waterfront, increase opportunities to experience the water, allow for lower level Harborwalk subject to intermittent flooding, provide stepped viewing
- *Long Wharf*: maintain marine access, harbor views, and pedestrian and vehicular access
- *New England Aquarium*: integrate the Aquarium's "Blueway Concept" into the district-level strategy
- *Harbor Towers*: explore outboard, in-water solutions to be integrated with the district-level strategy
- *Rowes Wharf to Hook Wharf*: These properties do not contribute to a larger flood pathway and therefore solutions should focus on self-protection in the near term & coordination across properties in the longer term.

## 2019 Wharf District Public Realm Visioning Study

The following summarizes our understanding of relevant Wharf District Stakeholder priorities and preferences expressed during the **2019 Wharf District Public Realm Visioning Study** based on notes and summaries prepared by Halvorson, Wharf District Council CRTF members, and a review of the Wharf District Council’s associated ‘A Vision for the Future’ video by NeoScape. **These will be reviewed with Wharf District Stakeholders, EDI Partners, and the City of Boston to inform the selection of evaluation criteria for the Project.**

### Resiliency Strategy Design Considerations:

- Provide attractive flood resiliency strategies within the Harbor, District Wide, and Parcel by Parcel
- Enhance public access and experiences, including facilitation of a world-class Harborwalk
- Facilitate the ability of residents and tenants to live and carry-on daily activities during and after a flood event
- Provide district-wide consistency of physical elements
- Be sensitive to historical context - highlight and reinforce the district’s heritage and history, including the clearly identifiable character of its wharfs
- Robust Cross-City Connections



2019 WDC Resiliency Visioning Workshop image from Wharf District Council’s ‘A Vision for the Future’ video by NeoScape



2019 WDC Resiliency Visioning Workshop image by Halvorson

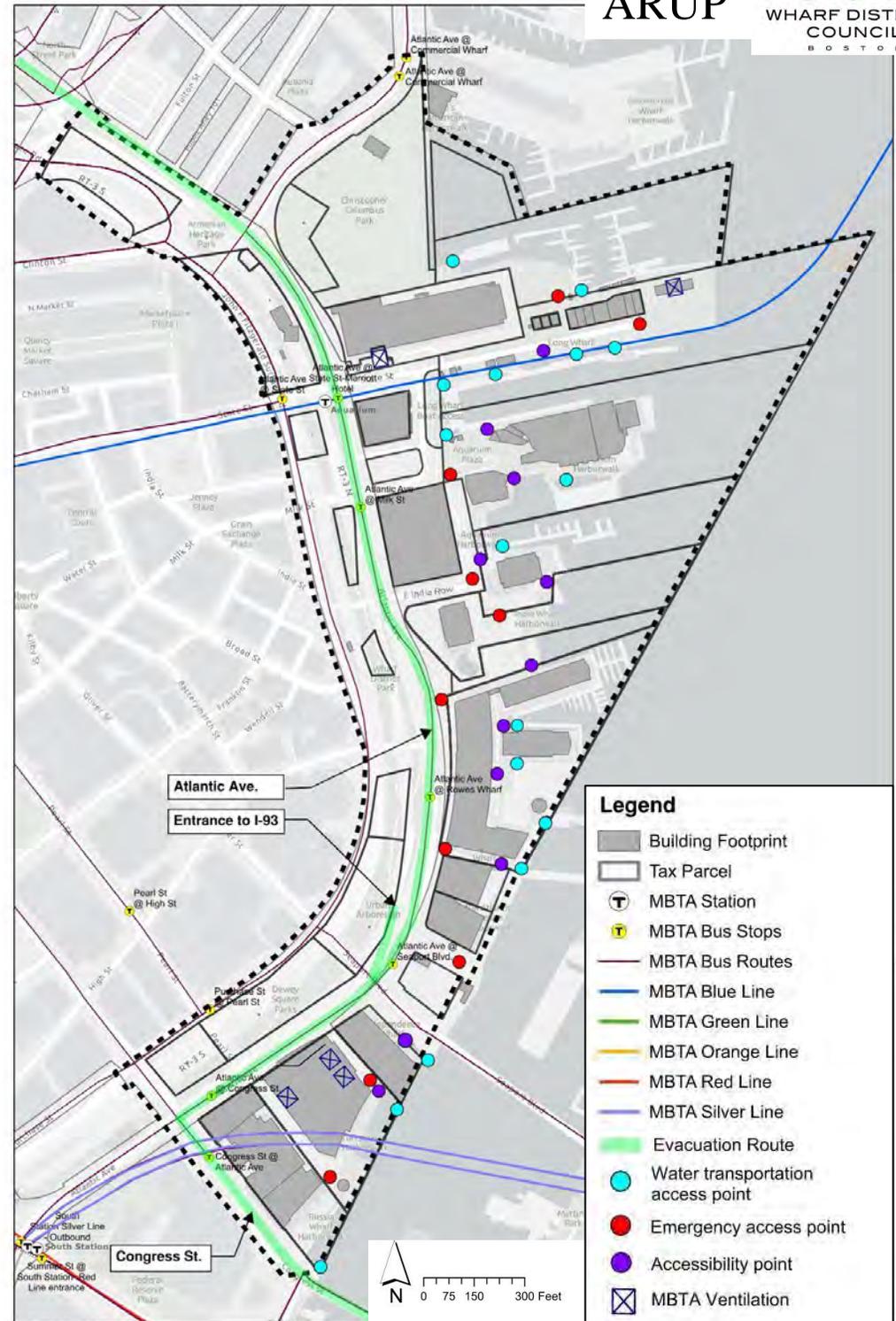
## Access Considerations

Our understanding of key considerations for access through the Wharf District and to the Waterfront are identified on the map to the right. These will be reviewed with Wharf District Stakeholders, EDI Partners, and the City of Boston to inform the selection of evaluation criteria for the Project.

**Key access points** to be considered in assessing resiliency strategies include:

- **Accessibility Points:** locations where ramps or grade changes accommodate ADA-compliant access to the waterfront
- **Emergency Access Points :** locations where vehicular routes to the waterfront terminate due to site constraints
- **Water Transportation Access Points:** dock entrances

**Priority evacuation infrastructure** to be considered in assessing resiliency strategies include: public transportation systems, Interstate 93, Atlantic Avenue, & Congress Street



# Understanding of Community Considerations

The following summarizes our initial review of the Community priorities and preferences that may be considered for selecting evaluation criteria for assessing resiliency strategies, based on this initial review of community engagement initiatives and key access considerations.

We will seek feedback from the Wharf District Stakeholders, City of Boston, and EDI Partners on this initial review to create an updated list of Community preferences and priorities which will be used to develop evaluation criteria for assessing and identifying preferred resiliency strategies.

## Considerations for assessment and identification of preferred strategies, applicable to this Project:

- Effectiveness
- Design Life + Adaptability / Flexibility
- Environmental Impact
- Social Impact/Equity: Accessibility
- Social Impact: Impacts on Views
- Engineering Feasibility / Difficulty of implementation
- Financial Feasibility
- Potential for Multiple Benefits
- Residual Risk / Layers of Protection
- Induced Risk

## Considerations for development of implementation timelines, applicable to this Project:

- Timing of Flood Risk
- Consequences for People & Economy
- Leverage Building Cycles
- Who and what are most at risk now
- Existing efforts that can be built upon
- Resources available to undertake work
- Precursor initiatives
- Risk or cost of delay
- Who has to take action
- Existing community support

## Additional considerations for public and private land improvement planning and design, applicable to subsequent projects:

- Social Equity
- Social Impact
- Value Creation
- Incorporate Local Involvement in Design

# Project Deliverables

# Project Deliverables

The intent of the Concept Design Deliverables are summarized below and on the following pages.

## Preliminary District Resiliency Plan

1. Serve as a 'first pass' at refining the City's Coastal Resilience Solutions for Downtown and North End report strategies to integrate Due Diligence Assessment and initial Stakeholder Engagement outcomes, and to identify assumptions for conditions at Wharf District boundaries
2. Solicit community feedback

## Draft Property-Specific Resiliency Plans for each waterfront property

1. Identify strategies to coordinate district and property owner objectives
2. Solicit waterfront property owner feedback

## Inland Property Resiliency Guidelines

1. Demonstrate updated flood projections for inland properties & infrastructure
2. Provide recommendations for inland properties to control their own destiny

## Final District Resiliency Plan and Report

1. Define constructable district flood protection strategies
2. Provide a flexible & adaptable implementation timeline
3. Summarize cost, schedule, and permit considerations
4. Identify funding and coordination opportunities

# Project Deliverables

## Project Deliverables – Examples

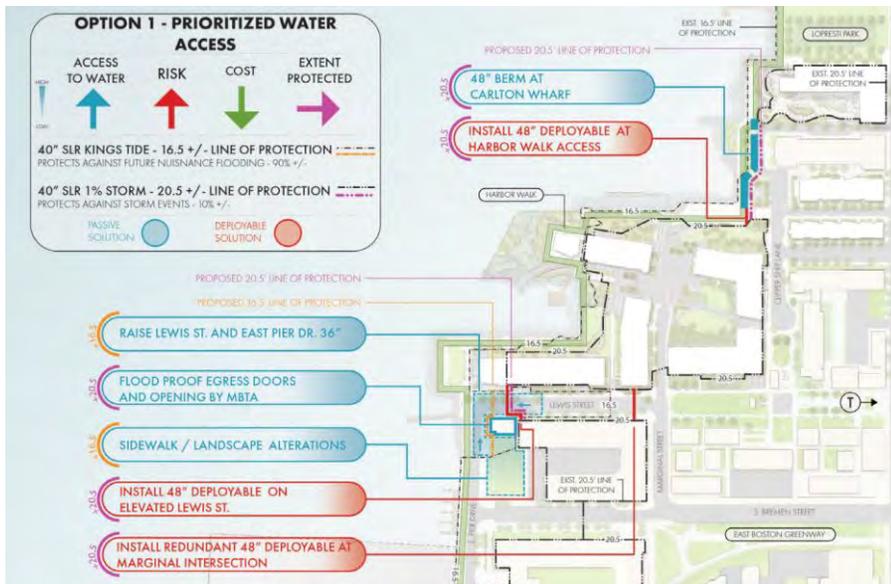
An example of the type of information to be provided by the **Preliminary District-Wide Resiliency Plan** is provided below. This deliverable will refine the resiliency strategies identified in the Coastal Resilience Solutions for Downtown Boston and North End report by identifying modifications to the locations and elevations based on engineering due diligence assessments of site-specific information. A range of viable strategies will also be identified by using and supplementing the Resiliency Toolkit provided in the Coastal Resilience Solutions for Downtown Boston and North End report.



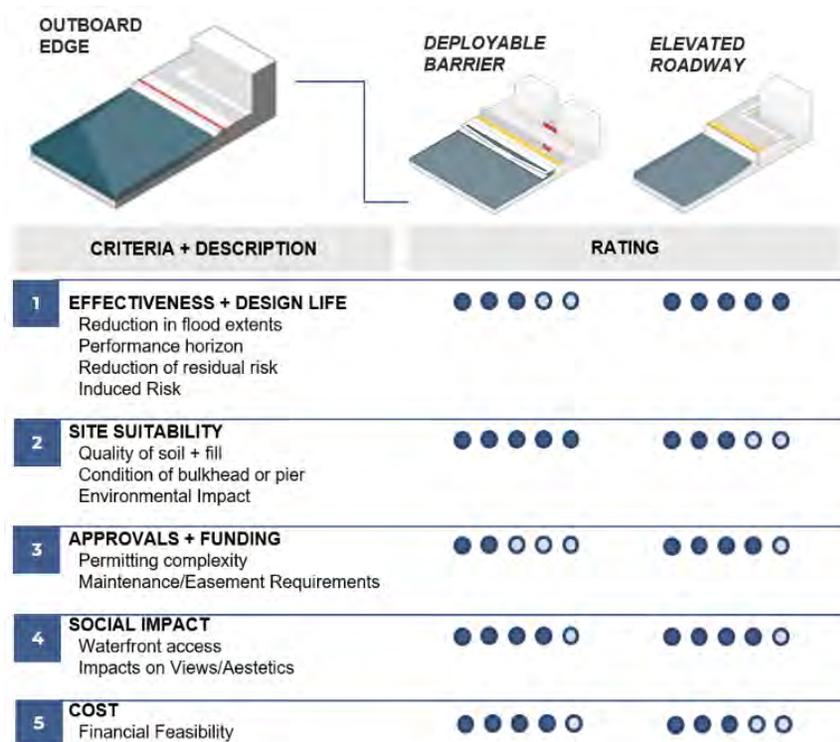
# Project Deliverables

## Project Deliverables – Examples

Examples of the type of information to be provided by the **Draft Property-Specific Resiliency Plans** are provided below. These draft plans will incorporate feedback received in a series of workshops with Waterfront Property owners, further refining the resiliency strategies identified in the Preliminary District-Wide Plan to an initial set of preferred and potentially alternative strategies addressing site-specific considerations. Permitting considerations and a high level cost benefit analysis will be provided for each property. Selection criteria used in the Cost benefit analysis and associated selection of preferred strategies will be based on Wharf District Stakeholder and Community priorities and preferences to be defined during the Project.



Plan of Clippership Wharf by Halvorson and Arup

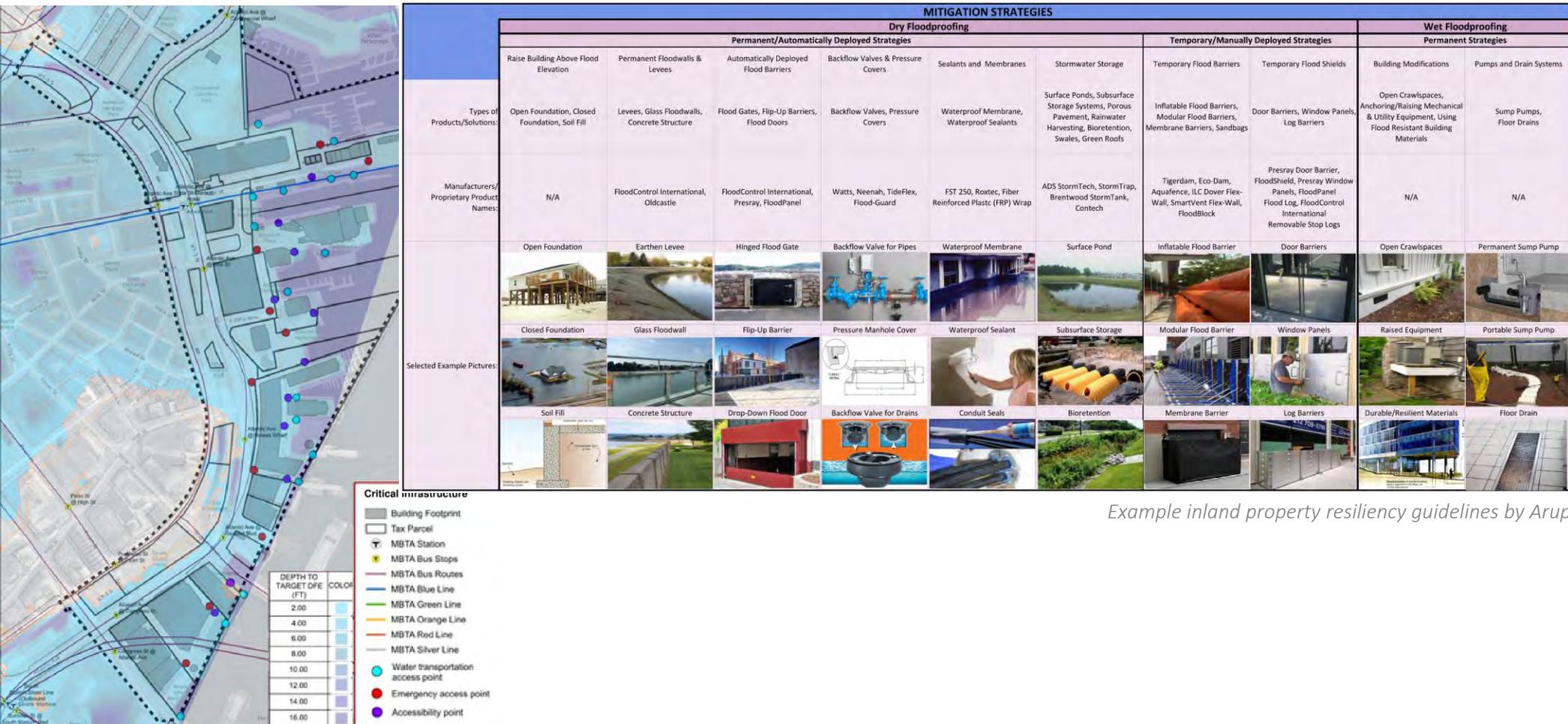


Cost Benefit Analysis example by Arup: Image is a preliminary example intended to convey the type of information that will be included in the Cost Benefit Analysis. Specific selection criteria and definitions for the qualitative rankings will be refined during the Project based on feedback from Wharf District Stakeholders, EDI Partners, and the City of Boston

# Project Deliverables

## Project Deliverables – Examples

Examples of the type of information to be provided by the **Inland Property Resiliency Guidelines** is provided below. A map of the flood hazards and flow pathways potentially impacting inland properties, along with an identification of critical inland infrastructure will be provided. A summary of strategies and products available for building-level flood protection will be provided. These strategies are intended to be implemented in addition to the district-wide strategy – providing layers of protection to support community resiliency.



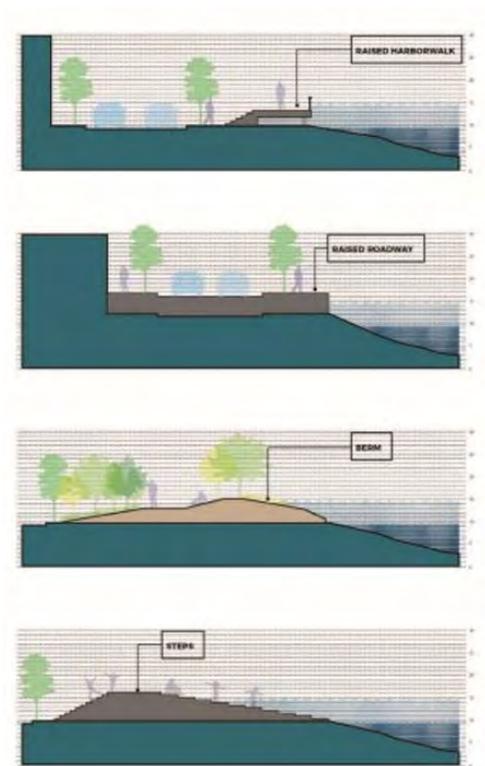
Example inland property resiliency guidelines by Arup

Example inland flood hazard map by Arup

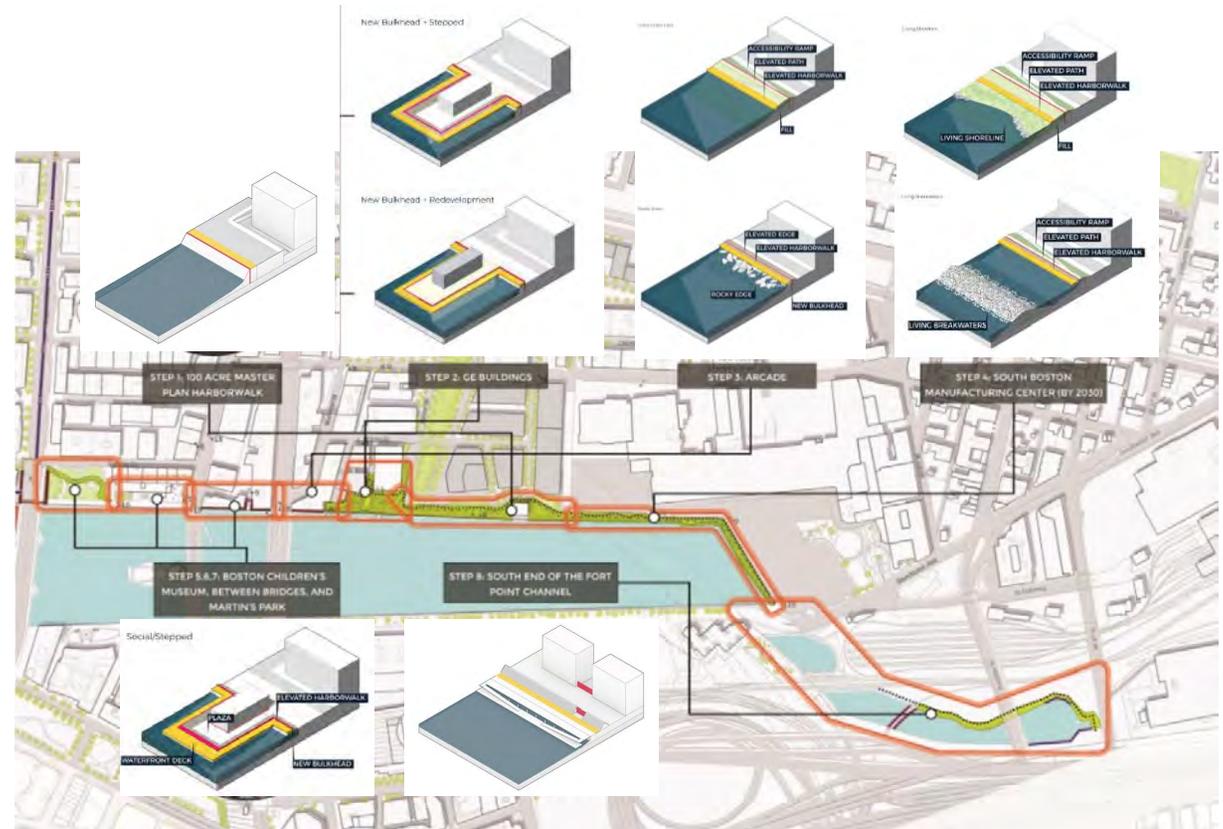
# Project Deliverables

## Project Deliverables – Examples

Examples of the type of information to be provided by the **Final District Resiliency Plan and Report** is provided below. Feedback from Wharf District Stakeholders, EDI Partners, and the City of Boston will be incorporated to produce a set of plans and sections demonstrating the preferred and alternative strategies for the district. A report will also be provided and will include an implementation timeline, cost and schedule estimates, permitting considerations, and funding and future coordination opportunities.



Reference: Coastal Resilience Solutions for South Boston (by Halvorson)

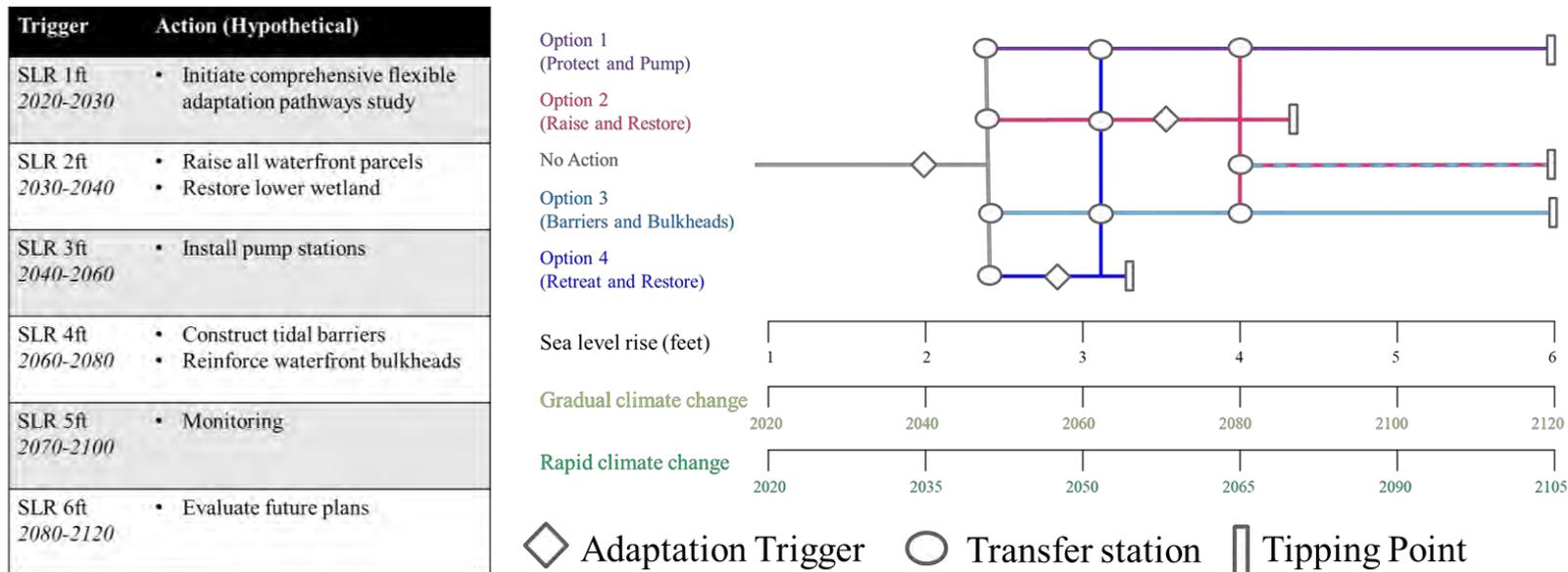


Reference: Plan by Coastal Resilience Solutions for South Boston (by Halvorson); axions from Coastal Resilience Solutions for Downtown Boston and North End and supplemented with additional axions developed for this Project by Halvorson

# Project Deliverables

## Project Deliverables – Examples

Examples of the type of information to be provided by the [Final District Resiliency Plan and Report](#) is provided below. Feedback from Wharf District Stakeholders, EDI Partners, and the City of Boston will be incorporated to produce a set of plans and sections demonstrating the preferred and alternative strategies for the district. A report will also be provided and will include and implementation timeline, cost and schedule estimates, permitting considerations, and funding and future coordination opportunities.

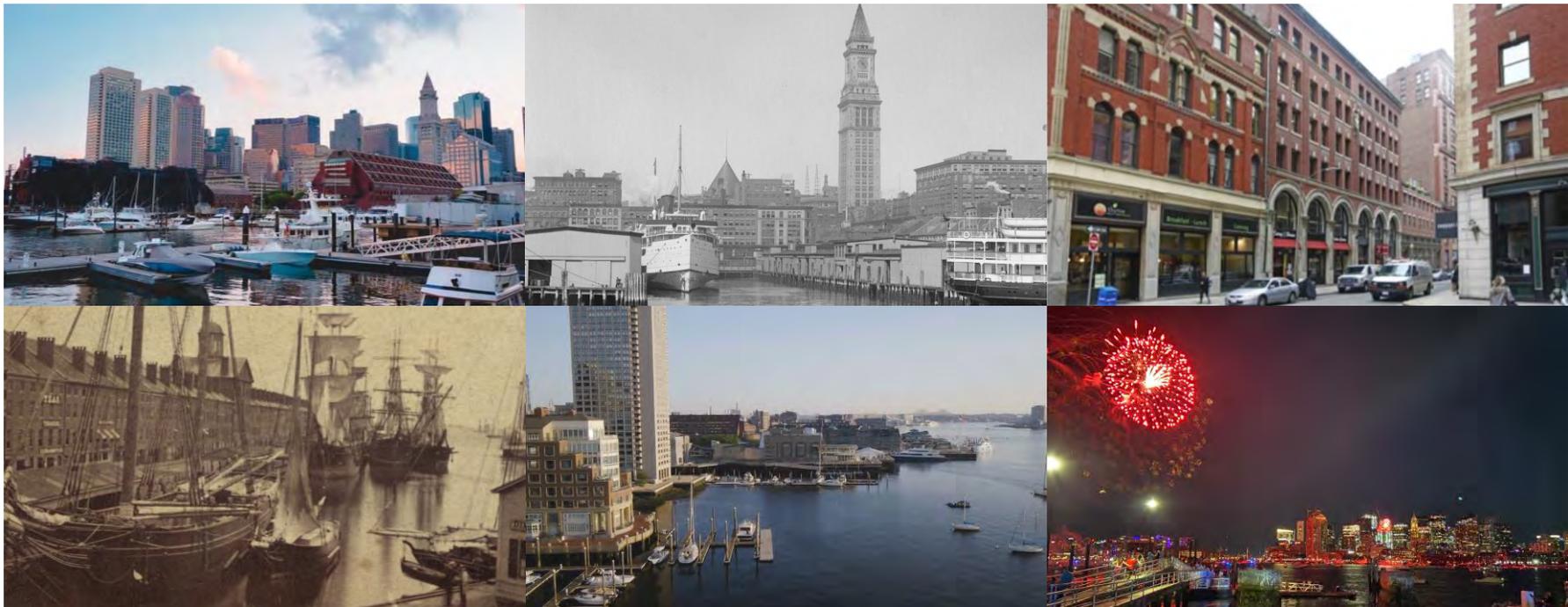


Example implementation timeline by Arup

# Project Deliverables

## Project Deliverables: A foundation for implementation

It is our intent is to provide actionable deliverables that leave our community with an understanding of the flood resiliency strategies that can be permitted, funded, and built, and a roadmap to coordinate subsequent planning and design efforts – a foundation upon which the Wharf District can build a thriving future.



# Project Design Flood Elevation Recommendations

# Project Design Flood Elevation Recommendations

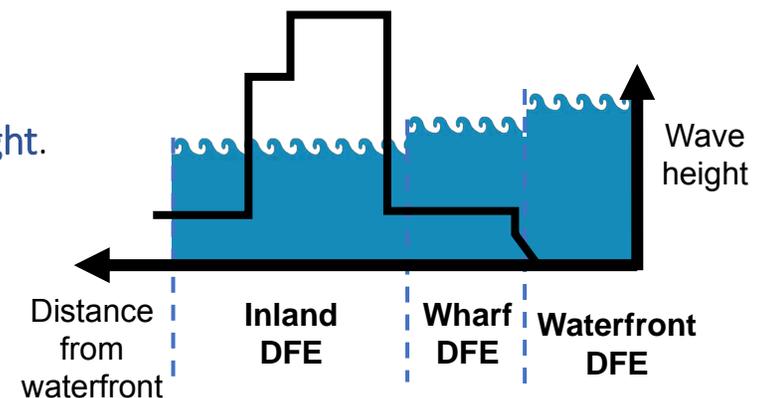
We recommend designing flood protection strategies to protect against flooding up to the **Project Design Flood Elevation (DFE) Recommendations** summarized in this section of the report. These recommendations are intended to minimizing permit risk and maximize funding opportunities by complying with federal, state, and city requirements for district flood protection strategies. The DFE Recommendations are based on the following:

## Regulatory Considerations:

1. **District Planning Reference DFE:** City of Boston's Target DFEs, which are defined in the Coastal Resilience Solutions for Downtown and North End report (CRS Report)
2. **Minimum DFE:** Present-day regulated DFEs are based on FEMA *and* Boston Zoning Commission & BDPA Article 25A Zoning overlay. The Minimum DFE is determined by the greater of these two elevations, which have been evaluated at each property. For all properties in the Wharf District, Article 25A has been determined to be the Minimum DFE.
3. **Strategic DFE:** based on similar considerations used by City of Boston to develop the CRS Report's Target and DFEs, but using the updated flood projections of MC-FRM and 2 feet of freeboard to align with the minimum requirements for FEMA Levee Certification Standards and Residential Building Use.

Flood Resiliency Strategy Location: As wave heights dissipate as they travel across land, flood protection strategies located at the waterfront will need to protect against higher flood elevations than those constructed further inland. The Project Strategic DFEs therefore vary based on the location of each flood resiliency strategy. **Strategic DFE locations are defined in the image to the right.**

We recommend flood resiliency strategies be constructed to the Minimum DFEs and designed to be incrementally raised to the Strategic DFEs. Refer to the [Project Design Flood Elevation Recommendations Appendix](#) for a summary of data used in selecting these DFEs.



### 3. Strategic DFE: Massachusetts Coast Flood Risk Model (MC – FRM)

**Regulatory Considerations:** Woods Hole Group anticipates the MC-FRM DFEs are likely to be required by the City of Boston within the next 5 years. The MC-FRM is in effect the state-standard tool for assessing vulnerabilities and informing resilient design for future coastal flood hazards under a changing climate. However, the City of Boston is currently using BH-FRM-derived DFEs and has not yet adopted the MC-FRM as the basis for Climate Ready Boston initiatives or coastal resilience zoning.

The DFEs are derived from the Massachusetts Coast Flood Risk Model (MC – FRM), are based on similar considerations as BH-FRM, but uses updated flood projections.

**Time Horizon:** 2070

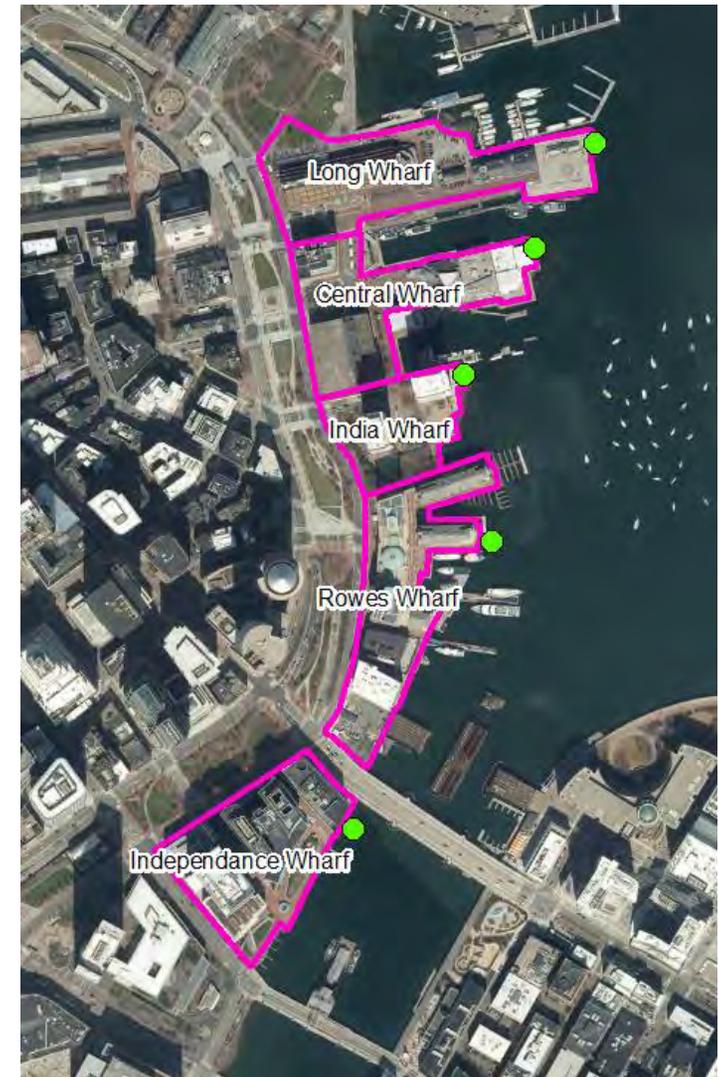
**Design Storm:** 1% annual chance flood

**BFE Assumptions:** Stillwater + Wave Crest, analysis point located at Water’s Edge, Wharf, and Inland

**Sea Level Rise projection:** 51.5” (4.29’) SLR

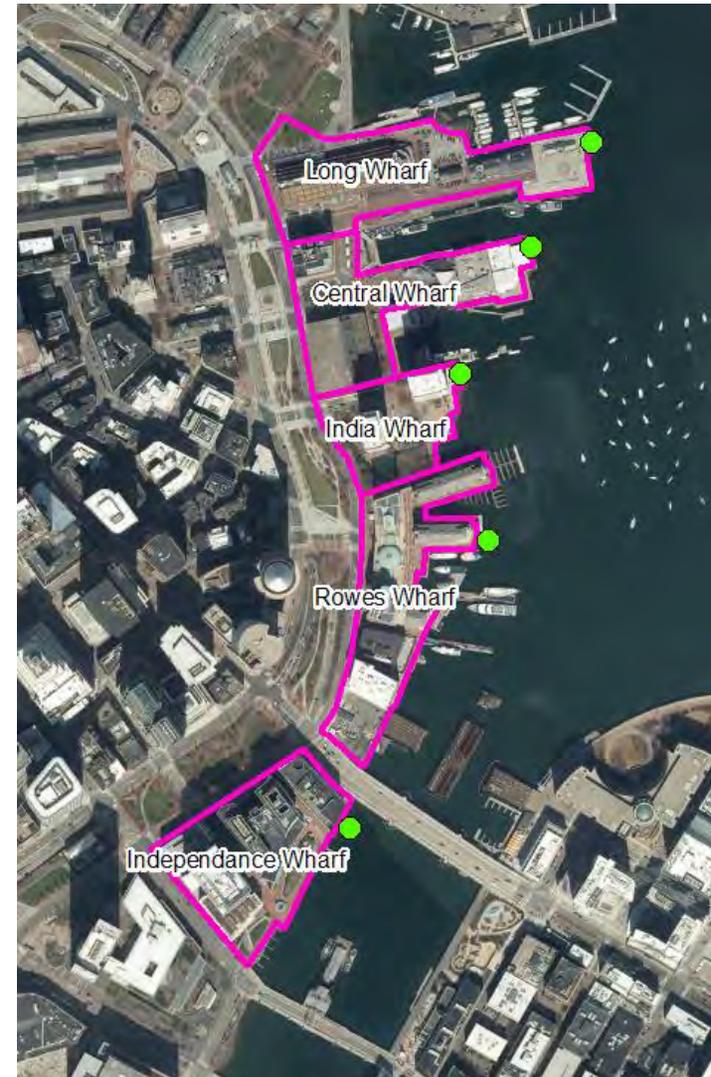
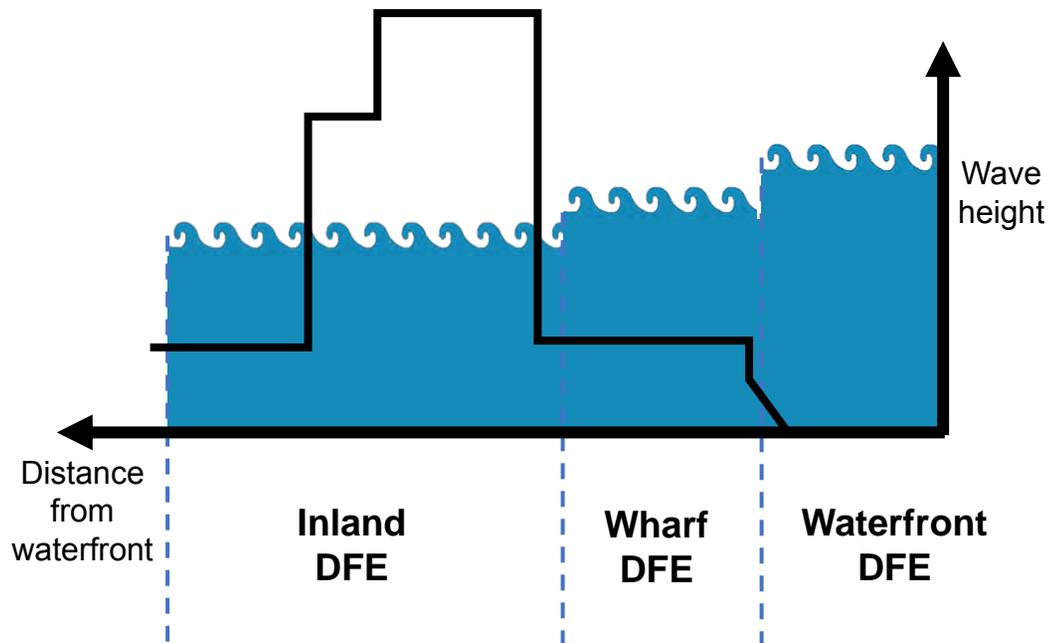
**Freeboard requirements:** 2-ft of freeboard applied across district to meet minimum requirements for FEMA Levee Certification Standards and Residential Building Use

Note: See Appendix B - Design Flood Elevation Background Information, for additional context.



### 3. Strategic DFE: Massachusetts Coast Flood Risk Model (MC – FRM) continued

**Results & Assumptions:** The MC-FRM model provides elevations at three different analysis points within the district, resulting in variability in the DFEs based on the distance of the asset or flood resiliency strategy to the water.



## Summary of Project DFEs

Property ID	Known As	1. District Planning Reference DFE	2. Minimum DFE	3. Strategic DFE		
				Waterfront	Wharf	Inland
<b>Model Assumptions</b>		2070 SLR, 1% Annual Chance Stillwater + Wave Crest (BH-FRM)	2070 SLR, 1% Annual Chance Stillwater (BH-FRM) + 2 feet of Freeboard	2070 SLR, 1% Annual Chance Stillwater + Wave Crest + (MC-FRM) + 2 feet of Freeboard		
<b>Project Specific DFE Recommendation</b>		Not Recommended	Present-day Regulated DFE	Future Anticipated Waterfront DFE	Future Anticipated Wharf DFE	Future Anticipated Inland DFE
P01	Christopher Columbus Park	15.0	15.04	19.3	18.6	17.6
P02	Long Wharf	15.0	15.04	19.3	18.6	17.6
P03	255 State Street	15.0	15.04	19.1	18.4	17.4
P04	Harbor Garage	15.0	15.04	19.1	18.4	17.4
P05	New England Aquarium	15.0	15.04	19.1	18.4	17.4
P06	Harbor Towers	15.0	15.54	19.3	18.0	17.2
P07	Frog Pond Park	15.0	15.04	19.1	18.4	17.4
P08	Rowes Wharf	15.0	15.54	19.5	17.5	16.9
P09	400 Atlantic Building	15.0	15.54	19.5	17.5	16.9
P10	Coast Guard Building	15.0	15.54	19.5	17.5	16.9
P11	Hook Lobster	14.0	15.04	19.5	17.5	16.9
P12	Independence Wharf	14.0	15.04	18.6	17.1	16.6
P13	Intercontinental Hotel Condos	14.0	15.04	18.6	17.1	16.6
P14	Atlantic Wharf (Russia Building)	14.0	15.04	18.6	17.1	16.6

All elevations reference NAVD88

### Definitions:

**DFE:** Project Design Flood Elevation Recommendations

**Stillwater:** water surface elevation considering tides, storm surge, & wave set-up

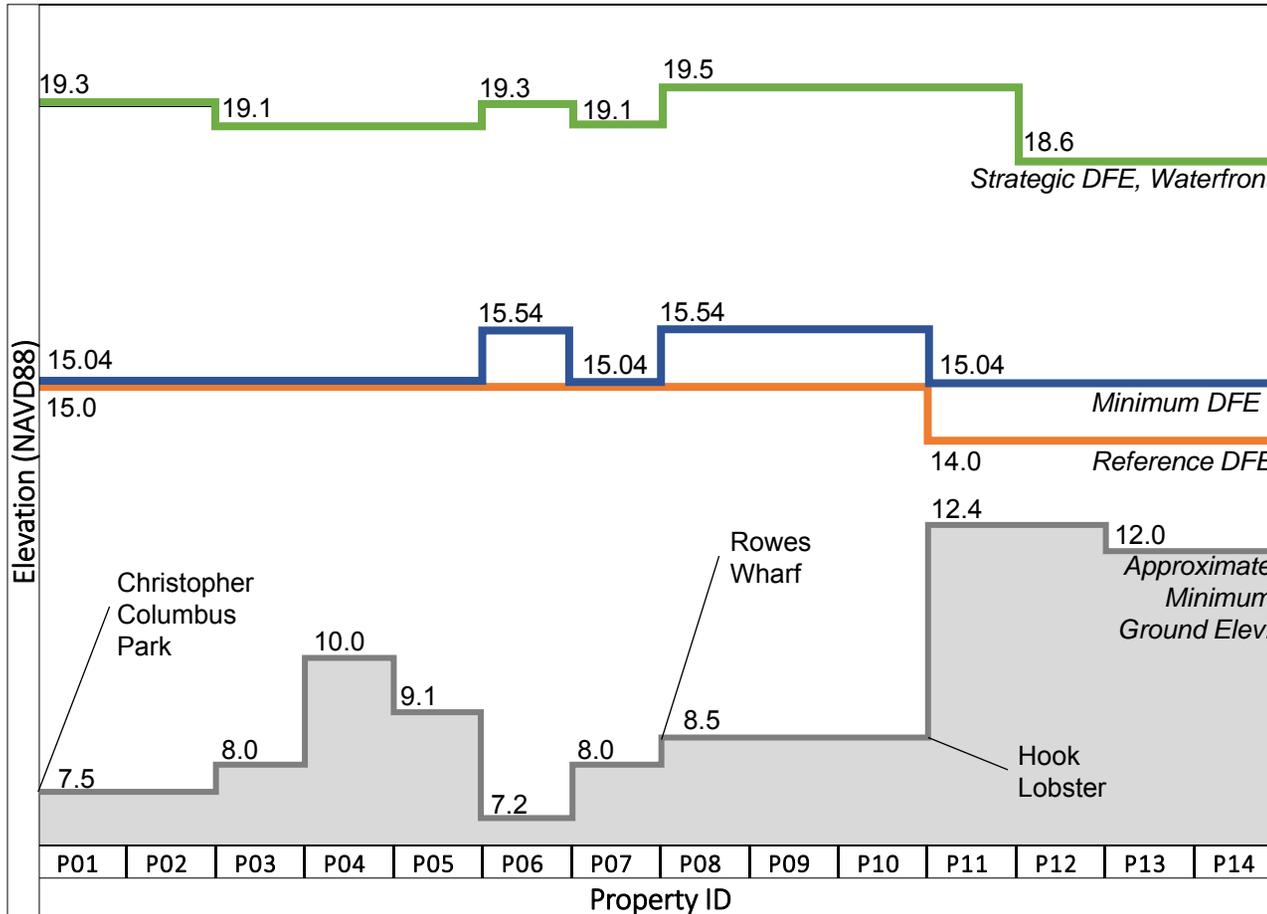
**Wave Crest:** wave height above the Stillwater elevation

**SLR 2070 (MC-FRM):** Sea Level Rise projected through 2070 by the Massachusetts Coast Flood Risk Model (51.5 inches)

**Freeboard:** 2-ft of freeboard applied across district to meet minimum requirements for FEMA Levee Certification Standards and Residential Building Use



## Summary of Project DFEs



All elevations reference NAVD88

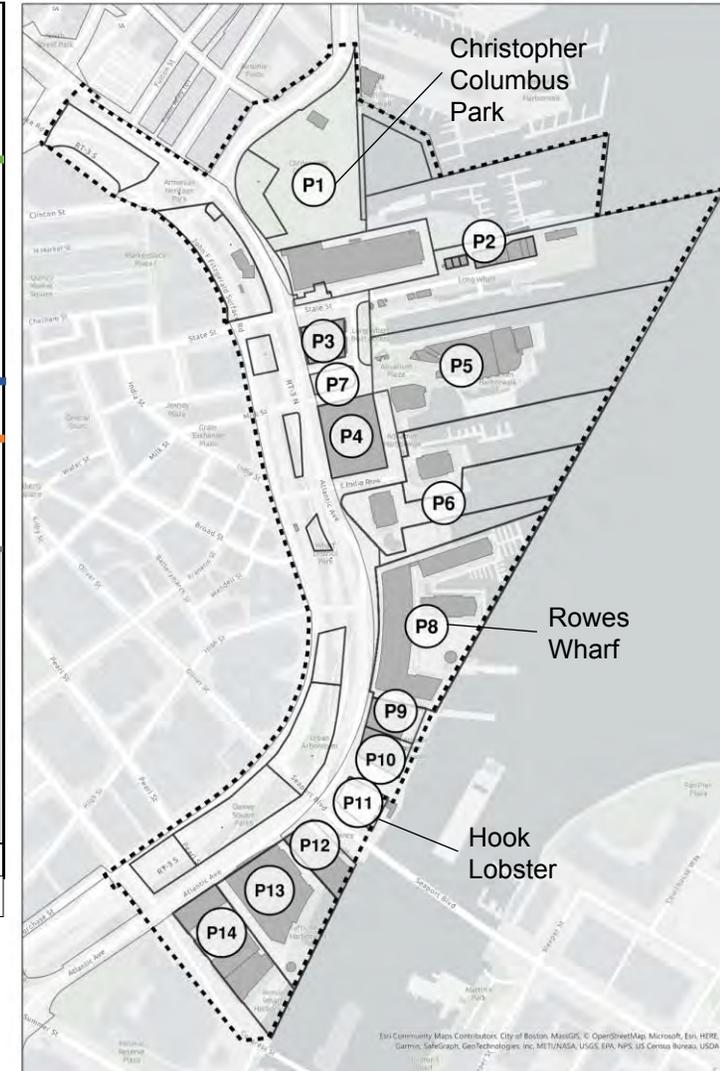
### Definitions:

**Approximate Minimum Ground Elevation:** Existing ground elevations along the waterfront

**Reference DFE:** City of Boston’s Target DFEs, which are defined in the Coastal Resilience Solutions for Downtown and North End report (CRS Report)

**Minimum DFE:** Present-day regulated DFEs Boston Zoning Commission & BDPA Article 25A Zoning overlay and 2 feet of freeboard

**Strategic DFE:** Updated flood projections of MC-FRM and 2 feet of freeboard



## Harborwalk Considerations

As the entire study area is within Chapter 91 jurisdiction, all proposed work will require a new or amended license or minor modification to an existing license. **We assume Chapter 91 licensing will require maintaining a contiguous Harborwalk throughout the Wharf District.** We also assume Chapter 91 licensing will require the Harborwalk to be elevated to minimize tidal “sunny-day” flooding. The Harborwalk elevation required by Chapter 91 licensing process is likely to vary by site based on the duration of each property’s Chapter 91 license.

For preliminary planning purposes, we recommend assuming **the Harborwalk will ultimately need to be elevated to between the 2070 Mean Higher High Water (MHHW) and the 2070 Highest Astronomical Tide (HAT) elevations.** We estimate this elevation range to be approximately 9.7’ to 11.8’, North American Vertical Datum of 1988 (NAVD 88). We note it may be possible to raise the Harborwalk incrementally as tides rise.



Reference: Rowes Wharf, Arup Site Walk - June 2022



Reference: 400 Atlantic, Arup Site Walk - June 2022

## Permit Considerations

# Permit Considerations

## Key Findings

- No regulation, plan or guideline categorically prohibits alterations to the shoreline
- Biggest permitting hurdle = Agency positions and unofficial policies – some agencies are not in practice comfortable with placing fill in waterways, raising seawalls, and placing fill in the floodplain
- Conflicting agency goals/lenses:
  - Public access
  - Conservation of the natural environment
  - Protection of property
- All resiliency strategies will likely be **subject to**:
  - Wetlands Protection Act/Boston Wetlands Ordinance
  - Chapter 91
  - MEPA
- Parcels along the Inner Harbor (not including Fort Point Channel) are **NOT subject to**:
  - Sections 401 & 404, Clean Water Act
  - Section 10, Rivers and Harbors Act
- Key Applicable Chapter 25A requirements:
  - Resilience measures should maintain access and egress between buildings and the public realm during flood conditions **for people of all abilities.**
  - To the greatest extent possible, resilience measures should be designed to support pedestrian connections
  - Enhancements at parcel level should not worsen risk at adjacent parcels or restrict implementation of district resilience system

Refer to the [Permit Considerations Appendix](#) for a detailed preliminary permitting report.

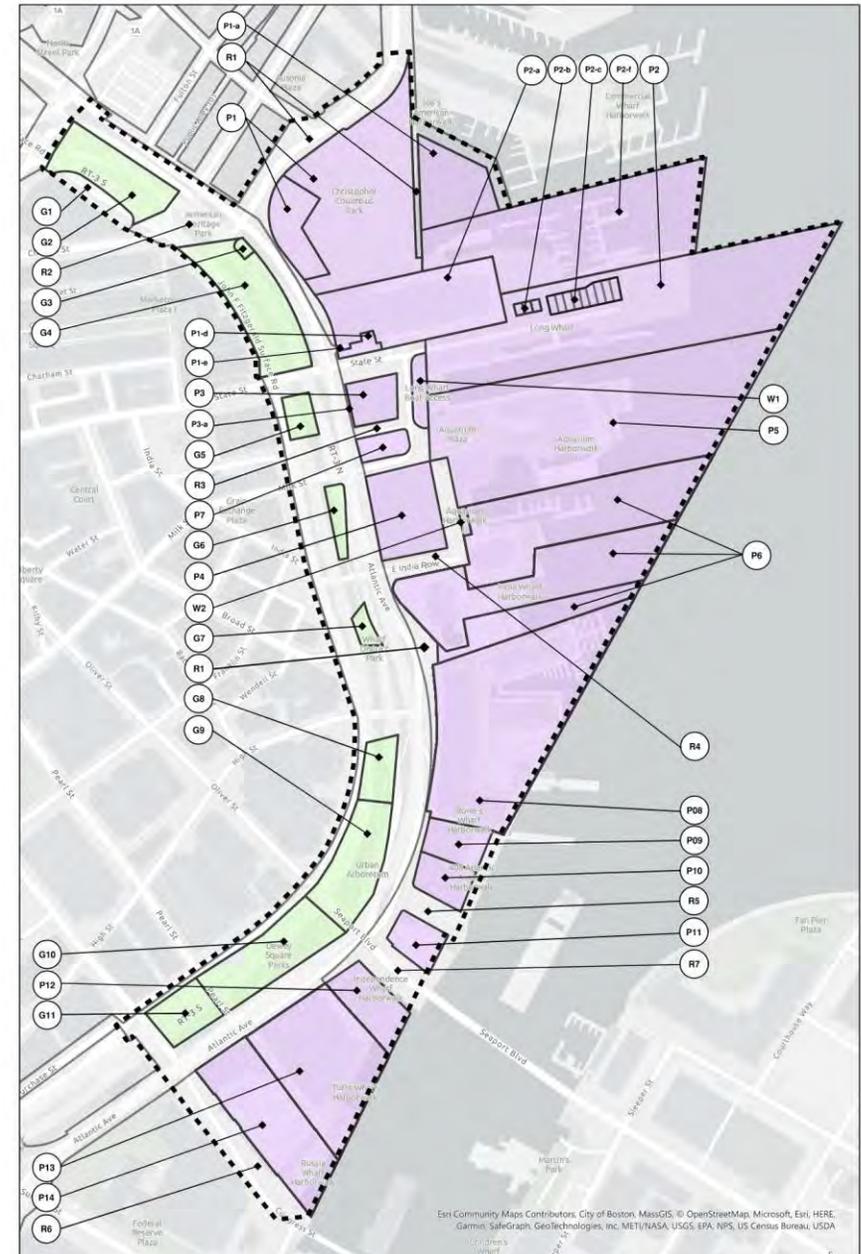
# Due Diligence & Data Gap Assessment

# Due Diligence & Data Gap Assessment

## Data Collection Overview

For the purposes of data collection, we have identified **19 constituents**:

- (16) Waterfront properties, which includes 25 tax parcels east of Atlantic Ave from Christopher Columbus Park to Congress Street Bridge
- Greenway, which includes 11 tax parcels
- (2) Roadways, DPW and City of Boston owned, which includes 7 tax parcels

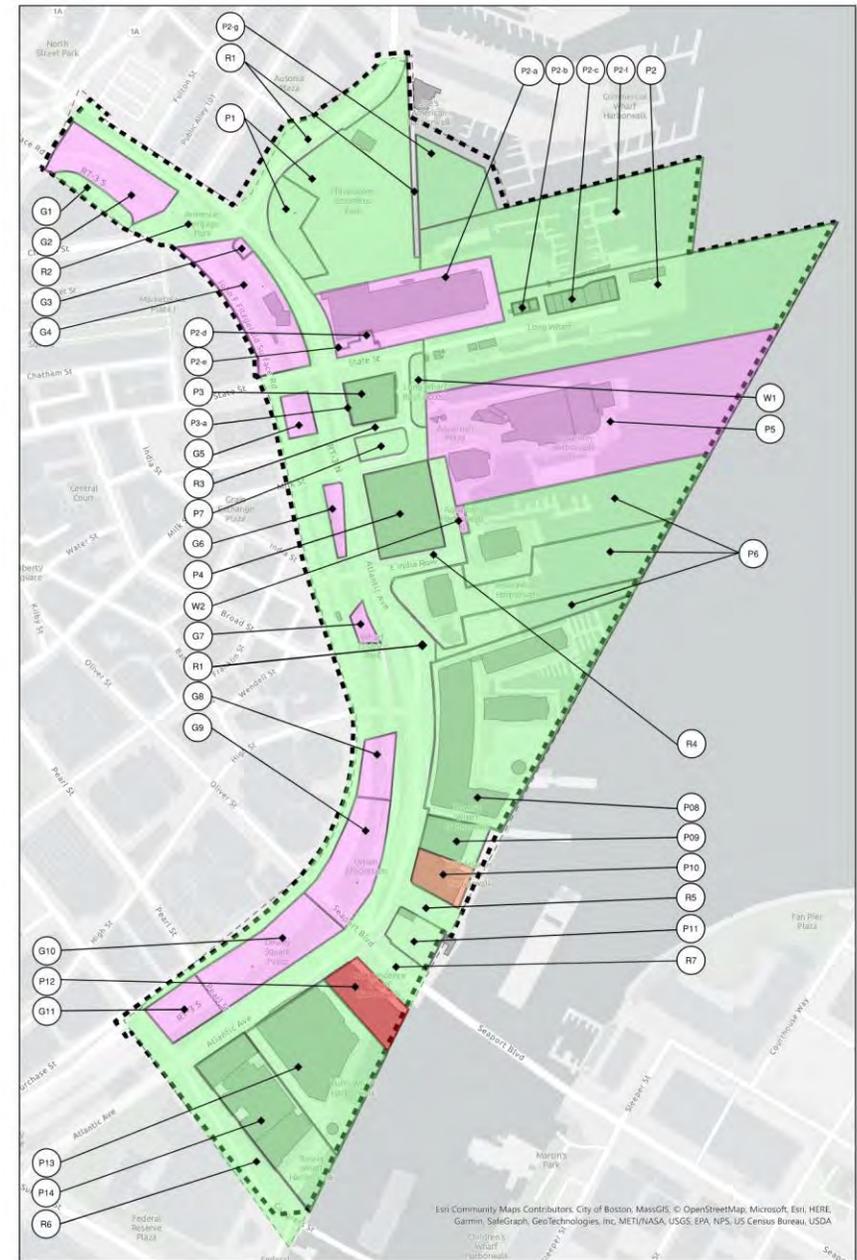


## Data Gap Summary

The status of the project data collection efforts for each constituent has been categorized into **4 levels**:

- **Complete (11)**: The primary contact has provided all information available
- **Partial (4)** : We successfully contacted the primary property owner, received some data and waiting on additional data uploads
- **Pending (3)**: We successfully contacted the primary property owner, but have received no data to-date and are still waiting on data uploads. Supplemental information has been identified.
- **Missing (1)**: We have not made successful contact with the primary property owner, but have identified some supplemental information

A comprehensive summary of data gaps for each waterfront property is provided in [Appendix A](#).



## Basis of Design Assumptions

# Basis of Design Assumptions

## Overview

The tables on the following pages provide a summary of the critical data being collected for the project, and the data assumptions that will be used as Basis of Design for the concept plan if the specified data is not available.

Additionally, a Risk Classification is provided to quantify the potential impacts of missing data on the confidence ranges for the estimates of construction cost, construction schedule, and permit and approval schedules that will be developed for the concept plan. The confidence range impacts are categorized as defined in the table below, and are intended to be applied to cost and schedule estimates at the property-scale.

Ranking	Construction Cost	Construction Schedule	Permits & Approvals
Low	+/- \$1M	+/- 9 months	+/- 9 months
Moderate	+/- \$1M to \$10M	+/- 9 to 18 months	+/- 9 to 18 months
High	+/- \$10M+	+/- 18 months +	+/- 18 months +

Recommendations for mitigating the risks classified as Moderate or High are also provided in the tables, along with examples of the types of flood resiliency strategies that are reliant on each type of critical data.

# Basis of Design Assumptions Overview

Data Type	Basis of Design (BOD) Assumptions for Missing Data	Risk Classification Associated with BOD Assumptions for Missing Data (Low, Moderate, or High) *			Recommendations (for mitigating Risks associated with Missing Information resulting in Moderate or High Impacts)	Examples of Relevant Adaptation Strategies	
		Construction Cost	Construction Schedule	Permits & Approvals			
Buildings & Structures	First Floor Elevation (FFE)	Use publicly available topo data & estimate FFE based on field observations of approximate height of FFE relative to adjacent ground elevations	Low	Low	Low	NA	Dry Floodproof Building, Inland flood walls, inland earthen berms, deployable barriers
	Building Construction Type	Assume typical building construction methods based on engineer's judgement	Low	Low	Low	NA	Dry Floodproof Building, Inland flood walls, inland earthen berms, deployable barriers
	Building Foundation (traditional or pier)	Field observations	Low	Low	Low	NA	Dry Floodproof Building, Inland flood walls, inland earthen berms, deployable barriers, pier pile reinforcement & repairs, sea wall reinforcement & repairs, breakwaters, living shoreline, outboard relocate/elevated harborwalk, harbor infill, new seawall, groundwater cut-off walls
	Significant / Historical Landmark Buildings & Cultural Heritage Sites	Publicly available data (Boston Landmarks Commission Online Portal, Boston Historic Districts Map, Mass GIS)	Low	Low	Low	NA	Dry Floodproof Building, Inland flood walls, inland earthen berms, deployable barriers, pier pile reinforcement & repairs, sea wall reinforcement & repairs, breakwaters, living shoreline, outboard relocate/elevated harborwalk, harbor infill, new seawall, groundwater cut-off walls, relocation of water access and marine transportation
	Critical Building Utility Elevations	Adaptation strategies for unidentified utilities within buildings below the DFE not included in project scope	Low	Low	Low	NA	Dry Floodproof Building
	Wharf / Pier Construction Type & Age	Due Diligence Coastal Facilities Assessment & proxy data from adjacent sea walls, wharves, and piers. Historic maps (BPDA Boston Atlas, David Rumsey Maps, Mapjunction). Typical construction types include; friction timber pile supporting a timber deck, end bearing steel or concrete piles supporting a concrete deck.	Moderate	Moderate	High	Detailed Engineering Assessment of seawalls, wharves, and piers, if recommended by due diligence assessment	Pier pile reinforcement & repairs, sea wall reinforcement & repairs, breakwaters, living shoreline, outboard relocate/elevated harborwalk, harbor infill, new seawall, inland flood wall, inland earthen berm, elevated roadways, elevated open space, utility relocations
	Seawall Construction Type & Age	Due Diligence Coastal Facilities Assessment & proxy data from adjacent sea walls, wharves, and piers. Historic maps (BPDA Boston Atlas, David Rumsey Maps, Mapjunction). Typical construction types include; timber pile supported granite block seawalls or sheetpile bulkhead walls.	Moderate	Moderate	High		
	Seawall Top and Bottom Elevations	Due Diligence Coastal Facilities Assessment & proxy data from adjacent sea walls, wharves, and piers. Typical bottom of granite block seawalls and steel sheetpiles located at or just below low tide elevation.	Moderate	Moderate	High		
	Seawall / Wharf / Pier Condition Assessment	Due Diligence Coastal Facilities Assessment & proxy data from adjacent sea walls, wharves, and piers with similar age & construction type	Moderate	Moderate	High		
	Seawall Tie Back Locations		Low	Low	Low	NA	
Dock Layout and Construction Type	Use publicly available data (Google maps, etc.)	Low	Low	Low	NA	Relocation of water access and marine transportation	

# Basis of Design Assumptions

Data Type	Basis of Design (BOD) Assumptions for Missing Data	Risk Classification Associated with BOD Assumptions for Missing Data (Low, Moderate, or High) *			Recommendations (for mitigating Risks associated with Missing Information resulting in Moderate or High Impacts)	Examples of Relevant Adaptation Strategies	
		Construction Cost	Construction Schedule	Permits & Approvals			
Site Conditions	Property Boundaries & Easements	Use publicly available data (Boston Assessors data)	Low	Low	Low	NA	All
	Utility Locations	Assume utilities can be relocated to accommodate adaptation strategies; design of relocation of unidentified utilities not included in project scope	Moderate	Moderate	Moderate	Utility Survey	All
	Ground Surface Elevations	use publicly available topo data (MassGIS LIDAR and BostonMaps, etc.)	Moderate	Moderate	Low	Topographic Survey	Dry Floodproof Building, Inland flood walls, inland earthen berms, deployable barriers, elevated roadways, elevated open space, relocation of water access and marine transportation, stormwater management, groundwater cut-off walls
	Seabed Floor Elevations	use public bathymetry data (USGS Science Data Catalog, etc.)	Moderate	Moderate	Low	Bathymetric Survey	Breakwaters, living shorelines, outboard relocated/elevated harborwalk, harbor infill, new seawall, relocation of water access and marine transportation
Environment	Soil Stratigraphy	Assume typical soils based on proxy data from adjacent properties. Soil conditions will vary site to site, but will likely include varying amounts of weak, compressible fill and organic deposits. Fill deposits likely contain miscellaneous debris from historical development.	Moderate	Moderate	Low	Geotechnical Subsurface Investigations	Pier pile reinforcement, sea wall reinforcement, living shoreline, new seawall, inland flood wall, inland earthen berm, elevated roadways, elevated open space, stormwater management, groundwater cut-off walls
	Soil Properties: Permeability Rate and Compressibility	Assume typical permeability rates and compressibility based on historic test results of similar subsurface conditions.	Moderate	Moderate	Low		Dry floodproof building, living shoreline, new seawall, inland flood wall, inland earthen berm, elevated roadways, elevated open space, deployable barriers, stormwater management, groundwater cut-off walls
	Depth to Bedrock	Assume based on proxy data from adjacent properties & publicly available data (1927 Crosby map)	Moderate	Low	Low		Dry floodproof building, pier pile reinforcement, sea wall reinforcement, living shoreline, new seawall, inland flood wall, inland earthen berm, elevated roadways, elevated open space, deployable barriers, stormwater management, groundwater cut-off walls, utility relocations
	Depth to Groundwater	Assume based on proxy data from adjacent properties & publicly available data (Boston Groundwater Trust, etc.)	Low	Low	Low	NA	Pier pile reinforcement, sea wall reinforcement, new seawall, inland flood wall, inland earthen berm, elevated roadways, elevated open space, stormwater management, groundwater cut-off walls, utility relocations
	Floodplain & Wetland Buffer Zones	Use publicly available data (MassGIS MassMapper, etc.)	Low	Low	Low	NA	All
	Environmentally Sensitive Area Boundaries		Low	Low	Low	NA	All

\*Risk Classifications are intended to quantify the likely accuracy range of the cost and schedule estimates and permit assessments that will be developed for the Conceptual District Resiliency Plans for this project. The Risk Classifications are based on engineer's judgement of typical concept-level order-of-magnitude estimates. These classifications are intended for use in preliminary planning only, and should not be used for any other purposes. Actual construction costs, schedules, and permit and approval accuracy ranges will vary site by site based on final design considerations and field conditions, and will need to be verified during design development.