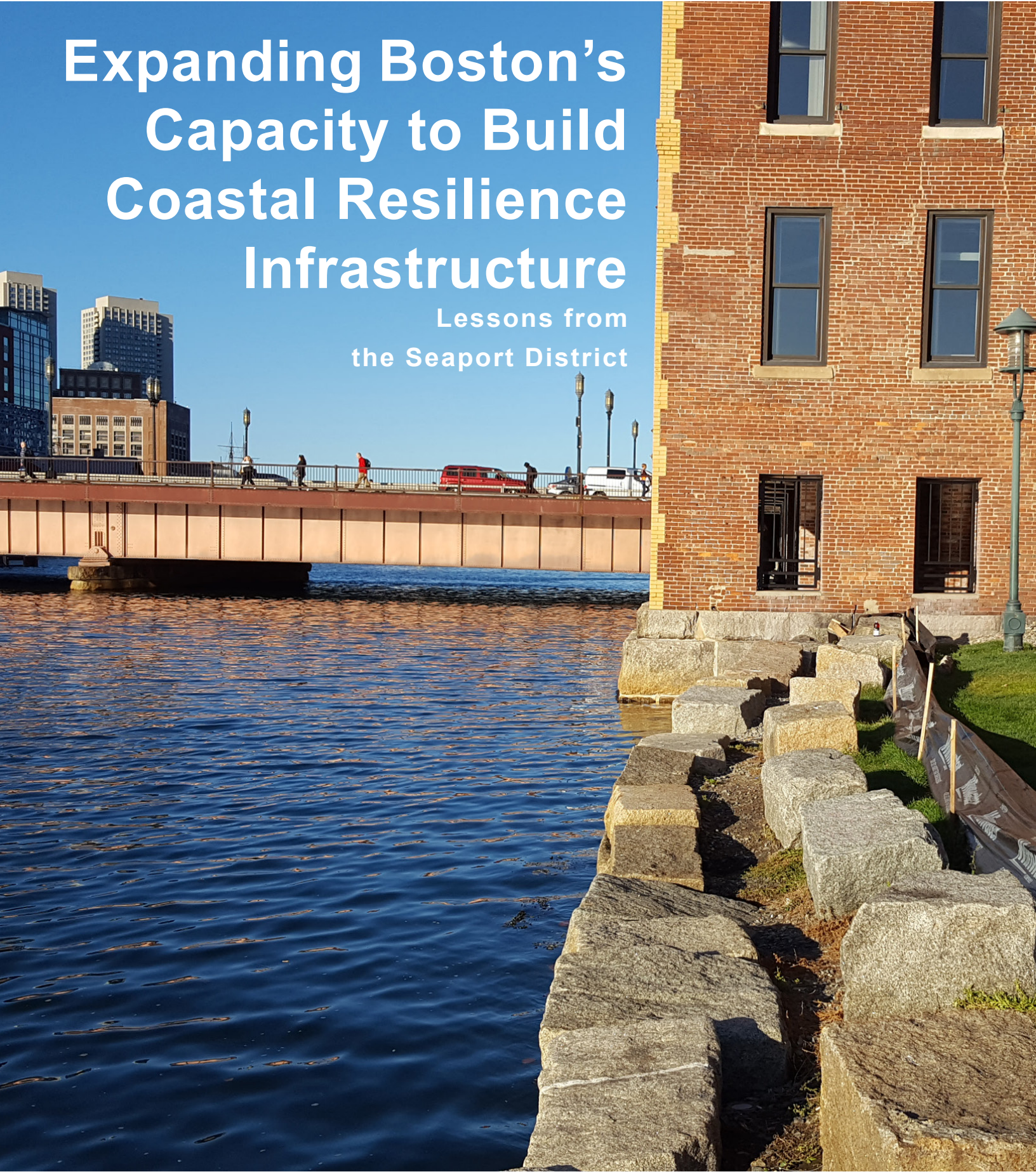
Expanding Boston's Capacity to Build Coastal Resilience Infrastructure

Lessons from the Seaport District



BOSTON Green Ribbon COMMISSION

ARCADIS Design & Consultancy for natural and built assets

EXPANDING BOSTON'S CAPACITY TO BUILD COASTAL RESILIENCE INFRASTRUCTURE

LESSONS FROM THE SEAPORT DISTRICT

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ACRONYMS AND ABBREVIATIONS

BFE – Base Flood Elevation

BPDA – Boston Planning and Development Agency

CRB - *Climate Ready Boston*

DRI – District for Resilience Improvements

EEOS – Boston Office of Environment, Energy, and Open Space

FEMA – Federal Emergency Management Agency

GRC - Boston Green Ribbon Commission

Massport – Massachusetts Port Authority

MBTA – Massachusetts Bay Transportation Authority

NFIP – National Flood Insurance Program

North American Vertical Datum of 1988 (NAVD88) – The vertical control datum of orthometric height established for vertical control surveying in the United States of America based upon the General Adjustment of the North American Datum of 1988. Provides for consistence comparison of elevations.

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EXECUTIVE SUMMARY

Climate Ready Boston, completed in 2016, demonstrated that Boston is facing serious threats from sea level rise and climate-related hazards. In the face of these challenges, the City is taking proactive steps to adapt the city's buildings, infrastructure, and neighborhoods to the impacts of climate change.

As part of these efforts, the Boston Green Ribbon Commission (GRC), a group of business, institutional, and civic leaders in Boston working to develop shared strategies for fighting climate change, commissioned a project to study and refine implementation pathways for coastal resilience with a focus on the Seaport District in South Boston. This Project, *Expanding Boston's Capacity to Build Coastal Resilience Infrastructure, Lessons from the Seaport District*, builds on strategies devised and recommended though *Coastal Resilience Solutions for South Boston*, published in October 2018. The focus of the analysis is on areas along Fort Point Channel and Seaport Boulevard where action is required either by 2025 or 2030. Nevertheless, the study has been conducted, and several recommendations developed, with the broader South Boston strategy in mind, as well as other waterfront districts in Boston. The Project was undertaken in close consultation with the GRC's partners at the City of Boston.

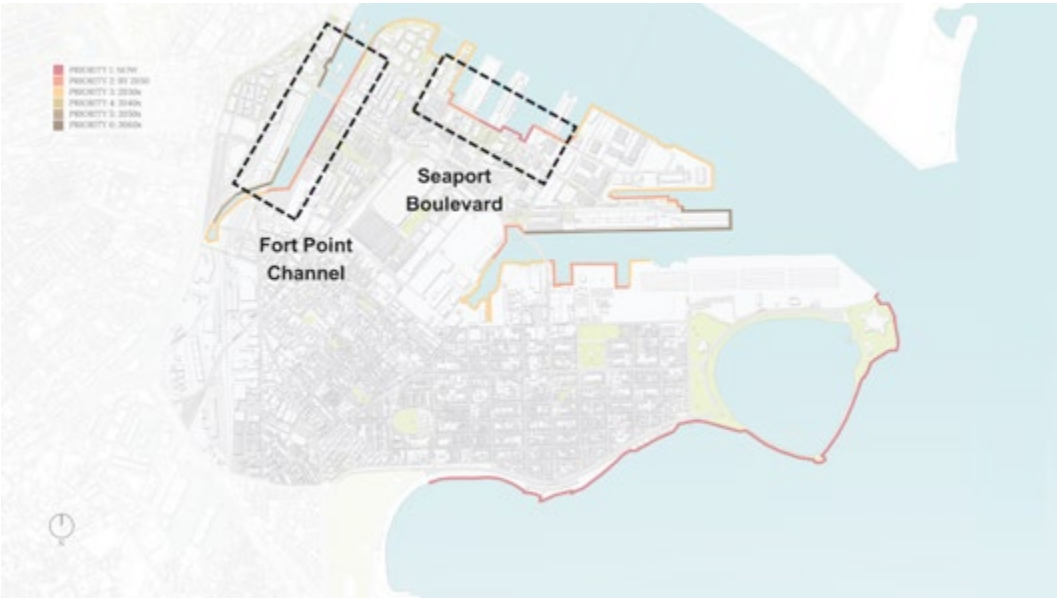


Figure 1 Project study area (South Boston) and key focus areas (Fort Point Channel and Seaport Boulevard)

This study emerges from the recognition that the need to adapt Boston's coastline to rising seas and extreme storms is both extremely urgent and challenging. The urgency results from flooding that already occurs today and from the accelerating pace of sea level rise, which will increase the reach of high tides and storm surges further inland over the coming decades (See Table 3 in Chapter 1 and Appendix D for the target flood elevations in these areas). The challenges are related in part to the lack of clear and proven governance frameworks for implementing solutions at the scale and speed necessary to mitigate risk of significant damage and disruption. The City has been a leader in the process of planning for climate change and its impacts, but now must grapple with the range of governance, funding, and

regulatory challenges raised by the process of designing, permitting, constructing, operating and maintaining, and ultimately adapting flood mitigation investments. **Table 1** outlines initial questions that prompted the GRC to initiate the Project.

Table 1 Initial questions that prompted this Project

Guiding question	Why this is important
What actions are already underway by individual property owners and the City of Boston in the study area?	The real estate market in the study area is highly dynamic, and some property owners are working to make climate adaption investments at the site- and building-scale. Understanding ongoing work is a necessary starting point for how implementation of coastal flood mitigation can be further accelerated. It will also be important to understand to what extent these actions are being taken in alignment with City's goals and direction to date, and drivers for such.
What governance, funding, and regulatory changes are needed to help advance individual and/or collective actions toward implementation of planned coastal flood risk projects?	Numerous studies demonstrate that governance, funding, and regulatory frameworks for proactively investing in major flood mitigation infrastructure (without the availability of major federal expenditure) still need development, particularly for district-scale solutions that span multiple public and private property owners.[1] Public and private stakeholders must work collaboratively to leverage existing frameworks, as well as devise new and evolved approaches for effectively and efficiently delivering flood mitigation projects.
What incentives or approaches would help create a coalition of South Boston stakeholders committed to moving forward with the most urgent projects?	Implementation of district-scale flood protection in South Boston and across the city will require significant participation and contributions by stakeholders, such as private property owners, and State and Federal entities whose responsibilities may lie outside of the City's sphere of control. Successful implementation will require these stakeholders to work in partnership with the City.

The initial goals included: update progress on implementation; build support for action among key stakeholders; and provide recommendations to the City for funding, governance, and regulatory approaches for urgent actions South Boston. The views expressed in this report are solely those of the Boston Green Ribbon Commission and the report authors.

Boston's Resilience Roadmap

Since the release of *Climate Ready Boston* in late 2016, the City has been aggressively analyzing potential impacts and planning for climate change. This Project was not completed in a vacuum and builds on studies in progress and recently completed, as described in

Figure 2.

[1] Refer to Bibliography for related studies that were reviewed for this Project.

Greater Boston Research Advisory Group & Climate Ready Boston

Comprehensive citywide vulnerability assessment and climate adaptation plan

Coastal Resilience Solutions for East Boston and Charlestown

First neighborhood scale flood vulnerability study and proposal for conceptual floor mitigation solutions

UMASS Boston Sustainable Solutions Lab Studies

Detailed evaluation of governance and funding approaches for coastal resilience solutions. Created robust set of options drawn on to inform this study

Resilient Boston Harbor Vision

Mayor Walsh's comprehensive vision for coastal resilience, knitting together long-term approaches to provide flood protection through a network of new waterfront open space

Coastal Resilience Solutions for South Boston

Second neighborhood scale vulnerability study and proposal for conceptual flood mitigation solutions. Explored funding, governance, and regulatory options. The proposed coastal resilience solutions and implementation tracks are foundation for this study

Coastal Resilient Design Standards & Guidelines

Provides guidance on and standards coastal flood risk mitigation measures in the city's public rights of way

Implementing District-Scale Solutions for the Border Street Area of East Boston

Study commissioned by City to study financing and funding options for implementation of coastal resilience solutions in East Boston. Provides detailed analysis of funding and financing approaches the City might use to advance project delivery.

Coastal Flood Resilience Design Guidelines

Provides design guidance and best practices for flood risk mitigation improvements to new and existing buildings

Climate Ready Downtown and North End
(target release early 2020)

Climate Ready Dorchester*
(target release late 2020)

*Study is ongoing; recommendations have not been reviewed for this Project

Figure 2 Summary of studies that have formed the starting place for and informed this Project

Study Process

The Project began in April 2019 and concluded in February 2020. The process involved background analysis and research on nationwide governance and funding models for resilience project implementation, engagement with property owners, the Green Ribbon Commission, and City of Boston officials, and development and refinement of a series of hypotheses designed to generate final recommendations. Figure 3 outlines the steps involved in the study.

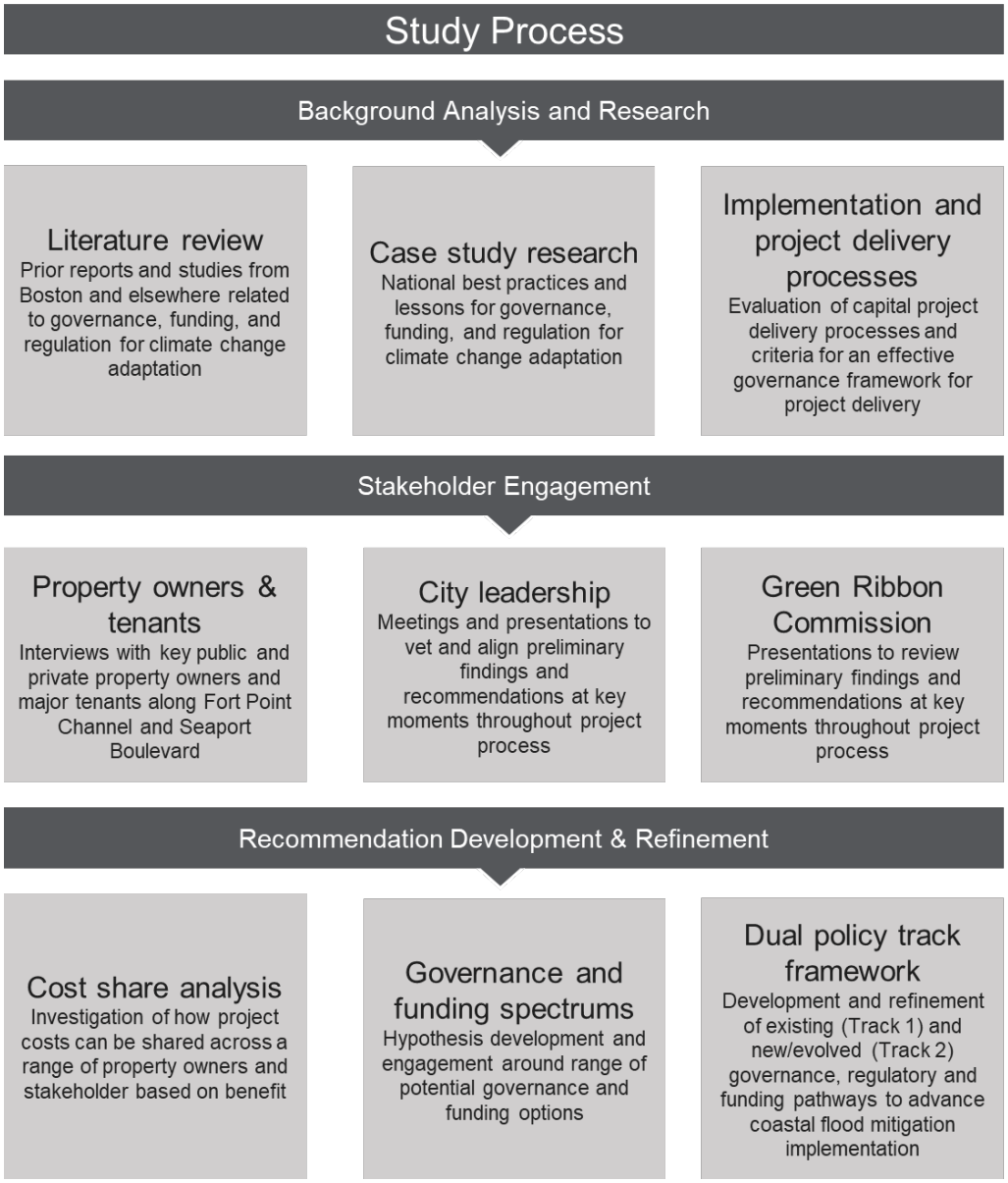


Figure 3 Summary of process and steps followed during this Project

Key Insights

The analysis, engagement, and refinement of hypotheses through this Project led to several key insights related to how the City can best advance project delivery along Fort Point Channel and Seaport Boulevard. In many cases, these insights relate to needs that likely exist on a citywide scale and thus have broader applicability beyond the specific study area that was the focus of this Project.[2] These findings were based both on interviews with property owners, particularly those with properties located on the waterfront who would need to directly contribute to district-scale flood mitigation solutions with capital investments, and on other research, analysis, and meetings conducted for the Project.

Property owners and tenants are aware of increasing flood risk in the Seaport District but are not always sure how best to respond

While some property owners are moving forward to implement site-specific solutions and/or undertake exploration of their options, others expressed some confusion and/or lack of awareness about target elevations and other design or engineering standards for flood protection, both in the short-term and the long-term. This confusion may be a barrier to unlocking investments needed for flood mitigation. Some property owners also expressed a desire to know more about the plans of various City and State agencies and were hesitant to make investments without confirmation of those plans. Given that the Seaport District has some of the highest rates of development and investment capacity in Boston, this concern will likely apply to areas with less development activity in other parts of the city.

There is broad consensus among stakeholders engaged for this Project on the need for a collective governance and funding solution that is both fair and equitable

Some property owners in the Seaport District appear eager to learn what options are available for protecting their assets and expressed a willingness to contribute to such a solution, but articulated concerns over how investments across contiguous properties and district-wide will be coordinated. Most property owners interviewed would prefer a funding approach that is fair, where property owners contribute to shoreline investments proportional to the benefits they receive. Nevertheless, there was also recognition from the majority of those interviewed of the need to account for equity and ability to pay. It is unclear the extent to which this finding will apply citywide, again given the scale of development and investment taking place within this part of the city.

It is likely possible to deliver urgent projects (those planned for completion by 2025) along Fort Point Channel by maximizing the effectiveness of existing governance, regulatory, and funding approaches – although increased coordination will be essential

Established policy frameworks can fulfill most basic needs of site-by-site project delivery and some cross-property coordination for the most urgent projects (based on the delivery schedule outlined in *Coastal*

[2] While feedback the Project team received from interviews cannot be assumed to be applicable citywide due to the uniqueness of the study area and relatively small number of very specific stakeholders engaged (major tenants and property owners who would have flood protection infrastructure installed across their properties per current City plans), parts of the research and key findings may be transferable to other parts of the city, and this is identified where appropriate within this report.

Resilience Solutions for South Boston), such as is occurring on the 100 Acres area along Fort Point Channel. Progress on these projects could be enhanced, however, by increasing internal City coordination and ongoing communication with stakeholders, as well as development of more detailed design and performance standards for coastal flood mitigation. This finding is expected to apply citywide; it's likely impractical to expect new governance and regulatory approaches to be available before construction on the most urgent projects must begin, forcing reliance on current available processes. Costs associated with planned urgent projects in other districts are expected to further stress current funding and financing approaches, also pointing to a need to evolve, refine, or expand those approaches, as described below.

New or evolved governance, funding, and regulatory approaches will need to be developed over the next three-to-four years to advance project delivery and district-scale coordination to stay on the desired implementation schedule for South Boston projects planned beyond 2025. This need will only deepen with consideration of the citywide coastal resilience strategy.

Starting in approximately 2023,[3] the funding need and necessity for large scale coordination of projects and stakeholders in South Boston will require an intentional framework to coordinate, raise, and distribute funds and build, manage, and operate a network of flood mitigation investments across the district. Such a network of flood protection will be most successful[4] with a governance structure that extends beyond the limits of specific electoral and programmatic cycles and that can effectively manage and coordinate planning, funding collection and distribution, engagement, project delivery, operations and maintenance, and future adaption across the city.

A preliminary analysis conducted as part of the Project indicates the possibility that cost share for flood mitigation approaches may be broadly and sustainably distributed across a range of public and private stakeholders using a model that assesses accrued benefits from flood protection over time. Expansion of such a model citywide could also support equity and affordability for individual payers.

In addition, the Project concludes that while current environmental and land-use regulations do not pose a substantial hinderance to flood mitigation investments in the near-term –primarily because near-term investments do not necessitate fill in waterways— in the longer-term regulatory reforms will be needed to advance, guide, and enforce delivery of district-scale protection that is consistent with established concept plans, Mayor Walsh's Resilient Boston Harbor Vision, and performance-based design standards.

Continuous, focused engagement with stakeholders with the ability to help facilitate or curtail implementation is needed to maximize available resources and collective action

Regardless of how the City proceeds with its governance, funding, and regulatory approaches, there remains an overarching need for consistent and ongoing engagement with property owners and other entities that may have a role in implementation at any scale, including State and Federal agencies and

[3] Based on a schedule of expenditure developed based on the *Coastal Resilience Solutions for South Boston* implementation roadmap described in subsequent sections of the report

[4] Success as defined by flood infrastructure project implementation in alignment with *Coastal Resilience Solutions for South Boston* implementation roadmap and Section 3.4 Criteria used to guide recommendation development.

authorities, such as Massport and the MBTA. The necessarily rapid pace of implementation being pursued by the City combined with the diversity of public and private property ownership along the coastal edge means that implementation will ultimately hinge on collaboration and even partnership between the public and private sectors. In addition, it will be important for the public and private sectors to stay coordinated to assure integration of recommended community benefits (also called co-benefits) with investment in coastal flood risk mitigation infrastructure. While flood risk mitigation may be the primary goal of such investment, the process should also aspire to create a more inviting, equitable, and inclusive waterfront for all Bostonians, which will in turn help generate support for implementation of flood protection. Accomplishing this will require close coordination with property owners, designers and engineers, and continuous feedback loops as plans are refined and implemented over time.

The City needs additional human and financial resources to manage implementation of the City's coastal resilience strategy

Implementation of coastal resilience infrastructure will require the City government to take on a new set of projects and challenges that are not easily absorbed within existing departments and functions given current resource availability. These needs relate to planned investment in South Boston but also to plans for similar investment citywide, starting today and continuing through the 2050s and beyond. The City will need to increase overall capacity and resources within to support project implementation without inadvertently cannibalizing existing resources and capacity from other needs.

Summary of Recommendations

The Project's key findings, case studies, and coordination efforts yielded recommendations along two parallel tracks of action, the first focused on leveraging existing frameworks to complete initial urgent actions and the second to identify opportunities for transformative measures needed to support district-wide, and even citywide, implementation. These recommendations fall within various governance, regulatory, and funding categories of action, and are interdependent in nature. Work on both tracks should begin today so that as funding and coordination needs increase over time, work along the first track can evolve into the second track of necessary actions. Recommendations associated with each track are summarized in Figure 4 and Table 2.

Track 1 recommendations maximize public private collaboration and coordinated action across properties through a site-by-site approach and clear communication of needs and expectations through the adoption of plans and performance-based design criteria. These actions are expected to have benefits beyond the most urgent action areas in South Boston and may help catalyze activity across those who are financially able in other parts of the City. The focus here is largely on waterfront property owners; these stakeholders serve as the linchpin in implementing the most urgent actions in certain parts of South Boston, and also have the capability to take independent action that could align with city needs, reducing the burden on the City to drive implementation alone.

Many of the findings and recommendations from this Project, while based on engagement with a relatively limited number of specific stakeholders and tailored to the unique development market and land-use conditions of the Seaport District, could apply to other areas of the city where coastal flood risk mitigation is planned. The central goal of this study was to examine pathways toward implementation for the most urgent projects along Fort Point Channel and Seaport Boulevard but during the course of the

study it became clear that the approaches with the most potential impact in the study area would be those that also advance implementation across the city. For example, a new senior level cabinet chief focused on climate resilience implementation would necessarily have citywide purview and help lead and coordinate project implementation beyond the Seaport District. This role would also have cascading positive effects in helping shape and refine project implementation policies moving forward over time on a citywide scale. Similarly, the establishment of coastal protection performance standards would be most effective if produced for all flood prone areas of the city's waterfront, though they could be developed over time with the highest priority areas published first. Nevertheless, as part of any effort to pursue the recommendations in this report on broader basis, it is recommended that the City conduct ongoing outreach to a variety of stakeholders to ensure alignment with needs and perspectives that may not have been captured within the scope of this Project.

The key actions recommended under Track 1 include:

- Establish a new senior level cabinet chief focused on climate resilience implementation with resources and capacity sufficient to support a large portfolio of complex projects and programs
- Publicize and adopt Climate Ready Boston district coastal resilience plans (i.e., *Coastal Resilience Solutions for South Boston,* the upcoming *Coastal Resilience Solutions for Downtown and the North End,* the upcoming *Coastal Resilience Solutions for Dorchester,* design criteria from *Coastal Resilience Solutions for East Boston and Charlestown,* and future reports planned for East Boston*)*
- Establish performance and design standards for district-scale coastal protection investments on private property and mandate project consistency with these standards through existing regulations, such as Article 80 Development Review
- Launch the Infrastructure Coordination Committee recommended by Climate Ready Boston. This may be accomplished through a citywide scale focus or through smaller, district or individual project area scale focuses
- Clarify expectations around public-private cost share for coastal flood mitigation projects, especially regarding which elements of the project delivery cycle the City intends to fund and which it anticipates the private sector will need to fund, and to what extent. This same approach may apply to coordination with State and federal investment entities.
- Launch a joint planning process with Massport to refine conceptual flood protection approaches and alignments along Seaport Boulevard
- Pursue agreement (MoUs) with key property owners, including State agencies, to establish and codify roles and responsibilities around cost share, design standards, and operations and maintenance
- Continue to pursue State and Federal funding opportunities, such as the upcoming FEMA Building Resilience Infrastructure and Communities program, to leverage both public and private sources of funding available at the local level
- Ensure the Flood Resilience Zoning Overlay District under development by the BPDA helps promote and is consistent with plans for district-scale flood risk mitigation, and supports implementation across both new construction and substantially improved property

Track 2 recommendations emerged from an appreciation of the scale of investment and action required to complete the district-level strategy on schedule, as well as ensure the system is appropriately maintained into the future. Such a scale requires governance, funding, and regulatory frameworks designed specifically to support and facilitate building, maintaining, and adapting coastal infrastructure within a changing risk context. Execution on key Track 1 recommendations can serve as the necessary foundation to advance Track 2 recommendations. For example, the senior level cabinet chief focused on climate resilience implementation would help lead development and refinement of Track 2 policies and approaches.

The key actions recommended under Track 2 include:

- Use Flood Resilience Zoning Overlay District in concert with established coastal protection performance standards to guide and enforce delivery of district flood risk mitigation with new development. Explore legal viability of Chapter 91 as enforcement mechanism to compel property owner action where no new development is planned and the owner is uncooperative or unwilling to allow flood protection infrastructure across their property.
- Expand the pilot cost share analysis undertaken for this Project to examine the merits of funding implementation using a system based on annualized benefits of flood protection. The citywide pilot evaluation should include a refinement of payers and payment mechanisms considered in this Project. The pilot evaluation should review multiple possible uses for the cost share analysis depending on need and stakeholder input, ranging from simply informing City policy on public vs private cost share responsibilities to potentially serving as the basis for a new risk-based utility fee structure. See **Section 5.5 Track 2 funding and cost** share considerations for additional details.
- Evaluate the potential for a Community-Based Public Private Partnership model to finance and deliver flood mitigation projects. This could be reviewed both as a standalone delivery approach in the near- to mid-term, as well as part of a broader district-scale governance approach, as described below.
- Vet and further develop the District for Resilience Improvements (DRI) framework and cost share approach with a coalition of local and state stakeholders. The DRI would be a new governance entity, similar in structure and role to an Authority, responsible to champion and manage a district-wide plan for coastal flood resilience project funding, financing, and implementation. Key functions could include: coordinating property owners, taking on debt, negotiating and establishing public-private partnerships, pursuing grants, procuring contractors and consultants, planning capital improvements, and operating and maintaining the solutions. DRI geographic extents may correlate with future coastal floodplains with the opportunity for (or mandated) periodic re-evaluation based on actual progression of sea level rise, as well as evolving time horizons of interest. The City may apply the concept of the DRI at the individual district or sub-district level or apply a single DRI across the city based on criteria such as floodplain extent. A variety of funding sources could be assembled and distributed by the DRI, including but not limited to federal and state grants, city capital allocations, and potentially risk-based utilities fees based on a cost share approach as outlined above. See **Section 5.3 Governance approach: District for Resilience Improvements (DRI)** for additional details.

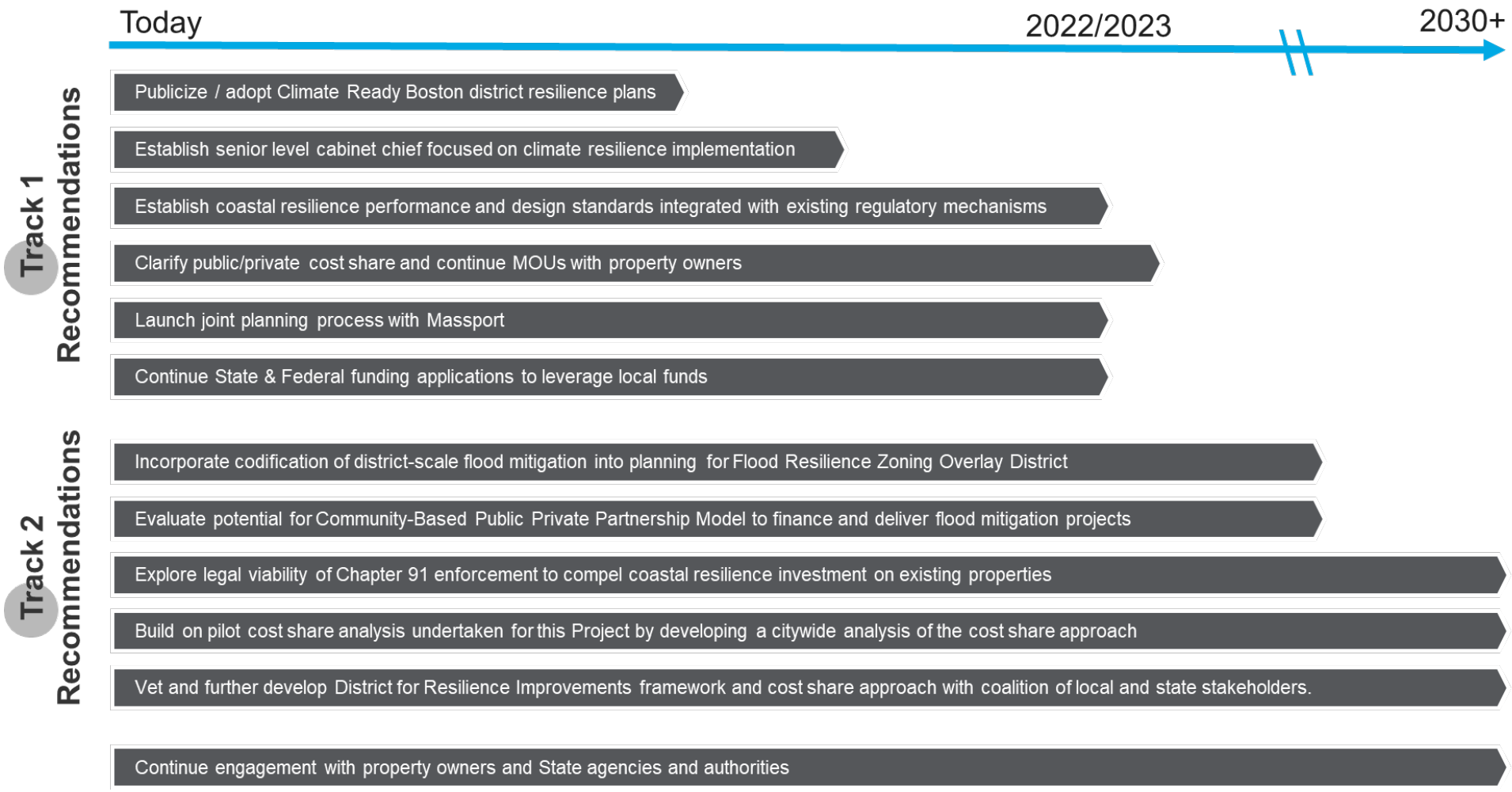


Figure 4 Summary of key recommendations along Policy Tracks 1 and 2

Table 2 Summary of Recommendations

Policy Track 1 (today through 2023)	Governance	Regulatory	Funding
First moves	Establish a new senior level cabinet chief focused on climate resilience implementation with resources and capacity sufficient to support a large portfolio of complex projects and programs	Adopt and publicize the alignment, design elevations, and key findings of Coastal Resilience Solutions for South Boston to ensure broad awareness of conceptual plans for coastal flood mitigation	Review project designs in the Capital Improvements Program
Second moves	Launch joint planning process with Massport to further develop coastal resilience solutions for Seaport Boulevard. In conjunction, create the Infrastructure Coordination Committee recommended by *Climate Ready Boston* to support planning in urgent action areas Pursue agreements (MoUs) with each and every property owner in urgent action areas along Fort Point Channel to ensure conformance with coastal flood mitigation performance standards and other project parameters, such as cost share and O&M responsibilities	Develop and adopt coastal flood mitigation performance-based design standards Ensure the Flood Resilience Zoning Overlay District under development by the BPDA helps promote and is consistent with plans for district-scale flood risk mitigation	Clarify City view on public-private cost share, including expected property owner investment in flood risk mitigation infrastructure
Ongoing	Continue and strengthen engagement with Massport and its tenants around implementation of urgent action areas along Seaport Boulevard, and later, the Marine Industrial Park	Use existing regulatory vehicles to guide and enforce implementation of conceptual plans with new development in accordance with coastal flood mitigation performance standards	Continue engagement with public and private property owners in urgent action areas to co-develop and refine opportunities for coastal mitigation investment
Ongoing	Continue and strengthen engagement with MBTA around implementation of district-scale flood mitigation actions at the base of Fort Point Channel	Commence work with State and other partners to provide regulatory clarity for the circumstances under which fill may be introduced to waterways as a basis for longer-term flood mitigation projects	Leverage range of public and private funding sources by continuing to apply for grants, engaging Federal and State funding gate keepers, and developing MOUs with private property owners. Continue to apply for available grants, including the upcoming FEMA BRIC funding program

Policy Track 2 (today through 2030 and beyond)	Governance	Regulatory	Funding
First moves	Further evaluate a Community-Based Public-Private Partnership approach as an option to expedite project delivery (approach can become part of governance recommendation 2 over time)	Use Flood Resilience Zoning Overlay District in concert with established coastal protection performance standards to guide and enforce delivery of district flood risk mitigation with new development.	Refine, advance, and further evaluate the benefits and cost share analysis completed for this study for citywide application
Second moves	Develop a district or citywide governance entity dedicated to implementing coastal resilience projects, such as the District for Resilience Improvements	Explore potential for Chapter 91 enforcement authority to incentivize property owner participation in flood mitigation	Explore feasibility of cost share analysis approach and related funding mechanisms citywide

1 PROJECT INTRODUCTION AND BACKGROUND

Climate Ready Boston, completed in 2016, demonstrated that Boston is facing existential threat from sea level rise and climate-related hazards. Nevertheless, the report also outlined a clear implementation roadmap to reduce risk and safeguard community vitality through the 2070s, based on current best available risk models. Implementation of Climate ready Boston recommendations has continued through the Boston Harbor Barrier Feasibility Study, more detailed neighborhood-level strategies for reducing the risks associated with coastal flood risk, physical risk reduction improvements at the East Boston Greenway and Martin's Park, expanded engagement and champion building through the Greenovate program, and exploration of improved regulatory frameworks (such as through the impending Flood Resilience Overlay Zoning District).

In October 2018, Boston Mayor Martin Walsh released a comprehensive plan, Resilient Boston Harbor, which lays out new coastal resilience infrastructure along Boston's 47-mile shoreline, knitting together the long-term approaches developed across multiple district level plans. The vision focuses on the creation of a new network of open space on the waterfront that is designed to provide flood risk mitigation while delivering a range of recreational and ecological benefits.

The plans articulated through *Climate Ready Boston* and Mayor Walsh's Resilient Boston Harbor Vision will demand new thinking about how to govern and administer a decades-long program of investment. Constructing flood mitigation infrastructure across the city will require unbroken alignment across a range of property types and stakeholders, (often with what appear to be competing interests), as well as significant funding, coordination of governmental and private actors, and potential reforms to regulatory and governance frameworks and processes. Without a proactive framework to fund, govern, and manage the implementation of coastal resilience infrastructure, the City and its constituents may be forced to draw on a limited pool of existing resources and attention. There is also a risk of losing opportunities to leverage and coordinate funding and capital improvements toward a common mission, possibly leading to unmitigated risk and inequitable outcomes.

Boston and the Commonwealth of Massachusetts have significant experience in undertaking transformative projects and driving institutional change; examples include the "Big Dig" and the creation of the Massachusetts Water Resources Authority to clean up Boston Harbor. Coastal flood risk mitigation is both similar to and different from these previous efforts, with lessons learned that can be gleaned and integrated into the implementation process. Nevertheless, the sheer magnitude of the change needed, and the geographic scale of improvements required, as well as the shifting uncertainties and evolving risks we are seeking to address, bring new challenges and complexity that touch citizens and institutions across the city and beyond.

In recognition of this complexity, the Boston Green Ribbon Commission (GRC), a group of business, institutional, and civic leaders in Boston working to develop shared strategies for fighting climate change, has partnered with City officials to study and refine implementation pathways for coastal resilience with a pilot focus on the Seaport District in South Boston. This study, *Expanding Boston's Capacity to Build Coastal Resilience Infrastructure, Lessons from the Seaport District* (the Project), builds on strategies devised and recommended though *Coastal Resilience Solutions for South Boston*, published in the

October 2018, to refine and roadmap approaches for implementing near and long-term coastal flood mitigation infrastructure.

1.1 Project goals

Coastal Resilience Solutions for South Boston outlined near-, mid-, and long-term coastal flood mitigation actions needed across the neighborhood and defined the most urgent actions in the areas of Fort Point Channel and Seaport Boulevard. The goal of the Project is to define pathways for implementing the critical early-action projects for Fort Point Channel and Seaport Boulevard while aligning with and informing longer-term citywide implementation processes to yield:

- Near-term desired outcomes:
    - Identify actions underway by individual property owners and the City of Boston in the area
    - Identify additional needs for individual and/or collective actions acceptable to South Boston stakeholders and the City
    - Advance a coalition of South Boston stakeholders committed to moving forward with projects
    - Provide recommendations to the City for funding, governance, and regulatory approaches for actions that are to be complete by 2030 along Fort Point Channel and Seaport Boulevard

- Long-term Project legacy:
    - Completion of urgent action projects by the timeframes recommended in *Coastal Resilience Solutions for South Boston*
    - Implementation of a framework that could be evolved over time to accomplish governance of overall South Boston flood risk reduction projects, and provide lessons learned for the citywide implementation framework

2 PROJECT STUDY AREA

2.1 Coastal resilience solutions for South Boston

The foundation for this Project is the planning study *Coastal Resilience Solutions for South Boston*, released in October 2018, which resulted from one year of engagement and analysis to produce a comprehensive set of recommended strategies for coastal flood risk mitigation across the South Boston neighborhood. The plan outlined a prioritized framework for investment through 2070 that would mitigate coastal flood risk to residents, businesses, buildings, and infrastructure while adding new open space that could be expanded over time. The plan, once implemented, is expected to prevent billions of dollars of potential losses due to coastal flooding in the neighborhood. In addition to recommendations for coastal flood mitigation infrastructure, the plan recommended programs to mitigate risk inland through infrastructure improvements, zoning and regulatory changes, retrofit programs, and recommended further investigation into stormwater flood mitigation.

Figure 5 depicts the projected evolution of the flood extent associated with the 1 percent annual exceedance probability flood elevation in the South Boston neighborhood over time. The image helps demonstrate why South Boston was selected as the study area for this Project:

1. **There is an urgent need to act**, as demonstrated by the progression of current flood risk concentrated in the Fort Point Channel and Seaport Boulevard across the entirety of the Seaport District. Many areas are expected to be subject to flooding by the average monthly hightide over the next 30 years or so
2. **The geographic area at risk is widespread**. Not only is nearly the entirety of the Seaport District and Conley Terminal and length of Day Boulevard expected to flood in a major coastal storm with sea level rise, but the district is expected to become a significant flood pathway to hundreds of homes in the South End
3. **Unprecedented levels of coordination (for the city) across public and private property owners will be required for implementation**. Because the Seaport District is mostly flat (it consists entirely of filled lands; only the South Boston neighborhood was historical terra firma), there is no high ground for flood mitigation infrastructure to tie into and provide flood mitigation "compartments." This means that, eventually, if coastal flood mitigation is in place at Fort Point Channel, but not Reserved Channel, for example, properties will flood from behind. Due to the urgency of flood risk, there is not time to elevate internal roadways and infrastructure and still ensure the viability of coastal assets, and no property owner has expressed a willingness to remain unprotected by the flood mitigation alignment. As such, coastal properties must "link arms" to provide a single line of defense against coastal flood waters. Coordinated action will also be required to manage stormwater. Nowhere else in the city is such an extensive line of defense required as early in the century.

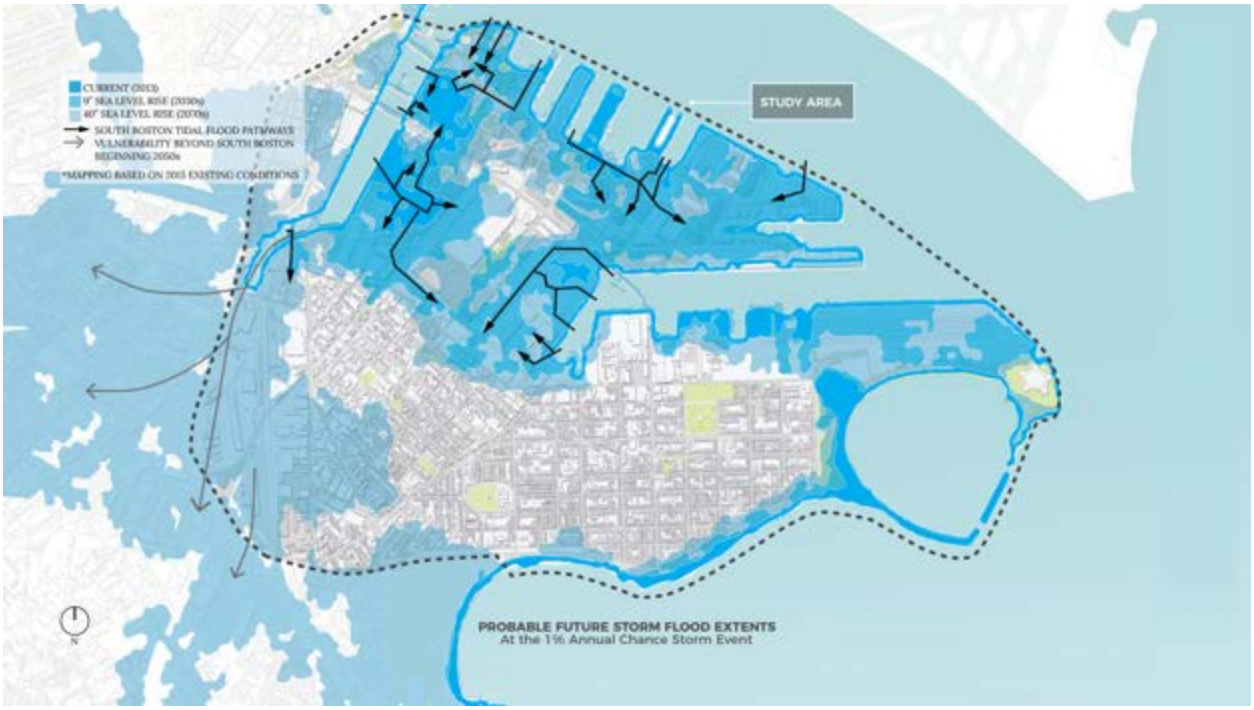


Figure 5 Current and Future Projected Flood Risk in South Boston (Source: *Coastal Resilience Solutions for South Boston* (2018))

Coastal resilience design strategies have three technical elements:

1. **Approach**. What type of coastal resilience solution will be selected and to what level of protection? Options might include a flood wall, berm, or dry or wet floodproofing of a structure.
2. **Alignment**. Where will the flood mitigation measure be located? Options might include along the waterfront, in the water, or inland along a public right of way.
3. **Design**. How will the flood mitigation measure be integrated into the broader structural or public realm design? Options might include new opportunities for public access, recreation and harbor views, with public plazas, esplanades, or docks; murals or sculptures integrated into flood protection structures; and ample seating and stairs, among many other options.

It is important to note that the South Boston coastal resilience planning process resulted in a set of preferred conceptual approaches and alignments for the Fort Point Channel, Seaport Boulevard, and Reserved Channel with options and recommendations for further evaluation in the areas of the Marine Industrial Park, Pleasure Bay, and Day Boulevard. The final report provided examples of possible design solutions, but detailed designs must be developed through the implementation process for all areas. Additional Stakeholder engagement and further technical analyses to make these decisions will be required.

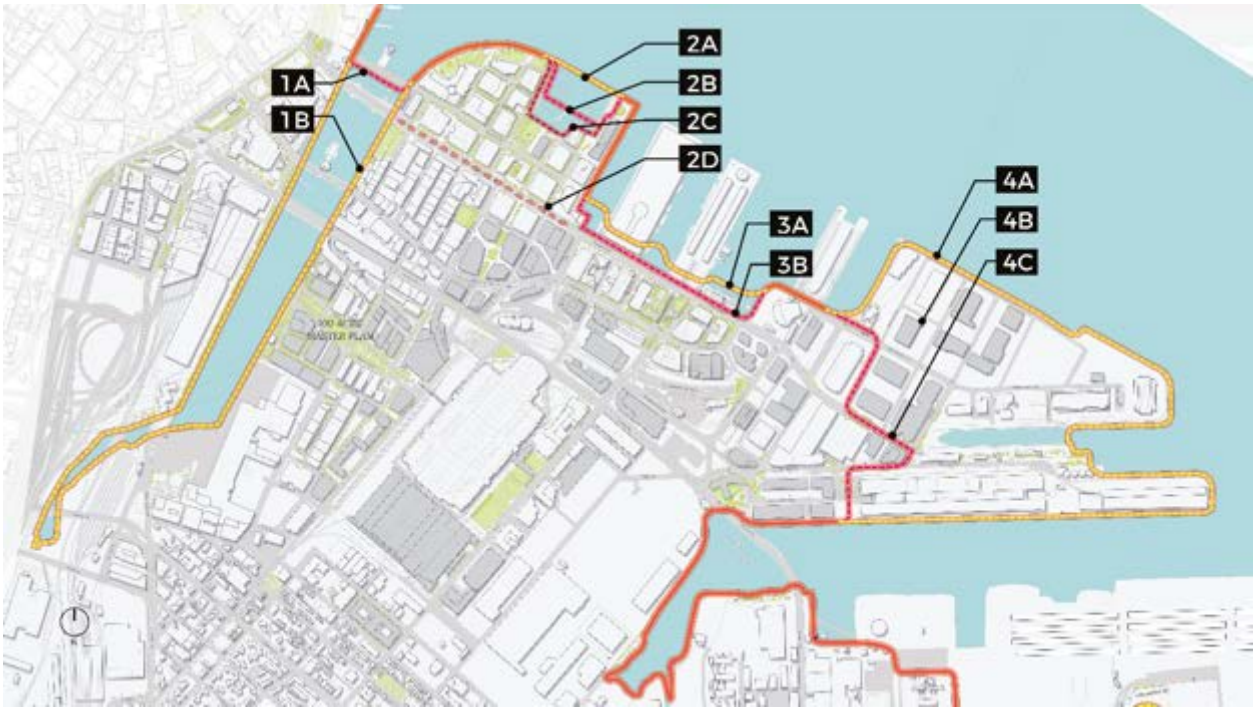


Figure 6 Alignment options presented in *Coastal Resilience Solutions for South Boston* (Source: *Coastal Resilience Solutions for South Boston* (2018))

Coastal Resilience Solutions for South Boston developed cost estimates and a prioritized timeline for coastal resilience investments based on magnitude and frequency of expected flood impacts, as depicted in Figure 8. Capital costs for waterfront alignments across the district are expected to total between $500 million and $1 billion through 2070 without escalation.[5] Expenditures are expected to begin modestly in the early 2020s but rapidly increase beginning in 2023 (see Figure 7**Error! Reference source not found.**).[6] As projects come online, there are also increasing costs associated with operations and maintenance beginning in the mid-2020s.[7]

The proposed level of flood risk mitigation (i.e. the "target" elevation) for all actions is the elevation of the 1-percent annual chance flood with 40 inches of sea level rise plus one foot of freeboard (a safety factor),

[5] Costs include all those integral to the design and implementation of the coastal infrastructure along the alignments presented in the report, including factors associated with stormwater pumping that will be required as a result of the solution. Costs do not include other resilience improvements, such as broader stormwater management needs within the community or retrofits for properties and infrastructure inland of the alignments presented in *Coastal Resilience Solutions for South Boston.* Escalation refers to changes in project costs over a given period of time.

[6] Analysts estimated annual capital expenditures using the full range of costs by project, assuming a ten-year implementation schedule for each project with the exception of early action solutions. In some cases, multiple alternatives may move forward over time. For example, the early action area along Seaport Boulevard may evolve from a flood wall to filled solution between the near and long-term; such additional costs are not captured in this graph.

[7] Maintenance costs projected at 1.5 percent capital cost, which may be conservatively high for the area. Maintenance costs are projected to begin incurring in 2025 as first projects are projected for completion, and then incurred incrementally based on annual capital expenditures (as opposed to project completion).

as expected in the 2070s in Boston.[8] In addition, investments should be adaptable to a higher elevation in the future (i.e. the "modular" elevation) to address higher flood elevations over time. More detail on correlating elevations is provided in *Coastal Resilience Solutions for South Boston* and in Table 3. Recommended implementation roadmaps and next steps were also provided in the report and provided the foundation for the Project.[9]

Table 3 Summary of base, target, and modular elevations for flood mitigation measures along Fort Point Channel and Seaport Boulevard. Elevations presented in reference to NAVD88.

Area	Base Elevation	Target Elevation	Modular Elevation
Fort Point Channel	12.0	14.0	16.0
Seaport Boulevard	13.0	15.0	16.5

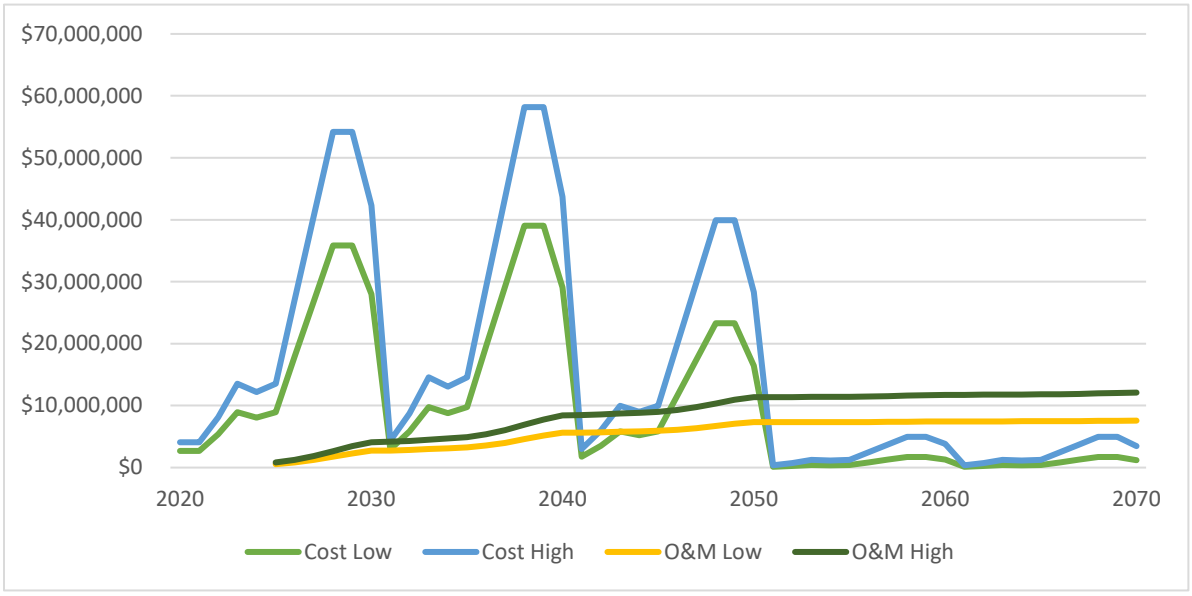
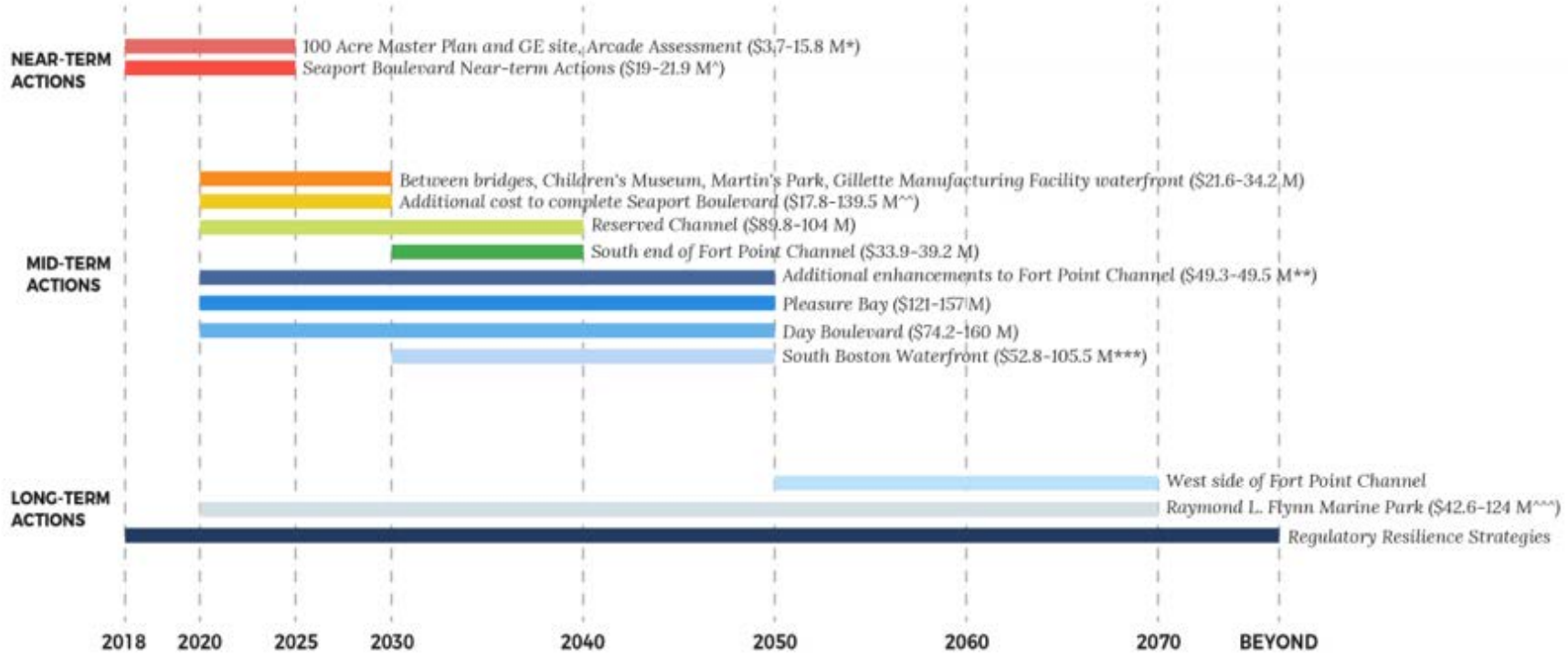


Figure 7 Preliminary annual capital and maintenance cost schedule for implementation of *Coastal Resilience Solutions for South Boston* assuming project completion

[8] See *Climate Ready Boston*, 2016
[9] Source: *Coastal Resilience Solutions for South Boston, Executive Summary, pp 38.*



* Upper limit includes additional park space

** Costs for Option A only

*** Costs for Options A and B only

^Costs for Option A only. Does not include costs to floodproof the Fish Piers

^^Cost range includes Options A and B. Floodproofing of Piers not included. No Dry Dock 4 costs included.

^^^Floodproofing all structures seaward of Option B would add $113 - $131 million. Costs not included

Both costs and phasing plans are estimates and recommendations only, and will require more detailed planning, design, and engineering.

Figure 8 Implementation Timeline for All Coastal Resilience Projects in South Boston (Source: *Coastal Resilience Solutions for South Boston* (2018))

2.2 Urgent action areas

The areas along Fort Point Channel and Seaport Boulevard include segments where action is required by 2025. As such, these were selected as the primary focus areas for the Project, along with segments where action is required by 2030. Project focus areas are highlighted in Figure 9.

Figure 9 Prioritization of Coastal Resilience Investment by Shoreline Section (based only on expected flood risk reduction based on the current population and current built environment) (Source: *Coastal Resilience Solutions for South Boston* (2018))

Figure 10 Project focus areas: Fort Point Channel and Seaport Boulevard

This section provides an overview of the alternatives advanced in *Coastal Resilience Solutions for South Boston* but does not replicate the analysis in that report. For more information on the decision-making process and details of both alternatives and preferred solutions, please refer to the source document.

2.2.1 Fort Point Channel

Coastal Resilience Solutions for South Boston investigated two mid- to long-term flood risk mitigation alignment options for the Fort Point Channel, as displayed in Figure 10**:** one along the perimeter of the Fort Point Channel (Option A), and the other at the mouth of the channel (Option B).

Conceptual approach options for Option A included berms, seawalls, and shoreline strategies that would integrate the Harborwalk and open space into a continuous perimeter solution across property lines. Along the existing Harborwalk between the two bridges, it might be possible to incorporate building structures into the line of defense using independent tight wall structures[10] or build into the water.[11] Bridge guardrails would be converted to flood mitigation assets. The many stormwater outfall pipes along the channel will require flap gates.

The western edge of Fort Point Channel is at a higher elevation and the report optioned dry floodproofing actions in the near-term with long-term approaches such as the eastern alignment. Conceptual approaches to Option B included the installation of a tide gate or gates at the mouth of the channel.

Implementation for Option A can be phased, with the most urgent flood risk possible to be addressed by 2025. Because Option A could begin in the near-term and phased over time, it was a viable alignment for early action solutions.

Coastal Resilience Solutions for South Boston concluded that while Option B might be added to Option A over the mid to long-term, it could not provide a standalone approach for the following reasons:

- It would take significantly longer to achieve flood risk reduction through Option B than Option A. The lengthy implementation schedule of Option B would leave significant unmitigated risk in the near-term
- Failure of Option B as a standalone mitigation solution would lead to significant consequences. Only the most catastrophic breach of Option A could produce the same level of flooding as failure of Option B.
- Option A would mitigate risk from sunny day flood conditions, such as those posed from astronomical high tides, while Option B is not expected to do so unless designed to permanently close the channel from tidal influence[12]

[10] A tight wall structure refers to a structurally independent wall erected against an existing structure to provide flood mitigation where existing structural walls are not able to withstand the loading associated with flooding.
[11] There are significant regulatory considerations related to building into the water, as described in *Coastal Resilience Solutions in South Boston*; these considerations are not duplicated within the scope of this Project
[12] The Boston Water and Sewer Commission (BWSC) is studying the potential for Option B to provide combined coastal flood mitigation and stormwater management benefits. This scenario considers the potential for Fort Point Channel to provide stormwater storage during extreme rainfall and coastal flood events. A tide gate would be introduced at the base of Fort Point Channel and closed at low tide, thus maintaining low tide water levels in the Channel while tides rise in Boston Harbor. Stormwater released through outfalls into the Channel would be stored there by the tide gate until being released once tides levels in the Harbor recede. It is important to note that

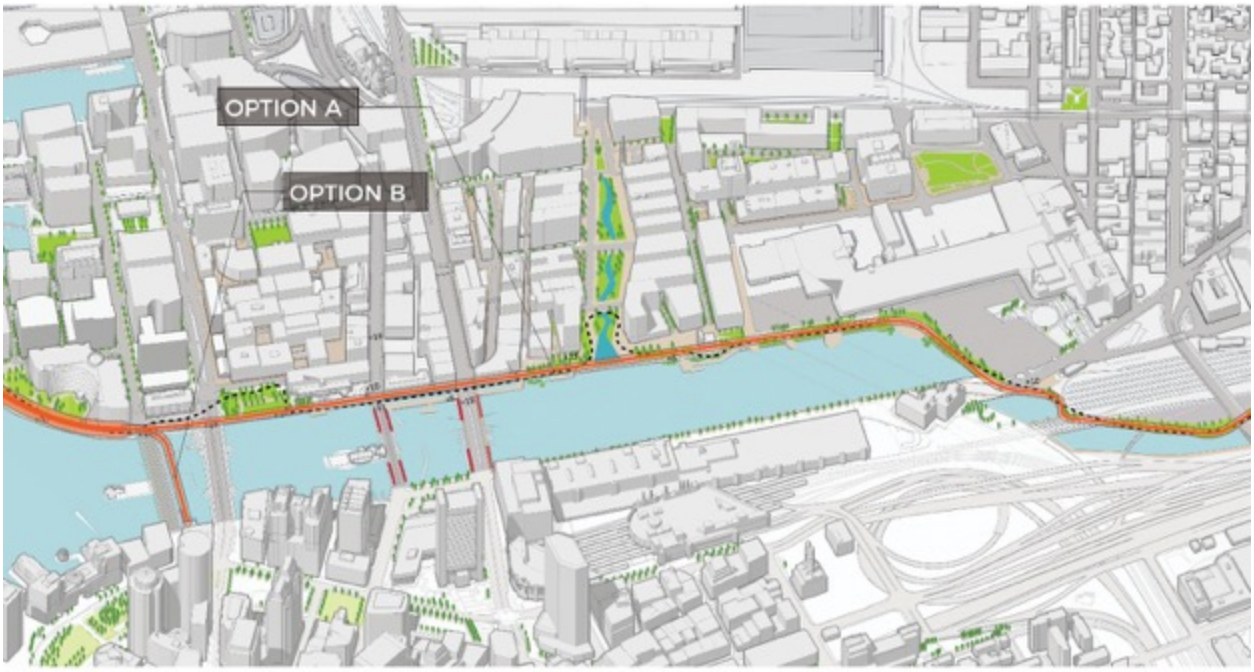


Figure 11 Coastal Resilience Alignment Options for Fort Point Channel (Source: *Coastal Resilience Solutions for South Boston* (2018))

Successful implementation of the Option A perimeter alignment solution will require sequenced flood mitigation implementation at seven variously owned segments of the Fort Point Channel study area with tie-ins across adjacent solutions. These seven segments can be seen in Figure 12. Urgent actions (to be completed by 2025), include Steps 1 and 2 in the image below and will require implementation of shoreline flood mitigation approaches at the 100 Acre Master Plan and adjacent site formerly planned for General Electric's Headquarters. The bulk of the remaining solutions along the Channel, such as those at the Fort Point Channel Manufacturing facility to the south of the 100 Acre site and the area to the north ending with the Children's Museum and Martin's Park[13] (Steps 3, 4, 5, and 6), must be completed by 2030 to curtail significant emerging risk based on the analysis completed for *Coastal Resilience Solutions for South Boston*. The Massachusetts Bay Transportation Authority (MBTA) rail yard at the South of the channel should be completed within the 2030s. The Fort Point Channel study area steps 1 through 7[14] require capital costs range from $37 to $47 million depending on approach and design decisions. $20 million or more is expected toward solutions for Steps 1, 4, and part of 2, which at the time of funding

shorelines solutions proposed under Option A would still be necessary under this approach, both to provide redundant protection and to increase the level storage provided in the Channel. Additional study is necessary to determine the feasibility of this scheme.

[13] The City of Boston has completed capital improvements at Martin's Park to increase its resilience. The park's design provides inland flood protection but will require additional investments to close all potential flood pathways.

[14] Note that construction costs for Step 3 have not been developed as *Coastal Resilience Solutions for South Boston* recommended an engineer assessment to determine whether the structure can withstand expected flood elevations through 2030. Costs include an engineer assessment. Nevertheless, the report did integrate costs for Step 3 in the long-term cost estimate for Fort Point Channel. This has not been integrated into the implementation schedule through 2030 developed for this Project.

application were owned by the same entity. The expected total funding allocation associated with the grant consists of about $10 million in FEMA Pre-Disaster Mitigation funding, $10 million in City funding toward construction, and additional private investment for design, permitting, construction, and possibly long-term maintenance, as well as easements.

As part of this Project, engineers refined the implementation schedules for these sites and analysts projected initial capital expenditure over time based on this schedule. The projected distribution of costs over time from present day until 2030 can be seen in Figure 13. The funding anticipated through FEMA and the City are captured within the diagram.[15]

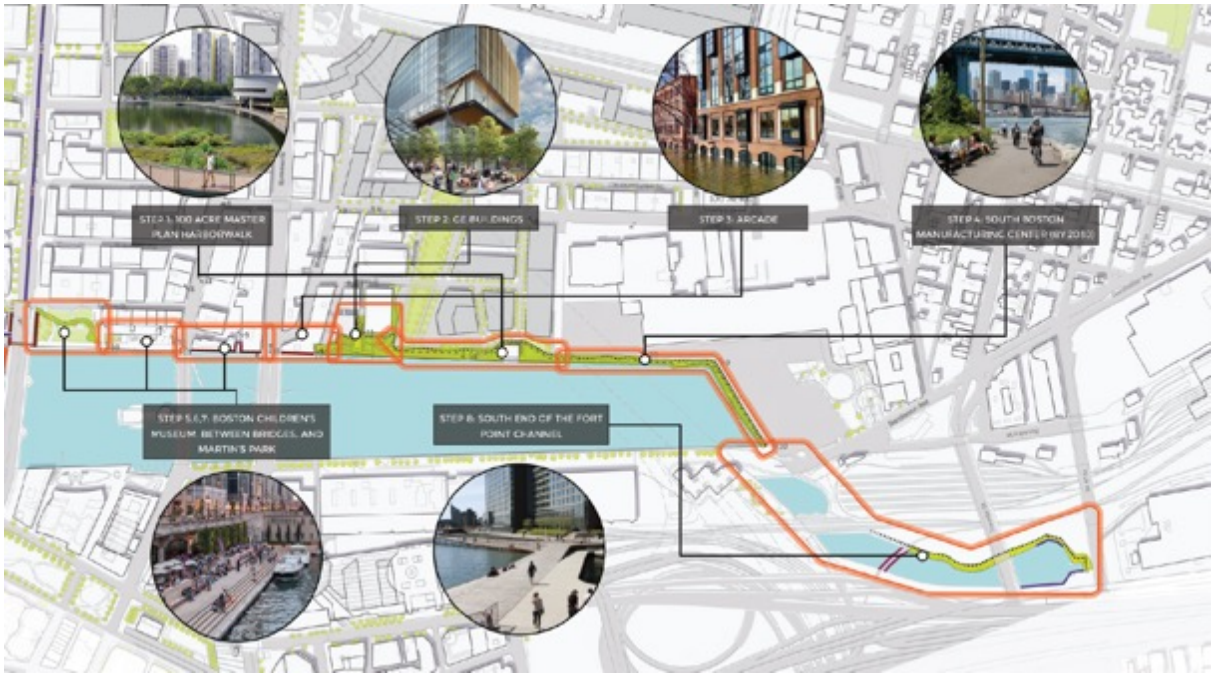


Figure 12 Study Segments Along Fort Point Channel (Alignment Option A) (Source: *Coastal Resilience Solutions for South Boston* (2018))

[15] There have and continue to be additional private investments described in further sections, not captured within Figure 13 as the intent of the image is to demonstrate the expected funding needed over time as of the beginning of the Project. Additionally, as private actors elevate the Harborwalk incrementally (such as occurred at the site located at Step 2 and a portion of Step 3), the urgency of action in this area is reduced so long as the elevation is structurally sound.

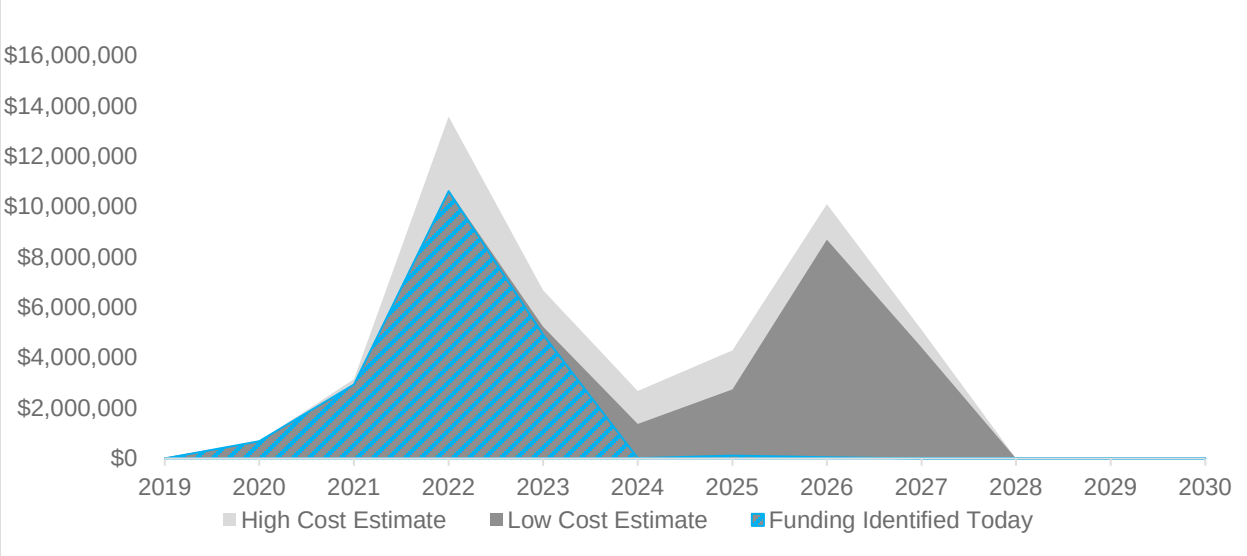


Figure 13 Cost Estimates Over Time for Urgent Action Fort Point Channel Coastal Resilience Projects

2.2.2 Seaport Boulevard

Coastal Resilience Solutions for South Boston identified two mid- to long-term flood risk mitigation alignment options for Seaport Boulevard, as displayed in Figure 14: one aligned with the existing shoreline (Option A), and the other building out into the water (Option B). These options are not mutually exclusive and could represent a phased approach to risk mitigation with Option A preceding implementation of Option B, as described in the report. Option A would maintain existing maritime operations and Option B would enhance public access to the waterfront, both preferences expressed by varying stakeholders.

The near-term action area begins between the World Trade Center and the Fish Pier and extends to the Blue Hills Bank Pavilion above Northern Avenue. The suggested near-term flood mitigation conceptual approach consists of new seawalls, dry floodproofing buildings outside the alignment, and a small earthen berm to reduce current flood risk while providing flexibility for future height or design adaptation. In order to be effective by 2030, flood resilience actions are needed along the remainder of Seaport Boulevard and around Dry Dock 4, and actions on neighboring properties must tie into one another to provide a seamless layer of flood risk reduction. Massport is the primary property owner in this area, including several of the piers and Seaport Blvd itself.

Cost estimates for priority coastal resilience projects along Seaport Boulevard to be completed by 2030 under Option A range from around $37 to $42 million (not including resilience measures that will be needed for the individual properties along this segment, such as the World Trade Center, Fish Pier,and Liberty Wharf). The projected distribution of costs over time from present day until 2030 can be seen in Figure 15. It's worth noting that the costs to complete the entire stretch adding in Option B could be as high as $180 million. Option B is not included in Figure 15 as this is assumed to be longer-term, if implemented.

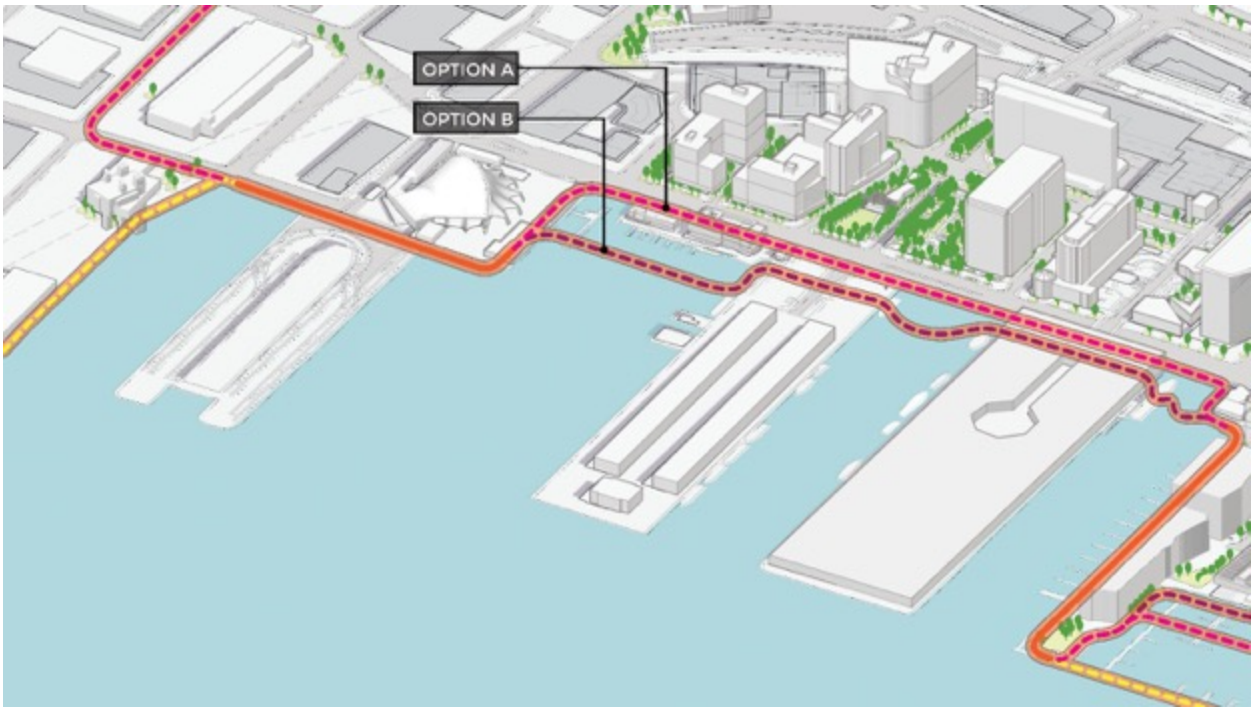


Figure 14 - Coastal Resilience Alignment Options for Seaport Boulevard (Source: *Coastal Resilience Solutions for South Boston* (2018))

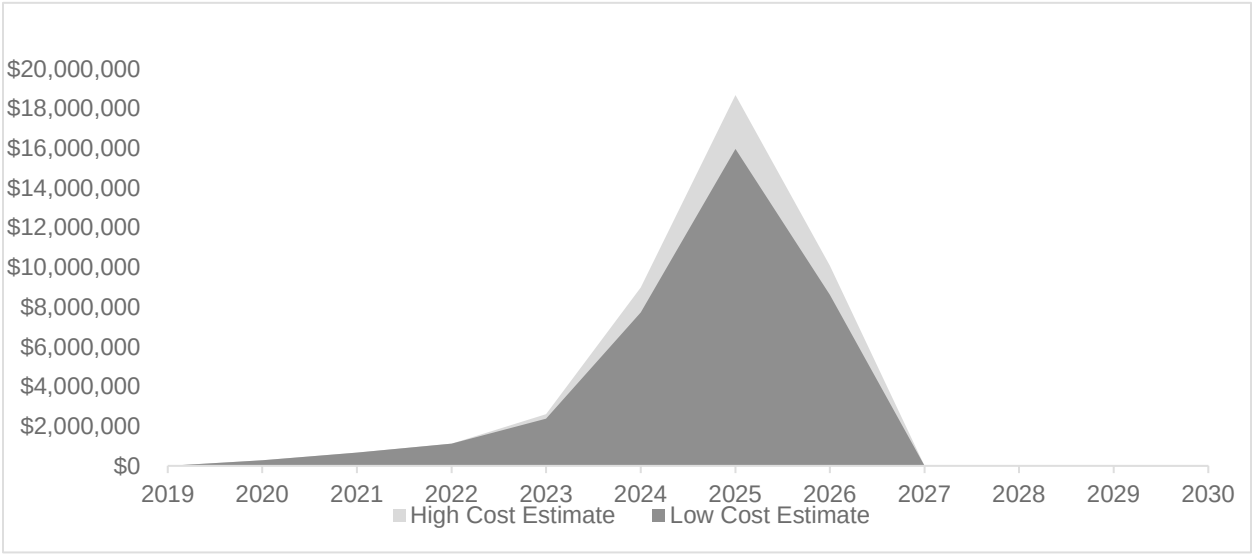


Figure 15 Cost Estimates Over Time for Urgent Action Seaport Boulevard Coastal Resilience Projects

2.2.3 Project Progress in Fort Point Channel and Seaport Boulevard

Table 4 below summarizes the status and type of coastal resilience project being pursued by property owners and government officials in the project area as of January 2020. The information in the table is based primarily on stakeholder interviews and publicly available information.

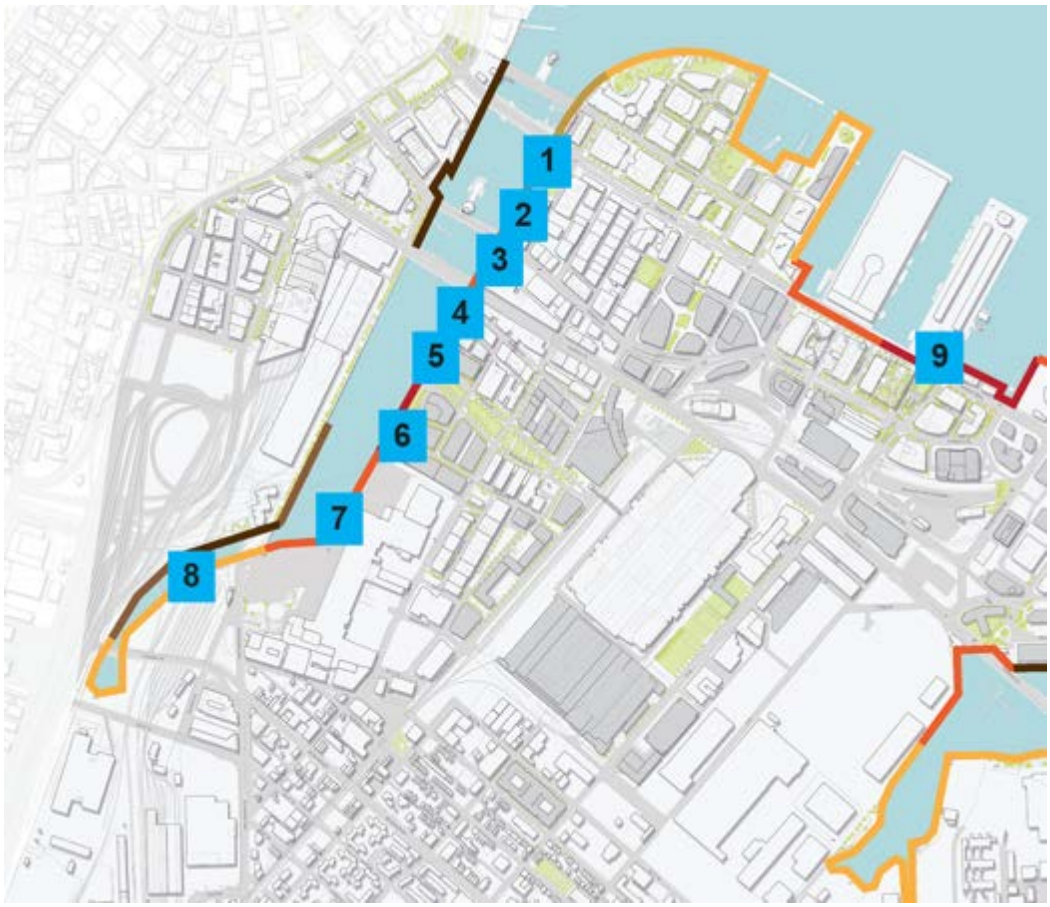


Figure 16 Key to Coastal Resilience Projects by Property Along Fort Point Channel and Seaport Boulevard (see table 2) (Source: *Coastal Resilience Solutions for South Boston* (2018))

Table 4 Coastal Resilience Projects and Statuses as of January 2020

	Key	Property	Target Completion	Status	Project Type
Fort Point Channel	1	Martin's Park	2030	Complete; Retrofit needed to address flood pathway	Elevated berm and concrete armoring
	2	Children's Museum	2030	Preliminary design	TBD
	3	Between Bridges Properties	2030	Not started	TBD
	4	Arcade Properties	2025	Not started	TBD
	5	National Development / Alexandria Property	2025	Preliminary design	Berms/Floodwalls/Elevated Harborwalk
	6	Related Beal Property (Resilient Fort Point Channel Infrastructure Project)	2025	Preliminary design	Berms/Floodwalls/Elevated Harborwalk
	7	Gillette / Proctor and Gamble Property (Resilient Fort Point Channel Infrastructure Project)	2030	Preliminary design	Berms/Floodwalls/Elevated Harborwalk
	8	MBTA Property / South End of Fort Point Channel	2030	Not Started	TBD
Seaport Blvd	9	Massport / Seaport Boulevard Near-Term	2025	Not started (additional planning needed)	TBD
	9	Massport / Seaport Boulevard Mid-Term	2030	Not started (additional planning needed)	TBD

3 PROJECT PROCESS

The *Expanding Boston's Capacity to Build Coastal Resilience Infrastructure, Lessons from the Seaport District* project began in April 2019 and concluded in January 2020. The process involved background case study research on nationwide governance and funding models for resilience project implementation, engagement with property owners, the Green Ribbon Commission, and City of Boston officials, and development and refinement of a series of approach hypotheses refined to arrive at final recommendations.

3.1 Other efforts leveraged toward the project

The Project was not completed in a vacuum and draws on studies in progress and recently completed. As such, this Project report will not duplicate the efforts of previous studies by recounting the full suite of possible governance and funding frameworks available to the city of Boston (see the **Bibliography** for a guide on further reading). Instead, the Project presents recommendations along with rationale for their selection. Alternatives are provided where further evaluation is appropriate to refine the approach. Ultimately, of course, it will be up to the City of Boston and other entities with jurisdiction in the area to determine what course of action to pursue.

The following is a snapshot of previous efforts leveraged toward the Project.

- In particular, this study has drawn on the comprehensive research completed by the UMASS Boston Sustainable Solutions Lab in concert with the GRC outlined in the reports *Financing Climate Resilience: Mobilizing Resources and Incentives to Protect Boston from Climate Risks* and *Governance for a Changing Climate: Adapting Boston's Built Environment for Increased Flooding*.
- In addition, the report builds on the work of Jones Lang LaSalle and the Boston Planning and Development Agency (BPDA) in studying funding and governance approaches for implementing coastal resilience solutions along the Border Street corridor in East Boston.
- The report uses data and investigations from the original *Climate Ready Boston* effort completed in 2016, and uses data updated through the *Climate Ready South Boston* effort
- The report leverages governance and funding strategies for advancing climate resilience developed through *Climate Ready South Boston*
- The report builds on stakeholder engagement feedback provided during *Coastal Resilience Solutions for South Boston* effort completed in 2018 and the *Climate Ready Downtown and North End* project completed in 2019 and slated for report delivery in early 2020
- The work reported here has used the recommendations from these reports and others to develop and refine a recommended set of governance, funding, and regulatory approaches to advance flood mitigation investment in the Seaport District

3.2 Case studies and literature review

In preparation for developing governance and financing recommendations, the Project team conducted a literature review to catalogue and cross-compare existing and conceptual governance approaches and financing models. Through a thorough investigation of the latest academic research and technical reports

from across the country, the Project team compiled a toolbox of options for potential revenue sources, financing instruments, and governance structures. The literature review revealed many possibilities of managing revenue sources as diverse as grants and contributions, direct user surcharges and service or utility fees, enterprise revenues, value capture mechanisms, general taxes, and strategic sourcing of existing or dedicated funds used in tandem with bonds or loans to finance resilient infrastructure. Additionally, the literature review included closer investigation into a handful of case studies demonstrating how different revenue sources, financing instruments, and governance structures can, and have been, used to successfully implement coastal resilience solutions at the scale of a district, city, state, or region. While the implementation of resilience investments is a relatively new field of focus, and thus is lacking many mature governance and policy structures, details on a selection of governance and funding case studies used to inform the Project team's recommendations can be found in **Appendix A**.

3.3 Coastal resilience delivery cycle and implementation framework

In pursuing the Project goals, it is helpful to consider both the specific steps required to construct a discrete coastal resilience project and the framework within which all related projects might be delivered. As such, for the purposes of this study, implementation refers to governance, funding, and regulatory processes by which design, permitting, construction, operations and maintenance, and long-term adaptation must all work to deliver specific projects that together build coastal flood resilience.

It is also helpful to note that while the particular objective of coastal resilience capital investment may be new in Boston, especially at the scale recommended through *Climate Ready Boston* efforts, technical design and construction processes are largely the same as for other types of public infrastructure, such as sewers, roads, and bridges. As such, we can adopt some of the same concepts and processes involved in project delivery. The following are typical stage gates that would be required steps for each of the concepts explored in the *Coastal Resilience Solutions for South Boston* report. The timing for each of these stage gates depends upon the scale, complexity, and available funding for a project:

1. Design:
    a. Preliminary Design (typically referred to as 30 percent design) for comment and vetting with stakeholders
    b. Final Preliminary Design (typically referred to as 60 percent design) for comment and revision with stakeholders
    c. Final Design (typically referred to as 90 percent design) for comment and revision with stakeholders
    d. Final Design (typically referred to as 100 percent design) for construction
2. Permitting (Permitting coordination and actions can co-occur within any of the design-related stage gates)
3. Construction
4. Operations and Maintenance
5. Future adaptation

These steps can be thought of as a cycle, as depicted in Figure 17, given the need for re-evaluation of a project over time to address the evolving climate change risk context. With changing risk and ever-improving data and knowledge, there will be a need to modify the solutions we implement today to incorporate new design standards and technologies. Each step must be accomplished within a funding, governance, and regulatory framework which will have a fundamental impact on project implementation success. In many ways, this framework is the core challenge facing Boston as it proceeds in its efforts to advance coastal flood resilience.

Figure 17 Typical Implementation Cycle for Coastal Flood Mitigation Projects, illustrating the need for a robust governance and funding structure.

3.4 Criteria used to guide recommendation development

A key element of the Project required identifying the characteristics of a desirable approach to implementation. The team developed these characteristics, which have effectively become criteria for the development of recommendations, based on stakeholder engagement throughout the *Climate Ready Boston* process, professional experience, and literature review. The team used the criteria to assess the relationship of possible recommendations to values such as equity, fairness transparency, sustainability, and adaptability. By defining these policy and operational criteria at the outset, we can best ensure that any governance, funding, or regulatory framework is structured to address priority objectives and align with higher-level values that may be necessary to achieve long-term sustainability and corollary goals. These criteria are outlined in Table 5.

Table 5 Criteria used to guide recommendation development

Characteristic	What this means	Why this matters
Equitable	Ensuring the benefits of flood mitigation are not concentrated exclusively based on financial contribution; consideration of how both the cost burdens of implementation as well as the disproportionate impacts of climate change are demographically distributed. An equitable approach would be reached through accessible, inclusive, representational, and collaborative decision-making processes.	Flood risk mitigation serves a greater good than simply protecting individual properties. It not only supports the economic vitality of a place and the city overall, but also the capability of residents to adapt to climate change in pursuit of a higher quality of life. Protection cannot be available to only those who can afford it, nor can decisions regarding flood mitigation be reached without a transparent and inclusive decision-making process.
Fair	A payer's financial contribution is proportionate to the benefit it receives.	Successful long-term implementation will depend heavily on perceptions of fairness.
Transparent and democratic	The approach must enable all affected parties to have a voice in the formation and decision-making powers of the governance framework. There should also be transparency about what, how, and why decisions are made.	Trust in the institutional basis and authority of the governance framework will be crucial to its long-term sustainability and effectiveness to reduce flood risks.
Legible and administratively elegant	A legible approach means the structures, responsibilities, and internal operations of the governance entity are clear and balance the need for solutions to complex problems with administrative simplicity.	A governance structure that is too complex and/or administratively burdensome is unlikely to be effectively deliver major capital projects. If the solution is overly administratively complex, resources required for project delivery may be expended on administrative tasks, thereby reducing the impact of the approach.
Sustainable through economic downturns	The revenue stream for the entity is durable and provides funding even in times of reduced economic activity.	Given the cyclical nature of the economy, it is important that expected economic downturns not inhibit the ability of the framework to implement necessary projects on time. Diverse funding sources will ensure sustainability through downturns.
Sustainable through political change	Governance is structured to withstand the influence of individual political cycles such that its mission and function remain clear and consistent under varying political administrations.	Implementing flood mitigation to mitigate climate change is a long-term effort whose benefits will accrue over decades. These benefits must be decoupled to the extent possible from the short-term focus of political cycles.
Applicable across initial investment, maintenance, adaptation	The framework provides adequate capabilities and responsibilities at all phases of project implementation and operation	Flood mitigation implementation is about more than building the infrastructure. There is also the need to operate, maintain, and ensure adaptation of the mitigation measure over time.
Adaptive over time, based on changing risk and resilience context and needs	The framework is flexible enough to allow for adaptation to a changing set of climate and social conditions	Our understanding of climate change is always evolving based on new science, new technology, and changing societal factors. Any entity addressing climate change must be adaptable to these changing conditions.

3.5 Required elements of successful project implementation

Key components of a system for reliable flood mitigation investments will need to include funding, planning, analysis, regulatory enforcement, and the implementation cycle described above (project design and construction, operations and maintenance, and ongoing adaptation). Any effective implementation governance framework must have clear authorities and responsibilities, capabilities and capacities, as well as cooperation and coordination across affected and responsible parties around each of these functions and steps.

Currently, these functions are decentralized across a range of agencies, departments, programs, and stakeholders. The governance and funding recommendations outlined here attempt to organize the functions in a way that maximizes efficiency and economies of scale, while addressing needs for fairness, equity, transparency, and sustainability over time, to delivery district-scale flood mitigation.

For a new governance structure to be effective in meeting the framing criteria for effective implementation described in Table 5, there needs to be a clear vision of how responsibility, authority, accountability, capability, capacity, and cooperation would all be allocated and aligned. The questions outlined below map the considerations and potential players that will need to be involved as the new governance entity's precise structure is defined.

- **What are the necessary responsibilities?**
- **What authorities and powers are needed related to decision-making, funding use, and enforcement?**
- **What capabilities in the form of skillsets and tools are required?**
- **What capacity in the form of funding and human and technical resources are required?**
- **Who needs to be involved and how?**
- **Who must endorse and support the framework?**

Tables 4 and 5 below summarize the responses to these questions in order to frame the existing implementation governance landscape and how its constituent elements may work together toward the formation of new frameworks.

Table 6 Governance responsibilities necessary for implementation, maintenance, and adaptation of coastal flood protection infrastructure

Category of responsibility	Subcategory	Why this responsibility is necessary	Where it currently lies	What skills and capabilities are necessary
Funding	Collect / generate	Coordination of existing and new funding sources	Budget Management Office, Assessor, BPDA, BWSC	Ability to manage and coordinate a variety of existing and new funding stream to leverage toward prioritized resilience investment
	Distribute			
	Manage			
Planning & Analysis	Master plan development / update	Understand risk and define mitigation options	Office of Environment, Energy, and Open Space (EEOS), BPDA, BWSC	Ongoing analysis of evolving risk context and development of risk mitigation plans
	Mapping and application of science		BRAG, EEOS	
	Risk evaluation		EEOS	
Regulatory enforcement	Standards development and enforcement (flood damage prevention, as well as zoning, design review, and building code)	Ensure adherence to codes and standards	BPDA, Inspectional Services, Conservation Commission, State/Federal agencies	Development and enforcement of common standards for resilience investments
	Permitting			
Management of project implementation	Procurement and contract management for project delivery	Administering implementation process over time	BPDA, EEOS, DPW, BWSC	Program management, financial management, policy oversight, and procurement and contract management to support seamless project delivery (including design, permitting, construction, etc)
	Financing		Budget Management Office, BPDA	
	Staffing		All	
	Monitoring and evaluation		Variable	
	Insurance		Variable	
Maintenance and operations	O&M planning	Ensure high standard of reliable risk mitigation	Variable dependent on project type/location	Ability to operate and maintain resilience infrastructure in keeping with Federal standards
	Operations (e.g., installation of deployable flood mitigation measures in advance of storm)			
	Maintenance			

Additional capabilities that could be accessible through an internal or external partner include mapping and risk evaluation, socio-economic and spatial analysis, insurance expertise, and benefit-cost analysis.

Table 7 Existing entities that must be engaged in the governance framework and their roles

Existing entity	Current role
Budget Management Office/Assessor	• Aligning funding strategy with the City's operating budget and capital plan
Boston Planning and Development Agency	• Support in planning and prioritizing projects • Standards development and enforcement • Coordinating with city-level capital construction and development
Boston Water and Sewer Commission	• Possibly developing and implementing a service fee • Coordination of drainage infrastructure needs
Office of Environment, Energy, and Open Space	• Coordinating with City parks capital projects • Coordinating with *Climate Ready Boston* process
Department of Public Works	• Coordinating with City capital projects, particularly related to stormwater and transportation
Mayor's Office of Resilience and Racial Equity	• Coordinating to ensure projects are planned, funded, and implemented in a way that pursues equitable outcomes, avoids inequitable outcomes, and includes an equitable and collaborative planning process
Public Safety	• Coordination of Emergency Management and First Responders
Property owners / Major employers	• Getting buy-in on district-wide resilience solutions and contribution of benefit-linked revenue • Ensuring alignment with any site-specific resilience measures • Community-based organizations in the district, particularly those representing vulnerable communities • Coordinating to ensure projects are planned, funded, and implemented in a way that pursues equitable outcomes, avoids inequitable outcomes, and includes an equitable and collaborative planning process
State government	• Some properties in South Boston are owned by State agencies and authorities (e.g., Massport, MBTA, MCCA) • Certain frameworks will require State authorization or legislation to be implemented • State regulators will need to be involved in the permitting of resilience solutions • Funding support
Federal government (i.e., FEMA, Army Corp, EPA)	• Funding support • Some solutions will require engagement of federal regulatory agencies

3.6 Establishing a common language through which to discuss and explore options

Governance and funding responsibility and accountability for implementation of each stage gate of a coastal flood risk mitigation project can be thought of as occurring across a range of spectrums (see Figure 18).

These spectrums can be used as a starting point for establishing a common language around discussing the implications of regulatory, funding, and governance options and gathering information on stakeholder preferences. Collecting information on preferences from property owners on the front line of proposed flood mitigation solutions is a first step in understanding how amenable or resistant these stakeholders might be to different types of institutional change that might be needed to ensure implementation of the most urgent flood mitigation actions, as well as longer term district-level solutions. Feedback from these property owners is not expected to be a proxy for nor indicative of the perspectives and sensitivities of the broader community, which would be a valuable next step in engagement.

These spectrums are not necessarily fixed in time and could evolve. For example, flexible/informal governance structure could evolve into a more fixed/formal structure over time.

Figure 18 Governance, funding, regulatory spectrums for coastal resilience implementation

3.7 Stakeholder engagement process and feedback

As noted above, an important component of the Project involved outreach and interviews with stakeholders critical to implementation. This includes the public and private owners and tenants of properties on the waterfront where coastal flood risk mitigation projects will need to be built and City officials who will be involved in policy, regulatory, and funding applied to the projects. The initial Project plan included engagement and workshops with state and federal regulatory entities. Nevertheless, as the Project progressed and new information and priorities emerged, this became a recommended near-term implementation step (see Section 4.1.3). The approach to engagement with both private and public stakeholders relied on presentation and discussion of a series of hypothesis recommendations, developed based on early engagement and analyses, that were then used to generate feedback from stakeholders. The resulting input was used by the Project team to refine and recalibrate the hypotheses into draft and final recommendations outlined in this report.

3.7.1 Property Owners

Outreach to property owners consisted of a series of interviews and meetings between the Project team and key members of the property ownership or tenant leadership. Figure 19 provides a map of interviews that were completed over the course of this Project.

The property owner interviews had two primary goals.

1. The interviews provided an opportunity to refresh and, in cases where new property owners were involved, introduce the process and recommendations of the *Coastal Resilience Solutions for South Boston* report. To facilitate this discussion, a packet of information was shared with a site-specific summary of the flood risk context, conceptual plans, cost estimates, regulatory considerations, and stakeholder input for each site or property.
2. The Project team asked property owners and tenants to provide an update on planned or ongoing flood resilience projects on their sites in order to catalog the status of progress made since the conclusion of the *Coastal Resilience Solutions for South Boston* study.

The interviews provided a forum to establish a common language around complex implementation concepts to facilitate future engagement on the topic, as well as discuss and establish a baseline understanding of property owners' perspectives on the range of governance, funding, and regulatory options for advancing coastal flood mitigation investment in South Boston. Stakeholders were asked to identify their preferences and interests across a series of spectrums representing the range of potential implementation paradigms (see Figure 18).

Figure 19 Map of Property Owners Interviewed and Engaged in the Project process

Property Owner Feedback

Although feedback from property owners and tenants was somewhat variable, a set of key findings and common themes emerged, as summarized below.

- Several property owners are moving forward to implement site-specific solutions and/or undertake exploration of their options.
- Others – especially those with more complex resilience challenges – are taking a “wait and see” approach when it comes to making significant investments in shoreline infrastructure due to the absence of specific requirements and/or design criteria; disagreement about the proposed flood protection alignment; and uncertainty around possible public funding and private investment expectations
- At least one major property owner is not ready to accept the coastal flood mitigation alignment as proposed and desires additional study before committing to an implementation plan or timeline
- Some property owners are eager to learn what options are available for protecting their assets, but express concerns over how investments across contiguous properties and district-wide will be coordinated.
- There was some confusion and/or lack of awareness about target elevations and other design or engineering standards for flood protection, both in the short-term and the long-term.

- Some property owners indicated a willingness and ability to contribute financially to district-scale solutions but wanted more certainty that their investments would be in keeping with the City's plans and that neighboring properties would also make investments to ensure an unbroken line of protection.
- Some property owners expressed a desire to know more about the City's plans and were hesitant to make investments without confirmation of those plans
- Many property owners raised concern about the viability of critical infrastructure, such as water/sewage, power, transportation, and communication during and after floods
- Most property owners would prefer a funding approach that is fair, where property owners contribute to shoreline investments proportional to the benefits they receive. Nevertheless, there was also widespread recognition from those interviewed of the need to account for equity and ability to pay
- Most property owners appear unlikely to pursue in-water solutions in the near-term (such as proposed for Resilient Boston Harbor) because of potential regulatory challenges that delay progress
- There was consensus that the problem is larger than any one property owner can address on their own and so there is a need for coordinated action across the district

3.7.2 City Leadership

The Project was undertaken in close consultation with City leadership, including officials from the Office of Environment, Energy, and Open Space, which manages *Climate Ready Boston*, and the Boston Planning Development Agency, responsible for land-use planning, development review, and certain components of resilience implementation, particularly on private property. Engagement with City leadership occurred through a series of briefings at key moments during the Project. City officials provided feedback that was valuable in ensuring that the Project's goals and preliminary recommendation hypotheses were aligned with City policies and goals.

3.7.3 Green Ribbon Commission

The Green Ribbon Commission (GRC) is comprised of civic-minded major business and property owners, non-profits, and philanthropic entities and provided a sounding board for Project progress and findings, and preliminary testing of hypotheses at key junctures. The Project team met with the GRC's Climate Preparedness Working Group on two occasions during the Project. The key takeaways from the meetings were that the members and the constituencies they represent appear to be aware of the flood risk facing the city and that investment is needed, but that there needed to be an entity tasked with coordinating collective action. With greater coordination and clarity around roles and responsibilities, the members suggested that private sector actors would be willing and able to work collaboratively to make the necessary investments in district-scale flood mitigation solutions on the properties they control and/or contribute to a district funding pool. Other key feedback was that the policy solutions for implementation needed to be simple, legible, and transparent in order to be feasible for adoption by the City.

3.8 Cost share analysis

In addition to performing stakeholder engagement and analyses into potential governance and regulatory frameworks and funding options, the Project team undertook an experiment to understand to how costs for an integrated flood risk mitigation system might be allocated across different payers based on share of benefits. The approach and results of the experiment are described in **Section 5.5 Track 2** funding and cost share considerations.

3.9 Dual policy track framework for implementation

Project recommendations are divided into two tracks covering topics of governance, funding and regulatory actions that can be taken to facilitate implementation (see Figure 20). This two-track approach recognizes the need for different sets of actions in the very near-term to move urgent projects forward and also support project delivery and management in the mid-to-long term due to the scale of investment and coordination necessary over time. It should also be noted that the utility of this framework depends on adherence to the implementation timelines outlined by the City in *Coastal Resilience Solutions for South Boston*. Recommendations could change based on the ultimate scale and speed of project implementation that is pursued by the City.

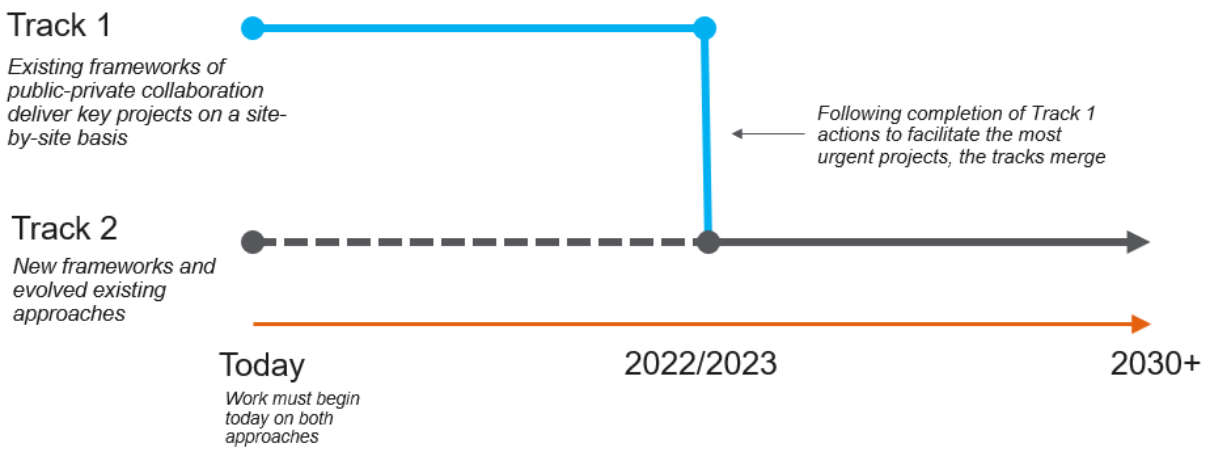


Figure 20 Diagram of dual track policy framework for coastal resilience implementation

Several construction projects in the *Coastal Resilience Solutions for South Boston* report proposed in Fort Point Channel are underway as of January 2020. The most notable of these is the Resilient Fort Point Channel Infrastructure Project consisting of a mix of earthen berms and mitigation of existing floodwalls along a portion of the Fort Point Channel from the 100 Acres Master Planning Area to the southern end of the Gillette World Shaving Headquarters site, funded in part by the City and (possibly) a FEMA Pre-Disaster Mitigation Grant. This project will mitigate flood risk along the most low-lying section of the Channel. Likewise, several other property owners are either taking steps to advance flood mitigation on their properties or are planning to do so.

In some cases, this work directly contributes to the strategy presented in *Coastal Resilience Solutions for South Boston* and is moving forward under existing governance, funding, and regulatory implementation frameworks. Thus, Policy Track 1 applies to actions that might be taken today through the 2022/2023 timeframe, working within existing frameworks, in order to expedite the delivery of flood mitigation along Fort Point Channel by 2030.

Existing available governance, regulatory, and funding approaches can fulfill most basic needs of site-by-site project delivery and some cross-property coordination in the near-term, such as that already occurring on the 100 Acres area along Fort Point Channel. Nevertheless, a more deliberate framework is required to coordinate, raise, and distribute funds to build, manage, and operate a network of flood mitigation investments across the district. Such a network would also require a governance structure that would extend beyond the limits of specific electoral and programmatic cycles.

This need is not exclusive to South Boston or even the city of Boston. Nevertheless, based on cost estimates and spending forecasts assembled for *Coastal Resilience Solutions for South Boston* and updated for this Project, we hypothesize that the projects located in South Boston alone will reach the threshold of needing a far more formalized structure for financing and governance in the 2022-2023 time horizon. Considering this, it is prudent to begin the process of establishing a new formalized governance structure, represented as Policy Track 2, as soon as possible, although the actual formation of the structure is not necessary to continue implementing near-term projects today (as outlined above).

4 RECOMMENDATIONS TRACK 1 – ACTIONS NEEDED TODAY THOUGH 2023

Policy Track 1 builds on early successes using existing project implementation frameworks and provides recommendations to expedite project delivery. Any recommended changes in governance, funding, and regulatory oversight for this track are designed to be incremental and achievable by the City and others within a six-to-nine-month timeframe. The sections below describe recommended Track 1 actions under the headings of governance, regulation, and funding.

4.1 Governance recommendations today through 2023

Policy Track 1 governance approaches focus on maximizing the effectiveness of existing vehicles for inter-departmental coordination within City government, formalizing expected design and performance standards, and continuing and increasing the level of ongoing engagement between City officials and potential implementation partners to facilitate a transparent and collaborative approach to delivery.

4.1.1 Establish a new senior level cabinet chief and office focused on climate resilience implementation with resources and capacity sufficient to support a large portfolio of complex projects and programs

Goal: Increase the City's capacity for climate adaptation by providing a dedicated senior role and office in City Hall. This role and office would be responsible to oversee implementation of city coastal resilience infrastructure and ensure site-specific project delivery is consistent and aligned with district-level plans in the near-term, while developing and refining longer-term policies and approaches.

The central action in this recommendation is to create a new senior position with a supporting office with a singular focus on the phased implementation of the city's portfolio of coastal resilience infrastructure projects planned through the *Climate Ready Boston* process. This new role and office would be situated in City Hall, ideally reporting directly to the Mayor with a cabinet level chief position. The role's title could be Chief of Climate Resilience or Adaptation, for example. Existing City roles focused on climate resilience planning and implementation within the various departments would be required to coordinate with the new cabinet position, and the new position would be given authority and resources sufficient to execute projects effectively across existing departments. We are not proposing to move all existing climate adaptation related roles into the department as each agency must have a mechanism to coordinate directly with the new office and, therefore, maintain alignment and compliance with City adaptation policies through their daily responsibilities.

The new position's responsibilities would include:

- Direct and mobilize resources that have been allocated to coastal resilience infrastructure
- Ensure compliance with the City's adaptation policy framework as it pertains to City capital improvements

- Coordinate adaptation-related capital improvement action by multiple city players across the governmental structure
- Facilitate public private partnerships, easements, memorandums of agreements (see **Section 4.1.2 Agreements with Property Owners in urgent action areas of Fort Point Channel**) toward the purpose of executing the City's coastal climate adaptation strategy
- Maximize alignment of City and infrastructure entity capital actions with City adaptation policies
- Enhance collaboration and partnerships with other public and quasi-public agencies outside of City purview, such as the Massachusetts Department of Environmental Protection, Department of Conservation and Recreation, MBTA, and Massport to advance and deliver projects on property these agencies own
- Lead City strategy for refining and implementing Policy Track 2 recommendations (see **Section 5 Recommendations track 2 – Actions needed Today through 2030 and beyond)**

Skills required would include:

- Project management
- Program administration
- Financial analysis and management
- Stakeholder engagement
- Policy analysis
- Communications
- Contract management
- Expertise in infrastructure design, construction management, operations, and maintenance

The role must have the power to influence the use of capital and resources within multiple departments and offices, including the Office of Environment, Energy, and Open Space (EEOS), Department of Public Works (DPW), Boston Water and Sewer Commission (BWSC), legal, and with a direct line to Boston Planning and Development Agency (BPDA) leadership, and ensure alignment of resource expenditure with the goal of district coastal resilience plans and the Mayor's Resilient Harbor Vision, where appropriate. The effectiveness of the role will be heavily dependent on the extent to which the position is provided with cross-cutting influence and authority to become involved in department-specific project delivery, as related to coastal resilience, to ensure alignment with the broader coastal resilience strategy.

There are likely to be sensitivities surrounding the power and jurisdiction of such a new position within the City government, particularly with respect to fears that the role would complicate or interfere with the mandates and scopes of services provided by existing departments and functions. While this certainly is an issue that will need to be acknowledged and discussed as the role is onboarded, it will nevertheless be important for all players in the government to understand that, to be effective, the cabinet Chief will need to be closely involved in any project with a coastal resilience component or with the potential to include such a component.

The City currently has staff roles dedicated to climate resilience issues and even more roles with responsibilities that pertain to climate resilience, though these roles are primarily planning, engagement, or policy-driven in scope. For implementation to date, existing staff have mostly integrated resilience-building into conventional project delivery processes. Examples include Parks and Recreation Department staff modifying the design at Martin's Park to increase flood risk resilience and Boston

Planning and Development Agency staff coordinating with property owners along Fort Point Channel and pursuing potential FEMA grant funding.

Existing staff have been effective to date in collaborating with and aligning perspectives among a range of external stakeholders, including community groups, residents, major property owners, and business associations, among others. They have also been advancing district level planning efforts, coordinating investigations into funding and policy change recommendations, and pursuing external funding sources. Resources are stretched as other responsibilities have not dissipated. As *Climate Ready Boston* initiatives progress toward design and construction, the complexity and scale of attention needed to advance coastal flood risk mitigation actions alone is very likely going to outstrip existing staff capacity; these staff have broader responsibilities and may not have the capacity and capability to implement and manage an entirely new type of integrated infrastructure within the city.

The primary benefit of the proposed new role and office is the relative ease with which it could be implemented in the near-term with the potential to have a significant impact in expediting project delivery. It does not rely on the creation any new governance entities and utilizes established mechanisms for adding new staff roles in the City government. Potential challenges and remedial measures are as follow:

- While adding a new role and office may be comparatively easy to implement, it may be difficult to ensure the role has the authority and autonomy it requires and is not hampered by interdepartmental coordination issues. As such, we recommend assigning key roles in each department that will be responsible for coordinating with the new office and ensuring alignment of climate resilient and capital improvement actions.
- The position would be highly subject to political influence and dependent on individual relationships, as the role's power would be a function of its proximity to political leadership and other key decision-makers. As such, the staff role would need to be insulated to the extent possible

Example application: NYC's Chief Climate Policy Advisor

Following Hurricane Sandy in October 2012, Mayor Michael Bloomberg created the Special Initiative for Rebuilding and Recovery (SIRR), an interagency task force charged with developing an action plan for advancing resiliency in the city while expediting recovery. This initiative set into motion a robust climate resilience program in the city that, under Mayor Bill DeBlasio, eventually evolved into new City offices and roles that today are comprised of the Mayor's Offices of Sustainability and Resiliency. Both offices are led by senior government officials and overseen by the First Deputy Mayor.

The City also established the Chief Climate Policy Advisor role, which is also under the First Deputy Mayor. Dan Zarrilli, who led the SIRR process and previously led the Mayor's Office of Recovery and Resiliency, currently fills this role. His tenure has spanned two Mayoral administrations exemplifying a degree a political durability. The role is responsible for the OneNYC planning process and implementing these plans. Implementation of the plans happens through coordination with a range of City agencies, such as the Departments of Transportation, Parks, Environmental Protection, City Planning, Design and Construction, and Housing Preservation and Development.

from turnover due to transitions in Mayoral administrations.

- As a centralized authority, this role and office would have potential issues related to democratic representation given its necessary centralized authority. As such, this role must be focused on *execution and enforcement only* of policies and decisions that have been established through transparent processes. In other words, this position will not set policy and direction but carry it out.

4.1.2 Agreements with Property Owners in urgent action areas of Fort Point Channel

Goal: Facilitate alignment of action and enforce consistent adherence to performance-based coastal infrastructure design standards

Agreements with individual or groups of property owners is one of the existing tools available to the City to advance project delivery, particularly along Fort Point Channel, over the next six to nine months. This approach builds on the preliminary success of the emerging partnerships between the City and private property owners along Fort Point Channel to deliver an integrated flood mitigation system located on private property and funded through a combination of public funds for construction, private investment in design, private donation of easements, and long term maintenance agreements. Partnerships such as this need to be formalized in order to ensure all parties agree on the terms of the partnership and that the respective contributions of each party are clear and enforceable.

The recommendation for agreements with property owners assumes any potential regulatory and governance tools that could be used to mandate flood mitigation elevations and certain design standards are likely to take longer than 24 months to implement. It further assumes that even if certain tools could be implemented sooner, they may not advance quickly enough to ensure work that is ongoing or about to be commenced is in alignment with the City's plans.

Coastal Mitigation Performance-based Design Standards

Performance standards provide the expected results and function of a coastal flood risk mitigation strategy for use by engineers and designers. Written performance standards help communicate the expected parameters of a design and provide consistency of application across a district, even when multiple and diverse parties are involved in the design process. Coastal mitigation performance standards for the Seaport District might include:

- Required minimum design elevations
- Preferred alignment for flood mitigation
- Requirements for unbroken structural integrity and integration of design across properties (also known as tie-ins)
- Criteria or stipulations for public amenities, such as recreation and open space or waterfront access (i.e., project co-benefits)
- Specific technical requirements (such as those necessary to obtain FEMA certification, for example)
- Operations & maintenance standards
- Roles and responsibilities
- Provisions for adaptation to accommodate increased risk / new risk data over time

In this context, a near-term approach relying on individual property owner agreements may be the surest way to confirm that district-scale flood mitigation investments happening today adhere to a common set of standards and align with a common vision for the long-term planned coastal mitigation. Additional elements included in the agreements could include project delivery timelines, cost share arrangements, and roles and responsibilities related to design, construction, and operations and maintenance.

As a prerequisite to this recommendation, the City would need to establish performance criteria for coastal flood mitigation and co-benefits (such as recreational space or waterfront access), a task which is described in greater detail in Section 4.2.2. Then, the City would sign individual legal agreements or memorandums of understanding (MOUs) with each urgent action site property owner to ensure criteria are met in a consistent manner and that the coastal mitigation structures are integrated across properties to provide comprehensive district-level mitigation.

Such agreements are likely to require the City to offer a carrot (or stick) of some kind. An example carrot could be funding for design or feasibility analyses necessary to further refine existing concept designs. An example justification for the use of public funding in this capacity would be the benefits of mitigation that would accrue to inland residents and businesses, as well as public infrastructure. The support offered by several Fort Point Channel property owners in 2018 regarding the need for and willingness to participate in district-level flood mitigation may provide a basis for initiating additional negotiations beyond those already underway for Fort Point Channel.

The proposed Climate Resilience Cabinet Chief would play a key role in managing the process of establishing agreements across the district and city, but this approach could also potentially move forward under existing staffing capacity.

Example application: Memorandum of Agreement for 100 Acre Master Plan Implementation

The 100 Acre Master Plan area is located along a section of Fort Point Channel in the Seaport District and is regulated, in part, through a Planned Development Area (PDA 69) by the Boston Planning and Development Agency. A number of private property owners control land in the master plan area and, as redevelopment occurs, are responsible for building out the district according to the requirements of the PDA. The Master Plan outlines a new open space network and public realm. Construction of this network requires delivery of a phased series of projects across multiple properties that will over time combine to form a cohesive infrastructure network and public realm comprised of streets, parks, and plazas.

In order to manage the funding and roles and responsibilities necessary for implementation of the open space network, in 2007 the City (Boston Redevelopment Authority) entered into a Memorandum of Agreement (MoA) with the property owners in the master plan area to address the allocation of responsibility for funding the construction and long-term maintenance of public realm enhancements in the area. Funding shares are divided across the property owners using a Fair Share Formula for both construction and maintenance based on the ratio of permitted full build-out density included in the PDA. A sinking fund is used to hold funds until such time that a project is constructed.

4.1.3 Engagement with Massport and tenants along the urgent action area at Seaport Boulevard

Goal: Ensure continued and coordinated planning for the refinement and ultimate implementation of coastal flood mitigation solutions along Seaport Boulevard and other flood pathways that originate through Massport property

Massport owns or otherwise controls the property in the urgent action area along Seaport Boulevard, including the right-of-way (roadway and sidewalks), as well as longer term flood pathways around the Marine Industrial Park and Reserved Channel. Development actions on Massport-owned property are not subject to local regulations, including local zoning or the Article 80 Development Review process. Nevertheless, Massport typically coordinates with the City and developers. During engagement for this Project, the City and Massport both expressed a willingness and desire to open a line of ongoing communication so that both parties can share information and collaboratively define a path toward implementation.

Massport is currently mitigating coastal flood risk on its properties through an asset-based approach, implementing flood protection improvements at the site- or building-scale. A primary driver of this approach to-date has been that both Massport and its tenants have infrastructural and access needs unique to maritime and water-dependent operations. This is especially true for businesses that rely on vessel berthing and ship-to-shore connections on Fish and Commonwealth Piers. District-scale flood protection strategies require careful study and development to be calibrated to the operational demands of water-dependent uses. For this reason, the conceptual coastal resilience strategies proposed through *Coastal Resilience Strategies for South Boston* will require additional planning and design refinement in order to meet Massport's needs while effectively reducing risk to inland areas exposed to flood pathways that originate through Massport property.

As such, starting immediately, close and ongoing collaboration between the City and Massport will be necessary to advance coastal resilience planning along Seaport Boulevard and ensure both the City and Massport are fully aware of their respective perspectives, performance criteria, and plans for investment.

This engagement process with Massport should include the following actions:

- As suggested in *Coastal Resilience Strategies for South Boston*, the City should initiate and lead a joint planning process with Massport to refine preliminary conceptual solutions proposed for Seaport Boulevard, as well as other flood pathways citywide that may originate through Massport properties. In conjunction with this effort, Massport should work to define its performance criteria for district-scale flood protection and how these criteria vary across its holdings portfolio in order to inform the joint planning process and eventual selection of coastal resilience approaches, alignments, and designs.
- To address concerns voiced by Massport, its tenants, and other property owners in the Seaport District regarding the need to address climate risks to utilities, the City should establish the Infrastructure Coordination Committee as recommended in *Climate Ready Boston.*
- Ultimately, the City and Massport should work together to mutually agree to plans for implementing district-scale flood mitigation that achieve the goals of both entities, which could be codified through a Memorandum of Understanding.

This engagement process will need to begin early and take place often in order to develop a clear implementation plan and mitigate risk along and inland from Seaport Boulevard by 2025. The new Cabinet Chief and office could play a key role in leading and coordinating this engagement in the near-term, or such engagement could be administered by existing City staff.

4.1.4 Engagement with MBTA around near-term actions at the base of Fort Point Channel

Goal: Ensure continued and coordinated planning for the refinement and ultimate implementation of coastal flood mitigation solutions at the southern end of Fort Point Channel

Similar to Massport's ownership of property and the right of way along Seaport Boulevard, the Massachusetts Bay Transit Authority (MBTA) owns a significant segment of the shoreline at the southern end of Fort Point Channel. This area, Cabot Yards, is used as a storage, staging, and maintenance facility for MBTA subway cars. If coastal flood risk mitigation measures are not implemented along Cabot Yards, with tie-ins to adjacent properties, the area will eventually provide a flood pathway from Fort Point Channel into a large section of the South End. It is therefore critical that appropriate resilience solutions be developed for this area – not only to protect the MBTA's assets, but Boston communities lying further inland.

Like Massport, the MBTA is not subject to local zoning regulations, though they may voluntarily choose to comply with applicable land-use controls. Nevertheless, the ability of the City to regulate and/or prompt MBTA action is limited and so, as described in the previous section, ongoing collaboration will be necessary in order to advance necessary flood mitigation investments and to ensure that such actions are in alignment with broader district plans. The goals for such engagement include:

- Ensuring alignment of objectives with regard to performance-based design criteria, the role of the area in broader district resilience, tie-ins to adjacent mid-and long-term solutions, as well as timeframe for implementation of coastal resilience improvements
- Mutual understanding of expectations related to funding and governance of each stage gate of project implementation, including the long-term operations and maintenance of coastal resilience infrastructure in the area
- Appropriate next steps on the path toward implementation, which could be codified through a Memorandum of Understanding

As with Massport, this engagement process will need to begin early and take place often in order to develop a clear implementation plan. The new Cabinet Chief position could play a key role in leading and coordinating this engagement in the near-term, or such engagement could be administered by existing City staff.

4.2 Regulatory recommendations today through 2023

4.2.1 Adopt and publicize the plans

Goal: Generate broader awareness of and adherence to the City's neighborhood coastal resilience plans

Despite the planning and promotional efforts around *Coastal Resilience Solutions for South Boston*, some property owners along Fort Point Channel expressed uncertainty about the City's plan for flood mitigation. Some property owners articulated that, although the City has published the report, alignment and target elevations have not been officially codified. They suggested that the publication of a plan is not the same as adopting or codifying the plan. This appeared to affect their perception of and preparedness for how they might contribute toward implementation of the plans.

Based on this feedback, which was corroborated by the Green Ribbon Commission, a productive step for the City would be to formalize the concepts recommended though the *Climate Ready Boston* neighborhood plans and to proactively publicize them through ongoing City outreach and engagement. Formalization of the resilience concepts could take several forms ranging in procedural complexity. A relatively straightforward approach would be to formally adopt the plans through a vote by the City Council or BPDA board. In this case, the adopted plans would then guide application of the recommendations, particularly intended design elevations, alignments, and tie-ins across adjacent properties through an existing regulatory process, such as Article 80 (as described in more detail in **Section 4.2.2**). This approach would rely heavily on City staff to ensure compliance when project proponents approach the City.

A more thorough approach would be to further integrate the coastal resilience concepts, along with associated performance standards, into the City's codes and standards. This would provide a readily accessible, predictable, and enforceable mechanism to ensure the City's plans are achieved, particularly when resilience infrastructure is built on private property.

Example application: Imagine Boston 2030

Released in summer 2017, Imagine Boston 2030 represented a significant milestone in Boston's planning history as the first citywide plan in 50 years. The plan was comprehensive in scope, building on a robust outreach and engagement process. The plan's goals spanned multiple sectors and policy areas, from encouraging affordable housing, to driving inclusive economic growth, to pursuing investments in transportation, open space, arts and culture, and other infrastructure.

Responsibility for the plan spans a wide array of City departments and functions, as well as a range of other stakeholders. Not unlike Climate Ready Boston plans, Imagine Boston outlined specific goals and implementation timelines, as well as departmental leads and associated steps. One element of the implementation process included adoption by the BPDA board. While the plan was publicized widely upon its release and has broad support across the city, adoption by the BPDA board provides confirmation that the plan's objectives will influence decision making by the board, particularly around new development projects. This confirmation helps promote and advance the plan's recommendations for land-use planning and growth in a way that provides greater certainty to the public and other stakeholders, including private real estate developers.

4.2.2 Use existing policy vehicles to guide and enforce plan implementation

Goal: Coordinated and consistent use of existing policy and regulatory levers can help ensure individual coastal resilience projects on private sites adhere with intended alignment, design elevation, and tie-in integration

A part of the Project, the team analyzed the extent to which existing regulatory tools or levers within the City of Boston's control or discretion might have material influence over the implementation of near-term coastal resilience in the Seaport District. While some stakeholders have called for wholesale reform to better align federal, state, and local environmental and land-use regulations with the types of investments that will be needed to help communities adapt to climate change, such reforms will demand a complex and time-intensive process, and there are many political, social, and environmental uncertainties at play. As such, this analysis aimed to identify opportunities for the City to use existing regulations to guide and enforce implementation of near-term coastal flood mitigation infrastructure, with particular focus on flood mitigation design elevation, alignment, and cross-property connections (tie-ins).[16]

One additional important distinction to make regarding the recommendations included here is that near-term projects, with limited exceptions, do not require significant in-water fill to accomplish their flood mitigation objectives. **Section 5.4 Track 2 Regulatory Recommendations** describes regulatory challenges where significant fill may be necessary for mid- and long-term solutions.

Table 8 summarizes the results of the Project team's analysis, including how each regulation or tool either supports or might support implementation of strategies that span multiple property owners and, therefore, contribute to district-scale mitigation.[17]

Our analysis, as summarized in Table 8, indicates that there are opportunities for the City to use existing regulatory processes and tools to document and enforce district-scale flood mitigation investments. An approach based on existing regulatory tools is likely to guide and control implementation through City approvals on a property-by-property basis. This mirrors the way that such investment is currently happening in the Seaport District, especially along Fort Point Channel, where individual property owners are working with the City and with each other through Article 80 and other processes to arrive at the appropriate coordinated coastal flood mitigation designs. Ongoing application of existing regulations in this way can be used to ensure that new investments in the Seaport District and elsewhere are made in coordination with the district-level plans.

This approach is unlikely to maintain the schedule momentum needed to implement district level strategies in areas where active development investment is not currently taking place.

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[16] The Project team is grateful to a group of expert reviewers who provided preliminary input on an early draft of the regulatory analysis and recommendations included in this report.

[17] Regulations evaluated for this study are not exhaustive of all those applying to coastal resilience infrastructure. Additional regulations that may apply depending on the scope and location of the specific project include: Army Corps Section 404 and Section 10 permits, Massachusetts Environmental Protection Act, Massachusetts Coastal Zone Management Consistency Review and Designated Port Area regulations, State Harbor Lines, Local and State Historic/Landmark Designations

Table 8 Strengths, weaknesses, and opportunities within existing and developing key policy mechanisms to support implementation of district-scale coastal resilience strategies

Policy vehicle	Strengths	Weaknesses	Opportunities
City of Boston Local Wetlands Ordinance and State of Massachusetts 310 CMR 10.00 (Wetlands regulations)	• Includes provisions to encourage climate change adaptation through district-scale flood mitigation • Explicitly addresses potential conflicts between wetland resource protection and flood mitigation solutions, including enabling use of fill under specific circumstances	• Details on regulations, including performance standards, are not currently available • Applicable only to properties requiring a wetlands permit, thus requiring a site-by-site approach • Depending on forthcoming regulations and performance standards may inhibit certain types of flood protection solutions that do not meet criteria used by the Conservation Commission • Local ordinance not compulsory for State entities	• Forthcoming guidelines, performance standards, and regulations could be written to help expedite projects planned through *Climate Ready Boston* • Potential near-term enforcement vehicle for mandating design elevations and tie-in coordination on a site-by-site basis through conditions placed on permit
Boston Planning and Development Agency, Coastal Flood Resilience Design Guidelines	• Promotes best-practices for building-scale flood resilience • Promotes public awareness of flood risk and mitigation options	• Voluntary • Is not intended to provide detailed options or performance standards for coastal mitigation	• Potential to add to or create a similar document with detailed design and performance standards for district-scale flood mitigation • Such design and performance standards could be enforced through other regulations described here
Boston Planning and Development Agency, Flood Resilience Zoning Overlay (in process)	• Potential regulatory authority for defining performance-based design criteria and tie-in requirements	• In progress. Details unknown at this time • Will not apply to existing development, unless substantial renovation is proposed	• Potential to require implementation of district-scale mitigation with new development and substantial improvements through zoning
Climate Resilient Design Standards and Guidelines for Protection of Public Rights of Way	• Provides guidance and design considerations for coastal flood mitigation projects in public right of way • Focuses on projects with potential for district-scale flood mitigation benefits	• Voluntary • Guidance applies to City-led projects (though could be used by private property owners) • Does not refer to elevations, alignments, and other criteria presented through *Climate Ready Boston* process	• Creates a foundation for expanded design guidelines and performance standards applying to private properties and referring the *Climate Ready Boston* flood mitigation concepts

Policy vehicle	Strengths	Weaknesses	Opportunities
Boston Planning and Development Agency, Article 80 Development Review and Article 37 Green Building and Climate Resiliency Policy and Checklist	• Established development review process • Enforceable mechanism for advancing coastal resilience • Creates requirement for consideration of climate change and adaption through development approvals process	• Non-Prescriptive; requires consideration of resilience, but does not provide standards or design criteria • Applies only to new development subject to certain types of Article 80 review • Relies on a site-by-site approach	• Potential to advance and enforce district-scale strategies in the near-term site-by-site if coastal mitigation plans and performance standards are established
State of Massachusetts 310 CMR 9.00 (Chapter 91 regulations) and 301 CMR 23 (Municipal Harbor Planning)	• Established regulatory process	• Base regulations do not incorporate best available climate projection data • Policy objectives may be interpreted as conflicting with coastal resilience solutions in some cases • Relies on site-by-site approval process • Applies only to properties within Chapter 91 jurisdiction	• Municipal Harbor Planning (MHP) (301 CMR 23) provides vehicle for localities to amend base Chapter 91 regulations • MHP could include or refer to climate projections, target elevations, tie-in specs, etc. and requirements for district investments • Chapter 91 enforcement power may incent property owner action (as discussed in greater detail under Track 2)

The following recommendations are intended to maximize the effectiveness of existing policy vehicles in supporting district plan implementation in the near-term:

- **Formally adopt coastal mitigation plans** (see **Section 4.2.1 Adopt and publicize the plan**)

- **Adopt performance-based design standards**. Performance-based design standards would predictably guide investment at the site scale across the district. Such performance standards could be flexible enough to enable project proponents to integrate investments into their site plans but need to include target standards for the items described in **Section 4.1.2. Agreements with Property Owners in urgent action areas of Fort Point Channel**

    - **This action could be taken by expanding the City of Boston Department of Public Works' Climate Resilient Design Standards and Guidelines for Protection of Public Rights of Way and applying them to both public and private properties where coastal flood mitigation is planned**. The Design Standards and Guidelines are a good first step in the development of citywide performance standards for coastal flood resilience. The document provides detailed information regarding design and permitting considerations, costs, and steps involved in delivering flood mitigation on properties owned by the City. A new set of standards, building on this document, could be expanded to include the district-specific design elevations and alignments recommended through the *Climate Ready Boston* district plans, guidance on the incorporation of co-benefits, and direction as to the ways in which sections of the flood mitigation system should tie into each other. In addition, the standards should apply to both public and private properties where coastal flood mitigation is planned.

- **Leverage existing regulatory processes to enforce performance-based design standards.** With comprehensive performance and design standards in place, it would be feasible to employ several regulatory processes currently applied in the city to guide and enforce adherence to these standards. In the Seaport District, for example, Article 37 Green Building and Climate Resiliency policy, applied through the Article 80 Development Review process, could be employed by City officials to guide and control application of the guidelines through a site-by-site approach to how and where coastal mitigation infrastructure is built. Over time, such a site-by-site approach could help realize a complete district-scale coastal mitigation strategy in targeted areas, such as along Fort Point Channel. The Flood Resilience Zoning Overlay is applicable to all areas of the City subject to coastal flooding and may be a viable mechanism, but would need to refer to an external set of Coastal Mitigation Performance Standards that could be tailored to the district or coastal reach level and be updated over time. An important caveat to this approach is that it will only apply to new development or potentially significant renovations, leaving unaddressed the need for district-scale investments on existing properties. This issue will be addressed in greater detail in **Section 5.4 Track 2 Regulatory Recommendations.**

- **Ensure the Flood Resilience Zoning Overlay District under development by the BPDA helps promote and is consistent with plans for district-scale flood risk mitigation**

The BPDA is in the process of developing text for the forthcoming Flood Resilience Zoning Overlay District, which, as we understand it, will enact and promote certain flood risk mitigation measures in the Sea Level Rise-Flood Hazard Area (areas with a projected 1 percent annual chance of flooding with 40 inches of sea level rise) to promote resilient new development and significant retrofits to existing buildings. As this zoning text is under development, we recommend that the BPDA work to ensure provisions guide and are consistent with needs for district-scale flood risk mitigation. This recommendation is further elaborated under section **5.4 Track 2 Regulatory Recommendations.**

- **Seek clarity on if and under what conditions fill may be allowed when not required strictly for flood mitigation**. It is noted that neither Chapter 91 nor the city's Wetlands Ordinance place a categorical restriction on fill when associated with flood control. In the latter case, the ordinance explicitly aims to allow fill when used for climate adaptation. However, the precise circumstances under which such permissions apply are not clear and may not extend to flood control projects that propose in-water fill in order to provide nature-based solutions designed to amplify flood mitigation with co-benefits, such as improved habitat and/or public amenities, as proposed through the Resilient Harbor Vision. Property owners engaged through this Project indicated that they would avoid proposing in-water fill as part of any flood mitigation project due to the potential regulatory hurdles, which may not be a concern in the near-term in the Seaport District but could create significant challenges in the longer-term or in other parts of the city. Therefore, starting immediately, regulators at the State and Local level should work to clarify if and under what conditions fill may be allowed when not required strictly for flood mitigation. This could begin with the as-yet undrafted regulations that will pertain to the city's Wetland Ordinance. Likewise, the City could lead or partner with a private project proponent to test and help define the current bounds of environmental permit-ability by submitting a pilot project or undertaking a table-top planning exercise with the State Department of Environmental Protection. The pilot or table-top exercise should present a case project that uses fill to support flood protection while offering additional co-benefits.

Additional Regulatory Considerations

As described above, existing City and State regulations, for the most part, are not expected to hinder investment in district-scale coastal mitigation in the near-term (as conceptually planned in *Coastal Resilience Solutions for South Boston*) and may support investment in some cases if employed as recommended above. Nevertheless, although there are opportunities to advance implementation of coastal flood risk mitigation through each of the regulatory tools examined here, none of them – nor all of them collectively – are sufficiently well-positioned to actively push investment forward at the pace and scale needed to address increasing risk due to the following reasons:

- No existing regulatory mechanism currently directly addresses the need for tie-ins and coordination of design at property lines
- Existing regulatory mechanisms that could become more effective with the establishment of performance-based design criteria are either discretionary or would only be triggered by specific project types

- All mechanisms are reactive in the sense that a project must be voluntarily initiated in order to be triggered (with the possible exception of existing Chapter 91 licenses as described in **Section 5.4**)
- Regulations apply only to new development or substantial improvements, not existing development (again, with the possible exception of existing Chapter 91 licenses as described in **Section 5.4**)
- As it pursues projects, the City will need to decide if it will seek to certify the levees to FEMA standards. FEMA certification has benefits in reducing mapped floodplain area but requires certain design standards and operations and maintenance protocols, as outlined in the text box to the right.

Therefore, the City may need to begin working with partners, particularly the State Department of Environmental Protection, to develop a comprehensive regulatory approach that can help drive investment in district-scale flood mitigation over the coming decades. As elaborated upon further under **Section 5.4**, the work currently underway to develop the City's Flood Resilience Zoning Overlay District represents a key opportunity to develop a citywide regulatory tool to help coordinate and guide district-scale investment, at least for properties undergoing new development. As work on this new zoning overlay is ongoing, we recommend that the City carefully consider how the zoning might incorporate and codify elements of the recommended coastal protection performance standards outlined in **Section 4.1.2 Agreements with Property Owners in urgent action areas of Fort Point Channel**.

FEMA Levee Certification

Design Requirements:

Must be designed to the 1% annual chance flood with wave action plus +1' or Base Flood Elevation (BFE) + max wave runup, whichever is greater, no less than BFE + 2'

Design must provide:

- Embankment protection (against erosion)
- Appropriate / sound design of closures
- Embankment and foundation stability
- Settlement mitigation
- Interior drainage requirements

Design must be certified by a structural engineer

Operation & Maintenance:
Operations and maintenance must be in accordance with official manual and must be under the oversight of an approved public entity: a Federal or State agency, an agency created by Federal or State law, or an agency of a community participating in the NFIP

Implications:

- Can lead to a Letter of Map Revision, thus removing mortgage requirement for insurance
- Reduces National Flood Insurance Program premium to preferred risk policy ratings
- FEMA certification is likely not required for private flood insurance premium reduction, but private certification of levees has similar standards

4.3 Funding recommendations now through 2023

In recent years, the City has sought to maximize use of existing funding streams, including philanthropic, private, local, state, and federal sources, to plan for and deliver high priority flood resilience projects. Key examples include the Resilient Fort Point Channel Infrastructure Project, the incorporation of resilience measures into the design of Martin's Park, vocalized commitments by private property owners along some segments of Fort Point Channel and Seaport Boulevard, and the Mayor's commitment of 10

percent of the City's capital budget to climate resilience projects. This opportunistic approach appears to be effective and reliable to fund urgent action projects, at least along Fort Point Channel.

Nevertheless, as the funding summary outlined in **Section 2** Project study area notes, project costs for Fort Point Channel are relatively modest in 2019, 2020, and 2021, but start to escalate rapidly starting in 2022 and 2023. Additionally, Seaport Boulevard project implementation is still uncertain as additional planning is needed in coordination with Massport. Thus, while the costs of very near-term projects along Fort Point Channel (next 1-3 years) can be organized on an opportunistic and ad hoc basis, the City will need a much more formalized system for funding and managing projects more broadly. Track 1 (below) provides recommendations for using existing funding avenues most effectively, while Track 2 (**Section 5.5 Track 2 funding and cost share considerations**) describes how the City might create new and compile existing funding sources to fund greater and longer-term needs.

4.3.1 Clarify Near-Term View on Public/Private Cost Share

Goal: Clarification of City expectations for property owner investment in district-scale resilience investments will provide a basis for moving forward and facilitating collective planning

Funding solutions will need to evolve over time as more projects are implemented, but in the near-term the City will need to maximize the utility of limited public funds to drive investment by all implementation-capable actors. Certainty and clarity around the ask will move this conversation and action forward. The City must set clear expectations as to which elements of the project delivery cycle the City intends to fund and which it anticipates the private sector and other public stakeholders will need to fund, and to what extent.

Waterfront property owners and tenants engaged through this Project consistently shared the following feedback related to cost share:

- Clarity is needed regarding expected public and private cost shares to deliver flood mitigation infrastructure; property owners in the private sector in the Seaport District appear to be open to the need for private investment and willing to make those investments but require clear parameters and expectations from the City
- Funding approaches should be both fair and equitable: fair in the sense that all benefitting parties should contribute something to the process, and equitable in the sense that there should be consideration of ability to pay
- A collective, district-wide solution to funding is preferable to a site-by-site approach in the long-term; a district-wide approach would be more likely to be transparent, fair, and equitable
- Some property owners particularly expressed concerns that site specific (property by property) negotiations around cost share and other expected contributions (such as easements) could lead to inequities and a lack of fairness due to expected variation in negotiating power
- Building on this, and perhaps to mitigate this concern, there must be clarity that any contributions made now will be considered and factored into any long-term cost sharing mechanism. Private actors will be less willing to contribute funds, now, if they fear that their contributions will be doubled upon the setting of a longer-term cost share approach

In the near-term, an effective cost share approach might involve the City sharing costs for engineering feasibility analysis and preliminary design to further refine the cost estimates and alignments developed through *Coastal Resilience Solutions for South Boston*, with construction also funded by a combination of public and private sources. The feasibility and design work could proceed without having completely worked out the funding formulas for construction and operations and maintenance. If FEMA certification is a goal, operations and maintenance would need to be managed by the City but could be funded through a district assessment model. A possible resource for defining cost share expectations is presented in **Section 5.5 Track 2 funding and cost share considerations.**

4.3.2 Leverage Range of Public and Private Funding Sources

Goal: Making continued strategic use of existing sources will enable progress on project delivery until additional funding sources are identified

The City has made good progress in advancing delivery of priority coastal mitigation projects using the available sources of funds, including FEMA Pre-Disaster Mitigation grants, State Municipal Vulnerability Preparedness Action Grants, and City capital budget allocations. Without a federal disaster declaration, the availability of federal funding is likely to remain limited, unless the City can advance action by the United States Army Corps of Engineers, which would likely be several years out.

Example City Actions To-Date

Examples of City action that could serve as precedents for roles the City could take in the near-term to advance coastal resilience projects:

- Analysis of citywide climate vulnerabilities and development of conceptual district-scale flood mitigation plans through *Climate Ready Boston* (funded by state grants, City and private foundations)
- Development of *Resilient Boston Harbor* vision (Funded by City, focus on public open space - both City and State)
- Investment in near-term deployable flood mitigation for East Boston Greenway (public parkland, funded by City)
- Investment in road elevation in Charlestown (public roadway, funded by City)
- Application to FEMA for Pre-Disaster Mitigation grant funding for investment along Fort Point Channel (City and Federal Funds, private land donation)
- Grant to Boston Children's Museum for feasibility study (funded by grant from City, non-profit property)
- Martin's Park resilience measures (City parkland, funded by City)
- Moakley Park resilience design (City and state parkland, funded by City)

By leveraging the available federal and state grant funds with other public funds to help unlock private investments by property owners, the City will likely be able to continue making incremental progress on project delivery. This approach will be most effective when paired with private contributions, as with the Resilient Fort Point Channel Infrastructure Project, where private property owners have donated property easements for the berm's footprint, have been funding design actions, and are willing to play a role in the operations and maintenance of the infrastructure. The City meanwhile, has contributed by seeking FEMA funds to pay for the construction of the berm and will be also contributing local funds from the capital

budget, as needed. A similar combined funding approach is emerging elsewhere on Fort Point Channel at the Boston Children's Museum, which is currently undertaking a feasibility and preliminary design study for a waterfront master plan that will incorporate flood mitigation elements. The study is partially funded by a grant from the City and will ideally result in a more refined plan that can tie into district-scale flood mitigation. The City could further accelerate a project such as this by continuing to apply for Federal and State grants on an annual basis to advance project design and construction.

Track 1 recommends the following funding-related actions:

- Annual submittal to FEMA's Flood Mitigation Assistance Program
- Annual submittal to FEMA's Building Resilience Infrastructure and Communities program (which is replacing the Pre-disaster Mitigation Program in 2020 and is better positioned to fund projects such as those envisioned by the City of Boston)
- Annual submittal to State Municipal Vulnerability Preparedness Action Grant Program
- Advocate to State and Federal legislators and agencies regarding Boston's adaptation needs
- Review of project designs in the Capital Improvements Program for the following:
    - Conformity to resilience performance-based design criteria (see Section 4.1.2)
    - Opportunities to refine or adjust projects to better align with *Coastal Resilience Solutions for South Boston*
- Creation of the Infrastructure Coordination Committee recommended by *Climate Ready Boston* to identify opportunities for fund-source leveraging across infrastructure entities, as well as opportunities for refinement of existing planned projects toward coastal resilience goals. This may also help advance the recommendations in Section 4.1.3 above

4.4 Sequence of actions to advance Track 1 recommendations

While the actions recommended under Track 1 may happen in a number of sequences and will have overlapping timelines in terms of their applicability, the chart below provides a summary of the recommended sequence along with ongoing parallel processes to support flood risk mitigation project delivery over the next three years.

Figure 21 Summary and sequence of actions needed to advance Track 1 recommendation

Highlight on Federal Post-Disaster Funding

Post-disaster recovery can be a chaotic time for any community. There is the ongoing pressure to make forward progress, the task of coordinating simultaneous relief, rehabilitation, and reconstruction projects, coordinating with multiple institutions that may operate according to different agendas, and the cacophony of political, public, and institutional voices calling for funds and initiatives. In order to maximize the effectiveness of federal disaster funds, Boston must fully coordinate available assistance and funding in alignment with existing community goals and priorities, using the disaster recovery process as the catalyst while honoring the need for changes that may have been made evident through the disaster. Communities that have not clarified post-disaster plans or adopted clear strategies to leverage funding post-disaster often struggle to slow down, plan properly, and ultimately speed recovery; the political climate may simply not allow for it.

Disasters bring with them not only tremendous damage and destruction, but also significant opportunity cost. As such, it would be beneficial for the City to contemplate the following proactive steps to ensure maximum funding and align expenditures toward the achievement of the City's resilience goals:

- Contemplate the development of SOPs or an on-call contract in order to conduct rapid damage assessments that may be leveraged toward the disaster declaration and recovery funding in the event of a major coastal storm or flood event
- Maintain maintenance and operations records for all infrastructure in order to establish pre-storm conditions for funding applications
- Maintain a purchase order and time-keeping system that can be flagged for time spent responding to and recovering from a major event in order to maximize reimbursement for eligible costs
- Familiarize key City and public infrastructure stakeholders with eligibility criteria for the FEMA Public Assistance program, particularly as it relates to 406 Mitigation and Alternate Procedures in order to maximize the City's capacity to self-advocate and fund mitigation projects in alignment with *Climate Ready Boston*
- Develop fliers and materials that can be distributed to non-profits that might support recovery so that their actions are aligned with City plans and policy
- Maintain communications to support the development of HUD Community Development Block Grant – Disaster Recovery State Action Plans, which will guide expenditures through that program
- Investigate the value of completing a post-disaster redevelopment plan and / or developing a plan to guide recovery. See, for example, the State of Florida developed a guide and pilots of Post-disaster Recovery Planning in 2010: *www.floridadisaster.org/globalassets/importedpdfs/post-disaster-redevelopment-planning-guidebook-lo.pdf*

Example post-disaster funding:

FEMA Individual Assistance and Small Business Administration grants and loans to support individuals and business recovery

FEMA Public Assistance and 406 Mitigation to support the recovery and risk mitigation of damaged public facilities and infrastructure

FEMA Hazard Mitigation Grant Program funds to support risk mitigation to undamaged public facilities and infrastructure

HUD Community Development Block Grants – Disaster Recovery to fill unmet resilience needs within presidentially declared areas

In recent years, HUD has also made use of billion-dollar competitions in disaster affected areas to support implementation of major resilience projects (e.g., Rebuild by Design and the National Disaster Resilience Competition), and in 2019 Congress and HUD allocated $18 billion dollars in hazard mitigation money to areas with recent disaster declarations.

5 RECOMMENDATIONS TRACK 2 – ACTIONS NEEDED TODAY THROUGH 2030 AND BEYOND

5.1 The case for transformative approaches to implementation

While the actions described in **Section 4 Recommendations Track 1 – Actions needed today though 2023** can help expedite urgent action project delivery along Fort Point Channel and Seaport Boulevard in South Boston, these approaches will need to evolve into new approaches with the capacity to raise and distribute the funds necessary to build, manage, and operate a network of flood risk mitigation investments across the district or city. This scale of investment is likely to require a combination of new and existing revenue sources that will need to be assembled and managed. The mid- and long-term need for capital investment will not be feasible on a site-by-site basis alone, and existing governance structures may not support coordinating action and cross-property project maintenance at the district or citywide scale within the timeframes needed.

Figure 22 illustrates this point through a hypothetical financing scenario for all projects proposed for South Boston in *Coastal Resilience Solutions for South Boston*. Using the capital expenditure schedule in Figure 7, we projected out bond amounts and payments if the City were to issue bonds for capital and maintenance costs needed for the next five years every five years at a rate of 2.5 percent over a 30-year period. The initial bond to cover costs from 2020 through 2024 would be $28 to $42 million and yield a low annual payment of $1.3 to $2 million. The City may hypothetically be able to support these costs, even if 100 percent of the cost were bonded, using the Mayor's existing capital pledge toward resilience improvements as the mechanism for repayment. This number jumps dramatically in 2024 to a $132 to $200 million bond to cover the next five years of expenditures for coastal flood protection infrastructure recommendations from *Coastal Resilience Solutions for South Boston* alone.

Annual payments grow six to seven-fold at that juncture, to peek in 2049 at $30 to $46 million with no escalation and depending on ultimate project design. It becomes difficult to imagine taking the Track 1 approach (site-by-site and opportunistic) to funding or even financing capital expenditures beyond 2023, except perhaps along Fort Point Channel, particularly when one considers that the City of Boston is also looking to fund coastal resilience infrastructure in Downtown and North End, East Boston, Charlestown, and Dorchester, not including stormwater improvements, home and critical facility retrofits, and additional layers of defense to mitigate risk from coastal flooding (such as through elevation of roadways, hardening of subway entryways, other infrastructure and utility improvements, and more).

Based on necessary capital expenditures alone, the process to define and establish a formalized implementation framework for coastal resilience infrastructure should begin presently. Without a framework to fund, govern, and manage the capital construction and long term maintenance and adaptation of coastal resilience infrastructure, the City and its constituents may be forced to prioritize a limited pool of resources and attention, as well as lose opportunities to leverage and coordinate funding and capital improvements toward a common mission, possibly leading to unmitigated risk and inequitable outcomes in the mid to long-term.

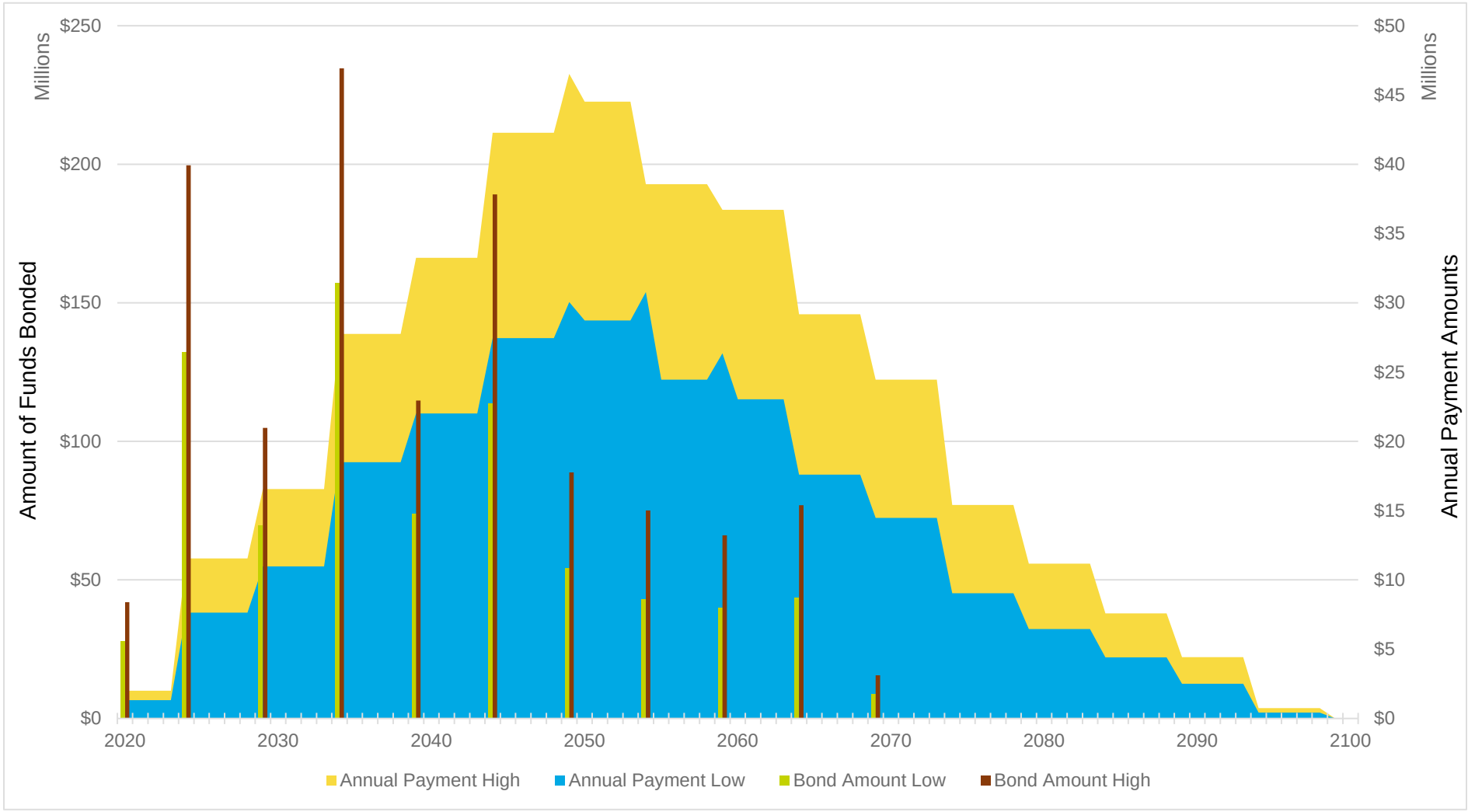

Figure 22 Illustration of 5 year rolling bond amounts and annual payments

The City is already acutely aware of the need for formal governance approaches to manage and fund coastal resilience infrastructure. For example, as part of his 2019 legislative package, the Mayor proposed creation of the Commission for a Climate Ready Commonwealth, which if established, would be a "regional commission to determine which entity should lead major coastal and inland resiliency projects, how such projects might be funded and how those projects should be prioritized."[18] If established, we hope this Project and other reports cited in the bibliography can help inform and support the decision making of the Commission.

In addition, recent studies have evaluated different long-term governance and funding approaches. The most exhaustive review of existing governance, funding, and regulatory models are the reports *Financing Climate Resilience: Mobilizing Resources and Incentives to Protect Boston from Climate Risks* and *Governance for a Changing Climate: Adapting Boston's Built Environment for Increased Flooding* released by the UMASS Boston Sustainable Solutions Lab. Another recent study by the BPDA and Jones Lang LaSalle Americas, Inc. (JLL) in 2019, evaluated a range of existing and potential funding and financing mechanisms for funding planned coastal mitigation along the Border Street Corridor in East Boston. One consistent theme across each of these studies is that all have identified two critical long-term needs: new revenue streams to fund coastal resilience projects and a new or evolved governance structure for delivering and operating district-scale flood mitigation. The studies varied in the exact recommendations for how to address these needs.

This Project builds on the strong foundations laid by the previous studies to further elaborate on two potentially interrelated approaches for accomplishing district-scale flood mitigation funding, governance, and regulation that might help form a path forward along Track 2: the Community-based Public Private Partnership and the District for Resilience Improvements.

This analysis also includes a possible approach for allocating all South Boston project costs for flood mitigation across all beneficiaries of the projects in the neighborhood based on accrued flood mitigation benefit over time. The cost share component could be developed in concert with or separate from governance solutions as new revenue is likely needed regardless of the governance framework that is ultimately selected.

All recommendations herein will require significant political alignment, stakeholder buy-in, and additional analysis and refinement prior to adoption. Nevertheless, there is enough potential benefit to these governance and funding frameworks, as well as alignment with studies to date, to justify further consideration.

[18] 2019 Environment and Transportation Legislative Agenda Announced. Accessed 12/17/2019. https://www.boston.gov/news/2019-environment-and-transportation-legislative-agenda-announced

5.2 Project delivery approach: Community Based Public-Private Partnership

The Community Based Public-Private Partnership (CBP3) is an existing adaptable project delivery mechanism that can nest within or become an arm of other governance frameworks. CBP3s have been used by municipalities to implement and manage stormwater improvements in compliance with the Clean Water Act and related State environmental regulations. The study released by JLL[19] also identified the CBP3 model as a viable approach for delivering district-scale flood mitigation and we concur with this assessment, particularly if used as interim approach in conjunction with other governance options we identified earlier in **Section 4.1 Governance recommendations today through 2023** or as part of a District for Resilience Improvements approach, as described below and depicted in Figure 23.

The CBP3 model, as currently applied, is a partnership between a local government and a private entity to share risk in the delivery and management of infrastructure. While the framework can be operationalized in different ways, the municipality commonly hires a private entity using a performance-based contract. The private entity serves as a master program manager responsible for delivering, operating, and maintaining the infrastructure and associated programs under the oversight of the municipality. In Boston's case, the CBP3 would be responsible for accomplishing performance based-design criteria (see associated recommendation in **Section 4**), and should also adhere to specific efficiency and schedule goals to be established by the City.

The program manager is entitled to fees if it meets identified goals over time. The private program manager may seek financing for the upfront delivery of projects from private capital markets with debt repayment from a dedicated public revenue stream. In the context of stormwater management, stormwater utility fees charged to private property owners based on their contributions to stormwater runoff typically provide the public revenue stream that fund the private investments. The community-based component of the model relates to certain public goals that may be built into the master program management agreement, such as workforce development metrics, local hiring goals, educational and outreach programs, as well as the overall efficiency gains realized through the private project delivery. For more information on how these approaches are applied, see **Appendix A** for case studies describing the Clean Water Partnership in Prince George County, Maryland, as well as the stormwater utility fee funding approach, as applied in Northampton, Massachusetts.

[19] JLL. 2019. *Implementing District-Scale Solutions for the Border Street Area of Easton Boston – Climate Resiliency Financing and Funding Options.*

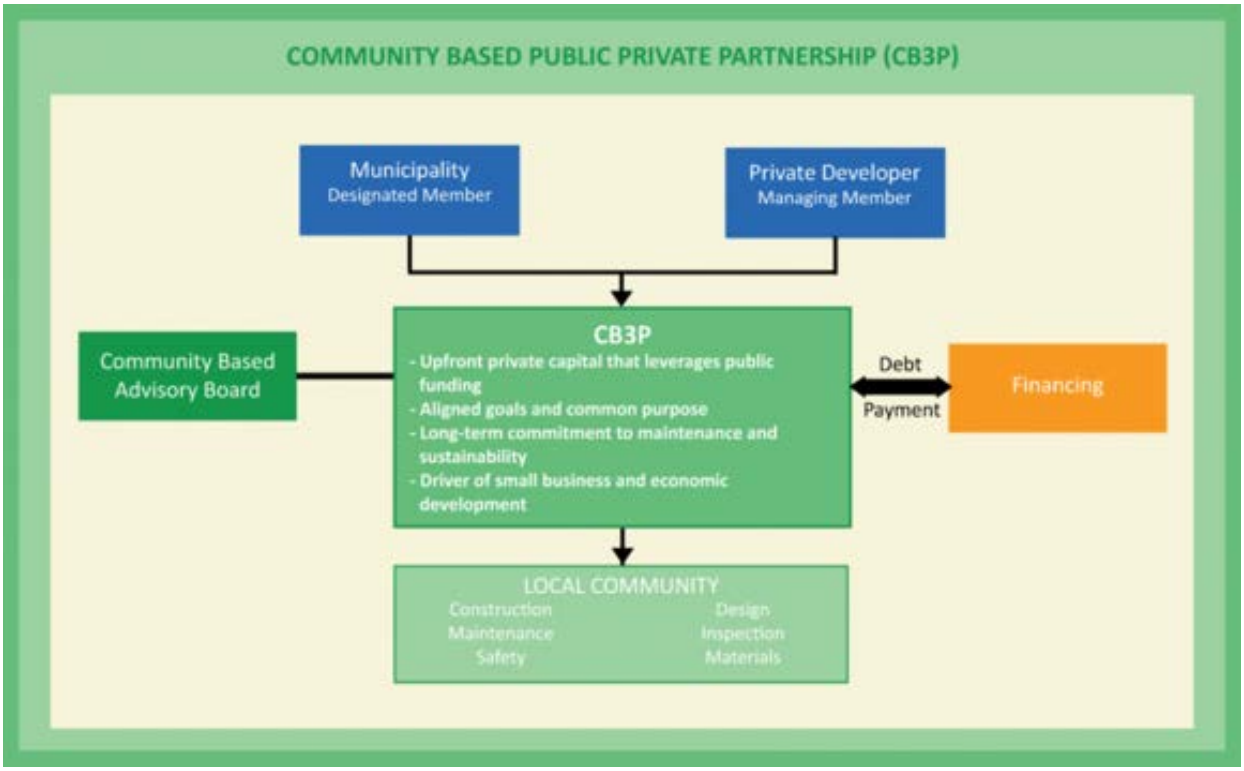

Figure 23 Typical Community-Based Public-Private Partnership Framework (courtesy EPA)

Applied to South Boston for the purposes of coastal flood resilience, the CBP3 model could provide an avenue for expediting project delivery of planned coastal resilience infrastructure while reducing the administrative burden on existing City resources. In the near-to-mid-term, the City would likely remain the primary governance authority in this case, providing planning, analysis, regulatory enforcement, and the funding stream, but would enter into a contract with a private program manager responsible for delivering the planned projects on schedule and budget, and depending on the specific scope of the agreement, could take on responsibilities for long-term operations and maintenance. The agreement would hold the program manager to certain performance metrics related to the accomplishment of coastal resilience objectives, potentially including reductions in modelled flood risk or actual flood damage within an allotted timeframe tied to implementation schedule outlined through *Climate Ready Boston*. In terms of advancing project delivery, the program manager's access to private capital may be more efficient and expedient in raising the necessary funds than financing instruments available to the City, such as General Obligation bonds. JLL's report provides a thorough discussion of how this arrangement might effectively function to the City's benefit based on research performed for *Climate Ready East Boston*.[20] It's conceivable that the City might engage in multiple CBP3 relationships or a single contract to manage implementation citywide, depending on private sector capacity.

Even with the adoption of a CBP3 approach to project delivery and governance in the near- to mid-term, there remain two major issues. First, there is no obvious dedicated revenue stream to cover the scale of

[20] JLL 2019

funding needed over time. Access to favorable public and private financing depends on assurance of debt repayment. While the full faith and credit of the City could be used, creation of a new dedicated source of funds would ensure no net loss of City funds needed for existing services and needs (see **Section 5.5 Track 2 funding and cost share considerations** for more on this). Second, a central authority in the City's governmental structure to manage and provide oversight for a CBP3 program must be identified. While existing City roles may be able to serve this function, the scale of work necessary, even if adopted at the district-scale rather than citywide, would likely require new staff or shuffling of existing responsibilities. Such roles could be tied to evolve from the Cabinet Chief and office recommended in **Section 4.1.1 Establish a new senior level cabinet chief and office focused** on climate resilience implementation with resources and capacity sufficient to support a large portfolio of complex projects and programs **.**

5.3 Governance approach: District for Resilience Improvements (DRI)

The concept that has become known as District for Resilience Improvements (DRI) was first contemplated for application in Boston through the public process and technical analysis that informed *Coastal Resilience Solutions for South Boston*, though not integrated into the final published report. Variations on the same idea were also explored in the UMASS Boston Sustainable Solutions Lab *Financing Climate Preparedness* report, which was informed in part by the South Boston planning process and research, as well as in JLL's study. In addition, the original *Climate Ready Boston* report called for the creation of local climate resilience committees to serve as long-term community partners for climate adaptation.[21]

In concept, the DRI could be structured to resolve all key questions in implementing coastal flood resilience infrastructure outlined in **Section 3.5 Required elements of successful project implementation**. Building on the work of the previous studies, we believe the DRI approach combines elements of previously-studied governance solutions to effectively address the fractured nature of decision-making under existing conditions, establish a clear rational nexus between risk and response, and manage and distribute a variety of funding sources, all while providing a degree of local autonomy and influence in decision-making. Furthermore, it should be noted that the DRI and CBP3 approaches are not mutually exclusive; the CBP3 model could be one project delivery approach used within the DRI framework to advance implementation.

The sections below illustrate how implementation of *Coastal Resilience Solutions for South Boston* might be operationalized within a DRI framework by outlining key considerations in DRI development and potential DRI configurations.

[21] Climate Ready Boston. Pp 101.

5.3.1 Key considerations in DRI development

Possible responsibilities/authorities within the DRI framework

The DRI would be a new governance entity, similar in structure and role to an Authority, responsible to champion and manage a district-wide plan for coastal flood resilience project funding, financing, and implementation. Key functions could include:

- Coordinating property owners
- Taking on debt
- Establishing public-private partnerships
- Pursuing grants
- Procuring contractors and consultants
- Planning capital improvements
- Operating and maintaining the solutions

These functions would need to involve substantial City agency participation, which could be ensured through formal operating agreements between the City and DRI or through City representation on the DRI board, due to the importance of the infrastructure to the health, safety, and welfare of the City of Boston. The primary focus of the DRI would be the provision of coastal flood mitigation infrastructure, but its focus could be extended to consider other resilience or adaptation improvements which may or may not be associated with flood hazards extents, such as stormwater, urban heat island, or resilience-related social, economic, or environmental programs.[22]

There are multiple options for assigning the responsibilities outlined in Table 6 within the DRI framework. These responsibilities may lie variably with the City, State, or a DRI-related entity, such as a city resilience commission overseeing DRIs. Table 9 presents these options, with a proposed approach presented in **Section 5.3.2 Potential DRI configurations.** Depending on its powers, a DRI would require State legislation, thus requiring support of the Governor and State legislature. The Mayor of Boston would need to file a home-rule petition and secure approval by the legislature and the Governor in order to implement the DRI. This can be a challenging and time-consuming process for the City - broad public support from the electorate would be essential to expedite this process. A variety of City departments must also buy-in to the approach, including:

- Mayor
- City Council
- Budget Management Office
- Boston Planning and Development Agency
- Boston Water and Sewer Commission
- Office of Environment, Energy, and Open Space
- Department of Public Works
- Mayor's Office of Resilience and Racial Equity

In addition, substantial private stakeholder support would be necessary, including all or a majority of property owners and community-based organizations in the district, particularly those representing vulnerable communities.

[22] An argument for expanding the scope of the DRI beyond coastal flood protection infrastructure could be the ability to leverage co-benefits into various infrastructure solutions

Table 9 Optional assignment of roles and responsibilities under the DRI model

Category	Subcategory	Options: Responsible Entity	Potential DRI Role
Funding	Collect / generate	• City • State • DRI	The DRI could generate, collect, and distribute funds or be responsible for managing the overall funding process (from generation and collection to distribution) that is administered by another body, such as the City government.
	Distribute	• DRI • City	
	Manage	• DRI	
Planning	DRI master plan development / update	• City • DRI	The DRI could lead and undertake planning itself or serve as a partner or stakeholder in the City's resilience planning efforts.
Analysis	Mapping and application of science	• Federal government • State • City • Regional Authority • DRI (support)	Due to economies of scale in flood risk mapping and analysis, and the need for certain policies to be in effect at a citywide or larger scale, the DRI is unlikely to lead in this category, but would be a vital stakeholder and implementation leader in how flood risk is mapped and evaluated, and how climate science is applied in policy/regulation.
	Risk evaluation	• State • City • Regional Authority • DRI (support)	
Regulatory enforcement	Standards development and enforcement (flood damage prevention, as well as zoning, design review, and building code)	• City • State • DRI	The DRI will not be well-suited to the development and enforcement of standards and permits that require a city or state-wide approach. The DRI could mandate certain performance-based criteria for the projects it manages or maintains, including design elevations and operations and maintenance (O&M) standards. The DRI may apply for or help coordinate applications to City or State permitting authorities and may support enforcement actions.
	Permitting	• City • State • DRI	
Project implementation	Procurement and contract management Financing Staff hiring and firing Monitoring and evaluation Insurance	• City • State • Regional authority • DRI	Project implementation is currently managed across an array of government entities. The potential role and value of the DRI would be to consolidate many of the necessary administrative functions of project implementation for a given geographic area under one body. In order to be viable, this role may need to be carefully configured through the governance structure to enable sustained implementation across potentially varying political regimes but provide some authority over decision-making to elected officials, including the Mayor.
Maintenance and operations	O&M planning Operations (e.g., installation of deployables in advance of storm) Maintenance	• City • State • Regional authority • DRI	The DRI could coordinate O&M planning by setting certain performance standards that must be met in the performance of O&M or, if staffed appropriately, could be responsible for conducting O&M itself.

DRI boundary – Geographic extent considerations

In the near-term, with a clear City focus on coastal flood risk reduction, DRI geographic extents may correlate with future coastal floodplains with the opportunity for (or mandated) periodic re-evaluation based on actual progression of sea level rise, as well as evolving time horizons of interest. While other risks and resilience-related concerns will apply across the city, there must be a system to ensure implementation, as well as long term maintenance and adaptation of coastal flood mitigation solutions, as these currently pose the greatest existential threat to the city and are geographically specific in their most direct effect and application.

District boundaries based on flood hazard boundaries provide a clear rational nexus, or a sound linkage between the establishment of the DRI and the benefits of the DRI, as far as coastal flood risk is concerned, and facilitate local connection for the long-term maintenance and adaptation of flood control structures. Flood risk can no longer be considered static; it is dynamic and changeable over time depending on many factors, not the least of which is the rate of sea level rise. Similarly, our understanding of future risk will change over time, as the science evolves and new information becomes available. As such, extents based on coastal flood hazard boundaries would need to be updated over time as sea level rise and coastal flood hazard is reassessed and re-evaluated.

The City is working to adopt a floodplain overlay zoning district. This district is expected to encompass the area modeled to be inundated by the 1 percent annual chance flood elevation with 40 inches of sea level rise expected through the 2070s. In South Boston, a DRI boundary consistent with the extent of the floodplain overlay district would include the South End. Aligning DRI boundaries with the boundaries of the flood overlay district provides the benefit of consistency of process and communication. Basing the extent on a 50-year time horizon of expected sea level rise also provides a basis for periodic re-evaluation and realignment of the district with best available data.

Extents based on coastal flood hazard do not consider other resilience or adaptation improvements which may not be associated with such extents, such as stormwater, urban heat island, or general social, economic, or environmental programs. This could be ameliorated through a periodic (e.g., every 5 years) re-evaluation of extent boundaries, but could introduce layers of complexity to the process that may be difficult to effectively communicate and execute.

DRI boundary - Geographic scale considerations

The City may apply the concept of the DRI at the individual district or sub-district level or apply a single DRI across the city based on criteria such as floodplain extent described above. **Section 5.3.2 Potential DRI configurations** outlines options and key considerations.

Regardless of the scale of DRI decision making and funding sources, it will be important to provide a mechanism for distributing funding in a way that ensures fairness and equity (see **Section 5.5 Track 2 funding and cost share considerations**). As such, **Section 5.3.2 Potential DRI configurations** only provides options related to boundaries of the District, not how improvements within the District are funded.

Scale at which contributions to the improvements and maintenance within the DRI would be made and distributed

Closely related to geographic extents for a potential DRI, is the question of the scales at which financial contributions are made and distributed within or across DRIs. The simplest approach would be to tie the collection and distribution of funds directly to each DRI. In this scenario, funding that is collected within the DRI is allocated within the same DRI. This approach provides the greatest level of “fairness” but may not allocate funding based

on citywide priority and may not generate enough revenue to fund all projects when they are needed. A more complex but related approach would be to combine funds collected from individual DRIs across the city and allocate them based on need and / or a robust analysis of risk priority. This approach may provide greatest alignment between funding allocation and project prioritization but would need careful management to mitigate potential issues of fairness. Both options could be supplemented with a range of additional revenue sources, including contributions from city, regional, state, private, philanthropic, or federal sources.

Nevertheless, the benefits of flood mitigation improvements extend to people and organizations who live, work, own property, visit, travel through, rent, or otherwise rely on an economically viable, operational, and accessible built environment in South Boston (and other neighborhoods in the city). As such, while property owners, tenants, businesses, and infrastructure in the area benefit most definitively and directly from improvements to the area, they are not the only beneficiaries. Certain benefits will be realized citywide, regionwide, and at the state level. As such, a funding model could accommodate contributions from multiple geographic scales: district, city, region, or state, as well as integrate federal grants.

An approach that can take advantage of key federal or state funding programs would be able to advance key projects strategically while mitigating the inherent unpredictability of grant funding with the more reliable DRI revenue stream. An overarching coordinating entity at the city-level could distribute those contributions to individual DRIs through one of multiple optional mechanisms. **Section 5.5 Track 2 funding and cost share considerations** provides more detail on funding options.

Table 10 Summary of DRI geographic scale and geographic extent considerations

Scale option	Explanation	Considerations
Citywide	There would be a single DRI for the city, but not every property would fall within the DRI. The extent of DRI participation would correlate with coastal flood hazard boundaries	A single DRI would streamline the financial contribution and distribution approach, but (by aggregating decision-making) may unintentionally rob hydraulically independent districts of autonomy or benefits associated with self-determination. Issues associated with process-related equity could be exacerbated in this case, though outcome-related equity could be better advanced by aggregated decision-making and the ability to have well-resourced areas of the City subsidize less-resourced areas. One possible remedial measure that could retain the benefits of a citywide approach may be to enable sub-committees by neighborhood.
Neighborhood	Current neighborhood plans based on *Climate Ready Boston* outcomes include South Boston, Downtown and North End, East Boston, Charlestown, and Dorchester. The South End is a separate neighborhood in the *Climate Ready Boston* report, but would benefit from flood mitigation measures in other areas, such as South Boston. The DRI could be based on flood hazard boundaries, now and/or in the future, within a neighborhood or district or could be scaled to include the neighborhood or district overall	This approach would likely increase the opportunity for direct beneficiaries of flood mitigation projects to affect the decisions and outcomes of the DRI and thus maximizes democratic participation. Flood mitigation strategies and co-benefits could be better aligned with community values. Nevertheless, without some mechanism to distribute funding across DRIs or to allocate funding from broader city and state scales, inequitable outcomes may arise between neighborhoods. Additionally, depending on how district boundaries are delineated, multiple districts may merge over time. For example, flood pathways from Dorchester, South Boston, and Downtown will eventually merge. This could now or in the future create confusion regarding what constitutes a district. This could be addressed through the periodic re-evaluation and reconfiguration of districts as sea levels rise and as risk is re-assessed. If the boundaries are drawn to include payers outside of the designated flood hazard zone, now or in the future, it could be difficult to provide a rational nexus between the district and its benefits
Other Potential Options		
Sub-neighborhood	Districts are defined at the sub-neighborhood scale based on flood risk criteria. In South Boston this could mean that flood pathways along Day Boulevard generate a DRI distinct from Fort Point Channel	The same concerns and benefits associated with the neighborhood scale approach apply here, but more concentrated. Rapid merging of flood pathways in South Boston make this approach less viable in the near-term.
Multi-scalar	Different responsibilities are assigned and implemented at different scales. For example, funds may be distributed at the city-scale, but improvements and maintenance are governed at more local scales	While this approach is likely to ameliorate equity concerns from other approaches if implemented effectively, it has the risk of being complex and bureaucratic in structure and could paralyze decision-making and change without careful structuring.
Other existing jurisdictional boundaries	The DRI could be based on flood hazard boundaries within another existing jurisdictional boundary (political district, existing utility districts, etc).	There may be some practical benefits to leveraging existing jurisdictional boundaries, such as greater pool of revenue and the ability to capture benefits that may accrue beyond baseline physical damage avoidance, but any other approach aside from flood risk may complicate providing a clear rational nexus between the district and its benefits

5.3.2 Potential DRI configurations

Based on the key considerations described in **Section 5.3.1 Key considerations in DRI development**, the Project defined two different DRI configurations:

1. District-Scale DRIs coordinated by Citywide Resilience Committee
2. Citywide DRI

These two approaches are not the only potential governance arrangements under which projects may move forward in the long-term. Rather, they are examples of how the frameworks described above can be organized to advance resilience implementation.

The two examples outlined here have similarities in terms of their roles and responsibilities but also have key differences that may influence feasibility, at least in the near-term, for the City of Boston. The role and office recommended as a Track 1 action can play a key role in developing and ultimately coordinating the work of a DRI governance entity, and so should not be seen as a mutually exclusive to this recommendation, but instead as a near-term step toward realizing the recommendations of Track 2.

An important note that applies to both approaches is that their effectiveness hinges on the ability to marshal the substantial amount of funding needed to implement coastal mitigation strategies across the city. Therefore, it is recommended that either of these configurations be accompanied by steps to implement the funding recommendations outlined in **Section 5.5 Track 2 funding and cost share considerations.**

District-Scale DRIs coordinated by Citywide Resilience Committee

This approach combines the benefits of a district-scale implementation authority (see Table 10) with citywide funding and coordination but may be viewed as organizationally and administratively complex.

In this configuration, funding collected on a citywide basis could be managed transparently through a City Resilience Committee, based on the governance model for Boston's Community Preservation Act. The Resilience Committee could establish a sinking fund with citywide funding earmarked for resilience and allocate funding to multiple DRIs established in coastal neighborhoods to support resilience in multiple areas at once. The Resilience Committee could be formed by representatives of DRIs, city agencies, the Mayor's Office, infrastructure agencies, and other key stakeholders, for example. The diagrams below explain the relationship between the DRI and Resilience Committee, as well as potential roles and responsibilities.

This approach would likely increase the opportunity for direct beneficiaries of flood mitigation projects to affect the decisions and outcomes of the DRI and thus maximizes democratic participation. Flood mitigation strategies and co-benefits could be better aligned with community values. A smaller, more focused entity is likely to more sustainably maintain infrastructure than a larger citywide entity, because it will have a more manageable portfolio of assets upon which to focus its resources and be more directly accountable to local stakeholders. Nevertheless, without some mechanism to distribute funding across DRIs or to allocate funding from broader city and state scales, inequitable outcomes between wealthier and less wealthy districts may arise.

Figure 24 provides a visual representation of this approach.

Citywide DRI model

The citywide DRI framework would be akin to the creation of a new authority or commission (depending on the exact powers and enabling legislation) dedicated to resilience planning and project implementation in all coastal areas of the city. So as not to replicate inter-departmental coordination issues that can delay project implementation, the citywide DRI would need to have authorities that span infrastructure, funding, operations and maintenance, and governance functions.

The citywide DRI would be responsible for all of the potential functions outlined earlier in this document, including raising and managing funds from a variety of sources, aspects of resilience planning and data analysis, community engagement, regulatory and permitting coordination, project feasibility analysis and design, construction management, and ultimate operations and maintenance. For many of these roles, the DRI would need to outsource work to external entities and so a major role for the DRI would be as a citywide procurement and project management authority. For examples, the DRI could manage one or more CBP3 programs to advance project delivery.

A single DRI would streamline the financial contribution and distribution approach and may realize certain economies of scale in the planning and delivery of coastal mitigation projects. The citywide approach would also promote greater equity regarding where and how projects are delivered since aggregated decision-making would enable redistribution of funds from more well-resourced areas of the resilience district to less resourced areas. This would offer a platform for city-scale subsidy to build projects in areas where a district-scale funding alternative may result in significant cost burden for property owners and residents. Nevertheless, aggregated decision-making also threatens to unintentionally rob hydraulically independent districts of autonomy or benefits associated with self-determination. One possible remedial measure that could retain the benefits of a citywide approach may be to allow sub-committees by neighborhood.

A potential benefit of the citywide approach is that it may be politically and procedurally less complicated to create and administer over time than the district-scale alterative discussed above, primarily due to the use of a centralized governing authority.

Figure 25 provides a visual representation of this approach.

Comparing the two configurations

The tables below provide additional summary details on the two DRI functions outlined in this section.

Table 11 provides additional detail regarding how specific functions and sub-functions would be delegated across the key categories of concern for the DRI under both configurations, including funding, planning, analysis, regulatory enforcement, project implementation, and maintenance and operations.

Table 12 compares geographic extent, benefits, challenges, and organizational complexity for the two options. Further evaluation is needed to determine the most appropriate configuration.

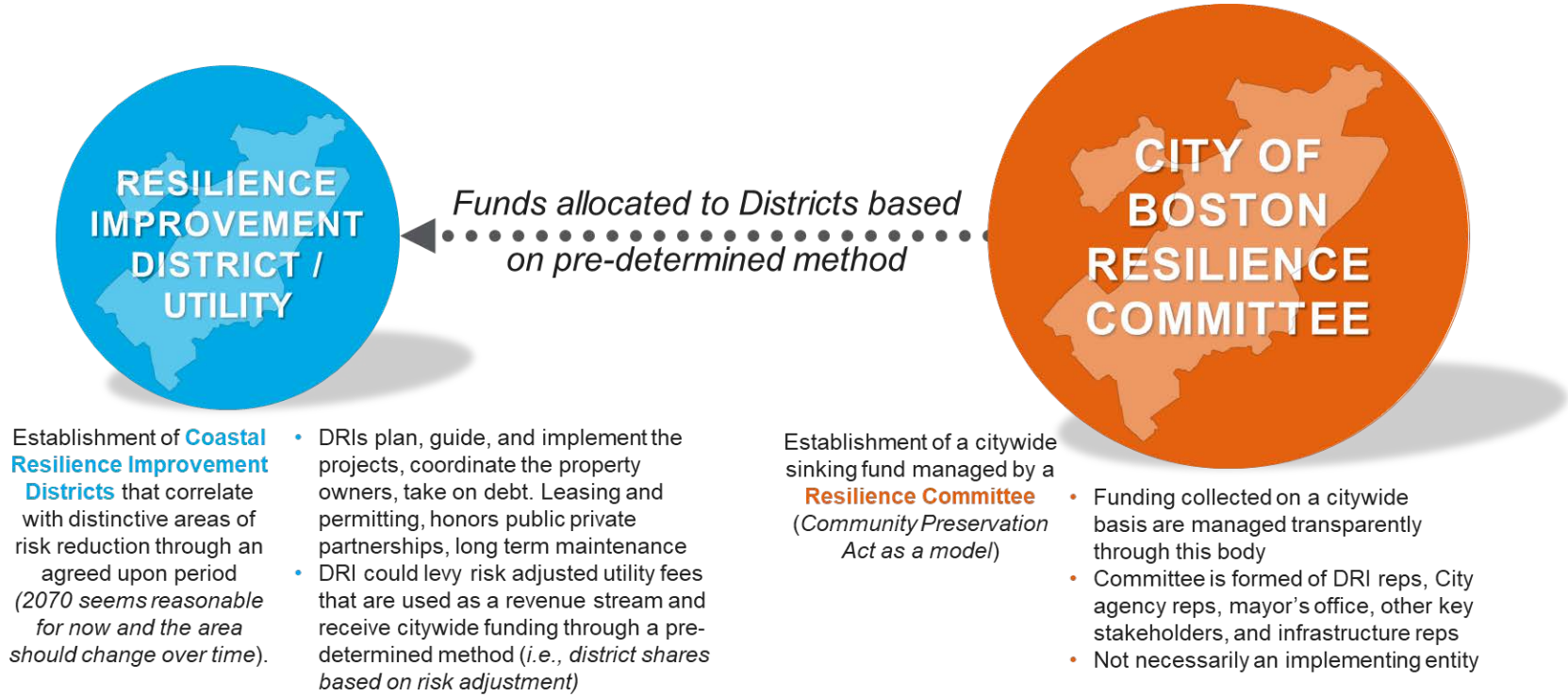

Figure 24 City Resilience Committee and District for Resilience Improvements

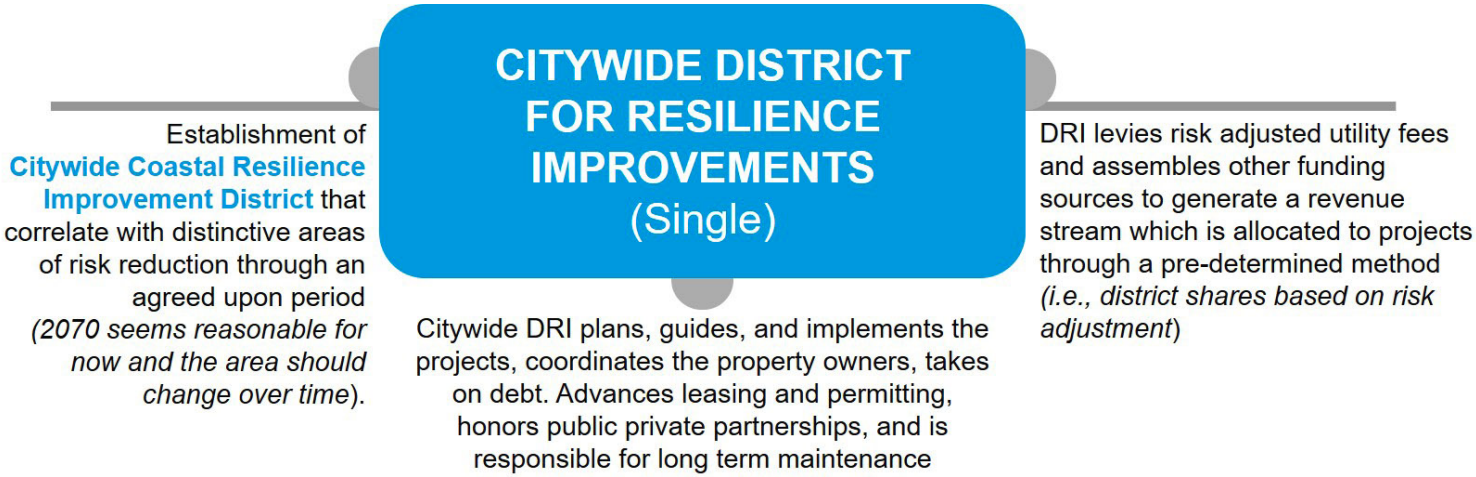

Figure 25 Summary features of a Citywide District for Resilience Improvements

Table 11 Summary of approach to core functions and sub-functions across DRI configurations

Functions	Sub-Function	Approach	Rationale
Funding	Collect / generate	Funds generated at all scales but distributed to projects at the Citywide scale through either Resilience Committee or Citywide DRI. Under either configuration, DRI authorities could include the ability to pursue grants, manage a DRI-specific sinking fund, and establish P3 agreements.	To enable a certain degree of flexibility in how the cost burden is distributed across scales. The right balance between fairness and equity is highly context-dependent and modes of revenue generation and funding may need to be adapted at different scales to account for varying socio-economic contexts.
	Distribute		
	Manage	DRI-level. Under the Citywide DRI, funds could be managed in coordination with neighborhood committees	To ensure funds are utilized in a way that is coordinated to meet district-level priorities and ensure maximum district-wide flood mitigation.
Planning	DRI master plan development / update built from the planning foundation created by CRB	Developed at neighborhood level by DRI with stakeholder engagement at broader scales (or vice versa). The stakeholder committee could include consistent members from a city-level body (either Citywide DRI or Resilience Committee), as well as stakeholders from other neighborhoods, with a heavy share of representation from the plan study area	An integrated approach with functional and geographic coordination could help ensure that there is significant local engagement in the planning process, with integration of broader stakeholder interests.
Analysis	Mapping & science	Retained at current city- or regional-level (BRAG/GBRAG)	To ensure consistence in approach, quality assurance, and economy of scale.
	Risk evaluation		
Regulatory enforcement	Standards development & enforcement	Likely retained at current city/state-level by regulatory agencies (e.g., BPDA, MassDEP, etc.) or in collaboration with DRI to facilitate enforcement and revenue gathering.	To align the City's funding and implementation approach with application and enforcement of regulations. Leveraging DRI for enforcement may benefit compliance rates
	Permitting		
Project implementation	Procurement & contract management	DRI-level	To ensure context-specific knowledge and capabilities are consistently applied, and that evaluation can be fed back into cycles of adaptive learning at a manageable scale
	Financing		
	Staffing		
	Monitoring & evaluation		
	Insurance		
Maintenance & operations	O&M planning	DRI-level, with staff assigned at the neighborhood (or equivalent scale) for the Citywide DRI approach	To ensure responsibility for managing and overseeing O&M in accordance with performance standards is provided locally by an entity with dedicated resources for such work
	Operations & Maintenance		

Table 12 Comparison of DRI configurations – geographic extent, benefits, challenges, and organizational complexity

DRI Configuration	Geographic extent	Benefits	Challenges	Organizational Complexity
District-Scale DRIs coordinated by Citywide Resilience Committee	Both DRI configurations could have extents correlating to flood hazard boundaries to provide an unambiguous link between the establishment of the DRI and the benefits of the DRI, as far as coastal flood risk is concerned. Extents based on coastal flood hazard boundaries would need to be updated over time as sea level rise and coastal flood hazard is reassessed and re-evaluated.	• Greatest self-determination at neighborhood scale • Localized O&M managed more sustainably	• May result in inequities if administrative capabilities and self-advocacy differ across districts • Complexity of formation process and administration over time may inhibit near-term implementation • Focus on transparency in decision-making and representation needed	High
Citywide DRI		• Centralized authority may more efficiently implement projects • Single entity will be more streamlined and faster to implement than multiple distract-scale DRIs • Neighborhood committees could mitigate lack of local representation • Ability to redistribute funds across city would promote more equitable outcomes	• Minimizes local authority and autonomy in decision-making • Centralized authority is harder to insulate from political influence • Although less complex than district-scale alternative, remains administratively difficult to implement in near-term • Focus on transparency in decision-making and representation needed	Medium

5.4 Track 2 Regulatory Recommendations

As noted under Track 1, current state and local regulations are largely neutral to the types of investments necessary to deliver coastal flood risk mitigation infrastructure in the Seaport District, particularly in the near-term along Seaport Boulevard and Fort Point Channel where substantial in-water fill is not necessary. Nevertheless, while the existing regulations are not a hinderance to delivery, neither do they serve to actively advance coastal flood resilience. In addition, in the longer term, present-day regulations that restrict placement of fill in the water may be a deterrent to the implementation of projects that provide higher levels of flood mitigation. All possible levers should be explored to ensure that the timelines outlined in *Coastal Resilience Solutions for South Boston*, as well as the other *Climate Ready Boston* neighborhood plans, are met. As such, the Project sought to answer the following question with respect to the longer-term need for coastal flood mitigation investment:

- How might regulations evolve to ensure implementation of *Coastal Resilience Solutions for South Boston*, rather than simply allow for it? This question pertains, in differing ways, both to new development or existing developments with substantial improvements and to existing developments without planned substantial improvements.

A pre-requisite action to respond to this question is the implementation of the Track 1 recommendation to publish and formally adopt district-specific coastal infrastructure plans and performance-based design criteria that provide targets and parameters for investment at the site scale across districts. Work on these performance standards should begin today, with the primary focus on the highest-priority sections of shoreline and associated projects, ultimately spanning all areas of the city's shoreline where coastal resilience infrastructure is planned. In the near-term, these performance-based design criteria can be applied consistently across a range of regulatory platforms. Such action will also effectively communicate risk tolerance, which could be used as the basis to trigger required actions for new and existing development, as described below.

5.4.1 Regulatory changes that may advance and ensure implementation of *Coastal Resilience Solutions for South Boston* with new development

As introduced in **Section 4.2.2 Use existing policy vehicles to guide and enforce** plan implementation, proposed new zoning regulations still in development as of the writing of this report – the Flood Resilience Zoning Overlay -- provide a significant opportunity to codify certain key elements of the coastal flood mitigation performance standards. As far as we understand, the zoning overlay will primarily focus on changing regulations in the Sea Level Rise-Flood Hazard Area (areas with a projected 1 percent annual chance of flooding with 40 inches of sea level rise) to promote resilient new development and significant retrofits to existing buildings. We also gather that an objective of the new zoning is to better regulate and guide district-scale coastal mitigation – or at a minimum to ensure new development does not impede district-scale mitigation. We support this approach and recommend:

- Codifying design elevations and alignments for coastal mitigation
- Requiring proper waterfront setbacks and allowing coastal mitigation projects in waterfront setback areas

- Requiring consideration of and design for cross-property tie-ins for coastal mitigation
- Referencing performance standards for coastal mitigation. As described earlier, such performance standards could be flexible enough to enable project proponents to creatively integrate investments into their site plans, but need to include engineering standards, design standards to promote co-benefits such as public amenities, and operations and maintenance requirements.

Local municipalities in Massachusetts are not currently permitted to enact design and construction requirements that are more or less stringent than the State Building Code (780 CMR). Therefore, according to subject matter experts that reviewed preliminary hypotheses, any coastal mitigation standards enacted through zoning would need to set targets without being prescriptive as to how those targets are met.

5.4.2 Regulatory approaches that may advance and ensure implementation of *Coastal Resilience Solutions for South Boston* with existing development

Establishing target elevations and other performance standards through zoning will help advance coastal resilience investment where new approvals are being sought. Nevertheless, this leaves the question of how to compel existing developments not seeking City approvals to pursue or allow coastal resilience infrastructure where such action is necessary for public health and safety.

For the strategy outlined in *Coastal Resilience Solutions for South Boston* to be effective, there must be an unbroken line of coastal flood protection infrastructure across property lines controlled by many public and private entities. If there is a break in the alignment, flood pathways could lead to deep and widespread flooding within the district during a coastal storm event. With sea level rise, this could happen even during average monthly high tides.

Short of the use of eminent domain to deliver coastal resilience infrastructure projects, which comes with a host of political, legal, and administrative issues, the remedy for this challenge is likely to be a carrot and stick approach, combining requirements with incentives for property owner action. Examples of incentives could include funding or other financial benefits such as property tax abatements, development entitlements, and expedited permitting. The evolving and increasing flood risk context may also come into play over time as an impetus for property owner action, particularly if flood risk tolerance has been clearly communicated through the adoption of performance-based design criteria.

Chapter 91 has the potential authority to compel flood mitigation action to preserve required public access rights. The trigger for this requirement is not clarified in the law; for example, it is not clear whether the trigger would only apply when flooding becomes so frequent as to regularly disrupt the use and enjoyment of the waterfront by the public or when there is a credible threat to that enjoyment in the form of risk of direct physical damage from a particular coastal storm event.

Flood protection is in alignment with the spirit and existing requirements of the law, but triggers for coastal flood protection improvements should be defined in order to use this existing lever. Furthermore, it would be beneficial to apply the requirement, based on established performance-based design standards, at the time a license is granted depending on the term of the license and useful life of the project.

As described in detail in the Conservation Law Foundation's (CLF) report *Climate Change and the Massachusetts Public Waterfront Act*, future sea level rise threatens to impede the public's right, as required through Chapter 91 regulations, to access the water through previously built public improvements, such as the Boston Harborwalk.[23] If the Harborwalk were to flood daily, monthly, or annually, preventing the public from using it, the spirit of Chapter 91 requirements would be violated. CLF recommends that new Chapter 91 licensees be required to show how the public improvements will be maintained over the life of the license, which could include the elevation of such improvements, including elements such as the Harborwalk. For existing licensees, Chapter 91 does not have an established mechanism that would cause a licensee to modify its Harborwalk and/or Facilities of Public Accommodation because of flooding, other than an enforcement action. Although enforcement has not be used in this way before, we recommend further exploration of the legal and procedural potential for using Chapter 91 to compel property owners to allow and contribute to the implementation of district-scale mitigation where other incentives are not sufficient.

5.5 Track 2 funding and cost share considerations

There are many flood prone communities in the United States that are also working to understand and address risk – New York City and State, Texas, Louisiana, and Florida are a few examples – in the context of having experienced recent major presidential disaster declarations.

While a disaster declaration yields considerable funding, Boston has (fortunately) not had a major presidential disaster declaration in recent years. This means that the City has avoided the significant opportunity cost that comes with being forced to invest in disaster response and recovery, in addition to direct physical damage and economic disruption. Nevertheless, this also reduces access to federal funding to catalyze major resilience-related improvements compared to areas that have been affected. Even with federal funding to stimulate resilience-related action, the scale of need in most areas outstrips apparent available federal funding. Boston cannot use a wait-and-see approach to federal funding and implementation support in the face of rising risk. The City must develop a proactive funding strategy that is not reliant on heavy federal investment, but that would also not preclude it.

As such, we explored the following key questions regarding non-federal funding to implement, maintain, operate, and adapt its portfolio of coastal flood risk reduction improvements:

- Payers and contributors: Who can and should be expected to contribute funds toward coastal flood risk reduction improvements (including implementation, maintenance, and adaptation)?
- Cost share allocation: How might these costs be shared fairly, equitably, and in a transparent fashion across those who should be expected to pay?
- Methods of payment: How might contributions be structured and collected?

The answers to these questions, which are outlined in the following sections, should, at a minimum, help guide decision making for allocations of City funding and set expectations between public and private cost shares (see recommendation in **Section 4.3.1**). In addition, the answers may help provide a rational

[23] See *Climate Change and the Massachusetts Public Waterfront Act* (page 16)

nexus for contribution negotiations in the near-term, and help to leverage existing and potentially new revenue models to construct, manage, and adapt coastal flood protection infrastructure over time.

The consideration of who should pay how much, including cost-share between the public and private sectors and methods of payment, should reflect the fairness and equitability criteria outlined in **Section 3.4 Criteria used to guide recommendation development**. In addition, the probability of a devastating coastal storm in Boston's future cannot be ignored. As such, the textbox between Sections 4 and 5 above provides an overview of how Boston might position itself to maximally leverage federal disaster aid in the wake of a major flood event.

5.5.1 Payers and contributors

Coastal flood mitigation infrastructure can be thought of as providing a service to flood-vulnerable properties (public and private). Based on this framing, the beneficiaries of this flood protection service could be asked to help fund it.

The most obvious potential beneficiaries in South Boston includes those who own, control, or rent property within the district. These include private property owners, non-profit institutions, City agencies, State agencies (e.g., Department of Conservation and Recreation), State authorities (e.g., Massport, MBTA, and the Massachusetts Convention Center Authority), private infrastructure entities, condominiums, commercial tenants, and residential renters. In addition, the City, State, Federal government, regional citizens, and interdependent infrastructure entities (i.e., a hypothetical wastewater plant outside of the study area that is served by a substation within the study area) also benefit from actions to protect South Boston through the significant economic output generated in the district, jobs, transportation-related infrastructure, other linear infrastructure, property tax, sales tax, income tax, other revenue sources, and more.

5.5.2 Risk adjusted cost share allocation approach

The Project built on previous efforts described in **Section 3.1 Other efforts leveraged toward the project** to develop the hypothesis that a risk / benefits adjusted approach to cost share may be a viable response to how major resilience infrastructure capital, maintenance, and long-term adaptation costs can be shared fairly, equitably, and transparently. As such, the Project team undertook an experiment to understand how costs for an integrated flood risk mitigation system might be allocated across different payers based on their proportionate share of benefits. While further refinement and evaluation is needed, some results of the experiment are sufficiently informative to draw some preliminary conclusions and recommendations about how funding burdens might be shared.

This cost share analysis used the following information:

- Flood hazard data developed by Woods Hole Group for the Boston Harbor Model, refined for use in site specific analysis through *Climate Ready Boston*[24]

[24] The analysis used loss calculations associated with 16 flood elevations – four each originally modeled for the 0 inch, 9 inch, 21 inch, and 40 inch sea level rise scenarios. Analysts correlated each of the 16 flood elevations to annual chance of occurrence with 40 inches of sea level rise. We selected this sea level rise scenario as the basis for calculating risk due to the fact that it represents the level of protection for the South Boston strategy, correlates to the

- Buildings data developed through *Climate Ready Boston* and refined through *Coastal Resilience Solutions for South Boston*
- Essential facilities, critical facilities, public facilities, and open space and parks data gathered through *Climate Ready Boston* and refined for this Project using City public data
- Loss estimations re-calculated in 2018 through *Coastal Resilience Solutions for South Boston*, along with new calculations developed for this Project (see Figure 27 and methodology in Appendix B[25])
- Capital and maintenance cost estimates developed through *Coastal Resilience Solutions for South Boston*
- Completion date requirements developed through *Coastal Resilience Solutions for South Boston* (see Figure 8)
- Schedule of expenditure estimates for all projects identified in *Coastal Resilience Solutions for South Boston* (developed for this Project)

Figure 26 provides an example of the different ways that risk, when realized, can reverberate across society beyond direct impacts to property owners. Different entities may benefit from flood protection actions to the same asset in different ways. For example, direct physical damage to a train station[26] from a flood event will not just affect the station owners and operators. There could be impacts along the entire route to riders and employees, and those who would rely on riders to arrive to a certain location on time, such as the riders' place of work. Local, state, and federal government entities, as well as the station company, may need to expend resources on emergency preparedness and response, as well as recovery. This, in turn, could affect taxpayers and riders through revenue collection. Depending on the extent of the direct physical damage, and the duration of any disruption, this could yield further strain into the community through job loss, loss of economic activity, mental health and social impacts (from those directly and indirectly impacted), as well as strain on government resources.

useful life, is most inclusive in terms of understanding the expected risk context over the next 50 years, and therefore most inclusive for calculating cost share. If, for example, cost shares had been calculated only based on current risk, costs would be heavily front loaded on relatively few payers in the near-term and many other beneficiaries would receive "free-rides" later on, yielding a cost share approach that would be neither fair nor equitable. It is therefore best to calculate cost share based on share of risk expected over the life of the project, assumed to be until there is a need for additional expenditure for adaptation to accommodate additional sea level rise.

[25] All methodologies used existing federally published approaches or variations and proxies, thereof

[26] While there are no train stations in South Boston, this example was selected for its ease of communication.

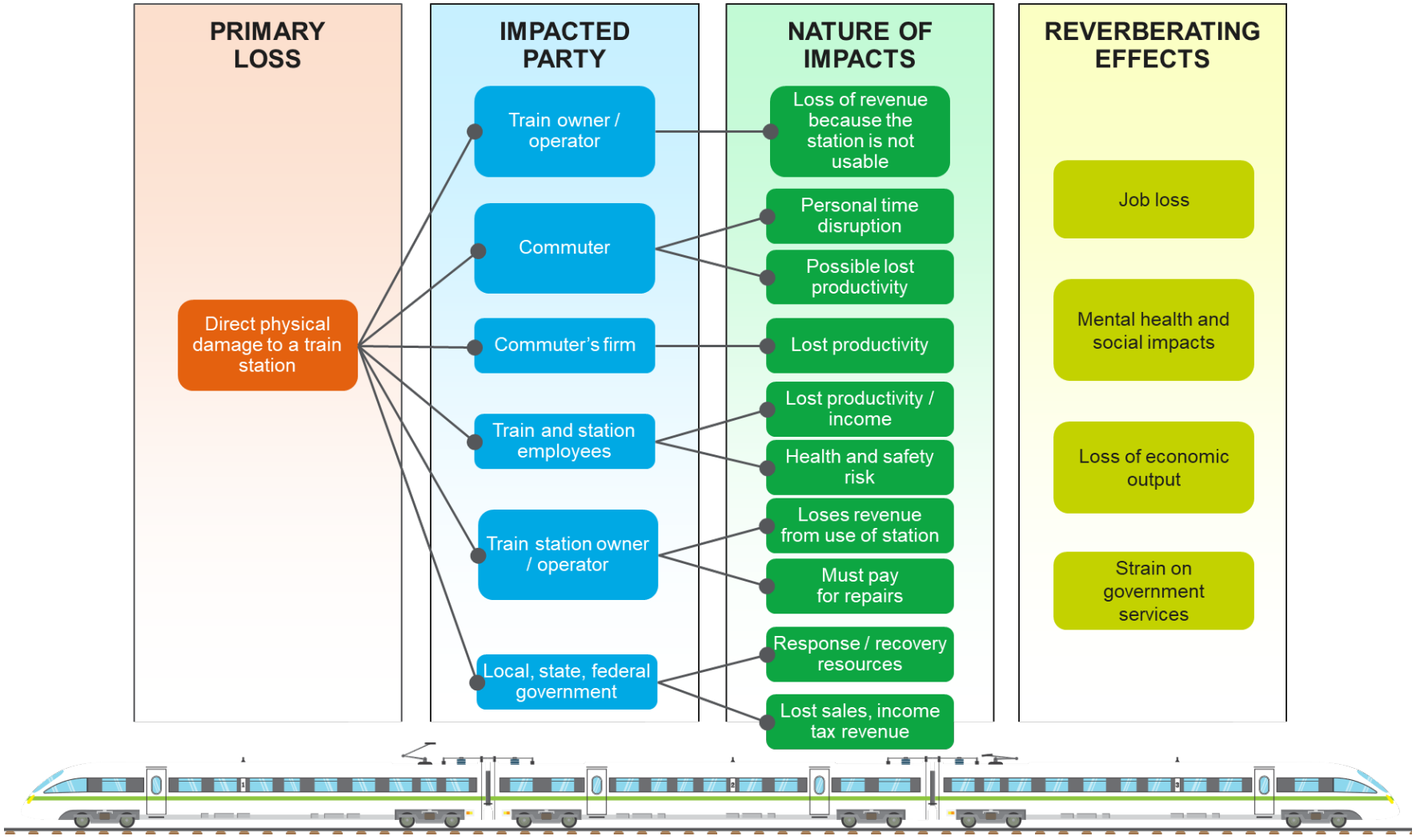

Figure 26 Example of how direct impacts to a single asset can reverberate across multiple parties and the community at large

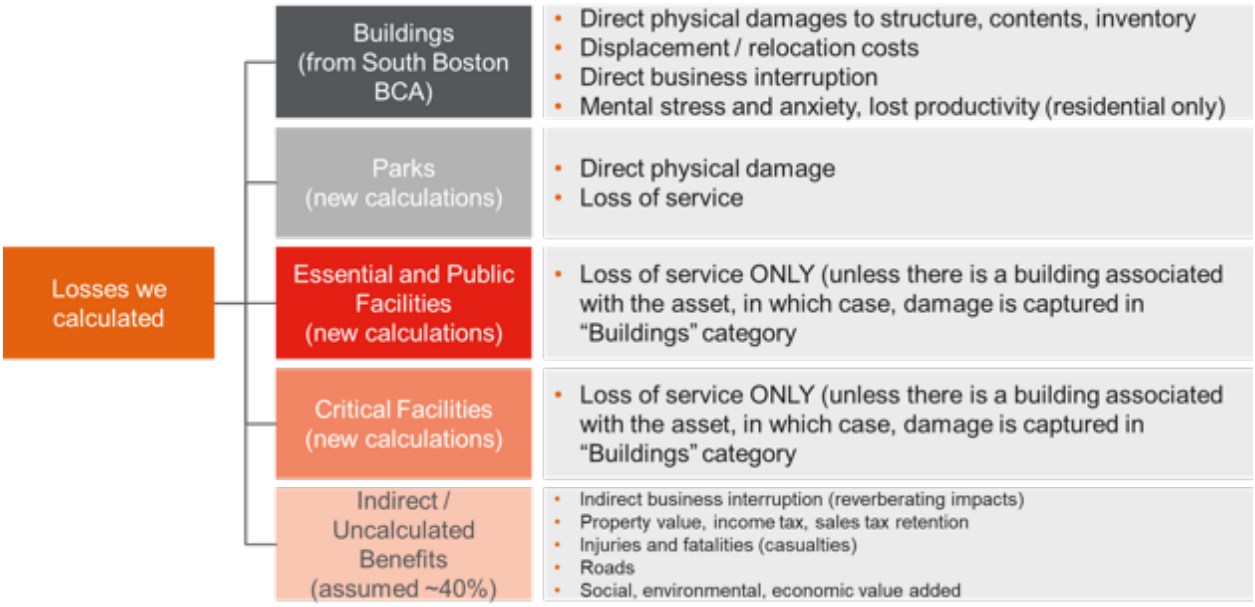

Figure 27 Losses included in this Project's cost share analysis

In order to complete the cost share analysis, we completed the steps outlined in Figure 28. The detailed methodology is provided in **Appendix B**.

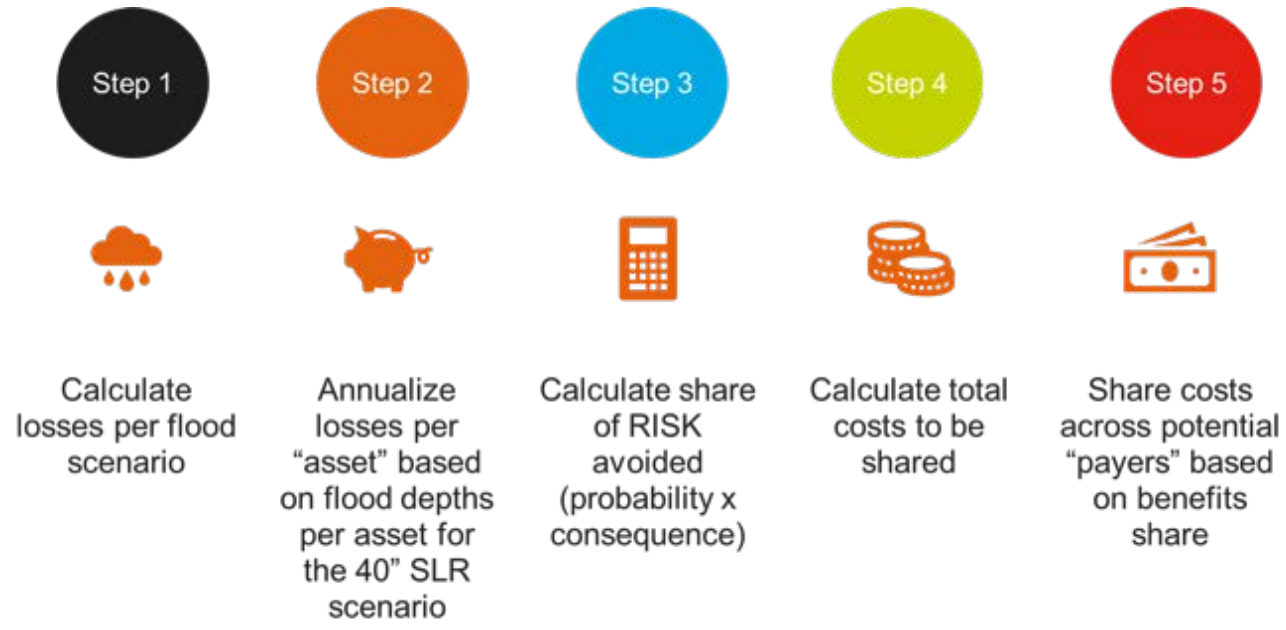

Figure 28 Cost share analysis process

The Project calculated cost share allocations across the sectors and payers list in Table 13 to assess the extent to which a payer's share of benefits could be used to approximate potential cost share for coastal flood resilience infrastructure proposed in *Coastal Resilience Solutions for South Boston* (see **Section 3.8 Cost share analysis** for an overview of the approach). Figure 29 provides a summary of cost share results summarized by payer.

Table 13 Sector and payer categories used to aggregate results of the cost share analysis

Sector Categories (Type of Asset at Risk)	Payer Categories (Responsibility for Asset at Risk)
Essential services	Private utility
General government	Federal government
Mixed use	Commonwealth of Massachusetts (all agencies aggregated)
Non-residential private	Private property owner / tenants
Residential	City of Boston (all agencies)
Transportation	Education / university
University	Other public benefits not currently allocated by payer (likely to fall within City, State, and / or Federal purview, but further analysis required)
Utility	
Recreational / open space	
Other public benefits (i.e., indirect economic benefits and uncalculated benefits)	

Based on property ownership and our preliminary calculations of risk share, the Commonwealth of Massachusetts and private property owners / tenants together would bear around 50-percent of the risk share in South Boston. A large amount of property is owned or controlled by the Department of Conservation and Recreation, Massport, and a smaller portion by the MBTA, for example, and there is significant private ownership along Fort Point Channel and the South Boston waterfront, as well as in the historic South Boston neighborhood north of Day Boulevard. A large share of expected loss lies in the sector of recreation and open space, which lies within both public and private control.[27]

Only a small share of the risks calculated currently lie with the Federal government, and approximately 10-percent with the City of Boston. This is because the benefits calculated are based on the effects of direct impacts to properties. A current limitation of this study, and an area for additional study, is the approximately 40-percent cost share attributable to broad public benefits (i.e., indirect economic effects) and uncalculated benefits (i.e., road transportation). This portion of the cost share is likely most appropriately shared across Federal, State, and City payers, but more research is needed to develop a more specific rational nexus between these benefits and the relevant payer. All other share divisions are calculated based the effects of site-specific impacts, as demonstrated in Figure 27.

[27] See Appendix B for commentary on park and open space risk methodology

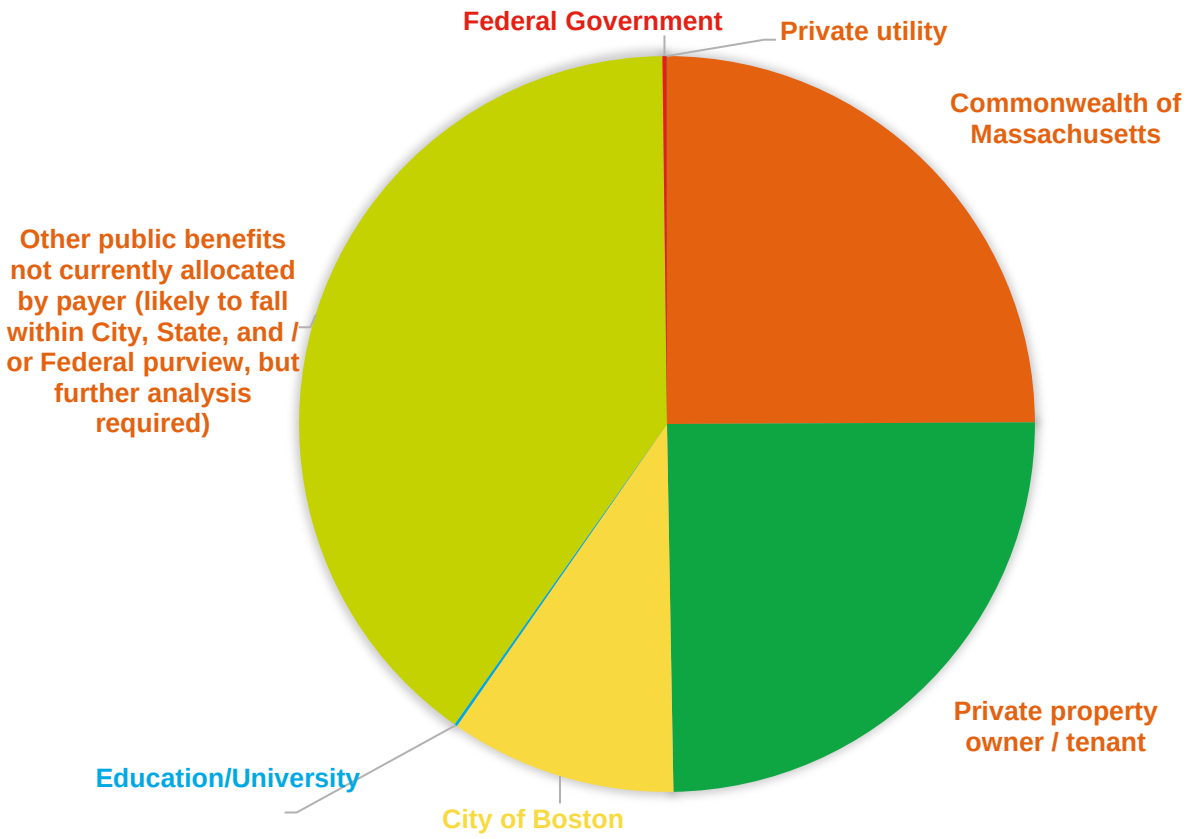

Figure 29 Cost share results for South Boston coastal resilience strategy summarized by payer type[28]

Cost share equity and affordability

A key consideration with this approach was individual payer cost burden and the concept of **equity**. We were interested to understand potential individual payer burden, expecting that cost increases within South Boston could further exacerbate existing issues with affordability and, by extension, gentrification. Any method of cost share for major new infrastructure is likely to increase annual costs for residents and other payers, though it must be acknowledged that these costs would pale in comparison to the costs of doing nothing, as demonstrated by *Climate Ready Boston* and subsequent district level benefit cost analyses.

There are numerous ways to look at the results of the analysis in order to understand and frame individual payer burden and affordability, particularly related to residents who may own or rent at risk properties. Figure 30 provides a scatter plot summary of the annual cost share, based on the high capital and maintenance cost estimates for the planned flood risk mitigation measures without financing, for

[28] Recreational and open space may be currently over-calculated due to the fact that the current methodology does not differentiate between green space and beach open space. There is significant beach located along Day Boulevard in South Boston.

individual private property payers. This payer category is responsible for approximately 25-percent of all the benefits (mixed use, non-residential commercial and industrial [non-public service assets], and residential sector assets). The figure summarizes annual cost share compared to current annual rental rates in the area and adds the dimension of building size. Assets with similar results to those shown are removed for legibility.

We replicated this experiment was replicated for the highest cost payment year (2049) of the rolling bond scenario approach for the high capital and maintenance cost estimates and found to be very similar. Over 98-percent of property owners would pay less than $0.50 per square foot per year. In both cases, there was an outlier with the cost share for that year at about 14 percent of current rental rate due to the particularly high risk of that structure. 5,634 of the 5,899 structures (or 96 percent) evaluated for reduced direct physical damage[29] as a result of implementation of *Coastal Resilience Solutions for South Boston* would pay less than one percent of current annual rent.[30]

Figure 31 provides another perspective on potential affordability by visually representing the annual cost share[31] per building and on a per square foot basis using an expanded set of sectors. Results are colored by sector and bubble size correlates to the size of the building; the largest building in the study area is over 7 million square feet. Even though the majority of buildings would pay a minimal share when compared with average annual rent, rent itself may have affordability concerns in this area. There are a few outliers that would be paying greater than $1.50 per square foot per year due to their relative risk (and thereby cost) share. Again, assets with similar results to those shown are removed for legibility.

[29] Excludes the evaluation for parks and certain sites only evaluated for loss of function
[30] Calculated based on 2019 average Zillow and Loopnet rates for the area
[31] Cost scenario: High capital and maintenance cost estimate, no financing

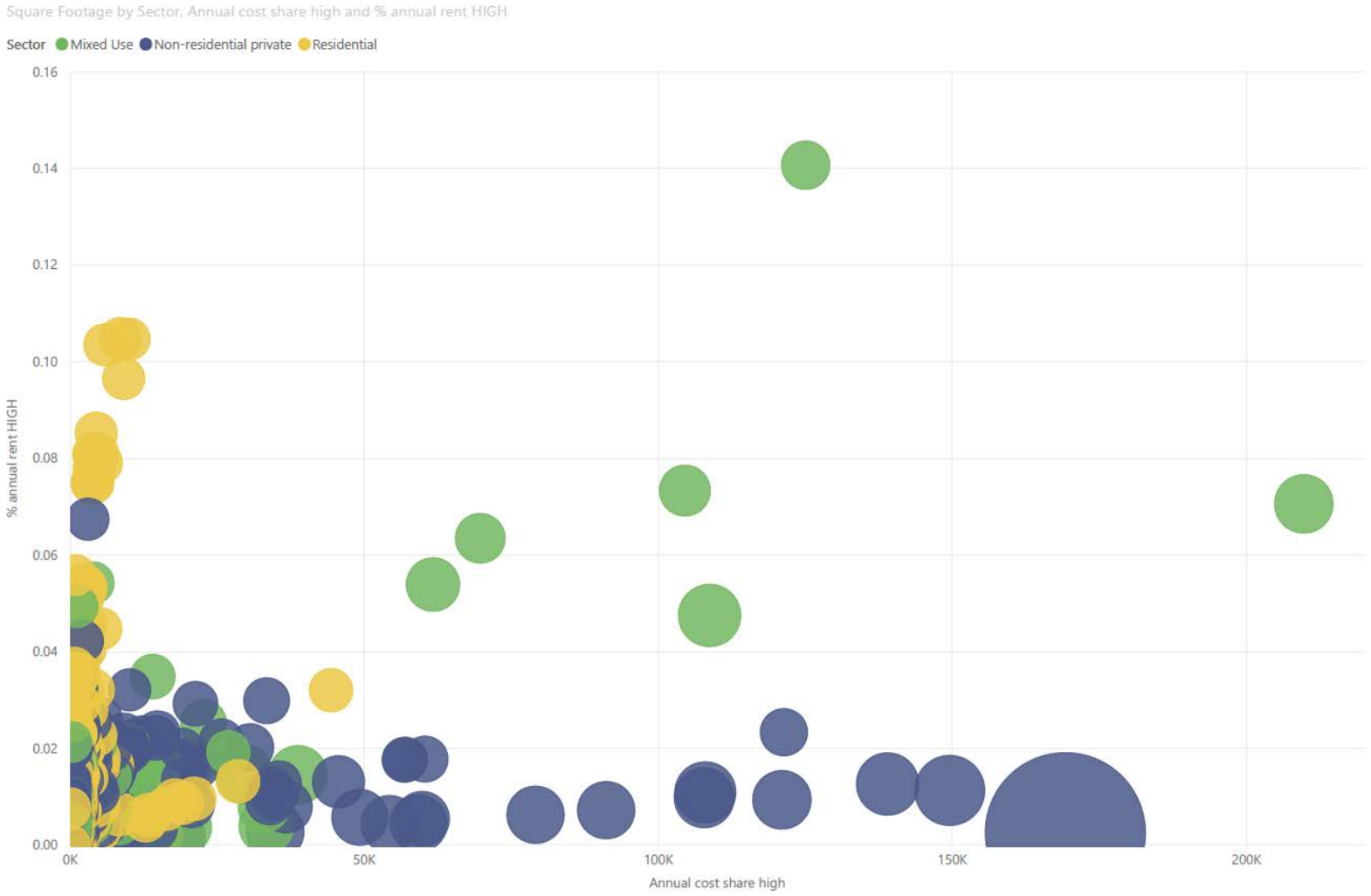

Figure 30 Scatter plot correlating annual cost share (high cost scenario, no financing) as a share of current annual rent to building size for mixed use, non-residential private, and residential sectors

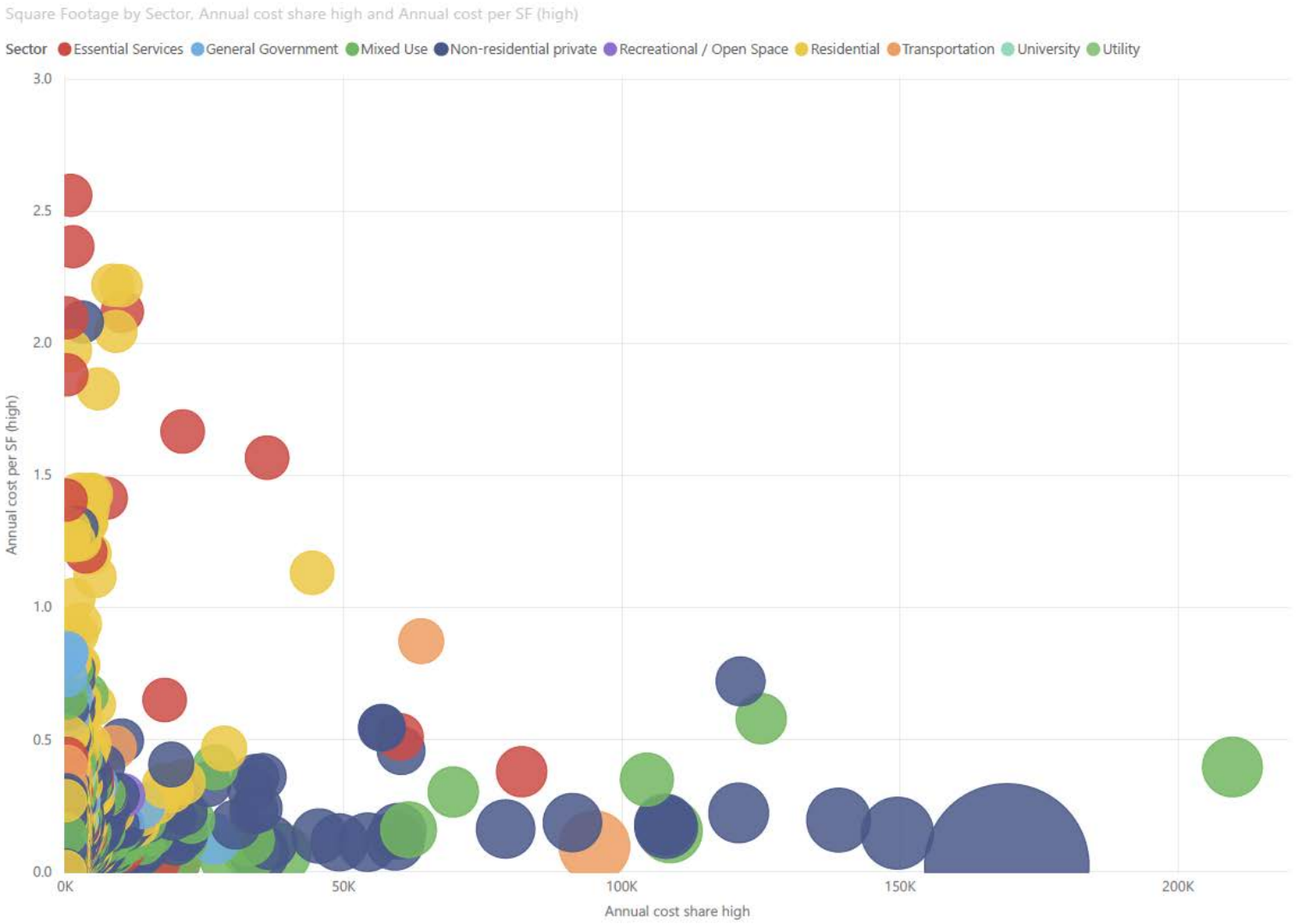

Figure 31 Scatter plot comparing annual cost share to annual cost share per square foot by sector with bubble size correlating to building size (largest building over 7 million square feet). Open space excluded. High capital and maintenance cost estimate, no financing.

There are some key insights to be gained from the results summarized in Figure 30 and Figure 31:[32]

- There is significant concentration of the highest risk across relatively few structures. Under the current calculations, about half of structures would be paying less than $50 a year, with over 1,600 estimated to pay less than one dollar a year under the high cost no financing scenario (1,425 under the highest year financing cost scenario).
- There may be opportunity to increase equity or create programs for support of lower income parties simply by instituting a minimum payment across benefitting parties, or capping payments at a certain amount per square foot and redistributing overages.
- The results do not integrate expected population growth or changes to the built environment over time. For example, according to *Climate Ready Boston*, South Boston is projected to double in population between 2015 and 2030. As such, as costs increase under the 5-year rolling bond financing scenario to peak in 2049, there are likely to be more entities and population present to share costs.
- As the rental rate calculations have been completed using averages for the area by structure and use type, more research is needed to understand specific cost burdens.
- As mentioned briefly above, cost burdens are likely to be higher as public entities and private utilities impose fees and taxes on property owners to cover their cost shares. The share of costs directly represented in these graphics is roughly 25%.

Calculations included assumptions that will affect the results. These assumptions are outlined in Appendix B.

Implications

While this experiment was intended to be a preliminary analysis to test whether further study and piloting was warranted, results to date are promising for the following reasons:[33]

- The benefits-based approach to cost share allocation provides **a clear rational nexus between fees and outcomes** by clearly tying project benefits to cost obligation. Note that this approach could either be used as a mechanism to set expected contributions from individual payers, or could provide a guide in the effort to establish payment mechanisms by payer type, or simply in supporting engagement and any negotiations that could be needed as payment structures are developed
- **Transparency** can be achieved by using the same method to calculate all cost shares, and by publishing methodologies used to complete the calculations

[32] Note that these calculations cover only direct cost share; it is expected that citizens will also pay for the shares attributable to utilities and public entities indirectly. For example, if a homeowner is paying 1-percent of current rent for flood protection (through any number of mechanisms) we have to also expect that they're paying indirectly through costs incurred to their utility provider, the City, the State, MBTA, etc. through whatever mechanisms those payers have to bill for their services. This is because the root payer of a public service entity is always a citizen. Nevertheless, those costs will be spread over a much larger service area and population than solely South Boston. Table 15 provides a demonstration of this process.

[33] Based on prior experience, Project analysts assumed approximately 40-percent of strategy benefits, and therefore costs, were attributable to indirect economic benefits and other benefits not calculated within the scope of the Project. Such benefits are calculable and could be integrated into a future, more detailed pilot.

- **Provides a possible incentive for payers to independently reduce risk.** The calculations used to develop this experiment can easily be updated with new information that may affect structure risk, such as the elevation at which flood loss will begin to occur. As property owners independently take action or participate in retrofit programs to reduce individual risk, this will affect their risk share and redistribute costs automatically across all payers. This provides an incentive to take verified action to meaningfully reduce risk, though it would not remove payment obligation as risk cannot be eliminated and contributions will still be made through public service entities such as transportation providers, utilities, and the City of Boston.
- **Can be continually updated and is adaptable over time**. The process can easily integrate new risk information, new structures, changes to the built environment, better population data, and more, making it adaptable over time. For example, it may be worth investigating whether the existing property tax assessment process for the city could be modified to gather additional data that would contribute to annual payment calibration based on flood risk-related building or site features
- **Provides a mechanism and framework to leverage multiple existing and new funding sources**. As grants are received, for example, the overall cost to payers drops and the process will automatically redistribute costs.
- **Provides a framework to honor early contributions from payers**. Some payers may be reticent to take independent action to help implement coastal infrastructure projects across their properties due to the fear that they may later be asked later duplicate their contributions. The process can easily recalculate necessary payments in consideration of past contributions. For in-kind work, this could simply be based on the estimated cost of the relevant project portion or elements.
- **There is precedent to taking similar approaches to sharing costs for public services**:
    - Stormwater utility fees are based on categories of impervious surface on a site
    - Property taxes are based on site-specific appraisal of property values
- **It may be possible to leverage existing public processes to gather the information needed to accommodate this approach, such as the property assessment data collection process**

It is unclear at this time how these calculations would play out under an expanded, citywide study area. South Boston is known for its relatively high income and new urban development, especially in the Seaport District. An expanded study area may positively or negatively impact affordability, depending on multiple variables, including costs and payer demographics along the coast. We hypothesize that an expanded study area would benefit affordability as costs would still be based on overall risk share and would include a much-expanded pool of potential payers along with costs to be shared.

The cost share approach evaluated here will require significant political alignment and stakeholder input in order to be implemented. We acknowledge that there are a number of challenges that will need to be overcome. As such, Table 14 summarizes some of the key challenges and potential strategies for overcoming these challenges as the approach is evaluated and refined moving forward.

Table 14 Potential challenges to implementing a risk adjusted cost share approach

Challenge	Potential remedy
May be seen as overly complex and administratively burdensome	The initial process of setting up the system and building consensus on its application will be complex and administratively burdensome. Additionally, it would be burdensome, similar to property assessment, to ensure that the risk evaluation remains up to date. One possible mitigation measure may be to borrow from stormwater utility fees and obtain contributions based on "class" or "category" of risk / benefit as opposed to actual risk
Data is currently lacking in some areas, and may be unavailable for some desired benefits calculations	There are multiple reasons to improve data collection, maintenance, storage, and sharing that extend beyond this process, particularly as it relates to the features of the built environment. It may be worth exploring the extent to which improved data gathering might be integrated into floodplain management processes (such as compliance touring of the floodplain) or the property appraisal process. Nevertheless, even in the absence of this information, data would be improved ad hoc as individual payers present information to help refine their expected payment obligations
Requires heavy quality assurance and quality control processes	The initial set up of the system will be the most administratively burdensome. Following initial set up, reviews and QA may occur organically as contributions are received and fees assessed. Risk of errors may be mitigated through adoption of an automated process to be reviewed and updated periodically with new risk data (i.e., every five years).
Lots of potential for contesting of rates (presenting of evidence to lower risk)	A process like that used to contest property assessments or other site-specific cost evaluations may be employed
May be difficult to reach consensus on a single methodology for each benefit type	This may be mitigated by using federally accepted or otherwise published peer reviewed approaches for calculating benefits and having a process for reviewing the integration of new benefits approaches on a regular basis correlating to re-evaluation of risk (i.e., every five years)
Adding more costs to an existing high cost area may further gentrification	This concern is common to other public infrastructure payment systems, such as stormwater and utility fees. In order to mitigate impacts, there are often cost share programs. Nevertheless, further research and refinement is needed to begin to articulate exact expected payments and compare these payments with demographic trends in the area, as well as possible mechanisms to alleviate cost share burden, where needed.

5.5.3 Methods of payment

Beneficiaries of coastal resilience improvements could contribute funds proportionate to the benefits they receive through various mechanisms; it is likely that a variety of revenue streams would be necessary to provide adequate funding and promote sustainability of the fund. Example funding streams could include infrastructure agencies' capital improvement budget contributions to the DRI, or municipal properties piloting an umbrella model for risk-adjusted premiums. Contributions from private property owners will also be critical. Additionally, any contribution made by a public entity (City, State, or Federal) or public service provider (i.e., private utility) is ultimately paid by citizens / individuals in the form of service fees, taxes, or surcharges.

The cost share analysis outlined in **Section 5.5.2 Risk adjusted cost share allocation approach** creates a framework or guide for allocating costs across a range of beneficiaries. Payments based on this cost share framework can be assembled from a variety of payment vehicles from beneficiaries, including taxes, utility fees, capital improvements, insurance surcharges, transfer fees, among others.

To facilitate this, an in-depth financial analysis and stakeholder engagement plan would be needed to establish an approach by which project beneficiaries would pay into the strategy in a manner that is equitable, fair, and not dependent on new development. Table 15 summarizes example contribution options by payer type. Any public entity receives its funding through some citizen contribution mechanism; as such, this is also captured within the table.

Table 15 Example contribution options by payer type (does not include financing mechanisms)

Payer type	Example payment options	Citizen contribution mechanism
Private utility	• Capital improvement projects/budget contributions • Paygo	• Utility / service fee
Federal Government	• Grant or allocation funding • Fee or surcharge (on at-risk property)	• Income tax (federal)
State Government	• *Umbrella model for risk-adjusted premiums (pilot)** • Grant or allocation funding	• Income tax (statewide) • Sales tax (statewide) • Surcharge or Fee (e.g., parking, gas, transportation, visitor surcharge at hotels / establishments)
City of Boston	• *Umbrella model for risk-adjusted premiums (pilot)** • Capital improvement projects/budget contributions • Paygo*	• Property tax • Surcharge or Fee (e.g., parking, transportation, visitor surcharge at hotels / establishments)
Private property owner	• Special assessments with subsidies to promote equity, as needed • Fees with a sinking fund (i.e., 100 Acre Master Plan) • Utility / service fee • Property transfer tax • *Risk-Adjusted Premiums (after initial pilot)*	

Payer type	Example payment options	Citizen contribution mechanism
	• Insurance surcharge (property, casualty, or both)	
Visitor / Worker	• Surcharge or Fee (e.g., parking, transportation, visitor surcharge at hotels / establishments) *	
Tenant	• Utility / service fee • Built into lease** • *Risk-Adjusted Premiums (after initial pilot)** • Insurance surcharge (property, casualty, or both)	

*See below for additional information

**Property owners would likely pass on costs to tenants in rental rates

All approaches, except for those leveraging risk-adjusted premiums, have been or are actively being used either in Boston or other places to fund infrastructure improvements. We believe that through a DRI governance approach, as outlined in **Section 5.3 Governance approach: District for Resilience Improvements (DRI)**, multiple funding mechanisms can and should be leveraged toward coastal infrastructure implementation. The options in Table 15 are those that appear to be potentially viable based on research and should be evaluated as potential methods for funding flood mitigation.

City budget allocations and capital improvements, as well as the sinking fund, have been addressed in **Section 4.3 Funding recommendations now through 2023** and are not replicated here.

Paygo – Immediate option

The Paygo approach uses existing sources of funding to pay for necessary capital projects. Any unallocated or unused funds at the close of a fiscal year can be consolidated into a resilience funding account. Applicable mechanisms for the Paygo approach may include leveraging existing capital improvement plans, fee collection programs, and operational budgets. This has the benefit of being immediately available, but is unlikely to yield significant funds. This could also potentially be leveraged by both State and City payers and could be applicable to the City-level or DRI-level approach.

Citywide Surcharges or Fees – City-level funding contributions – Near-term funding option

Boston has an existing governance model for the management of surcharges and fees: the Community Preservation Act (CPA). The CPA finances a fund for affordable housing, historic preservation, open space, and public recreation through a 1 percent property tax-based surcharge of residential and business property tax bills. The City can use lessons learned from the CPA and establish a similar surcharge and management system for citywide resilience. Options for a basis of assessment could include a carbon surcharge or sales tax.

Utility / Service Fees – Risk adjusted for DRI-level funding or City-level funding – Mid-term funding option

Service fees must be tightly connected to services and users, which the risk adjusted cost share approach described in **Section** Error! Reference source not found. may supply. Nearly every New England state has a legal basis for collecting stormwater fees, for example, including Massachusetts. Boston has not been successful in adopting a stormwater utility fee to date. If reformulated as a

"Resilience Fee," such a fee could be tied to annualized expected losses avoided (benefits accrued) due to flood mitigation (see **Section** Error! Reference source not found. Error! Reference source not found.. The cost distribution could be structured to evolve over time based on the changing risk context. Service fees should be coupled with capital improvements and/or budget contributions.

Insurance surcharge – City-level funding – Mid-term option

New York City is an example city that recently enacted an insurance surcharge in order to support funding resilience-related improvements. This could be applied at the city level and potentially be risk adjusted.

Transfer Tax – DRI-level funding – Mid-term option

A transfer tax may be a beneficial model within a DRI in order to mitigate risk of gentrification and also exact contributions from new property owners commensurate to the avoided risk share that the buyer has adopted through the purchase.

Insurance and Risk-Adjusted Premiums – DRI-level funding – Longer term funding option

Insurance with risk-adjusted premiums prices actual risk, which is then reduced through implementation of resilience projects and policies. Cost savings from reduced premiums can be used to repay loans for resilience measures. The alternative to a statewide risk-adjustment model is an umbrella policy model: a voluntary agreement between property owners to pool resources, umbrella insurance policies, and share the responsibility of implementing and maintaining flood risk mitigation measures that will protect all members and create cost savings for all. Before implementing on a large scale, a feasibility study and pilot for the umbrella model could be applied through the South Boston DRI, possibly including municipal properties only. This option does not seem as viable in the near-term as others and may only be worth exploring if service fees and insurance surcharges are untenable.

Figure 32 and Figure 33 provide a visual overview of how multiple different funding sources could be leveraged into the DRI configurations presented in **Section 5.3.2 Potential DRI configurations**.

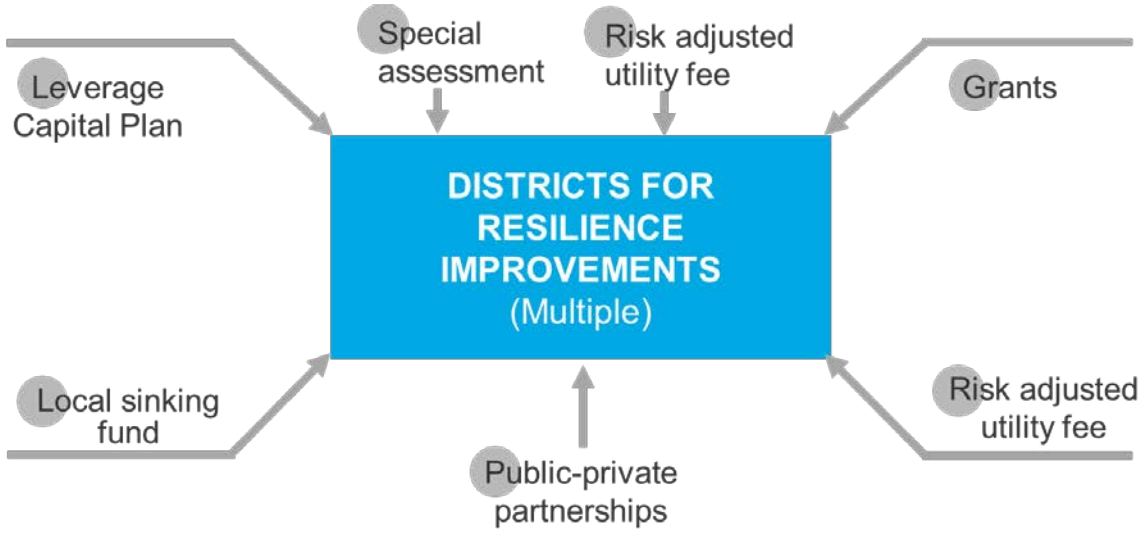

Figure 32 Example DRI funding mechanisms under the multiple DRIs within the city DRI configuration described in Section 5.3.2 Potential DRI configurations

Figure 33 Example DRI funding mechanisms under the single DRIs within the city DRI configuration described in Section 5.3.2 Potential DRI configurations

5.5.4 Recommendations based on the preliminary cost share analysis

We conducted the cost share analysis experiment in order to begin to test the hypothesis that a risk adjusted cost share approach may support cost share allocation decision making, as well as establish a rational nexus for revenue generation. While intended to be preliminary and refinement is needed, the results seem to indicate we are on the right path and are promising enough to warrant continued evaluation. Based on this preliminary assessment, we recommend the following actions:

1. Continue to investigate the feasibility of this approach through the following steps:
    - Integrate additional benefits and data, where possible:
        - Consider integrating value added benefits (e.g., new open space for certain planned long-term improvements)
        - Confirm and update asset specific data, as applicable (for example, loss of function values for infrastructure, consider integrating rental rate variation)
        - Refine the methodology for calculating costs associated with beach erosion
        - Integrate additional financing options and scenarios as this affects costs to be shared
        - Calculate proxy benefits identified in the uncalculated pool. There are federal methodologies available for each
    - Ground truth the assumption that 40 percent of the cost may be shared publicly (State, Federal, Municipal) over and above the site-specific benefits currently calculated. We hypothesize that much of this cost should be borne by the State and Federal government, but further research into precedent and rational nexus is needed.
    - Conduct an analysis to linking shares to funding mechanisms (i.e., property taxes, utility rates, subway, bus, and rail tickets, etc) to understand scenario and general cost burdens to citizens.
    - Pilot the approach across the city to understand to what extent results and individual payer burden may change.
2. Evaluate the feasibility of collecting data that would facilitate quantitative risk assessment, and thus increase the accuracy of cost share evaluations, as part of existing data collection processes (for example, as part of the property appraisal process).
3. Pilot the cost share evaluation approach citywide in order to better understand potential payer burden. This would require calculating the total pool of risk and costs as has been done in South Boston, but on a citywide basis, likely further increasing equity over time.
4. Consider the preliminary results in conversations with potential payers to facilitate funding decisions and advance implementation.

5.6 Recommendations Track 2 immediate actions

While Recommendations Track 2 proposes a series of actions that will apply over a longer-term time horizon, beginning approximately in the 2023 and evolving into the 2030s and beyond, work on development of these approaches must begin today. This work involves the following immediate actions that the City can undertake:

- Establish coastal resilience performance/design standards (also recommended under Recommendations Track 1)

- Incorporate codification of district-scale flood mitigation into Flood Resilience Zoning Overlay District (also recommended under Recommendations Track 1)
- Build on pilot cost share analysis undertaken for this Project by developing a citywide analysis of the cost share approach, including additional refinement of payers and payment mechanisms
- Vet and further develop CBP3, DRI framework, and cost share approach with local and state stakeholders

6 SUMMARY OF RECOMMENDATIONS

The *Climate Ready Boston* process has created an excellent foundation on which to build to implement coastal resilience strategies in South Boston and elsewhere across the city. Implementation will require ongoing collaboration between the public and private sectors, and creative approaches to leveraging existing funding, governance, and regulatory mechanisms to ensure coordinated and consistent project delivery in accordance with the plans outlined in *Coastal Resilience Solutions for South Boston*.

Effectively advancing implementation on the City's published timelines will require substantial political will and a coalition of stakeholder and champions working together, starting today, to foster near-term project delivery and, ultimately, to bring about necessary transformative changes in our governance, regulatory, and funding approaches.

Figure 34 provides a summary of the recommendations and next steps contained in this report separated across Recommendations Tracks 1 and 2. As described, the recommendations and next steps provided under Track 1 are intended to be immediately actionable approaches for continuing to advance project delivery by maximizing the utility of the existing governance, funding, and regulatory tools. Under Track 2, recommendations provide actions with longer-term applicability and with the potential to adapt to district- or city-wide models for governance, funding, and regulation to advance substantial investment in coastal flood mitigation infrastructure. Planning for Track 2 actions should begin today in concert with ongoing work under Track 1 with key early actions creating the frameworks and capacities necessary to accelerate adoption of longer-term approaches.

Figure 34 Summary of key recommendations along Policy Tracks 1 and 2

Arcadis U.S., Inc.

www.arcadis.com

Boston Green Ribbon Commission

www.greenribboncommission.org

Boston Green Ribbon Commission

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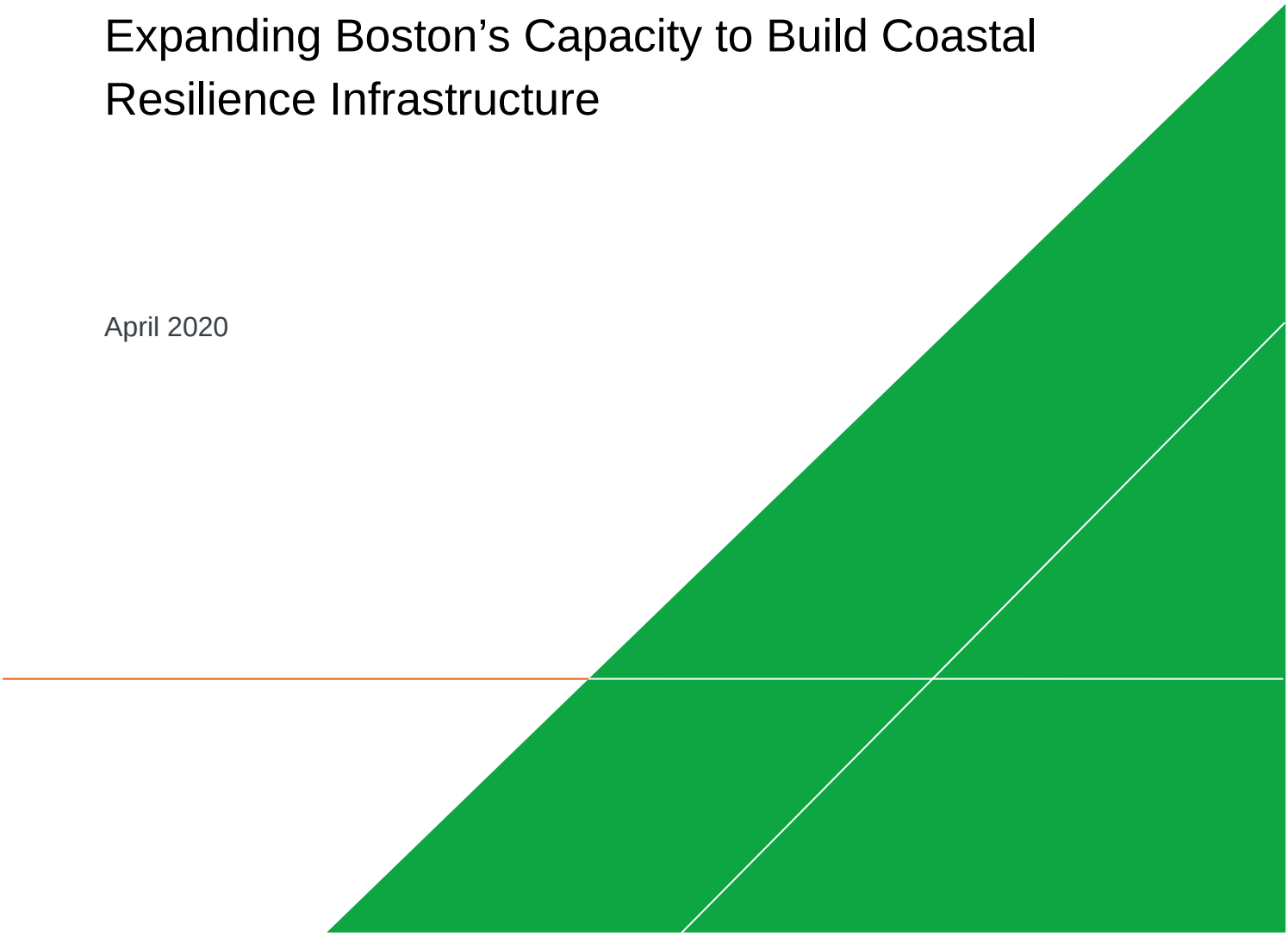
Boston Green Ribbon Commission

APPENDIX A CASE STUDIES

Expanding Boston's Capacity to Build Coastal Resilience Infrastructure

April 2020



CONTENTS

1 OVERVIEW

In preparation for developing governance and financing recommendations, the Project team conducted a literature review to catalogue and cross-compare existing and conceptual governance approaches and financing models. This literature review included closer investigation into a handful of case studies demonstrating how different revenue sources, financing instruments, and governance structures can, and have been, used to successfully implement coastal resilience solutions at the scale of a district, city, state, or region. Governance and funding responsibility and accountability for implementation of each stage gate of a coastal flood risk mitigation project can be thought of as occurring across a range of spectrums (see **Figure 1**). These spectrums were used as a common language with which to understand and cross-compare the case studies.

Figure 1 - Governance, Funding, Regulatory Spectrums for Coastal Resilience Implementation

2 MASSACHUSETTS: MASS SAVE PROGRAM

2.1 What Is It?

Mass Save is a Massachusetts state-level program that aggregates public funds to provide financial assistance to property owners for private investments in site-specific retrofits. It is designed to further incentivize private investments in energy efficiency by providing free residential energy audits, zero-interest loans, and rebates on efficient equipment.[1] The program is funded by a system benefits charge (SBC) on electricity bills.

2.2 How Does It Approach Governance and Finance?

This case study is an example of a funding source utilizing low-cost loans and rebates. It can be typified based on the governance and funding spectrums identified in **Figure 1** in the following ways:

- **Responsibility:** Publicly funded to leverage private investment and implementation.
- **Governance Scale:** The funding mechanism collects SBCs uniformly at the state-level. Program use is tailored and site-specific.
- **Governance Structure:** The program structure is flexible insofar as it can play a role in a variety of different approaches for governance to implement resilience solutions and project delivery.
- **Participation:** The funding mechanism is compulsory. Program use is voluntary.
- **Cost Burden:** The SBC is paid by all on their electricity bills based on their level of consumption. This enables a broad sharing of costs for a public benefits program that is largely, but not exclusively, available to lower-income property owners and those with limited financial capacity to undertake retrofits.

2.3 Lessons Learned for South Boston

This program or a similar type of financing structure could be extended to resilience-related projects at the building- or site-scale, potentially funded with a charge on water and sewer bills, as recommended by the UMass Boston Sustainable Solutions Lab financing report.[2] It would need to be available statewide or on a municipal level, rather than at a district scale. This type of approach would support the following options and recommendations made in the main report:

- Clarify near-term view on public/private cost share
- Leverage range of public and private funding sources
- Methods of payment:
    - Citywide surcharges or fees

[1] Sustainable Solutions Lab. 2018. *Financing Climate Resilience: Mobilizing Resources and Incentives to Protect Boston from Climate Risks*.

[2] Ibid.

3 CALIFORNIA: SAN FRANCISCO GENERAL FUND DEBT/CAPITAL PLANNING PROGRAM

3.1 What Is It?

The City of San Francisco plans to use a $350 million general obligation (G.O.) bond, backed by the City's property tax revenue, to fund a Seawall Fortification project, as proposed in the City's 10-Year Capital Plan.[3] The City also leverages its Capital Plan to channel existing funds for ongoing capital costs while generating revenue to issue debts to finance large capital projects, such as the Seawall Fortification project. Capital sources leveraged include: various long-term debt programs (inclusive of the G.O. bond and revenue bonds); a Pay-As-You-Go (Paygo) Program that draws on a General Fund comprised of property, sales, business, and hotel taxes collected at the city-level; a separate, revolving Capital Planning Fund that supports critical project development outside the regular General Fund budget; development impact fees for specified planning areas; and additional local sources designated for specific purposes.[4]

3.2 How Does It Approach Governance and Finance?

This case study is an example of a comprehensive funding source and financing approach utilizing existing structures and revenue sources to earmark funds for specific purposes. It can be typified based on the governance and funding spectrums identified in **Figure 1** in the following ways:

- **Responsibility:** Publicly funded. Potential to involve the private sector at various points in the process with public oversight.
- **Governance Scale:** Revenue is collected, and funds managed, uniformly on a citywide scale.
- **Governance Structure:** Fixed governance structure owing to its legal character, with some flexibility as to how funds are utilized.
- **Participation:** Participation is compulsory; however, there is potential for voluntary agreements to be reached in project implementation.
- **Cost Burden:** The variety of capital sources and nature of revenue sources utilized distribute the cost burden broadly across the City and over time, which likely reduces the overall cost burden per household while ensuring future beneficiaries of capital projects also bear some of the burden. Additionally, revenue generation is partially linked to property value.

3.3 Lessons Learned for South Boston

The City of Boston does issue general obligation bonds; however, these bonds are not secured by a particular source of revenue.[5] Rather than solely securing these G.O. bonds on the full faith and credit of the City, the City could consider tying funding to a dedicated revenue source, such as a citywide

[3] San Francisco Office of Resilience and Capital Planning. (2017). City and County of San Francisco Proposed Capital Plan: Fiscal Years 2018-2027.

[4] San Francisco Office of Resilience and Capital Planning. 2020. "ONESF: The Capital Plan 05. Capital Sources." Available online at: https://onesanfrancisco.org/the-plan-2018/capital-sources.

[5] City of Boston. 2014. "General Obligation Bonds." Available online at: https://www.cityofboston.gov/treasury/bonds/.

resilience fee[6] or other surcharge or fee based on the governance model for Boston's Community Preservation Act (CPA). Additionally, in 2018, the City of Boston pledged 10% of new revenue in the capital budget toward climate resilience, though the types of eligible projects have yet to be clarified. As described in the main report, such revenue, budget contributions, and other existing funding sources could go toward a sinking fund similar to San Francisco's General Fund but earmarked specifically for resilience and managed through a citywide Districts for Resilience Improvements (DRI) model or, to achieve a more tailored governance model, through a City Resilience Committee that coordinates district-scale investments. This type of approach would support the following options and recommendations made in the main report:

- District-scale DRIs coordinated by Citywide Resilience Committee
- Citywide DRI model
- Methods of payment:
    - Paygo
    - Citywide surcharges or fees
    - Service fees

4 MARYLAND: PRINCE GEORGE'S COUNTY CLEAN WATER PARTNERSHIP (CWP)

4.1 What Is It?

The Clean Water Partnership (CWP) is an innovative community-based public-private partnership (CBP3) program adopted by Prince George's County, Maryland to modernize and retrofit its stormwater infrastructure.[7] The CWP leverages private sector resources to pursue a public vision, seeking to meet and exceed regulatory requirements and promote operational efficiency and innovation in design, construction, and maintenance, while also furthering the County's commitments toward economic growth and environmental stewardship. The governance structure for the CWP is founded in a Master Program Agreement and Master Maintenance Agreement with a private firm (Corvias) contracted as the program manager, outlining Corvias' responsibilities for implementation and maintenance of green infrastructure best management practices (BMPs) over clear timeframes. Corvias' compensation is performance-based, including a base fee for successful project implementation and an additional incentive fee for meeting the County's socioeconomic goals. The County's Clean Water Act Fee, a stormwater utility fee, serves as the dedicated funding source for the CWP.

4.2 How Does It Approach Governance and Finance?

This case study is an example of a community-based public-private partnership (CBP3) and Master Program Agreement governance structure for implementation and maintenance. It can be typified based on the governance and funding spectrums identified in **Figure 1** in the following ways:

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[6] Wong, A. 2019. *Strategies to Advance Investments in Coastal Resilience Solutions in Boston*. Master's Thesis at the Massachusetts Institute of Technology.

[7] Prince George's County Department of Environment. 2016. *Prince George's County's Approach to Meeting Regulatory Stormwater Management Requirements*. Available online at: https://thecleanwaterpartnership.com/wp-content/uploads/2016/06/PGC-CBP3-Clean-Water-Partnership.pdf.

- **Responsibility:** Publicly funded with private Design-Build-Operate-Maintain responsibilities.
- **Governance Scale:** Involves uniform funding, implementation, and maintenance at a citywide scale. However, this model could be adapted to reach partnership agreements at varying scales.
- **Governance Structure:** Uses a relatively fixed formal contractual agreement as the basis for its governance structure with a fixed funding mechanism. However, it is flexible insofar as this approach can accommodate different styles of and distributions of responsibility for financing, implementation, and O&M, and can take on multiple iterations.
- **Participation:** Participation is compulsory once the agreement is reached; however, entering into the agreement is voluntary.
- **Cost Burden:** Distributes the cost burden across the City to all properties through a stormwater utility fee, which likely reduces the overall cost burden per household. Ultimately, however, whether the distribution of beneficial outcomes against cost is equitable for this type of approach is highly dependent on the equitability of the planning process.

4.3 Lessons Learned for South Boston

This model could be adapted to enable the City of Boston to enter into a Program Management Agreement with a private entity to build, or, more likely, operate and maintain resiliency infrastructure across the City over a set time period. It could also be adapted into a Program Management Agreement or Master Developer Agreement to construct and maintain resiliency infrastructure in a certain district or flood-prone area, utilizing a performance-based fee structure to compensate the program manager. Such an approach could also integrate with the citywide District for Resilience Improvements (DRI) model described in the main report; for example, a DRI could manage one or more CBP3 programs to advance project delivery. This type of approach would support the following options and recommendations made in the main report:

- Agreements with property owners in urgent action areas of Fort Point Channel
- Project delivery approach: Community Based Public-Private Partnership (CBP3)
- Methods of payment:
    - Service fees

5 MASSACHUSETTS: NORTHAMPTON STORMWATER AND FLOOD CONTROL UTILITY FEES

5.1 What Is It?

In recent years, the City of Northampton, Massachusetts, received directives from the USACE and EPA to invest in flood control and stormwater management projects. The City implemented a stormwater and flood control utility fee in 2014 as a new source of dedicated revenue to fund operations and capital projects around the City. The fee is a fee for service, like a water or sewer fee; all property owners participate, including the non-profit sector and City properties, given all land produces stormwater runoff. Property owner contributions are proportional to the amount of impervious surface area producing runoff, with the billing rate approved each year by the City Council.

5.2 How Does It Approach Governance and Finance?

This case study is one example amongst many others of a fee-based funding model to fund infrastructure and other programs. It can be typified based on the governance and funding spectrums identified in **Figure 1** in the following ways:

- **Responsibility:** Publicly funded. Potential to involve the private sector at various points in the process with public oversight.
- **Governance Scale:** Involves uniform funding at a citywide scale.
- **Governance Structure:** The City formally manages and implements the projects using a fixed funding mechanism in order to meet federal regulatory requirements.
- **Participation:** Participation is compulsory.
- **Cost Burden:** Distributes the cost burden across the City to all properties based on impervious area calculation.

5.3 Lessons Learned for South Boston

There is frequent ongoing discussion about using a stormwater or flood control fee to fund resiliency and flood control infrastructure in Boston. A fee on water or sewer bills could be used as a funding stream for projects selected through a formal vetting or selection process. Projects constructed on private property could qualify for credits or a rebate proportional to their contribution to citywide resiliency objectives. This type of approach would support the following options and recommendations made in the main report:

- Leverage range of public and private funding sources
- Methods of payment:
    - Service fees

6 WASHINGTON: KING COUNTY FLOOD CONTROL DISTRICT

6.1 What Is It?

The King County Flood Control District is a special purpose (taxing) government created to provide funding and policy oversight for flood protection projects and programs in King County, Washington.[8] The Flood Control District's Board is composed of the members of the King County Council. The Department of Natural Resources and Parks carries out the approved flood protection projects and programs under an interlocal agreement. The District manages the River Management Program, which is funded from a countywide property tax levy called the River Improvement Fund (RIF) levy. The RIF levy is part of the County's overall property tax assessment and is collected from both incorporated and unincorporated properties. The District then uses this revenue to award grants through various programs.

6.2 How Does It Approach Governance and Finance?

This case study is an example of a district-scale governance structure and funding model for flood mitigation investments. It can be typified based on the governance and funding spectrums identified in **Figure 1** in the following ways:

- **Responsibility:** Publicly funded and governed. Potential to involve the private sector in project implementation.
- **Governance Scale:** Involves county-wide uniform funding and oversight.
- **Governance Structure:** The District is a fixed governing body with powers of taxation and managerial authority over a dedicated sinking fund.
- **Participation:** Participation is compulsory; however, there is potential for voluntary agreements to be reached in project implementation.
- **Cost Burden:** Distributes the cost burden across the district, which in this case is countywide. Revenue generation is linked to property value. However, this is not an example of a longer-term financing approach that would distribute the cost burden across time; the funds are levied and subsequently awarded via grants. Applied elsewhere, the equitability of the cost burden distribution borne by this type of model would depend in part on the scale of implementation and the specific method of revenue generation (e.g., the degree to which revenue collection is directly linked to benefits).

6.3 Lessons Learned for South Boston

Revenue collected on a citywide (as opposed to countywide) basis in Boston could be managed transparently through a City Resilience Committee, based on the governance model for the Community Preservation Act (CPA). The Resilience Committee could establish a sinking fund similar to King County's River Improvement Fund with citywide funding earmarked for resilience, such as a carbon surcharge, sales tax, grants, and/or Paygo, and allocate funding to multiple District Resilience Improvements (DRIs) established in several neighborhoods to support resilience in multiple areas at once. The Resilience

[8] King County Department of Natural Resources and Parks. 2020. "King County Flood Control District." Available online at: https://www.kingcounty.gov/services/environment/water-and-land/flooding/flood-control-zone-district.aspx.

Committee could be formed by representatives of DRIs, city agencies, the Mayor's Office, infrastructure agencies, and other key stakeholders, for example. The City of Boston can use lessons learned from the CPA and establish a similar surcharge and management system for citywide resilience. This type of approach would support the following options and recommendations made in the main report:

- District-scale DRIs coordinated by Citywide Resilience Committee
- Citywide DRI model
- Methods of payment:
    - Citywide surcharges or fees

7 NEW YORK METROPOLITAN AREA: REGIONAL RESILIENCE COMMITTEE & TRUST FUND

7.1 What Is It?

The Regional Resilience Committee is a regional financing and governance structure currently being explored by the New York Metropolitan Area's Regional Plan Association (RPA) under the Fourth Regional Plan.[9] The structure would consist of a series of state trust funds designed to provide financial products to support resilience efforts. The financial model, known as a Regional Resilience Trust Fund (RRTF), would be governed by a Regional Resilience Commission (RRC) made up of political appointees from the states of New York, New Jersey, and Connecticut who would serve as stewards of each state's respective trust fund. A Regional Coastal Commission (RCC) would coordinate adaptation strategies undertaken by coastal communities, develop and manage adaptation standards, and prioritize projects for funding based on the potential for region-wide resilience. Funding would come primarily from Adaptation Trust Funds serving as public benefit corporations for NY, NJ, and CT and funded by surcharges on insurance premiums, but the commission could also prioritize projects funded from other federal and state sources. These trust funds would finance resilience investments via reserve fund direct investments, bond service debt, and loans to local borrowers. Under this model, the RRC would serve as a third-party asset manager for all three state trust funds, with responsibilities including the underwriting and approving of loans and grants.[10]

7.2 How Does It Approach Governance and Finance?

This case study is an example of a concept for a regional financing and governance structure to collectively manage and coordinate dedicated funds for resilience investments at multiple scales. It can be typified based on the governance and funding spectrums identified in **Figure 1** in the following ways:

- **Responsibility:** Publicly funded and governed. Potential to involve the private sector in project implementation.
- **Governance Scale:** Involves regional management of funds collected uniformly at the state level.

[9] Regional Plan Association. 2017. *Coastal Adaptation: A Framework for Governance and Funding to Address Climate Change.* Available online at: http://library.rpa.org/pdf/RPA-Coastal-Adaptation.pdf.

[10] Keenan, J.M. 2017. Regional Resilience Trust Funds: An Exploratory Analysis for Leveraging Insurance Surcharges. *Environment Systems and Decisions*.

- **Governance Structure:** Depends on implementation. Potential for it to take the form of a formal/semi-formal chartered agreement or network or to become a more fixed structure governed by legal entities.
- **Participation:** Theoretically, the Adaptation Trust Funds could opt in or out, but revenue collection would be compulsory. High-level oversight and coordinated implementation would also require more binding participation on the part of property owners.
- **Cost Burden:** Aligned with physical risk exposure due to the nature of the revenue source (insurance surcharge). The cost burden would be distributed statewide. An important consideration regarding the degree of equitability is the extent to which coastal property owners, who are at higher risk, cross-subsidize landlocked properties who are arguably less vulnerable to the effects of storm surge and sea level rise.

7.3 Lessons Learned for South Boston

In the longer-term, if the City of Boston undertakes a DRI approach or similar, the Trust Fund model could be applied at a citywide scale with varying possible levels of administrative complexity. A City Resilience Committee or coordinating entity, with a Climate Resilience Implementation Czar, could play the role of asset manager for district-level funds and work to ensure consistency and alignment in project delivery with the formalized *Coastal Resilience Solutions for South Boston* plan, similar to the roles of the Regional Resilience Commission and Regional Coastal Commission. Insurance surcharges as a revenue source would likely have to be implemented at a statewide level and could also be adapted to a risk-adjusted premium revenue model. In the longer-term, a regional or statewide approach may be desirable. In the medium-term, Boston may still be able to apply a similar trust fund model at the district or city level but may need to tap into alternative sources of revenue using the Community Preservation Act model. This type of approach would support the following options and recommendations made in the main report:

- Create a Climate Resilience Implementation Czar in City Hall
- Adopt and publicize the *Coastal Resilience Solutions for South Boston* plan
- Adopt performance-based design standards
- District-scale DRIs coordinated by Citywide Resilience Committee
- Citywide DRI model
- Methods of payment:
    - Insurance and risk-adjusted premiums
    - Citywide surcharges or fees

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APPENDIX B RISK ADJUSTED COST SHARE APPROACH

Methodology

Expanding Boston's Capacity to Build Coastal Resilience Infrastructure

April 2020

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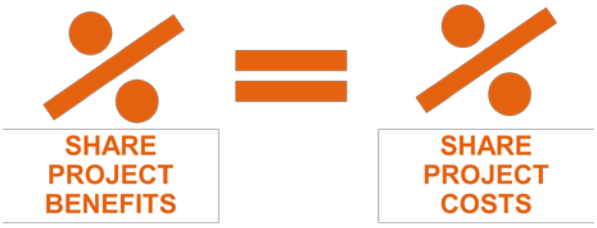
TABLES

FIGURES

PROCESS OVERVIEW

At its most basic, the risk adjusted cost share allocation approach assumes that the extent to which a particular entity benefits from flood protection infrastructure, in the form of risk reduction, it will also share costs toward construction and long term maintenance and operations of said infrastructure. In order to make such an approach work, all potential project beneficiaries should be identified.



In order to complete the cost share allocation experiment introduced in *Advancing Coastal Flood Risk Mitigation in Boston's Seaport District*, we followed a three-part process, described in more detail below.

Part 1: Calculate risk

1. Select flood hazard data
2. Select study area
3. Select risk and asset types to be included
4. Calculate losses for each flood elevation (methodologies)
    a. (by type)
5. Determine risk context to annualize based on
6. Annualize
7. Determine share of uncalculated benefits

Part 2: Determine appropriate cost

1. Determine costs to use
2. Schedule projects
3. Determine financing scenarios

Part 3: Calculate cost share allocation

1. Calculate share of cost based on share of benefits
2. Identify sectors and payer categories
3. Determine share of benefits per asset
4. Determine assessment time period
5. Calculate cost share in a variety of ways

Each part also includes the following sections:

- Assumptions that may affect results
- Future analysis improvements / next steps

1 CALCULATE RISK

1.1 Select flood hazard data

We used flood hazard data developed by Woods Hole Group for the Boston Harbor, as follows:

- Flood depth and elevation data developed as part of the 0 feet of sea level rise scenario with the baseline year of 2013. We used flood depths and flood elevations that correlate to the 10-percent, 2-percent, 1-percent, and .001-percent annual chance exceedance probabilities. These data were not modified from their original form, which required the exclusion of some date within the edge regions of flood extents due to data coarseness.

- Flood depth and elevation data developed as part of the 9 inches of sea level rise scenario (expected 2030). We used flood depths and flood elevations that correlate to the 10-percent, 2-percent, 1-percent, and .001-percent annual chance exceedance probabilities. These data were refined for site specific analysis using LiDAR and topographic data in *Climate Ready Boston* in 2016 according to the methodology associated with that report.

- Flood depth and elevation data developed as part of the 40 inches of sea level rise scenario (expected 2030). We used flood depths and flood elevations that correlate to the 10-percent, 2-percent, 1-percent, and .001-percent annual chance exceedance probabilities. These data were refined for site specific analysis using LiDAR and topographic data in *Climate Ready Boston* in 2016 according to the methodology associated with that report.

In addition, the *Climate Ready Boston* process in 2016 developed flood depths and elevations associated with a sea level rise scenario of 21 inches (expected year 2050) as an intermediary step to understand the progression of flood risk every 20 years through 2070. These data were developed by interpolating between the 9 inch and 40 inch sea level rise scenarios and produced expected depths per site associated with the 10-percent, 2-percent, 1-percent, and .001-percent annual chance exceedance probabilities with 21 inches of sea level rise.

This yielded 16 potential flood depths per site that could be used to calculate losses and, therefore, risk.

1.2 Select study area

The study area for the cost share analysis experiment includes all properties that are expected to receive coastal flood mitigation as a result of the strategy outlined in *Coastal Resilience Solutions for South Boston.* This includes assets within the South Boston neighborhood, which includes sub-areas outlined in that study (Fort Point Channel, South Boston Waterfront, Seaport Boulevard, Marine Industrial Park, Pleasure Bay, and Day Boulevard), as well as portions of South End, which would benefit from flood mitigation actions along Fort Point Channel. The study excludes the following areas:

- Along the west side of Fort Point Channel, where flood mitigation has not been integrated into the overall strategy cost estimate
- Conley Terminal, which is being mitigated through an alternate strategy
- Moakley Park, which is being mitigated through an alternate strategy
- Portions of South End expected to flood through alternate flood pathways
- Assets not expected to flood, such as those interior to the historic South Boston neighborhood

Figure 1 provides a snapshot of the study area, as demonstrated by assets included in the analysis.

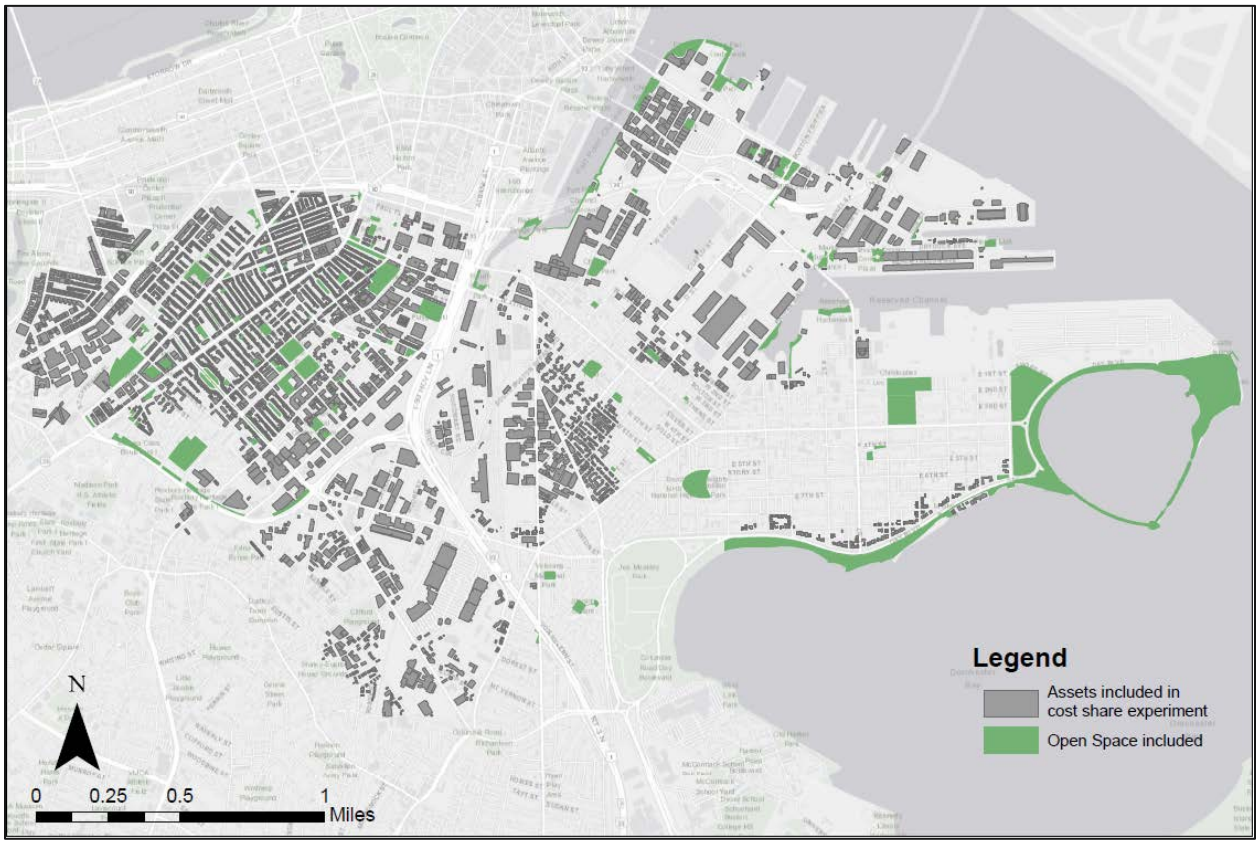


Figure 1 Study area and assets integrated into the analysis, by asset type

1.3 Select risk and asset categories to be included

The cost share allocation experiment integrated the risk categories and asset categories outlined in Table 1, which also identifies the source of data and calculations used in the experiment. The final column is expanded upon in more detail in **Section** Error! Reference source not found. **Calculate losses for each flood elevation (methodologies)**.

Table 1 Asset types, risk categories, and source of calculations integrated into the cost share allocation experiment

Asset type	Risk category	Source of calculations
Buildings	Direct physical damages to structure, contents, inventory Displacement / relocation costs Direct business interruption Mental stress and anxiety, lost productivity (residential only)	*Coastal Resilience Solutions for South Boston*
Parks	Direct physical damage Loss of service	New calculations completed for this analysis
Essential and public facilities (e.g., libraries, schools, hospitals, police, fire, etc)	Loss of service ONLY (unless there is a building associated with the asset, in which case, damage is captured in "Buildings" category	New calculations completed for this analysis
Critical facilities (e.g., power, transportation, water, wastewater, stormwater pumping)	Loss of service ONLY (unless there is a building associated with the asset, in which case, damage is captured in "Buildings" category	New calculations completed for this analysis
Indirect / Uncalculated Benefits[1]	Indirect business interruption (reverberating impacts) Property value, income tax, sales tax retention Injuries and fatalities (casualties) Roads	Assumed to be ~40% of total risk

We mapped each asset to a "Quick Category" based on Climate Ready Boston assigned quick category, as well as ownership and use type. The Quick Categories included:

- BHA
- BRA
- City of Boston
- Commercial
- Commonwealth of Massachusetts
- Cultural/Religious
- Essential Services
- Education / University
- EMS
- Essential Services
- Food Supply

[1] Social, environmental, and economic value added are also not included in the analysis

- General Government
- Hospital
- Industrial
- MBTA
- MassDOT
- Massport
- Mixed Use
- Parking and Storage
- Power
- Private Property Owner / Tenant
- Residential
- Recreational
- Transportation
- USA
- Utility
- Water and Wastewater

1.4 Calculate losses for each flood elevation (methodologies)

Buildings

Loss estimates for buildings are based on *Climate Ready Boston* buildings and population data from within the South Boston study area, with updates for *Coastal Resilience Solutions for South Boston*. The loss estimates are based on the current building stock inventory as of 2018, population data used in *Climate Ready Boston*, and do not include avoided emergency response costs or expected future development, property values, or population.

Table 3 provides an overview of the data and methodologies used for the analysis.

Table 2 Data and methodologies used to calculate loss types associated with buildings

Loss type	Data	Methodology
Direct physical damages to structure, contents, inventory	USACE North Atlantic Coast Comprehensive Study depth damage functions and assumptions Grade elevation data (2009 LiDAR, survey, where available) 2016 RS means, increased to 2019, for building and contents values Building stock developed for *Climate Ready Boston* and updated with any completed construction and available survey data for *Climate Ready South Boston* Square footage is based on the number of floors in each building and the building footprint.	Mapped building use types to appropriate damage functions Calculated square footage appropriate for use in the specific damage function Calculated building and contents replacement costs for the square footage analysis for each structure Correlated percent loss to the building and contents for each site for each of the available 16 flood elevations Calculated direct physical damage to structure and contents in dollars for each structure for each flood elevation based on percent loss
Displacement / relocation costs	Average commercial and residential rental rates for South Boston in 2019 based on Zillow and Loopnet FEMA Benefit Cost Analysis Depth to Displacement functions	Mapped building use types to appropriate damage functions Calculated square footage appropriate for use in the specific damage function

Loss type	Data	Methodology
	Building stock data (see above) One-time displacement assumptions Calculation for relocation and displacement costs sourced from FEMA Benefit Cost Analysis methodologies	Calculated rental rates and one-time displacement based on square footage analysis for each structure Correlated displacement period to each site for each of the available 16 flood elevations Calculated one-time displacement and relocation rental costs for each structure for each flood elevation based on expected displacement and period of displacement
Direct business interruption	IMPLAN data for 2016 Restoration periods sourced from FEMA Hazus Technical Manual Restoration multipliers[2] sourced from FEMA Hazus Technical Manual Buildings and building use data	Mapped building use types to appropriate restoration functions (developed based on interpolation of restoration periods) Mapped building use types and expected damage percentage to appropriate loss of function multipliers Mapped building uses to IMPLAN categories Per zip code, obtained output data per IMPLAN category type Determined per SF annual output per IMPLAN category per zip code Calculated share of annual output per building based on use and proportionate share of square footage per IMPLAN category per zip code Determined period of direct business interruption based on percent damage multipliers by building use and restoration period functions Calculated direct business interruption based on period of direct business interruption and square footage per building

[2] These multipliers account for variation in business resilience to structure damage. For example, some businesses can continue business in a new location (i.e., accounting office) while others cannot (i.e., movie theatre).

Loss type	Data	Methodology
Mental stress and anxiety, lost productivity (residential only)	*Climate Ready Boston* population data FEMA Benefit Cost Analysis figures for mental stress and anxiety, lost productivity	Distributed population and housing units based on population data using total residential square footage per building as share of total residential square footage per census tract and population per census tract, cross-checked with units and census data of persons per unit Determined residential units exposed to flooding Calculated mental stress and anxiety and lost productivity using FEMA standard values

Parks

We downloaded the open spaces GIS shapefile from the City of Boston's Analyze Boston open data website[3] and selected parks and open spaces in the study area expected to experience risk reduction as a result of the *Climate Ready South Boston* strategy. We cross-referenced this with Parks and Recreation's Open Space & Recreation Plan 2015-2021[4] to clarify areas owned by the City of Boston, the United States of America, Boston Housing Authority, Boston Redevelopment Authority, MBTA, Commonwealth of Massachusetts, Boston Water & Sewer Commission, Massport, MassDOT, and community groups/non-profits.

Loss of function at various flooding depths was determined using depth damage functions for parks and open space developed for a similar project in a similar urban area, and a GIS analysis of the total park square footage impacted at each of the 16 flood depths. The operating budget per park square foot of $4.34 was determined based on the City of Boston's Parks & Recreation Departments operating budget of $23,548,202.00[5] and total City owned park square footage of 2,346.[6] The park replacement value was determined to be $115 per square foot based on cost estimates for recent park improvement, repair, and development projects in the northeast. Due to limited availability of data, all parks and open space values were calculated using the data available from the City of Boston and the average value developed based on engineer judgment and previous projects.[7]

[3] https://data.boston.gov/dataset/open-space
[4] https://documents.boston.gov/parks/pdfs/OSRP_2015-2021.pdf
[5] https://www.boston.gov/departments/parks-and-recreation
[6] https://data.boston.gov/dataset/adopted-operating-budget
[7] An improvement to this evaluation for beach properties would be the use of depth damage functions and values specific to beaches, such as expected volume of removal and nourishment costs.

Essential, public, and critical facilities

We integrated the following essential, public, and critical facilities into the cost share analysis:

- Libraries
- Fire stations
- EMS
- Police stations
- Hospitals
- Schools
- Utility
- Water and wastewater
- Transportation (Subway

Any facility that has a building associated with it received direct physical damage calculations as part of the buildings evaluation described in Table 3. For critical facilities with expensive specialized equipment, like substations at wastewater treatment plants, for example, the direct physical damage calculations may thus be conservatively low.

Nevertheless, the value of essential, critical, and other public facilities predominantly lies in the services such facilities provide to the public. As such, analysts calculated expected loss of function for these assets based on the expected period of direct business interruption at each flood depth scenario. As described in Table 3 above, direct business interruption can be calculated based on percent damage multipliers by building use and restoration period functions sourced from FEMA's Hazus documentation. Next, we multiplied the expected period of disruption by the value of the service provided by the essential, critical, or other public facility per day to determine expected loss of function.

Each type of facility required a unique methodology to determine the value of service per day based on the specifics of the asset type. We sourced most methodologies from FEMA benefit cost analysis approaches. Table 4 provides an overview of the infrastructure type, data, source, and approach used to calculate daily service value per asset. In many cases, site specific data were not available and proxies or estimates had to be used. For example, we used operating budget as a proxy for police, fire, EMS, and schools, which will yield conservatively low results for the full value of these assets to the service population.

Table 3 Approach to calculating daily service value for essential, critical, and public facilities integrated into the analysis

INFRASTRUCTURE TYPE	APPROACH	SERVICE POPULATION DATA SOURCE	ANNUAL VALUE SOURCES
Libraries	Divide the total operating income per library by the number of libraries in the City of Boston. This number was then divided by 365 to determine the value per day. Only branches of the Boston public library were included in the analysis.	N/A for calculation. Annual visitors for 2017 by location[8]	Total Boston Public Library Operating Budget FY19[9]

[8] https://www.bpl.org/about-us/statistics/
[9] https://mblc.state.ma.us/programs-and-support/library-statistics/index.php

INFRASTRUCTURE TYPE	APPROACH	SERVICE POPULATION DATA SOURCE	ANNUAL VALUE SOURCES
Fire stations	Divided the City fire department annual operating budget by the number of stations (34) to determine how much of the budget could be allocated per station per year. Only City of Boston fire stations were included in the analysis	South Boston and South Boston Waterfront Population (via BPDA) [10] South End Population[11]	Fire Department Operating Budget[12] FY19[13]
EMS	Divided the operating budget for EMS FY17 by the total number of EMS stations.[14][15] This number was divided by 365 to determine the value per day. Only EMS stations in the study area were included in the analysis.	South Boston and South Boston Waterfront Population (via BPDA) [16]	Total operating budget FY17[17]
Police stations	Divided the police department operating budget by the total number of police stations. This value was then divided by 365 to determine the value per day. Only Boston City police were included in the analysis. State, Port Authority, and Amtrak police were excluded.	South Boston and South Boston Waterfront Population (via BPDA) [18]	Police Department Budget (from City of Boston FY19 Operating Budget) [19]
Hospitals	The hospital's operating budget was divided by 365 to determine the value per day. The Boston Medical Center campus was counted as one entity. Medical schools teaching campuses were not included.	Service Population for City of Boston[20] Primary service area: South Boston, Dorchester, Chinatown = roughly 130,000 people (4444 Chinatown, 85000 Dorchester, 35000 South Boston) [21] [22]	Total operating budget FY18 (per financial statements) [23]

[10] http://www.bostonplans.org/getattachment/f719d8d1-9422-4ffa-8d11-d042dd3eb37b
[11] http://www.bostonplans.org/getattachment/f719d8d1-9422-4ffa-8d11-d042dd3eb37b
[12] https://data.boston.gov/dataset/adopted-operating-budget
[13] https://data.boston.gov/dataset/employee-earnings-report
[14] http://www.umassmedia.com/news/boston-ems-budget-proposal/article_2bbf22ac-1409-11e6-bab1-379ac94bbfda.html
[15] https://www.boston.gov/sites/default/files/document-file-02-2017/boston_ems_szp_082616.pdf
[16] http://www.bostonplans.org/getattachment/f719d8d1-9422-4ffa-8d11-d042dd3eb37b
[17] https://www.boston.gov/sites/default/files/document-file-04-2019/2018_boston_ems_vital_stats.pdf
[18] https://data.boston.gov/dataset/employee-earnings-report
[19] https://www.governing.com/gov-data/safety-justice/police-officers-per-capita-rates-employment-for-city-departments.html
[20] https://www.bphc.org/healthdata/other-reports/Documents/Healthcare%20Access%20Report%20FINAL.pdf
[21] https://www.census.gov/quickfacts/bostoncitymassachusetts
[22] https://www.tuftsmedicalcenter.org/-/media/Brochures/TuftsMC/About-Us/Institutional-MasterPlan.ashx?la=en&hash=011383077FC298430C008415D42B119EC62BBCDC
[23] https://www.bmc.org/sites/default/files/About_Us/Commitment_to_Our_Community/field_Attachments/BMC-Community-HealthNeedsAssessment-HNA.pdf

INFRASTRUCTURE TYPE	APPROACH	SERVICE POPULATION DATA SOURCE	ANNUAL VALUE SOURCES
Schools	Divided school operating budget by the number of students enrolled to determine value per person. For Catholic and private schools where budget was not available, the average public school cost per student was multiplied by total enrollment to determine average cost per student. This number was then divided by 365 to determine value per day.	School enrollment 2019[24][25]	School operating budget
Electric Utility	We estimated service population based on plant capacity. The average annual electricity consumption for a U.S. residential utility customer in 2017 was 10,399 KWh, an average of 28.5 kWh per day. This converts to 1.18kw per household per day. The M Street Jet energy plant has a capacity for 47 MW (47,000 kW) meaning it has capacity to serve 1,649 households per day (47,000/28.5), or an estimated 3,981 people[26] (based on an average 2.36 people per household from the 2018 American Community Survey) [27] [28] Impacts on economic activity is estimated using Gross Domestic Product (GDP) dollar values combined with "importance factors" for each economic sector. The importance factors used by FEMA are from a study by the Applied Technology Council on the impact of power outages due to earthquakes to various sectors. While FEMA used national GDP values for their analysis, regional GDP data was used according to the methodology to determine the impact to economic activity per capita per day, summarized in tab Loss of Electric Service. See Table 5 below.		
Water & Wastewater	The capacity per plant was used to determine the value per person, which is the total service population of South Boston and South End. [29] This number was divided by the total number of wastewater pump stations, stormwater pump stations, or water pump stations in South Boston and South End.[30] [31] The per person per day value for wastewater service is described in Table 5.		
Transportation: Subways	Operating cost per ride was multiplied by the number of daily rides, based on data on entrances into each subway station. Fair per ride was calculated by multiplying the cost per ride by the number of entrances into each station per day. The fair per day was subtracted from the operating cost per day to determine the total public value per day. To determine the impact of loss of function of public transportation during the flooding scenarios, ridership data was collected for typical weekday station entries (exits were not included) from a 2014 MBTA "Ridership and Service Statistics" report for the stations in the project area.[32] Fare and cost per ride were collected from 2017 MTBA data.[33] Operating cost per ride was multiplied by the number of daily rides, based on data on entrances into each subway station. Fair per ride was calculated by multiplying the cost per ride by the number of entrances into each station per day. The fair per day was subtracted from the operating cost per day to determine the total public value per day. Silver line cost per ride (trolleybus) = $6.07 per ride Red line Cost per ride (heavy rail) = $2.16 per ride		

[24] https://www.bostonpublicschools.org/cms/lib/MA01906464/Centricity/domain/184/budgetvisualization/index.html#/SchoolAllocationActivities/DistrictView
[25] https://www.upeducationnetwork.org/boston/
[26] https://www.census.gov/quickfacts/bostoncitymassachusetts
[27] https://www.eversource.com/content/docs/default-source/rates-tariffs/ema-greater-boston-rates.pdf?sfvrsn=c27ef362_38
[28] https://www3.epa.gov/region1/npdes/remediation/noi/2010/TheGilletteCompanySBMC2010NOI.pdf
[29] http://www.bostonplans.org/getattachment/b36845a3-7c7a-4a0b-9626-4bd89bb6f45b
[30] http://mwraadvisoryboard.com/wp-content/uploads/2019/05/AB_Operations-Comm-Presentation-May19.pdf
[31] http://www.mwra.com/cso/pdf/uparknews0904.pdf
[32] https://old.mbta.com/uploadedfiles/documents/2014%20BLUEBOOK%2014th%20Edition(1).pdf
[33] http://mbtaanalysis.com/index.php/compare-mbta/

Value of Wastewater Service – per person per day

To gain a better understanding of the specific impact to the local regional economy due to the loss of wastewater service to South Boston, the Team used regional economic data in place of national GDP data. South Boston is part of the Boston-Cambridge-Newtown, MA-NH (Metropolitan Statistical Area. Direct economic impact is estimated from the most recent Bureau of Economic Analysis' Gross Domestic Product dollar values, inflated to the current year value.[34] The GDP data is broken down by economic sector as defined by the North American Industry Classification Systems Economic Census.[35] The Team took GDP values for each economic sector and combined them with the importance factors for each sector from the FEMA-sponsored publication of the Applied Technology Council, Seismic Vulnerability and Impact of Disruption of Lifelines in the Conterminous United States, 1991 (ATC-25) in accordance with the methodology defined in FEMA's Benefit-Cost Analysis Re-engineering Version 6.0.[36]

Analysts divided the GDP data by the metropolitan statistical area population and 365 days in order to determine the GDP per capita per day. The analyst then multiplied the GDP per capita per day per sector by the wastewater service importance factor in order to determine the economic impact per capita per day of lost service in 2019 dollars. The economic impact of lost wastewater service per capita per day is $70.14

Population served was estimated based on the plant's capacity. The average annual electricity consumption for a U.S. residential utility customer in 2017 was 10,399 KWh, an average of 28.5 kWh per day. This converts to 1.18kw per household per day. The M Street Jet energy plant has a capacity for 47 MW (47,000 kW) meaning it has capacity to serve 1,649 households per day (47,000/28.5), or an estimated 3,981 people (based on an average 2.36 people per household from the 2018 American Community Survey).

To determine loss of function for the water and wastewater infrastructure, including sanitary sewage pump stations, headworks, storm pump stations, and the Union Park Pump Station, the value per day of lost wastewater service was multiplied the days of service loss for each scenario as determined by the flooding during each event.

Table 4 Value of Wastewater Service

Economic Sector	Electric Power Importance Factor	GDP (in millions of dollars)	GDP Per Capita	GDP Per Capita Per Day	Economic Impact Per Capita per Day of Lost Service
Construction	0.20	-			
Manufacturing - Nondurable Goods	0.65	-			
Manufacturing - Durable Goods	0.75	$ 25118.4	$5,184.83	$14.21	$10.65
Transportation and Warehousing	0.10	-	$0.00	$0.00	$0.00
Utilities	0.20	-	$0.00	$0.00	$0.00
Wholesale Trade	0.20	-	$0.00	$0.00	$0.00

[34] Federal Emergency Management Agency (FEMA). December 2011). *FEMA Benefit-Cost Analysis Re-engineering (BCAR): Development of Standard Economic Values, Version 6.0*. Washington, D.C.: FEMA.
[35] https://apps.bea.gov/iTable/index_regional.cfm
[36] Federal Emergency Management Agency (FEMA). (May 2001). *What is a Benefit? Guidance on Benefit-Cost Analysis of Hazard Mitigation Projects Draft Revision 2.0.* Washington, D.C.: FEMA.

Economic Sector	Electric Power Importance Factor	GDP (in millions of dollars)	GDP Per Capita	GDP Per Capita Per Day	Economic Impact Per Capita per Day of Lost Service
Retail Trade	0.20	$ 16678.1	$3,442.62	$9.43	$1.89
Real Estate, Rental, Leasing	0.20	$ 69375.2	$14,320.12	$39.23	$7.85
Finance and Insurance	0.20	$ 44445.9	$9,174.32	$25.14	$5.03
Information	0.20	$ 26096.9	$5,386.81	$14.76	$2.95
Professional, Scientific, & Technical Services	0.20	$ 59002.6	$12,179.05	$33.37	$6.67
Education, Healthcare, Social Assistance	0.80	$ 49119.3	$10,138.99	$27.78	$22.22
Arts, Entertainment, Recreation	0.80	$ 4873.5	$1,005.97	$2.76	$2.20
Accommodation & Food Service	0.80	$ 11824.1	$2,440.68	$6.69	$5.35
Other Services, Except Government	0.20	$ 7757.6	$1,601.29	$4.39	$0.88
Government	0.20	$ 39354	$8,123.28	$22.26	$4.45
TOTAL					**$70.14**

Value of Electric Service – per person per day

The loss of electric service for South Boston was calculated similarly to wastewater. Utilities considered included the M Street Jet Station, 3 NSTAR stations, and 3 substations. Impacts on economic activity is estimated using Gross Domestic Product (GDP) dollar values combined with “importance factors” for each economic sector. The importance factors used by FEMA are from a study by the Applied Technology Council on the impact of power outages due to earthquakes to various sectors. While FEMA used national GDP values for their analysis, regional GDP data was used according to the methodology to determine the impact to economic activity per capita per day, summarized in tab Loss of Electric Service.

In addition to impacts on industries, economic impacts to residential customers is calculated based on estimates of willingness-to-pay (WTP) to avoid power outages. The estimates that FEMA recommends using are from a Department of Energy study from 2003 that analyzed five major electric utilities over 15 years to assess the value of electric service to residential customers. From a total of 11,368 respondents, the average WTP to avoid a 12-hour outage was $26.27 in 2002 dollars. To adjust for a 24-hour outage and update for 2019 dollars, the cost per day becomes $74.70 per household, or $26.30 per capita.

Table 5 Value of Electric Service

Economic Sector	Electric Power Importance Factor	GDP (in millions of dollars)	GDP Per Capita	GDP Per Day	Economic Impact Per Capita per Day of Lost Service
Manufacturing - Nondurable Goods	0.98				
Manufacturing - Durable Goods	0.99	25118.4	$5,184.83	14.20500699	$14.06
Transportation and Warehousing	0.3				
Utilities	0.89				
Wholesale Trade	0.9				
Retail Trade	0.9	16678.1	$3,442.62	9.431831927	$8.49
Real Estate, Rental, Leasing	0.9	69375.2	$14,320.12	39.2331996	$35.31
Finance and Insurance	0.9	44445.9	$9,174.32	25.13513282	$22.62
Information	0.9	26096.9	$5,386.81	14.75837023	$13.28
Professional, Scientific, & Technical Services	0.9	59002.6	$12,179.05	33.36726644	$30.03
Education, Healthcare, Social Assistance	0.8	49119.3	$10,138.99	27.77804318	$22.22
Arts, Entertainment, Recreation	0.8	4873.5	$1,005.97	2.756071309	$2.20
Accommodation & Food Service	0.8	11824.1	$2,440.68	6.686788296	$5.35
Other Services, Except Government	0.9	7757.6	$1,601.29	4.387093215	$3.95
Government	0.6	39354	$8,123.28	22.25555151	$13.35
				TOTAL economic impact	***$170.87***
				Residential value (see method above)	***$26.30***
				Total value per person per day	**$197.17**

Indirect / Uncalculated Benefits

We estimated approximately 40-percent in benefits not yet calculate based on similar evaluations in other urban areas completed by Arcadis. Uncalculated benefits included:

- Indirect business interruption (reverberating impacts)
- Property value loss
- Income tax loss
- Sales tax loss
- Injuries and fatalities (casualties)
- Road impacts and disruption
- Disruption and damage to other linear assets

1.5 Determine risk context for annualization

The analysis used loss calculations associated with 16 flood elevations expected to be mitigated by the *Coastal Resilience Solutions for South Boston* strategy – four each originally modeled for the 0 inch, 9

inch, 21 inch, and 40 inch sea level rise scenarios. Analysts correlated each of the 16 flood elevations to annual chance of occurrence with 40 inches of sea level rise.

We selected this sea level rise scenario as the basis for calculating risk due to the fact that it represents the level of protection for the South Boston strategy, correlates to the useful life, is most inclusive in terms of understanding the expected risk context over the next 50 years, and is therefore most inclusive for calculating cost share. If, for example, cost shares had been calculated only based on current risk or graduated over time with expected rate of sea level rise, costs would be heavily front loaded on relatively few payers in the near-term and many other beneficiaries would receive “free-rides” later on, yielding a cost share approach that would be neither fair nor equitable. It is therefore best to calculate cost share based on share of risk expected over the life of the project, assumed to be until there is a need for additional expenditure for adaptation to accommodate additional sea level rise.

1.6 Determine share of benefits per asset

The evaluation yielded annualized losses (risk, or probability times consequence) per asset demonstrated in Figure 1. All annualized losses were summed and divided by 0.6 in order to yield the approximate share of risk mitigation not yet calculated. We then calculated the per asset share of total annualized risk by simply dividing the asset’s annualized risk into total annualized risk. The analysis assumed the strategy would mitigate risk to its stated level of protection. As such, we assumed annualized risk share is commensurate to benefits share.

1.7 Assumptions and analysis decisions that may affect results

The following are some assumptions and decisions made during the analysis that may affect results.

- Neither population, building stock, nor any costs have been projected over the life of the project. As such, risk is necessarily disproportionately shared with the existing population. This is expected to lead to an estimate of higher costs per payer over time, as the population of South Boston alone is expected to double between 2015 and 2030
- Any losses with a greater than 1,200 percent annual exceedance probability at 40 inches of sea level rise have been capped at that frequency in order to avoid overestimating losses for properties that would no longer be usable, but also provide a proxy for permanent loss of use. A future improvement would be to evolve this assumption and potentially calculate impacts from permanent loss of use balanced with potential savings
- Assumptions about building use type, replacement costs, rental rates, grade elevations, distribution of business outputs, and loss of function will all affect outcomes and could be updated with site specific information in the future
- The park methodology currently uses the same values for all types of open and recreational space and would benefit from a detailed analysis for beaches, as well as Boston specific park restoration costs
- The assumption regarding share of loss for uncalculated benefits affects approximately 40-percent of the results. Future iterations could integrate these values.

2 DETERMINE APPROPRIATE COST

2.1 Determine project costs

We used the highest and lowest preliminary capital and annual maintenance cost estimates developed through *Coastal Resilience Solutions for South Boston* in order to produce a range. All assumptions and caveats applicable to those preliminary cost estimates also apply here. These costs will necessarily be refined as various projects within the strategy proceed through design.

Figure 2 provides a summary of high and low cost estimates by alignment and approach option by area (see Figure 3 for a map of the areas). Figure 4 provides a summary of high and low cost estimates by sub-area within Fort Point Channel and Seaport Boulevard (see Figure 5 for a map of the areas).

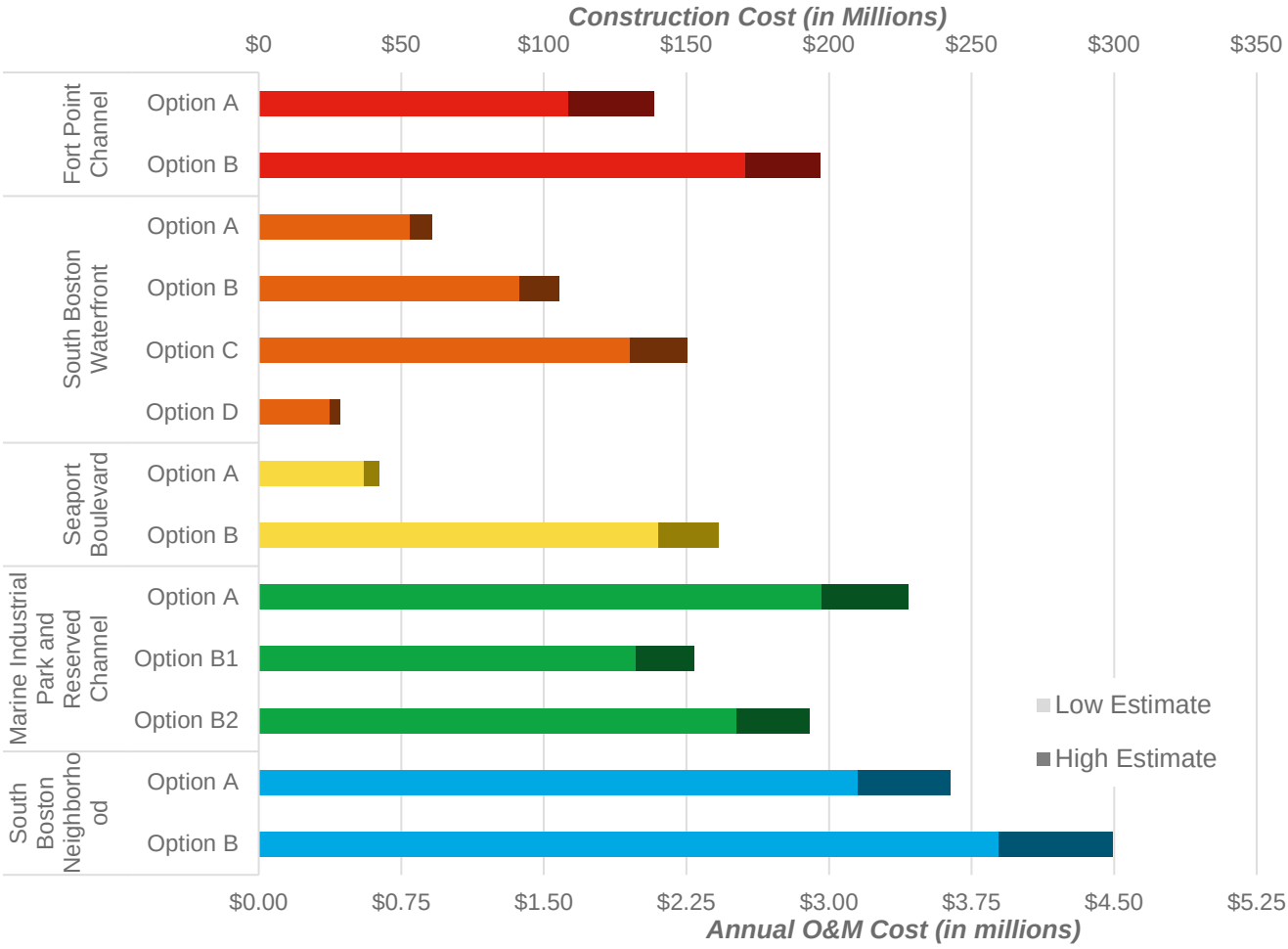


Figure 2 Preliminary cost summary by area – overall South Boston coastal strategy

Figure 3 South Boston Project Areas

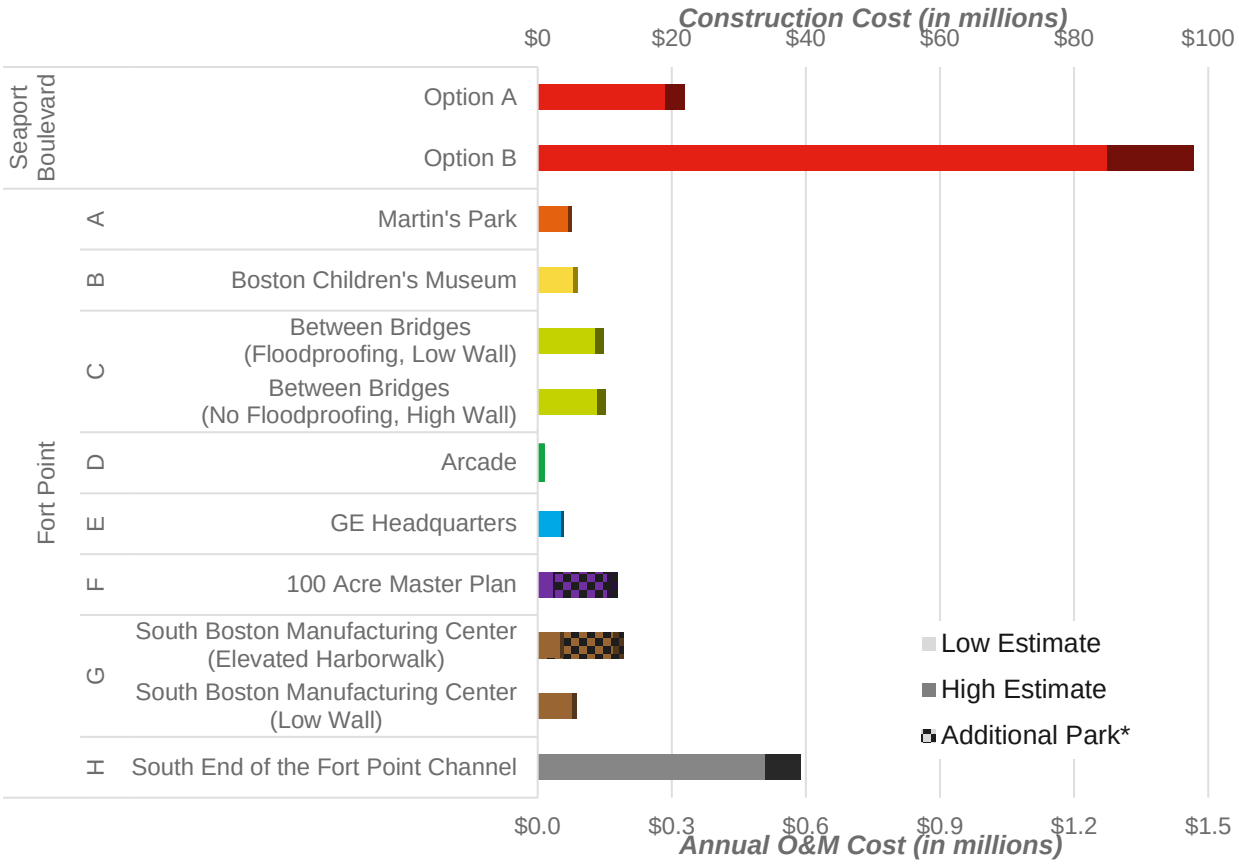


Figure 4 Preliminary cost summary by area – Fort Point Channel and Seaport Boulevard (note Arcade includes only study costs)

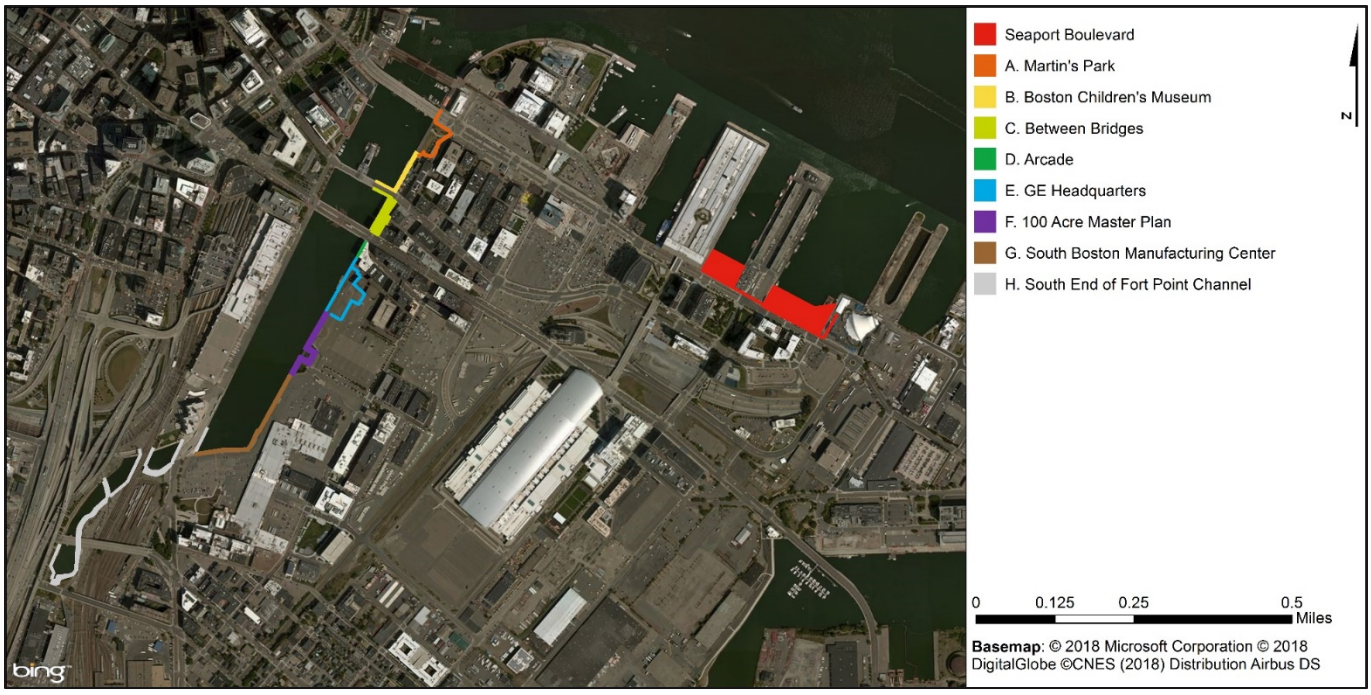


Figure 5 Fort Point Channel and Seaport Boulevard Sub-Areas

2.2 Schedule projects

We scheduled projects along two tracks: 1) only the urgent action projects, and 2) all South Boston projects. Engineers developed the urgent action project schedule to meet key milestones outlined in *Coastal Resilience Solutions for South Boston*. The cost share analysis assessment focused in on Track 2, which used the overall implementation schedule, including urgent action projects, provided in the implementation roadmap for *Coastal Resilience Solutions for South Boston*. For all projects other than those identified for completion by 2025, *Coastal Resilience Solutions for South Boston* assumed a ten-year implementation schedule from initial planning to completion. This generated key completion milestones at 2025, 2030, 2040, 2050, 2060, and 2070, with projects initiated in 2020, 2030, 2040, 2050, and 2060.

We projected capital costs over each ten-year implementation schedule as described in the example in Table 7. We assumed that maintenance costs would begin in 2025 for the projects completed by that date, amounting to 1.5-percent of capital costs. As individual parcels may come online on a rolling basis, we assumed that maintenance costs would be incurred thereafter commensurate with 1.5-percent of the total outlays to date each year. Figure 6 provides a visual representation for how this schedule plays out over time.

Table 6 Example implementation and capital cost schedule, project from 2050 through 2060 in South Boston

Year	Activity	Percent total capital costs	EXAMPLE Capital Cost Low	EXAMPLE Capital Cost High
0-1	design	2%	$127,800	$372,000
1-2	design	2%	$127,800	$372,000
2-3	design	3%	$255,600	$744,000
3-4	design	5%	$426,000	$1,240,000
4-5	design	5%	$383,400	$1,116,000
5-6	construction	5%	$426,000	$1,240,000
6-7	construction	10%	$852,000	$2,480,000
7-8	construction	15%	$1,278,000	$3,720,000
8-9	construction	20%	$1,704,000	$4,960,000
9-10	construction	20%	$1,704,000	$4,960,000
Year 10	construction	14%	$1,192,800	$3,472,000
	Total expected outlay 2050-2060		$8,520,000	$24,800,000

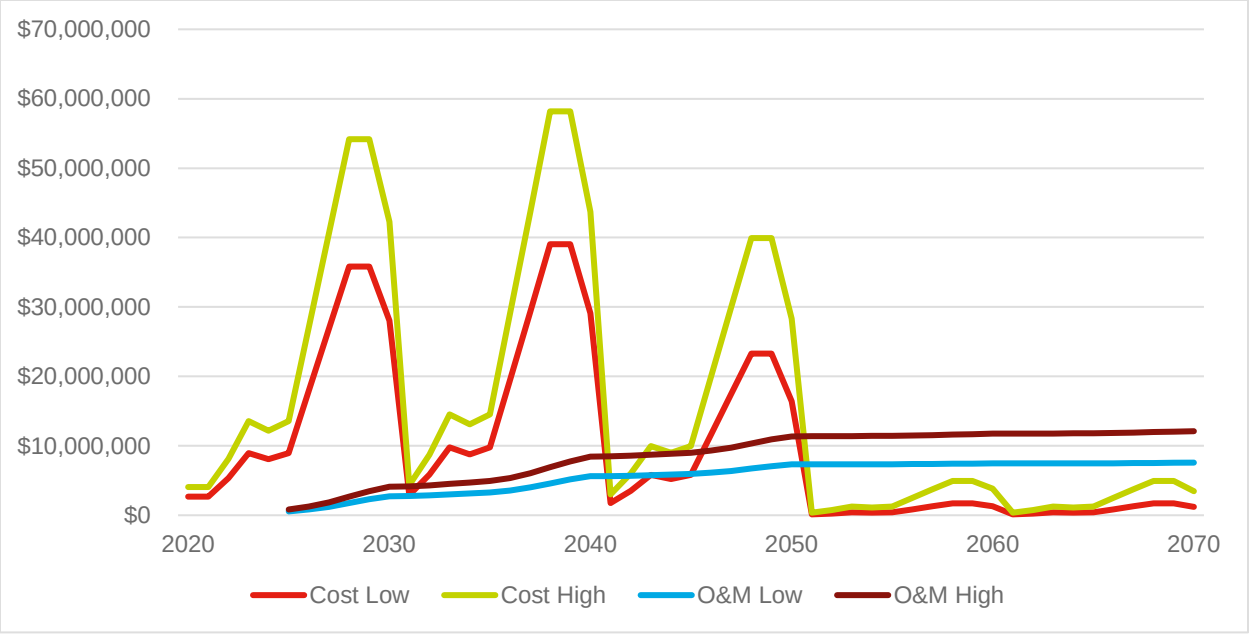


Figure 6 Expected capital and maintenance costs for implementation of *Coastal Resilience Solutions for South Boston* over time

2.3 Determine financing scenarios

We used two different financing scenarios: 1) no financing, and 2) 30-year bonds at 2.5-percent issued every five years for costs needed over the next five years, including capital and maintenance costs. This yielded a preliminary bonding and payment schedule as depicted in Figure 7.

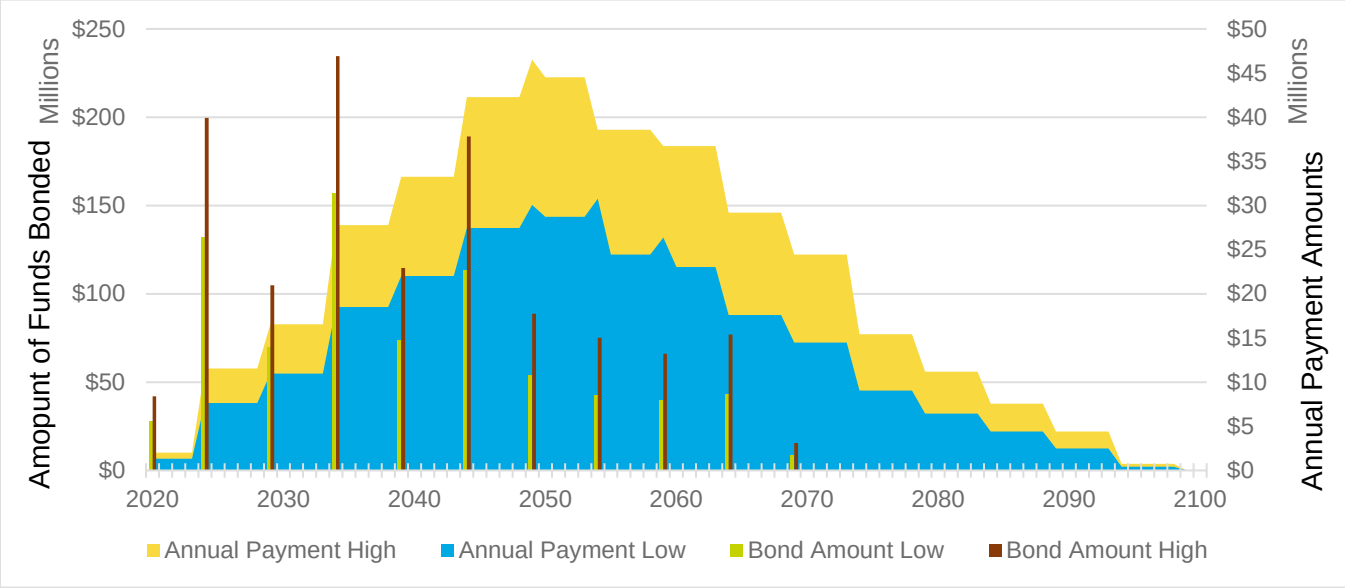


Figure 7 Potential bonding and payment schedule based on capital and maintenance costs needed every five years (no escalation) per the implementation schedule for *Coastal Resilience Solutions for South Boston*

2.4 Assumptions and analysis decisions that may affect results

The following are some assumptions and decisions made during the analysis that may affect results.

- No escalation included in cost estimates (because rents and population are not projected)
- Financing terms. Future iterations could integrate more financing options and combinations of funding and financing options
- Project schedule
- Cost estimates are preliminary and will evolve with design progression

3 CALCULATE COST SHARE ALLOCATION

3.1 Calculate share of cost based on share of benefits

For each asset, we calculated share of cost in three ways:

1. Average annual share of cost in the no financing scenario using high costs
2. Average annual share of cost in the no financing scenario using low costs
3. Share of cost for each year from 2020 to 2100 using the financing scenario with high costs

For the no financing scenario approaches, we simply multiplied each asset's risk / benefit share by the appropriate lifecycle capital and maintenance cost estimate. For the financing scenario, this calculation occurred for each year from 2020 to 2100 based on expected annual bond payments according to the schedule visualized in Figure 7.

3.2 Identify sectors and payer categories

Based on the quick category, cross-checked occasionally using Google Street View, we assigned each asset to a sector and expected payer category, as listed in Table 7.

Table 7 Sector and payer categories used in the preliminary cost share analysis

Sector Categories
Essential services
General government
Indirect / Uncalculated benefit
Mixed-use
Non-residential private
Recreational / Open space
Residential
Transportation
University
Utility

Payer Categories
City of Boston
Commonwealth of Massachusetts
Education / University
Federal Government
Indirect / Uncalculated benefit or undefined
Private property owner / tenant
Private utility

3.3 Calculate cost share in a variety of ways

We calculated cost share by asset, then summarized the results also by sector and payer categories to better understand how costs might be distributed. We created a dashboard by which results can be

reviewed, as well as ways to refine and modify calculations over time as new information is gathered and the building stock, costs, or population changes. In addition to calculating cost share per year per asset, sector, and payer group, we summarized results in the following ways to better understand affordability and impacts to individual payers:

- Cost per square foot
- Cost per building
- Cost per person
- Cost per household / unit
- Cost as a percent of annual rent

3.4 Assumptions and analysis decisions that may affect results

The following are some assumptions and decisions made during the analysis that may affect results.

- The decision not to include social, environmental, or economic value added in addition to risk will affect outcomes
- Payer and sector assignments were sometimes based on analyst judgment where data was missing outcomes and could be updated with site specific information or overall data improvements in the future
- Additional financing, schedule, and funding scenarios will change results by asset, sector, and payer
- Additional benefits calculations, as outlined in Section 2, are likely to have an effect on results

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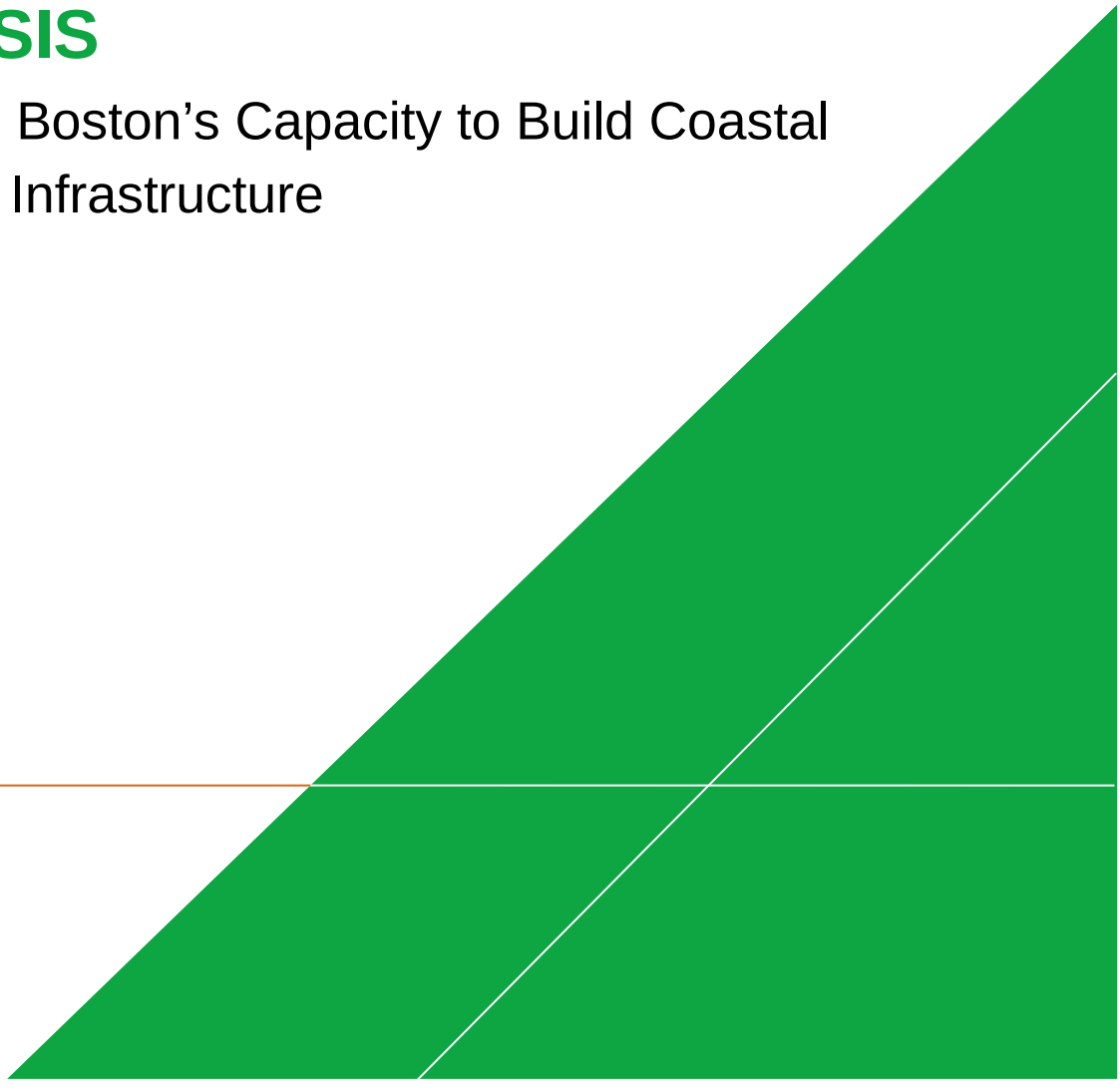
APPENDIX C REGULATORY GAP ANALYSIS

Expanding Boston's Capacity to Build Coastal Resilience Infrastructure

April 2020



CONTENTS

1 INTRODUCTION AND SUMMARY

The Boston Green Ribbon Commission (GRC) is working with Arcadis U.S. (Arcadis) to develop a refined implementation roadmap for the high priority flood risk mitigation projects identified through *Coastal Resilience Solutions for South Boston*. These high priority projects – slated for completion within the next 5-10 years – are located along Fort Point Channel and Seaport Boulevard in the Seaport District. A central question is how well existing regulatory frameworks are positioned to guide how, when, and where coastal flood protection infrastructure is built. While the focus of the GRC study is on projects located in South Boston, this question also applies at the citywide scale with respect to how existing regulations can hinder or help advance the Mayor's long-term Resilient Harbor Vision. Implementation of this vision will require introducing new fill into waterways in order to create coastal protection infrastructure that also provides a range co-benefits, including improved ecological function and new opportunities for public access and recreation.[1]

The goal of this memorandum is to identify opportunities and potential gaps in the ability of existing and proposed regulations to guide the design elevation, alignment, and cross-property connections (tie-ins) of coastal flood protection infrastructure proposed through Coastal Resilience Solutions for South Boston and the Resilient Harbor Vision. The scope of this review is narrowly focused on regulatory tools and levers that are within the City of Boston's control or that apply at the State level with the opportunity for local input and discretion, and that will influence the implementation of near-term coastal resilience in the Seaport District. The results described here have informed additional analysis and recommendations for governance, funding, and regulatory approaches for coastal resilience project implementation provided in the forthcoming GRC report Advancing Coastal Flood Mitigation in Boston's Seaport District.

The regulatory tools considered under the scope of this memorandum include:

- City of Boston Local Wetlands Ordinance and State of Massachusetts 310 CMR 10.00 (Wetlands regulations)
- Boston Planning and Development Agency, Coastal Flood Resilience Design Guidelines
- Boston Planning and Development Agency, Flood Resilience Zoning Overlay (Not Complete)
- Boston Planning and Development Agency, Article 37 Green Building and Climate Resiliency Policy and Checklist
- State of Massachusetts 310 CMR 9.00 (Chapter 91 regulations) and 301 CMR 23 (Municipal Harbor Planning)

[1] The authors are grateful to the following individuals who provided feedback on early drafts of this document: Barbara K. Landau, Noble, Wickersham & Heart LLP; Stephanie Kruel, VHB; Deanna Moran, Conservation Law Foundation; Alice Brown, Boston Harbor Now

We analyzed each of the above regulations, as available, relative to two key questions that will need to be addressed in order to implement the City's coastal flood protection plans: 1) how does the regulation address strategies that span multiple property owners to provide district-scale protection, and 2) how does the regulation address the need for in-water solutions in some locations?

It is important to note that the regulations evaluated here do not include all those applying to coastal flood mitigation infrastructure. Additional regulations that may apply depending on the scope and location of the specific project include: Army Corps Section 404 and Section 10 permits, Massachusetts Environmental Protection Act, Massachusetts Coastal Zone Management Consistency Review and Designated Port Area regulations, State Harbor Lines, Local and State Historic/Landmark Designations.

2 KEY FINDINGS

Table 1 summarizes the overall strengths and weaknesses of the reviewed regulations relative to coastal flood mitigation, and outlines opportunities for improvement or utility in guiding district scale flood mitigation projects.

The primary overall finding is that while most of the applicable regulations do not hinder near-term investment in coastal flood mitigation in Boston – particularly those not requiring fill – none are well-positioned to help actively drive that investment forward at the pace needed to address increasing risk. Development and environmental regulations tend, in general, to apply on a site-by-site basis to new development. This is not necessarily a shortcoming in and of itself. Nevertheless, the City's plans for an integrated network of district-scale flood protection will necessitate consistent and coordinated action across multiple properties. The existing regulatory framework would be improved if regulations were to reference a set of published and formally adopted coastal protection plans and performance/design standards that would predictably guide investment at the site scale across districts and the city. Such performance standards should be flexible enough to enable project proponents to integrate investments into their site plans, but need to include at a minimum:

- Target design elevations as identified through Climate Ready Boston district planning
- Target engineering standards and guidance
- Design guidance to promote co-benefits such as public amenities
- Specification for integration of coastal resilience solutions across adjacent properties (also referred to as "tie-ins")
- The standards may also include operations and maintenance protocols

In addition, as each of the regulations reviewed here primarily apply to new development, there will also need to be regulatory mechanisms developed to incentivize or compel investment on coastal properties that are already built but lack sufficient flood protection.

Table 1 Strengths, weaknesses, and opportunities within existing and developing key policy mechanisms regarding their abilities to support implementation of district-scale coastal resilience strategies

Policy vehicle	Strengths	Weaknesses	Opportunities
City of Boston Local Wetlands Ordinance and State of Massachusetts 310 CMR 10.00 (Wetlands regulations)	• Includes provisions to encourage climate change adaptation through district-scale flood mitigation • Explicitly addresses potential conflicts between wetland resource protection and flood mitigation solutions, including enabling use of fill under specific circumstances	• Details on regulations, including performance standards, are not currently available • Applicable only to properties requiring a wetlands permit, thus requiring a site-by-site approach • Depending on forthcoming regulations and performance standards, may inhibit certain types of flood protection solutions that do not meet criteria used by the Conservation Commission • Local ordinance not compulsory for State entities	• Forthcoming guidelines, performance standards, and regulations could be written to help expedite projects planned through *Climate Ready Boston* • Potential near-term enforcement vehicle for mandating design elevations and tie-in coordination on a site-by-site basis through conditions placed on permit
Boston Planning and Development Agency, Coastal Flood Resilience Design Guidelines	• Promotes best-practices for building-scale flood resilience • Promotes public awareness of flood risk and mitigation options	• Voluntary • Is not intended to provide detailed options or performance standards for coastal mitigation	• Potential to add to or create a similar document with detailed design and performance standards for district-scale flood mitigation • Such design and performance standards could be enforced through other regulations described here
Boston Planning and Development Agency, Flood Resilience Zoning Overlay (in process)	• Potential regulatory authority for defining performance-based design criteria and tie-in requirements	• In progress. Details unknown at this time • Will not apply to existing development, unless substantial renovation is proposed	• Potential to require implementation of district-scale mitigation with new development and substantial improvements through zoning

Policy vehicle	Strengths	Weaknesses	Opportunities
Boston Planning and Development Agency, Article 80 Development Review and Article 37 Green Building and Climate Resiliency Policy and Checklist	• Established development review process • Enforceable mechanism for advancing coastal resilience • Creates requirement for consideration of climate change and adaption through development approvals process	• Non-Prescriptive; requires consideration of resilience, but does not provide standards or design criteria • Applies only to new development subject to certain types of Article 80 review • Relies on a site-by-site approach	• Potential to advance and enforce district-scale strategies in the near-term site-by-site if coastal mitigation plans and performance standards are established
State of Massachusetts 310 CMR 9.00 (Chapter 91 regulations) and 301 CMR 23 (Municipal Harbor Planning)	• Established regulatory process	• Base regulations do not incorporate best available climate projection data • Policy objectives may be interpreted as conflicting with coastal resilience solutions in some cases • Relies on site-by-site approval process • Applies only to properties within Chapter 91 jurisdiction	• Municipal Harbor Planning (MHP) (301 CMR 23) provides vehicle for localities to amend base Chapter 91 regulations. • MHP could include or refer to climate projections, target elevations, tie-in specs, etc. and requirements for district investments • The license renewal process provides opportunities to reassess site conditions in light of evolving data, including how successful measures have been to reduce climate risks like flooding • Enforcement power may incent property owner action

The structure of this memorandum is as follows. Each of the regulations is first introduced along with a summary evaluation of its current utility in facilitating district-scale coastal resilience strategies. This review does not include an exhaustive evaluation of how the regulations relate to climate adaptation, but rather a narrower review of the key questions outlined above. This evaluation provides the basis for a discussion of changes that could be made to improve upon the existing language or applicability to better advance district-scale coastal resilience strategies. Lastly a conclusion provides a synthesis of the findings and over-arching recommendations.

3 CITY OF BOSTON LOCAL WETLANDS ORDINANCE

Purpose

Regulates wetlands resources, including land under the ocean and land subject to coastal storm flowage (LSCSF). Projects must obtain an Order of Conditions from the Boston Conservation Commission with conditions designed to protect resource areas from the impacts of development.

Review Body

Implementing legislation 310 CMR 10.00: MassDEP Wetlands and Boston Conservation Commission, which administers the Massachusetts Wetland Protection Act.

Current Utility in Facilitating Implementation of District-Scale Coastal Resilience Strategies

The local wetlands ordinance establishes Boston's first such ordinance. The justification for the ordinance is linked in part to the need to better enable City regulators to manage and plan for climate change. The ordinance provides supplemental requirements related to coastal wetlands that are not currently included in the State Wetlands Protection Act; however, the local ordinance cannot conflict with the state wetland regulations. State regulations and standards will trump the local ordinance in cases where they are more restrictive.

There are a number of details related to how the local ordinance would be applied that should be articulated in rules and regulations and not in the ordinance itself. Therefore, the effectiveness of the ordinance will hinge on the regulations, including performance standards for required mitigation elements, that follow from it, which are as-yet un-drafted but should align with any district-scale coastal flood mitigation strategy. Nevertheless, according to the ordinance, the regulations will "set forth a policy for treatment of qualifying work in the flood resilience zones, take into account climate resilience, specify resource areas subject to Commission jurisdiction as provided for in the Ordinance including the Waterfront Area, Coastal Flood Resilience Zone and Inland Flood Resilience Zone, and prescribe performance standards for activities in any or all resource areas and their buffer zones."

At the highest level, the ordinance makes explicit the need for applicants to integrate climate resilience and adaptation considerations into development projects taking place in resource areas (areas subject to protection under the ordinance).

> *Climate Change Resilience. The Applicant shall, to the extent applicable as determined by the Commission, integrate climate change and adaptation planning considerations into their project to promote climate resilience to protect and promote Resource Area Values and functions into the future. These considerations include but are not limited to: sea level rise, increased heat waves, extreme precipitation events, stormwater runoff, changing precipitation patterns and changes in coastal and stormwater flooding.*

With the jurisdiction of the Conservation Commission spanning the entirety of the coastal waterfront as well as inland buffer areas, this requirement holds significant potential to promote and advance climate resilience across the city. Nevertheless, more specificity is required to ensure alignment of coastal protection projects, new development, and rehabilitation actions with the City's published coastal adaptation strategies. Such specificity, for example, would reference the target elevations and tie-in considerations detailed for preferred actions in the plans, themselves, and could be included in the rules and regulations propagated after the adoption of the ordinance.

With respect to jurisdiction, the ordinance adds a new regulated area to lands subject to coastal storm flowage (LSCSF), the typical inland extent of wetland regulatory authority. The new areas, called the coastal flood resilience zone (CFRZ), are those "beyond the current boundary of land subject to coastal storm flowage or land subject to tidal action that the Commission determines has a reasonable probability of becoming subject to future coastal storm flowage or tidal action due to sea level rise (SLR) within approximately the next 50 years." The Commission will consider impacts to these areas and in its regulations establish measures to protect area resources.

One of the challenges in administering the ordinance is that, historically and in practice, regulatory objectives of protecting and preserving resource areas have often been treated as incompatible with constructing coastal protection and adaptation measures. This is because in some areas of the city, infrastructure to protect inland communities will require filling of the water column and impacts to wetland resources. The ordinance acknowledges this, offering that:

> *Nothing in this Ordinance shall be intended to prevent beneficial projects whose primary purpose is protection of resource areas and reduction of risk from coastal flooding, inland flooding, extreme weather, sea level rise and other adverse impacts of climate change. The Commission may enact guidelines, performance standards and implementing regulations specific to beneficial projects identified through the Climate Ready Boston process or equivalent or successor initiatives to advance and expedite such beneficial projects. The Conservation Commission may issue an Order of Conditions for district scale flood resiliency and flood protection projects where such projects require fill, including coastal fill above and seaward of existing seawalls only when necessary for flood protection, provided that the Commission finds by a preponderance of the evidence that the project will protect and improve coastal, riparian or aquatic habit over current and projected conditions, including but not limited to change from vertical seawall to intertidal habitat.*

This provision is notable, first, because it ostensibly provides a pathway for permitting coastal flood protection infrastructure, even if it involves placing fill in resource areas, as long as the fill-based activity creates improved habitat over time. How the Conservation Commission interprets this provision in its determinations will be important in assessing how effectively it may address any potential conflicts.

Second, the provision acknowledges the need for district-scale flood protection, potentially articulating a need for cross-property coordination for applicants as they pursue permits for flood protection.

Discussion of Changes to Advance Implementation of District-Scale Coastal Resilience Strategies

The inclusion of language in the ordinance that specifically enables fill and other investments in and around resource areas, if meeting certain climate resilience and ecological goals, is important because it provides a degree of flexibility in how proposals for coastal flood mitigation might be evaluated by the Conservation Commission.

To further advance coastal resilience investment it will be important for the rule and regulations associated with the ordinance to clearly outline the performance and design standards that applicants will be expected to meet. Ideally, an applicant seeking a wetland permit for investments in coastal resilience infrastructure would be referred to target coastal protection performance standards established in the city's published coastal resilience plans and be required to meet these standards in their design as a condition of the permit. Because the wetlands ordinance provides for a discretionary process of project review and issues project approvals subject to conditions, City officials could include such performance standards in the Order of Conditions provided to property owners. For a property owner pursuing new development along Fort Point Channel, for example, since a wetland permit would be necessary, the Boston Conservation Commission could include in its conditions terms related to the required elevation of the coastal protection element and perhaps requirements related to the alignment and tie-in to adjacent properties, as articulated in *Coastal Resilience Solutions for South Boston*. This could be an effective near-term means of facilitating and coordinating coastal resilience project implementation, though ultimately will not advance complete district-scale implementation quickly enough in most areas to meet the deadlines established through the Climate Ready Boston planning process. Another issue is that an Order of Conditions likely could not require district-scale flood protection be built where the project proponent was not already planning to do so.

4 COASTAL FLOOD RESILIENCE DESIGN GUIDELINES AND ZONING OVERLAY

Purpose

The Design Guidelines provide detailed and consistent standards for project reviews by the staff of BPDA and other City agencies, to encourage a quality streetscape and building design that is pedestrian-friendly and flood-proofed. The Design Guidelines also inform residents and businesses how to assess their coastal flooding hazards and identify measures they can implement to reduce risks from those hazards. The guidelines will inform the types of the actions enabled and encouraged through the in-progress coastal flood resilience zoning overlay district. The intended boundary for both the guidelines and the zoning overlay district is areas with a projected one percent annual chance of flooding in the year 2070 with 40 inches of sea level rise. This area is also referred to as the Sea Level Rise – Flood Hazard Area [SLR-FHA].

Regulatory Authority

Guidelines inform project review by BPDA staff as part of the Article 80 Development Review Process. Zoning Overlay will potentially regulate uses and dimensions within the zoning overlay district including aspects of building design, layout, height, and placement, as well as landscape configuration and design.

Current Utility in Facilitating Implementation of District-Scale Coastal Resilience Strategies

The Coastal Flood Resilience Design Guidelines provide a detailed overview of strategies for flood resilient development in the city's current and future floodplain. The focus of the document is providing guidance on building-scale flood mitigation solutions for a variety of typologies located throughout the floodplain in Boston.

Intended to serve as design guidelines and as a public information tool, the document does not have any statutory regulatory authority and does not supplant State building code, though the document was adopted by the BPDA board in September 2019. Although the guidelines are not regulatory, they still have power in guiding how staff at BPDA and other regulatory agencies review and permit developments in the City's floodplain. It must also be noted that the guidelines precede consideration and potential adoption of new zoning regulations that would control how new development occurs in the floodplain. As of the writing of this memorandum, the draft text for the Coastal Flood Resilience Zoning Overlay district was not available for external review.

While the guidelines create an extensive toolkit for and background on the technical approaches to building and retrofitting a range of structure types in the floodplain, as well as the relationship to building code rules based on FEMA and ASCE standards. However, there is less of a focus on how the guidelines might relate to site- or district-scale coastal resilience solutions. The section on district-scale strategies provides a high-level, non-exhaustive overview of the types of approaches that could be used to deliver district-scale flood protection (i.e., waterfront parks, vegetated berms, temporary flood barriers, seawalls, and raised roadways); but it does not provide guidance on standards related to how (elevation) or where (alignment) such structures should be designed, nor on design guidelines for such solutions or the process for ensuring district-scale implementation.

Discussion of Changes to Advance Implementation of District-Scale Coastal Resilience Strategies

As described above, the Coastal Flood Resilience Design Guidelines are primarily aimed at measures to promote building-scale flood resilience, an important citywide initiative that is necessary with or without other resilience investments. As such, the focus of the guidelines is not on providing guidance or any regulatory oversight of district-scale coastal protection strategies. Discussion of district-scale protection is limited to a brief overview of several different types of coastal protection with reference to the strategies being contemplated and recommended through the Climate Ready Boston district plans.

The design guidelines are intended to inform and support the related implementation of the Flood Resilience Zoning Overlay, which at present is still undergoing internal City review. As far as we understand, the zoning overlay will primarily focus on changing regulations in the SLR-FHA in order to promote resilient new development and significant retrofits to existing buildings. We also gather that an

objective of the new zoning is to better regulate and guide district-scale coastal protection – as opposed to the design guidelines that focus on individual buildings. If this is the case, we suggest that this be done by codifying reference to target performance standards for coastal protection that will need to be built on private property, as identified through the Climate Ready Boston process. Such performance standards could be flexible enough to enable project proponents to integrate investments into their site plans, but need to include target design elevations and engineering and design guidance to promote co-benefits such as public amenities, and tie-ins between adjacent properties. The existing Design Guidelines reviewed here could be revised, or a new set of guidelines issued, to offer more detailed analysis and recommendations pertaining to coastal protection infrastructure. Alternatively, design guidelines could be issued on an area-by-area basis, following the example of the ongoing 100 Acre Master Planning effort.

The City of Boston Department of Public Works' Climate Resilient Design Standards and Guidelines for Protection of Public Rights of Way provide another useful precedent. The Design Standards and Guidelines are a good first step in the development of citywide performance standards for coastal flood resilience. The document provides detailed information regarding design and permitting considerations, costs, and steps involved in delivering flood mitigation on properties owned by the City. A new set of standards, building on this document, could be expanded to include the district-specific design elevations and alignments recommended through the Climate Ready Boston district plans and should apply to both public and private properties where coastal flood mitigation is planned.

The overall effect of this would be to establish a comprehensive citywide regulatory framework and set of performance standards for district-scale flood protection. From a project proponent perspective, zoning regulations that refer to published design/performance standards would offer a clear and predictable statement of the coastal flood protection goals and requirements that need to be met on a given site.

5 ARTICLE 37 RESILIENCY POLICY AND CHECKLIST

Purpose

The purposes of this article are to ensure that major building projects are planned, designed, constructed, and managed to minimize adverse environmental impacts; to conserve natural resources; to promote sustainable development; and to enhance the quality of life in Boston. The Resiliency Policy requires that all projects consider present and future climate conditions in assessing project environmental impacts, including carbon emissions, extreme precipitation, extreme heat, and sea level rise. Projects must identify building strategies that eliminate, reduce, and mitigate adverse impacts including those due to changing climate conditions.

Review Body

Inform project review by BPDA staff as part of the Article 80 Development Review Process.

Current Utility in Facilitating Implementation of District-Scale Coastal Resilience Strategies

Article 37 is the City's formal resiliency policy applying to certain projects subject to the Article 80 development review process. The policy has two components, the first relating to green buildings and energy efficiency and the second relating to climate change adaptation. Administered by BPDA, the policy "requires that all projects consider present and future climate conditions in assessing project environmental impacts, including carbon emissions, extreme precipitation, extreme heat, and sea level rise. Projects must identify building strategies that eliminate, reduce, and mitigate adverse impacts including those due to changing climate conditions." To comply with the policy, applicants must complete the resiliency checklist, which provides "a framework and specific resiliency targets for assessing project vulnerabilities and adverse impacts. Projects are to identify initial (first build) strategies for reducing vulnerabilities and adverse impacts AND future adaptation strategies for meeting or exceeding resiliency targets and further reducing vulnerabilities and adverse impacts due to future climate conditions."

Regarding coastal flood risk, the primary objective of the policy is "reduce or eliminate" flood risk and potential damage for new building projects. The applicability of the policy extends to the area covered by either the FEMA Special Flood Hazard Area (SFHA) or the BPDA Sea Level Rise-Flood Hazard Area (SLR-FHA) which is the modeled extent of the 1% annual chance flood event with 40 inches of SLR as modeled by the Boston Harbor Flood Risk Model (BH-FRM). Proponents of projects located in areas subject to flooding in either of these geographies are then to determine a "Sea Level Rise - Base Flood Elevation" (as mapped by BPDA) and then calculate a "Sea Level Rise – Design Flood Elevation" by adding a minimum of 24" (for critical facilities and buildings with ground floor residential units) or 12" for all other buildings and uses.

Based on this screening, project proponents are then asked to describe the strategies they will employ in their project design to meet the adaptation requirements. Suggested strategies include "raising the elevation of the site and access routes, elevating building ground floors, dry and wet flood proofing, locating critical building equipment and systems above potential flood elevations, and deploying temporary barricades."

The focus of the resiliency policy and check list is primarily on new development projects, given its applicability to the Article 80 process. This emphasis on site-scale actions limits its effectiveness in coordinating district-scale resilience investments, as neighboring properties are rarely seeking approval at the same time. One exception to this could be its applicability to Planned Development Area review (for example, the 100 Acres Master Plan Area) where a coastal resilience strategy, such as a berm or other shorelines solution, could be proposed as an adaptive strategy for multiple properties. The policy can also help advance coastal resilience investment on individual sites. Over time, assuming continued development, these individual actions could be knit together to create a district-scale solution, but this depends on the availability of published costal protection plans for an area and established performance standards that can be applied over time on a site-by-site basis. While the policy does refer applicants to Climate Ready Boston for guidance but as discussed elsewhere more detailed performance standards are needed.

Discussion of Changes to Advance Implementation of District-Scale Coastal Resilience Strategies

The applicability of the Article 37 Resiliency Policy and Checklist is limited by its association with the Article 80 development review process, but it nevertheless could serve to advance investment in district-scale coastal resilience if the policy serves to coordinate action on individual sites within a given district as new development occurs over time. To be most effective in this, the policy would need to clarify when a landscape-scale strategy, such as a berm, is necessary (or required) as opposed to when building-scale adaptation measures might be appropriate. For example, along Fort Point Channel, where several new development projects subject to Article 80 are occurring at the same time, the policy could be used to articulate the need for investments in planned coastal protection by neighboring private properties and to ensure that such investment meets the same performance standards for alignment, design elevation, and cross-property tie-ins. However, this potential function would be improved if the policy referred to a published set of performance and design standards for coastal flood protection, such that project applicants would have established and predictable criteria to meet in their coastal adaptation standards. These standards could be codified through the new Flood Resilience Overlay and/or be promoted through a new set of Resilience Design Guidelines. The City would also need to firmly establish and publicize the preferred coastal resilience strategies and alignments developed through Climate Ready Boston. In addition, as noted above, the site-by-site approach is not likely advance implementation of complete district-scale solutions quickly enough at the scale needed to provide the planned level of protection.

6 310 CMR 9.00 (CHAPTER 91, THE MASSACHUSETTS PUBLIC WATERFRONT ACT) AND 301 CMR 23 (MUNICIPAL HARBOR PLANNING)

Purpose

310 CMR 9.00 (Chapter 91) protects the public's right to access and use of tidelands and waterways in the Commonwealth and regulates water-dependent uses and non-water dependent projects by requiring project proponents to obtain a license from MassDEP Waterways outlining permitted development and other activities in tideland areas. 301 CMR 23.00 establishes a voluntary procedure by which municipalities may obtain approval of Municipal Harbor Plans (MHPs). MHP provides communities with an opportunity to modify state Chapter 91 standards to meet local planning objectives.

Review Body

Massachusetts Department of Environmental Protection (MassDEP) Waterways Program and Office of Coastal Zone Management (CZM)

Current Utility in Facilitating Implementation of District-Scale Coastal Resilience Strategies

The Conservation Law Foundation's (CLF) report Climate Change & the Massachusetts Public Waterfront Act[2] provides a detailed discussion of the how Chapter 91 considers and could be amended to support climate change adaption. Climate change is not an explicit focus of Chapter 91, the goals of which are focused on ensuring public access and protecting marine-dependent use of the waterfront. Nevertheless, resilience to climate change related hazards is inherently required to maintain public access, use, and enjoyment of the waterfront. As the CLF report notes, although many of Chapter 91's provisions can be interpreted through policy or rulemaking to address aspects of climate change adaption, the regulations themselves only make one reference to how climate change should be considered in the design of projects before the State for Chapter 91 licensing.

This reference (*310 CMR 9.37)* creates special requirements for the location of structures and design standards for new buildings with non-water dependent uses intended for human occupancy. These standards require that such buildings be designed to withstand wind and wave forces associated with the one percent annual chance storm and incorporate sea level rise projected to occur over the design life of the building. Importantly, the sea level rise projections are specifically to be based on "historical rates of increase in sea level in the New England coastal areas" and not modeled projections of sea level rise based on current best available science.

According to CLF, there are several other means by which the regulations can be modified or interpreted to influence and advance climate adaptation, as summarized belo*w.*[3]

- The first is through MassDEP's discretionary licensing process. Under this process, MassDEP may include "special conditions"[4] in a Chapter 91 waterways license. CLF's review documents recent MassDEP-imposed special conditions that relate to coastal flood resilience, such as mandates to elevate lowest occupied floors, entrances, and critical building systems above Building Code requirements. Nevertheless, as CLF notes, these conditions are focused on measures to protect individual buildings and their occupants, rather than the property overall or adjacent properties that may be vulnerable to a flood pathway across the subject property. Moreover, these special conditions are created on a license-by-license basis and may not lead to coordinated district-scale climate change adaptation. This is a fundamental weakness toward achieving the South Boston plan's goal of coordinated coastal resilience in the neighborhood.

- Another issue identified by CLF is ambiguity around the conditions under which in-water fill is permissible under Chapter 91. Although CLF finds that the regulations do not categorically prohibit the use of fill, particularly for flood control projects, ambiguities in the language of the regulations make it unclear under which circumstances fill may be appropriate and for what types of flood control

[2] Web version available: https://www.clf.org/wp-content/uploads/2019/03/CLF_ClimateChangeReport2.pdf

[3] See CLF report, pp 19-26

[4] "Special conditions" are conditions included by MassDEP Waterways is Chapter 91 licenses to supplement the standard conditions

projects. For this reason, CLF recommends amending the regulations to "encourage flood control measures that improve resiliency on a neighborhood- or area-wide scale by explicitly stating that new fill may be introduced in connection with such measures and clarifying the specific circumstances under which it would be allowed."

- The Municipal Harbor Planning (MHP) process is another means by which Chapter 91 regulations have been modified to incorporate more robust climate adaptation provisions. Municipal harbor planning affords local jurisdictions the ability to modify some aspects of the standard Chapter 91 regulations, particularly use and dimensional standards for structures. MHPs are reviewed and approved by the State prior to coming into effect as the controlling waterways regulations for a given area of the waterfront. It is important to note that MHPs are regulated separately from Chapter 91 and any changes to the underlying Chapter 91 regulations would not affect adopted MHPs.

Recently, the City of Boston has sought to incorporate its climate resilience planning efforts into MHPs. The Downtown Waterfront MHP is the most applicable example and is therefore described in detail here. As noted in the plan, because an MHP cannot supersede building code and can only "substitute or amplify" provisions found within the Chapter 91 regulations, the potential reach of harbor planning is limited. Even so, the Downtown MHP includes several important additions to advance coastal flood protection in the district. First, it mandates that flood mitigation project design elevations for structures include freeboard that "shall be determined in accordance with the sea level rise ranges associated with the moderate to high emissions scenarios specified by Climate Ready Boston guidance documents [and that] consideration shall be given to the design life of the building and the most conservative, applicable range of anticipated sea level rise."5 This change thus requires consideration of sea level rise projections that are forward looking based on the best available data, rather than backward looking as required in the base regulations. To facilitate incorporation of additional freeboard, building heights can be increased without penalty by the amount of freeboard applied above the elevation required by building code or to accommodate space required by electrical and mechanical equipment located above the building code design elevation in existing buildings. Second, the MHP specifies that "areas improved for public open space shall also be incrementally elevated6, to improve resiliency." The plan further states that:

> *The Downtown Waterfront should also serve as the city's first Flood Resiliency District, with property owners collectively evaluating risks of future sea level rise, district wide measures that can be implemented to reduce the risk and potential future damage, as well as funding mechanisms for area-wide infrastructure enhancements. Measures to consider could include offshore storm surge barriers and wave attenuators to break up wave action; armoring and fender systems at the ends of piers and wharves; and the elevation and utilization of waterfront plazas and Harborwalk as a heightened seawall that can protect the district from inundation while continuing to provide public waterfront access.*

The appropriate elevations for such district-scale investments required through the MHP are to be guided by the City's Design and Use standards, including Climate Ready Boston, which has articulated a design

[5] Downtown Waterfront MHP (Accessed 10/28/2019) http://www.bostonplans.org/getattachment/3793434f-a668-49dc-a318-288cac46e845

[6] The exact meaning of "incrementally elevated" is unclear as included in the text of the MHP

elevation of 16.5 feet (NAVD88) for the Downtown waterfront. The provision is implemented through changes to public benefits criteria in the Boston Zoning Code Article 42A—Harborpark District, North End/Downtown Waterfront. The exact implementing language is included below for reference:

> *Section 42A-16E(2) - Planned Development Areas within the Downtown Waterfront Subdistrict: Public Benefit Criteria.*
>
> *Development Plan Approval for the Provision of Street Improvements or Climate Resiliency Improvements. The Boston Redevelopment Authority may approve a Development Plan providing, either directly or through funding, for substantial street improvements to streets adjacent to and in the vicinity of the PDA, or for direct contribution or funding of district-scale climate resiliency projects. Such street improvements must be consistent with any applicable street improvement regulations or guidelines and must be sufficient, as determined by the Boston Redevelopment Authority, to improve the appearance, condition, quality of design and materials, and accessibility and usability of the affected streets by pedestrians and general vehicular traffic, taking into account increased vehicular and pedestrian flows.*[7]

Discussion of Changes to Advance Implementation of District-Scale Coastal Resilience Strategies

As described in detail in CLF's report, a number of potential reforms to the regulations and rules underpinning Chapter 91's application to projects would be necessary in order to make it a more effective tool for advancing coastal flood mitigation, or at a minimum ensure its authorities do not hinder it.

The current site-by-site approach of incorporating climate resilience measures into Chapter 91 project licenses does minimally advance coastal resilience by providing a binding mechanism for requiring project proponents to meet certain standards, including shoreline elevations, as a condition of their license. Nevertheless, this approach does not provide the necessary level of consistency or predictability to effectively advance coastal protection at the district-scale. In order to provide that consistency and predictability, clear standards would need to be produced and applied across all Chapter 91 applicants in a given district, with provisions for updating these standards over time. This approach would draw on the positive example set by the Downtown Waterfront MHP, the language of which serves to explicitly address and advance district-scale investment in resilience.

Chapters 91's ambiguous position regarding the placement of fill in the water is a potential though not definite hinderance to advancing coastal protection in certain areas where such fill is deemed necessary. However, since Chapter 91 does not categorically prohibit fill, a potential remedy, as noted by CLF, would be to clarify the conditions under which in-water fill is appropriate and "by explicitly stating that new fill may be introduced in connection" with flood control projects.[8] Under the current regulations, CLF also recommends pursuing pilot projects to determine what may be permittable today without regulatory reforms.

Another dimension of Chapter 91 highlighted by CLF pertains to its authority to compel property owners to implement flood protection actions at some juncture in order to preserve public access rights. The

[7] SUMMARY OF PROPOSED ZONING AMENDMENTS TO ARTICLE 42A, October 7, 2019 (Accessed 10/28/2019) http://www.bostonplans.org/getattachment/60aed3c2-53f6-4e82-8166-9d4efeca2b68

[8] CLF, pp 5

trigger for this requirement is not clear and may be applicable only at the time that flooding begins to disrupt the regular use and enjoyment of the waterfront by the public. CLF argues that licensees be required to implement flood mitigation measures to protect public access during the entire term of the license (e.g., a applicant seeking a 50-year license would need to show how flood risks expected over that 50-year period would be addressed through protective measures). As described in detail by CLF, future sea level rise threatens to impede the public's right to access the water through previously built public improvements, such as the Boston Harborwalk.[9] If the Harborwalk were to flood daily, monthly, or annually, preventing the public from using it, the spirit of Chapter 91 requirements would be violated. CLF recommends that Chapter 91 licensees be required to show how the public improvements will be maintained over the life of the license, which could include the elevation of such improvements, including elements such as the Harborwalk. We concur with this assessment, with the addition that triggers for compulsory flood protection (i.e., risk tolerance) clearly be defined in the regulations.

Lastly, there is the potential for investment in district-scale flood mitigation to interfere with the requirements of existing Chapter 91 licenses. For example, a new berm or seawall could limit access to the water that is a require Facility of Public Accommodation (FPA). Regulatory changes should address this issue by clarifying how new flood mitigation elements can and should be integrated with existing licenses.

7 CONCLUSIONS

This memorandum has reviewed a set of existing and proposed regulations for their effectiveness in supporting implementation of district scale coastal protection, as proposed in Climate Ready Boston plans and the Resilient Boston Harbor Vision.

Based on this review, it is clear the City of Boston is making important strides in its efforts to update regulations to account for future risk and climate change. This places the City among the forefront of similar efforts nationwide based on experience in other cities, as well as case study research.

The review shows that the existing and proposed regulatory tools, for the most part, do not hinder investment in district-scale coastal protections. In some case, they may help advance such investment. In particular, the Downtown Municipal Harbor Plan improves upon the baseline Chapter 91 regulations by incorporating forward-looking climate change projections based on best available data and creating a mechanism to advance private investment in district-scale coastal flood protection solutions. Likewise, the proposed local wetland ordinance, Article 37 Green Building and Climate Resiliency policy, and, from what we understand, the proposed Flood Resilience Zoning Overlay District, all include provisions and processes that could be employed by City officials to guide and control a site-by-site approach to how and where coastal protection infrastructure is built. Over time, such a site-by-site approach could help realize a complete district-scale coastal protection strategy in targeted areas, such as along Fort Point Channel.

Nevertheless, this analysis concludes that although there are opportunities to advance implementation of coastal protection through each of the regulatory tools examined here, none of them – nor all of them collectively – are sufficiently well-positioned to help actively push that investment forward at the pace and

[9] CLF, pp 16

scale needed to address increasing risk. The following conclusions would help improve the available tools:

The regulations should refer to a set of published and formally adopted coastal protection plans and performance/design standards that would predictably guide investment at the site scale across districts and the city. Such performance standards could be flexible enough to enable project proponents to integrate investments into their site plans, but need to include target design elevations, engineering standards, design standards to promote co-benefits such as public amenities, and standards or performance criteria for tie-ins between adjacent properties. There should also be provisions or recommendations for measures to ensure coastal protection is designed to be adapted over time as our understanding of future climate flood risk evolves.

There should be consistency in applications and guidance related to each of the regulatory tools. For example, as the new or reformed rules and regulations associated with Chapter 91 and the City's local wetland ordinance are developed, efforts should be made to ensure that both treat issues around climate change adaption, particularly parameters around the placement of fill in waterways, consistently.

Related to the above, it is noted that neither Chapter 91 nor the proposed local Wetlands Ordinance place a categorical restriction on fill when associated with flood control, and in the latter case, aim to specifically allow it when used for climate adaptation. However, such permissions may not extend to flood control projects that propose in-water fill in order to provide nature-based solutions designed to amplify flood protection with co-benefits such as improved habitat and/or public amenities, as proposed through the Resilient Harbor Vision. Therefore, any regulations controlling fill should clarify if and under what conditions fill may be allowed when not required strictly for flood protection.

Lastly, as these regulations primarily apply to new development, ultimately there will also need to be a regulatory mechanism or program for incentivizing or compelling investment on coastal properties where development has already taken place but remains vulnerable to increasing flood risks. Given that district scale flood protection requires collective action, to not address existing properties would represent a major shortcoming of the City's comprehensive implementation approach.

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APPENDIX D TIDAL DATUM AND FLOOD ELEVATION REFERENCES

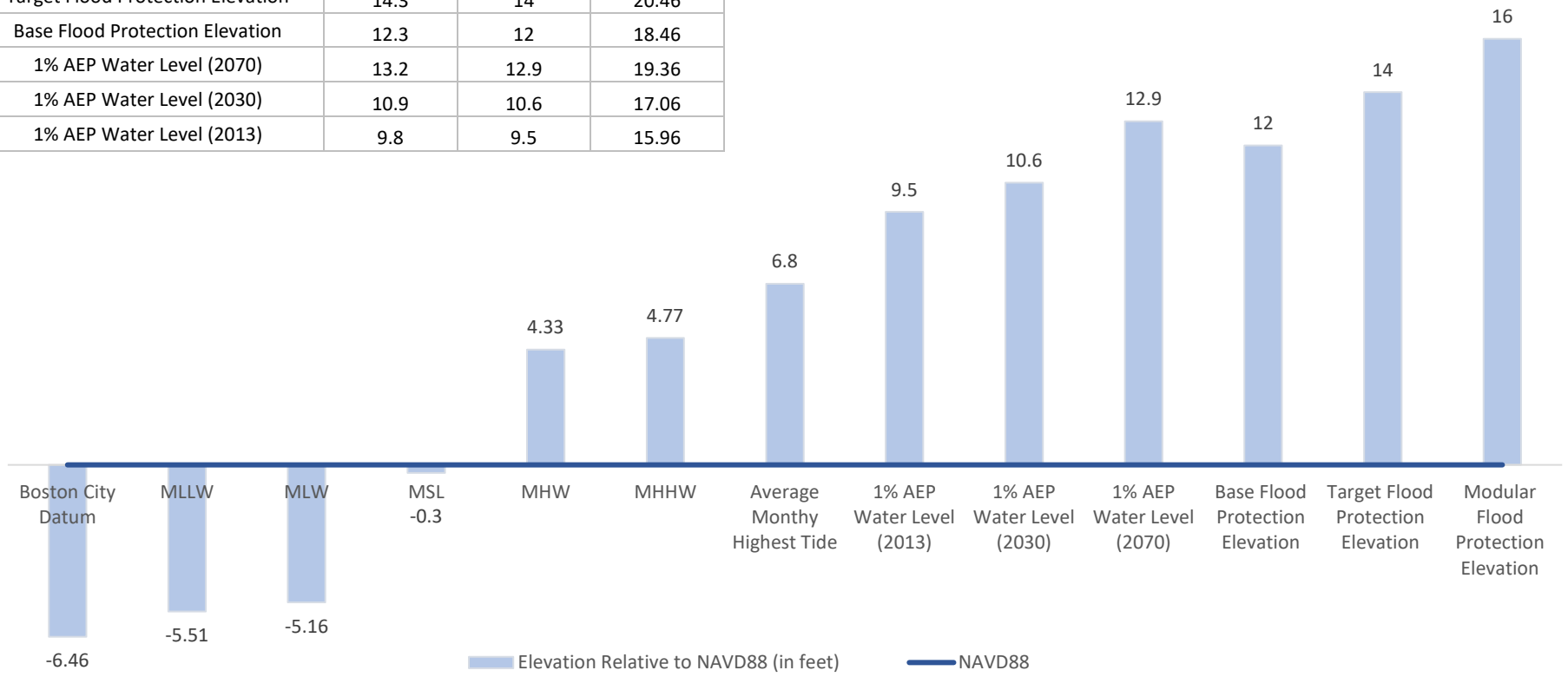
Expanding Boston's Capacity to Build Coastal Resilience Infrastructure

April 2020

Tidal Datum and Flood Protection Elevation Reference Sheet

Fort Point Channel

Datum Conversion	Elevation Relative to:		
	Mean Sea Level	NAVD88	Boston City Datum
Modular Flood Protection Elevation	16.3	16	22.46
Target Flood Protection Elevation	14.3	14	20.46
Base Flood Protection Elevation	12.3	12	18.46
1% AEP Water Level (2070)	13.2	12.9	19.36
1% AEP Water Level (2030)	10.9	10.6	17.06
1% AEP Water Level (2013)	9.8	9.5	15.96



See reverse for definitions

Key Definitions

Annual Exceedance Probability (AEP) – The probability of a flood event occurring in any year. The probability is expressed as a percentage. For example, a large flood which may be calculated to have a 1% chance to occur in any one year is described as 1% AEP. The water surface elevations included here are based on the Boston Harbor Flood Risk Model.

Average Monthly Highest Tide - Created for Climate Ready Boston, the average of the highest tide experienced each month in 2015. Average monthly high tide is approximately two feet higher than the commonly used mean higher high water (MHHW), and lower than king tides (the twice-a year high tides that occur when the gravitational pulls of the sun and the moon are aligned).

Base Flood Protection Elevation – Designed to the 1% AEP flood elevation with 9 inches of sea level rise, plus 1 foot of freeboard.

Boston City Datum (BCD) – The vertical control datum established for the City of Boston.

Boston Harbor Flood Risk Model (BH-FRM) - Created as part of the Massachusetts Department of Transportation (MassDOT) and Federal Highway Administration (FHWA) Resilience Pilot Project. The model was developed by UMass-Boston, Woods Hole Group, Inc. and the University of New Hampshire. The project uses climate projections to simulate flooding from extreme weather and sea level rise, in order to plan for future resilience. The BH-FRM is considered the best available flood hazard data for the City of Boston.

Mean High Water (MHW) - The average of all the high water heights observed over the National Tidal Datum Epoch.

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 Low Water (MLW) – The average of all the low water heights observed over the National Tidal Datum Epoch.

Mean Lower Low Water (MLW) – The average of the lower low water height of each tidal day observed over the National Tidal Datum Epoch.

Mean Sea Level (MSL) - The arithmetic mean of hourly heights observed over the National Tidal Datum Epoch.

Modular Flood Protection Elevation – Designed to the 0.1% AEP flood elevation with 40 inches of sea level rise, plus 1 foot of freeboard.

North American Vertical Datum of 1988 (NAVD88) – The vertical control datum established in 1991 by the minimum-constraint adjustment of the Canadian-Mexican-United States leveling observations.

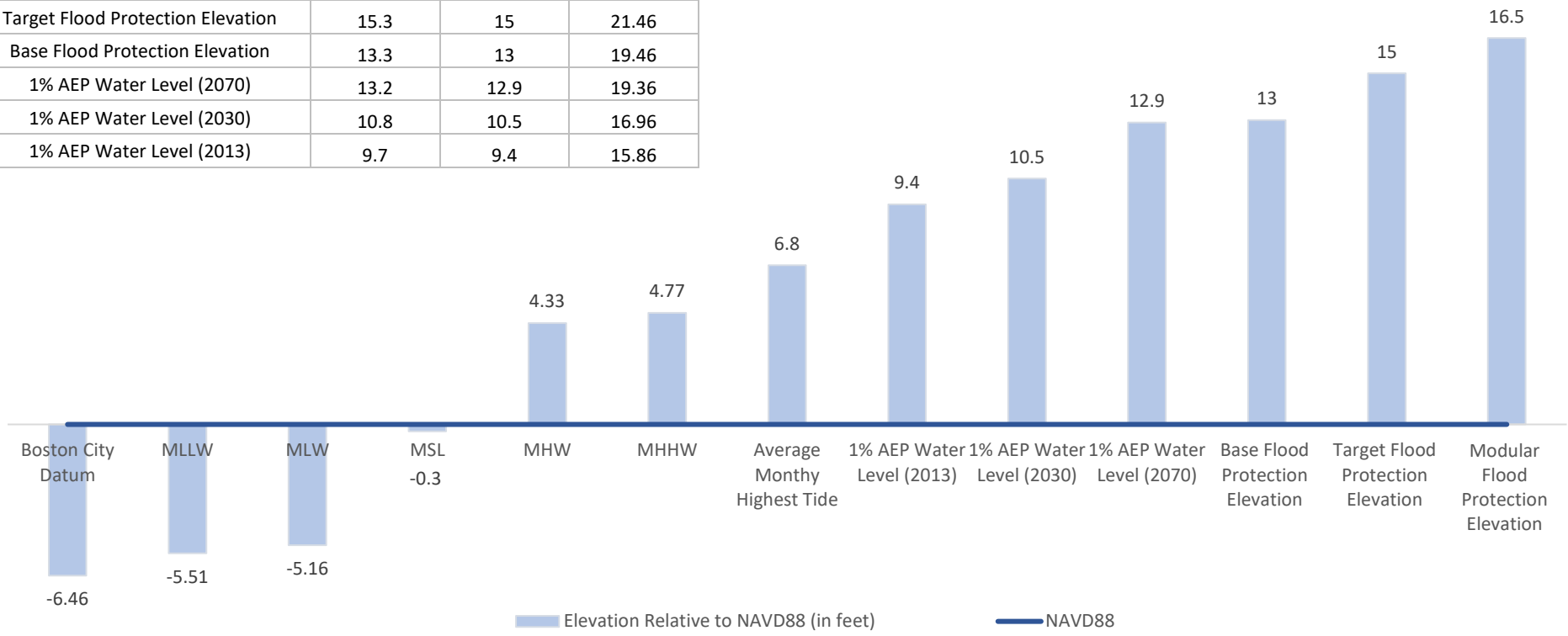
Target Flood Protection Elevation – Designed to the 1% AEP flood elevation with 40 inches of sea level rise, plus 1 foot of freeboard.

Sources: NOAA, FEMA, City of Boston

Tidal Datum and Flood Protection Elevation Reference Sheet

Seaport Boulevard

Datum Conversion	Feet Relative to:		
	Mean Sea Level	NAVD88	Boston City Datum
Modular Flood Protection Elevation	16.8	16.5	22.96
Target Flood Protection Elevation	15.3	15	21.46
Base Flood Protection Elevation	13.3	13	19.46
1% AEP Water Level (2070)	13.2	12.9	19.36
1% AEP Water Level (2030)	10.8	10.5	16.96
1% AEP Water Level (2013)	9.7	9.4	15.86



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Mean Low Water (MLW) – The average of all the low water heights observed over the National Tidal Datum Epoch.

Mean Lower Low Water (MLW) – The average of the lower low water height of each tidal day observed over the National Tidal Datum Epoch.

Mean Sea Level (MSL) - The arithmetic mean of hourly heights observed over the National Tidal Datum Epoch.

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Sources: NOAA, FEMA, City of Boston

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