

Strategies to Advance Investments in Coastal Resilience Solutions in Boston

By

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Abstract

Coastal flooding due to a combination of sea level rise, high tides, and coastal storm events is a significant risk to Boston's population, built environment, and economy. The City of Boston is proactively planning for built district-scale resilience solutions along the shoreline to protect vulnerable neighborhoods. The upfront implementation costs are over a billion dollars and annual maintenance costs add to several tens of millions.

Recent studies have conducted a review of the menu of funding and financing options to pay for municipal investments in climate resilience. However, cities face barriers to implementing these new options given existing municipal processes and other near-term policy priorities.

In order to advance investments in district-scale resilience solutions in Boston, this study investigates: What is the City of Boston's municipal process, key questions that need to be answered, and stakeholders that need to be involved in order to determine viability and to implement new mechanisms to pay for investments in coastal resilience? What are the key barriers and potential solutions for the City to pursue funding and finance for coastal resilience? This is a client-based masters thesis for the Boston Planning and Development Agency.

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Contents

- 1. Introduction 5
 - 1.1. Boston’s coastal resilience challenge..... 5
 - 1.2. Challenges and opportunities for local government investments in climate resilience..... 6
 - 1.3. Research questions and approach 9
- 2. Background on City of Boston’s institutional and enabling environment 10
 - 2.1. Municipal policy and planning for climate and coastal resilience 10
 - 2.2. Municipal revenue, budget, and process..... 11
 - 2.2.1. Revenue 11
 - 2.2.2. Budget 12
- 3. Funding and financing for coastal resilience..... 14
 - 3.1. Existing funding and financing mechanisms 14
 - 3.1.1. Federal 14
 - 3.1.2. State 15
 - 3.1.3. City 16
 - 3.2. Potential funding and financing mechanisms..... 16
 - 3.2.1. State 17
 - 3.2.2. Processes for city-level funding sources 18
 - 3.2.3. Processes for city-level financing mechanisms..... 21
 - 3.2.4. Processes for district-level funding sources..... 22
 - 3.2.5. Processes for district-level financing mechanisms 24
 - 3.2.6. Parcel..... 26
 - 3.3. Role of risk pricing and insurance 27
- 4. Key findings, recommendations, and conclusion 28
 - 4.1. Key findings 28
 - 4.2. Recommendations 33
 - 4.2.1. Funding..... 33
 - 4.2.2. Financing 35
 - 4.2.3. Planning and policy 36
 - 4.3. Conclusion..... 37
- Appendix A – Departments and experts consulted 38
- Appendix B – Environmental Impact Bonds 39
- Appendix C – Insurance-linked Securities..... 44

References 47

1. Introduction

1.1. Boston’s coastal resilience challenge

The City of Boston is a leader in taking action to prepare for a changing climate. Under the Climate Ready Boston initiative, Boston released its city-wide foundational report in December 2016 which includes a detailed vulnerability assessment and principles and initiatives to enhance climate preparedness.¹ Coastal flooding due to a combination of sea level rise, high tides, and coastal storm events is a significant risk to Boston’s population, built environment, and economy. Sea level rise in Boston is projected to increase 9 inches by 2030, 21 inches by 2050, and 36 inches by 2070. Currently 90,000 people and 12,000 buildings are in areas that will be inundated by a 1% annual chance flood under the 2070 sea level rise scenario and estimated economic losses are over \$14.2 billion.

To further assess the coastal flood risks and identify specific resilience solutions to protect vulnerable neighborhoods, Climate Ready Boston completed district-level studies for East Boston, Charlestown, and South Boston and is currently undertaking studies for Downtown & North End and Dorchester (Figure 1). The studies identified coastal resilience strategies including berms and floodwalls, elevated waterfront parks and harborwalks, elevated roads, and natural wetland buffers to protect neighborhoods from current and projected flooding.

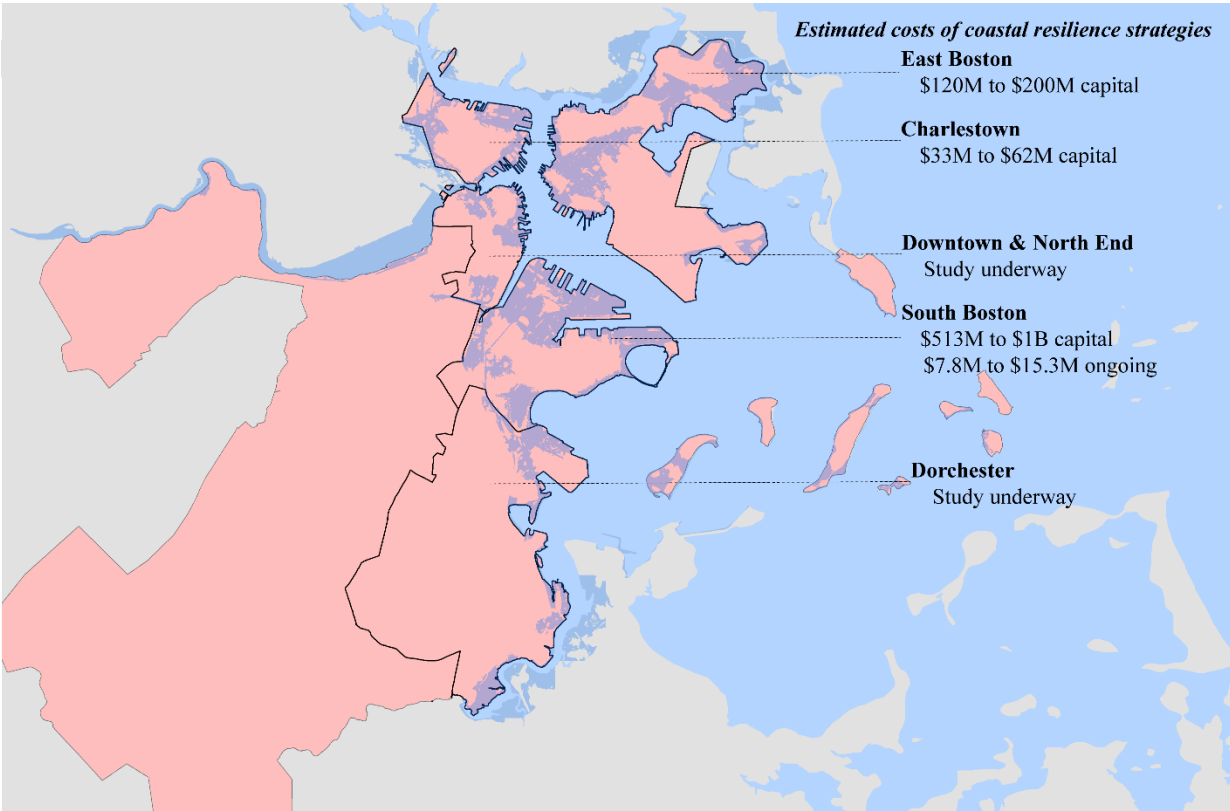


Figure 1. Districts with detailed coastal resilience studies and proposed coastal resilience strategies. The blue indicates coastal flood inundation under a 1% annual chance flood with 21 inches of sea level rise by 2050.

Preliminary cost estimates for upfront implementation of district-scale coastal resilience strategies in three of the five completed neighborhood studies total \$666 million to \$1.26 billion (Table 1). However, the actual total costs across coastal neighborhoods in Boston will be much greater. Due to variations in the district studies, some of the initial estimates do not include implementation costs for certain sections of the shoreline, annual maintenance costs, and costs to protect against new coastal flood pathways that will emerge by the 2050s. Additionally, the total costs across the city will increase once cost estimates are developed for the remaining two study areas, and additional studies are carried out for new neighborhood and districts that will be exposed to coastal flooding beyond 2050 such as the South End and Back Bay. The district studies performed to date do not outline specific methods to fund and finance the projects and lack clear identification of the governance necessary for building and maintaining specific projects, although these elements are less common in planning-level studies.

Table 1. Estimated implementation and annual maintenance costs for priority, near-term, and mid-term district-scale coastal resilience strategies^{2,3}

	Upfront implementation costs	Annual maintenance costs
East Boston	\$120M to \$200M [*]	\$1.8M to \$3M ^{**}
Charlestown	\$33M to \$62M [*]	\$0.5M to \$0.9M ^{**}
South Boston	\$513M to \$1.0B	\$7.8M to \$15.3M
Downtown and North End	TBD	TBD
Dorchester	TBD	TBD
Total (3 of 5 districts)	\$666M to \$1.26B+	\$10.1M to \$19.2M^{**}

^{*}District study estimates not include costs for coastal resilience solutions that will be needed to protect against new coastal flood pathways that will emerge by the 2050s.

^{**}Author's rough estimate based on 1.5% of capital costs, a methodology used for the South Boston study.³

The costs for implementation across all neighborhoods, the costs for annual maintenance, and the urgency to address present and near-term coastal risks place significant new burdens on the City's budgets, as elaborated in Section 2. Implementation of priority district resilience measures are already underway, including public investments in deployable flood walls and elevated roads and open spaces. The City is also engaging with ongoing waterfront development projects in vulnerable areas to incorporate coastal protection that would benefit the wider neighborhood. However, these opportunistic interventions reflect only a small fraction of the overall coastal protections needed.

1.2. Challenges and opportunities for local government investments in climate resilience

Having limited financial resources is one of the top challenges that cities in the US and around the world are facing for climate change resilience planning and implementation.⁴⁻⁶ Many cities have a deficit of investment in even basic infrastructure projects, and lack capacity to undertake more complex investments for climate-resilient systems. The added challenges of investments in resilience under a changing climate include local impacts as part of a larger global challenge, risks that will emerge over time,

and evolving understanding of risks. At the local level in the US, climate adaptation and resilience assessments and planning to date have been funded by a mix of local government budgets and federal, state, and foundation grants.⁵ However, implementation of the resulting recommendations and built solutions would require significantly more resources.

Funding refers to capital that is available or will be collected and does not need to be repaid. Funding for coastal resilience investments will require new revenue sources given the scale of the costs. Meanwhile, financing refers to capital available upfront that must be repaid with interest. Since coastal resilience projects often require large upfront expenditures, financing may be necessary to pay for the design and construction. Project finance is the financing of infrastructure construction that will be repaid using revenue that the project generates. Project finance is more common with infrastructure agencies which tend to build transit lines and water pipelines for example and charge a fee for use, rather than with local governments which tend to build public amenities such as schools and parks. Even with innovative financing mechanisms, funding availability serves as a key component for securing financing.

Several studies have surveyed and evaluated the menu of potential funding and financing mechanisms for climate adaptation and resilience.⁷⁻¹⁴ These studies are tailored towards local and state governments at the forefront of adaptation planning, including Boston and California. The layered funding and financing mechanisms from the federal, state, city, district, and parcel levels that are applicable to Boston are summarized in Section 3.

The studies used key criteria to evaluate the potential of each funding mechanism, such as:

- *Revenue-generating potential*: the potential amount that can be raised is ideally predictable and sustainable and matches the scale of the need;
- *Efficiency*: the time required and the administrative and transactional costs to implement the mechanism are ideally low;
- *Equity and fairness*: the cost burden is ideally based on ability to pay, and the degree of the cost burden reflects the scale and degree of the benefits provided; and
- *Feasibility*: the likelihood that the mechanism could be implemented is ideally high.

Equity and fairness in particular need to be carefully evaluated and weighed especially since funding mechanisms are essentially various forms of taxes and fees which place the cost burden on parties. Climate change impacts and responses have the potential to exacerbate existing social and economic inequities, and establishment of taxes and fees without equity considerations will place additional burdens on already vulnerable populations.⁸ For instance, low income households already tend to have fewer resources to prepare for and recover from disasters and have lower rates of insurance coverage.

Feasibility is also a critical consideration that needs to be weighed heavily, yet many funding mechanisms score low on this criterion. Despite the menu of potential funding and financing mechanisms available, multiple challenges to feasibly implement these mechanisms persist. Upon closer inspection, the challenge of “we do not have enough money” is more nuanced and embedded within economic,

institutional, administrative, and legal barriers. Characteristic patterns of adaptation funding and financing challenges for local governments include:⁵

- inability to make the economic case
- low priority
- lack of champion/leadership
- conflict of interest
- disproportionate burden/prior disadvantage
- inappropriate funding scale
- disjointed risk structure
- chronic underfunding or basic lack
- siloed government functions
- lack of capacity
- discontinuous funding
- aversion of innovation
- funding biases
- lack of knowledge about funding sources
- eligibility

Adaptation implementation can generate significant benefits that exceed costs, but the inability to make the economic case and the lack of appropriate financing mechanisms hinders the role of markets. A significant gap in research lies in rigorously quantifying the benefits, in the form of avoided losses, and the co-benefits, which may range from economic development, to equity considerations, to protection of historical landmarks, to improved health and the environment.¹⁵ Challenges include lack of data, uncertainty over climate projections on timing and magnitude, and valuation techniques, especially since different people may value benefits differently. The benefits cannot be aggregated into a single monetary value since the different types of benefits and valuation techniques cannot be treated uniformly. Additionally, the benefits of investments in adaptation and resilience to a changing climate may be diffuse, long-term, and non-monetary. These characteristics make such investments more difficult to justify and prioritize among other funding priorities that demonstrate visible, near-term benefits. Furthermore, traditional finance models which rely on predictable, future cash flows are less suitable for resilience investments since both the benefits in terms of avoided losses and co-benefits are difficult to capture monetarily. The monetary benefits that will arise over the long-term are also heavily discounted under traditional finance methods, since a dollar today is worth more than a dollar in the future.

Strong leadership can help overcome funding constraints to adaptation and resilience planning and implementation.^{16,17} On the other hand, existing governance structures can serve as a major barrier to adaptation implementation. Governance systems will need to evolve with a changing climate in order to provide functions to address emerging challenges. These functions include: communicate and integrate rapidly evolving climate information into planning and capital investments; coordinate with a new variety of stakeholders to develop and implement plans; and develop the capacity to design, finance, construct, and maintain district-scale flood protection measures as well as resilient conventional infrastructure.¹⁸

Given the cross-cutting impacts of climate change, opportunities for adaptation finance extend beyond budget line items for projects designated solely for adaptation and resilience. Opportunities include incremental adaptation and resilience elements in investments to meet needs across the range of sectors.⁷ For instance, while planning for district coastal flood protections are underway, municipal investments in sewers, schools, and buildings also present opportunities to reduce coastal flood risks at the site and district levels. Additionally, asset management serves as an avenue to systematically

incorporate climate change considerations across an entity's entire portfolio of assets while considering lifecycles.⁷

1.3. Research questions and approach

This client-based thesis provides research support to the Boston Planning & Development Agency (BPDA) around financing and funding mechanisms to advance implementation of coastal flooding resilience solutions. The project is motivated by the inference that unlocking financing and funding mechanisms is a critical step for implementing Climate Ready Boston's district-scale coastal resilience strategies to protect people and infrastructure from coastal risks.

This project is designed to complement existing work on funding and financing for resilience in Boston. In April 2018, the University of Massachusetts (UMass) Boston's Sustainable Solutions Lab released a report "Financing Climate Resilience: Mobilizing Resources and Incentives to Protect Boston from Climate Risks" which serves as a strong foundation for this thesis.⁸ Following the release of the report, the BPDA began the project "Implementing District-Scale Solutions for East Boston: Climate Resiliency Financing and Funding Models" in Fall 2018 with the goal to identify specific and practical financial and funding models to construct, maintain, and administer coastal protection infrastructure in a priority site in East Boston. The final report for the BPDA project is expected in early Summer 2018.

To complement existing work, this project focuses on the following questions: *What is the City of Boston's municipal process, key questions that need to be answered, and stakeholders that need to be involved in order to determine viability and to implement new mechanisms to pay for investments in coastal resilience? What are the key barriers and potential solutions for the City to pursue funding and finance for coastal resilience?*

This report will focus on the municipal processes needed to evaluate and implement the following potential city- and district-level funding and financing mechanisms:

- *Funding*: City- and district-level resilience fees
- *Financing*: Specialty bonds (green bonds and environmental impact bonds) and district improvement financing
- *Insurance-linked securities*: Catastrophe bonds and resilience bonds

To address the questions, the project approach consisted of: literature review of the menu of municipal funding approaches and financing mechanisms for climate resilience, and framing in the context of the City's resilience plans and other budget priorities; interviews within the various departments in the City of Boston to understand existing processes for evaluation of and coordination on funding and financing for coastal resilience; and consultations with practitioners and experts on climate resilience finance, public finance, and public sector engagement for private sector finance. A list of departments and experts consulted is available in Appendix A.

2. Background on City of Boston’s institutional and enabling environment

An enabling environment needs to be in place to facilitate municipal implementation of district-scale coastal resilience solutions. First, strong policies establish priorities and guide decisions on resilience, and plans systematically identify resilience strategies for implementation. In addition, resources are needed to allow staff time to work on emerging resilience needs relative to other municipal priorities, and large amounts of resources are needed to construct and maintain infrastructure projects. Ultimately, decision-makers are behind the establishment of policy, planning, and resource priorities. However, the new challenges under a changing climate require new types of decision-making outside of typical assigned roles and responsibilities. This section provides background context on the City of Boston’s existing policy and planning and budget considerations.

2.1. Municipal policy and planning for climate and coastal resilience

The City’s policies, plans, regulations, and guidelines around climate and coastal resilience inform both public investment priorities, and investments and design on privately-held land given future risks.

Imagine Boston 2030, released July 2017, is the City’s first comprehensive plan in 50 years. It outlines key goals to guide the future of the City including “encouraging continued economic growth, becoming more affordable and equitable, and preparing for climate change”.¹⁹ Future municipal planning, programs, and investments are guided by the priorities identified in *Imagine Boston 2030*, which elevates the priority of integrating climate change across sectors.

The Climate Ready Boston initiative operationalizes the high-level goal under *Imagine Boston 2030* to enable the city to thrive under a changing climate. To comprehensively stitch together the shoreline resiliency strategies across districts that were identified through Climate Ready Boston’s coastal flooding analyses, Mayor Martin Walsh announced the Resilient Boston Harbor vision in October 2018 to increase open space along the waterfront while protecting the city from sea level rise and flooding.²⁰ While the Climate Ready Boston and Resilient Boston Harbor initiatives are led by the Environment Department, multiple City departments are tasked with implementing climate resilience recommendations.

For example, the BPDA utilizes the development review process and zoning code to support climate-ready buildings. Under the City’s Article 80 development review process, new development projects over 50,000 square feet are required to provide site-level planning responses to sea level rise and other climate change hazards through completion of a Climate Resiliency Checklist.²¹ The BPDA is also currently developing a flood resiliency zoning overlay district and related resiliency design guidelines for new construction and building retrofits.²² Once the zoning overlay district and guidelines are integrated and adopted into regulatory processes, developers will be responsible for considering, implementing, and bearing the cost of parcel-level flood resilience strategies or potentially contribute to district-scale strategies.

Complementing the resiliency design guidelines for private property, the Boston Public Works Department developed *Climate Resilient Design Standards & Guidelines* to protect the public rights-of-way, and serves as another example of a multi-agency approach to climate resilience.²³ The standards and

guidelines address cost considerations, including: consideration of capital costs and life-cycle costs; triple bottom line cost-benefit analysis for financial, social, and environmental impacts if several conceptual barrier types are being considered; and design for incremental adaptation and resilience if funding and/or site constraints are significant.

The City's resilience policies and plans foster an enabling environment for resilient public investments by establishing direction for municipal budgeting and design decisions, as well resilient private investments through design guidance.

2.2. Municipal revenue, budget, and process

Financial resources and allocations towards resilience are currently limited by existing revenues and annual budgeting processes. In order to understand funding and financing needs and challenges for coastal resilience relative to other important municipal public policy areas, this subsection provides an overview of the City's revenue, budget, and process. Revenue generation is reliant on maintenance and growth of the tax base, and budget allocations need to balance multiple near-term priorities, both of which have the potential to conflict with long-term coastal resilience needs.

2.2.1. Revenue

Annual municipal revenues determine the size of the City's annual budget to pay for the range of public services and infrastructure, including resilience planning and district-scale coastal protections. The City's anticipated revenue for Fiscal Year (FY) 2019 totals \$3.29 billion and for reference, the Commonwealth's FY18 revenues totaled \$27.8 billion.^{24, 25} With revenue growth increasingly dependent on expanding the local economy, planning and investments for short-term revenue generation and long-term coastal resilience are to be carefully balanced.

Property taxes serve as the largest source of revenue for the City, but while it may serve as a potential source of funding for coastal resilience, the property tax levy is legally capped. Generally, local revenues are primarily generated through property taxes while federal and state revenues are primarily generated through income taxes. In FY19, property tax revenue is estimated to total \$2.30 billion, 71% of the City's total revenue.²⁴ However, Massachusetts' Proposition 2½ limits the annual property tax revenue the City can raise each year from its existing tax base to no more than 2.5% of the total value of all taxable property and no more than a 2.5% increase over the prior year's total levy.²⁶ Proposition 2½ is a current constraint to municipal revenues and budgets to fund investments in coastal resilience.

Despite the limit on property tax increases, the City has seen unprecedented new growth in property tax revenue over the past few years. Growth in property tax revenue comprises 85% of the new increase in total revenues compared to FY18.²⁴ The growth in property tax revenue is driven by new developments entering the City's tax base. However, without changes in policies or incentives, the tension between increasing the tax base through new development, and developing in areas vulnerable to coastal flooding will likely continue into the future.

Other major sources of recurring municipal revenue include state funding and other local sources, and their trends also indicate dependence on the local economy. Revenue transfers from the Commonwealth comprise the City's second largest revenue source. However, net state aid to the City has decreased over the past decade after factoring in increases in state assessments relative to modest increases in state aid.²⁴ The City will likely need sizeable state funding for a layered approach to climate and coastal resilience funding from the various levels of government. The Commonwealth would continue to serve as an important funding source, as it can generate a large amount of revenues given its state-wide tax base and has greater authority over revenue-raising mechanisms. Meanwhile, municipal revenue from local receipts including fines, fees, and excise taxes has grown over the past few years given the expansion in the local economy.

2.2.2. Budget

Municipal capital availability for investments in coastal resilience projects are dependent on revenues and determined through the municipal budgeting process. Every year, the City issues an annual operating budget and a five-year capital plan through an institutionalized budgeting process.

Process: The annual appropriations for all of the City's departments and operations (except Boston Public Schools) are prepared under the direction of the Mayor, reflecting the Mayor's policy priorities and obligations. Each department first proposes budgets to the Office of Budget Management (OBM) and mayoral meetings are held with departments to discuss funding and policy. The Mayor then submits the recommended budget to the City Council which holds public hearings. The City Council may approve, reject, or reduce the proposed budget, but not increase the budget. Lastly, the Mayor approves the budget adopted by City Council by July 1.

Since the budgeting process is annual, allocation of budgets prioritizes short-term needs, which may conflict with long-term needs for resilience. However, the enabling environment of policies and plans under *Imagine Boston 2030* and *Climate Ready Boston* intend to guide planning and budgets to meet long-term resilience goals.

Operating budget: Funding for staff time to work on climate and coastal resilience initiatives, resilience infrastructure maintenance, and repayment of borrowing for resilience infrastructure will primarily come out of the operating budget. Revenues directly fund the operating budget, which covers personnel costs and services including routine operations and maintenance, and are allocated by department. The largest departmental appropriations go towards public schools followed by public safety, reflecting the City's primary responsibilities and priorities that need to be balanced with resilience. Expenditures under the operating budget also include fixed costs, covering debt service to repay bond issuances, pensions, and state and county assessments. As such, the size of the City's debt service and legacy pension obligations dictates the remaining funds available to allocate to departments to work on other policy priorities including climate and coastal resilience. For FY19, the City's operating budget totaled \$3.29 billion. Of the total, \$2.5 billion (76%) was allocated to departments and \$720.1 million (22%) to fixed costs.²⁴

Capital budget: Unlike the operating budget, the capital budget funds longer-term investments in the City's infrastructure; as such, investments in coastal resilience infrastructure will primarily come out of the capital budget. The umbrella plan *Imagine Boston 2030* guides the investments under the capital plan, which funds the planning, construction, upkeep, and renovation of the City's capital assets. The capital plan also covers matching funds to leverage state and federal construction funds on projects. Each investment within the five-year capital plan is sequenced by the anticipated study, design, and construction phase and expenditure per year. Budget requests for each project phase are then placed into a multi-year spending plan along with previously authorized projects. The FY19-23 capital plan totals \$2.43 billion, with \$337.9 million allocated for expenditures in FY19.²⁴ In alignment with *Imagine Boston 2030*, the FY19 capital plan dedicates a majority of the budget to transportation, school buildings, and open space, and \$1.6 million to Climate Ready Boston for additional resiliency analyses and planning. While a five-year capital budget (\$2.43 billion for FY19-23) is large enough to finance implementation of coastal resilience strategies in three of the five neighborhoods (\$666 million to \$1.26 billion), full allocation is limited by previously authorized projects and new capital requests for other needs.

The annual capital planning process takes into consideration needs across departments as well as short-term and long-term costs and savings, which may deprioritize resilience projects if not carefully bundled with other needs. At the beginning of the annual process, departments consider their planning, infrastructure, and equipment needs and submit capital budget requests to OBM for consideration. Development of project requests may involve both internal assessments of current needs and a review of external constituent requests. The project requests include a cost estimate – both capital costs and short-term and long-term impacts on the operating budget. OBM works with the departments to estimate potential operating budget savings from projects, since balancing future savings and future costs is vital for the City's long-term financial health. For instance, investments such as energy efficiency projects generate cost savings for the City. While coastal resilience protections mitigate costs following extreme storm events, the resilience field generally lacks a method to tangibly capture cost savings from avoided losses.

Projects in the City's capital plan, including physical investments in resilience, are primarily financed by borrowing through the issuance of general obligation bonds. As such, budgets for capital investments is dependent on the City's fiscally responsible debt affordability limits, which is a 7% ceiling on debt service as a percentage of the operating budget expenditures. The City also considers the projected municipal revenue since the debt repayment policy requires at least 40% of debt repaid within 5 years and 70% in 10 years. To finance the FY19-23 capital plan, the City assumes \$1.01 billion in new general obligation bonds over the next five years.²⁴ The City holds a AAA credit rating, the highest possible rating, which allows for low interest rates on its bonds. Over the past few years, the separate departments that work on municipal finance and on climate resilience projects has had to work more closely together as credit ratings agencies begin to incorporate physical climate risk considerations into municipal credit ratings.^{27,28} In addition to general obligation bonds, state and federal grants are the next largest source of funding for the capital plan, followed by other City funds and private grants.

3. Funding and financing for coastal resilience

The coastal resilience solutions will need to be funded and financed through multiple sources from the federal, state, city, district, and parcel levels given the gap between the resources available from a single source and the scale of costs for coastal resilience, detailed above. Subsection 3.1 below describes existing funding and financing mechanisms for resilience before subsection 3.2 explores the municipal processes, opportunities, and challenges to implement potential mechanisms.

3.1. Existing funding and financing mechanisms

Existing funding and financing mechanisms for the City of Boston are available from across the various scales of government and geography. Existing funding and financing options that can be utilized specifically for resilience are outlined in Table 2. The summaries of each mechanism that follow within this subsection draw from UMass Boston Sustainable Solutions Lab’s foundational report which identifies and evaluates options for Boston.

Table 2. Existing funding and financing mechanisms for resilience

Federal	<i>Mechanism to deploy funds</i>	<ul style="list-style-type: none"> Federal grant programs
State	<i>Mechanism to deploy funds</i>	<ul style="list-style-type: none"> Municipal Vulnerability Preparedness Program
	<i>Financing mechanism</i>	<ul style="list-style-type: none"> General obligation bonds
	<i>Funding source</i>	<i>Policy proposals underway:</i> <ul style="list-style-type: none"> Deeds excise tax Exploratory Commission
City	<i>Financing mechanism</i>	<ul style="list-style-type: none"> General obligation bonds and capital budget
	<i>Funding source</i>	<ul style="list-style-type: none"> Community Preservation Act

3.1.1. Federal

Federal grants are commonly used to fund a portion of major infrastructure projects.

Federal grant programs: Multiple existing federal grant programs serve as sources of funding for projects explicitly designed for resilience as well as projects in various sectors in which resilience can be integrated. Select examples include Federal Emergency Management Agency’s (FEMA) various hazard mitigation programs, Department of Housing and Urban Development Community Development Block Grants, and National Oceanic and Atmospheric Administration Coastal Resilience Grants.

The City, recognizing the competitiveness yet value of seeking funding from the federal level, has submitted a proposal in January 2019 for a \$10 million FEMA pre-disaster mitigation grant for a coastal resilience project along the Fort Point Channel.²⁹

3.1.2. State

The Commonwealth recognizes the need to financially support municipalities and towns to manage climate risks. As such, the Commonwealth is deploying funds specifically for resilience, dedicating financing for resilience, and exploring additional potential strategies.

Municipal Vulnerability Preparedness (MVP) Program: The Commonwealth's MVP Program deploys funding to communities specifically for climate adaptation and resilience. The City of Boston, a designated MVP Community, is eligible for MVP Planning and Action Grants to advance priority climate adaptation actions including design studies, redesign and retrofits, nature-based solutions, and education and outreach. For FY19, \$10 million is available through the MVP Action Grants which award up to \$2 million per project.^{30,31} However, the award cap and the requirement to utilize the grant within a year may be limiting for costly coastal resilience projects that require multi-year planning and implementation.

General obligation bonds: Bond financing mechanisms are appropriate for resilience infrastructure projects which typically require substantial upfront investment and generate benefits over multiple years. General obligation bonds provide upfront financing that is repaid over several years and is backed by the credit and taxing power of the issuing jurisdiction. Alternatively, revenue bonds are backed by revenue from a dedicated source.

The Commonwealth issues state bonds to support capital investments within its jurisdiction as well as to provide state aid to its municipalities and towns. Governor Charlie Baker signed legislation in August 2018 to authorize over \$2.4 billion in capital allocations for climate adaptation, environmental protection, and community investments, financed through a general obligation bond.³² While a large amount, \$75 million of the total is dedicated to the MVP program and over \$5 million will go towards coastal resilience measures at specific sites in Boston.³³

Proposed deeds excise tax: Policy actions are underway at the state level for additional funding resources for climate resilience. In January 2019, the Governor submitted a proposed bill to the Legislature for a 50% increase in the excise tax on real estate transactions in order to fund future adaptation infrastructure investments to protect cities and towns across the state.³⁴ The fee would increase from \$2 to \$3 per \$500 of property value; for a home priced at \$500,000, the proposed increase would raise the cost of the real estate transfer by \$1,000. The deeds excise tax is estimated to generate approximately \$137 million annually. While the fee increase proposal required a lot of political will and could generate a significant amount, additional funding will be required from the state level to support its cities and towns. Furthermore, an increase in the excise tax does not help align incentives for climate action, unlike a gasoline tax that could encourage investment in low emission transportation, water and sewer fees and credits that could incentivize on-site stormwater capture, or an insurance surcharge that could align the cost burden with physical risk exposure.

Proposed Exploratory Commission: The Massachusetts Legislature is also currently considering a proposal to establish a Climate-Ready Commonwealth to explore solutions to fund, implement, and prioritize climate adaptation infrastructure.^{35,36} Recognizing the need to answer critical questions that municipalities are currently struggling with in planning for local adaptation and resilience, the proposed

commission would investigate the responsibilities of the state for funding and implementation of adaptation infrastructure and identify existing financial, legal, regulatory, and governance barriers for adaptation and resilience. The commission would be tasked with developing a report with recommendations within 18 months.

3.1.3. City

In addition to seeking existing federal and state sources, the City of Boston is already dedicating a portion of its budgets to resilience.

General obligation bonds and capital budget: Similar to how the Commonwealth issues bonds to finance resilience investments, the City issues municipal bonds to support capital projects within its jurisdiction. Most coastal resilience projects require large upfront expenditures, requiring financing to access capital to pay for design and construction. However, responsible bond issuance needs to be assessed in tandem with projected funding to pay back the debt over time, the underlying challenge of financing for resilience. To date, the City solely issues general obligation bonds secured by full faith and credit of the City, rather than by a particular source of revenue. Over the past six years, the annual municipal bond issuances ranged from \$140 million to \$153 million to finance capital asset needs across the city.³⁷

In October 2018, Mayor Walsh announced that the City of Boston will commit at least 10% of all new spending in the capital budget (an estimated \$12 million to \$16 million annually) to resilience projects.³⁸ The types of projects that qualify as a “resilience project” has not yet been defined by the City. While a significant policy action, the capital budget allocation of financing does not entail generation of additional amounts of money and as such, a funding gap for infrastructure investments remains given the scale of resources needed for an interconnected system for coastal resilience throughout Boston.

Community Preservation Plan: A unique pot of municipal funds that can be used for resilience capital investments comes from the Community Preservation Act (CPA). Voters in Boston passed the CPA in November 2016 for a 1% property tax surcharge to generate additional funds for: open space, parks, and outdoor recreation; affordable housing; and historic preservation. The surcharge costs the average Boston homeowner about \$25 annually and is expected to generate an estimated \$20 million annually.³⁹ By state law, 10% of CPA funds must be spent in each of the three categories and the remaining is discretionary between the categories. A Community Preservation Committee (comprised of five representatives from BPDA, Boston Housing Authority, Parks Commission, Landmarks Commission, and Conservation Commission, and four seats appointed by the City Council) is responsible for recommending the funding allocations. The City’s Community Preservation Plan aligns with the City’s long term plan, *Imagine Boston 2030*, and includes a goal to fund investments in open space that can mitigate climate impacts from coastal flooding, intense heat, and major storms. However, the CPA funds are limited to upfront implementation costs of capital projects and may not be used for operations and maintenance.

3.2. Potential funding and financing mechanisms

To supplement existing funding sources, new revenue sources are needed for investments in coastal resilience. Table 3 summarizes potential funding and financing mechanisms for coastal resilience from across levels of jurisdiction and geographies. Potential funding sources from the federal government are

outside the scope of this study. The orange box indicates the city- and district-level funding and financing mechanisms of particular focus in this study in order to elucidate processes, opportunities, and challenges for the City of Boston to implement them.

Table 3. Potential funding and financing mechanisms for coastal resilience

State	<i>Funding source</i>	<ul style="list-style-type: none"> State-wide resilience fees based on income taxes, carbon or gasoline tax, water and sewer fees, or insurance surcharge
City	<i>Funding source</i>	<ul style="list-style-type: none"> City-wide resilience fees based on water and sewer fees or property taxes
	<i>Financing mechanism</i>	<ul style="list-style-type: none"> Specialty bonds including green bonds and environmental impact bonds
District	<i>Funding source</i>	<ul style="list-style-type: none"> District resilience fees based on special assessments and business improvement district mechanisms
	<i>Financing mechanism</i>	<ul style="list-style-type: none"> District increment financing
Parcel	<i>Funding source</i>	<ul style="list-style-type: none"> Exactions

3.2.1. State

The state government will need additional sources of revenue given the scale of resources required to fund climate resilience across Massachusetts, among other existing needs for public goods and services.

Resilience taxes and fees: Additional funding can be generated through state-wide resilience taxes and fees, potentially based on: income taxes, a carbon or gasoline tax, water and sewer fees, or an insurance surcharge.

Income taxes provide the largest source of revenue for the Commonwealth,²⁵ but raising state-wide income taxes and dedicating a portion of it to climate resilience may be particularly challenging given the desire for flexibility in allocations from the state’s General Fund.

A state-wide resilience tax based on a carbon tax or gasoline tax, if properly priced, would create incentives to help mitigate carbon emissions, the underlying cause of climate risks. The Legislature is currently considering two bills to put a price on carbon emissions from most sectors,^{40,41} which would encompass a carbon tax on gasoline. One bill is designed to rebate 100% of the revenues back to households and businesses. The other bill allocates 30% of revenues, an estimated \$400 million to \$600 million a year, into a Green Infrastructure Fund for investments in clean energy, clean transportation, and resilience.

However, allocating revenues from such taxes to fund both climate change mitigation and adaptation will need to be carefully and intentionally bundled early on so as to not divert funding from one to another. For example, Massachusetts receives revenue from the Regional Greenhouse Gas Initiative (RGGI) cap and trade market, which has funded primarily greenhouse gas mitigation programs in the state including the main energy efficiency program Mass Save. The Commonwealth has received over \$646 million in revenue since the initiative’s inception in 2008, including over \$40 million in 2018.⁴² Governor Baker’s

budget proposal for FY20 to utilize RGGI revenues for both mitigation and adaptation programs has received criticism for shifting funding away from mitigation programs.⁴³ However, if RGGI tightens the carbon cap and the prices of the carbon allowances increase, the state could consider carefully allocating the new incremental revenues to also fund adaptation programs.

State-wide resilience fees based on water and sewer fees has the advantage that all properties pay in, unlike property taxes. The Commonwealth could also establish a stormwater fee and if tied to a stormwater credits system, the fees and credits could incentivize property owners to invest in on-site stormwater runoff reduction to help mitigate stormwater flooding.

Another potential source of revenue is a state-mandated insurance-based fee, which would help align exposure to climate risks with costs. For example, a proposed Adaptation Trust Fund for the New York metropolitan region based on an insurance surcharge demonstrates a novel revenue-generating method that is tied to coastal flood risk and can be used to support bond issuances.⁴⁴

3.2.2. Processes for city-level funding sources

Additional municipal funding for resilience may be captured through city-wide resilience taxes and fees, potentially based on property taxes or water and sewer fees to the extent that the City has jurisdiction. This study dives into the municipal processes, opportunities, and challenges to generate additional funding.

City-wide resilience fees based on property taxes

A potential source of new revenue includes a city-wide resilience fee based on property taxes, the City's main source of revenue. A resilience fee through this approach would be proportional to the assessed value of a property. However, since the City's property tax levy is at its maximum legal limit under Proposition 2½, increasing the levy requires an override vote according to state legislation.

Example process: The process to establish a city-wide property tax surcharge under the Community Preservation Act (CPA) provides an example of a voter-approved tax increase for dedicated purposes. However, the CPA approval process is slightly different from a Proposition 2½ override process, since the revenue generated by the CPA surcharge are not subject to the levy limitations of Proposition 2½. The Massachusetts Legislature passed the CPA in 2000, allowing individual cities and towns to put on the local ballot a proposal for a property tax surcharge to raise revenue for historic preservation, affordable housing, and parks and open space. Boston's City Council issued a bill in 2016, with the Mayor's support, to put the CPA ordinance on the city-wide ballot.^{45,46} An overwhelming 74% of Boston voters approved a 1% property tax surcharge under the CPA. Community preservation advocacy coalitions were influential in: creation of the CPA through state policy, issuance as a local ballot proposition through Boston's City Council, and local voter outreach and education during the election season.

Process for the City of Boston: The decision to establish city-wide resilience fees based on property taxes would likely be made by the Mayor, Cabinet, and City Council. Climate Ready Boston and the Cabinet play an influential role in conveying to the Mayor and City Council the scale of costs, benefits, and urgency to fund coastal resilience investments. Since voter approvals are required for an override of Proposition 2½

or another state-enabled funding mechanism similar to the CPA, the Mayor and City Council would need to carefully communicate the benefits and drawbacks of the property tax-based resilience fees to constituents. Advocacy groups for climate and coastal resilience action will likely be influential in proposed fees for dedicated resilience funds and outreach to voters.

Opportunities for implementation: City-wide resilience fees based on property taxes can be issued through a Proposition 2½ override or increase in the CPA. Since the CPA charge is currently 1% and legislation allows up to a 3% of the tax levy, the City could decide to issue another ballot referendum to increase the CPA charge by 2%. This increase would generate another \$40 million annually, a portion of which can be used for resilient open space along the waterfront. However, the CPA funds may not be used for operations and maintenance, which also require significant funding.

While increasing property taxes is politically undesirable, doing so to fund resilience would solidify the Mayor's and City Council's leadership and commitment to climate action. With early and adequate public outreach, the constituency may be accepting of a tax increase to address climate impacts that are already being felt; the overwhelming approval of the CPA by voters serves as a positive indicator of willingness to accept property tax increases for particular causes. Local ballot propositions across the US to authorize climate resilience infrastructure investments have also been received positively. For example, in 2018, 83% of voters in San Francisco voted to raise taxes and issue \$425 million in general obligation bonds for seawall enhancements;⁴⁷ 84% of voters in Austin authorized \$184 million in bonds for flood mitigation, open space, and water quality protection supported by tax levies;⁴⁸ and 73% of voters in Miami approved \$198 million in bonds for infrastructure including flood mitigation measures and accompanying tax increases.⁴⁹

Challenges for implementation: Key challenges to implementing this funding mechanism include desire for flexibility in allocation of property tax revenues rather than dedicating them to resilience, especially given competing near-term policy priorities. Additionally, approximately 30% of Boston is not subject to property taxes due to exemptions for public facilities and for institutions such as colleges, healthcare facilities, and churches. As such, a resilience fee based on property taxes would add unfair burdens on properties that pay taxes.

[City-wide resilience fees based on water and sewer usage](#)

Unlike property taxes, water and sewer-based fees are paid by all properties, serving as a potential basis for resilience fees that are truly applied city-wide.

Process for the City of Boston: The Boston Water and Sewer Commission (BWSC) has broad authority to set rates and fees for water and sewer services and also holds bonding authority separate from the City.⁵⁰ The Commission sets the rate at a level to cover the projected annual expenses, with approval from the Mayor. As such, the BWSC would be the lead decision-making entity to establish city-wide resilience fees based on water and sewer usage, driven by funding needs for resilience of the water, wastewater, and stormwater infrastructure systems within its oversight. Currently, water and sewer rates set by the BWSC reflect expenses for the cost to purchase drinkable water and transport wastewater through the Massachusetts Water Resources Authority (MWRA), to operate the water and sewer systems within the

city, and to support improvements to comply with federal and state regulations to protect health and the environment.

Raising city-wide resilience water and sewer fees through the BWSC may require coordination with the MWRA. The legislatively-established MWRA is responsible for water and sewer services for 61 communities in the greater Boston metropolitan area and provides a governance structure for integrated regional planning and investment at the watershed level that cannot be achieved through the BWSC alone. While the decision to raise water and sewer fees at the city level does not require approval from the state-level authority, BWSC fees are not independent of the MWRA's funding decisions; over 60% of BWSC expenditures in FY18 went to assessments to the MWRA.⁵⁰ Alternatively, the MWRA is suited to raise state-wide resilience fees based on water and sewage usage, but this decision falls at the state level.

Opportunities for implementation: The BWSC is already utilizing its capital budget to address flooding under a changing climate. The BWSC prepares an annual three-year Capital Improvement Plan and as part of the process, solicits input from private and public entities regarding planned capital projects and potential impact on the Commission's systems.⁵¹ For example, the BWSC is: implementing new tide-gates for storm drain outfalls in coastal tidal areas to prevent backflow during storm events and high tides under sea level rise scenarios; constructing green infrastructure to reduce stormwater runoff especially given projected changes in rainfall volume and intensity; and contributing funds for construction of green infrastructure projects led by the Boston Public Works Department.

The BWSC is evaluating implementation of a city-wide stormwater fee, which is separate from a water and sewer fee, to reflect costs associated with stormwater infrastructure needs. The four-year stormwater fee feasibility study is expected to be complete by May 2019.⁵¹ However, revenues from such fees will likely be used to fund capital projects to improve water quality of sewer and stormwater discharge in compliance with a settlement with the U.S. EPA.⁵² Within the BWSC's 2019-2021 capital budget of \$220 million, almost 90% is allocated to water and sewer system projects while 3%, or \$7 million, is allocated to stormwater projects.⁵¹ The relatively small budget emphasizes BWSC's current financing constraints for stormwater projects within its oversight.

Challenges for implementation: A resilience fee based on water and sewer fees captures a larger base compared to property taxes since everyone pays in, but the City's revenue potential based on such fees is much lower compared to that of the Commonwealth. The BWSC would not be able to generate significant revenue for resilience without a large percentage rate increase for its customers. The BWSC's FY18 revenues totaled over \$370 million and a 1% increase would generate less than \$4 million.

Most importantly, without expanded scope of BWSC's responsibilities by the Massachusetts Legislature, the City would encounter legal challenges in using BWSC's water and sewer-based fees to fund coastal and stormwater flooding solutions led by other departments. The BWSC was enacted by the Massachusetts Legislature to own, maintain, and operate the water, wastewater, and stormwater systems within Boston and is an entity independent from the City.

3.2.3. Processes for city-level financing mechanisms

In recent years, new forms of bonds have emerged to drive investments from the capital markets into environmental and social issues including climate resilience. These new financing mechanisms, which could be implemented at the city level, could be of relevance to the City of Boston. However, financing mechanisms cannot be leveraged without the availability of consistent funding streams to repay the bonds over time.

Specialty bonds (green bonds and environmental impact bonds)

New forms of bonds including green bonds and environmental impact bonds (EIBs) are designed to attract investors seeking additional benefits from their investments since certain types of investors designate pools of capital for projects with environmental and social benefits. Given investor interest in variations of traditional municipal bonds, issuance of these new types of bonds has the potential to offer a marketing advantage and potentially low rates for the City. Both green bonds and EIBs can be issued as general obligation bonds or revenue bonds.

Green bonds are intended to finance “green” initiatives which can include coastal resilience measures. Municipalities might consider green bonds because the designation enhances the reputation of the issuer and the financing mechanism may carry lower interest rates, although there may not be a pricing advantage for municipalities that already receive very low rates.

Environmental impact bonds (EIBs) utilize a “pay for success” model, in which risk for undertaking new environmental project approaches is shifted to the private capital market and investors receive a higher rate of return if a certain predetermined environmental objective is met. The outcomes must be measureable and the performance metrics must be well-defined since the investment returns are determined by the measured outcome. Performance metrics for coastal resilience solutions would require creative thinking because the solutions tend to have diffuse benefits over a wide geography and emerge over a long timeframe. To date, only two environmental impact bonds have been issued, primarily for stormwater flooding mitigation projects. A detailed description of EIBs and case studies are provided in Appendix B.

Since these new forms of bonds serve as potential sources of financing for resilience projects, the study explored the municipal process to implement them, while recognizing their constraints.

Process for the City of Boston: Decisions around municipal bond issuances are made by Treasury and primarily driven by the cost of capital, revenue projections, and debt limits. However, financing of resilience projects through new forms of bonds, including green bonds and EIBs, will require communication between the project teams within the various departments, OBM, and Treasury.

Growing interest from investors in the types of underlying projects with potential environmental and social returns would require some level of communication between project teams and the team structuring and marketing the bonds. Project teams should work with OBM during the capital planning process to indicate projects that qualify as “green”. Then, OBM packages the projects for Treasury to finance. Treasury and its municipal financial advisor decide on the appropriateness of a unique type of bond and market the bond to investors. Marketing of the bond and the underlying projects is important

for drawing interest from a diverse investor base, potentially lowering the price. In order for Treasury to market the projects with environmental and social benefits to investors, the project development and financing processes would rely on an institutionalized communication thread from the project teams to Treasury. Project teams also play a role in bringing attention to new emerging financing mechanisms tailored to advance implementation of specific types of projects with environmental benefits; project teams in other cities piloting EIBs to date have been the primary points of contact within their municipalities to champion and implement EIBs.

Opportunities for implementation: Treasury is in the process of considering issuance of green bonds for the Renew Boston Trust initiative to finance energy efficiency retrofits for municipal buildings.³⁸ The Renew Boston Trust initiative represents a large, “green” project that is authorized for \$35 million in the FY19-23 capital budget.²⁴ Once the City issues its first green bond, the financing process would be more efficient in the subsequent issuances.

In addition, the new 10% capital budget allocation for resilience projects provides an entry point for project teams, OBM, and Treasury to mark and track projects to package and market under green bonds.

Challenges for implementation: Municipal bonds, especially issued by cities with excellent credit ratings, already enjoy low interest rates. Treasury would be incentivized to closely consider new types of bonds if they demonstrate a pricing advantage relative to conventional bonds. However, such specialty bonds currently demonstrate a low to no pricing advantage. Additionally, the City is limited to the debt affordability limit of 7% of debt service as a percentage of the General Fund expenditures.

3.2.4. Processes for district-level funding sources

The City should also consider funding sources at the next geographically granular scale, the district level. Revenues from the district level help ensure fairness since properties that most directly benefit from district-scale coastal resilience solutions contribute to the cost. The City could define an area over which an assessment is levied to fund district-scale coastal resilience investments, through special assessments or a business improvement district approach. The Boston Harbor Flood Risk Model serves as a critical reference to identify future coastal flood risk exposure and can potentially be used to inform the boundaries of a resilience funding and financing district.

District resilience fees

A special assessment, also known as a betterment, is a special property tax on properties within a determined area. Betterment taxes are allowed by state law and are levied in Boston by the City’s Public Improvement Commission for public improvement projects undertaken by the Public Works Department. The special assessment reflects the special benefit that properties receive from the construction of a public improvement such as upgrades to streets, sidewalks, and sewers.^{53,54} While coastal infrastructure is not within the realm of the Public Works Department, elevating streets to protect against coastal flooding could potentially be considered a betterment. Betterment tax amounts are based on the overall cost of the betterment project and parcel-specific factors such as length of frontage and the land area of the parcel.

Another potential district-level funding mechanism can be formed and implemented in a legal process similar to that for a business improvement district (BID). Property owners in the district who would most directly benefit from the coastal resilience solution can decide to voluntarily request that the City levy an agreed upon assessment on their properties in order to fund the investment. Under state law, a BID is defined as a contiguous geographic area in which at least 75% of the land is zoned or used for commercial, retail, industrial, or mixed uses.⁵⁵ Establishment of a BID would require support from more than 60% of property owners representing at least 51% of the assessed value of the property in the district and the agreement can be renewed every five years. Lastly, the revenue generation potential will depend on the assessment formula, but the maximum assessment is 0.5% of the total assessed values.

Example process: The successful process to establish the Rose Kennedy Greenway BID in Downtown Boston in 2018 provides a case study of the implementation process. The Rose Kennedy Greenway is a 1.5 mile-long park on land owned by MassDOT, and the state-established Greenway Conservancy is responsible for care for the park. To establish a framework for the BID, the parties entered into a Memorandum of Understanding (MOU) between the Greenway Conservancy, the City, Commonwealth, and abutting commercial property owners.⁵⁶ The external self-organization of commercial property owners was led by the non-profit A Better City, originally established to unite business leaders around a common goal to enhance the Boston region's economic health, competitiveness, and sustainability. A Better City worked with property owners and the City to determine BID boundary lines and a fair assessment formula.

For the property owners to ensure that private dollars would supplement rather than substitute public funding, the MOU established funding contributions by the Commonwealth and the City as preconditions for the funding contribution by the BID. The final negotiated contributions were: \$750,000 to \$1 million annually from MassDOT, \$250,000 annually from the City, and a BID assessment formula from 50 parcels that generates approximately \$1.5 million annually. The City's annual contribution is funded by investment of proceeds from the sale of a public property into a trust. The Conservancy will also continue to raise and earn \$3 million annually through private donations, earned revenue, and endowment income. In total, annual funding for the Rose Kennedy Greenway comes from approximately 80% private BID funds and 20% government funds.

Process for the City of Boston: Since the BID model is voluntary initiated by property owners, the lead external and internal entity to champion implementation of this mechanism for coastal resilience is ambiguous. The process to create an assessment district for coastal resilience through a BID mechanism could begin with establishment of a MOU between the City and coastal commercial property owners. An external organizing entity would need to lead, convene, and represent the commercial property owners within the district. The external organizing entity would need to put together a proposal for the coastal resilience assessment district boundary, assessment formula, and governance structure that would receive support from a majority of owners based on the City's assessed values. The City would be an active participant during the process, by: conveying the economic benefits of a voluntary assessment district; providing data support from the Assessor's Department; coordinating on estimated plans and costs for

coastal resilience and open space solutions from the Environment Department and Parks and Recreation; and helping to define the boundaries potentially based on the flood overlay district and district-level adaptation plans. The proposal would be submitted to City Council for approval.

Opportunities for implementation: To voluntarily raise funds for coastal resilience investments, commercial property owners need to be motivated by economic incentives, potentially framed around near-term benefits. The Resilient Harbor Vision provides an opportunity and economic incentive for commercial property owners along the coast to contribute to enhancements of shared spaces including elevated harborwalks and parks since these open space amenities draw people to the waterfront and benefit businesses. The district approach also engages multiple property owners that benefit from district-scale coastal resilience and waterfront investments, which is particularly useful for commercial areas with a wide geography exposed to coastal flooding, rather than a particular site that serves as a flood path entryway. Given the voluntary nature of BIDs, the funds could potentially go to support annual maintenance and enhancements of resilient waterfront open spaces rather than serve as a reliable revenue source to back bonds for upfront capital costs.

A fair formula of the levy per property could potentially be a function of exposure to sea level rise and coastal flooding and building square footage of property protected. The amount of revenue that could be generated depends on the size of the district and the assessment formula. For example, properties in areas expected to be inundated by a 1% annual chance flood under 9 inches of sea level rise by 2030 according to the Boston Harbor Flood Risk Model could serve as the basis for an assessment district. A 0.5% assessment on the 230 commercial, retail, industrial, and mixed uses properties in the South Boston waterfront exposed to a 1% annual chance flood under 9 inches of sea level rise would generate an estimated \$20 million annually.

Challenges for implementation: Since private property owners already pay property taxes as well as contribute to the CPA funds, BID participants would need to see that the additional assessments would supplement rather than substitute public funding. The funding models would be viewed as unfair if assessments through a BID model supported coastal resilience solutions in one district, but public operating budgets supported coastal resilience in another district. As such, property owners will be more likely to contribute supplemental amounts through a BID if there is commitment of public contributions.

Furthermore, the City would need to ensure continuity of public funding for operations and maintenance should the properties choose not to voluntarily renew the BID every five years or property values decrease. While the BID model would generate additional funding from private properties, the City would still need to dedicate funding for coastal resilience in order to ensure that the additional assessment would not displace public responsibility.

3.2.5. Processes for district-level financing mechanisms

District improvement financing

District improvement financing (DIF), known as tax increment financing (TIF) in other states, borrows against the future stream of additional property tax revenue in the area that a new public investment is

expected to stimulate. A DIF captures the value through a dedicated tax revenue stream over a specified period of time. A DIF does not necessarily generate new public revenues, but rather claims the projected incremental assessed values to pay for the public investment. While public coastal resilience investments do not necessarily increase property values, a DIF could be utilized to capture value from urban development that may be increasing independent of a particular catalyzing public investment.

There are similar variations of a DIF to finance significant infrastructure improvements that are required to support new developments. In Massachusetts, these include the Infrastructure Investment Incentives Program (“I-Cubed”) and Local Infrastructure Development Program (“23-L”). However, value capture mechanisms to finance and fund resilience rely on increased development, creating a tradeoff between encouraging density and development with an added need for coastal resilience investments given increased physical exposure.

Example process: The City of Somerville, Massachusetts approved a DIF in 2017 to finance needed stormwater, sewer, and streetscape infrastructure improvements with the incremental tax revenue from anticipated redevelopment in Union Square associated with a transit line extension and rezoning.⁵⁷ Somerville’s Office of Strategic Planning and Community Development identified a development district and created a development program, per state legislation regarding DIFs.⁵⁷ The development program requested financing for \$66 million in infrastructure projects. The Assessing Department led a financial analysis to calculate the baseline assessment and projected tax increment, which was vital for making the financing case. Lastly, the City held multiple public hearings and presentations to City Council prior to final approval.

Process for City of Boston: Multiple municipal departments will need to coordinate in order to establish a DIF for infrastructure investments. Key actors include the Mayor and Cabinet based on their roles to broadly set funding priorities, BPDA based on its role to guide current and future development, OBM based on its role to forecast revenues and allocate funding, the Assessor’s Office based on its role to calculate taxes, and the Treasury based on its role to issue and oversee repayment of bonds. The BPDA would likely be the lead to implement a DIF, which involves designating a development district and a corresponding development program. The development program would need to identify existing and proposed uses, zoning, and planned construction. Successful DIFs rely on careful planning of uses and investments to address the needs of a district.

Opportunities for implementation: A DIF can be utilized to capture value from development that is occurring independent of a particular catalyzing public investment. A DIF is attractive because borrowing is not included in municipality’s debt limits, no new taxes are levied, and the DIF does not reduce or redirect existing property tax revenues. A DIF also does not require explicit consent from property owners, unlike a BID.

East Boston is positioned for significant development and economic growth over the next few years. Establishment of a DIF could dedicate the tax increment to public infrastructure investments that would be needed to accommodate the growth in the district, including the elevated parks and harborwalk

coastal resilience solutions from Climate Ready East Boston as well as other infrastructure plans from *Imagine Boston 2030*. The DIF district boundaries would likely depend on areas of projected development, rather than areas of projected coastal flooding.

Challenges for implementation: A DIF relies on expected revenues in the district, up to three decades into the future, which are challenging to reliably forecast. Stagnant property values in a district due to rising interest rates or a recession could stymie a DIF financing plan. However, revenue growth is less uncertain in East Boston, where new development is already positioned to enter the tax base. Additionally, for a DIF in a coastal area, reliance on growth and speculation in a district that is vulnerable to coastal flooding creates a tradeoff between encouraging density and keeping populations out of harm's way.

Another key challenge to establishing a DIF is desire from municipalities in general for flexibility in allocation of revenues, especially since local revenue growth in Boston is increasingly dependent on growth of the local economy as described in Section 2.2.1. However, allocating a tax increment to finance *Imagine Boston 2030* initiatives within a district is more politically palatable than designating revenues specifically to coastal resilience infrastructure.

3.2.6. Parcel

Coastal resilience measures will require both direct public investments and private action. Developers and large property owners could potentially contribute to fund district-scale resilience measures, in addition to implementing parcel-level resilience measures, in order to avoid developing buildings that would stand as islands of resilience. A funding mechanism from the private parcel level could include exactions.

Exactions: Up-front exactions, which can take the form of development impact fees and linkage payments, are typically evaluated and paid during the permitting process of new development.

Development impact exactions are one-time, up-front fees or conditions for new development to help reduce the economic burden on the local government from bearing the additional cost of public services, infrastructure, or facilities. In Boston, the BPDA leads the review of impacts of proposed development projects through the Article 80 Project Review. Depending on the project's size, location, and use, the review could include impacts on the surrounding environment and infrastructure systems. The BPDA may require the developer to take measures to reduce such impacts.⁵⁸ To address the increased coastal risk exposure associated with new coastal developments, development impact exactions through impact fees could potentially be requested to fund district-scale coastal flood solutions. Alternatively, the City and the developer can enter into a cooperation agreement in which the development project provides agreed upon public coastal resilience benefits.

Linkage payment are fees to "link" new development with community needs, typically for affordable housing. In Boston, the linkage payment policy requires new, large commercial developments seeking zoning relief to pay into a linkage fund over seven years to fund affordable housing and job training programs across the city. The linkage payments are established amounts per square foot, and have generated \$31.4 million for housing programs since 2014.⁵⁹ Given the relationship between new coastal

development and increased exposure to coastal risks, the City could consider establishing a linkage payment program to support coastal resilience investments.

Additional research on parcel-level financing and funding solutions are discussed in the forthcoming BPDA report, “Implementing District-Scale Solutions for East Boston: Climate Resiliency Financing and Funding Models.”

3.3. Role of risk pricing and insurance

Insurance that is priced to reflect current and future flood risk can provide the appropriate price signals to incentivize adaptation and resilience in flood-prone areas. However, both commercial and federal insurance premiums currently do not adequately price risk, as rates are set based on historical data of flood risk rather than future projections. Furthermore, FEMA’s National Flood Insurance Program underprices risk to provide affordable insurance but this encourages development in risky areas.

The City is self-insured in most areas of risk including City property damages.⁶⁰ The City’s financial risk management strategy focuses on reducing the cost of liabilities, which includes overseeing physical risk reduction measures on City-owned property. The City also carries a commercial catastrophic property insurance policy and maintains a catastrophic risk reserve for unexpected large losses. The catastrophic property insurance policy provides \$100 million for all risk protection after a \$10 million deductible. The size of the reserve was \$34.8 million at the end of FY18.

Catastrophe and resilience bonds

Catastrophe bonds provide additional coverage for losses from low probability, high consequence natural disasters. Catastrophe bonds are more like insurance policies than conventional municipal bonds for financing. They transfer catastrophic risk to the private capital markets, pay out if the natural disaster exceeds a defined threshold, and is considered a more cost-effective way to supplement or replace conventional insurance. Catastrophe bonds are particularly applicable for entities required to hold insurance.

While insurance does not necessarily increase a city’s resilience, insurance can be leveraged to capture the cost savings from physical risk reduction measures through the new concept of a resilience bond. A resilience bond builds off of the catastrophe bond model, with the intention to provide access to capital for resilience projects while capturing the value of reduced physical risk due to the project. However, a resilience bond produces cost savings only if an entity is already required to hold insurance. The City’s \$100 million catastrophic property insurance serves as a starting point, although large infrastructure asset holders in Boston such as the Massachusetts Bay Transportation Authority (MBTA) and utilities have higher property insurance compliance requirements. Additionally, this model is only applicable to projects that reduce catastrophic physical risk, not those geared towards chronic physical risk. The resilience bond model has not yet been applied by other cities, but Houston is currently considering this form of financing to construct new levees, seawall enhancements, and floodgates. The concepts of catastrophe bonds and resilience bonds are further detailed in Appendix C.

Since the catastrophe bond and resilience bond models serve as a potential source of risk transfer and financing, the study explored the municipal process to implement these mechanisms, while recognizing their constraints.

Process for City of Boston: Since a catastrophe bond is more like an insurance policy than a conventional municipal bond, OBM's Risk Management program which manages the City's self-insurance and catastrophe insurance would be the key decision-maker to implement a catastrophe bond. Key considerations include the degree of physical risk exposure and amount of insurance needed, budget available for the catastrophic risk reserve, the cost of a catastrophe bond relative to conventional insurance, and an insurance mechanism that covers all types of catastrophic risk rather than a specific type of disaster risk with a defined threshold.

Consideration of a resilience bond would involve: OBM's Risk Management program based on its role related to the City's insurance; OBM's Capital Budgeting program based on its role to allocate budgets to projects; project teams developing resilience projects; and the Treasury based on its role to issue and repay bonds. The resilience bond can be championed by either a project team seeking to finance a resilience project or the Risk Management program seeking to reduce and shift insurance costs. The ultimate decision-maker will likely be the Risk Management program, which would have to consider pricing of the resilience bond relative to the current cost of commercial catastrophe insurance.

Opportunities for implementation: A resilience bond captures the value of reduced physical risk, providing an opportunity for project teams working on large resilience and physical risk reduction projects to increase coordination with the team responsible for physical insurance.

Challenges for implementation: The resilience bond model is economically attractive if the sponsoring entity is already purchasing a large amount of insurance. However, the City only holds \$100 million of catastrophic property insurance. The Risk Management program could consider coordinating with the risk management departments of large infrastructure asset holders in Boston such as the MBTA and utilities which have higher property insurance compliance requirements. However, co-sponsoring a resilience bond poses a logistical, governance, and legal challenge for the local, state, and private entities to pool risk and insurance.

4. Key findings, recommendations, and conclusion

4.1. Key findings

The costs for coastal resilience solutions are significant relative to existing budgets and potential revenues from the City, as summarized in Table 4. Even with a layered funding approach with contributions from the federal and state governments, coastal resilience infrastructure investments require large amounts of upfront capital from the City that need to be balanced among other competing near-term priorities and long-term obligations. Costs for annual operations and maintenance, which often cannot be funded under federal and state grant terms, are also significant new burdens for the City and should not be overlooked.

Table 4. Summary of costs, existing budgets, and potential revenues for coastal resilience.

Costs of coastal resilience solutions		
Upfront implementation	\$666M to \$1.26B+	Total from three of five district resilience studies completed to date
Annual maintenance	\$10.1M to \$19.2M+ annually	Author’s rough estimate based on 1.5% of capital costs
Existing budgets		
Operating (City)	\$3.29 billion	FY19 operating budget
Capital (City)	\$337.9 million	FY19 capital budget
	\$2.43 billion	FY19-23 capital plan
Capital (BWSC)	\$220 million	FY19-21 capital plan
Potential city- and district-level funding sources for resilience		
City-wide resilience fees based on property taxes	\$40 million annually	Estimated based on 2% increase of CPA
City-wide resilience fees based on water and sewage usage	<\$4 million annually	Estimated based on 1% increase of FY18 revenues
District resilience fees	<i>South Boston Waterfront example: \$20 million annually</i>	Estimated based on 0.5% of assessed values of commercial, retail, industrial, and mixed uses properties exposed to a 1% annual chance flood under 9 inches of sea level rise

In many cases, funding and financing of the coastal resilience projects within the capital planning process are currently not the greatest barrier to implementation. Rather, the hurdle has been prioritization among other near-term needs within the various departments tasked with implementation. Coastal resilience elements have not conventionally been within the scope of responsibility of the various departments. Implementation requires commitment from the individual departments to prioritize and pursue pre-development of the coastal resilience capital projects relative to other needs that fit directly under their scope of responsibility. To do so will require elevating elements of resilience within departmental decision-making, expanding the roles of existing departments, and funding through the operating budget for additional staff time.

Early stage planning and preliminary design is often a prerequisite prior to submission of a capital budget request for design and construction and is particularly important when the project involves innovative infrastructure or emerging technologies. As resilience elements are increasingly being integrated across the departments in response to emerging climate change and coastal risks, resilience is an additional need within a set of priorities that needs to be placed into an existing multi-year capital spending plan along with previously authorized projects.

Although funding and financing of resilience projects is currently not the greatest barrier, once resilience projects move further along the capital planning pipeline, the balloon upfront implementation costs across districts will strain the City's financing and debt limits. Operations and maintenance costs of resilience solutions also present a new ongoing cost that will require sustained funding.

Funding options that seem politically unpopular are feasible. Strategies to generate new revenues through increased taxes and fees are often quickly deemed politically infeasible. However, political leadership is beginning to trade off the substantial costs of climate and coastal resilience solutions with the benefits to its constituents, especially as communities are already beginning to experience climate impacts. Furthermore, constituents may be willing to support increases in taxes and fees for specific causes, especially when engaged early and properly informed. Indicators include approval by voters in Boston to increase property taxes under the CPA, a proposal initiated by the Governor for a tax excise fee to fund climate resilience, and approval by voters in other states of bond issuances and tax increases for resilience projects. However, as the cost burden mounts with growing climate and coastal risks, taxpayers may become weary of multiple increases in taxes and fees for resilience, especially if they do not tangibly experience the benefits of future avoided losses.

Property ownership is a key consideration in the financing and funding of district-scale coastal resilience measures, but the City is the ultimate long-term investor in all local properties. Disjointed ownership of parcels along the waterfront presents multiple complex challenges for continuous shoreline coastal resilience measures, including funding and financing challenges. However, property ownership can help guide the City towards the appropriate funding and financing mechanisms to prioritize and pursue in the short term, summarized in Table 5 and discussed below. The City should consider property ownership of the parcels immediately along the shoreline on which a segment of the coastal resilience solution will be built, but also the ownership of inland parcels that would be protected by the district shoreline measures.

Table 5. Potential funding and financing mechanisms by property ownership

	Publicly-owned		Privately-owned		
	Federal / state	City	New development	Existing dev., large private institutions	Existing dev., other
Financing of upfront costs	<ul style="list-style-type: none"> Federal & state capital budgets 	<ul style="list-style-type: none"> Federal & state grants Local revenue and CPA Bonds backed by resilience fees District increment financing 	<ul style="list-style-type: none"> Exactions Value capture 		
Funding of ongoing costs	<ul style="list-style-type: none"> Federal & state operating budgets 	<ul style="list-style-type: none"> State aid City-wide resilience fees District resilience fees 	<ul style="list-style-type: none"> Cooperation agreements 	<ul style="list-style-type: none"> MOUs 	

Publicly-owned

Public funding and financing is necessary for coastal resilience solutions on public parcels.

Federal / state: Where there is federally- or state-owned property along the shoreline, and thus exposed to coastal flooding, the City has a strong case to request that the federal and state governments fund the capital and maintenance costs of the coastal protection segment. Federal and state properties are tax-exempt, excluding them from funding contributions through city-wide resilience fees based on property taxes. However, it is in the interest of federal and state agencies, including those with large, critical infrastructure such as the MassPort and the MBTA, to enhance the coastal resilience of their properties and assets.

Challenges prior to arriving at such funding agreements will include inter-governmental coordination for integrated shoreline protections rather than site-scale resilience measures, and engagement to elevate the political priority of these parcel-level investments at the federal and state levels. The federal and state funding agreements will likely require a funding contribution from the City for capital and maintenance costs.

City: Where there are City-owned parcels, the City should pursue multiple avenues of funding and financing for upfront capital and ongoing maintenance costs. First, the City should request state and

federal grants as part of a layered funding approach. These could include grants specific to climate resilience such as the Commonwealth’s MVP Action Grants, as well as grants in various sectors into which resilience can be integrated. State and federal grants should be applied to cover upfront costs rather than ongoing costs, given requirements for when the grants should be spent. In addition, as with most investments on City-owned properties, the City will need to issue bonds to finance upfront capital costs. The bonds could potentially be backed by city-wide resilience fees. The City should also utilize CPA funds, which can be applied to pay for upfront capital costs. Lastly, if the City decides to dedicate a tax revenue stream over a specified period of time to infrastructure, those funds could be used to pay for the upfront costs through a DIF model. The potential revenue sources to pay for ongoing maintenance costs on City-owned parcels include: state transfers, city-wide resilience fees based on property taxes and/or water and sewer fees, and district-scale resilience fees through special assessments or a BID model.

Privately-owned

Where coastal district resilience solutions need to be built on privately held land, the BPDA will likely be the lead to engage with the property owners, given its role to oversee development permitting and regulation. In addition to requesting easements to build public infrastructure on private land, the BPDA should also explore unique parcel-level funding and financing approaches for district resilience. For both new development and existing private properties, the BPDA will need to make the case to private property owners to contribute to district-scale resilience in addition to investing in building-scale resilience measures. Additional funding and financing strategies that are relevant to privately held land are discussed in the forthcoming BPDA report on “Implementing District-Scale Solutions for East Boston: Climate Resiliency Financing and Funding Models.”

However, since funding strategies with private property owners described below would generate piecemeal revenues, the City will still need additional revenues to: complement or match the private contributions; provide stable funding in case property owners decide to no longer voluntarily contribute to coastal resilience; and provide funding for investments across the City that may not be picked up by parcel or district funding solutions.

Even with investment contributions from private property owners, these individual and institutional property owners have a relatively limited time horizon and the City is the ultimate long-term investor in all local properties. The City has a financial interest, in both the short- and long-term, to invest in physically protecting its tax base.

New development: On parcels where new development will occur but is exposed to coastal flooding, the BPDA could request upfront exactions, in the form of development impact fees or linkage payments for resilience. Since this parcel-level mechanism may not generate sufficient funding to pay for upfront costs, the City will also need to draw on a mix of funding and financing through grants, bonds, CPA funds, and/or district increment financing. Some state and federal grants, such as the MVP Action Grant, may be used for projects on privately-held land with consent of the property owners. Additionally, parcel-level value capture financing through the I-Cubed program is available via MassDevelopment.

The BPDA could also negotiate legally binding cooperation agreements with developers through the Article 80 review process for public benefits and mitigation to be provided by the development project, which could cover portions of the upfront and ongoing costs. However, the potential for funding and financing from private developers along the shoreline also encourages development in vulnerable areas.

Existing development, large private institutions: On parcels where there is existing development exposed to coastal flooding, BPDA could attempt to negotiate a memorandum of understanding to financially contribute to that segment of the coastal district resilience solution. Property owners that may be most willing to participate likely include property owners with larger net operating budgets and longer time horizons, such as large private institutions. The revenues should be used to cover maintenance costs since the funding mechanism generates relatively small amounts of revenue. In order to pay for upfront costs, the City will need to draw on a mix of funding and financing through grants, bonds, and CPA funds.

Existing development, other: On parcels where there is existing development without large private property owners, these parcels will rely on funding and financing mechanisms led by the City. A large proportion of privately owned land falls under this category, reemphasizing that the City is the long-term investor in all local properties.

4.2. Recommendations

The City should consider implementing the following recommendations for city- and district-level funding, financing, and policy and planning to facilitate investments in coastal resilience solutions.

4.2.1. Funding

Continue to engage with the Mayor, Cabinet, and City Council about steady funding and investments in coastal resilience. Decisions to generate and dedicate new revenue streams, such as raising property taxes, raising CPA assessments, and establishing a DIF, are made by these key high-level decision-makers. The Mayor and its Cabinet and City Council are already leading the City on climate resilience action. Climate Ready Boston and the municipal departments implementing its recommendations should continue to communicate to senior decision-makers the scale of the capital and ongoing costs of coastal resilience solutions, the timing of coastal risks and costs, and the costs of doing nothing. Continued engagement is needed to urge responsible generation and allocation of additional city-wide and district-wide funding for coastal resilience. Since the City is the ultimate long-term investor in all local properties, it is in the long-term interest of the City to strategically invest resources in coastal resilience.

Engage with property owners to explore and pilot a resilience assessment district funding model. While the BPDA is currently working with individual private property owners to explore funding and financing mechanisms at the parcel level, the assessment district approach engages and spreads the costs among a broader base of beneficiaries. An initial pilot would generate lessons learned about strategies to scale up the approach across the districts.

The BPDA should work with property owners within a district who would benefit from coastal resilience solutions to evaluate implementation of an assessment district. Existing models through which an assessment district may be pursued include betterment fees, BID model, or the Local Infrastructure

Development Program. The BPDA should engage with MassDevelopment for consultation on the Local Infrastructure Development Program. Criteria to identify the district to pilot include: an area that is already experiencing coastal flooding impacts to appeal to short-term incentives, has a preliminary coastal protection solution proposal which the discussion can be framed around, has above average property values to address fairness and equity, and has an existing external organizing entity. The assessment formula could be a function of the projected coastal flood risk, total square footage, and assessed value. The pilot would also engage with large property owners who are exempt from property taxes but would benefit from district resilience measures, including state infrastructure agencies and universities.

However, the City will still need to dedicate public funding to coastal resilience within the assessment district. The property owners would want assurance that a voluntary assessment would supplement rather than displace public funds. Additionally, since these assessment district models generate relatively low amounts of revenue and the voluntary nature is associated with a risk of withdrawal of property owners, the funds raised through the assessment district should support operations and maintenance.

Integrate climate and coastal resilience into the City's portfolio of assets and programs and across lifecycles in order to maximize investments. Resilience does not need to solely be a separate budget line item but rather, should be incorporated into investments that the City is already making. That is, while the City seeks funding to elevate coastal roads and parks as part of an integrated district shoreline protection system, investments such as renovations of schools and libraries also present opportunities to enhance community resilience. Climate Ready Boston is already working with departments that own physical assets to opportunistically identify avenues to integrate resilience into their capital projects, and with OBM's Capital Budgeting program to flag proposed capital projects with potential climate change and coastal risks. However, rather than identifying climate risks through the annual budgeting cycle, the City should implement a strategy to comprehensively identify and integrate resilience opportunities into the management of the City's portfolio of assets.

Climate Ready Boston should continue to facilitate and refine a process to systematically and comprehensively integrate climate and coastal risk and resilience into the entire portfolio of assets in order to maximize existing dollars and investments. Departments that own physical assets, including the BPDA, will need to assess future climate and coastal risks and resilience across the lifecycle of the portfolio of assets to identify needed resilience investments that should be incorporated into future capital budget requests. The City should also leverage the existing capital planning and budgeting process to comprehensively identify investments in resilience that could be integrated into upkeep, upgrade, and new infrastructure projects. For instance, the City of San Francisco is working towards the resilience and long-term sustainability of the City's capital assets under its integrated Office of Resilience and Capital Planning.

At the same time, decision-making for strategic investments for resilience will need to involve discussions about deprioritization and disinvestment of other programs and assets given the size of the long-term funding challenge for resilience. The Mayor, Cabinet, and City Council will need to engage in difficult

conversations within departments and with constituents about phase out of programs and assets that may not be beneficial to continue to invest in over the long-term under a changing climate.

4.2.2. Financing

Accelerate the predevelopment planning and design of coastal resilience solutions in order to be considered for financing. Since funding and financing of the coastal resilience projects within the capital planning process are currently not the greatest barrier to implementation because the projects have not yet been prioritized by project teams, predevelopment is the prerequisite next step. Predevelopment includes early stage planning, preliminary design, and entitlement of complex built resilience solutions prior to bid for engineering and construction. Predevelopment could also include benefit-cost analysis; while the City’s Capital Budgeting program does not formally require a robust analysis of benefits relative to costs, the benefits analysis would quantify for decision-makers the value of the resilience project across its lifecycle and may be required for state and federal grant sources.

In addition to opportunistically integrating resilience into capital projects that are already in the pipeline, the departments should prioritize predevelopment of coastal resilience solutions that are needed to protect against flood risks under current and near-term 2030 projections. Climate Ready Boston should continue to work with departments to accelerate predevelopment in order for the solutions to be considered for capital funding and financing through city, state, and federal sources.

Predevelopment requires staff time and in some cases, initial funding. Where initial predevelopment funding is needed, Climate Ready Boston should work with departments that would be leading the initiatives to request resources from the City’s general fund, apply for MVP Action Grants, and utilize grant sources across other sectors. Climate Ready Boston should also engage with the Boston Green Ribbon Commission and the strong local philanthropic community in the Boston area, which have helped fund the Climate Ready Boston studies. Investments in predevelopment are critical next steps for moving from conceptual resilience designs to built resilience solutions.

Finance the 10% capital budget resilience projects with green bonds. The new 10% capital budget allocation for resilience provides an entry point for project teams, OBM, and Treasury to mark and track projects that can be packaged, marketed, and financed under green bonds. The green bonds could potentially offer slightly lower pricing and would enhance the reputation of the City among investors seeking environmental benefits.

Climate Ready Boston should work with OBM’s Capital Budgeting program to define projects qualifications for “resilience” that qualify for the 10% budget allocation. These two key actors should also develop an approach to integrate resilience tracking into the capital budgeting process, in order to have a consistent thread of communication regarding the resilience components from the capital project teams, to the Capital Budgeting program, to Treasury. Ultimately, Treasury would decide on the appropriateness to finance the projects through green bonds based on the pricing relative to conventional bonds and the marketing advantage to the City.

4.2.3. Planning and policy

Establish a regional resilience financing working group. Climate and coastal resilience measures within Boston would benefit people and economies well beyond the city's geographic boundaries, but allocation of funding and financing is currently constrained by municipal and agency delimitations. Since climate and coastal risks are not confined within municipalities and agencies, resilience measures in some cases may be more cost-effective if implemented jointly across a region or by another agency with jurisdiction.

Climate Ready Boston should work with the BPDA and OBM to establish and lead a resilience financing working group to convene state infrastructure agencies, utilities, and cities and towns in the Boston metro region. The working group should explore existing and potential opportunities to jointly fund and finance climate and coastal resilience and to pool risk and insurance. For example, the MVP Action Grant opportunity offers greater funding availability to regional proposals and Climate Ready Boston could apply to a grant to enable the working group to implement regional solutions. As another example, the City's capital budget already makes financial contributions to MBTA and MassDOT for the design of capital projects, and the parties could discuss mechanisms to tie those contributions to solutions that enhance resilience region-wide. The working group should also closely examine associated governance challenges and present recommendations to the proposed Climate Ready Commonwealth Commission to address at the state level.

Discuss funding, financing, and associated governance questions with the proposed Climate Ready Commonwealth Commission. Boston, like many other cities and towns, will need funding and financing assistance from the state level for climate and coastal resilience. If the proposed Climate Ready Commonwealth Commission is established, the representative for the City of Boston should bring forward the following recommendations in order to address municipal and regional adaptation funding and financing needs at the state level.

The Commission should explore state-wide resilience fees to generate additional revenues for resilience. The state-wide fees could be based on income taxes, carbon or gasoline tax, water and sewer fees, or insurance surcharges.

In addition, the Commission is uniquely positioned to implement recommendations that extend beyond the search for additional funds, but rather are associated with governance. For example, the Commission will need to evaluate expansion of the roles and responsibilities of a given state agency or establishment of a new agency to collect and spend new resilience fees and should establish a framework for regional coordination across municipalities and with state infrastructure agencies for joint funding and financing of resilience projects.

Continue to pursue city- and district-level funding and financing options while monitoring state-level action. The City should not wait for the proposed state-level real estate excise tax and recommendations from the proposed Climate Ready Commonwealth Commission although they are vital components for a layered and more comprehensive approach. The deeds excise tax, if passed, is estimated to generate approximately \$137 million annually which is not sufficient for needs across the state. The Climate Ready Commonwealth Commission, if legislatively established, will generate a report of recommendations

within 18 months, while current and near-term 2030 coastal flood risks continue to mount. Rather, the City should continue to pursue city- and district-level mechanisms as part of the layered funding approach.

4.3. Conclusion

In order to advance municipal investments in coastal resilience solutions, the City of Boston will need to overcome barriers and leverage opportunities for additional sources of money. While previous studies have proposed and evaluated numerous new funding and financing options, decision-makers and departments are yet to be empowered to lead implementation of such options. This study provides a roadmap for specific actors, processes, and opportunities to put in place city- and district-level funding and finance mechanisms.

Property ownership is particularly pertinent when evaluating local government funding and coastal resilience strategies since property taxes serve as the largest source of revenue for the City. The type of property owners in a vulnerable area can help inform the funding and financing approaches to prioritize to pursue. Meanwhile, the City should recognize its long-term interest to invest in resilience to protect private properties in order to maintain its revenue base.

The City of Boston will also need to carefully consider populations' ability to pay and populations in districts that should be prioritized for resilience investments. Since additional sources of funding for resilience distills down to different forms of taxes and fees, the City will need to weigh parties that should bear the burden of the costs. At the same time, given limited funding for resilience, the City will also need to weigh the neighborhoods that are vulnerable to coastal flooding that should be protected first; while wealthy districts serve as large sources of revenue that could generate additional funding for resilience, less wealthy districts for which additional resilience fees may be disproportionately burdensome are especially vulnerable to coastal risks.

However, the challenge to strategic investments in coastal resilience does not stem for solely a lack of money. Governance can be a barrier to funding and financing, as well as a barrier to steps that lead up to capital budgeting, since traditional roles and responsibilities of departments do not account for emerging complexities and challenges under a changing climate. External factors will also add pressure for investments in resilient infrastructure, including: increases in liability, potential downgrade of municipal credit ratings, rise in insurance premiums, and changes in the coastal real estate market. To address these new challenges, departments will need to continue to work collaboratively within the City as well as with other actors across geographic scales.

Appendix A – Departments and experts consulted

Public sector departments consulted:

- Boston Environment Department
- Boston Office of Budget Management
- Boston Treasury
- Massachusetts Executive Office of Energy and Environmental Affairs
- Massachusetts Bay Transportation Authority Treasury

Resilience finance experts consulted:

- Carolyn duPont, Quantified Ventures
- Jesse Keenan, Harvard University
- David Levy, University of Massachusetts Boston
- Karl Seidman, Massachusetts Institute of Technology
- Shalini Vajjhala, re:focus partners

Appendix B – Environmental Impact Bonds

Overview

Environmental impact bonds (EIBs) utilize a pay for success approach to provide upfront capital to implement a new environmental intervention and pay back investors based on the project performance. The EIB process consists of the following process shown in Figure 2.

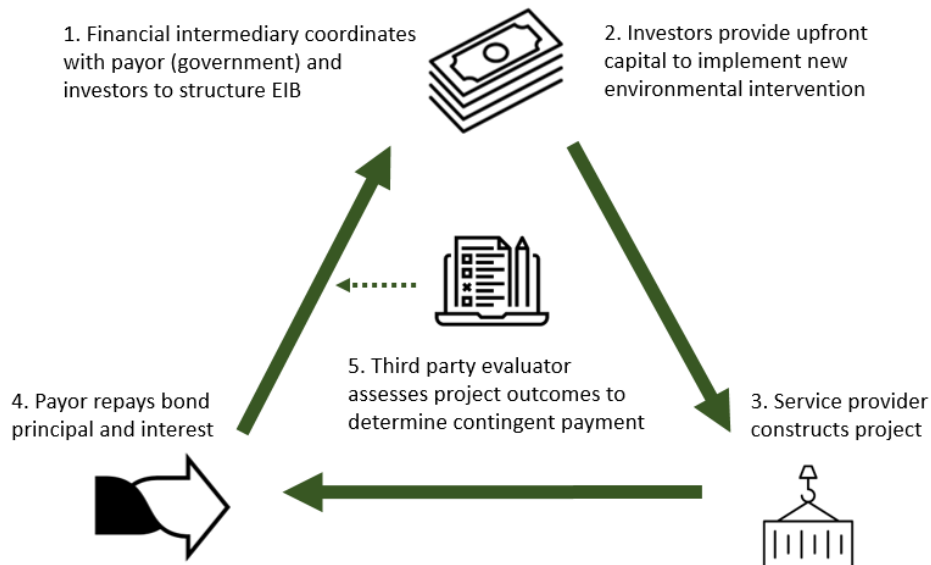


Figure 2. EIB process. Adapted from EDF & QV (2018).

Under the pay for success approach, the investor receives or pays back an agreed upon amount based on achievement of the project outcomes within a defined period of time.

- If the project performs as expected, neither the payor or investor receive a contingent payment.
- If the project performs better than expected, the payor makes a lump sum performance bonus payment to the investor.
- If the project underperforms, the investor makes a risk share payment to the payor.

An EIB may be an appropriate financing mechanism under several conditions.^{62,63} The outcomes must be measurable and performance metrics must be well-defined, since investment returns are determined by the measured outcome. In addition, the new environmental intervention should generate cost savings. Furthermore, an EIB may be appropriate when piloting a new type of intervention where the outcomes of the intervention are uncertain, since the government can transfer the risk of the new intervention to investors through the financing mechanism. Lastly, an enabling environment should be conducive to exploring an EIB; Massachusetts has passed legislation that allows pay for success contracting.

Innovations of EIBs and benefits for the government include risk transfer and attracting new sources of capital. The approach identifies, quantifies, and shares risk associated with the new intervention and is outcome-based rather than output-based. If the solution fails to perform, the government could receive

a risk share payment from investors who will bear the burden of the risk. Another benefit is that impact investors are willing to provide upfront capital because they have an appetite for investments that not only produce financial returns, but also generate social and environment benefits. Municipal bond holders typically invest based on issuers' ability to repay on schedule, while investors in EIB invest based on how well the new intervention will produce outcomes.

However, there are several limitations with EIBs. One challenge is the need to identify well-defined performance metrics that measure the outcome of the project over a defined period of time; outcomes or proxies for outcomes need to be easily quantified. Performance metrics for coastal resilience solutions would require creative thinking because they tend to have diffuse benefits over a wide geography and actualize over a long timeframe. Furthermore, environmental conditions, climate impacts, and effectiveness of adaptation solutions are location-specific. Given these constraints, project-specific technical analyses may be required to specify the performance thresholds that would trigger a contingent payment, as opposed to adoption of performance metrics and thresholds from similar projects in other geographies.

A data tracking system also needs to be in place to measure the performance metrics. Even if a tracking system already exists and offers a strong set of baseline data, the performance measurement should consider how the benchmark historical data may change under changing climate conditions within the defined period of time, since performance measurements need to be compared to a benchmark of outcomes that would result in the absence of a project. The need to define performance metrics presents an opportunity to identify standards and metrics for resilience, since monitoring and evaluation of resilience in itself is an area in the field that has not received sufficient attention.

Structuring this new type of financing mechanism requires high transaction costs to: identify and coordinate parties; conduct financial, legal, and technical due diligence analyses; and identify performance metrics and negotiate appropriate payoffs.⁶² It is possible that pursuing an EIB may not lead to overall monetary savings given the transaction costs, even if the financial and technical risk of implementation of the resilience intervention is shifted to the investors. The complexities and transaction costs increases with more stakeholders involved, despite the appeal of enlisting multiple investors and multiple payors who would benefit from the project. A project investment should be large to accommodate the transaction cost and to attract investors.

Since contingent payments may be triggered by short-term outcomes, the need for long-lasting outcomes under a changing climate should not be lost during the project development.⁶⁴ Interventions are intended to produce long-term outcomes but pay for success contracting tends to have a relatively short term. In the EIB structure of the DC Water case study below, the contingent payment is triggered in year five from the bond issuance. A longer time period for the performance-contingent payment would require patient capital from investors and/or higher contingent payment amounts given the increased risk over the longer period. The EIB approach has yet to reconcile the mismatch between the short-time frame of the performance-contingent payment with the decades-long benefits that climate change and coastal resilience solutions should be designed for.

Case study: DC Water & Sewer Authority green infrastructure for stormwater reduction

Project background

Washington, DC has a combined sewage system, designed to carry both sewage and stormwater runoff through combined pipes to a wastewater treatment plant before safely discharging the wastewater into the local waterways. During periods of heavy rainfall, the existing combined sewage system reaches capacity and the untreated wastewater overflows into Rock Creek and the Anacostia and Potomac Rivers.

In order to be compliant with the U.S. Environmental Protection Agency's Clean Water Act, DC Water is undertaking the Clean Rivers Project to reduce combined sewer overflows (CSOs) annually by 96% system-wide, reduce the probability of flooding in any given year from 50% to 7%, and improve the local water quality.⁶⁵ The project established in the 2005 Consent Decree included construction of three large underground tunnels to transport stormwater to the wastewater treatment plant. In January 2016, DC Water modified the project to include green infrastructure practices in place of building one of the underground tunnels while achieving reduction of CSO volume. Green infrastructure filters stormwater into the ground where it falls, which reduces the volume of stormwater that flows into the combined sewage system. The modified agreement specified that DC Water will build green infrastructure and targeted sewer separation in two sewershed drainage areas. These practices will be designed to manage the volume of stormwater runoff in the combined sewage system produced by 1.2 inches of rain falling on 498 impervious acres of land. All of the construction will be completed by 2030.

The total cost of the project, including the two tunnels and green infrastructure, is estimated at \$2.6 billion.⁶⁵ To fund the Clean Rivers project in an equitable way, DC Water's board of directors established the Clean Rivers Impervious Area Charge in 2008 based on the amount of impervious surface on a property and requires a program to reduce the charge for low-income customers by 50%.⁶⁶

EIB overview

In September 2016, DC Water issued the first-ever EIB, a \$25 million tax-exempt bond sold in a private placement to Calvert Impact Capital and Goldman Sachs Urban Investment Group. The bond pays a 3.43% interest rate over a 30-year term with a payment contingent on performance in year five.⁶⁷

Measurement of the performance will provide the following evaluation:

- If the green infrastructure pilot performs as expected, DC Water can scale up the green infrastructure approach with confidence that a certain volume of stormwater will be reduced.
- If the green infrastructure pilot performs better than expected, DC Water can scale up the approach with confidence as well as potentially modifying the green infrastructure design prior to scaling up in order to maximize operational and cost efficiency.
- If the green infrastructure pilot underperforms, investors make a risk share payment to DC Water. DC Water can use the data to compare the stormwater reduction outcomes with that of the tunnel solution.

The EIB is structured such that based on the measured outcomes of the green infrastructure, DC Water will pay investors an additional \$3.3 million if the green infrastructure performs better than expected, or the investors will pay DC Water \$3.3 million if it underperforms (Table 6). In relation to the 3.43% base interest rate, investors receive a total of a 6.4% return if the intervention outperforms, versus a total of 0.5% return if the intervention underperforms. Development of the performance tiers was informed by technical modeling of stormwater volume reduction within a 95% confidence interval using key parameters including historic rainfall data, 12 months of rainfall and stormwater data monitoring, and expected infiltration rates of soils.⁶⁷

Table 6. Contingent payment based on performance⁶⁷

Performance Tier	Measureable Outcomes	Contingent Payment
1 (over performance)	Runoff Reduction > 41.3%	DC Water will make an Outcome Payment to investors of \$3.3 million
2 (base)	18.6% <= Runoff Reduction <= 41.3%	No contingent payment due
3 (under performance)	Runoff Reduction < 18.6%	Investors will make Risk Share Payment to DC Water of \$3.3 million

The performance metric aligns with data on volume of stormwater runoff that DC Water has already been collecting under the EPA Consent Decree. The data helped establish a baseline for performance. A monitoring system was already in place and as such, data collection did not add too much to their existing workload. Green infrastructure offer other diffuse outcomes and cobenefits, such as increased property values, cooler temperatures, enhanced public space, and local green jobs, but are not measured as a performance metric.

The EIB was issued as a general obligation bond. DC Water has a strong revenue stream, through general taxes and a Clean Rivers Impervious Area Charge and Stormwater Fee, which are both calculated based on the amount of impervious surface on a property.^{68,69}

This EIB application to green infrastructure and stormwater reduction is being replicated in Baltimore for a \$6.2 million project and Atlanta for a \$12.9 million project.

[Case study: Wetland restoration in Louisiana](#)

Project background

Louisiana's natural coast helps buffer the region from storms, but has lost 1,900 square miles of land since the 1930s and is projected to lose another 4,120 square miles over the next 50 years.⁷⁰ Louisiana's coast has suffered damage and degradation from Hurricanes Katrina and Rita in 2005 and the BP Deepwater Horizon oil spill in 2010. Sea level rise and future storms will not only exacerbate land loss and flooding

impacts but also highlight the urgency to restore the coast. Coastal land loss in the state may increase economic costs by up to \$138 billion in infrastructure damages and \$53 billion in economic disruptions from a single storm.⁷¹

The 2017 Coastal Master Plan developed by the State of Louisiana's Coastal Protection and Restoration Authority (CPRA) identifies projects to restore the coastal habitats and infrastructure.⁷² The plan incorporates the latest sea level rise projections. The plan identifies 124 projects that include levees, flood walls, marsh and wetland creation and restoration, and hurricane protection. The 124 projects cost \$50 billion over a 50-year period and are projected to reduce expected damage by \$8.3 billion annually by year 50. CPRA's FY18 Annual Plan had a budget of \$644 million to support 30 of the Master Plan's projects.

CPRA's revenue sources include allocations under the federal RESTORE Act that resulted from the 2010 Deepwater Horizon oil spill settlement and future oil and gas production revenues through the Gulf of Mexico Energy Security Act, Oil Pollution Act, and the National Fish and Wildlife Foundation Gulf Environmental Benefit Fund.⁷³ Louisiana is expected to receive \$500 million annually for the next 15 years for coastal restoration and protection through the oil spill settlement.

EIB overview

A team of intermediaries are currently working with the CPRA Governor's advisory committee and financial working group to develop an EIB for a wetland restoration and resilience project in the Master Plan. If successful, it will be the first EIB for wetland restoration. The team has proposed issuing an EIB to fund a \$40 million pilot project with a tenor of 10 to 15 years to restore up to 835 acres of the Belle Pass-Golden Meadow Marsh at Port Fourchon. The infrastructure at the oil port are vital for the local and regional economy but vulnerable to storms. The study for the proposed EIB was released in August 2018.⁷⁴

The EIB structure is slightly different from that of the green infrastructure projects in other cities to date since this case has only two tiers for performance: base and over performance. The proposed funding stream for the bond is the future annual Deepwater Horizon oil spill settlement revenues. Local private asset owners include oil and gas companies, port owners, utilities. They would receive direct benefits of avoided land loss would also be involved as "partner payors" – if the intervention overperforms, they will provide a performance payment currently estimated to be between \$3.5 million to \$8 million. Both investors and contractors would share the predetermined performance payment, to attract investors for taking on a financial and technical risk, and to incentivize contractors to build a high performance intervention. The state bond commission/treasury will also need to be engaged and establish a special purpose entity for the project financing.

In order to advance the EIB, CPRA will need to authorize its bonding capacity for the EIB. CPRA will need to resolve any restrictions on use of oil spill settlement funds to repay the bond, determine the bond's tax-exempt status, and secure willing partner payors.

Appendix C – Insurance-linked Securities

Catastrophe bonds

Catastrophe bonds are a form of insurance that pays out if a natural disaster exceeds a defined threshold. As represented in Figure 3, public sector entities can serve as a sponsor of a catastrophe bond, which will pay out if a triggering event occurs, in order to help insure against damages. The issuer serves as the intermediary between the public sector and the investors in the private capital markets. Investors fund a collateral account and receive interest payments but

under the risk transfer mechanism, may lose a portion of their principal if a catastrophe exceeds a specified level. Catastrophe bonds are attractive to investors because they are not well correlated with other financial risks. Catastrophe bonds typically have contract terms of three to five years.

Catastrophe bonds are particularly applicable for entities required to hold insurance, and for insurance holders facing challenges in securing insurance coverage. For instance, regions typically expect insurance premiums to increase after a major hurricane, with a year timelag after the disaster due to the annual contract terms of insurance.

The New York Metropolitan Transit Authority (MTA) was the first to issue a catastrophe bond in 2013. The MTA issued a \$200 million catastrophe bond to cover risk from storm surge measured during named storm events on a parametric basis, in which payment is based on a triggering event.⁷⁵ The MTA sought to diversify its sources of reinsurance protection given contraction in the market and pricing increases after Hurricane Sandy (the MTA had only secured \$500 million of cover from conventional reinsurers after Hurricane Sandy for policy year 2013-2014, and had to search for an additional \$300 million to meet coverage levels for policy year 2012-2013).⁷⁵⁻⁷⁷ The MTA also sought to obtain some coverage on a parametric basis which tends to payout more quickly than indemnity coverage, in which payment is based on actual loss. The MTA renewed the catastrophe bond in 2017 at \$125 million and added earthquake coverage.

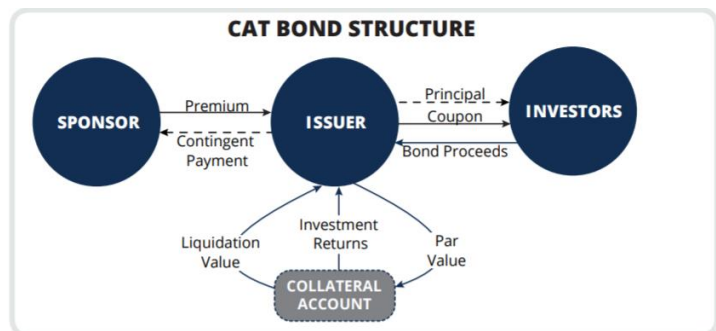


Figure 3. Catastrophe bond model. Source: re:focus partners, 2017.

Resilience bonds

A resilience bond is a new proposed concept that combines resilience financing with risk transfer. A resilience bond links catastrophe bonds that entities can already purchase, with investments in capital resilience projects that reduce risk. As represented in Figure 4, the resilience bond provides access to capital for resilience projects while capturing the value of reduced risk due to the project. When a resilience project is constructed, the reduced risk to investors through the resilience bond model will lead to a reduced premium through a rebate on insurance savings. The bond sponsor

will continue to pay the rate prior to the resilience project and the savings on the premium will go toward paying off the resilience project. The resilience bond model has not yet been applied by other cities, but Houston is currently considering this form of financing to construct new levees, seawall enhancements, and floodgates.

The resilience project would need to reduce physical risk over a defined geographic area in a way that is measureable and can be modelled. The resilience bond issuer uses a catastrophe model to estimate baseline risk and establish the size of the bond for the project. The same catastrophic event is then modeled with the resilience project, and the resilience rebate is calculated based on the anticipated loss reduction relative to the baseline.

There are three main drivers for interested public sector sponsors:⁷⁸

1. Public agencies concerned over a major peril or liability. Resilience bonds cover catastrophic risk rather than chronic risk.
2. Public agencies with demand for resilience project finance. Resilience bonds can provide financing for large resilient infrastructure projects.
3. Large asset holders, such as the MBTA and utilities, with high property insurance compliance requirements and increased need for insurance coverage. These entities may be driven to pursue resilience bonds to expand existing insurance coverage, reduce anticipated premium increases, or fill gaps in coverage.

Different actors within the public sector can initiate the conversations about the potential for resilience bonds. Resilience departments will need to engage with the risk management offices to understand insurance requirements. Meanwhile, risk management offices typically want to reduce and shift insurance costs and will need to work with resilience and capital planners to understand resilience infrastructure investments underway to reduce physical risk. Additionally, engineers working on resilience infrastructure projects with constrained budgets may consider alternative financing approaches.

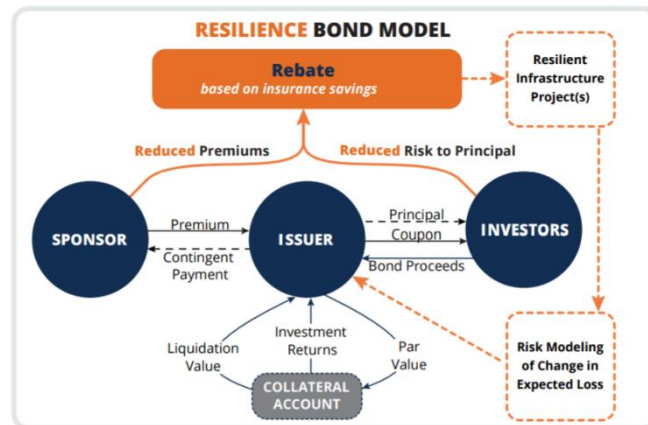


Figure 4. Resilience bond model. Source: re:focus partners, 2017.

While it is more efficient to accrue benefits to a single entity, a resilience bond could have multiple public sector co-sponsors for a large resilient infrastructure project. This approach would pool risk and look across the insurance portfolio of multiple parties including the City, MBTA, utilities, and large infrastructure owners.

There are several challenges to implementation.^{7,8} Pricing of the resilience bond and rebate relies on linking physical risk reduction strategies with risk reduction that can be modeled. However, future advancements in modeling of climate change impacts can mitigate this barrier. Another concern is the need for the investment project to be large enough for the resilience rebate to be meaningful. In addition, entities must carry insurance in order to capture insurance savings. While the City currently carries catastrophic insurance, entities that own large assets such as the MBTA have greater insurance requirements. Engaging other co-sponsors could be beneficial, but would add to the high transaction costs of multiple intermediaries.

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