



Designing for Sea Level Rise

Back Cove, Portland, Maine

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FOR DAD

My passion for and appreciation of the
Maine landscape began during our early
morning fishing trips on Casco Bay

ABSTRACT

At the heart of Portland, Maine is a 500-acre tidal bay framed by a linden tree-lined trail and boulevard. Back Cove physically and visually defines the city and is regarded as an important natural, historical, and recreational resource. However, data from the National Oceanic and Atmospheric Administration (NOAA) projects sea levels in Back Cove to rise six feet over the next fifty years. This poses an immediate risk to the historic boulevard and trail—originally designed by Olmsted, Olmsted & Eliot, the bordering low-lying neighborhoods, and the extensive network of stormwater and sewer pipes that outlet into the Cove. Additionally, it has been more than twenty years since the city of Portland has published a comprehensive master plan for Back Cove, which did not account for climate change and predates the most recent sea level rise projections.

This project engages in the constructivist ‘research-through-designing’ approach set forth by Lenzholzer, Duchhart, and Koh (2013) that emphasizes the contextual role of physical and social environments. Methods used in support of this approach include literature review, interviews, site visits, and archival research. Values of historic and ecological integrity and four sea level rise design strategies guide the outcome—a master plan design for the year 2070, when NOAA projects sea levels to rise six feet at Back Cove, and focal area designs across multiple spatial and temporal scales.

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The linden tree
allée around Baxter
Boulevard, August
2017.







View from the western edge of Back Cove looking towards Munjoy Hill, September 2017.

1 INTRODUCTION

At the heart of this project is the desire to propose a design that will inspire positive change at a specific site of interest. This chapter will set the bounds of the research inquiry by explaining the motivation for the project, identifying the research question, recognizing the relevance of the project, and establishing methods that were used to scope the research inquiry.

MOTIVATION

Back Cove is an enclosed tidal bay that physically and visually defines the city of Portland, Maine. The cove is encircled by a 3.5-mile pedestrian trail and vehicular boulevard (Baxter Boulevard) that are lined with linden trees and offer dramatic views of the city skyline and distant hills. Twice daily the tide rises and falls at Back Cove, filling with glistening ocean water and then receding to reveal the shimmering, grey mudflats. The cove is surrounded by residential neighborhoods and parks to its north, south, and west, while its eastern edge is bordered by Interstate 295 (Figure 1.1).

Back Cove, the encompassing trail, and Baxter Boulevard are regarded as important natural, historical, and recreational resources to the city and its residents. Despite this, it has been more than twenty years since the city of Portland published a comprehensive master plan for the site. Published in 1996, the *Baxter Boulevard Improvement Plan* was written by Richardson & Associates Landscape Architects in collaboration with T.Y. Lin International (engineers), Bartlett Tree Experts (arborists), and Eleanor Ames (landscape historian). The master plan provides a useful historical overview, summarizes issues and concerns from the public, and concludes with a series of recommended improvements that focus on planting strategies and the circulation of cars, bicycles, and pedestrians.

In the years since the *Baxter Boulevard Improvement Plan* (hereafter *Improvement Plan*) was published, we have learned that sea level rise over the next fifty years will dramatically change Back Cove's coastline. Research on rising oceans resulting from increased global temperatures was just beginning to enter the scientific community in the early 1990s (Watson and Adams 2011). Therefore, it is assumed that this information was not common knowledge in the master planning process when the *Improvement Plan* was published, meaning recommended solutions specific to Back Cove and rising sea levels were not included in the report.

The results of this research project are more important now than ever. Globally, sea levels have risen an

average of three inches in the past quarter century and are projected to rise at least two feet by the end of the century (Bornstein 2018). Sea levels in Portland, Maine rose 7.5 inches from 1912 to 2011 and this rate of increase is doubling every two decades (Miller 2015). The most extreme projections from the National Oceanic and Atmospheric Administration (NOAA) show sea level rising 10.79 feet in Portland by 2100. Short term changes in sea level rise are natural, but longer-term, accelerated increases are attributed to human-inflicted climate change.

Climate change will impact the historic boulevard, estuarine habitat, adjacent neighborhoods, and the extensive urban infrastructure that surrounds the cove. Portland’s Bayside neighborhood, an industrial area located on the southeastern border of Back Cove, has already experienced significant flooding in August 2014, September 2015, and more recently in January and March 2018, when extreme high tides combined with significant precipitation.

To date, several studies have been conducted that identify sea level as an impending risk to the city of Portland, but no physical changes have been implemented. In 2016, the city of Portland allocated \$100,000 to engage the public, study infrastructure gaps, and begin the “Bayside Adapts” initiative—a resiliency study that included a design ideas competition for the Bayside neighborhood and southern edge of Back Cove. In February 2018 the cities of Portland and South Portland announced they were contributing \$110,000 each towards the development of a “Climate Change and Adaptation Plan” to be completed by a hired technical consultant (Bouchard 2018). These efforts suggest that the city of Portland is aware of the risks of climate change and sea level rise and is willing to allocate funding towards planning strategies. However, funding efforts should also address specific physical infrastructure changes rather than just general planning efforts. This project proposes a design that offers physical solutions to sea level rise at Back Cove.

RESEARCH QUESTION

Given that:

- NOAA projects the sea level at Back Cove will rise six feet above 2018 mean high higher water (MHHW) by the year 2070
- The master plan, *Baxter Boulevard Improvement Plan*, was published in 1996 before sea level rise data were available
- Sea level rise will impact the historic boulevard, estuary, adjacent neighborhoods, and urban infrastructure that surrounds the cove
- No infrastructure changes have been made at Back Cove to prepare for sea level rise

this research asks the question:

How can Back Cove be designed to prepare for extreme projections of sea level rise, while prioritizing historic and ecological integrity?

To answer this question, this project proposes a design for Back Cove at varying spatial and temporal scales using research-through-designing strategies.

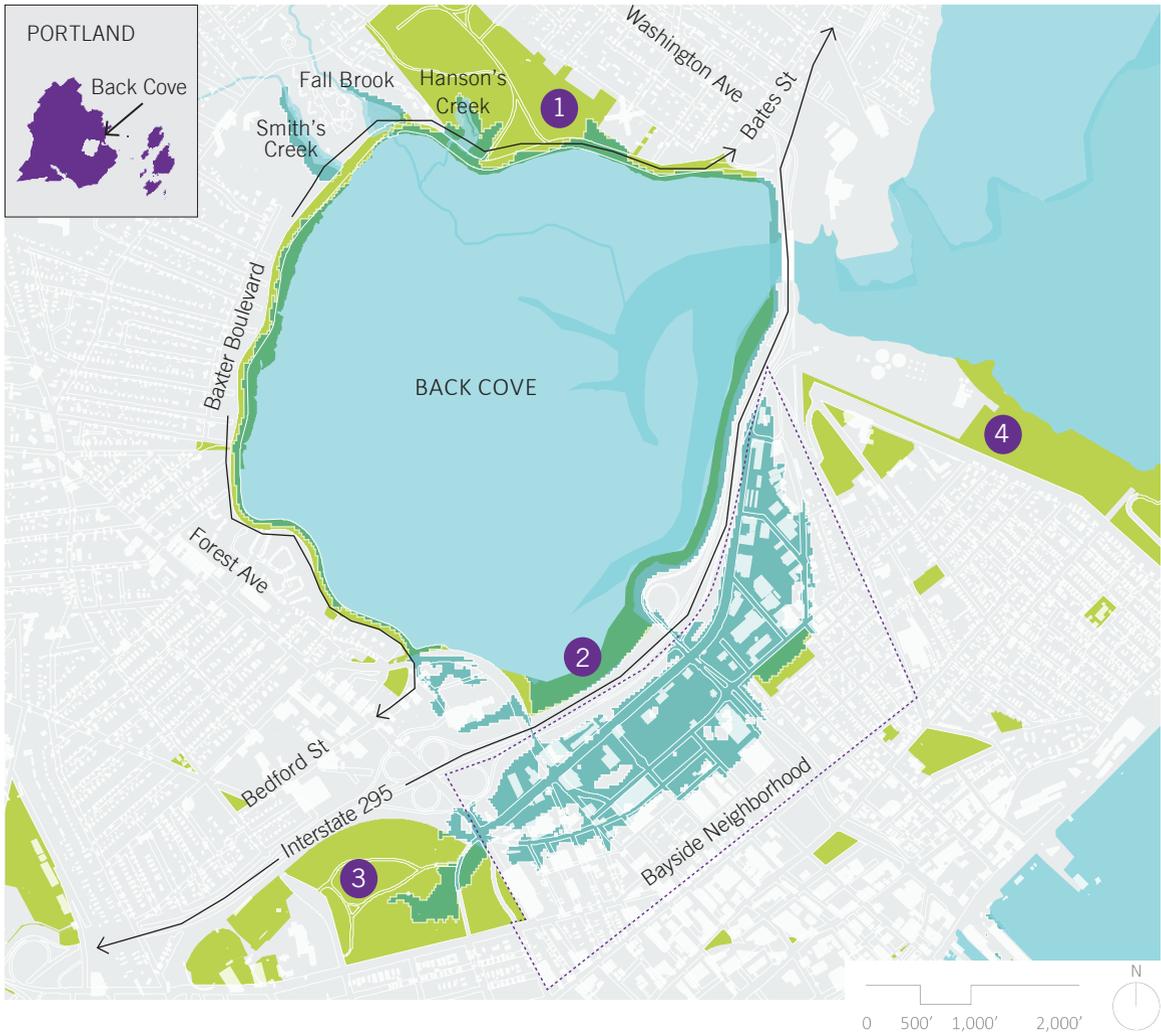


Figure 1.1: The location of Back Cove within the northeast United States, the Casco Bay watershed, and Portland, Maine

- PARKS**
- 1 Payson Park
 - 3 Deering Oaks
 - 2 Back Cove Park
 - 4 Eastern Promenade
- Area of inundation at 6' sea level rise (2070)

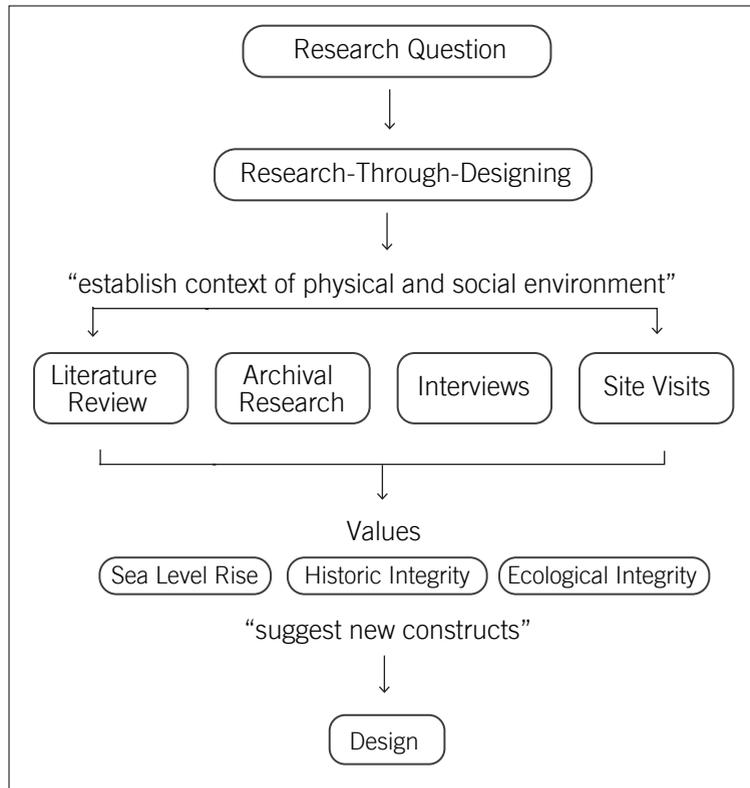


Figure 1.2: Project Process & Methods Diagram, quoted text from Lenzholzer, et al. 2013

PROJECT SIGNIFICANCE

The audience for this research project is intended to be broad as many will benefit from this work, including the general public, public officials, and other designers. Back Cove is part of the Casco Bay Watershed (Figure 1.1), Maine’s most populous watershed that also includes Casco Bay. Scientists with an area of interest that falls within this broader watershed network will find this work informative. Residents in Portland (particularly those that live near Back Cove or use its recreational resources) and anyone with a concern for or interest in the health of the natural environment in Maine will find this work relevant. There are several non-profits with an interest in the health of Casco Bay that will find the scope of this work relevant including Casco Bay Estuary Partners, Portland Trails, and The Gulf of Maine Research Institute. Public officials that work for the City of Portland in departments including Parks and Recreation, Urban Planning, Water Resources, and Public Works will find this research of interest as it suggests designed alternatives that they may have not yet considered or encountered in their work.

This research project will contribute knowledge to the field of landscape architecture and many of its subinterests. The work’s relevancy to the study of history, environmental science, ecology, wetland restoration, and urban planning (among other fields) is an example of the increased complexity and interdisciplinary nature of the profession of landscape architecture. Other designers in the fields of landscape architecture and planning will find this work useful as it pertains to aspects of coastal resiliency, site planning, parks and recreation, stormwater

	(Post)positivism	Constructivism	Advocacy/participatory	Pragmatism
Kind of new design knowledge	Predictive 'Objective' Deductive/generalizable Quantitative Verified theory/design guidelines Patterns, prototypes	Suggestive 'Individual', meaning Contextual Qualitative New artifacts/projects Making tacit knowledge explicit/procedural	Transformative Collaborative Contextual Agendas for action Qualitative (and sometimes quantitative) Procedural/theoretical	Combination of design knowledge of (post)positivist, constructivist and advocacy/participatory knowledge claims depends on specific needs per research project
Issues that research questions address	Physical/functional Psychological	Social Interpretations and meanings New forms and artifacts Esthetics	Adaptation Social Emancipatory Appreciative Political Real-world Economical	Combinations of issues e.g. physical and social, psychological and esthetics, search for meanings and political
RTD methods	Design hypothesis testing Design experiments tested with surveys, simulations or measurements Strict protocol	'Creative' reflection in action Personal involvement Question driven design process Thick description Intense designer involvement/immersion Systematic 'reflexive journal' Triangulation	Qualitative/quantitative Collaborative/interactive Recursive design and participant feedback loops Emergent Normative Sequential/concurrent	Depends on research questions – mixed methods: e.g. design hypothesis testing with surveys and participatory methods; creative form generation, testing with simulations
Research evaluation criteria and methods	'Objective' Validity Reliability Generalizability Quantitative/numerical Statistical analysis Empirical science test methods	Originality Dependability Transparency Credibility Effect on perception and feelings of users Shift in values Mainly qualitative Precedent comparison Design competitions	Shift in values Ownership of knowledge Participant commitment to change Mainly qualitative On-going researcher commitment Monitoring of emancipation	Directly depends on research question and research methods chosen

Figure 1.3: Overview of research-through-designing knowledge claims. This project aligns with constructivism, as it is embedded in context of physical and social environments. (Lenzholzer et al. 2013, 125)

management, environmental restoration, green infrastructure, recreation facilities, transportation, and ecological design. Researchers and designers may also look to this work as a case study for future research and design of historically significant landscapes that are faced with a similar challenge.

Without the knowledge that this research seeks to uncover, many of the mentioned stakeholders may never be aware of the potential that a landscape architecture-driven intervention can have on the long-term health of Back Cove and its importance to the City of Portland as a natural and cultural resource.

METHODS

A variety of methods were combined in the research process (Figure 1.2) to answer the research question. Literature review, archival research, site visits, and interviews were employed to establish the context of Back Cove's biophysical and cultural history. The collection of extensive information on Back Cove's context led to a set of values that guided the design process. It is important to note that the methods were not conducted in a linear manner. For example, when the design was in progress, it was often necessary to conduct more in-depth literature

review or interviews about a specific area of the site. This was particularly true with the Bayside neighborhood, which was not part of the original research interest, but later became necessary to learn about as sea level rise at Back Cove directly effects it.

Research-through-Designing

This project engages in the ‘research-through-designing’ (RTD) approach set forth by Lenzholzer, Duchhart, and Koh in 2013 as a strategy to engage in design as part of the research inquiry. This approach emphasizes the validity of design as a research inquiry that is capable of producing valuable new knowledge or insights. Lenzholzer et al. notes that typical classifications of relationships between design and research are too narrow for the “dynamic, highly complex larger scale natural and socio-cultural system” (121) that embody landscape. In response, four RTD strategies are developed using Creswell’s knowledge claims in research theory: (post)positivist, constructivist, advocacy/participatory, and pragmatic (Figure 1.3). Constructivist RTD aligns most closely with this research inquiry as it is “embedded in the context of physical and social environments” and “revolves around suggesting new constructs” (Lenzholzer et al. 2013, 123).

Literature Review

Literature review was primarily conducted in 2017, the first year of research. Peer-reviewed articles, newspaper articles, books, and reports were read, summarized, and analyzed to comprehend Back Cove, tidal estuaries in Maine, and climate change in Casco Bay. Analyzing these sources helped me establish context and identify the gap in knowledge. Three primary texts were reviewed to understand the history of Back Cove, the city of Portland, Maine, and the local park network: *Bold Vision*, edited by Theo Holtwijk and Earle G. Shettleworth Jr. (1999), *Designing the Maine Landscape*, by Theresa Mattor and Lucie Teegarden (2009), and *Back Cove Improvement Plan*, written by Richardson & Associates Landscape Architects, T.Y. Lin International (engineers), Bartlett Tree Experts (arborists) and Eleanor Ames (landscape historian) (1996).

As the research topic narrowed in early 2018, further literature review was conducted on more specific topics relating to Back Cove. Understanding the effects of climate change and sea level rise on Portland was aided by reviewing reports by Casco Bay Estuary Partners (CBEP). These were particularly helpful because they summarize complex, scientific phenomenon for a general audience. Newspaper articles from the Portland Press Herald were also helpful for similar reasons, but they were additionally useful for investigating recent (within the past 2-3 years) developments and events happening in the proximity of Back Cove.

Archival Research

Maps, site plans, drawings, photographs, and correspondence from three sources—The Library of Congress, The Olmsted Archives, and The Maine Historical Society—were consulted to determine changes in the landscape surrounding Back Cove and to understand the work conducted by Olmsted, Olmsted & Elliot and Olmsted Brothers.

The Library of Congress (LOC) in Washington, D.C. was visited in August 2017 to review correspondence (stored on microfilm) in the Olmsted Associates Records that pertained to Back Cove. Only two letters relevant to the 1896 Back Cove proposal by Olmsted, Olmsted & Elliot were uncovered in the LOC archives. Correspondence in the 1930s between officials with the city of Portland and employees of Olmsted Brothers is detailed further in Chapter 2.

The Olmsted Archives, located in Brookline, Massachusetts, did not allow in-person research appointments. Contact was initiated via e-mail in August 2017 and digital scans of plans, section drawings, photographs, and maps were received via mail a few weeks later.

The Maine Historical Society was first visited in March 2017 when my interest in work by the Olmsted firms in Maine began. Subsequent visits in August and December 2017 provided guidance on using the Maine Memory Network, an online archive of maps and photographs. Information relevant to Back Cove on the Maine Memory Network was limited to a few photographs, maps, and sketches. One primary source from the Maine Historical Society, a map from the City of Portland Department of Public Works, "Filling in Back Cove, Portland, 1837-2003," was used to track historic shoreline changes surrounding the Cove.

Site Visits

Visits to Back Cove in August 2017, December 2017, and January 2018 resulted in photographic and written documentation of the site at varying tide levels, times of day, and seasons. Visits during the winter months provided a useful perspective of the site when it was relatively unoccupied. Back Cove can be under snow from November through April, therefore there is a potential opportunity to provide year-round recreation on the site.

Living in Portland for twenty-plus years has provided a long-term, engaged perspective that could not have been obtained from a site that I was unfamiliar with before beginning research. However, spending time on site after receiving training as a landscape architecture masters student gave me the ability to more effectively assess the condition.

Interviews

Even with all the digital tools available to researchers today, conversations with people personally knowledgeable about a topic reveal information that may otherwise be undiscoverable. Conversations with individuals employed by The City of Portland, CBEP, and the University of Southern Maine provided valuable insight into the past, present, and potential future of Back Cove. Formal and informal interviews were conducted over phone, in person, and via e-mail. In person and phone conversations were not audio-recorded nor fully transcribed, though selected points were documented as hand-written notes. While questions were posed to individuals, the conversation was also allowed to flow naturally depending on the response from participants. The following individuals were interviewed:

- Dr. Karen Wilson & Dr. Theo Willis from University of Maine's Department of Environmental Science and Policy were interviewed in person on January 2, 2018. Both longtime residents of Portland, Wilson specializes

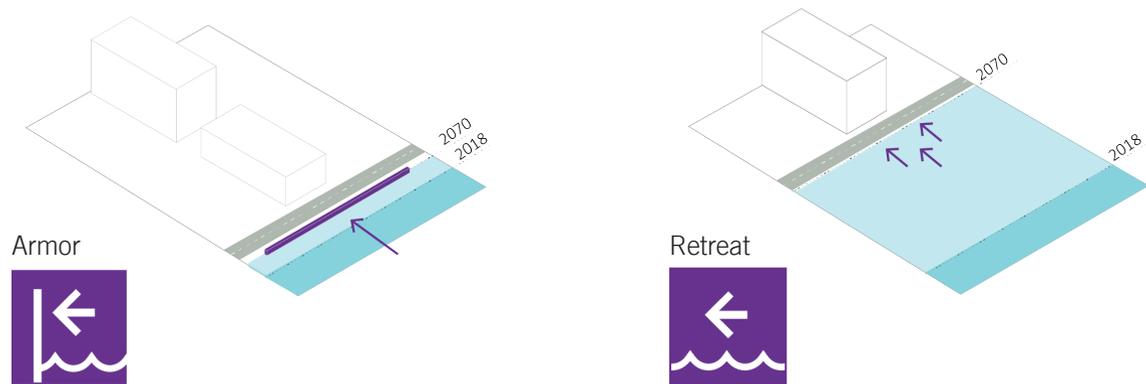


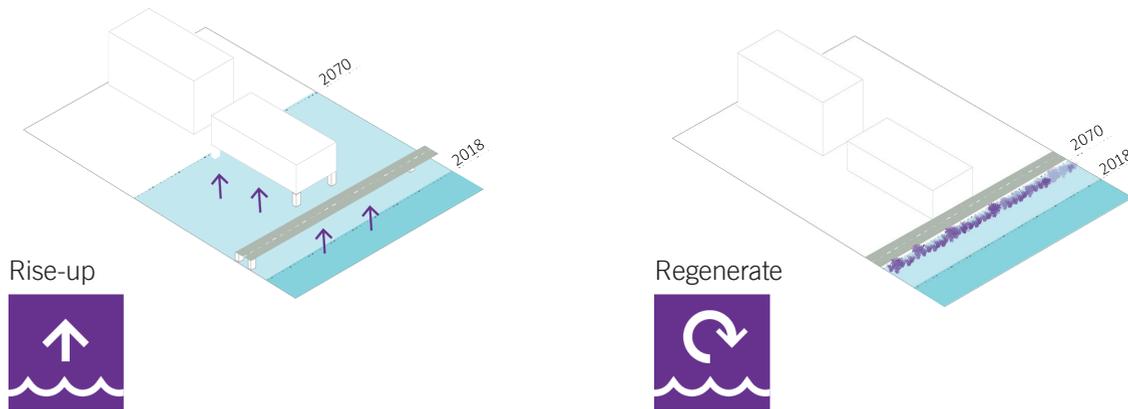
Figure 1.4: Sea level rise design strategies

in wetland ecology and limnology, while Willis has a background in limnology and oceanography.

- Bill Needleman, Waterfront Coordinator for the City of Portland, was interviewed over the phone on February 6, 2018. Needleman has a background as a planner with the city and is working at the forefront of climate change and sea level adaptation strategies in Portland.
- Matt Craig, Habitat Program Manager at CBEP, was interviewed on February 21, 2018. Matt had great insight on plant and animal species in tidal estuaries and had suggestions for ways to use aquaculture to help stabilize nitrogen levels in Back Cove.
- Curtis Bohlen, Executive Director at CBEP, was interviewed by phone on February 27, 2018. Also a professor and researcher, Bohlen provided suggestions for narrowing down the research topic and specifying the research question while also answering questions on sea level rise, combined sewer systems, and the behavior of different types of shell fish found in Back Cove.
- Jeff Tarling, arborist for the City of Portland, was interviewed several times via e-mail from December 2017 to May 2018. Jeff provided useful information on the historic linden tree allée and shared historic photographs of the trees and the greater Boulevard area.

SEA LEVEL RISE DESIGN STRATEGIES

Designing a coastal community for sea level rise is a massive undertaking that should be approached through collaboration among landscape architects, planners, engineers, architects, and scientists. Implementation requires the coordination and input of several agencies and stakeholders. In order to formulate design strategies that were applicable to Back Cove, I explored online sources, past design competitions, and *Design for Flooding*, a book by Donald Watson and Michele Adams (2011). Competitions such as *Rising Tides* (2009), *Resilient By*



Design (2017-2018), and Rebuild by Design (ongoing) provided useful design case studies for the development of these design strategies and the design proposal, found in Chapter 3. During my exploration of other design case studies, I discovered that a common way to approach a master plan design that addresses a complex challenge is to formulate a dynamic set of approachable strategies. A single sea level rise design strategy for the entirety of Back Cove would not be appropriate as land uses and projected water inundation varies. Therefore, a hybrid approach that implements the use of four strategies where appropriate is used in this project. Uncovered in the design case studies and *Design for Flooding*, these strategies were inspired by some of the common actions used to prepare for sea level rise and flooding, Shown in Figure 1.4, they are defined as follows:

Armor: The use of infrastructure to hold back rising waters. This would include “hard” solutions, such as sea walls and levees, and “soft” solutions like berms.

Rise-Up: The adjustment of existing infrastructure and the construction of new flood-proof structures to accommodate or allow water in. Common solutions include the adjustment of a building’s ground floor into parking that can flood or the conversion of roads and bridges to causeways.

Regenerate: The restoration or creation of natural infrastructure to absorb, stabilize, and protect coastal edges from rising sea water and storm surge; often combined with another strategy temporarily during establishment.

Retreat: The withdrawal or abandonment of at-risk property and infrastructure in the projected area of inundation. The simplest, yet least common, response as valuable coastal real estate generates tax revenue for cities. Unfortunately, this strategy is most common after a disaster has occurred, but is very effective if implemented in the most vulnerable areas (Bird 2015).

CHAPTER PREVIEW

This chapter set the bounds of the research inquiry by explaining the motivation for the project, recognizing the relevance of the project, identifying the research question, describing methods that were used to scope the research inquiry, and defining four design strategies for addressing sea level rise at Back Cove.

Chapter 2 will establish the context of the site by describing the estuarine environment (biophysical) and designed (cultural) landscape of Back Cove. It will include the history of the past, the conditions of the present, and conclude with a set of values that guided the design process. Chapter 3 outlines the design proposal across multiple spatial and temporal scales while Chapter 4 concludes with suggestions for further research, an evaluation of the research-through-designing process, and a personal reflection on the completion of the project.

View across Back
Cove from the walking
path parallel to Baxter
Boulevard, January 2018.







High and Low fringe marshes along the northern edge of Back Cove, September 2017.

2 CONTEXT

Back Cove’s landscape is the result of layers of cultural and biophysical forces interacting and influencing each other over time. These forces have occurred at varying scales and rates of time throughout history. Kenny Helphand argues that this interaction is what defines landscapes,

The interaction between people and place is embodied in the creation of landscape. Landscape is not scenery, although it includes the scenic, nor is it the natural world without the human presence. The landscape is a creation, the record and repository of the discourse between people and the physical environment (Helphand 1991, xxi).

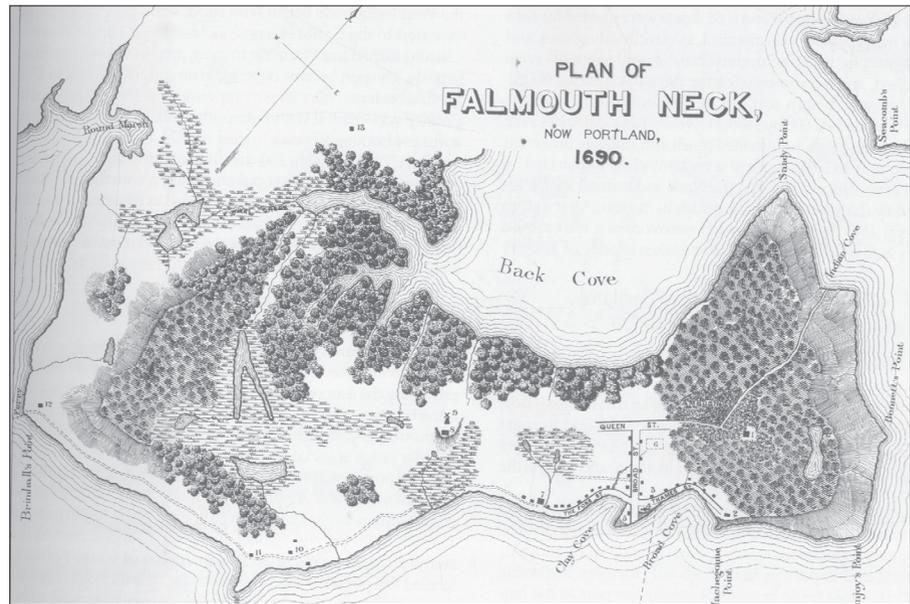
This chapter offers a comprehensive and condensed overview of centuries of dynamic discourse between people and the physical environment at Back Cove. The goal of this chapter is not to present an exhaustive inventory of Back Cove’s history and ecological function but to call attention to historic land use and design decision making that made the landscape at Back Cove what it is today. This information results in a set of values that guide the designing process.

TIDAL ESTUARY

Back Cove is a semi-enclosed, tidal estuary basin. Estuaries are dynamic bodies of water where freshwater rivers and streams meet the ocean. They have a diverse and complex ecology that plays an important role in the transitional zone between land and sea, provide crucial ecosystem services, and serve as a protective buffer between land and open ocean.

The complexity and significance of estuaries has not always been accepted and understood; historically, these landscapes were associated with pestilence and disease and were diked and filled to increase farmland and urban development (Weis and Butler 2009). An 1868 article published in *Scientific American* on diking and draining salt marshes in New Jersey refers to this landscape type as “unproductive of anything which can subserve any important purpose, but productive of numerous evils. Teaming with miasma, the home of mischievous and annoying insects they are blotches upon the otherwise fair face of nature” (“Diking and Draining Salt Marshes” 1868). Estuaries were often the first land to be filled for agricultural use or urban development because of their accessible position between rivers and coastal areas with maritime trade. Dutch settlers that arrived in the northeastern United States in the late 17th century diked marshes to increase agricultural land and prevent flooding, similarly to how they had done in the Netherlands, while English settlers built roads over marshes

Figure 2.1: 17th century map of Portland showing the expansive wetlands and forests bordering Back Cove before land filling began (Bold Vision, 25).



to harvest salt hay for feeding livestock, mulching agriculture, and insulating homes (Weis and Butler 2009). Estuaries are still being intensely altered and the effects of historic land use decisions continue to handicap natural processes. By far the most detrimental damage to estuaries is caused by the filling of the water body to create railroad beds, airports, highways, and, in the case of many cities, land expansion for urban development. Even if an estuary is not entirely filled, such a drastic change to this ecosystem can essentially cut off tidal action and cause large scale drainage issues and potentially irreversible disruptions in habitat (Weis and Butler 2009).

The size and function of Back Cove today is drastically different than it was 200 years ago. Before European settlement, it was at the center of a complex and dynamic ecosystem of dense forest, streams, wetlands, and marshes that extended inland past present-day Deering Oaks (Figure 2.1). As Portland's population and industry grew in the mid-1800s, filling of Back Cove's marshes and mudflats allowed for the expansion of valuable coastal land (Figure 2.2). The decisions that lead to these changes are detailed in the next section.

DESIGNED LANDSCAPE

European Settlement, Development, Industrialization (1632-1866)

Portland, Maine was first settled by Europeans in 1632 on a peninsula jutting into Casco Bay. Portland's early history was defined by contested settlement between Native Americans and the British that led to several iterations of building, rebuilding, and staggered growth with many name changes. The economy throughout the 18th and early 19th century was dependent upon lumber exports and molasses and sugar imports from the Caribbean. Originally part of Massachusetts, Maine gained its statehood in 1820.

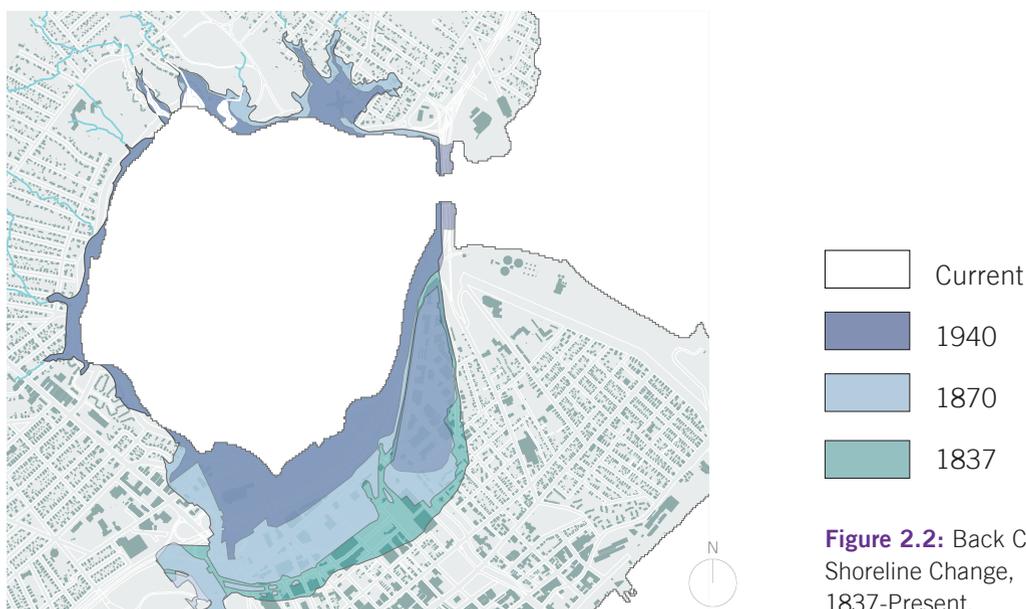


Figure 2.2: Back Cove Shoreline Change, 1837-Present.

The landscape surrounding Back Cove to the north, west, and south remained a densely forested, open wetland with a few farms for the first half of the 19th century, while the city center grew on the narrow peninsula to the south-east. Industrial development along the shores of Back Cove (in the present-day Bayside neighborhood) began in the 1840s with the arrival of the Grand Trunk Railroad from Portland to Montreal, Canada. The railroad development spurred the beginning of over one-hundred years of filling in Back Cove’s mudflats, marshes, and streams. Tanneries, tile manufacturers, and a fish cannery were some of the many commercial enterprises along Back Cove in this period. In addition to providing acreage for commercial real estate, Back Cove was a convenient location for the disposal of raw sewage and industrial waste from expanding industry and subsequent population growth. On July 4th, 1866, a fire ravaged almost half of downtown Portland. Fire debris was dumped along the shores of Back Cove as fill, claiming even more land for development.

Olmsted Firms Plans (1885-1905)

By the late 19th century, conditions at Back Cove were becoming a nuisance to Portland’s residents. In 1884, city engineer William Goodwin proposed a sewer system that would address the polluted flats, but it was never built (Mattor and Teegarden 2009, 34). In his March, 1895 inaugural address, Mayor James P. Baxter described the conditions at Back Cove as:

a slimy and ill-odored waste not only offensive to nostril and eye, but a menace to the health of the city. What can be done with the sink of corruption, which if left to itself will grow worse as time goes on? We may see when we look upon what Boston has done in transforming similar vile places into beauty spots, conducive alike to the pleasure and health of her people (Baxter 1895).

Baxter was referencing the work of Frederick Law Olmsted, Sr. 100 miles south of Portland, in the location of a polluted marsh and mudflat in Boston's Back Bay. Over the course of 200 years, Boston's acreage had expanded from 487 to nearly 1,600. Similarly to Back Cove in Portland, but at a much greater scale, land cut from surrounding hills, gravel from neighboring communities, and waste from industry and fires were used to fill tributaries to the Charles River, Back Bay, and surrounding coves (Brooks 2011). In the tidal mudflats and marshes of the Muddy River, human and industrial waste had created unpleasant conditions for residents. While the tide flushed some of the waste out to sea twice daily, remaining residue in the mudflats "baked odoriferously in the sun" (Zaitzevsky 1992). The estuary was so polluted that in 1877, the Boston Park Commission surveyed the area and found no evidence of animal life (Eisenman 2013). In 1879, Olmsted Sr. proposed the design of a city park in the location of the polluted estuary. Working with his nephew and adopted son, John C. Olmsted, the design called for the conversion of the estuary into a salt marsh with naturalistic, winding channels, and native plants, an innovative concept at the time. Stone bridges were proposed over channels to accommodate foot and carriage traffic. A 20-acre tidal basin and dredged channels would retain 30 additional acres of storm and flood waters. The constant water elevation, controlled with an engineered tidal gate at the outlet to the Charles River, meant that any former mudflats were converted into a more lush and picturesque saltmarsh. While the main design objective of The Fens was to improve sanitation, Olmsted also recognized the benefit that recreational space would provide residents and the increased tax revenue from real estate surrounding the park.

In 1894, before his aforementioned inaugural mayoral address, Baxter visited Boston to view Olmsted's designs in progress along the Emerald Necklace. Impressed with this work, particularly at the tidal marshes and mudflats of The Fens, Baxter recognized that Back Cove had a similar potential for improved sanitation, increased property value, and added recreational opportunities for residents (Richardson et al. 1996).

In late 1895, Baxter commissioned the Boston firm Olmsted, Olmsted & Eliot to prepare a report on the current conditions at Back Cove. Olmsted Sr. retired from practice at some point in 1895, so it is not clear if he was involved in the first proposal for Back Cove. However, his name was still included in the firm's name, along with his collaborator on The Fens, John C. Olmsted and new firm partner, Charles Eliot. In May 1896 the city of Portland was presented with a site plan design, "A Preliminary Plan for the Improvement of Back Cove" (Figure 2.3a) and accompanying text "Landscape Architects' Report on the Improvement of Back Cove, 1895 - 1896." The report provided additional detail and narrative that supplemented the illustrative plan drawing. Drawing on the firm's experience at The Fens, the written proposal highlighted three main benefits of improving the smelly, polluted mudflats: tax revenue from valuable real estate creation, health and sanitation improvements, and a scenic recreational asset for residents. The proposal called for the construction of a dike (Figure 2.3b) with a small inlet channel at the eastern outlet to Casco Bay. This would force the Cove's salt water to be at a nearly constant elevation, thus preventing the mudflats from being fully exposed at low tide and giving off an unpleasant stench. A constant water elevation would also provide recreational boating opportunities in the "pleasure basin" and views of water, regardless of tides. The suggestion of the conversion of the mudflats to a basin is not surprising, given the similar approach used at The Fens and the unsatisfactory cultural perception of estuarine landscapes at the time. The report notes, "even if they became wholesome in time, they would always be mud flats, and as such

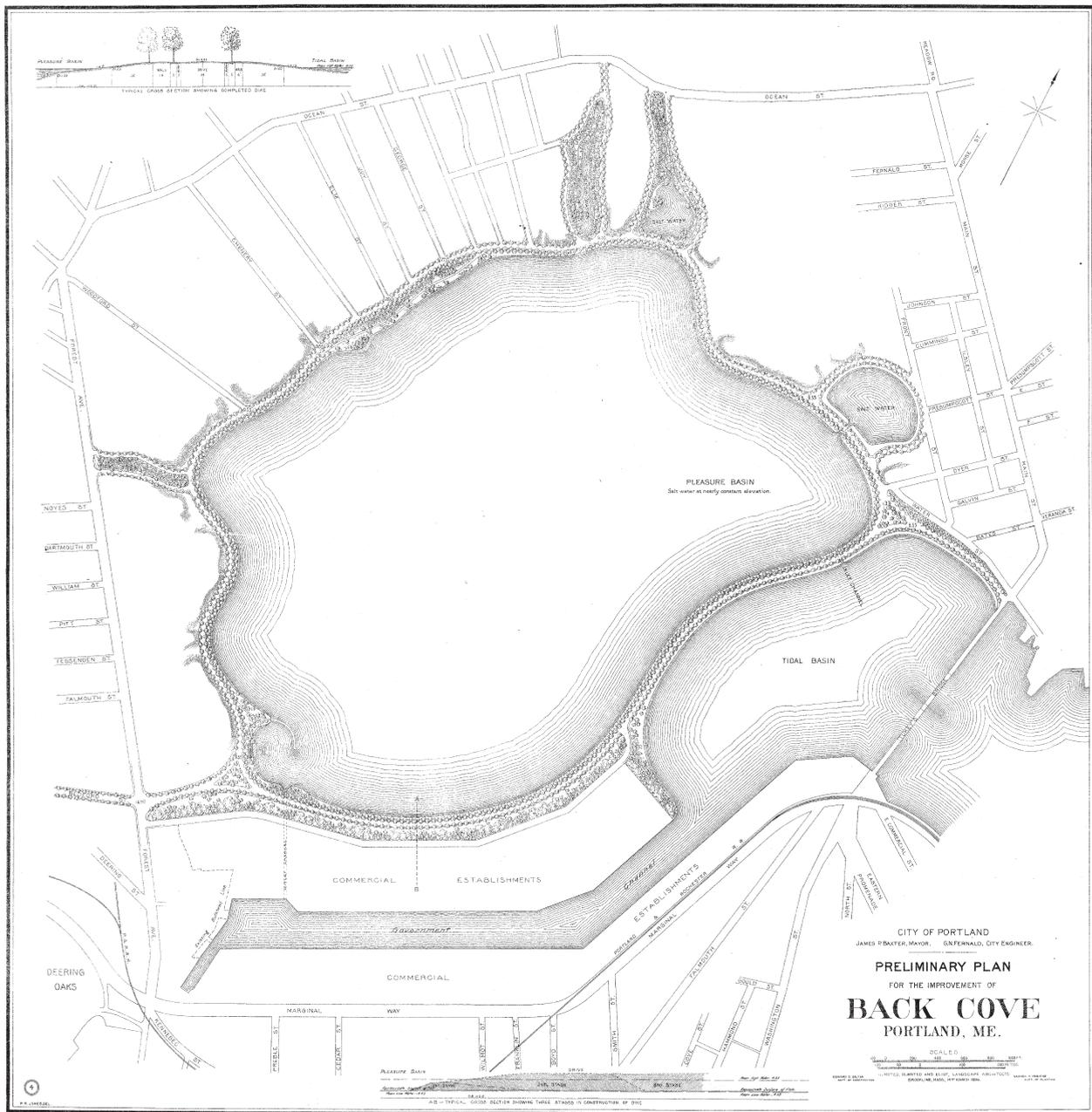
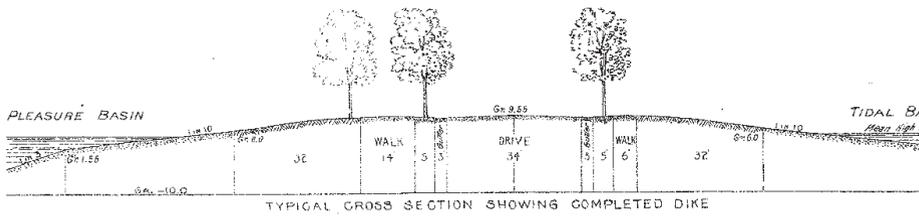


Figure 2.3a (top): Olmsted, Olmsted & Eliot Preliminary Plan for Back Cove, 1896.

Figure 2.3b (bottom): Cross section of the proposed dike which would also serve as a drive and "walk" (path) with allée (both, Courtesy Olmsted Archives Collection).



not as attractive when exposed at every tide as if constantly covered with salt water” (Olmsted, Olmsted & Eliot 1896, 6). The report emphasizes that the dike’s proposed location still allows larger ships to access commercial establishments and railways in the present-day Bayside neighborhood.

In a characteristic Olmstedian move, the proposal also called for a curving, tree-lined parkway encircling the basin with separate paths for pedestrians and carriages (Figure 2.3b). The construction of the dike would support this vision as it would allow for a complete, three-mile “circuit shore drive” and the proposed allée would create a picturesque setting that would help “the lands surrounding Back Cove to realize their highest value for residence purposes” (Olmsted, Olmsted & Eliot 1896, 8). Illustrated in the plan, but not mentioned in the report, are tree-lined paths that encircle the fresh and saltwater streams outletting into the cove and connecting to neighboring streets. The construction of a city-wide intercepting sewer system that would dump sewage further out in Casco Bay’s deep waters was suggested as a way to keep Back Cove clean for the years to come. The report concludes with the suggestion that land acquisition of the mudflats and the right-of-way around Back Cove begin immediately. The proposal was considered controversial at the time and was used against Baxter in his 1896 bid for re-election as mayor, which he lost (Holtwijk and Shettleworth 1999).

In 1904, Baxter was re-elected mayor of Portland and hired the Olmsted Brothers firm (successor firm to Olmsted, Olmsted & Eliot) to prepare a plan for his vision of a complete park network (Richardson et al. 1996, 13). The 1905 “City of Portland, Maine, General Plan for Park System” (Figure 2.4) eliminated the dike and pleasure basin from Back Cove that was seen in the 1896 plan, maintained the allée, parkway, and paths, and additionally proposed a series of tree-lined boulevards connecting Back Cove to Portland’s parks. In the same year, Baxter managed to secure a 100-foot right-of-way around the boulevard from Bedford Street to Tukey’s Bridge (Igleheart 1989). Baxter lost re-election again in 1905, further delaying improvements to Back Cove.

Although they were never fully realized, the design proposals made by the Olmsted firms are significant because they inspired the look and feel of the eventual boulevard and linear park construction and were the first attempt to address the polluted mudflats. The work done by the Olmsted firms at the Fens in Boston and that proposed for Back Cove in Portland had many similarities: both dealt with the remediation of a polluted estuary centrally located in a growing city and doubled as real estate, transportation, and recreation projects that also aimed to improve sanitation and quality of life for urban residents. This connection with The Fens adds to the historic significance of Back Cove.

Boulevard & Interstate Construction, Linden Allée Planting, Sewer Installation (1915-1980)

In 1911, the parks commissioners decided to begin work on the proposed boulevard. Using the Olmsted plans as a guide for improvements, city engineers led the boulevard construction. Over the next several years, more fill was added to the edges of the cove, fringe marshes, and streams while granite blocks were used as rip-rap to stabilize the edges. In 1916, the project gained pace with grading of the road bed, surfacing of gravel, construction of pedestrian paths, and commission of bridges over Smith Creek and Fall Brook. Coincidentally, while all of this alteration to the estuary was underway, the state designated a portion of Back Cove a bird sanctuary. On



Figure 2.4: Olmsted Brothers General Plan for Portland Park System, 1905. The plan still includes a tree-lined boulevard encircling Back Cove, omits the dyke and enclosed “pleasure basin”, and adds an emphasis on connections to other city parks via tree-lined parkways (Courtesy Olmsted Archives Collection).



Figure 2.5: Boulevard paving, grading, and rip-rap construction in the vicinity of Payson Park in the 1920s (All photos, Bold Vision, 98-99).

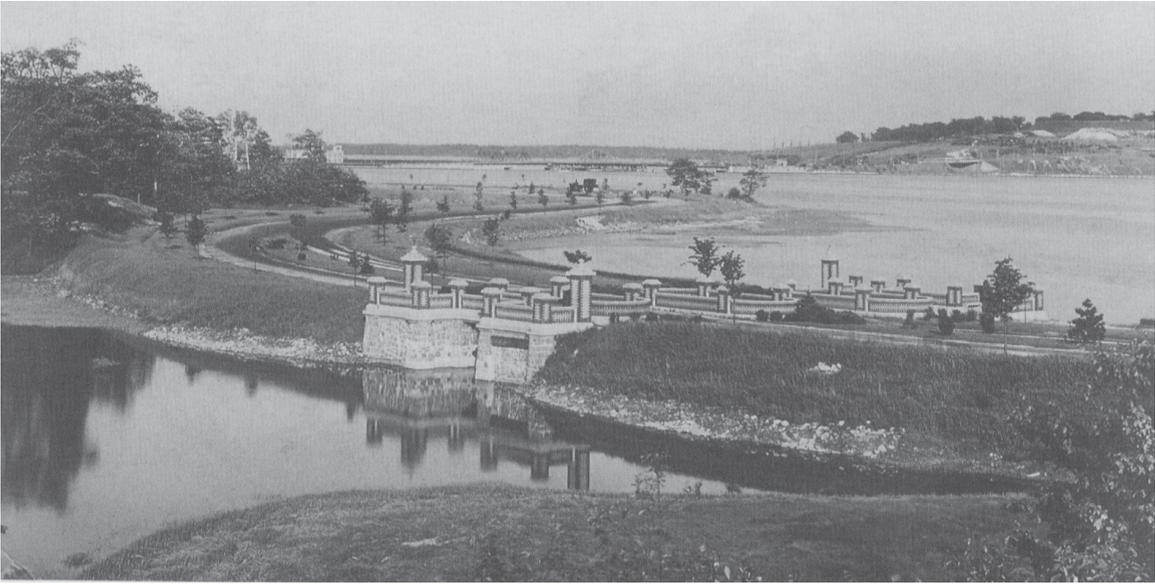


Figure 2.6: View of double bridges in 1928. The newly planted linden allée is shown along the edges of the cove and shrubs and evergreen trees can be seen in the road median (Bold Vision, 99).

November 13, 1917, Back Cove Boulevard was opened to the public. That same year, the city purchased 48 acres of land north of Back Cove from William Payson, which would later be converted into Payson Park (Holtwijk and Shettleworth 1999, 99).

On Memorial Day in 1920 and again in 1921, 100 European “Littleleaf” Linden (*Tilia cordata*) trees were planted in an allée as a memorial to Maine World War I veterans. This was the start of the tree-lined drive that the Olmsted firms first envisioned in their 1896 plan. Planting of the allée began at the Forest Avenue and Bates Street entrance and proceeded east then north. Twenty four of the linden trees planted in 1921 at the Bates Street entrance were from a tree nursery that was started in Payson Park (Richardson et al. 1996, 14). Metal tags were attached to the original trees with a number associated with a specific veteran. The planting of Linden tree Memorial Groves occurred in many cities throughout the United States and Europe after World War I. Throughout the 1920s and 1930s other trees—maples, birches, and assorted evergreens—were planted by the city as were shrubs such as hydrangea, forsythia, spirea, privet, and deutzia. These trees and shrubs were not part of the allée though, which continued to be planted with Littleleaf linden.

The 1920s also saw slope stabilization, grading, and macadam pavement construction in the vicinity of the recently acquired Payson Park (Figure 2.5). City engineer Percy Richardson and Sanders Engineering Company designed the double brick and concrete bridges over Smith Creek and Fall Brook, which were also completed in the 1920s (Figure 2.6). In 1924, brick gutters and granite curbing were installed and power lines along the boulevard were buried to maintain views of the cove (Igleheart 1989).

In 1921, former mayor James Baxter was honored for his stewardship of Back Cove by driving in the first

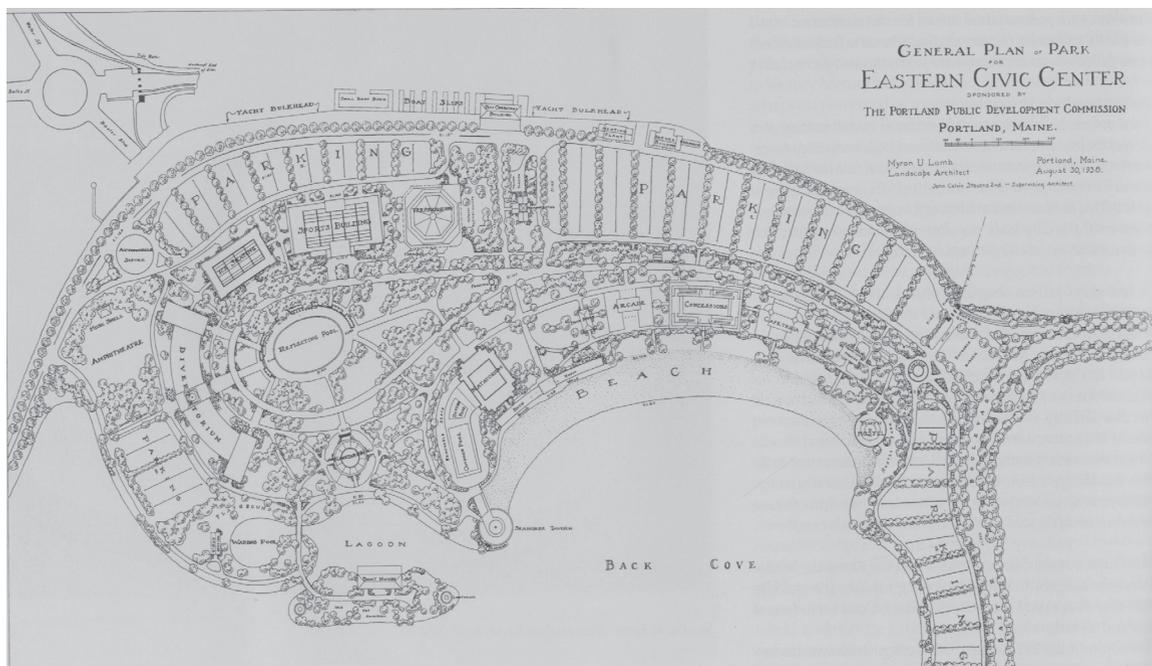


Figure 2.7: 1938 “General Plan of Park for Eastern Civic Center” by Myron Lamb and John Calvin Stevens (Bold Vision, 102).

car on the boulevard. Later that year, he died and the boulevard was renamed Baxter Boulevard in his honor. In October of 1925 a memorial was dedicated to James Baxter on the west side of Baxter Boulevard at the intersection with Vannah Avenue. The design, a sundial set atop an elliptical granite plinth, is encircled with three stone benches that face the boulevard and Back Cove.

In the early 1930s the city revisited the idea of building a dike or other development around Back Cove. The Olmsted Brothers were contacted again, this time by City Manager James Barlow. The correspondence between Barlow and Carl Rust Parker of the Olmsted Brothers firm is found at the Olmsted Archives at the Library of Congress. After a rather uneventful exchange, the Olmsted Brothers were not re-hired by the city. In 1938, landscape architect Myron Lamb and architect John Calvin Stevens II proposed a “General Plan of Park for Eastern Civic Center” (Figure 2.7). The development included a convention center, sports buildings, music shell, canoe and boat house, tavern, concessions, and ice rink. The plan was never constructed and was the last effort at a comprehensive design of the site until 1996.

Back Cove experienced a period of neglect from the 1940s through the 1970s. While residential expansion took off in the vicinity of the cove, the popularity of the automobile and the continued degradation of the estuary contributed to a lack of recreational users. Still, no interventions were put in place to ameliorate the lengthy history of pollutants that were disposed of in the mudflats. Articles in the Portland Press Herald from 1948 and 1957 noted concerns from residents about the stench from the cove and the potential health threat. Records from the 1940s and 1950s detail several estimates (but no construction work) for the installation of interceptor sewers, dredging,



Figure 2.8: Photo from the 1960s showing the Bayside neighborhood before construction of I-295. Photo is taken looking north; Marginal Way is the straight road in the far left of the photograph (Portland Press Herald Archives).



Figure 2.9: Photo during construction of I-295 in the 1970s. Photo is taken looking south. Shown on the right is the large area of landfill that became Back Cove Park. Marginal Way is shown at the bottom left corner (Bold Vision, 92).

Figure 2.10:
Linden tree
removal during
installation of
interceptor sewer
in the 1970s
(Photo Courtesy
Jeff Tarling).



damming, and “flat clean up” ranging from \$1.5 to \$7.7 million (Richardson et al. 1996, 15). In the 1960s the interior of the Fall Brook Bridge was removed and paved over while the deteriorated Smith Creek bridge was fully demolished and a culvert was installed in its place (Holtwijk and Shettleworth 1999, 103).

In 1971, a large south-eastern portion of Back Cove was filled to construct Interstate 295 (Figures 2.8, 2.9). This cut off any existing connection Back Cove had with downtown Portland and the main peninsula. Four acres of park land were taken from the northern portion of Deering Oaks park to accommodate the interstate construction. As compensation, the state granted the city 26 acres of filled land west of Interstate 295 (Figure 2.9). The land was later turned into present-day Back Cove Park. There was mention of a boating and marina facility on the new land, but nothing was ever built (Richardson et al. 1996, 16). The interstate construction was the last recorded instance of land fill at Back Cove.

In the late 1970s, the city finally began construction of an interceptor sewer system, first proposed by Goodwin in 1884 and later in the 1896 Olmsted report (Mattor and Teegarden 2009, 37). In 1979, the wastewater treatment plant was built on the eastern promenade, near the northern outlet to Back Cove. The construction of the interception sewer was a disruption to several of the historic lindens encircling Back Cove (Figure 2.10). Even before the sewer construction, reports from the 1970s detailed the decline of the linden trees, assumed to be a result of road salt. In 1980, 20 new linden trees were replanted and rededicated near the intersection of Dartmouth Street and Baxter Boulevard. Construction in the late 1980s to complete Tukeys Bridge included a pedestrian lane on the bridge, thus completing the trail around the cove and fulfilling the original design intent of the 1896 Olmsted plan. However, construction of highway ramps and connections near the Bates Street and Baxter

Boulevard intersection damaged some of the original lindens from the 1920s (interview with Jeff Tarling).

National Register of Historic Places Designation, Recent Proposals (1989-Present)

In 1989, Back Cove and Baxter Boulevard were listed on the National Register of Historic Places with the unique designation as a dual listing of park and historic roadway (Mattor and Teegarden 2009, 37). Back Cove and Baxter Boulevard were deemed historically significant for their connection to the Olmsted firms, their place in the Portland open space network, and their early representation of natural area reclamation to solve an issue of public health (Igleheart 1989). The historical designation applied to the cove itself and approximately 50 acres of boulevard and parkway from Baxter Boulevard's intersection with Forest Avenue in the southwest to the Bates Street entrance in the north (Figure 2.18). The cove and boulevard are also recognized by the city of Portland as a historic landscape.

In 1989 the *Portland Shoreway Access Plan* was published. This report emphasized the need for water access to Back Cove for residents but none of the suggestions were implemented. Throughout the 1980s and 1990s, usage of Back Cove Park and the trail increased while traffic around the boulevard also intensified. Now the most frequented park in the city, funds were designated to publish *The Baxter Boulevard Improvement Plan*, the last comprehensive look at the site. According to *Bold Vision*, the proposals were controversial because they compromised the historical integrity of the boulevard. In fall of 1997, Richardson & Associates submitted a revised cross section that prioritized the historic linden allée and maintained the cobblestone curbing from the historic roadway. The *Improvement Plan* was adopted as part of *Portland's Comprehensive Plan*, but none of the specific changes or recommendation were made (Mattor and Teegarden 2009, 37).

November 2017 marked exactly 100 years since the opening of Baxter Boulevard. The area is still a popular recreation destination for residents of greater Portland and the tree-lined boulevard is an important connection for vehicular traffic. Over hundreds of years, population growth in Portland has greatly altered the form and function of Back Cove's estuarine environment and its encircling historic boulevard and path.

The next section of this chapter, Site Inventory, documents the current conditions at Back Cove. It focuses on two key themes that have emerged from exploration of the site's past context: the natural integrity of the estuary and the historic elements of the boulevard and path. It also details future sea level rise projections for Back Cove and highlights the effect these projections will have on these two key themes.

SITE INVENTORY

Ecological Integrity: The Tidal Estuary

Back Cove is a semi-enclosed tidal estuary basin comprised of wetland subclasses (Figure 2.11). The subclasses of wetlands, designated by the U. S. Fish and Wildlife Service National Wetlands Inventory, vary based on frequency of water inundation, salinity levels, plant life, and sediment makeup (Figure 2.12). Ocean water fills and drains Back Cove twice daily, carrying sediment, biota, and nutrients to the worms, clams, shellfish, and microscopic organisms living in the mudflats and fringe marshes. A subtidal (permanently flooded) channel leads to Casco Bay via a single, narrow, bottle-neck opening in the northeast. Historic maps indicate that a portion of this subtidal channel may have been dredged in the mid to late 1800s to allow ships to access the commercial establishments in present-day Bayside. The remaining approximately 450 acres of the main basin is intertidal, meaning it is flooded and exposed by tides at varying frequency and quantity. The intertidal landscape is further categorized into mudflat, low marsh, and high marsh. The 420 acres of mudflat are reached by the tide twice daily, as is the low marsh. The high marsh, which hugs the majority of the boulevard, is flooded during the highest tides and storm surge. Smith's Creek, Fall Brook, and Hanson's Creek are classified as riverine, which means they are always flooded and contained in a channel. The lower portions are estuarine and contain mudflat, high, and low marsh. The outlets of Smith and Hanson's Creeks into Back Cove were placed in a culvert under the road during construction of the boulevard. Fall Brook has been channelized and filled over the years, but flows relatively unrestricted underneath a bridge.

Comparison of historic maps and the present-day wetland inventory revealed the effect urban development has had on the function of the estuarine environment at Back Cove. A healthy, thriving estuary requires a dynamic cross section of landscape types with a variety of plants as a buffer between water and land (Figure 2.13). Over the years, the upper border, upland zones, and several small streams have been eliminated during the construction of Baxter Boulevard, neighborhoods, and industrial development (Figures 2.14 and 2.15). In this process, streams are placed in culverts or filled, and the upper border and upland zones are graded and paved over. This negatively affects the hydrologic cycle, damages and eliminates habitat, and decreases the buffer between land and water—making developed land more vulnerable to flooding.

Although filling of the central basin, streams, and fringe marshes has ceased, the estuary at Back Cove is still not as healthy as it should be. As of October 2017, there are still twelve active combined sewer overflows (CSOs) outlet pipes draining to the edges of Back Cove (Figures 2.11 and 2.17). These pipes are part of a combined sewer system (CSS) in Portland that collects and conveys both sanitary sewage and stormwater to the wastewater treatment facility. During precipitation events, when the treatment capacity of the wastewater treatment plant is overwhelmed, untreated stormwater and raw human sewage overflow directly into the cove (Figure 2.16). CSO overflow contains “microbial pathogens, suspended solids, floatables, and other pollutants, and can lead to beach closures, shellfish bed closures, contamination of drinking water supplies, and other environmental and human

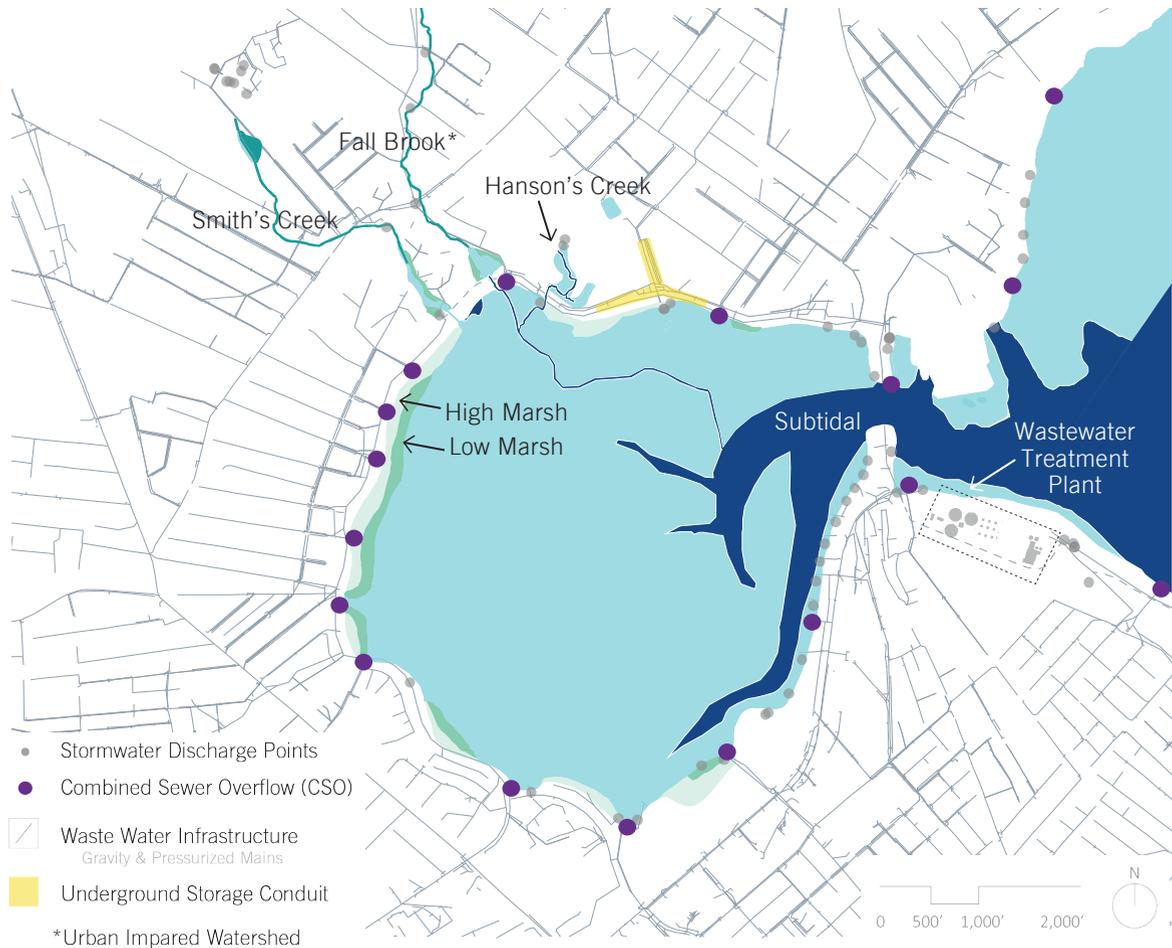


Figure 2.11: Map of Back Cove wetland types and waste water network (Wetland data from U. S. Fish and Wildlife Service, National Wetlands Inventory - Sewer and stormwater data from The City of Portland, Water Resources division)

	NAME	SYSTEM	SUBSYSTEM	WATER REGIME
	Subtidal	Estuarine	Subtidal	Subtidal
	Mudflats	Estuarine	Intertidal	Regularly flooded
	Low Marsh	Estuarine	Intertidal	Regularly flooded
	High Marsh	Estuarine	Intertidal	Irregularly flooded
	River	Riverine	Lower perennial	Permanently flooded

Figure 2.12: Table of Back Cove wetland types (Aggregated with data from U. S. Fish and Wildlife Service, National Wetlands Inventory)

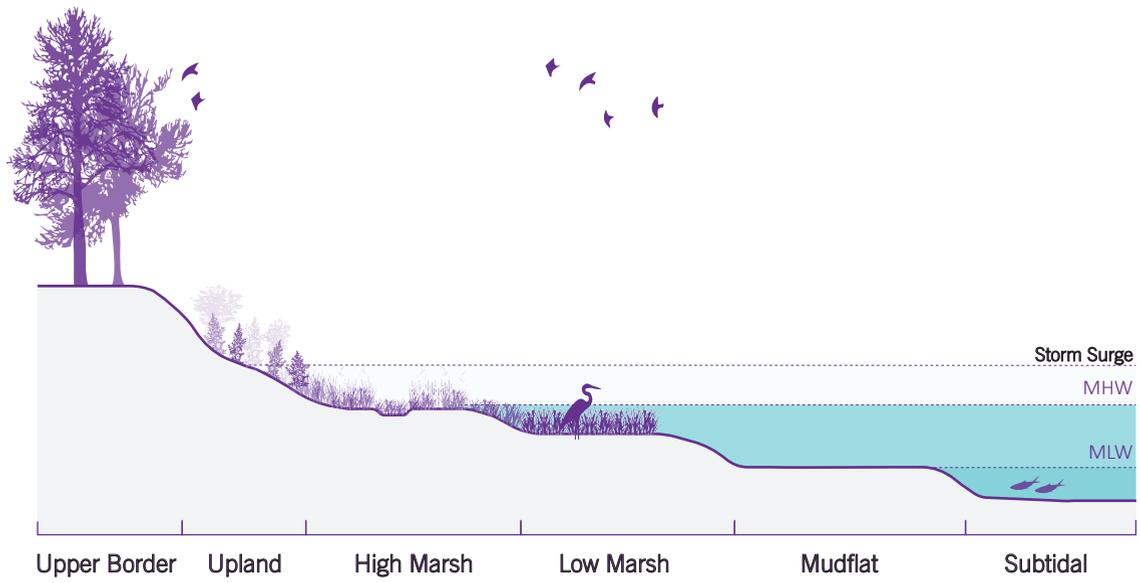


Figure 2.13: Cross section diagram of Back Cove before development. The healthy estuary cross section contains upland and upper border zones which help buffer storm surge and provide habitat for species of all sizes.

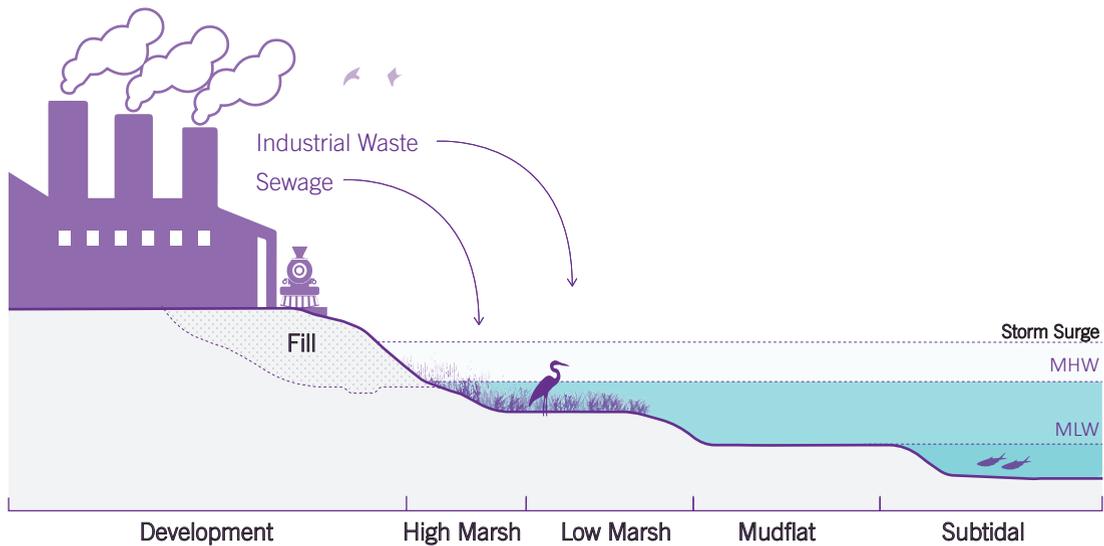


Figure 2.14: Cross section diagram of Back Cove after industrial development, which began in the 1840s. Fill added to expand available land for factories and railroads has eliminated the upland and upper border estuary zones and reduced the high and low marsh. Industrial waste and raw sewage are disposed of directly into the cove.

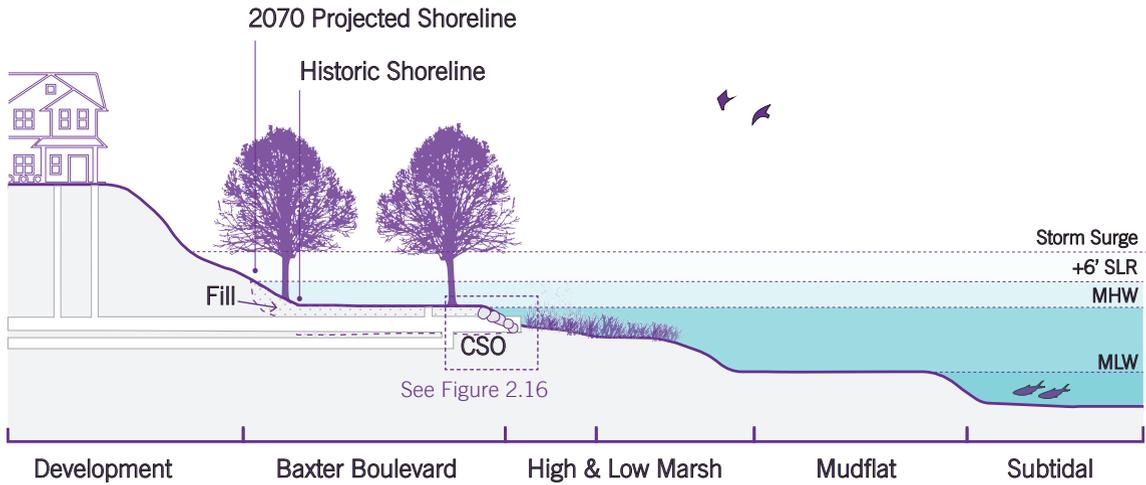


Figure 2.15: Cross section diagram of Back Cove’s northern and western shore bordering Baxter Boulevard. Today, the roadway and residential development have eliminated the upland and upper border estuary zones and reduced the high and low marsh. A combined sewer system directs untreated stormwater and sewage into the estuary.

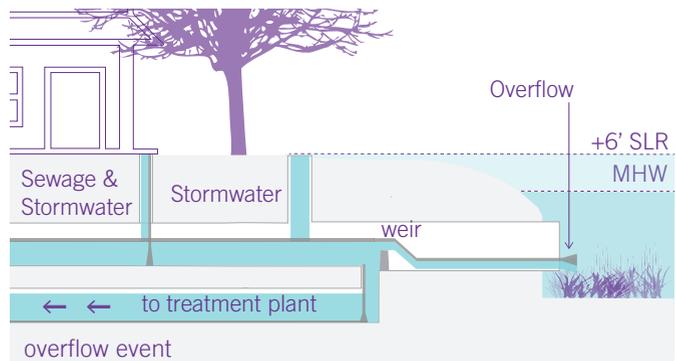
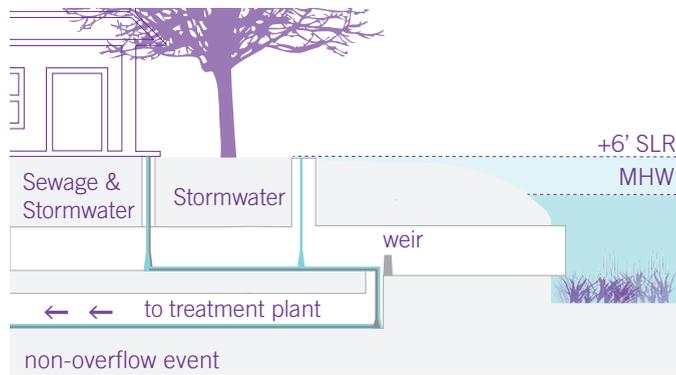


Figure 2.16: Diagram of a combined sewer system (CSO) during a non-overflow precipitation event (top), and a more extreme event which would lead to overflow (bottom).

health impacts” (Mittman et al. 2014, 5).

As of 2012, Portland’s sewer system had approximately 120 miles of underground combined sewer and stormwater pipes (Koenig 2012). The majority of those are gravity fed—meaning they flow towards the lowest point topographically on their way to the waste water treatment plant near the opening of Back Cove. The topographic location of Back Cove not only makes it the most convenient location for combined sewer overflow, but it also means it acts as a catch basin for stormwater from half of Portland’s peninsula, surrounding neighborhoods, and bordering roads and highway. Impermeable surfaces, like those that comprise much of the Bayside neighborhood, worsen the problem as the inability of the stormwater to permeate into the groundwater table means stormwater enters directly into the combined sewer system—overwhelming its capacity and leading to overflow. In July 2012, the Portland City Council approved a stormwater fee based on the amount of impervious surface on a property. These fees were implemented to help offset nearly \$170 million in sewer upgrades the city was mandated to make by the Environmental Protection Agency (Koenig 2012). In total, upgrades to reduce the amount of overflow into Portland’s waterways are estimated to cost \$250 million over forty years (Miller 2018). A portion of the money is going towards the actual separation of combined pipes that were installed almost 150 years ago, while other funding has gone towards the installation of underground storage conduits along the northern edge of Baxter Boulevard and Payson Park. While progress is slow, these efforts have helped reduced total overflow volumes by 80 percent, from an average of 1.8 billion gallons a year in the late 1980s, to 318.4 million gallons in 2016 (Miller 2018). Despite these significant decreases in untreated wastewater overflow as a result of multi-million dollar investments, 162 million gallons of untreated sewage and stormwater still entered Portland’s waterways in 2017 (MilNeil 2018).

During storms that coincide with high tides, the gravity-fed overflow pipes entering Back Cove are filled with tidal waters and gravity cannot work to bring the overflow downhill to outlet in the cove. This means untreated stormwater and sewage are backing up into the streets of Bayside (Figure 2.17, bottom left). The separation of Portland’s century-old sewer pipes is a huge financial undertaking. However, design interventions that reduce the volume of stormwater entering the combined system during storm events will vastly improve the amount of sewage and untreated stormwater entering Back Cove.

Figure 2.17, Opposite Page: Photographs of the estuarine environment and combined sewer outlets at Back Cove, August 2017.

Opposite, Top: A combined sewer outfall pipe emerges below the path into Back Cove (Bennett, 2012).

Opposite, Middle: A combined sewer outfall on the eastern edge of the cove near Back Cove Park at low tide (left) and Fall Brook at high tide (right).

Opposite, Bottom: A combined sewer storm drain backs up into Marignal Way during a March 2018 storm (*left, photo courtesy Lee Goldberg*). Green signs mark the CSOs along Back Cove’s edge, this one on the north western border during low tide (right).



Troy R. Bennett, Bangor Daily News, May 2012



Lee Goldberg, March 2018



Historic Integrity: The Designed Landscape

Site elements that were proposed by Olmsted, Olmsted & Eliot in 1896 and designed and carried out by Portland engineers and designers in the first half of the 20th century remain today in varying conditions. The encircling path is a complete 3.5-mile circuit and is part of the Portland Trails, a network of over 70 miles of trails in the greater Portland area. The concept of a complete circuit path around Back Cove is a valuable resource to the community and an important element of the original Olmsted proposal that should be maintained.

Few of the original Littleleaf linden trees (*Tilia cordata*) remain as part of the present day allée. Salt water spray, compact clay soil, wind exposure, construction impact, and salt from road de-icing have all taken a toll on the trees (Figure 2.19). Trees close to the original Boulevard entrances at Bates and Bedford Streets (Figure 2.18) and those on the land-side of the boulevard appear in much better condition as the salt and wind exposure is less and the soil quality is slightly better (Tarling, personal communication, 2018). Tarling estimates that five of the original trees have been lost in the past three years but a survey of which trees are original and which are replacement does not exist (2018). The Baxter Boulevard memorial grove is one of the few remaining World War I linden memorial groves (Tarling 2018). In an effort to maintain the same tree species, the city is replacing expired Littleleaf lindens with a native cultivar of the American Linden, *Tilia americana* ‘McKSentry’ (Tarling 2018). However, these replacement trees are also showing signs of stress and damage (Figure 2.19b). While the replacement of the trees fulfills the Olmsted, Olmsted & Eliot proposal for a “tree-lined parkway” and the use of a linden species serves as the intended memorial, the removal and replacement of the trees at staggered times over the years has decreased the intended aesthetic value of the allée. While the tree species has remained consistent, the tree size, age, and canopy height is inconsistent (Figure 2.19a).

A remnant of the brick and concrete bridges that were constructed in the 1920s remains today over Fall Brook (Figure 2.20). The interior section of the bridge is blocked by a guard rail and is inaccessible by pedestrians. Granite pavers that were installed in 1924 remain along some of the boulevard curbs, but are becoming overgrown with weeds and grass (Figure 2.19a). On an August 22, 2017 site visit, the lawn surrounding the 1925 memorial to James Baxter appeared to have been recently dug up during construction (Figure 2.21).

Other important features mentioned in historic proposals include providing access to the cove’s water and maintaining views from the roadway, path, and edges of Back Cove. At present, there is no direct access to water from Back Cove. Boat access in Back Cove could be difficult as the majority of the estuary is tidal mudflats and the subtidal channel has strong currents. Access by boat would need to be timed with the tides, but access to the marshes and mudflats on foot via boardwalks or docks is possible.

Views of the Portland skyline to the southeast and the hills and residential neighborhoods in the northwest have been maintained over the years (Figure 2.22). The view of the city was altered with the extensive filling and grading during construction of Interstate 295, but the downtown skyline is still able to dominate from its position on the ridge. The fifty-foot spacing of the Linden allée has allowed views to be maintained for motorists. While the original cross section and plan drawings from Olmsted, Olmsted & Eliot showed a tree-planting between the path and cove edge, this was never completed. This has allowed for uninterrupted views from the path, but does not provide the experience of an allée for users of the path.

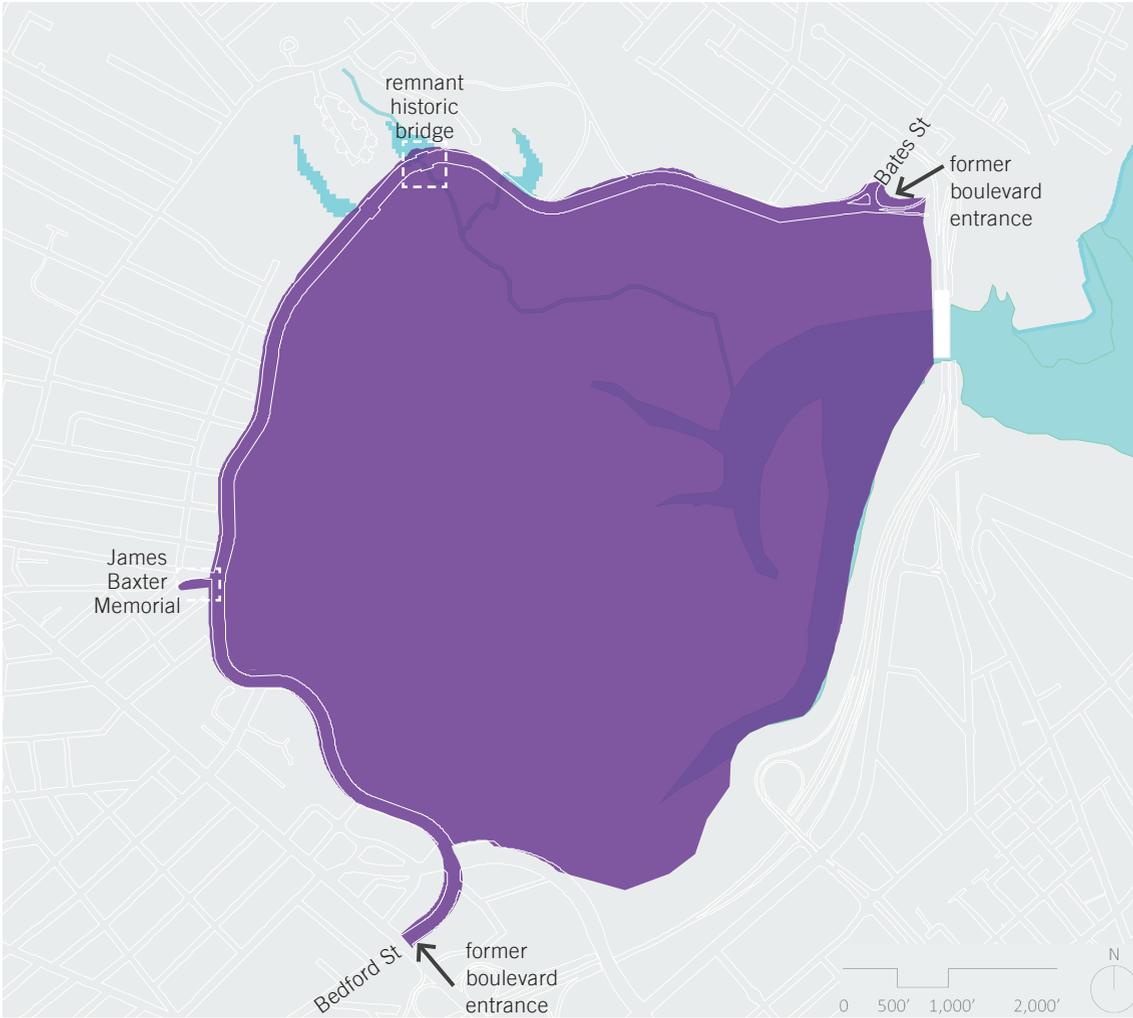


Figure 2.18: Map of Designed Historic Features at Back Cove (data from Portland Maine GIS office)

- Portion of Back Cove listed on:
 - National Register of Historic Places
 - City of Portland Historic Landscapes



Figure 2.19: Photographs of the linden allée around Baxter Boulevard, August 2017.

- a) Top: The removal and replacement of lindens over the years has led to varying sizes and heights of trees, lessening the aesthetic value of the allée.
- b) Bottom Left: Lindens that have been recently replaced are showing signs of decline.
- c, d) Bottom Middle & Right: Lindens closest to the cove are the most vulnerable to decline from salt spray and wind.



Figure 2.20: A remnant of the brick and concrete historic bridges constructed in the 1920s, August 2017.



Figure 2.21: The Baxter Memorial, opened in 1924, pays homage to the former mayor and steward of Portland parks. At present, the memorial's landscape is in a state of disrepair, August 2017.



Figure 2.22: A winter view of downtown Portland from the western edge of Back Cove, January 2018.

Back Cove's Future: Sea Level Rise

The burning of coal and natural gas in the twentieth-century has led to an overall increase in global temperature. Some of the many effects of this phenomenon, known as climate change, are the warming of ocean waters and the increasing frequency and intensity of precipitation. Warming oceans cause the expansion of water and the melting of glaciers which results in greater ocean water volume and levels, also known as sea level rise (Bornstein 2018). Natural environments, like Back Cove, are capable of recovering from gradual changes, but human activity has increased the rate at which global temperatures have risen and altered landform processes to the point that the environment has difficulty reacting to sudden, dramatic changes. More frequent and intense precipitation leads to flooding, coastal erosion, and changes in ocean salinity. Portland's Bayside neighborhood, an industrial area which is located on the southeastern border of Back Cove, has already experienced significant flooding in August 2014, September 2015, and more recently in January and March 2018, when extreme high tides combined with significant precipitation (Figure 2.24). While many effects of climate change will have an impact on the historic and ecological integrity of Back Cove, sea level poses the most immediate and extreme risk.

On a global scale, sea levels have risen an average of three inches in the past quarter century and are predicted to rise at least two feet by the end of the century (Bornstein 2018). As shown in Figure 2.23, sea level in Portland, Maine has risen 7.5 inches from 1912 to 2011, and this rate of increase is doubling every two decades (Miller 2015). This project used sea level rise projection data from NOAA to visualize the projected impact on Back Cove¹ (Figures 2.25 and 2.26). NOAA's projections are measured in feet above current Mean Higher High Water (MHHW) conditions. Scenarios can be viewed by decade (from 2020-2100), feet above MHHW (1-10), and level of risk (intermediate low, intermediate, intermediate high, high, and extreme). Because the data does not account for erosion, subsidence, storm surge, or any future changes in an area's hydrodynamics, the most extreme risk scenario was used in this project. This scenario projects sea levels to reach +10.79' by 2100, but current visual data is limited to a maximum of 6.' Because of this limitation, the year 2070—when SLR is projected to reach +6' MHHW in Portland—was chosen as the target year for design interventions (Figure 2.23).

Climate change will have a great effect on the CSOs that outlet into Back Cove. Frequency and severity of overflow events is directly tied to precipitation quantity and intensity. Increased weather events will mean greater CSO discharge and higher sea levels mean that CSO pipe outlets will be filled with water leading to back up and overflow of untreated waste water into the surrounding streets.

¹ "These data depict the potential inundation of coastal areas resulting from a projected 1 to 6 feet rise in sea level above current Mean Higher High Water (MHHW) conditions. The process used to produce the data can be described as a modified bathtub approach that attempts to account for both local/regional tidal variability as well as hydrological connectivity. The process uses two source datasets to derive the final inundation rasters and polygons and accompanying low-lying polygons for each iteration of sea level rise: the Digital Elevation Model (DEM) of the area and a tidal surface model that represents spatial tidal variability. The tidal model is created using the NOAA National Geodetic Survey's VDATUM datum transformation software (<http://vdatum.noaa.gov>) in conjunction with spatial interpolation/extrapolation methods and represents the MHHW tidal datum in orthometric values (North American Vertical Datum of 1988)" (NOAA, 2012).



Figure 2.23: Graph of sea level rise, observed and projected, for Portland, Maine. Because of the uncertainty associated with SLR projections, this project used the most extreme projection scenario (Data from NOAA <https://tidesandcurrents.noaa.gov/sltrends>; station ID # 8418450)



Figure 2.24: High tide flooding at Back Cove Park (left) during a nor'easter on March 3, 2018. At right, flash floods brought over six inches of rain to greater Portland on August 13, 2014, causing flooding at the intersection of Preble Street and Marginal Way (Left photo, courtesy of Jonathan Zak, Right photo, by Yoon S. Byun for Portland Press Herald).



Figure 2.25: Map of sea level rise projections at Back Cove (Data Source: NOAA, <http://www.csc.noaa.gov/slr>)



-  2018 Shoreline
-  2020 +1' SLR
-  2045 +2-3' SLR
-  2070 +4-6' SLR
-  FEMA 100-year Floodplain



Figure 2.26: Map of low level areas that are projected to flood from ground water with sea level rise (Data Source: NOAA, <http://www.csc.noaa.gov/slr>)

EMERGING THEMES: A SUMMARY OF CONTEXT AND SITE INVENTORY

Ecological Integrity

Back Cove provides important habitat for a variety of species that depend on the environment to maintain its integrity. The hydrologic and sedimentary processes of the marshes, streams, rivers, and tides should be encouraged to function as closely as possible to their pre-development state. Restoration efforts that would improve natural processes at Back Cove would provide additional habitat and resources for biota living in this urban estuary. The alteration of Back Cove's marshes and wetlands have made it more vulnerable to risk from climate change, as these estuarine landscapes provide a natural buffer to sea level rise and increased storm surge.

Back Cove's topography and location in the heart of the city means it serves as a catch basin for a large area of Portland's impervious surface. During large storm events, particularly when they coincide with high or astronomical tides, the waste water treatment plant's capacity is overwhelmed and raw sewage and storm water overflow into Back Cove. Despite the recent installation of underground storage conduits and sewer separation efforts, millions of gallons of untreated sewage and stormwater still empty into Back Cove, creating the biggest threat to the ecological integrity of Back Cove.

Historic Integrity

Site elements from the Olmsted firms' design proposals have historic integrity (as deemed by their NRHP designation) and deserve to be maintained where possible. These include the allée, encircling path, Baxter Boulevard, and views of the cove. The Olmsted proposals also emphasized access to water for recreation purposes, which still does not exist today, and the cleaning of sewage from the mudflats, which is still an issue. Back Cove's encircling road and path were important elements in the Olmsted designs and still serve an important function today. Circulation should be maintained where possible.

Sea Level Rise

Sea level rise projections for the next fifty years will dramatically alter Back Cove's shoreline. Baxter Boulevard will become inundated with sea water in several areas, adversely impacting the allée, encircling path, and roadway. The combined sewer pipes that outlet into Back Cove will be covered with water, which will make it difficult (if not impossible) for gravity to bring stormwater and sewage to the treatment plant, even during small storm events. If changes addressing sea level rise are not implemented, the historic and natural integrity of Back Cove will be compromised.

These themes became values that will be addressed in the design portion of the research project, presented in the following chapter.

Rip-rap stabilizes the shore and marsh near Back Cove Park, looking north, August 2017.







A portion of the 3.5-mile path that encircles Back Cove, September 2017.

3 DESIGN PROPOSAL

Projected sea level rise will significantly alter Back Cove’s shoreline, effecting the historic and ecological integrity. The linden allée will die away as it is submerged in salt water, the boulevard and path will be impassable in areas, and combined wastewater pipes will regularly back up into the streets as their openings are filled with water. This is the future of Back Cove if changes are not made.

We return to the research question;

How can Back Cove be designed to prepare for extreme projections of sea level rise, while prioritizing historic and ecological integrity?

GOALS AND OBJECTIVES

Thus far, the research-through-designing process has focused on establishing the context of Back Cove. The themes that emerged as values from this— historic and ecological integrity, and sea level rise—led to a set of goals that guided the designing of the physical space. They are as follows:

Prepare Back Cove for sea level rise: using a hybrid design strategy that employs design interventions that armor, retreat, rise-up, and regenerate. The use of specific interventions is site-specific to the conditions and projected inundation of the area being addressed.

Maintain and improve the ecological integrity of Back Cove’s estuarine environment: the use of regenerative interventions that encourage and sustain natural processes provides “ecosystem services to absorb, filter, and diffuse severe storm and rising sea level impacts” (Watson and Adams 2011, 200). Dynamic estuarine processes—such as the tidal and sedimentation cycle—are encouraged and preserved. Any removal, alteration, or degradation of streams, wetlands, and marshes must end immediately.

Retain and fulfill historic aspects of the site that were emphasized in the Olmsted firm’s design proposals: Site elements that were part of the Olmsted firm’s proposals will be reimagined to accommodate sea level rise and, when possible, provide ecosystem services. Additionally, an important element from the proposal that is missing from the site—access to water—is proposed.

With these three goals in mind, I began to wonder if it were possible that some design interventions could fulfill more than one of these goals. For example, a bermed walking path could serve as protection from rising

water for traffic lanes around the boulevard, while also stabilizing Back Cove’s shore, and maintaining the circular path originally envisioned by the Olmsted firms. I began to view sea level rise adaptation design interventions as an opportunity to improve the overall site rather than a risk reduction exercise to keep things exactly how they are today.

SPATIAL AND TEMPORAL SCALES

In addition to the values and goals that guided the design, the variable of time emerged as an important factor during designing. Sea level rise has and will not occur overnight at Back Cove, but over the course of decades. The designing process used NOAA’s most extreme projections for Back Cove that show levels gaining six feet by 2070 (Figure 3.2). That means there are 50 years to prepare for a drastically different Back Cove. This inspired the need for a cove-scale master plan (Figures 3.4) with the year 2070 and six feet of sea level inundation as a guide. The “site” for this plan includes the full extent of six foot inundation and includes design interventions at a master plan scale for Baxter Boulevard, the fringe streams and marshes, and the Bayside neighborhood (Figures 3.4-3.9).

In *Design for Flooding*, the need to design for sea level rise across several scales is encouraged (Watson and Adams 2011). Therefore, two focal areas that illustrate land-use typologies and the challenges on site have been given phased designs in 25-year increments (Figure 3.2, 3.3) that coincide with inundation levels from NOAA’s most extreme projections for SLR: 2020 (+1’ SLR), 2045 (+2-3’ SLR), and 2070 (+4-6’ SLR). These two focal areas are the Bayside neighborhood (that includes Back Cove Park and Interstate 295) and Baxter Boulevard (which includes the road, path, and estuary). The design of Baxter Boulevard has been even further broken into interventions for the marsh and roadway over the three time periods because it effectively illustrates the key values of historic and ecological integrity.

STRATEGIES

As a review, the design uses four strategies (first outlined in Chapter 1) to address SLR; Armor, Retreat, Rise-Up, and Regenerate. When implemented, strategy icons are located next to design intervention graphics:



Figure 3.1: Sea Level Rise Design Strategies, Icons

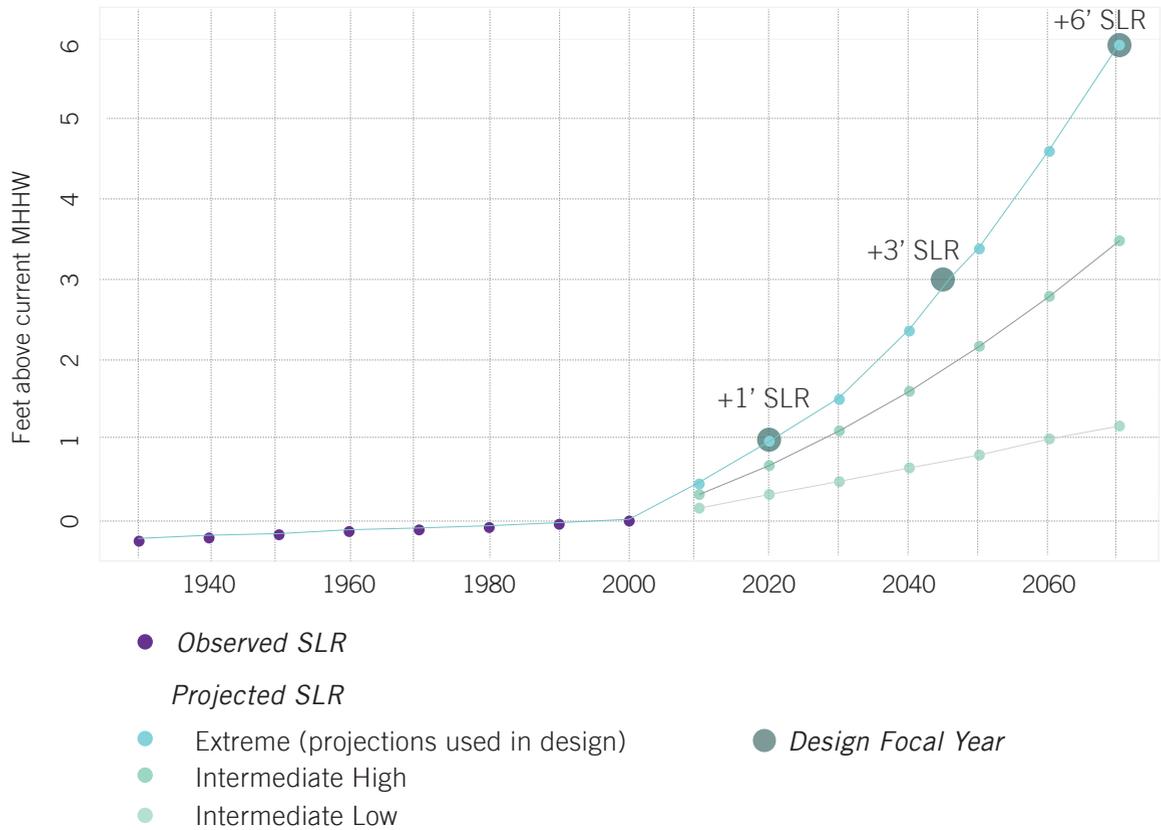


Figure 3.2: Graph highlighting design focal years that coincide with NOAA's most extreme SLR projections

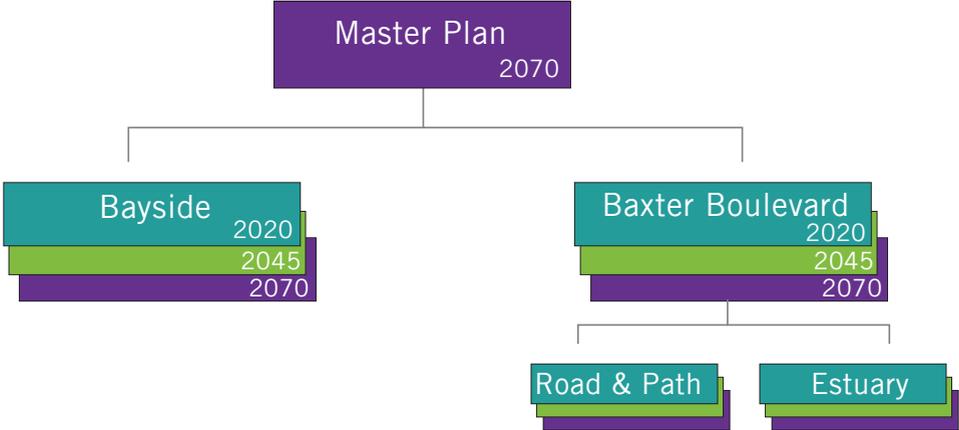
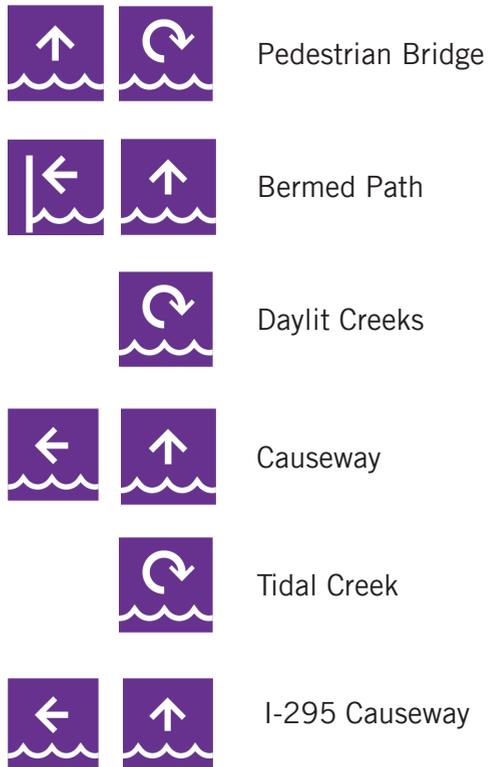


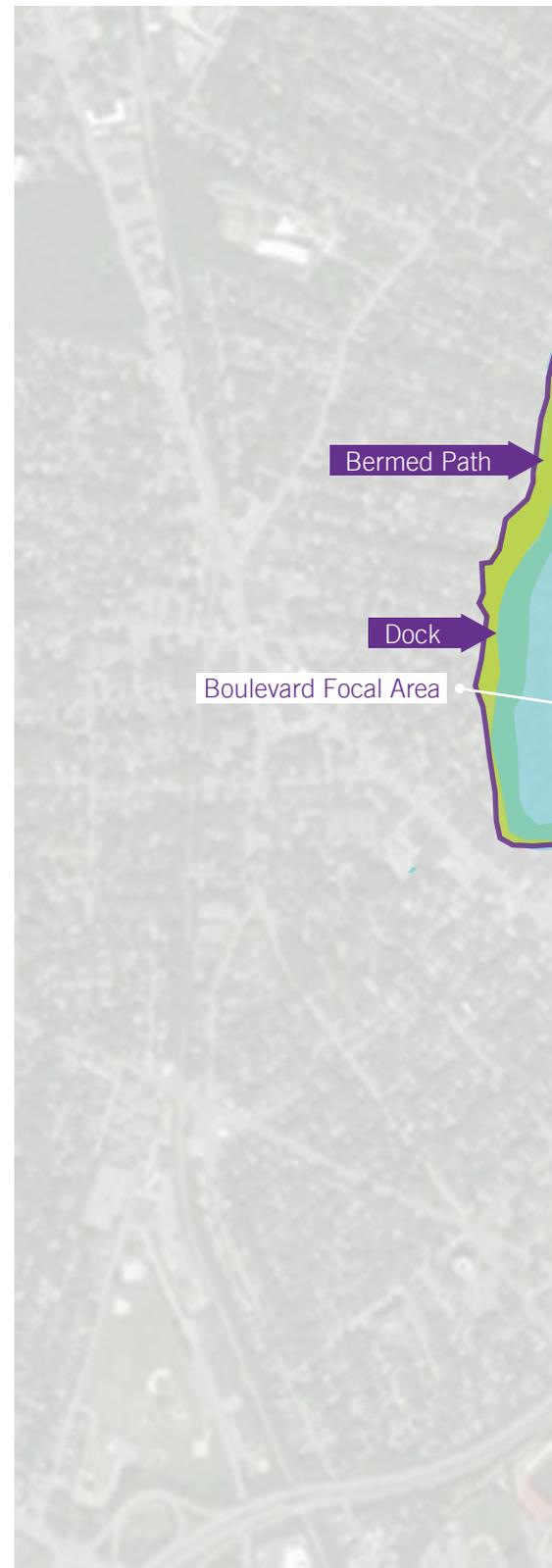
Figure 3.3: Diagram of design proposal breakdown across spatial and temporal scales

COVE-SCALE MASTER PLAN



Shown at right, the “cove-scale” master plan was designed with + 6’ sea level rise and the year 2070 as a guide. The following pages detail current conditions and proposed interventions that align with the values of historic and ecological integrity—circulation, the estuary, the shoreline, and the allée.

Figure 3.4: Cove-Scale Master Plan





CIRCULATION

2018

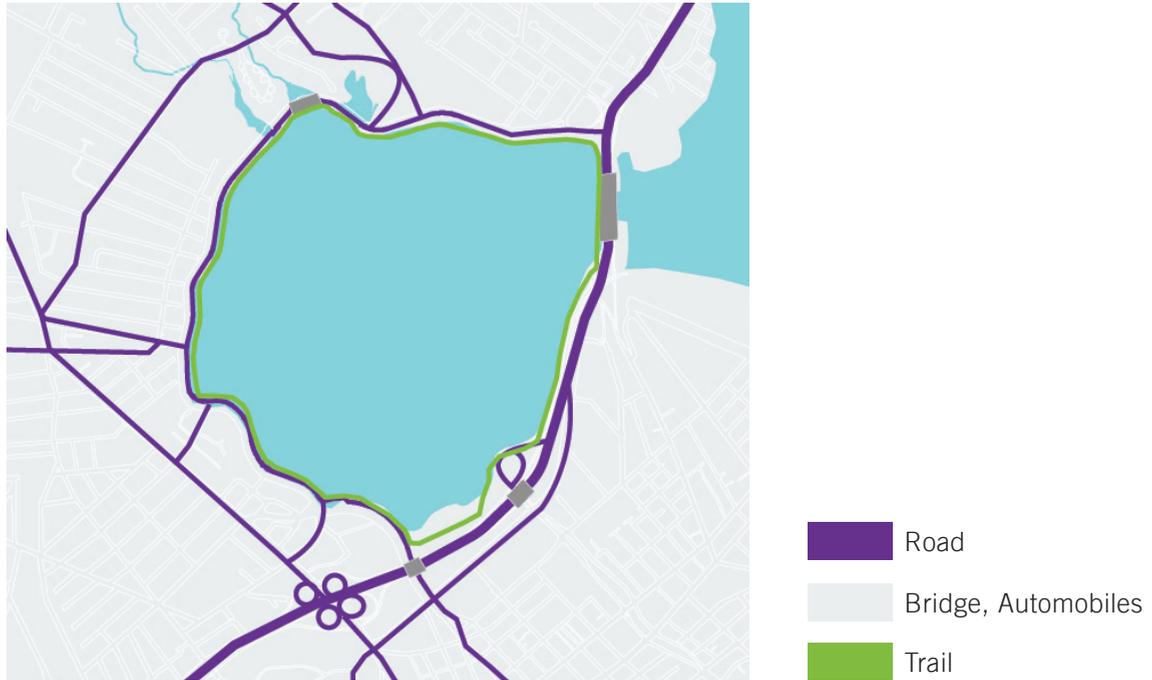


Figure 3.5a: Circulation, Existing

Today, Back Cove's edges are defined by encroaching roadways that prohibit the landward migration of marshes and restrict available land for open space. By 2070, ocean water is projected to inundate at least the interior lane of Baxter Boulevard and totally flood Back Cove Park.

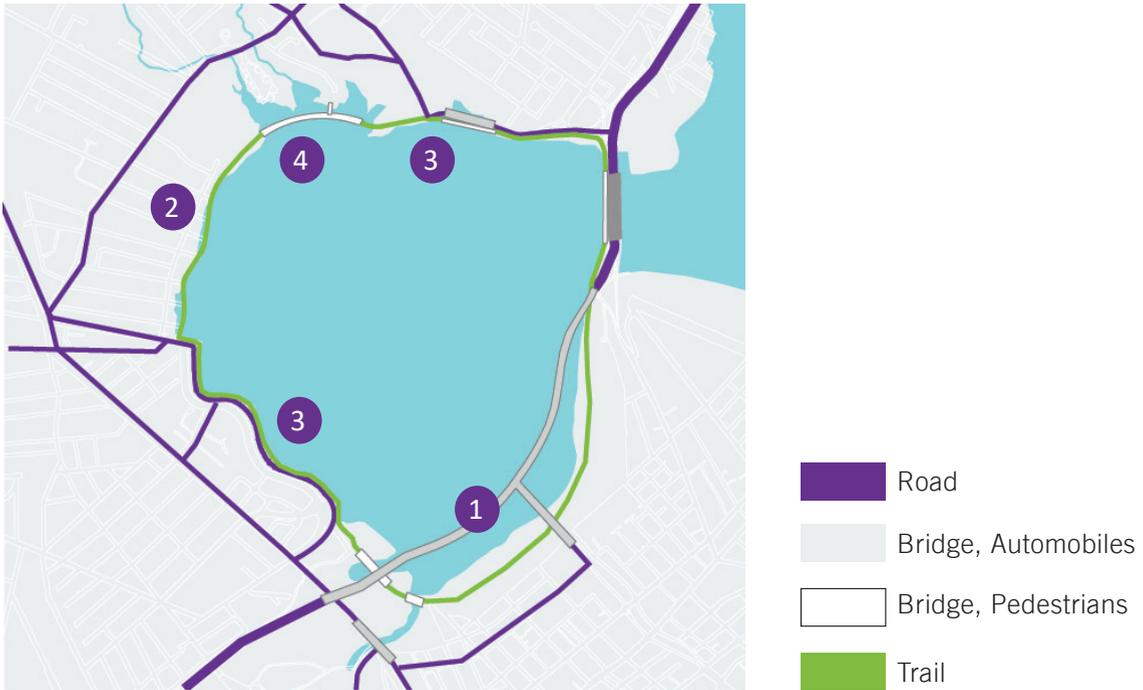


Figure 3.5b: Circulation, Proposed



1 A one mile stretch of Interstate 295 is elevated onto a causeway opening up 60 acres of land for salt marsh migration and public open space on the southeast border of Back Cove.



3 The gravel trail has been converted into a bermed path around the north, west, and southwest edges of the cove. Pedestrian bridges, boardwalks, and berms have been used in other areas to maintain the Olmsted’s vision of a circular route around the cove.



2 Vehicular traffic is restricted from the northwest portion of Baxter Boulevard that is the most inundated.



4 Pedestrian bridges over Fall Brook, Smith’s and Hanson’s Creeks allow the removal of culverts and the day lighting of the creeks.

THE ESTUARY

2018

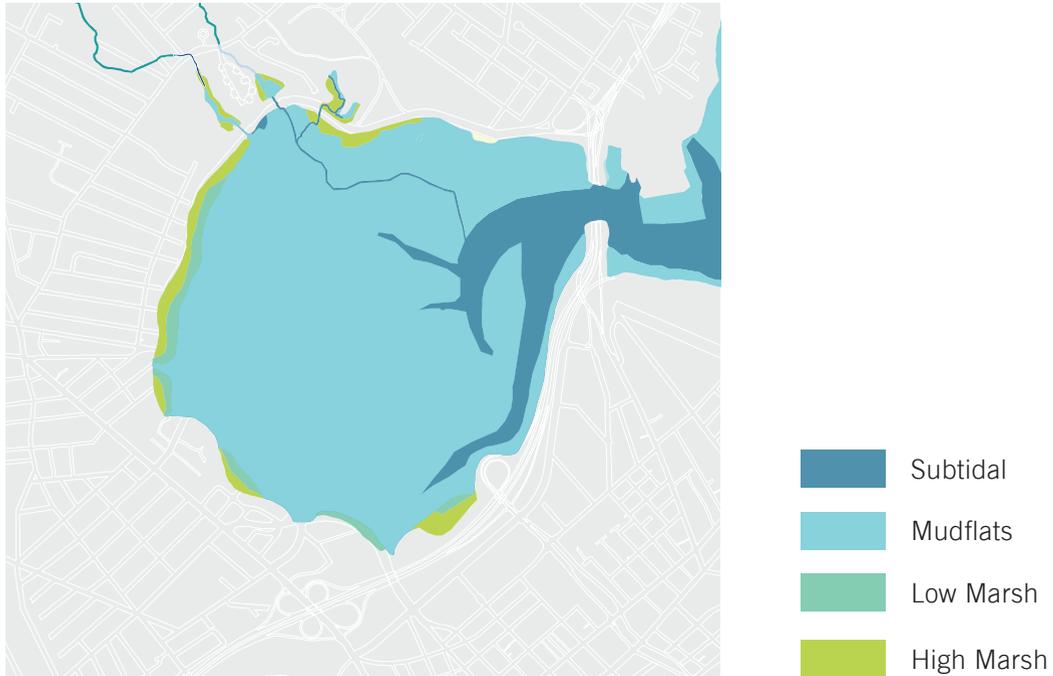


Figure 3.6a: Estuary, Existing

Back Cove's estuary has been reduced and restricted from centuries of alterations to the landscape.



Figure 3.6b: Estuary, Proposed



Sediment and marsh grasses are added around existing salt marshes to encourage their expansion. The expanded estuary increases the elevation of the cove's edge, creating a living buffer that holds back rising sea levels and protects against storm surge.

- 1 In the southeast corner of the cove, salt marshes are constructed where infrastructure has risen up or retreated. Upper border and upland estuary zones (Figure 2.13) are reintroduced as part of a 60-acre park in the southeast corner—creating habitat and recreational opportunities.

OPEN SPACE

2018

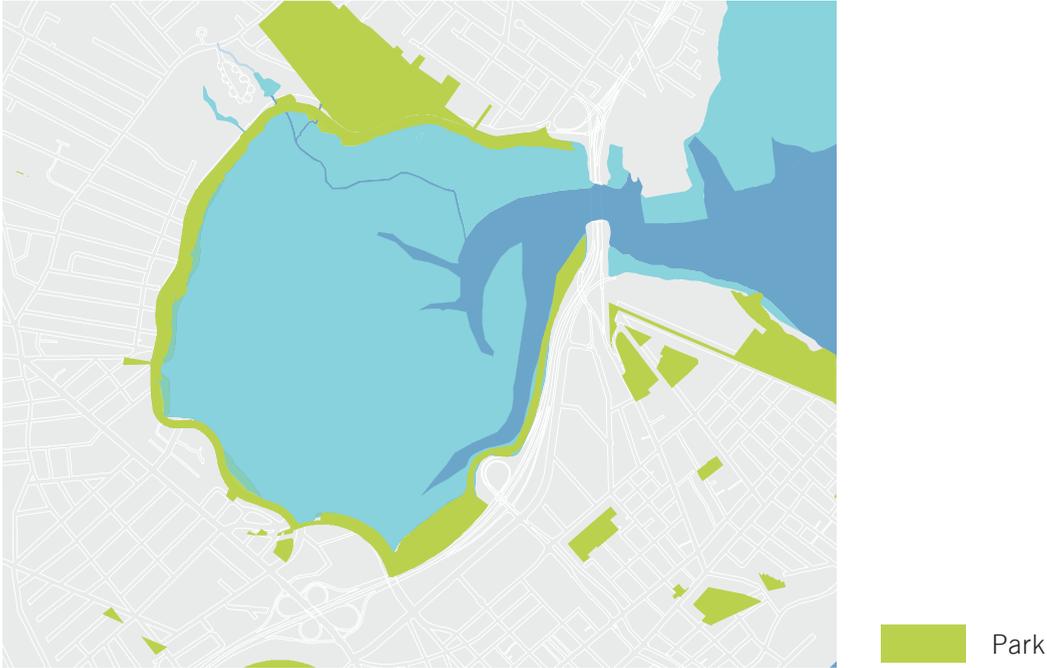


Figure 3.7a: Existing, Open Space

Back Cove’s estuary has been reduced and restricted from over a century of alterations to the landscape.

2070

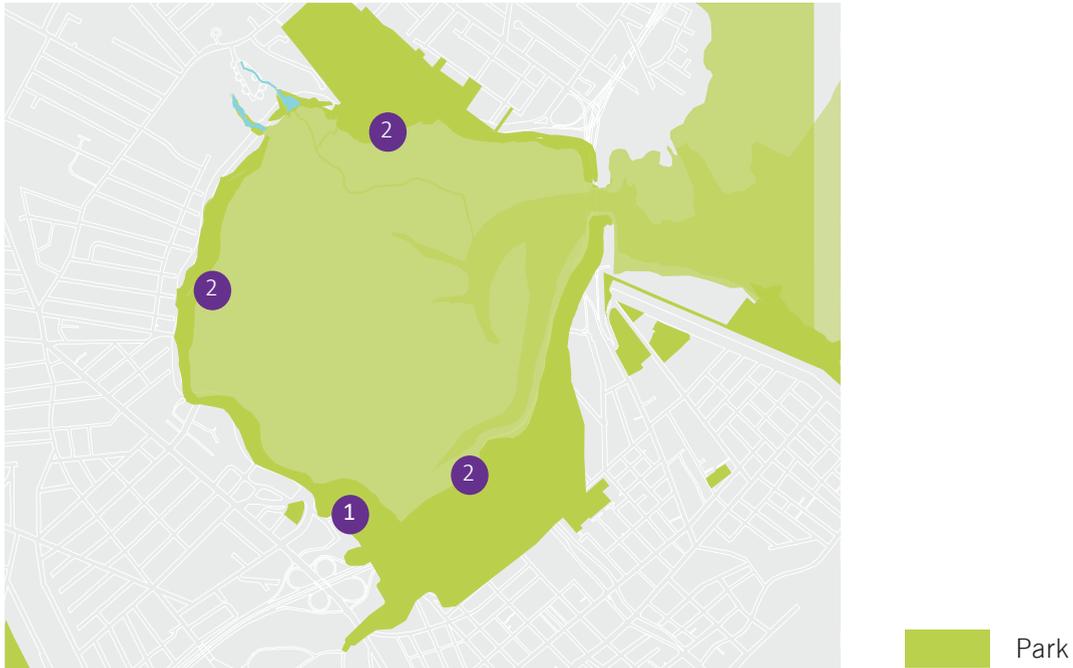


Figure 3.7b: Proposed, Open Space



The open space serves multiple functions as a recreational asset, habitat, and a critical buffer of land handling rising sea levels and storm surge. Public water access opens up the entirety of the cove to use.

- 1 A marsh discovery center on the former lot of a grocery store provides opportunities for educational outreach and programming at Portland's new salt marsh.

- 2 Water access is now provided from three docks around the cove. This fulfills more than a century of proposals that were never completed, beginning with the Olmsteds in 1896. Access to the nearly 500-acres of the cove makes Back Cove Portland's largest park.

SHORELINE

Pre-Development

1918

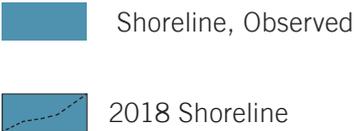
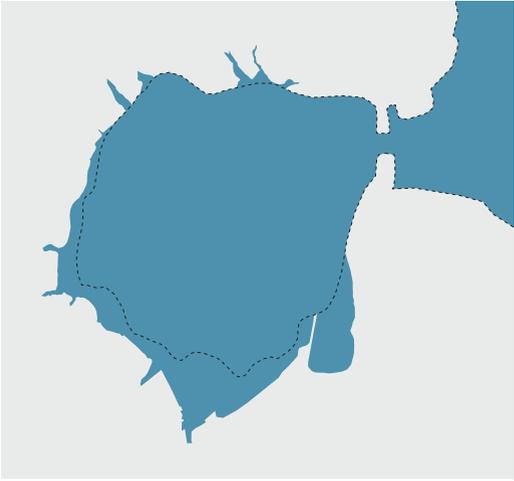
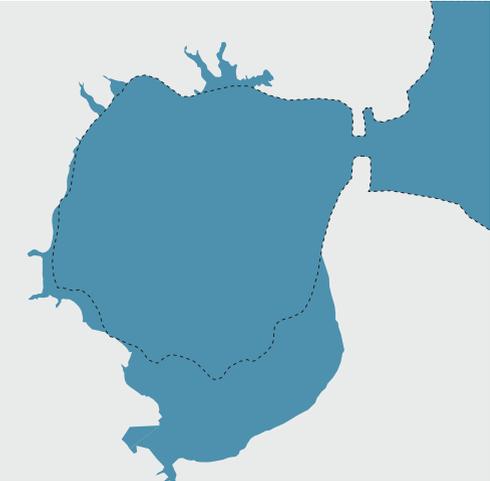
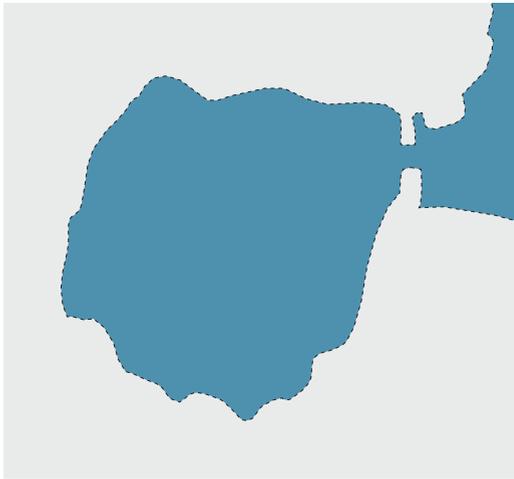
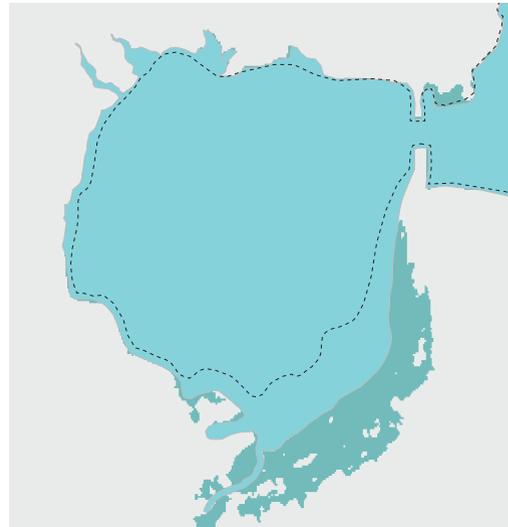


Figure 3.8: Shoreline Change Past, Present, and Future

2018



2070



-  2018 Shoreline
-  2070 Projected Shoreline
-  2070 Proposed Shoreline



The proposed shoreline for Back Cove is the result of a combination of large and small scale design interventions proposed over the next fifty years. The decision was made to not allow sea level rise to completely claim its projected territory because of buildings in the Bayside neighborhood with historic character and certain environmental conditions, such as brownfields. In order to achieve the proposed shoreline, this design utilizes all four of the sea level rise design strategies across multiple spatial and temporal scales.

THE ALLÉE

2018



Figure 3.9a: Allée, Current Planting



1 Littleleaf Linden (*Tilia cordata*)

Hundreds of Littleleaf lindens line historic Baxter Boulevard. Over the past century, salt water spray, clay soil, road salt, and construction have severely damaged the trees. Tree replacement over the years has weakened the aesthetic of the allée. Furthermore, the replacement trees are also in poor condition.

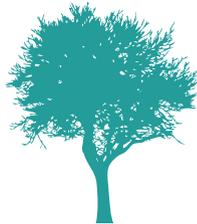
Planting Strategy

In order to maintain the look and feel of an allée around the historic boulevard perimeter, hardy, salt-tolerant species will replace the majority of the lindens (Figure 3.9b). The 1996 *Improvement Plan* mentions, “the introduction of new species should be done only if it can be achieved in ways that do not jeopardize the current allée experience of the Boulevard” (Richardson et al. 1996, 44), but this proposal looks beyond the current experience and plans for a future in which Back Cove must become more resilient.

The use of properly adapted, native species will not only mean healthier, longer living trees with consistent form, height, and canopy, but it will also help stabilize the cove’s edge and provide habitat. The *Improvement Plan* suggested planting new species in a pattern that relates to logical sections of the roadway (such as a curve) to maintain the “formality and character” of the boulevard. I have proposed the introduction of three new tree species to replace the deteriorating linden allée. The change of species at strategic moments maintains the allée aesthetic first envisioned by Olmsted, Olmsted & Eliot. A variety of species also fulfills an early vision of Mayor Baxter of the boulevard as an arboretum.



Figure 3.9b: Allée, Proposed Planting



- 1** American Linden (*Tilia americana* 'McKSentry')

The oldest lindens at the original entrances to the boulevard are not vulnerable to SLR and should remain. Their care and maintenance should be a priority. When not possible, the trees should be assessed and replaced as a unit with the American Linden.



- 3** Eastern White Pine (*Pinus strobus*)

Maine's state tree matures into a sculptural form along salt marshes throughout Maine. An evergreen, it also provides winter interest.



- 2** Northern Red Oak (*Quercus rubra*)

A hardy, native species found growing along salt marshes throughout the northeast. The mature canopy is full and round.

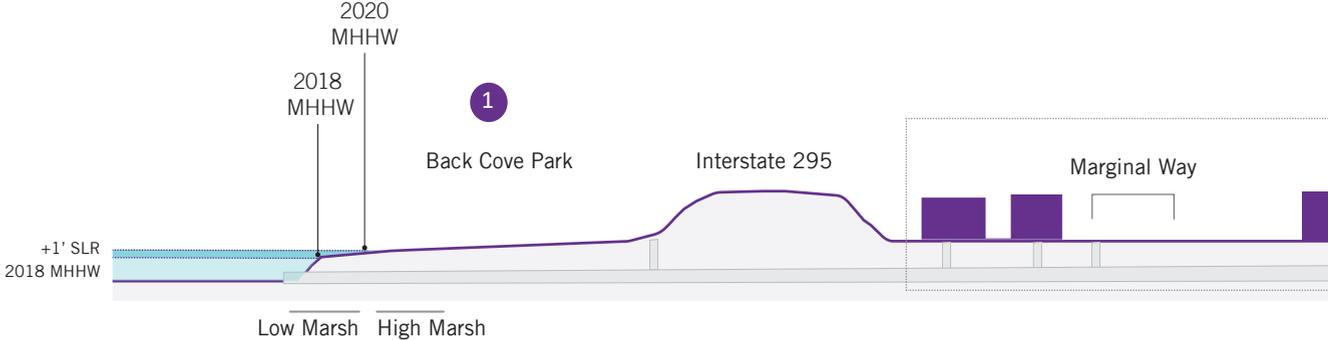


- 4** Red Maple (*Acer rubrum*)

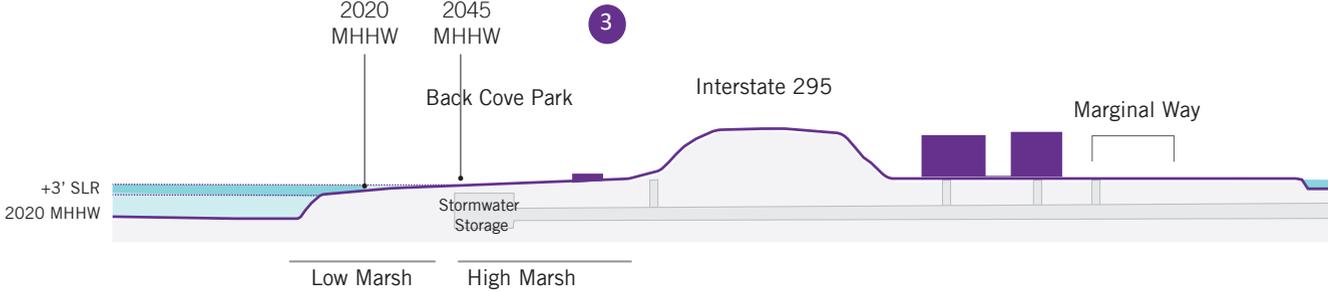
Providing brilliant fall color and a stately canopy, the planting of maples is proposed for a portion of the boulevard that serves vehicles and pedestrians.

FOCAL AREA: BAYSIDE, INTERSTATE 295 & BACK COVE PARK

2020: +1' SLR



2045: +2-3' SLR



2070: +4-6' SLR

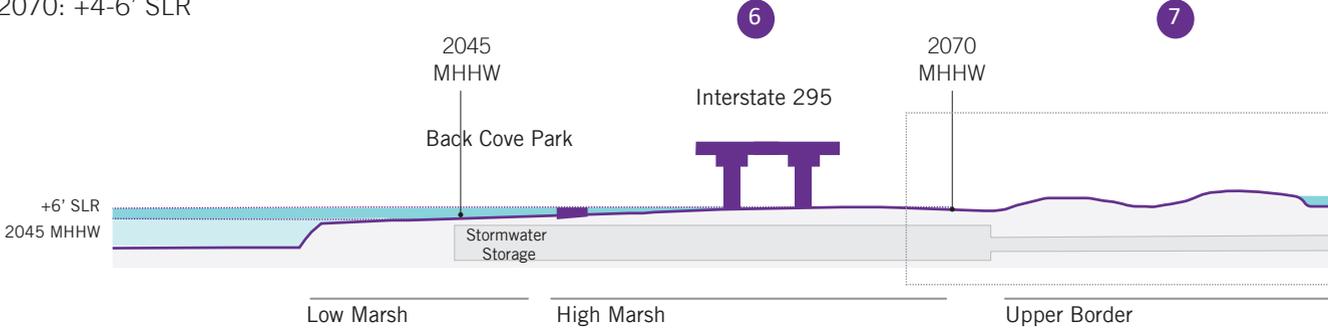
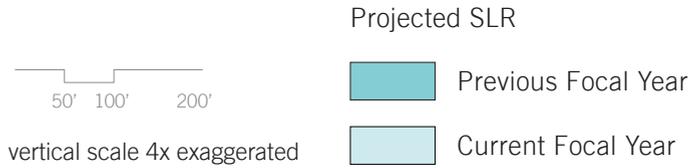
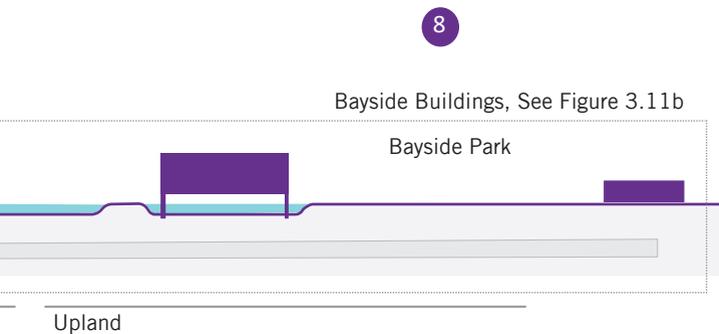
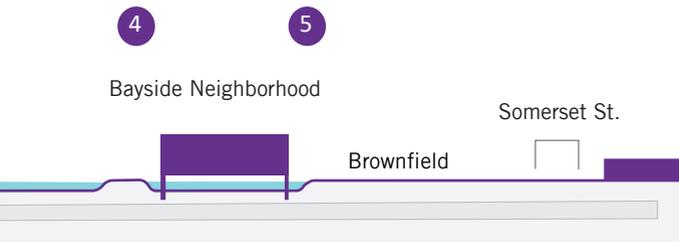
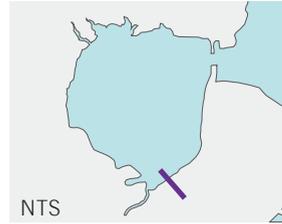


Figure 3.10: Bayside, Interstate 295, and Back Cove Park, Focal Cross Section by year



Section Location



- 1 Former soccer fields at Back Cove Park have been abandoned and allowed to transition into salt marsh.

- 2 A brownfield from historic industrial land use is remediated with plants that remove metals from the soil.



- 3 Now that Back Cove park is inundated more frequently, a boardwalk has replaced gravel paths.

- 4 Low-lying areas that are flooding from rising ground water have been converted into stormwater retention basins.



- 5 Buildings vulnerable to SLR have been adapted for more frequent flooding.



- 6 A one-mile portion of Interstate 295 has risen from a berm to a causeway to allow salt marshes to migrate landward and open up physical and visual connections between Bayside and Back Cove.



- 7 Berms have been constructed in the new Bayside Park to protect from flooding and to add topographic interest.



- 8 A former brownfield, now remediated, is converted into additional open space.

BUILDINGS

2018

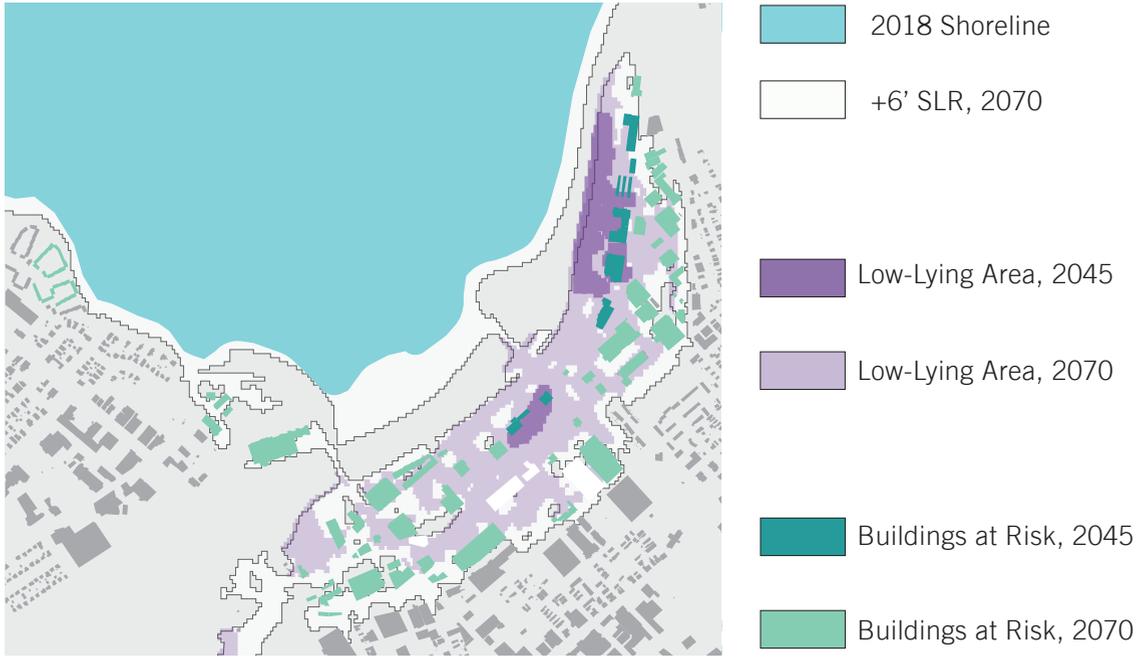


Figure 3.11a: Existing, Buildings



Buildings in low-lying areas of Bayside neighborhood will see the effects of SLR as soon as 2045.

2070

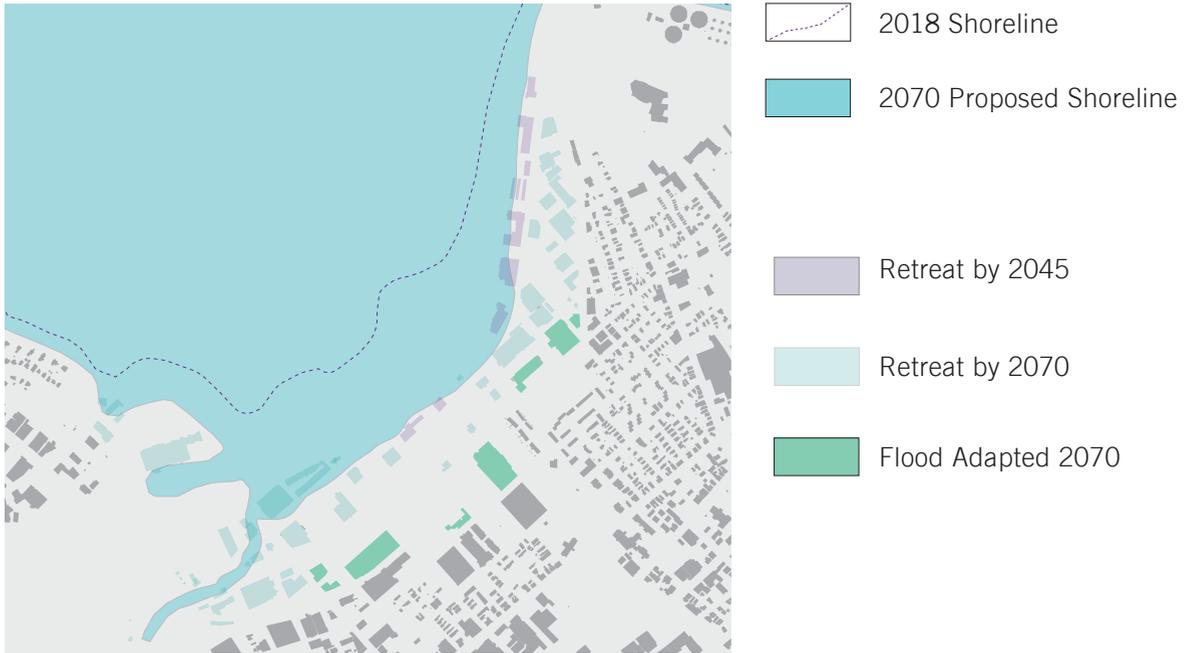


Figure 3.11b: Proposed, Buildings

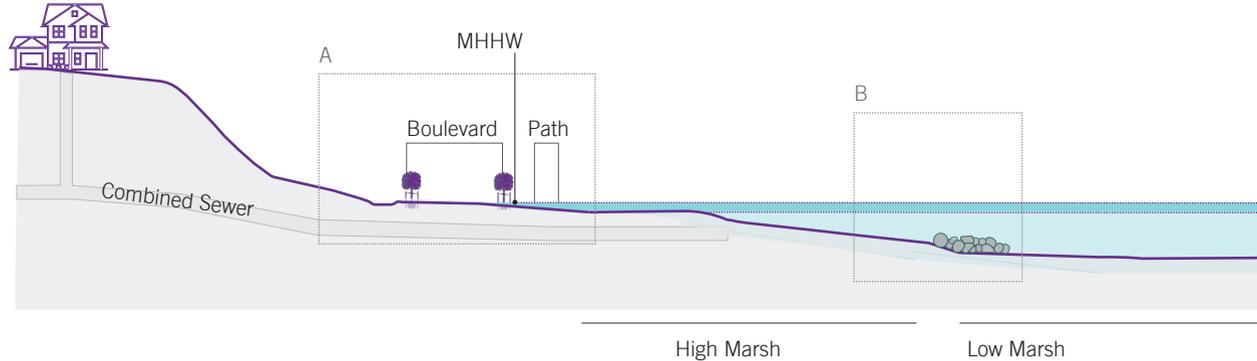


Several options were explored to try and avoid the removal of any buildings. However, the most vulnerable buildings will be difficult to save. This plan proposes the phased retreat (demolition) or adaptation of all vulnerable buildings.

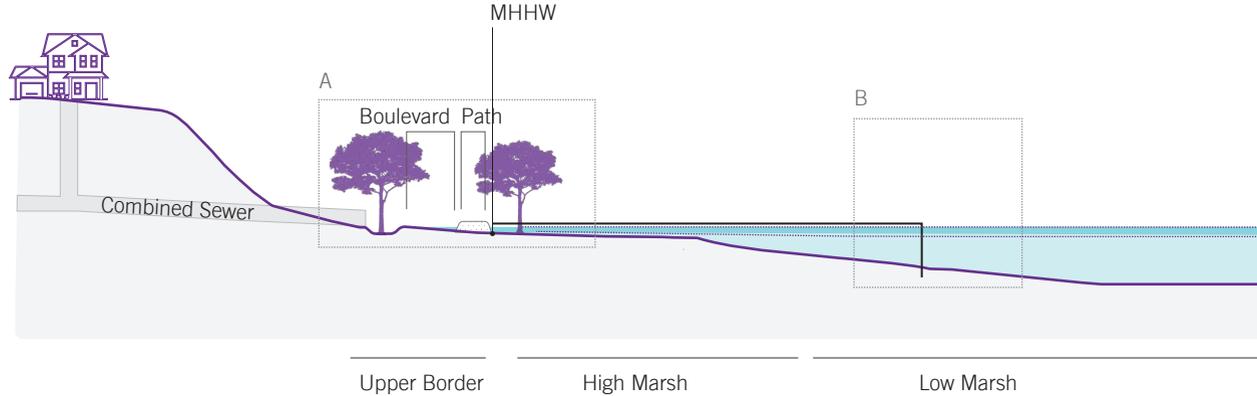


FOCAL AREA: BAXTER BOULEVARD, PATH & THE ESTUARY

2020: +1' SLR



2045: +2-3' SLR



2070: +4-6' SLR

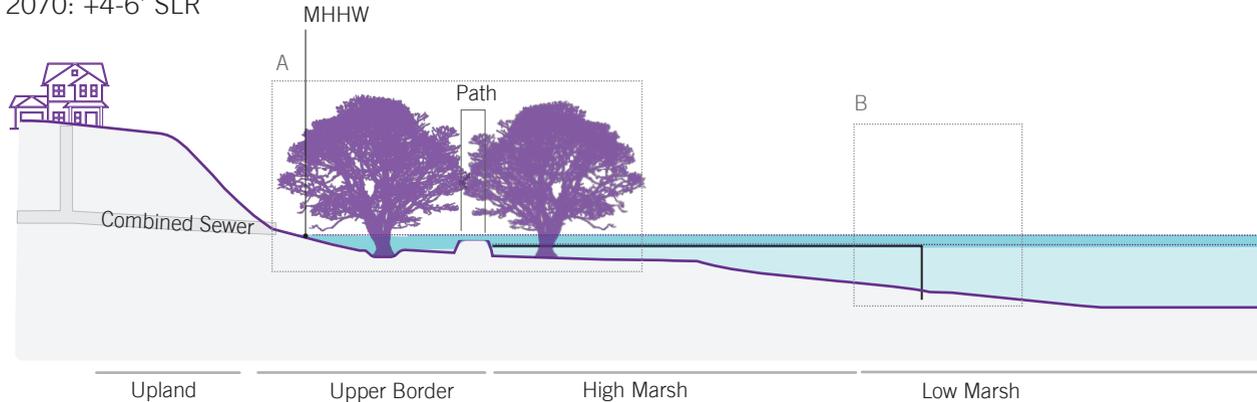
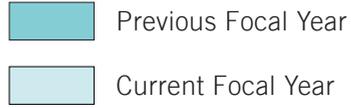


Figure 3.12: Baxter Boulevard & Estuary, Focal Cross Section by year

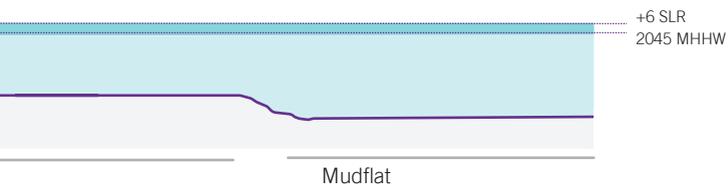
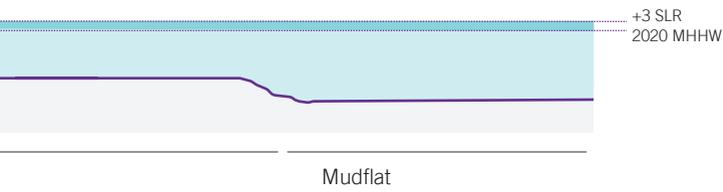
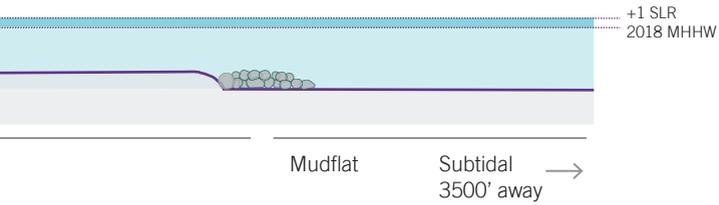
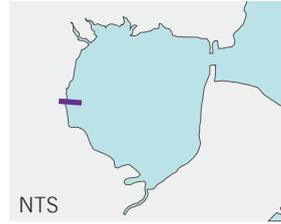


vertical scale 2x exaggerated

Projected SLR



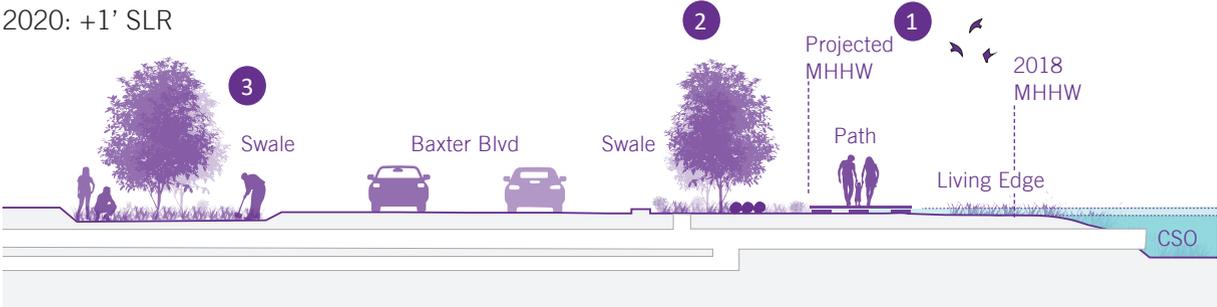
Section Location Diagram



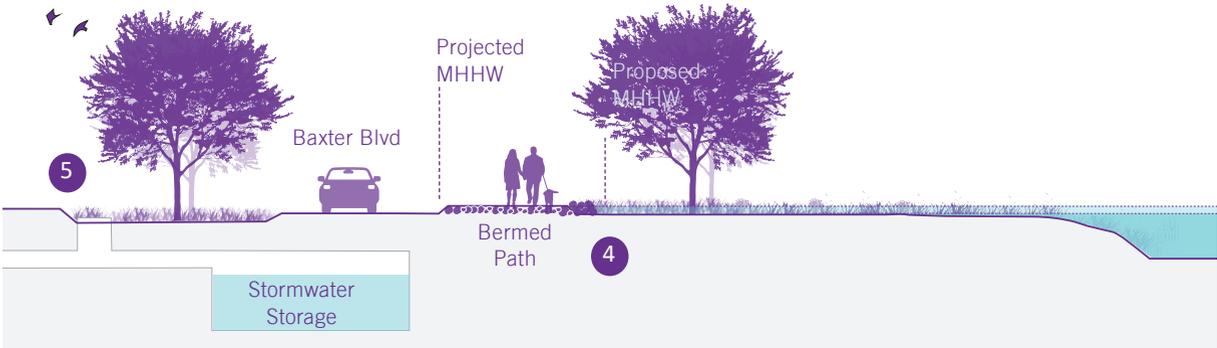
Interventions for Focal Area shown in more detail on following pages.

A: BAXTER BOULEVARD & PATH

2020: +1' SLR



2045: +2-3' SLR



2070: +4-6' SLR





1

In 2020, water levels are projected to make their way onto the encircling path in this section of Back Cove. The path is capable of withstanding occasional inundation, but planks are placed in the most frequently inundated areas to elevate the level.



2

In a patch of land between the path and shoreline that is currently lawn, salt marsh grasses have been selected to stabilize and regenerate the shore's edge while absorbing the impact of the additional water. The deteriorating Linden Trees have been replaced with native Northern Red Oak, a more salt and urban tolerant tree species. An understory of native plants has been added to improve soil quality for the new trees and filter stormwater and road runoff. At a much larger scale along the boulevard than shown here, rain gardens and swales will help reduce stormwater entering the Combined Sewer System and lessen the harmful overflows into the estuary.

3

Community involvement is emphasized and encouraged at this stage to ensure that the community is aware of the risk of sea level rise, understands the changes taking place, and embraces their role as stewards of the future Back Cove.



4

In 2045, high water levels are more frequently inundating the location of the former path and make their way towards Baxter Boulevard. The walking path is moved inward and sculpted into a berm to armor the now one-lane boulevard. This frees up additional space for upland marsh plants where the path, lawn and traffic lane once were. The Oak trees are maturing and beginning to form a canopy.



5

To improve the health of the estuary, the CSO pipes have retreated from their outlet into Back Cove. Rain gardens and swales help filtrate and absorb stormwater prioritizing the underground pipes for sewage. In larger storms, overflow is directed to underground stormwater storage tanks that now encircle the inland side of the boulevard. Stored watered is later re-used for irrigation.

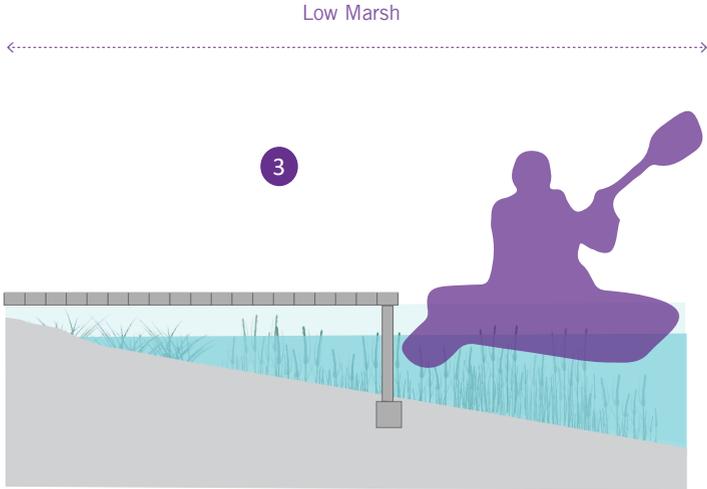
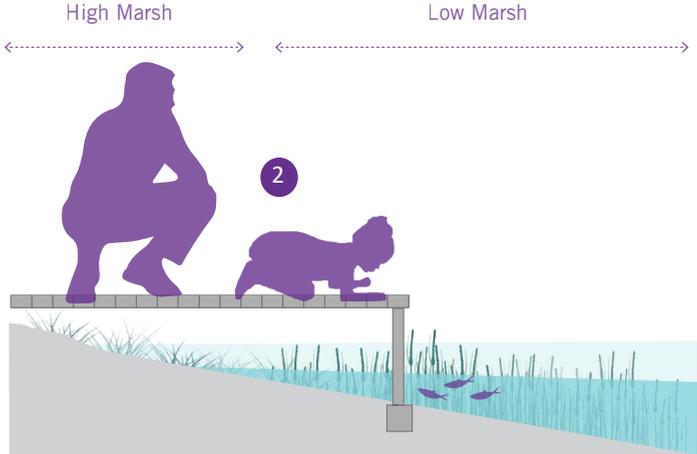
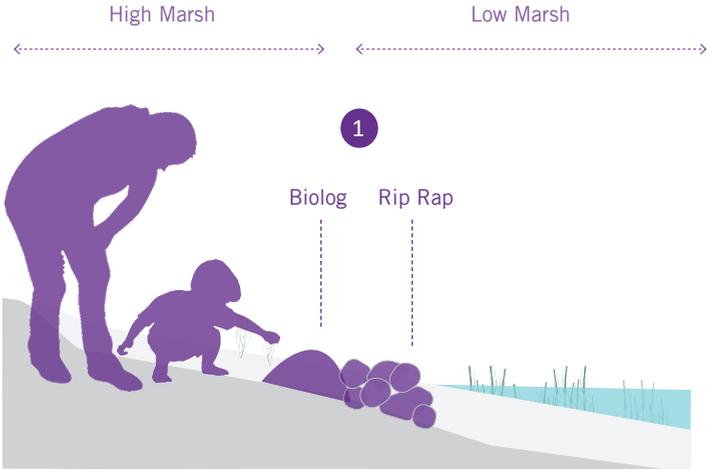


5

By 2070, high water levels are projected to rise all the way to the interior of the former road, but interventions in the salt marsh, at the former location of the path, and on the now planted berm help prevent the path from being constantly inundated. The path has retreated to the lane of the boulevard that was a one-way in 2045. Now in the center of the allée canopy, the path is framed by mature, consistently-sized Red Oaks spaced at 50' to maintain views of the cove.

Figure 3.13: (left) Baxter Boulevard & Path, Change Over Time

B: THE ESTUARY





There is currently no management plan for the marshes encircling Back Cove. These environments provide a critical buffer against storm surge and rising sea levels and provide habitat for a variety of shore birds. With the land-ward migration of saltwater, the growth of marsh grasses will also move inland. Current sediment deposition occurs at 7-10” per century, a rate that will not be able to keep up with rising sea levels. Because of this, I am proposing the expansion of the marshes into a portion of the mudflats. This will increase the cove’s edge elevation and decrease salt water migration onto the bordering path and road. This proposal is transferrable to other edges of Back Cove.

- 1 In the year 2020, biologists and rip rap stabilize added sediment. Members of the community volunteer to plant Saltmeadow Cordgrass (*Spartina patens*) in the high marsh and Smooth Cordgrass (*Spartina alterniflora*) in the low marsh. Community planting efforts encourage stewardship of Back Cove for generations to come.

- 2 By 2045, a steel dock is proposed to allow for water access and engagement with the marsh environment. Water access has been proposed several times since the 1896 Olmsted plan and has never been implemented. The grasses have grown in as the water rises, moving the low marsh inland in this area. The same child who volunteered with the original planting now observes his child watching small fish in the marsh.

- 3 In 2070, the Smooth Cordgrass has grown in at this spot as the low marsh dominates. The same man, now retired, enjoys launching his kayak from the dock as water rises to meet it.

Figure 3.14: (left) The Estuary, Change Over Time



Salt marsh grasses line the edge of Back Cove, August 2017.

4 CONCLUSION

While there are several unknown variables associated with climate change, there is evidence that the earth's temperature has been steadily increasing and that it is continuing to increase at a faster rate. Sea level rise is just one of the many results of a warming climate and the biggest climate change threat to Back Cove's historic and ecological integrity. The goal of this research project was to propose a series of design interventions specific to Back Cove that would serve as new knowledge or insight and inspire future change at the site.

A critique and review of the performance of the design is impossible as it currently exists as a proposal. Also, an evaluation of only the proposed design would undermine the much larger exercise—the process of research-through-designing. Because the project used the constructivist approach to research-through-designing (proposed by Lenzholzer, Duchhart, and Koh as a framework, drawing parallels between this framework's claims and the outcome of the process is one useful means of evaluation. This research was closely guided by the context of the physical environment emphasized in Lenzholzer's definition of constructivist research-through-designing. The analysis of extensive historic writings, scientific data, reports, GIS data, maps, and photographs resulted in three key themes (or values) that guided the designing process; historic integrity, ecological integrity, and sea level rise.

Lenzholzer claims that design as a research inquiry can produce valuable new knowledge or insights. In this case, a design that examines the full extent of Back Cove had not been proposed since Olmsted's efforts in 1896. Efforts since then have focused on individual elements of the site—the Bayside neighborhood, Baxter Boulevard, Back Cove Park, Fall Brook—and have placed little or no emphasis on projected sea level rise and the effect it will have on the entirety of the cove. This project is the first attempt to propose a design at Back Cove that combines sea level rise strategies, values of historic and ecological integrity, and multiple spatial and temporal scales in response to the projected effect of sea level rise at Back Cove. Furthermore, the creation and application of sea level rise design strategies—armor, rise-up, retreat, and regenerate—that are specific to Back Cove are a new approach and contribution to knowledge.

Designing for sea level rise at a historic and ecologically valuable landscape is a challenging task that requires extensive collaboration of individuals and the combination of several strategies. However, it is a challenge that many communities will begin to encounter in the coming years. The sea level design strategies defined and implemented in this work are transferrable to other landscapes facing the threat of sea level rise. Perhaps elements of the proposed design scheme could return the inspirational favor that the Fens in Boston provided to Back Cove

and serve as a model for the Fens to address sea level rise. The emphasis on the combination of several strategies as the best approach is also a valuable approach transferable to similar circumstances, such as the Fens.

This project is the result of more than a year of work at the culmination of a three-year educational experience. The work was an opportunity for me to apply the skills I have acquired as a landscape architecture master's student to the process of researching and designing at a site that I value personally. This work has led to a set of personal values that emphasizes the importance of collaboration and the power of design to inspire change. While scientists are responsible for the accurate collection and presentation of data, designers have the power and ability to translate that data into knowledge in the form of creative solutions. Having all of that information is great, but then what do we do about it? How do we act and respond? Landscape architects are trained to distill a vast amount of context about a place—circulation, history, ecology, geology, climate—and respond in a way that is appropriate given all of the information. Yes, infrastructure around Back Cove will be expensive to construct and buildings will be forced out of vulnerable areas, but the historic and ecologic integrity of Back Cove are worth the exploration and implementation of bold design solutions in a future that is certain to include higher sea levels. Design that pushes boundaries, forcing us to rethink what might be the easiest solution to a physical problem, has the ability to generate new knowledge and insight and make a positive, lasting impression for generations to come. That is the quality of knowledge I hope to contribute to the profession with this work and in the years to come.

The southwest edge of Back Cove with Baxter Boulevard shown in the background, September 2017.





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