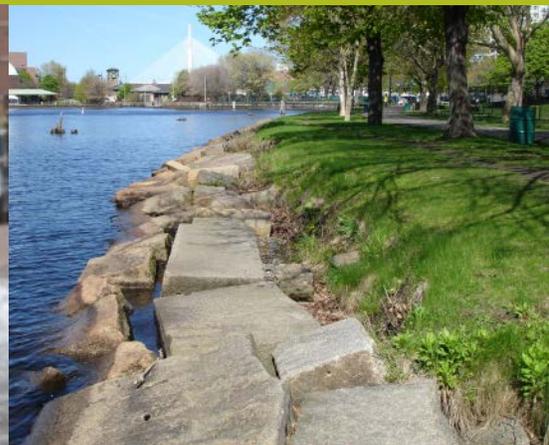


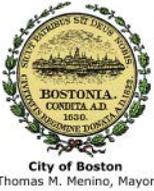
# CLIMATE READY BOSTON



## MUNICIPAL VULNERABILITY TO CLIMATE CHANGE







# Climate Preparedness Task Force

Convened by Mayor Thomas M. Menino

## TASK FORCE MEMBERS

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Joanne Massaro, Commissioner of Public Works  
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## TASK FORCE CONTRIBUTING DEPARTMENTS

Boston Centers for Youth & Families	Neighborhood Services
Boston Public Health Commission	Office of Arts, Tourism & Special Events
Boston Public Library	Office of Budget Management
Boston Redevelopment Authority	Office of Business Development
Boston Water and Sewer Commission	Office of Food Initiatives
Department of Innovation and Technology	Parks & Recreation Department
Emergency Management	Police Department
Emergency Medical Services	Property & Construction Management Department
Emergency Shelter	Public Works Department
Emergency Storm Center	School Department
Environment Department	Transportation Department
Inspectional Services Department	Treasury Department
Neighborhood Development	

## REPORT WRITTEN BY

Carl Spector, Director of Climate and Environmental Planning  
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# Letter from the Mayor



Dear Friends,

Boston Harbor has long been the epicenter of our city. It's what attracted the first Europeans to settle the City on a Hill; its port drove Boston's growth through the 19th and 20th centuries; and now, its revitalization in areas like the Innovation District and East Boston is bringing new life and energy to our City.

Our Waterfront has helped make Boston the great city it is today, but it also presents challenges, and at times, threats. Climate change is increasing these risks and Boston must prepare. That is why – a few months after Hurricane Sandy devastated New York and New Jersey, and missed Boston's high tide by just five hours – I announced Climate Ready Boston. While the City of Boston had been preparing for the impacts of climate change since 2007, Hurricane Sandy was a gut check. We needed to do more.

As part of Climate Ready Boston, I tasked my Cabinet chiefs to examine how the impacts of climate change – including more extreme heat, sea-level rise, and storms like Sandy – may affect city facilities, services and programs through a Climate Preparedness Task Force. The pages that follow are the result of the work of this Task Force, who over the course of just nine months, were able to come together to better understand our vulnerabilities to climate change, and what we must do to address them.

This Report identifies many actions my administration, and the next, can take to ensure that we continue to provide our constituents with the infrastructure and services they require and deserve. The City of Boston must do its part to help make Boston the most prepared and resilient city in the country.

Sincerely,

A handwritten signature in black ink that reads "Thomas M. Menino". The signature is fluid and cursive, with a large, sweeping initial "T" and "M".

Thomas M. Menino,  
Mayor

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# Summary and Key Findings

As a coastal city with many neighborhoods built on filled tidelands, Boston has always been vulnerable to storms. And in the past 12 months, Superstorm Sandy, nor'easter Nemo, and this summer's three heat waves have reminded Bostonians of the power of natural forces. As the climate changes, the risks from these types of events will grow. Sea-level rise, rising temperatures, and more intense storms will increase the vulnerability of all parts and sectors of the city. That is why Boston is taking steps to prepare for climate change and to make Boston the most resilient city in the country.

Building on initiatives dating back to his 2007 executive order on climate action, Mayor Menino, in February 2013, directed his cabinet to form a Climate Preparedness Task Force to assess the vulnerability of municipal facilities, operations, services, and policies in light of climate change and to recommend next steps to better understand and reduce that vulnerability. To perform this task, City Hall staff relied on local projections of the effects of climate change and their considerable internal knowledge of the City's assets, programs, and constituents. The Task Force's work will form one foundation of the community-wide climate preparedness plan that will be the primary policy focus of the 2014 update of Boston's Climate Action Plan.

Climate preparedness is a long-term process; many City departments have made good starts. The Boston Water and Sewer Commission is two-thirds through a capital planning process that will determine how the Commission will ensure that the city's sewer and stormwater infrastructure is ready for sea-level rise and more intense precipitation. The Office of Emergency Management has incorporated climate concerns into the City's updated Natural Hazards Mitigation Plan, currently in draft form. As the Mayor directed last February, the Boston Redevelopment Authority is examining the climate preparedness of new large projects so that anything constructed in Boston today will be ready for conditions of the future.

The departmental assessments included in the appendix detail the next steps necessary to better understand and reduce the vulnerability of individual buildings to flood or heat, maintain or increase the level of service that the City provides, and increase its safeguarding of health and safety as the climate changes. Based on these specific evaluations, the Task Force has five key findings.

***Climate preparedness must be an important and explicit criterion in the City's capital planning. The City's critical IT, communications, and transportation centers need particular attention.***

The City of Boston and its agencies are Boston's largest property owners with approximately 16 million square feet of property in 300 buildings. As many departments noted, the construction of new buildings and the repair and renovation of existing ones are critical opportunities for increasing preparedness. Possible measures include increased flood-proofing; elevating sensitive equipment, such as electrical equipment; installing or increasing cooling capacity; and, in some cases, in the long term, relocating buildings to less vulnerable areas. These considerations should also apply to vehicles to ensure, for example, that the City has the best vehicle fleet to cope with emergencies. Individual departments are best equipped to determine their priorities; however, on a City-wide basis, a climate preparedness analysis should be part of every capital decision. The Office of Administration and Finance intends to modify its process and procedures to institutionalize these concerns.

Most of City Hall is well above projected levels of flooding for the rest of the century, but the first floor is not. The Department of Innovation and Technology (DoIT) identified a variety of digital and communications infrastructure located on the first floor as a high-priority vulnerability; and many other departments identify their reliance on this infrastructure for their core operations as a high concern. Changes to the building may be necessary to eliminate this as a concern going forward, and DoIT is already instituting changes to the IT

hardware and software systems to reduce risk.

The Frontage Road facilities serve as the major hub for vehicles and off-road equipment for many departments, including Public Works and Transportation. Moreover, it is already prone to flooding. Both short-term and long-term vulnerability need to be addressed.

***The effects of rising temperatures should be a high priority.***

Discussions of climate preparedness in Boston usually turn first to sea-level rise and coastal flooding. However, excessive heat can be just as—or more—deadly than a flood. Those who are vulnerable include: the poor and elderly who may not have air-conditioning, the homeless, and those with chronic health conditions; Parks or Public Works personnel—as well as employees of private businesses—who must work outside; tourists and attendees at summer festivals and other events. Fortunately, the City has many tools available at a relatively low cost to address these risks including: improving and expanding the capacity of its cooling-center system; revisiting operational procedures to ensure worker safety; requiring event organizers to provide spray-mist fans and more drinking water; and aggressively continuing Grow Boston Greener’s tree-planting initiative. Grow Boston Greener is an example of a preparedness measure with multiple benefits: in addition to helping cool the city, trees improve stormwater management, beautify neighborhoods, and absorb carbon dioxide.

***Municipal emergency plans should be reviewed and practiced in light of the expanded risks posed by climate change.***

Climate change is likely to increase the frequency and extent of emergencies caused by natural events. Identifying various areas of concern, many departments recognized their continuity of operations plans (CoOPs), which every department is responsible for updating annually, as the appropriate mechanism for improving their ability to fulfill core responsibilities during emergencies. The Office of Emergency Management (OEM), which is responsible for overseeing these plans, helps departments refine their plans and ensures that they are sufficient to meet the increasing risks from climate change. It may be particularly important to examine systemic effects—for example, if a department located in City Hall has designated 1010 Massachusetts Avenue as a secondary location, 1010 Mass. Ave. may not be operational as well. City departments and OEM should undertake an in-depth updating of all CoOPs.

Beyond the CoOPs, the climate assessments will assist OEM in updating the City’s emergency operations plan (EOP) to reflect the effects of climate change. This should include coordination with the plans of private institutions and businesses (for example, hospitals, universities, and any organization with large numbers of employees) that have key roles to play. Practice of the evolving plans is another essential element of preparation.

EOM will also work with departments to insert, as appropriate, new measures into the City’s Natural Hazards Mitigation Plan, while it is still in draft form or later as amendments to an approved plan. The Mitigation Plan, updated every five years, is another tool for identifying long-term risks and ways to reduce them.

***Close coordination with regional, Commonwealth, and federal partners is necessary to address cross-jurisdictional infrastructure vulnerability.***

The City of Boston does not have authority over much of Boston’s critical infrastructure. Examples include the Central Artery/Tunnel and the MBTA, the Charles River Dam, the Deer Island Waste Water Treatment Plant, Storrow Drive, Morrissey Boulevard, and the Jamaica Way, and the electric and gas distribution systems. In these areas, the City cannot directly address long-term vulnerability or manage short-term conditions during emergencies. Several departments highlighted the limitations on their ability to ensure the safety of Boston residents because of these jurisdictional restrictions.

Over the past few years, Boston has worked with many offices of the Commonwealth, with regional authorities, and with municipal neighbors specifically on climate preparedness. In some areas, for example, the work of the Massachusetts Water Resources Authority and MassPort, progress has been excellent. To address the critical infrastructure issues facing the City, it is essential that this progress be uniform across agencies and jurisdictions. Recently, Governor Patrick announced that climate adaptation will be a major priority of the Commonwealth's Executive Office of Energy and Environmental Affairs for the rest of his term. The City of Boston needs to work closely with the Commonwealth and its agencies to address important needs.

Federal support is also important. For example, the federally-funded Muddy River Project, which will greatly reduce the risk of flooding to the surrounding communities, involved a partnership with multiple federal agencies, the Commonwealth, and several local cities and towns. Securing additional federal support for climate preparedness capital projects will be critical for the City.

***Education, engagement, and communication—within City government and with the community—are essential for preparing for both the short-term and long-term effects of climate change.***

For all its resources, commitment, and authority, City government relies on active partnerships with the residents, businesses, and institutions to help prepare Boston for climate change. These partnerships range from communication during emergencies (locating individuals in need of assistance, coordinating early release of employees before major storms, and tracking the capacity of hospitals) to longer-term discussions on the appropriate climate preparedness requirements for property owners and major infrastructure. Climate preparedness will require continued development of educational materials, outreach strategies, and community and organizational networks. Similar development is necessary within City government to ensure short- and long-term coordination on preparedness issues.



# Introduction

As a coastal city with many neighborhoods built on filled tidelands, Boston has always been vulnerable to storms. The effects of climate change, including sea-level rise and more intense precipitation, are increasing this vulnerability as well as increasing the city's risks from extreme heat and other phenomena related to climate change. In 2007, responding to more detailed projections of how climate change will impact Boston, Mayor Thomas M. Menino issued an executive order that directed City offices to incorporate climate change into all municipal and community planning, projects, permitting, and review processes. Since then, evidence on the causes, mechanisms, and consequences of climate change has continued to build. A 2013 paper by the Organisation for Economic Co-operation and Development published in the journal, *Nature Climate Change*, ranked Boston the eighth highest metropolitan area worldwide in expected annual economic losses (\$237 million) due to coastal flooding. And in the past 12 months, Superstorm Sandy, nor'easter Nemo, and this summer's three heat waves have provided concrete reminders of Boston's vulnerability to natural forces.

Climate preparedness is the effort to reduce these risks and to prepare for responding to new conditions, when they arrive. In 2010, building on the Mayor's 2007 order, the Mayor's Climate Action Leadership Committee recommended that:

Every city government department and agency should undertake a formal review of the possible implications of climate change for its on-going programs and infrastructure in the next ten years, and implement changes or establish programs and policies based on that review.

This recommendation was incorporated, along with the Leadership Committee's other recommendations, into the City of Boston's 2011 Climate Action Plan update for a comprehensive climate adaptation framework. Since then, City departments have continued the work of integrating climate change into all policies and planning. These measures include: the Complete Streets Guidelines and Grow Boston Greener's promotion of green infrastructure to reduce the urban heat-island effect and flooding; the Boston Redevelopment Authority's development and review of a climate preparedness questionnaire for all new large projects; and the Park Department's inclusion of climate change in its new open space plan, currently in development.

On February 5, 2013, a few months after Superstorm Sandy, Mayor Menino announced a new set of preparedness initiatives under the name of Climate Ready Boston, in concert with the release of The Boston Harbor Association's (TBHA) report, *Preparing for the Rising Tide*. One key component of the report was a guide for private property owners for how to think about reducing their own risks and vulnerability. In his announcement, Mayor Menino asked the Boston Green Ribbon Commission, a group of business and institutional leaders to extend TBHA's work and recommend further actions that institutions and businesses can take and actions that the City of Boston can take to support them. The Mayor also directed:

- The Cabinet to form a Climate Preparedness Task Force to review internal climate change preparedness and the next steps for their further development
- The Boston Redevelopment Authority to survey the preparedness of existing buildings throughout the city
- The Boston Redevelopment Authority to make climate change preparedness a formal requirement under its Article 80 Development Review Guidelines
- The Environment Department to draft a local wetlands ordinance that incorporates best practices for protection against sea-level rise
- Inspectional Services Department and Boston Public Health Commission to better communicate and enforce flood proofing standards for buildings

All of these efforts will contribute to advancing climate preparedness policies in the 2014 update of the City's climate action plan.

## CLIMATE PREPAREDNESS TASK FORCE

This report presents the assessments and key findings of the Climate Preparedness Task Force, as directed by the Mayor. The Task Force, under the leadership of the Chief of Environment and Energy, comprised cabinet and department heads across municipal government, and was supported by a staff-level working group.

The task force established the following procedure for completing the assessment:

1. EES staff compiled summaries of likely consequences of climate change in Boston over the next 50-75 years (see below).
2. Based on these summaries and their knowledge of their facilities, operations, and services, departmental staff prepared tables indicating vulnerabilities, priorities, and ongoing or next steps to reduce vulnerability.
3. Cabinet and department heads provided a summary for areas under their responsibility and a designation of the highest-priority items.
4. The Task Force developed City-wide key findings and the integrated report. The Task Force did not review departments' determinations of their internal priorities.

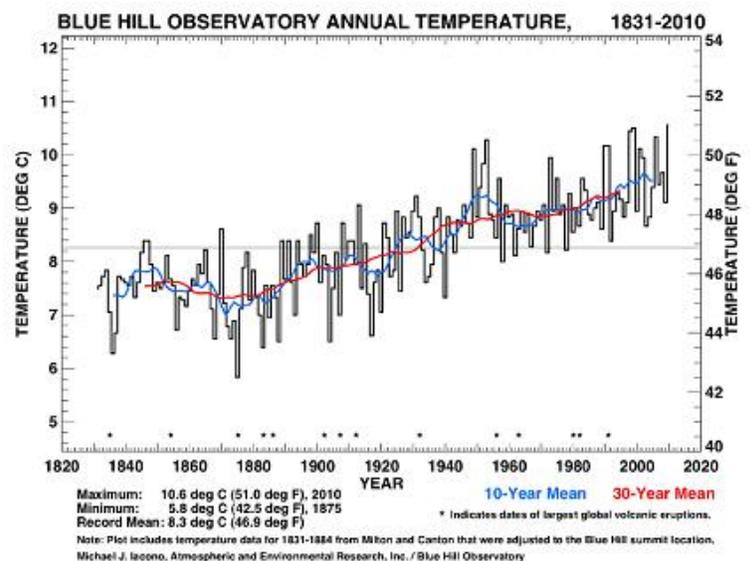
The Task Force agreed that the major focus of this assessment would be internal facilities and operations. Furthermore, the goal would be to identify high-priority items and next steps, not necessarily solutions.

## EFFECTS OF CLIMATE CHANGE

The City of Boston did not commission any new studies of the likely effects of climate change for this assessment. The Task Force concluded that existing regional and local studies provided a more-than-adequate level of information for current purposes. Major sources included the 2013 draft National Climate Assessment, Massachusetts Climate Change Adaptation Report (2011), and studies by the Union of Concerned Scientists and The Boston Harbor Association.

### *Changes in Temperature*

Records at the Blue Hill Observatory indicate that average annual temperature has risen about three degrees F in the past hundred years (see Figure 1). Winter temperatures have risen more than summer temperatures. Climate change projections indicate that this trend will accelerate, with the average annual temperature in the Northeast rising between three and 10 degrees F by the 2080s. The number of days over 90 degrees in Boston could rise from the current average of 10 per year to an average of 31 to 62 per year by the end of the century; and days over 100 degrees, still quite rare, could become a regular occurrence (see Figure 2). Milder winters will likely mean more freeze-thaw cycles, less precipitation falling as snow and instead as rain and freezing rain. Hotter summers will increase the number, intensity, and duration of heat waves and lead to poorer air quality. Overall, these changes can affect the timing of plant blooming and animal migration and stress people, animals, plants, power systems, and our built environment.



**Figure 1: Records at the Blue Hill Observatory indicate that average annual temperatures have risen about three degrees F in Boston.**

### Changes in Precipitation

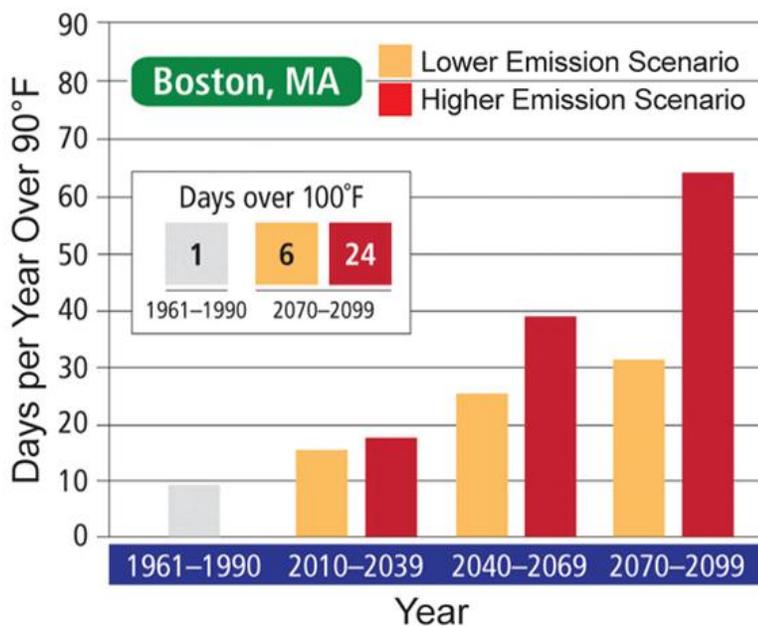
Climate projections suggest that precipitation rates in Massachusetts will likely stay about the same or slightly increase over the next 100 years. However, precipitation (including snow) will fall in fewer, more intense storms, in part because humidity levels are projected to increase. There may be more time between precipitation events, producing more severe periods of drought. By the end of the century, droughts lasting one to three months in Massachusetts could increase from about four in every ten years to about six or seven every ten years. Snow or rain, when it does fall, will likely fall in more concentrated bursts. This can overburden storm water management systems and lead to inland flooding.

### Changes in Sea Level

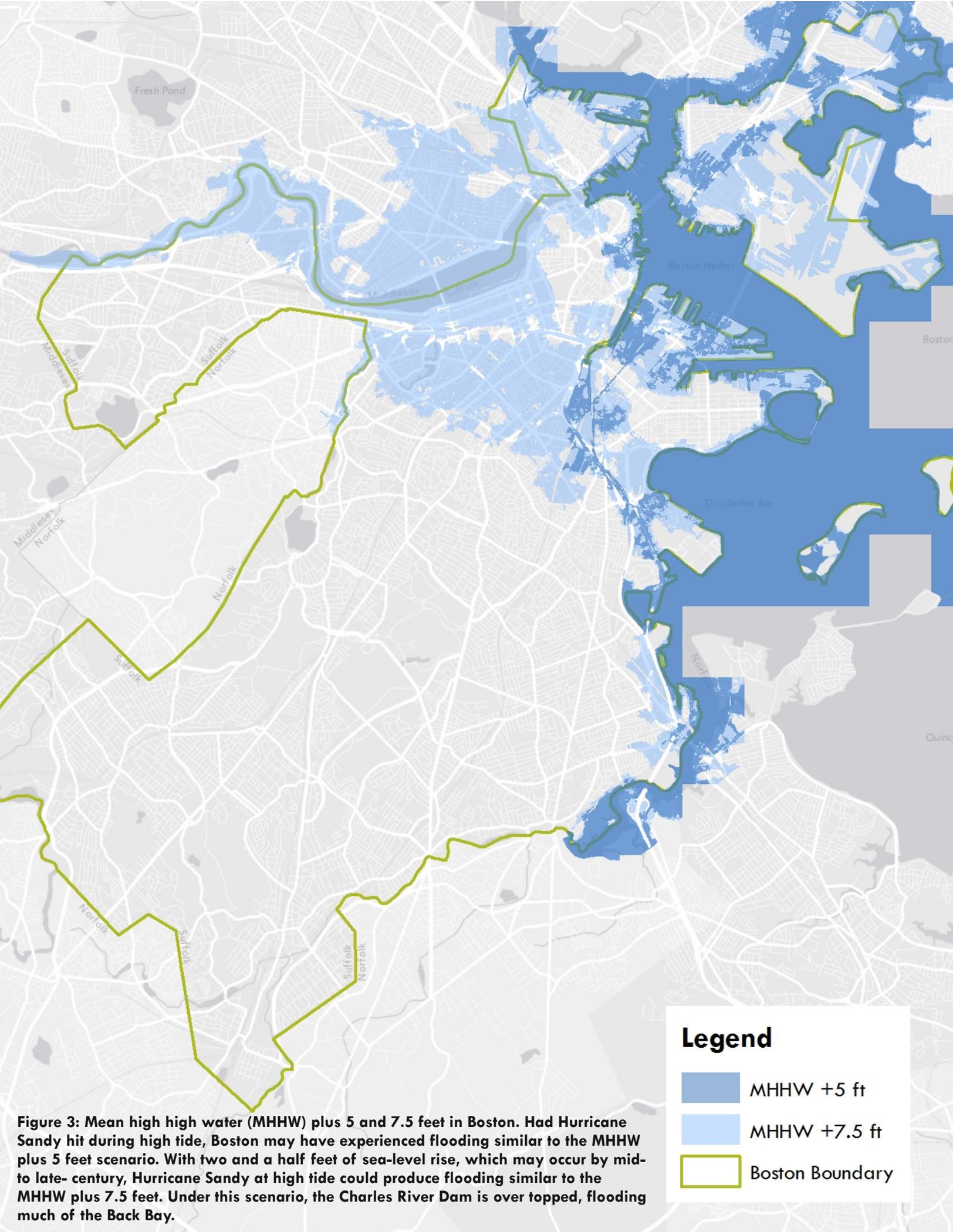
The National Climate Assessment concluded that there is a greater than 90 percent chance that average global sea level will rise between eight inches and 6.5 feet by the end of the century. Sea-level rise in Boston is likely to be greater than the global average, because Boston's land mass is subsiding, or sinking, at about six inches per century, and changing ocean currents and other features affecting the distribution of ocean water. For the internal assessment, the Task Force relied on three flood maps as screening tools:

- The current Boston flood map under the National Flood Insurance Program (also known as the FEMA map). The building and zoning codes for Boston use this map to officially define today's floodplain. (New draft FEMA maps will be released for review in November 2013).
- A map showing the extent of flooding at mean high high water (MHHW), that is, the average level of the higher of the two daily high tides, plus an additional five feet of water, created by TBHA. This is an approximation of the flooding that would be caused by a five-foot storm surge (which occurred during Sandy) coming at high tide (which was not the case during Sandy).
- A map showing the extent of flooding at MHHW plus an additional 7.5 feet of water, also created by TBHA. This would roughly be the previous result with an additional 2.5 feet of sea-level rise.

Figure 3 shows a map of MHHW plus 5 and 7.5 feet. None of these maps is a definitive projection of what the City of Boston expects the effect of sea-level rise to be. Their use is to identify areas of potential vulnerability.



**Figure 2: Extreme heat will rise as the climate changes. By the end of the century, we may experience 31 to 62 days over 90 degrees F, up from our current average of just 10. Image credit: Union of Concerned Scientists**



### Legend

- MHHW +5 ft
- MHHW +7.5 ft
- Boston Boundary

**Figure 3: Mean high high water (MHHW) plus 5 and 7.5 feet in Boston. Had Hurricane Sandy hit during high tide, Boston may have experienced flooding similar to the MHHW plus 5 feet scenario. With two and a half feet of sea-level rise, which may occur by mid-to late- century, Hurricane Sandy at high tide could produce flooding similar to the MHHW plus 7.5 feet. Under this scenario, the Charles River Dam is over topped, flooding much of the Back Bay.**

# Facilities and Capital Planning

Municipal facilities—including administrative buildings, libraries, schools, community centers, and public housing—are critical for the City to be able to carry out its core duties and functions. Facility managers identified short- and long-term vulnerabilities of City facilities to increased flooding, extreme heat, and other risks that call for capital investment. Facility preparedness measures will vary greatly depending on the vulnerability and type, age, and use of building. Examples of measures include elevating or relocating critical equipment (boilers, electrical infrastructure, and computer equipment) in areas vulnerable to flooding, installing air conditioning for spaces prone to overheating, and replacing roofs to be higher performing in high-wind events. As we approach the middle of the century, the City may need to develop plans to replace or relocate facilities that may be unsustainable due to their design or location.

## GENERAL MUNICIPAL BUILDINGS

Although most of City Hall is above both mean high high water (MHHW) plus 5 and plus 7.5 feet (see Figure 4), the first floor, which currently houses the City’s primary IT and communication servers, may be vulnerable to sea-level rise and storm surge. Loss of this infrastructure, a concern raised by many departments, would severely disrupt municipal operations. The Department of Innovation and Technology (DoIT) is addressing this vulnerability by diversifying where data is stored and creating redundancy in the system.

Another major set of facilities is the complex of buildings and assets around 400 Frontage Road and Southampton Street (see Figure 5), which include Central Fleet Maintenance, the City’s largest fueling station, operations facilities for the Transportation Department, ground-level telecommunications equipment for the Police Department, Boston Public Health Commission’s methadone clinic, and more. All these departments identified the increasing flood risk to this area as a high priority, especially because it is already prone to flooding.

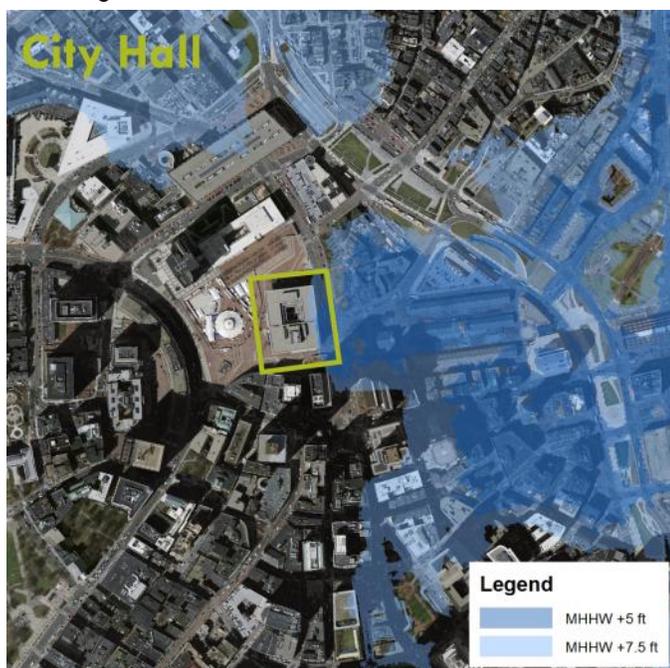


Figure 4: City Hall with MHHW plus 5 and plus 7.5 feet.

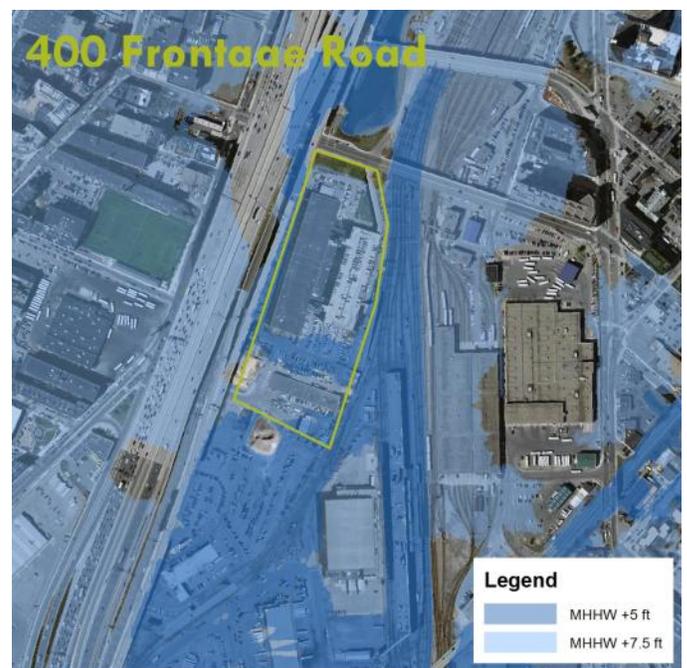


Figure 5: 400 Frontage Road with MHHW plus 5 and plus 7.5 feet.

The City is already taking measures to prepare this critical facility for the impacts of climate change. In 2010, the City, with money from a federal grant, installed solar panels on the roof of one of the complex's building. Most days, this array supplies renewable energy that lowers the City's electric bill, but, during electricity outages from any cause, it can power the fuel pumping station to ensure that emergency vehicles have access to fuel.

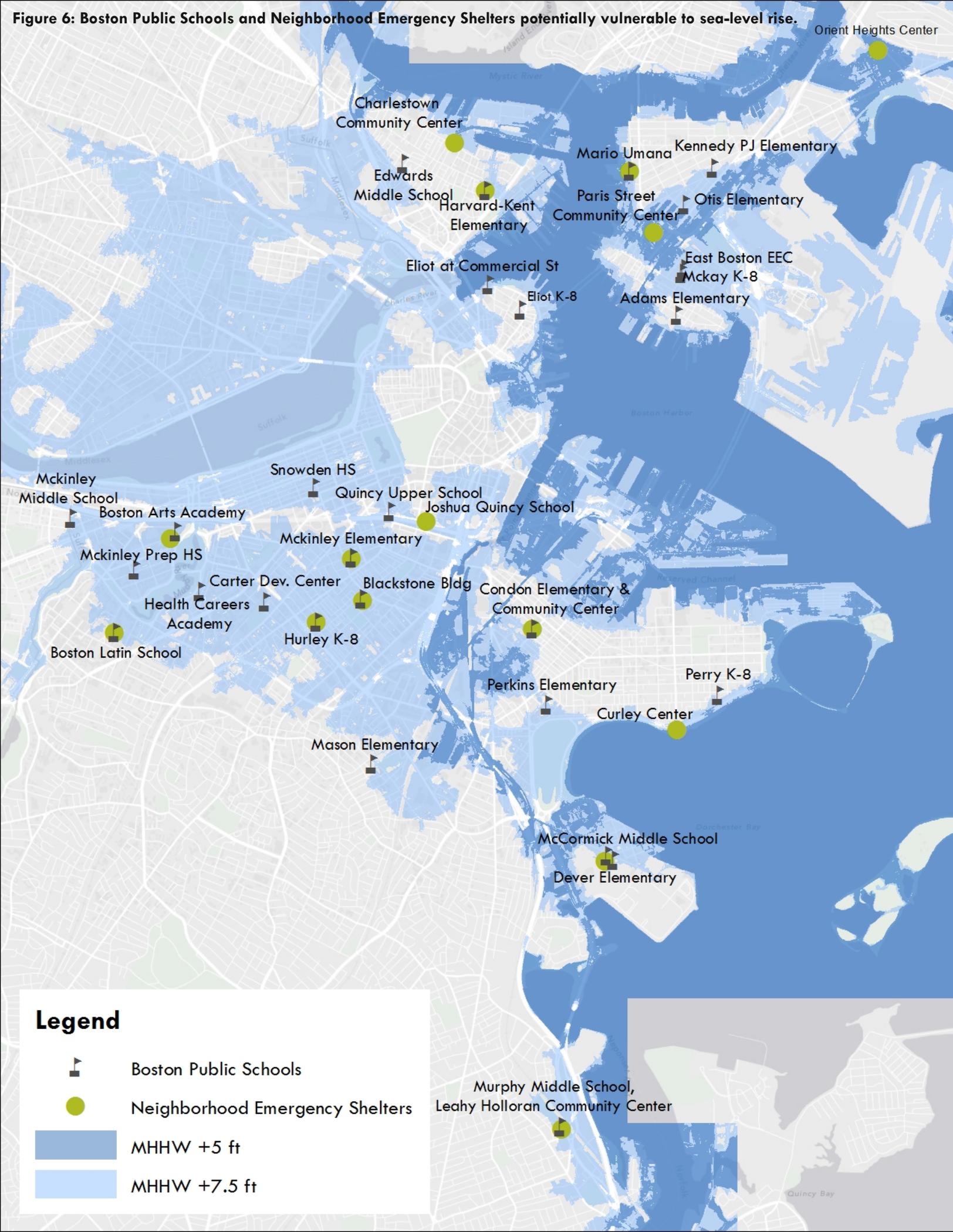
## SCHOOLS AND COMMUNITY CENTERS

Many schools and community centers act as emergency shelters during severe weather events or other emergencies. Table 1 shows schools that have high-priority vulnerabilities, many of which are also community centers. Figure 6 on the next page shows a map of these facilities in relation to MHHW plus 5 feet, which is the flooding we would have likely experienced if Hurricane Sandy hit at high tide, and MHHW plus 7.5 feet.

**Table 1: Boston Public Schools High-Priority Vulnerabilities**

Facility Name	Emergency Shelter	Vulnerabilities	Next steps
Marion Umama MS	Yes	Roof needs replacing (immediate). Heating and water systems in basement are old and may be destroyed by flooding (20-50 years). Elevators are subject to breakdown due to flooding.	Future work must address climate change. Replacing roof. Seawall needs to be rebuilt. Complete HVAC upgrade needed.
West Roxbury HS	Yes	Adjacent to river and basement prone to flooding (immediate). Elevator is subject to breakdown due to flooding or loss of electricity.	Paving and site work is needed. Work will take into account flooding vulnerability.
Condon ES	Yes	School experiences flooding now. Electrical switchgear (which is shared with BHA) needs replacing (immediate). Flooding from sea level rise and storm surge (50-100 years) may impact HVAC in basement. Elevator is subject to breakdown due to flooding or loss of electricity.	Replace electrical switch gear and complete a study to determine cost for relocating equipment to higher floors.
Eliot K-8	No	Flooding potential from storm surge (immediate).	Renovation/addition being planned for the school 2013-2015. Flooding and storm surge potential will be a factor when designing the project.
Eliot at Commercial St	No	Flooding potential from storm surge (immediate). Elevator is subject to breakdown due to flooding or loss of electricity (immediate).	Building being renovated to house Eliot school students. 1st phase being completed for Sept. 2013, other floors will be renovated 2013-2015.

Figure 6: Boston Public Schools and Neighborhood Emergency Shelters potentially vulnerable to sea-level rise.

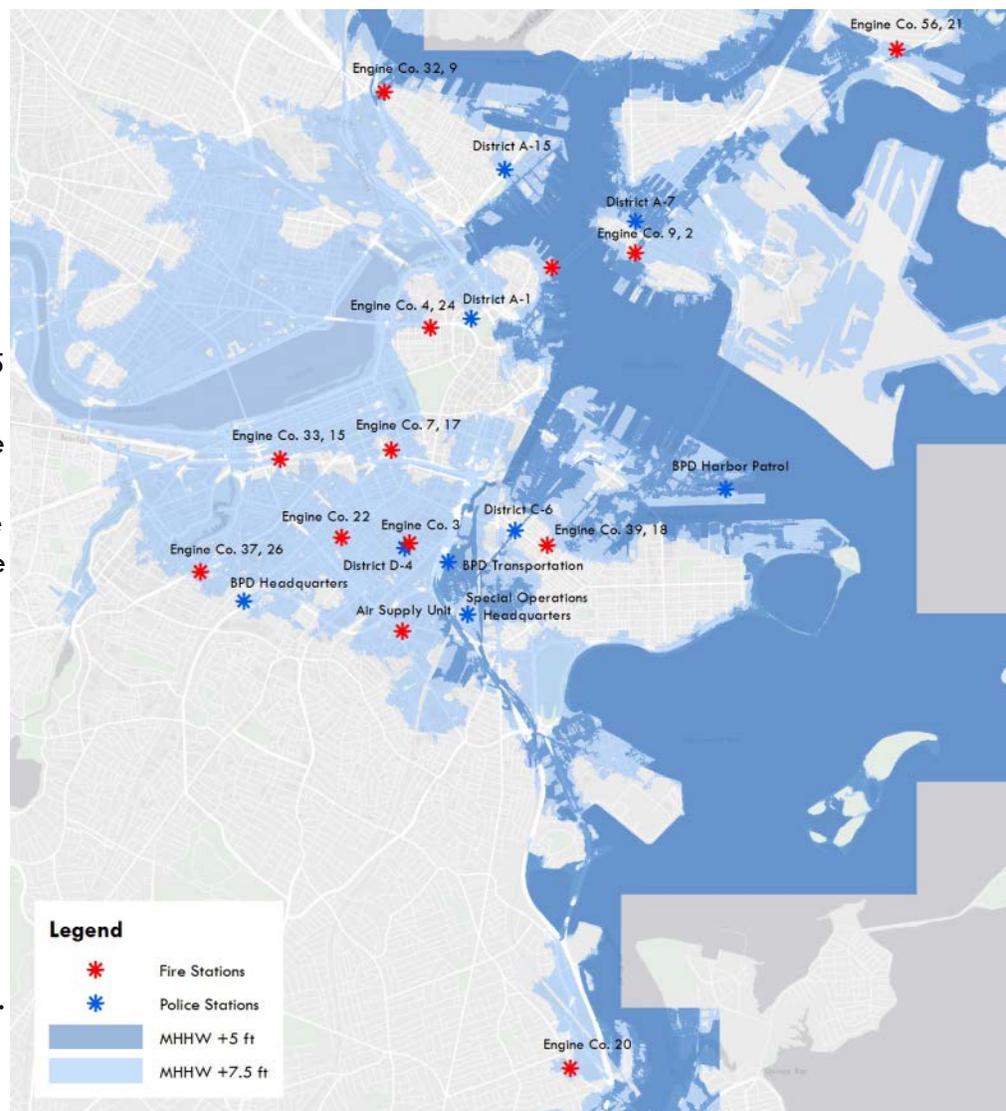


Only one school, the Mario Umana School in East Boston is located in the current FEMA 100-year floodplain. A new roof and HVAC system are in the near-term capital improvement plan, which could help improve other aspects of its resilience. MHHW plus 7.5 feet could threaten 28 more schools. More and more Boston schools are being used for summer programs, so lack of reliable air conditioning units in some classrooms will be an increasing problem. In an example of how current capital plans can be used to increase resiliency, BPS has indicated that, although the Eliot School in the North End is outside the projected flood zones, its new design and construction work will strive to increase its preparedness. BPS is considering strategies such as break-away walls, operable windows, locating the mechanical and electrical equipment on top floors, and secured in case of storm surges, and siting an emergency generator onsite.

Boston Public Schools (BPS) and the Boston Centers for Youth & Families (BCYF) facilities that serve as emergency shelters need to have backup power and cooling capability to cope with extreme weather events. More extreme heat events will require BCYF to have additional supplies, including greater access to drinking water, shade, or spray tents. Even if its facilities are operational, BCYF—as well as other departments—expressed concern about the ability to ensure that staff can reach their facilities in the event of a major weather event. At least one-third of identified emergency City shelters are affected by flooding at MHHW +7.5 feet directly or by accessibility problems. Over the past four years, the City has activated six shelters, with the longest activation lasting four days. Climate change increases the likelihood that City residents will use shelters during or after severe weather. A high priority of the Office of Emergency Management is to work with BCYF and BPS to conduct more detailed evaluations of shelter vulnerability. OEM will also determine whether these vulnerabilities may create gaps in the availability of shelters for Boston residents.

### POLICE, FIRE, AND EMS STATIONS

Figure 7 shows police and fire stations that may be vulnerable to MHHW plus 5 and plus 7.5 feet. The Fire Department has identified three stations that now are affected by occasional flooding that will likely become worse with climate change and has already started to elevate some building systems and take other actions to reduce flooding vulnerability. Other stations within MHHW plus 5 and plus 7.5 feet and the headquarters building are undergoing further analysis to determine appropriate next steps. Boston Police Department (BPD) is examining electrical systems and back-up power supply to become better prepared for flooding, especially facilities affected by MHHW plus 5 feet. BPD headquarters in Roxbury, which houses many critical functions such as 911 operations, is not vulnerable until



**Figure 7: Boston Police and Fire stations vulnerable to coastal flooding.**

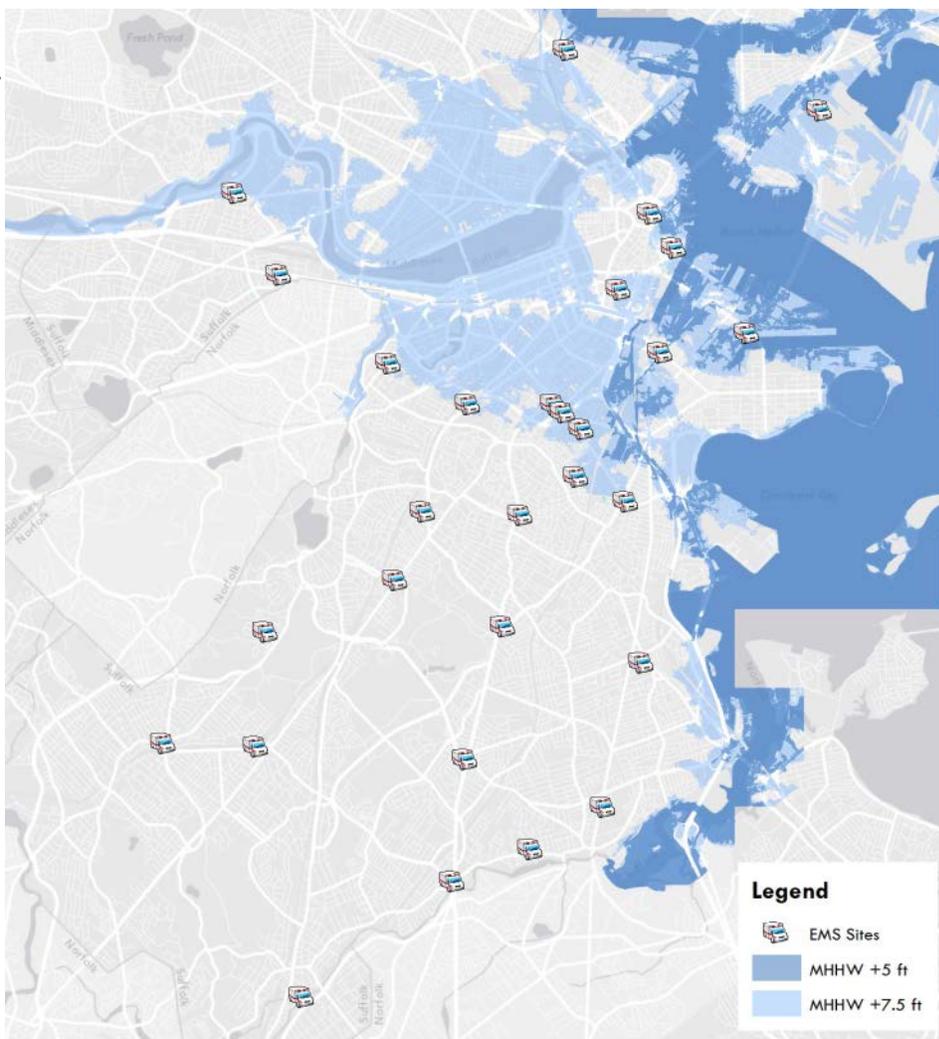
water levels reach MHHW plus 7.5 feet. BPD is particularly concerned about its communications facilities at Frontage Road, discussed above.

Emergency Medical Services (EMS) has garage locations in several neighborhoods where their ambulances can shelter during extreme storms and also have rapid access to the neighborhoods they serve (see Figure 8). EMS has identified as a high priority a more detailed evaluation of these locations and the development of additional neighborhood locations.

### **PUBLIC HOUSING AND OTHER PROPERTY**

The City of Boston is the largest landlord in the city. The Boston Housing Authority (BHA) is responsible for almost 12,000 units of housing. The Boston Redevelopment Authority (BRA) is responsible for many commercial and retail properties, including Charlestown Navy Yard and the Boston Marine Industrial Park (BMIP).

In its assessment, BHA identified seven high-priority vulnerable properties, which account for approximately 1,500 units of housing. These facilities include Ausonia in the North End, Bellflower in Dorchester, and West 9th and West Broadway in South Boston (see Figure 9). Maverick Landing in East Boston, which is a privately managed affordable housing development with 323 units located on BHA land on the Harbor, is another at-risk property. BHA will begin to incorporate in its annual and five-year capital construction plans measures to address the impacts of climate change, including flooding from sea-level rise and storm surge. In the short-term, buildings can be upgraded when old or outdated equipment is replaced.



**Figure 8: Boston Emergency Medical Services (EMS) stations and potential sea-level rise and storm surge.**



Figure 9: Boston Housing Authority developments in relation to MHHW plus 5 and 7.5 feet.



**Figure 10: Boston Marine Industrial Park and Charlestown Navy Yard shown with potential sea-level rise and storm surge.**

The BRA’s BMIP and Charlestown Navy Yard are both at risk from flooding due to their proximity to the Harbor (see Figure 10). Following an inventory of BMIP’s properties, leases, and uses within the coastal flooding area, the BRA will develop an action plan for evacuation during extreme weather events. They are also stockpiling barriers and sand bags in key areas, and plan to implement storm drain and sewer improvements to reduce flood risk.

### **CAPITAL PLANNING AND INSURANCE**

The Office of Administration and Finance (A&F) recognizes that all departments need to address climate change impacts in their capital and operating budget proposals. Currently, A&F’s Capital Planning Budget Procedures Manual includes the potential for funding from Federal Emergency Management Agency’s (FEMA) natural hazard mitigation programs as a “consideration” in the evaluation of project requests. This does not currently address the future impacts of climate change. A&F intends to modify its process and procedures to make climate preparedness and natural hazard mitigation key factors in the review of capital project proposals.

A&F is also finding that higher natural-hazard risks, as determined by the insurance industry’s natural catastrophe models, are raising the City’s insurance costs, which also impacts the City’s annual budget. A&F is responding by gathering additional building data to ensure that the insurance modeling is accurate and increasing loss reserves to support higher self-insurance.

Climate change may affect the annual budget due to impacts to revenue streams as well. For example, tax revenue from the convention and tourism industry, much of which is centered around areas vulnerable to sea-level rise, generates approximately 20 percent of the City’s revenue. The Department of Neighborhood Development is developing programming and outreach to help local businesses reduce risk and prepare for the impacts of climate change.

# TRANSPORTATION AND WATER INFRASTRUCTURE

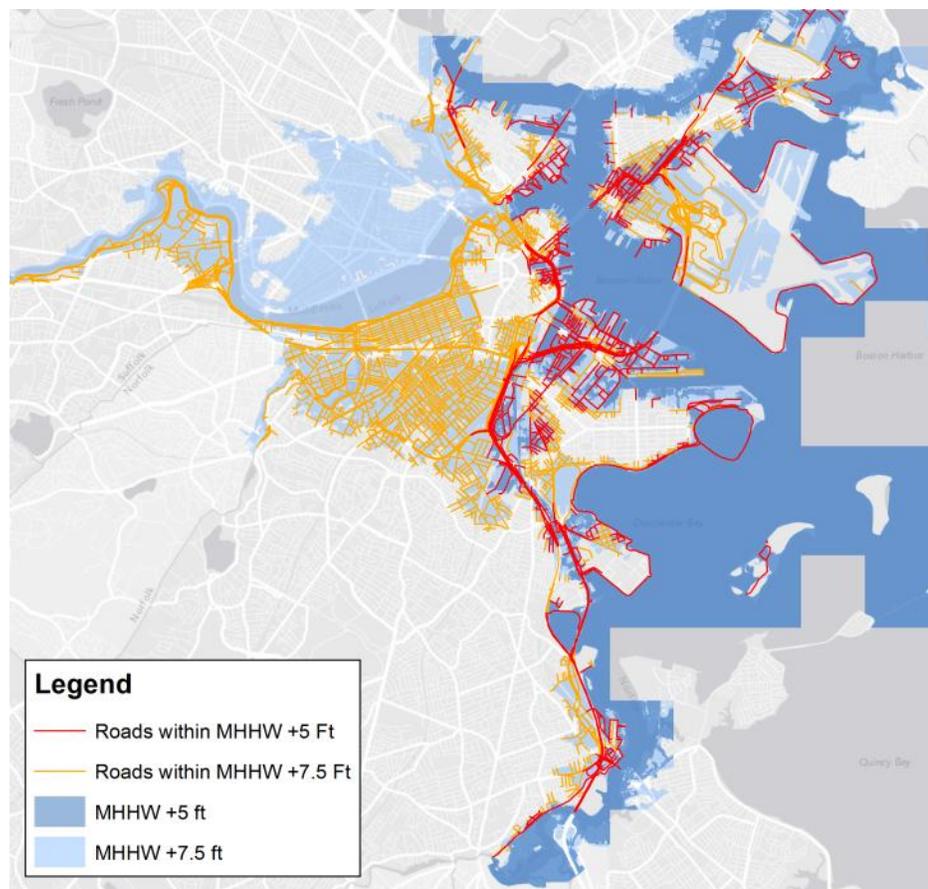
Boston's infrastructure systems are complex and only partially under the jurisdiction of municipal government. The Public Works Department (PWD) and the Boston Transportation Department (BTD) share responsibility for planning, building, and maintaining the city's transportation network with the Massachusetts Department of Transportation and other state and regional authorities. Boston Water and Sewer Commission (BWSC) handles fresh water, storm water, and waste water within city limits, and connects to the regional system run by the Massachusetts Water Resources Authority (MWRA).

## TRANSPORTATION

Climate change will pose major challenges for Boston's transportation infrastructure. Extreme heat can compromise or even buckle road surfaces, railroad tracks and other critical infrastructure. Sea-level rise and more severe storms could lead to increased coastal and inland flooding, which will threaten major thoroughfares. Approximately 132 miles of road are vulnerable to MHHW plus 5 feet, and another 300 miles are vulnerable to MHHW plus 7.5 feet (see Figure 11). A rising water table, a result of sea-level rise, coupled with more frequent freeze-thaw cycles could damage the road surface and threaten infrastructure beneath the roadways. More frequent and intense storms could block roads with downed trees and other debris.

Increasing the climate preparedness of the transportation system involves the design and location of its components, materials and equipment, and operations. BTD is incorporating climate change concerns into all of its planning. The City is now using its new Complete Streets Guidelines, which includes climate preparedness measures such as green infrastructure, to provide shade and control storm water run-off. BTD uses Transportation Access Plan Agreements, required for all large development, to ensure that climate preparedness measures appear at street level, building by building.

The City will also test new technologies, materials and tools to increase preparedness. These may include new pavement materials that can withstand extreme weather, inflatable flood barriers, and various means of back-up power to protect traffic-control facilities, including central operations points and street controllers, and communications. More operational concerns around emergency operations are discussed below.



**Figure 11: Roads in Boston vulnerable to coastal flooding.**

The vulnerability of the Long Island Bridge is a high priority identified by the Boston Public Health Commission (BPHC), because it is a vital link to the BPHC Homeless Services campus, addiction treatment programs, a camp, an organic farm, and several other essential programs and properties. The bridge is already subject to restrictive weight limits and is closed during major storms.

### **CITY COORDINATION WITH OTHER TRANSPORTATION AUTHORITIES**

Most of the City's key transportation infrastructure is outside of the City's jurisdiction. The Commonwealth is responsible for major bridges, tunnels (including the Central Artery and the Harbor tunnels), public transportation, the Port of Boston, train stations, and Logan Airport. Figure 13 shows some of the state transportation infrastructure in Boston that may be vulnerable to climate change, including the MBTA, tunnels, and Logan Airport. City departments are coordinating with the Massachusetts Department of Transportation (MassDOT) and the Massachusetts Bay Transit Authority (MBTA) as they undertake a federally funded study of the climate preparedness of the Central Artery, to be completed in 2014. MassPort is analyzing the impacts of climate change on Logan Airport as part of the Federal Aviation Administration's "Sustainable Master Plan Pilot Program" and should finish early next year. There are more state assets that will need to be similarly examined.

BTD and PWD both emphasized the importance of coordination with federal and state authorities during emergencies. For example, when roads are closed due to flooding or debris blocking the road, state and local officials must coordinate where the detours are going, and who is directing the traffic, since Boston's road network includes both local and state roads.

### **WATER AND SEWER**

The Boston Water and Sewer Commission (BWSC) has made the long-term effects of sea-level rise and increased precipitation a major factor in analysis for and development of its new 25-year capital asset plan for the city's storm water and sewer system. The planning process began in 2011 and is scheduled to be completed in 2014. Because this work is underway, the BWSC was not asked to submit an assessment to the Task Force.

BWSC pipes waste water to the MWRA's Deer Island Waste Water Treatment Facility, which was constructed in the 1990s and was designed to anticipate at least two feet of sea-level rise (see Figure 12). Regarding fresh water, climate projections indicate that New England will probably experience an increase in total annual precipitation, and the MWRA has determined that changes in rainfall patterns (more in winter and less in summer) are unlikely to create water supply problems for member communities, including Boston.



**Figure 12: Deer Island, home to Boston's wastewater treatment facility, was elevated two extra feet in order to provide additional hydraulic head. This also has an added benefit of making the facility more prepared for sea-level rise and storm surge. As shown by this map, the facility is not likely to be inundated by sea-level rise or storm surge this century.**

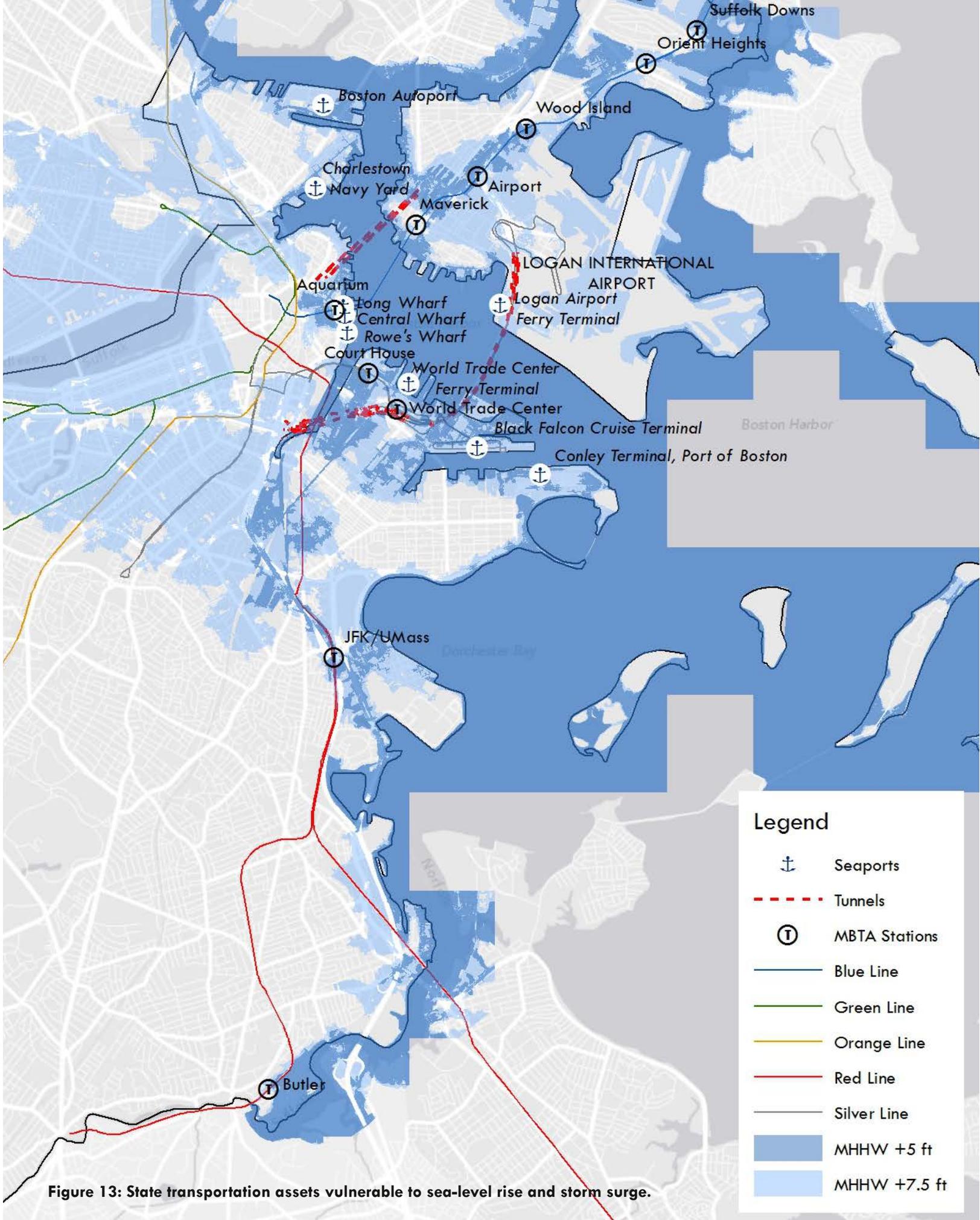


Figure 13: State transportation assets vulnerable to sea-level rise and storm surge.

# NEIGHBORHOODS

Boston's neighborhoods are characterized by their buildings and homes, historic character, and natural features including parks, open space and trees. Through its planning, permitting, and project review oversight, the City plays an important role in ensuring all Boston buildings and neighborhoods are prepared for the impacts of climate change.

As required by the 2011 climate action plan update and the Mayor's February 2013 directive, the City is currently taking many steps to increase the preparedness of new and existing buildings throughout Boston's neighborhoods. These include:

- The inclusion—first informal, now formal—of climate preparedness criteria in the Boston Redevelopment Authority's (BRA) review of new projects under Zoning Article 80.
- The work of the Inspection Services Department and the Public Health Commission to better communicate and enforce existing flood-proofing requirements.
- The Conservation Commission's recommendations to the Mayor of guidelines for a new local wetlands ordinance that would take into account sea-level rise.
- The partnership with the Green Ribbon Commission to encourage property owners to take their own steps to reduce vulnerability and identify ways that the City can support them.
- The work of Boston Public Health Commission, Office of Emergency Management (OEM), and others to ensure that vulnerable populations have access to preparedness resources and that all of Boston is planning for the long-term economic impacts of climate change.

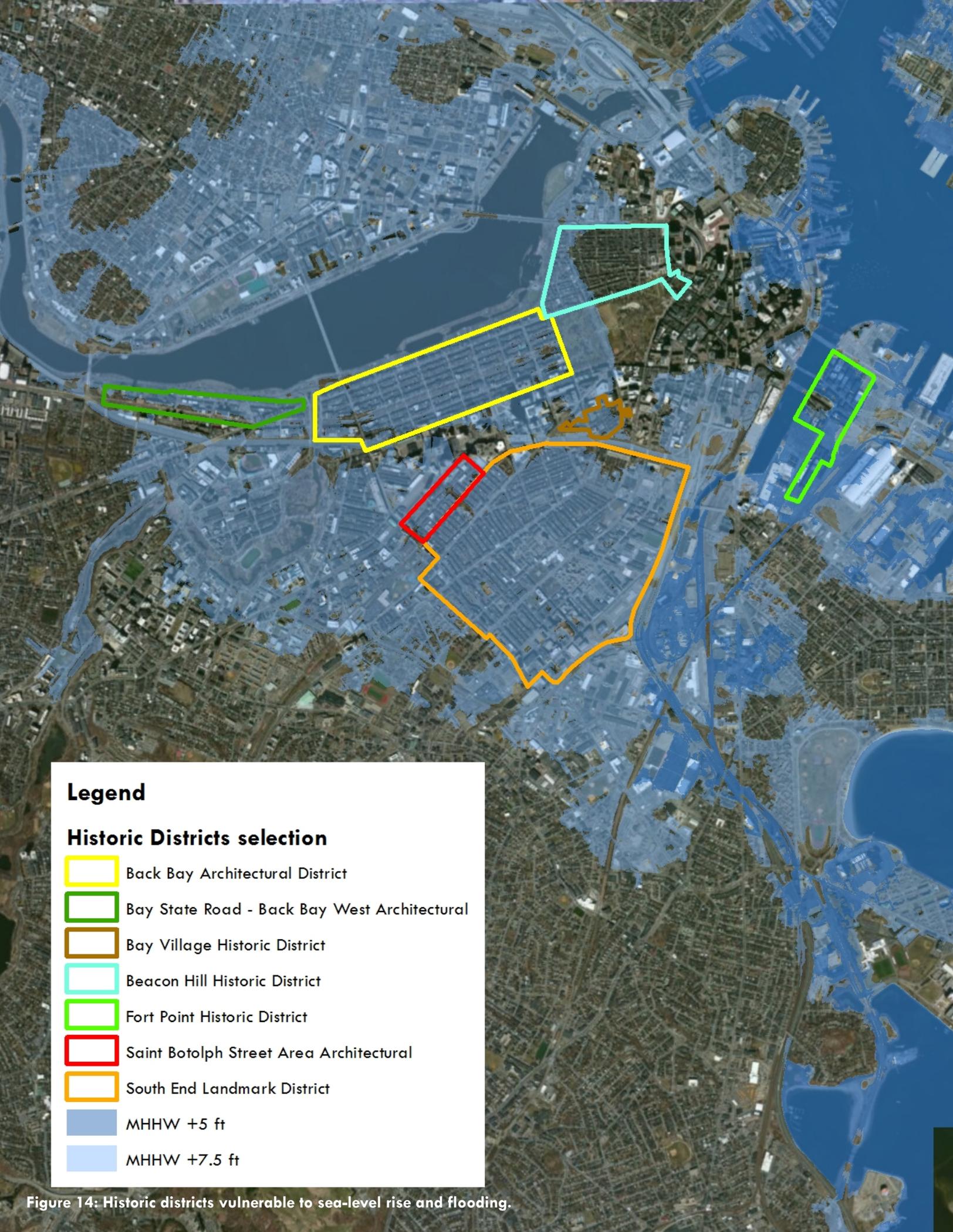
The Task Force's assessment identified additional areas that need increased attention.

## **HISTORIC PRESERVATION**

Many historic districts, such as Back Bay Architectural District, Bay Village Historic District, and Fort Point Channel Landmark District, are built on fill and therefore susceptible to flooding (see Figure 14). The Landmarks Commission will begin outreach to and develop suggestions for owners of historic properties in areas likely to be impacted. These will take into account the constraints on the building modifications allowed by current law.

The City's Archaeology Program in the Environment Department is focused on increased documentation of important historic sites, in particular, the several sites on the Boston Harbor Islands of which our knowledge is inadequate and which could disappear or be severely compromised due to sea-level rise, coastal erosion, and flooding.

For more information on historic preservation and climate change, please see the Environment Department's assessment in the Appendix.



## Legend

### Historic Districts selection

-  Back Bay Architectural District
-  Bay State Road - Back Bay West Architectural
-  Bay Village Historic District
-  Beacon Hill Historic District
-  Fort Point Historic District
-  Saint Botolph Street Area Architectural
-  South End Landmark District
-  MHHW +5 ft
-  MHHW +7.5 ft

Figure 14: Historic districts vulnerable to sea-level rise and flooding.

## **PARKS, OPEN SPACE, AND THE URBAN FOREST**

Parks, open space, street trees, and other green infrastructure are an important part of Boston's history and character and an important asset for public health and livability. In addition to providing recreation, beauty, and wildlife habitat, they help reduce the urban heat island effect, which can elevate daytime and nighttime temperatures, especially in summer. They reduce stormwater runoff and help absorb flood waters. Changes in temperature and precipitation patterns could stress trees and other vegetation due to heat, storms, or other extreme weather. Flooding, especially by salt water, could be very damaging. Climate change may also result in the introduction of new pests, diseases, or invasive species, causing additional stress. A warmer climate may also be causing some trees and other vegetation to produce more pollen, which can be a potent trigger for asthma and allergies. Although many agencies are responsible for vegetation on their properties, the Parks and Recreation Department is the primary custodian of public greenery. It has confirmed that monitoring the health of trees as the climate changes is a high priority for them, and that they will continue to review the evolving scientific research in this area and revise tree-planting guidelines, as appropriate. At a broader scale, Parks and Recreation is leading the City's development of a new open space plan, which will integrate climate change concerns throughout.



# PUBLIC HEALTH AND HEAT

Public health is an overriding concern in emergency preparedness and response, which is discussed in the next section. However, climate change will also raise important issues of public health in non-emergency situations.

Rising summer temperatures, especially, but not only, during heat waves, raise concern for everyone outdoors. Several City departments, including Parks and Recreation and Public Works, noted that they will need to review and possibly modify work schedules of employees and contractors—and even evaluate the times on permits for Parks facilities—to ensure personal health and safety. The Mayor’s Office of Arts, Tourism, and Special Events is already increasing the deployment of spray mists and water stations at outdoor public events during the summer, and will require applicants for Special Event Permits to do the same.

For the many Boston residents that do not have air-conditioning in their homes, the City is evaluating the need for additional cooling centers to prepare for more frequent and intense heat waves. The expanded use of libraries for this purpose is an important resource. However, as the experiences of Chicago and other cities have shown, a crucial factor in heat waves (and many other responses) is neighborhood connectedness, which decreases isolation and ensures that those who need help receive it. This means that fostering social and community health and cohesion is an important element of preparedness.

Higher temperatures, especially in summer, are also likely to worsen air quality, because they increase atmospheric chemical processes that produce ozone (smog). As discussed earlier, climate change may also increase pollen production. Increased humidity and frequency of flooding will encourage the growth of mold. All of these can increase the frequency and severity of asthma attacks, already a serious problem in many neighborhoods. The Public Health Commission places a high priority on increasing education and outreach about these long-term health impacts.

## **PUBLIC SAFETY AND EMERGENCY PREPAREDNESS**

Preparing for and responding to emergencies of all kinds involves all municipal departments and agencies. Many of the climate concerns that City departments raised in their assessments reflect current concerns in potential emergencies that could worsen due to climate change. For example:

- Cleaning up contaminated floodwater, sand bags, and other debris from streets and other public areas after floods;
- Effectively communicating road closures and other critical information to the public, and coordinating closures with emergency responders;
- Preventing staff fatigue and exhaustion (both physically and mentally) from more frequent or longer duration emergencies;
- Ensuring the availability of power supply for critical functions;
- Ensuring the availability of critical supplies for both staff and constituents;
- Providing secure and functional space in which to work in the event that primary and secondary office locations are unavailable; and
- Ensuring mobility of City workers to reach offices, constituents needing assistance, and other critical sites.

The City addresses these concerns through a variety of planning documents, in particular, the Emergency Operations Plan, overseen by the Mayor’s Office of Emergency Management (OEM), and the Continuity of Operations Plans (CoOPs), developed by individual departments under OEM guidance. The next steps of many departments include reviewing and revising their CoOPs in order to take account of the impacts of climate

change; and one of the top priorities of OEM is to update the Emergency Operations Plan and to assist individual departments in the CoOP revisions. As the Mayor directed last February, OEM also plans to review and update the city's evacuation routes and evacuation plan.

In terms of coordinating response in actual emergencies, OEM considers that the current Emergency Operations Center on Bragdon Street in Jamaica Plain is already inadequate based on a 2010 needs assessment and that climate change may increase demands on its use. The City is actively pursuing relocation of this facility.

During emergencies, the goals of the Boston Police Department shift beyond preventing and responding to crime to focus largely on emergency response to ensure the safety of Boston residents. Emergency responses may include: rescuing people who may become trapped in their homes or at work; directing traffic around flooded zones; and working with other agencies and first responders to provide access to emergency shelters and other emergency response centers and reduce fear and panic. A key component of this is maintaining open lines of communication to and from residents and internally. The vulnerability of some key communications infrastructure has already been discussed. One lesson from the 2013 Boston Marathon bombing was the effectiveness of social media. The City recently participated in Twitter's launch of Twitter Alerts, which builds off of the City's existing notification system, Alert Boston, to make public safety information more visible and accessible. In addition, the nature of crime can change during disasters. For example, in floods or extreme heat, street crime tends to go down, because people are likely to stay their homes—but that, in turn, sometimes leads to an increase in domestic disputes and violence. However, looting can also follow widespread destruction.

The Public Health Commission's responsibilities in emergencies include the set-up of emergency shelters, emergency response by EMS, and environmental health response to chemical spills and other hazardous conditions. Because of the growing risks from climate change, BPHC identifies assessment of staffing and resource levels and of current response and continuity of operations plans for these programs, including explicit consideration of vulnerable populations, a priority. Regular tabletop exercises or simulations to test plans and resources are also important.

Another important responsibility of City government is to help Boston businesses and residents prepare for emergencies. The major events of the past 12 months, including Hurricane Sandy, Nor'easter Nemo, and the 2013 Boston Marathon bombings, and the Mayor's 2013 February climate preparedness directive have increased the focus of many departments on this effort. For National Preparedness Month in September 2013, the Office of Business Development, OEM, and the Public Health Commission hosted events including "Mattapan is Preparing. Are you?" and a Twitter chat that connected the public with preparedness resources (Ready Boston), such as how to make a go-bag and how to create a family preparedness plan. The Marathon bombing taught the Department of Neighborhood Development many lessons in helping businesses and residents recover from disaster, such as how to navigate recovery resources including insurance, employment and wage information, access to donated work space, and assistance coping with trauma. It is particularly important that this help also be accessible and available for low-income and vulnerable populations. Boston's many tourists, who are not familiar with city and its resources, are another special concern during emergencies.

Another major concern is continuity of care for vulnerable individuals, including those with serious chronic health conditions and those whom BPHC serves through its addictive treatment services, homeless services, and services at the Tuberculosis Clinic. Planning for disaster response and recovery also needs to include protocols for relocation/rescue of incarcerated populations and those in medical care facilities. BPHC is reviewing contingency plans and other efforts to ensure that critical services will remain functional during a major disaster, including those that are becoming more likely due to climate change, and that the needs of vulnerable populations will be met. Concerns about the Long Island Bridge, already discussed, are linked to this. The City will need to work more closely with the community and the utilities to identify individuals who rely on electronic medical devices to ensure continuous availability of power.

# STATE AND FEDERAL COORDINATION

In their assessments, many departments identified the importance of coordination and engagement with other levels of government as essential for increasing the climate preparedness of Boston. This concerns both short-term operational coordination for different jurisdictional responsibilities and longer-term engagement involving infrastructure and planning subject to different jurisdictional ownership and authority.

## MAJOR INFRASTRUCTURE NOT UNDER CITY JURISDICTION

Several systems and specific infrastructure essential to the climate preparedness of Boston are not under the City's direct or regulatory control. These include:

- The Central Artery, the Harbor Tunnels, the Mass Pike (MassDOT)
- The public transportation system (MBTA)
- Logan Airport and Port of Boston (Massport)
- Deer Island Waste Water Treatment Plant and the Quabbin Reservoir (MWRA)
- Storrow Drive, Arborway and Jamaicaaway, Morrissey Boulevard (DCR)
- Electricity and natural gas distribution system (regulated by Public Utilities Commission)
- Regional electricity grid and electrical generating units (ISO-New England and FERC)
- Various state and federally owned buildings

All of these systems and facilities need to be climate-prepared. The City is working with the Commonwealth and its agencies and authorities and the federal government at many levels, formally and informally, to make faster progress in assessing vulnerability and taking preparedness actions.

## NEED FOR OPERATIONAL COORDINATION

As climate vulnerabilities in Boston and across the region increase, emergency response will require more extensive coordination and regional planning with the Commonwealth, neighboring cities, and important private and institutional entities. This will include:

- Communication on, for example, road closings, evacuation routes, critical risks, areas of need;
- Sharing of resources, including emergency personnel and equipment;
- Management of the regional transportation system;
- Management of the regional health-care system; and
- Allocation of resources for recovery.

Much of this is already managed through the alignment of city, state, and federal emergency plans through frameworks of the Federal Emergency Management Agency (FEMA). Nonetheless, as with the City's own emergency plans, these need to be reviewed in light of growing climate-related vulnerabilities.