Open Space Plan 2015-2021

Section 4
Environmental Inventory & Analysis

Section 4.1:
Geology, Soils and Topography

INTRODUCTION

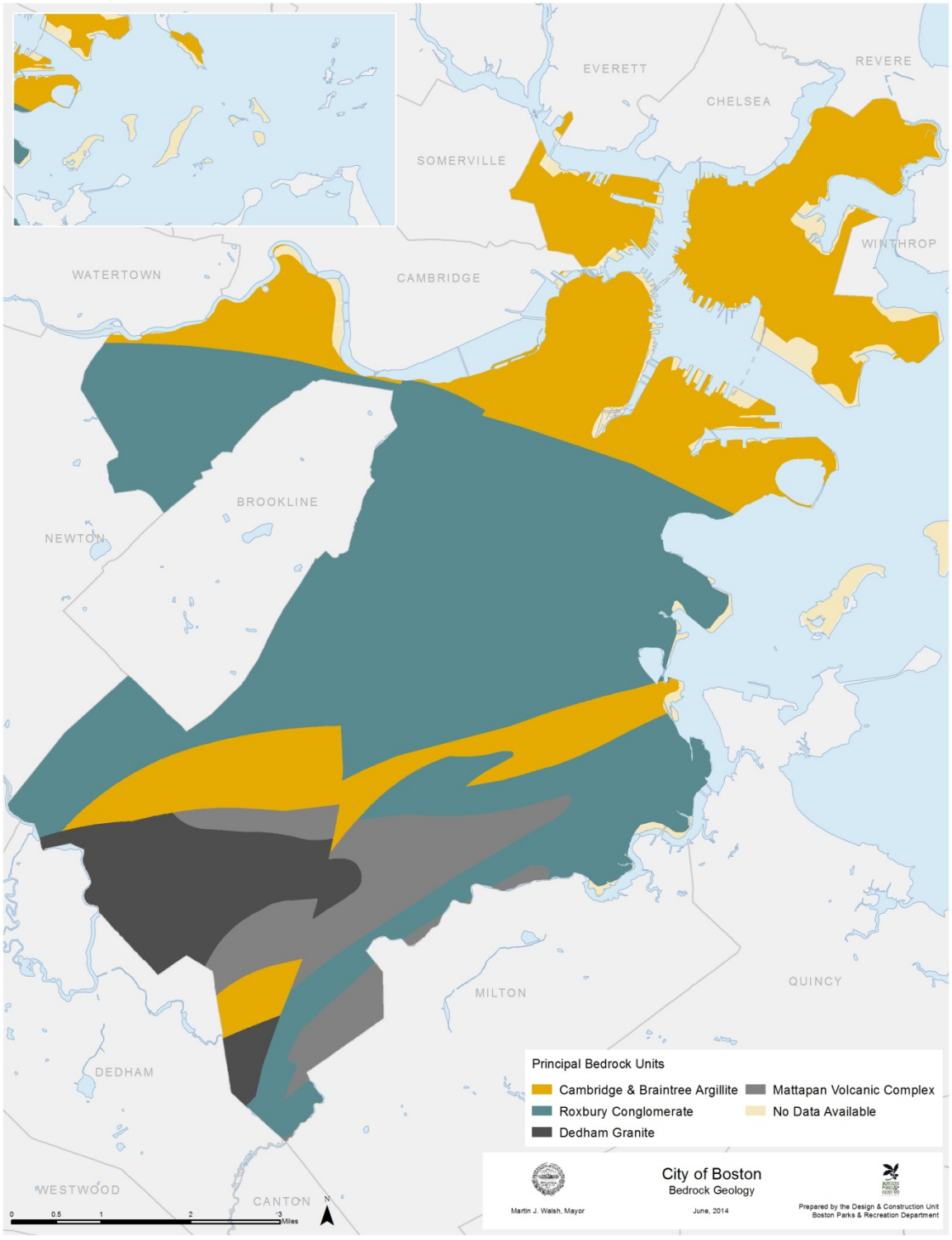
Boston is situated in topographic lowland, referred to as the Boston Basin. This lowland is surrounded by a ring of hills that circle it from the Middlesex Fells to the north, inland to the Belmont Hills and Newton Highlands to the west, and around to the Blue Hills to the south. As with most areas in the Northeast, Boston's geology is attributed to several different geologic processes. The geology of Boston can be described by its bedrock, structural, and surficial features including glacial, fluvial, and wind deposited sediments. The soils of Boston reflect these geological factors, as well as influences due to vegetation and humans.

BEDROCK GEOLOGY

The principal bedrock units that belong to the Boston Basin include the Cambridge Argillite, Roxbury Conglomerate, Mattapan Volcanic Complex, and the Dedham Granite. The Cambridge Argillite is classified as a shale or mudstone. This fine-grained sedimentary unit was most likely deposited in deep oceanic waters millions of years ago when the Boston area was below sea level. This unit currently lies well below Allston, Back Bay, Central Boston, Charlestown, East Boston, South Boston, and the South End.

The Roxbury Conglomerate is known as Puddingstone. This unit consists of pebbles and cobbles within a matrix of varying rock types. The range of size of the cobbles suggests that a river or stream deposited this unit. The Roxbury Conglomerate underlies much of Boston including Brighton, Kenmore/Fenway, Jamaica Plain, Mission Hill, Dorchester, Roxbury, and the northern portions of Mattapan, Roslindale, and West Roxbury.

The Mattapan Volcanic Complex is one of the oldest rock units found in Boston. These volcanic rocks are primarily granite.



Pebbles and cobbles from this unit have been found in the Roxbury Conglomerate. This suggests that the Mattapan Volcanic Complex is older than the Roxbury Conglomerate, having experienced

erosion, producing pebbles and cobbles that later formed the Roxbury Conglomerate. The Mattapan Volcanic Complex lies under the southern portion of Mattapan and large portions of Hyde Park.

The Dedham Granite is most likely the oldest rock unit found in Boston. This unit, which is found below the southern portions of Hyde Park and West Roxbury, is a Precambrian age rock that indicates an age well in excess of 600 million years.

STRUCTURAL GEOLOGY

Structurally, several features distinguish the Boston Basin. These include plunges, folds, anticlines, synclines, and faults. These structural features are found throughout the many rock units in the Boston Basin. Geologists use these features to date rock units relative to each other.

Plunges are physically represented by a significant dip in the bedrock. In the Boston Basin, the bedrock generally plunges east/ northeast. This means that if a plunging rock unit were exposed at the surface in a southwest area of Boston, that same rock unit would be hundreds of feet deep in a northeast area of Boston.

Structural features such as folds in the bedrock are evident in the Boston Basin. These folds occurred over 600 million years ago as the rocks were subjected to tectonic stress, causing the once flat-lying rocks to bend and fold. This stress also resulted in the formation of anticlines and synclines. These features are simply bedrock that has been folded up or down, respectively. Anticlines underlie Central Boston, Mattapan, and the Lower Mills. Synclines are found under the Charles River basin, Roslindale, and Hyde Park.

Inactive faults can also be located within the Boston Basin. These faults mark boundaries where different rock units once met and moved relative to one another. Thrust faults, where one rock unit is lifted above the other, are found at Mt. Hope Cemetery, the Neponset Valley, and the Blue Hills. Transverse faults, where units move in opposite directions, include the Stony Brook fault.

Environmental Inventory & Analysis

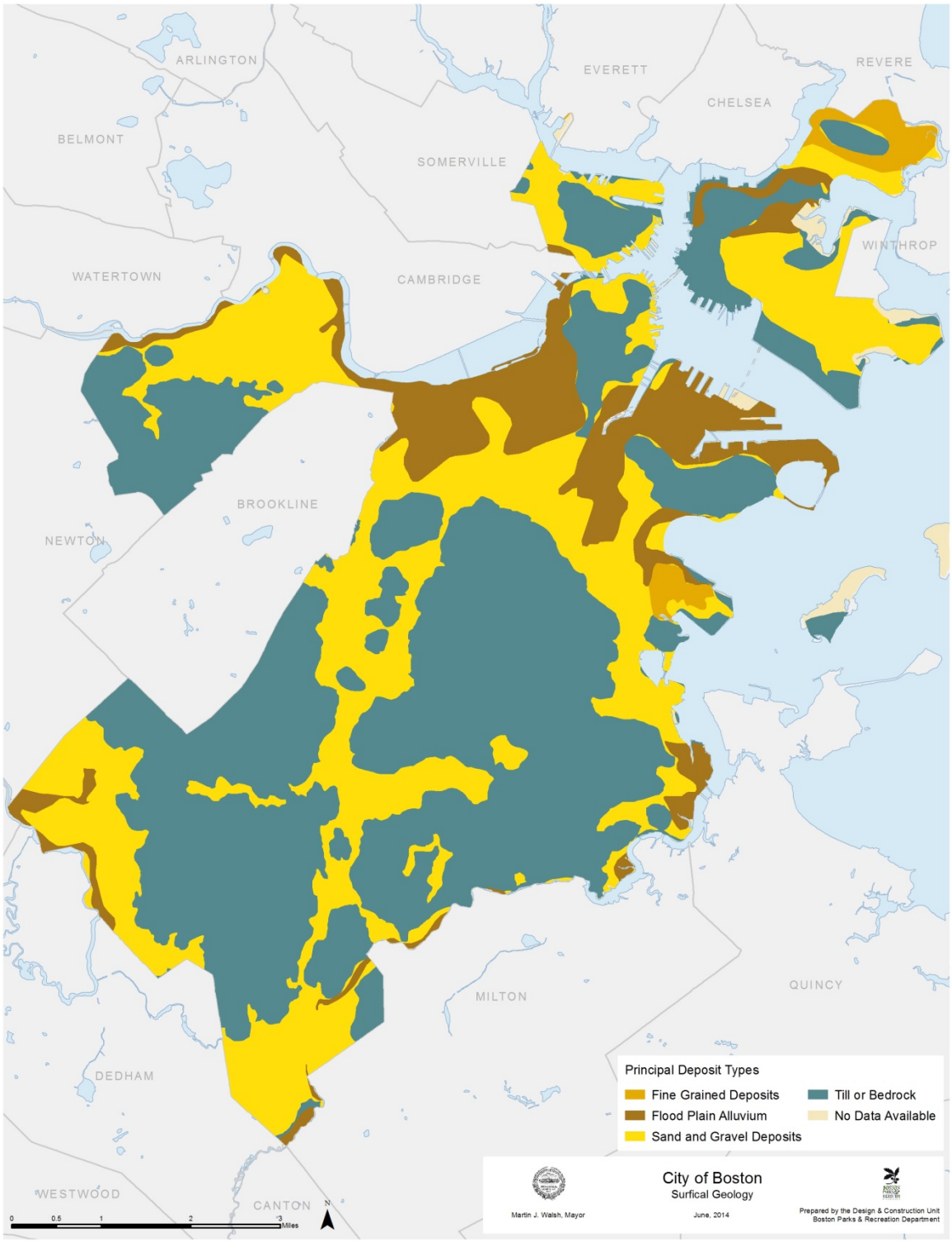
SURFICIAL GEOLOGY

The surficial geology of the Boston Basin is the dominant factor regarding Boston's landscape. The surficial geology of Boston includes glacial drift, glacial outwash, riverine deposits, and marine clays, as well as loess, which is fine silt deposited by wind.

Glacial landforms dominate the current topography of Boston. These landforms resulted from periods of extensive glaciation approximately 10,000 to 50,000 years ago. Repeated advances of thick glacial ice resulted in deformation of the earth's crust. Valleys that existed 50,000 years ago were scoured, deepened, and widened by glacial ice. Glacial till – unconsolidated, non-stratified glacial drift – was deposited in depths of up to 150 feet. This till was commonly deposited as smooth, oval shaped hills known as drumlins. The Boston Basin has more than 100 of these drumlin features including the Harbor Islands, Breeds Hill, and Bunker Hill. A major factor in the Boston Harbor Islands' designation by the National Park Service as a National Recreation Area is that it is the only drumlin field in North America to intersect a coastline.

Deglaciation of the Basin had a profound effect on the current landscape. As glacial ice began to melt, the run-off deposited sands, gravel, and silts that had been trapped in the glacial ice. Changing sea levels, freshwater streams, wind, and erosion then modified these glacial deposits, thereby forming varied, sorted layers throughout the basin.

The prominent deposits on Boston's current topography include sand, gravel, till, bedrock, and silt and clay deposited by both fresh and estuarine water. Sand and gravel deposits run north/south through Boston. These deposits represent glacial outwash that was deposited as glacial ice melted. These deposits are found in abundance in Allston, Hyde Park, Jamaica Plain, North Dorchester, Roslindale, the South End, and West Roxbury. These deposits are well suited for development, as they are relatively stable and flat. Sand and gravel deposits typically, however, have a high water table, which may cause basements to be more susceptible to


ARLINGTON
EVERETT
REVERE
CHELSEA
BELMONT
SOMERVILLE
WINTHROP
WATERTOWN
CAMBRIDGE
BROOKLINE
NEWTON
MILTON
QUINCY
DEDHAM
WESTWOOD
CANTON
0 0.5 1 2 3 Miles
N
Principal Deposit Types
Fine Grained Deposits
Flood Plain Alluvium
Sand and Gravel Deposits
Till or Bedrock
No Data Available
City of Boston
Surfical Geology
June, 2014
Martin J. Walsh, Mayor
Prepared by the Design & Construction Unit
Boston Parks & Recreation Department

flooding. A high water table and the speed at which fluids move through sand and gravel can increase a surface release's capability to pollute groundwater.

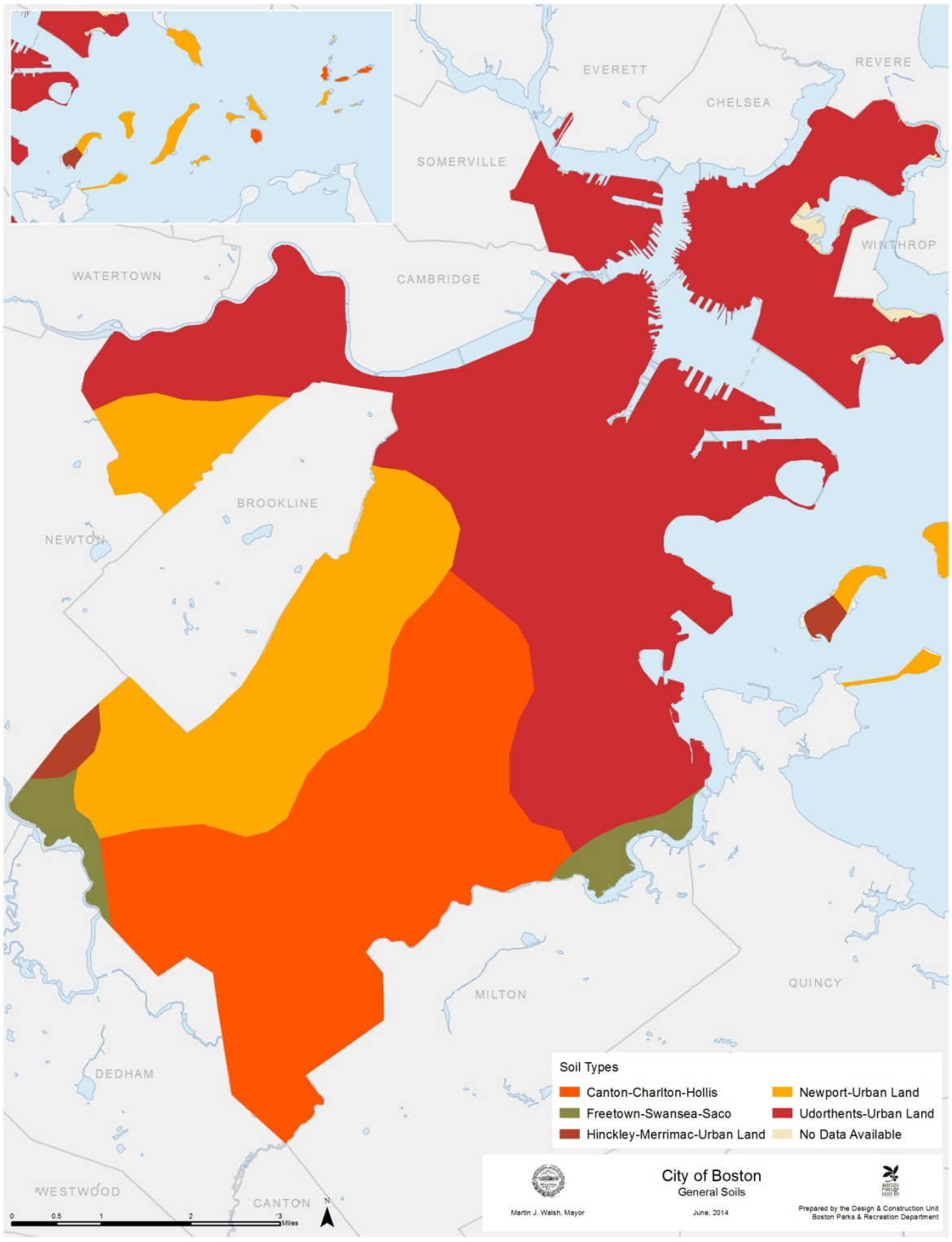
Till and bedrock are found throughout the city and are characteristic of areas which contain drumlin hills. Neighborhoods that are dominated by till and bedrock deposits include Brighton, Central Boston, Dorchester, Mattapan, Roslindale, Roxbury, and West Roxbury. Till and bedrock are considered to be extremely stable materials for development, although they also present constraints. Bedrock presents difficulties in excavation while till is commonly found as a drumlin hill, possibly causing topographic restraints for development.

Floodplain alluvium consists of fine-grained material such as fine sands and silts that are found adjacent to, and deposited by, rivers and tidal marshes. These deposits underlie the Back Bay, Fenway/Kenmore, and South Boston. These deposits are now covered by artificial fill that was laid down in the late 18th and 19th centuries to allow development of these lands. The obvious development constraints associated with this material include instability and a high water table. The material does, however, possess a low permeability, thus trapping pollutants and resulting in a slow migration which can be contained should a release of pollutants occur.

SOILS

The soils of the Boston Basin are derived from natural glacial processes and artificial processes attributed to the extensive filling of lands by humans. The three largest generalized soil units in Boston are Udorthents-Urban Land, Canton-Charlton-Hollis, and Newport-Urban Land units. These units are typically deep deposits found on land with a topographic range from nearly level to moderately steep.

Udorthents-Urban Land soils occupy most of Boston. These soils are found in areas that were previously tidal marshes, flood plains, bays, harbors, and swamps. Udorthents are classified as areas where native soil has been removed and filled with artificial soil material. The fill consists of soil material, rubble, refuse, and



channel dredgings. Depth of this unit ranges from 2 to 20 feet. Land that is 85% or more covered by an impermeable surface such as concrete and asphalt including roads, sidewalks, and buildings

is defined as Urban Land. Urban Land overlays actual soil units that cannot be determined due to the urban coverage.

The Canton-Charlton-Hollis unit is characterized by well drained, loamy soils formed from glacial deposits. This unit is typically found on low hills and uplands in Hyde Park, Mattapan, and Roslindale. Canton soils are found on small undulating hills adjacent to valleys. Charlton soils are located in depressions between ridges at higher elevations. Hollis soils are found at the top of ridges and near rock outcrops. These soils are conducive to woodland growth, and are suitable for development.

Newport-Urban Land is commonly found on steep hillsides in the Boston Basin. This unit is found on top slopes and side slopes in Jamaica Plain and West Roxbury. Course fragments of flat dark gray shale and slate in the substratum characterize it. A layer of compacted glacial till causes low permeability and a perched water table, potentially contributing to wet basements in residential areas.

TOPOGRAPHY

Ten to twelve thousand years ago, glaciers shaped the landscape that subsequently Native Americans inhabited and Europeans colonized. These massive sheets of ice moved across the land, totally displacing all flora and fauna in the area. The ice sheets' great weight caused the coastal lands to sink below the surface of the ocean.

After the glaciers retreated, the most prominent landscape features were the drumlins, hills made up of glacial till. They tend to have an oval shape, with the "points" of the oval aligned in the direction of the glacial retreat. (Many of the harbor islands are such drumlins.) The glaciers also left sand and gravel deposits through many parts of Boston, such as along the Charles in West Roxbury and Allston-Brighton, in the Stony Brook Valley in Jamaica Plain, Roxbury, Roslindale, and Hyde Park, and near Dorchester Bay in Dorchester and South Boston. Overall, the terrain of Boston is gently rolling, with heights ranging from near sea level along the coast to 370 feet above sea level at the highest point, Bellevue Hill in West Roxbury, within the Department of Conservation and Recreation's (DCR) Bellevue Hill Reservation.

Section 4.2: Landscape Character

INTRODUCTION

Boston's landscape is rich in history. It has been changing since the city's founding in 1630. These changes have left traces on the landscape of the city. The growth of the city's landmass has been the most significant evidence of the change of this landscape.

HISTORY OF THE LANDSCAPE

Boston's original landscape is considerably different from its present day appearance. This landscape has changed more than any other city in the country. Boston was originally settled on the Shawmut Peninsula, which is now Central Boston. This peninsula was comprised of three hills: Beacon Hill, Copp's Hill, and Fort Hill. Washington Street, a thin neck of land that often flooded at high tide, connected the peninsula and its hills to the mainland. Originally an area of 1,000 acres, the city has grown to its current area of approximately 30,000 acres through land reclamation and annexation.

Development of the city involved the filling of its coastal and bay areas. The first salt marshes destroyed by European settlers were the land around the perimeter of Shawmut Peninsula and the Boston Neck. Between 1810 and 1850, Mill Cove was filled and development of South Boston had begun. By 1870 the Commonwealth was filling the Back Bay. During that same period, the City of Boston had planned and was developing the South End (the area surrounding Washington Street). Charlestown and South Boston continued to be filled during this period. Between 1870 and 1880 the Back Bay was completely filled while South Boston and East Boston continued to grow. Filling of salt marshes continued into the 20th century as East Boston and Breeds Island were connected and South Bay and Columbia Point were filled.

While the filling of salt marshes added new area to the city, annexation incorporated towns into the city's jurisdiction. Annexation began with Roxbury in 1868 and by 1874 Dorchester, Charlestown, Brighton, and West Roxbury had been added. Hyde Park was the last town annexed when it joined the City of Boston in 1912. These annexed towns now represent Boston's neighborhoods. Fenway/Kenmore and Mission Hill were formerly parts of the Town of Roxbury. Roslindale and Jamaica Plain were parts of West Roxbury. Dorchester included Mattapan, and Allston and Brighton were part of the Town of Brighton.

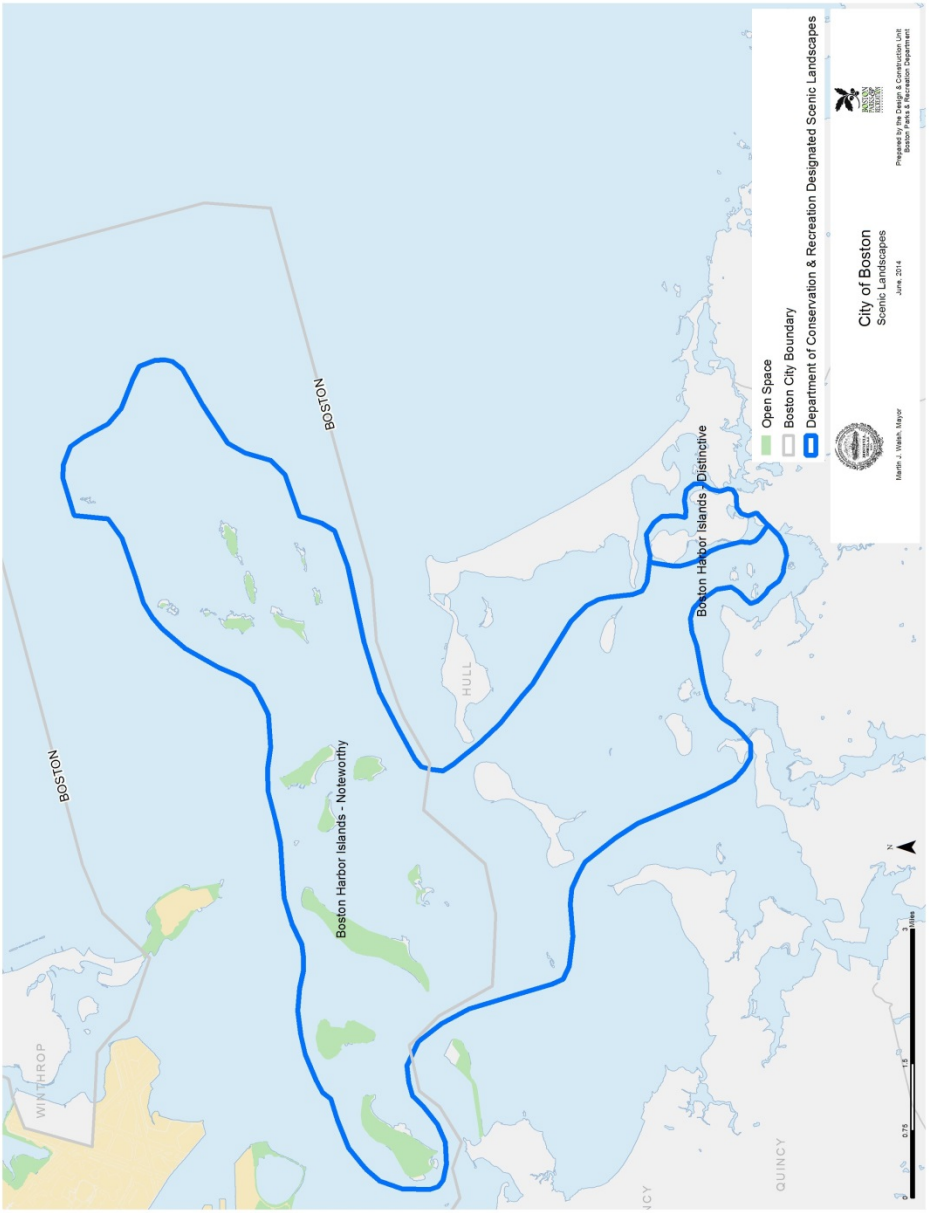
CURRENT ASSESSMENT

Boston has become a highly urbanized area from the perspective of openness of the landscape. High-rise towers and dense apartment buildings dominate the landscape in the downtown areas. Nearby neighborhoods such as Charlestown, East Boston, South Boston, and Allston have considerable low-rise industrial development. Low-rise residential developments dominate the neighborhoods further out from downtown, such as Roxbury, the South End, Jamaica Plain, Mattapan, and Dorchester. A mix of high- and low-density residential developments dominates the landscape in neighborhoods such as Roslindale, West Roxbury, and Hyde Park.

Despite this historical spread of development across Boston's landscape, the city has retained much natural beauty and many open lands thanks to the cumulative wisdom of its citizenry over time. It was felt that a portion of the city's land must be preserved for the recreation, relaxation, and scenic enjoyment of its citizens. Both the municipal and the metropolitan park systems preserve much of this landscape character. For example, hills, ponds, and wetlands are preserved in Allandale Woods under the city's jurisdiction, and in the Stony Brook Reservation under the DCR.

Water is a prominent part of the landscape character of Boston. With extensive miles of coastline and riverfront, Boston is blessed with aquatic resources, coastal and estuarine wetlands, and scenic vistas. Within city limits are many of the Boston Harbor Islands that now make up the Boston Harbor Islands National Recreation Area. Much of this area is considered a "noteworthy landscape," by the Department of Conservation and Recreation's statewide Landscape Inventory. Boston's open lands are a mixture of

uplands and wetlands. Most of the upland areas consist of forest, with the remainder in fields and meadows. These upland areas are generally either publicly owned parklands and cemeteries or privately owned cemeteries. The larger, expansive wetland areas are primarily under public ownership. Boston is a highly mature, developed community. Developable land that is as yet undeveloped is extremely limited. The protection of the natural resources and open areas of Boston's landscape is as vital a function now as it was in the 19th and 20th centuries.



Section 4.3: Water Resources

INTRODUCTION

The settlement of Boston upon the Shawmut Peninsula took place due to the area's outstanding water resources. Mainland Boston is bordered by water to the north, south, and east. These water resources include an ocean harbor, rivers, streams, ponds, and wetlands.

BOSTON HARBOR

To the east, ten miles of the city's shoreline lies on Boston Harbor. The Harbor consists of several unique areas which border Boston, more specifically, its Charlestown, Central Boston, East Boston, South Boston, and Dorchester neighborhoods. Sections of the Harbor include the Inner Harbor, the Outer Harbor, and Dorchester Bay.

Charlestown, East Boston, Central Boston, and South Boston bound the Inner Harbor, which stretches from the confluence of the Mystic and Chelsea Rivers to the Fort Independence and Fort Winthrop sections of South and East Boston, respectively. The Inner Harbor is used for recreational fishing and boating, and maritime/ industrial uses. Freighters and ferries are common in its shipping channels and designated deep port areas. The Inner Harbor includes three channels: the Little Mystic, Fort Point, and the Reserved Channel. These channels are large capacity docking points that can provide protection during rough seas.

The Outer Harbor is home to dozens of islands. The City owns four islands: Long Island, Moon Island, Rainsford Island, and a large portion of Spectacle Island. The islands are partly submerged drumlin hills formed through glacial action. Rounded hills, open fields, forests, and historical sites characterize these islands. The Harbor Islands, which once had uses such as military forts, hospitals and industrial plants, have generally reverted to a more natural state. Beaches are found on Spectacle Island, Long Island, Lovells Island, Thompson Island, and Gallops Island. The water of

the Outer Harbor is typically used for swimming, boating, fishing, and navigation by commercial ships.

Constitution Beach Bay (aka Orient Heights Bay) is located on the eastern coast of East Boston between Logan Airport and Orient Heights. Swimming and fishing are common activities here. The bay includes 275 acres in Belle Isle Marsh, which is part of the designated Rumney Marshes Area of Critical Environmental Concern (ACEC). These marshes are among the most important biological resources in the city. They are host to numerous species of waterfowl, wading shore birds, migrant songbirds, invertebrates, and fish. Constitution Beach is a small beach area on tidal flats located in the northern section of the bay. Marshes to the west and the Belle Isle Marsh to the east border the beach.

Dorchester Bay stretches from Castle Island at Pleasure Bay in South Boston to the mouth of the Neponset River at Commercial Point in southern Dorchester. Dorchester Bay is used primarily for boating, fishing, and swimming. Swimmers gain access to the water at several locations along the bay in both South Boston and Dorchester. Access points include the beaches of Pleasure Bay, L & M Street Beaches, and Carson Beach in South Boston, and Savin Hill and Malibu Beaches in Dorchester.

WATERSHEDS

Boston is divided into two major watersheds: The Charles River watershed and the Boston Harbor watershed. The Water Resources map shows the major watersheds and the minor watersheds.

More than half of the city's land area is within the Charles River watershed, including the western half of the city and portions of Charlestown, the West End and the Back Bay. Much of the eastern and southernmost portions of the city are part of the Boston Harbor Watershed. This watershed is further subdivided into three minor watersheds: the Mystic River sub-watershed, which includes such large water bodies as the Chelsea River, Constitution Bay, and Belle Isle Inlet, as well as the Rumney Marshes ACEC; Boston Harbor (Proper), which includes portions of the Inner Harbor and the whole of Dorchester Bay; and the Neponset River sub-watershed, which includes Mother Brook in Hyde Park. The Neponset River sub-watershed includes two Areas of Critical Environmental

Concern (ACEC): the Fowl Meadow/Ponkapoag Bog ACEC along the southernmost segment of the Neponset, and the Neponset Estuary ACEC in the vicinity of the mouth of the Neponset.

Both the Charles and the Boston Harbor watersheds are heavily urbanized, yet both contain valued ecosystems and heavily used recreation areas. Regulated by the Charles River Dam at its mouth, the wetlands in the Charles River watershed are dominated by freshwater, whereas estuarine and saltwater wetlands predominate in the Boston Harbor watershed. The Charles River watershed has such heavily used park systems as the Charles River Reservation and the Emerald Necklace, as well as Stony Brook Reservation, Cutler Park, and Millennium Park. The Boston Harbor watershed has major metropolitan beaches such as Constitution Beach, Pleasure Bay, Carson Beach, Savin Hill Beach, and Tenean Beach. It also contains the Boston Harbor Islands National Recreation Area in the Outer Harbor. These islands contain trails, paths, campsites, beaches, and vistas that are attracting a growing number of visitors. Thanks to the Coastal Zone Management program and the Chapter 91 regulations, as well as Boston Redevelopment Authority (BRA) policy, a Harborwalk has been put in place, enabling the public to access the Boston Harbor waterfront. The open spaces listed above are now connected together to form a linked system akin to the Charles River Reservation. (please see Section 7.1.2 for further details)

RIVERS

The City of Boston is traversed by five rivers: the Charles River, the Muddy River, the Neponset River, the Chelsea River, and the Mystic River.

Charles River

The Charles River originates southwest of Boston at Echo Lake in Hopkinton, MA. The upper section of the Charles River drains a watershed of approximately 310 square miles. The river meanders 80 miles from its source to the Charles River Dam where it empties into Boston Harbor. Before reaching the Harbor, the Charles flows along West Roxbury, Allston, Fenway/Kenmore, the Back Bay, and the West End of Boston. The river comprises eight miles of shoreline within the city including the Charles River Reservation and the parkways of Soldiers Field Road and Storrow Drive. The portion of the Charles between the Charles River Dam and Boston University Bridge is referred to as the Charles River Basin. This section of the river, which once inundated the Back Bay, is a wide and deep impoundment of freshwater used extensively for rowing

and sailing. The water of the Charles River is classified as Class B by the Massachusetts Department of Environmental Protection (MADEP). This type of water is considered swimmable and fishable, though these uses of the Charles River are currently impaired (see Water Quality section).

Neponset River

The Neponset River flows for a total of 28 miles from the Neponset Reservoir in Foxborough to Boston Harbor at Dorchester Bay. The river drains a watershed of 323 square miles south and west of Boston. The small gradient of the river results in slow currents and several wetlands along the Neponset. The Neponset flows east along seven miles of natural, meandering banks to the south of Boston through Hyde Park and along Mattapan and South Dorchester. This section of the River is bordered by the Neponset River Reservation, which includes a large tidal wetland in South Dorchester. The lower four miles of the river from Dorchester Bay to the Lower Mills Dam in southern Dorchester are tidal and frequently used for bird watching, picnicking, canoeing, and fishing. The MADEP has classified these waters as SB, allowing fishing and swimming, but restricting shellfishing.

Muddy River

The Muddy River originates at Jamaica Pond and flows north 3.5 miles before joining the Charles River. It flows through four distinct parklands designed by Frederic Law Olmsted: Olmsted Park from Ward's Pond to Leverett Pond, the Riverway from Leverett Pond to Park Drive and Brookline Avenue, the Back Bay Fens from Park Drive and Brookline Avenue to the Boylston Street Bridge, and Charlesgate from the Boylston Street Bridge to the Charles River. Within these parks, the Muddy's Class B (MADEP) waters are primarily used for passive recreation.

The river's watershed drains 8.6 square miles of land, only 25% of which are in Boston. From Jamaica Pond to Leverett Pond, the 2% gradient is steep – an average of a two-foot drop in elevation every 100 feet downstream. This section of the river flows through Olmsted Park, including Ward's Pond, Willow Pond, and several small waterfalls.

The lower section of the river flows from Leverett Pond to the Charles River with a gradient of less than 0.01%, causing the river to be essentially flat with little current. From Leverett Pond, the

Muddy meanders through the Riverway before reaching the Brookline Avenue gates at Park Drive. When these gates are opened during times of flood, a portion of the Muddy's flow is directed through the Muddy River Conduit under Brookline Avenue and is emptied directly into the Charles River. During periods of normal flow, river water travels one and one-half miles through the Back Bay Fens to the Charles River.

Since October of 1996, the Muddy River has flooded three times, causing damage to residences, businesses, academic, medical and cultural institutions and the public transit system in Boston and Brookline. To alleviate this problem, a dredging and ecological restoration project for this river, managed by the US Army Corps of Engineers, began construction in 2013. The objectives of the Muddy River Restoration project are:

- Improvement of flood control;
- Improvement of water quality;
- Enhancement of aquatic/riparian habitat;
- Rehabilitation of landscape and historic resources; and
- Implementation of Best Management Practices (BMPs).

Planned work includes channel improvements, removal of undersized culverts, installation of two new culverts, and daylighting two sections (about 700 linear feet) of the Muddy River; dredging approximately 200,000 cubic yards of sediment from the Fens, Riverway, Leverett, Willow and Wards Ponds; eradication of Phragmites from wetland and riparian areas by dredging and cutting/herbicide treatment; and preservation and restoration of the historic park shoreline and vegetation in construction areas. The multi-phase project is anticipated to be complete by spring of 2016.

Chelsea River

The Chelsea River, also known as Chelsea Creek, is a short tidal estuary and Boston's only remaining undammed river. From its origin as Mill Creek in Chelsea and Revere, it flows approximately three miles past the heavily industrialized north shore of East Boston and into the Inner Harbor.

Mystic River

The Mystic River originates at the Mystic Lakes section of the Middlesex Fells Reservation, approximately five miles northwest of Charlestown. There are approximately two miles of Mystic River

frontage on Charlestown's north shore, and most of this is dominated by industrial marine transportation enterprises. The Mystic meets the Chelsea River under the Tobin Bridge to form the northern part of the Inner Harbor.

BROOKS & STREAMS

Stony Brook

At one time, Stony Brook traversed Boston for approximately seven miles. The majority of the stream has been culverted to accommodate development and stormwater conveyance. Currently, the only portion remaining above ground is at its origin in the Stony Brook Reservation in West Roxbury. The Stony Brook Conduit (SBC) discharges into the Muddy River in the Back Bay Fens. The SBC carries mostly brook flow in dry weather and combined sewer overflows (CSOs) along with stormwater flows in wet weather. The conduit discharges to the Charles River, and occasionally overflows to the Back Bay Fens Pond at Boston Gatehouse No. 1.

Canterbury Brook

Canterbury Brook is a tributary of Stony Brook. It is a partially culverted and partially exposed body of water that is fed by Scarborough Pond within Franklin Park, as well as by storm drains from surrounding neighborhoods in Mattapan and Roslindale. The brook flows southwest through both sections of the former Boston State Hospital site, along the edge of the Boston Nature Center, through part of the Canterbury I Urban Wild on the edge of the Greenleaf Composting operation, through part of St. Michael's Cemetery, and then briefly along the northern side of American Legion Highway south of Walk Hill Street. The brook disappears and reappears at various points along its route, dropping underground south of Walk Hill Street and ultimately merging with the Stony Brook Conduit underground.

Mother Brook

Mother Brook was the first canal constructed in the New World. Originating at a diversion dam on the Charles River in Dedham, it flows east through Hyde Park where it joins the Neponset River. The first three-quarter mile section of Mother Brook, located in Dedham, is an artificial canal excavated to connect the Charles

River to a branch of the Neponset River formerly known as East Brook. Therefore, Mother Brook diverts one-third of the flow of the Charles River. This represents the equivalent of 60 square miles of drainage area added to a natural drainage basin of five square miles.

Bussey Brook

Bussey Brook flows through portions of West Roxbury, Roslindale, and Jamaica Plain before discharging underground into the Stony Brook Conduit near the Forest Hills MBTA station. Like other streams in Boston, it has been almost completely buried, though remnant above-ground sections can be found in Allandale Woods and the Arnold Arboretum. Though seriously degraded by culverting and urban run-off, these remaining sections of Bussey Brook represent some of the most important aquatic resources in Boston.

Sawmill Brook

Sawmill Brook traverses the perimeter of both Millennium Park (the former Gardner Street landfill) and the DCR Brook Farm Reservation in West Roxbury. Though channelized in sections and diverted by construction of the landfill, it is an important tributary to the Charles River. Small, wooded sections of Sawmill Brook occurring within the Brook Farm Reservation are critical habitat to a number of wildlife species, including a state-listed rare amphibian (see Wildlife section).

Dana Brook

Dana Brook was formerly the main drainage channel in West Brighton. It now lays completely underground from Chandler Pond to the Charles River, a distance of approximately one and one-half miles. Segments of Dana Brook still exist upstream of Chandler Pond, on the Newton Commonwealth Golf Course within Newton. This is the main inlet for Chandler Pond.

PONDS

Boston contains several ponds and a reservoir. These bodies of water vary in nature and origin from glacial ponds to river ponds to artificial ponds and reservoirs. Glacial ponds were formed by glacial processes involving melting water and large blocks of ice

deposited upon Boston's landscape, forming ponds. These glacial ponds are referred to as kettle ponds. Kettle ponds are common in the Boston Basin. One example is Jamaica Pond, at approximately 80 acres the largest natural pond in Boston.

Turtle Pond is located within the Stony Brook Reservation in Hyde Park and is another natural pond of great significance. It is a popular fishing spot and, despite the presence of the adjacent Turtle Pond Parkway, is relatively undisturbed and has generally good water quality. In addition, several small, unnamed ponds within the Stony Brook Reservation provide critical habitat to a number of important wildlife species. Other small woodland ponds occur in Allandale Woods.

Boston also contains many artificial ponds, and ponds that are part of river systems. One of the most notable artificial ponds is the Public Garden Lagoon. This pond was created in 1838 during the construction of the Public Garden. Mill Pond in Hyde Park is an artificial pond that was created through an impoundment of Mother Brook. Chandler Pond, located in Brighton, was originally excavated for the purpose of producing ice. It is the last of more than 20 ponds once found in Brighton. Scarborough Pond in Franklin Park was dug out in the 1890s during the park's construction.

Among Boston's ponds that are part of river systems are Ward's, Willow, Leverett, and Cow Island Ponds. Ward's, Willow and Leverett Ponds are part of the Muddy River system located in Olmsted Park in Jamaica Plain. Cow Island Pond is a still water section of the Charles River in West Roxbury. The DCR Havey Beach borders this pond.

The DCR Chestnut Hill Reservoir, located in Brighton, is an artificial impoundment of water that once served as Boston's only water supply. The Reservoir was discontinued as a source of drinking water following completion of the Quabbin Reservoir in Western Massachusetts. The largest body of water located within Boston, the Reservoir is now used for scenic recreation purposes.

WETLANDS

Wetlands serve a vital function for Boston. They assist in flood control, treat stormwater run-off, and provide food and shelter to fish, birds, amphibians, and other important animals. However, in the last 100 years, 6,000 acres of coastal wetlands and approximately 50% of Boston's inland wetlands have been destroyed.

The largest single wetland in Boston, at 275 acres, is the Belle Isle Marsh in East Boston. Other substantial wetlands are found in the Neponset River Reservation in South Dorchester, the Stony Brook Reservation in Hyde Park, and the Brook Farm Reservation in West Roxbury.

Smaller yet still significant forested wetlands are found near the Leatherbee/Hancock Woods in West Roxbury, and at Allandale Woods in Roslindale/West Roxbury. Wetlands associated with rivers and streams include those along the banks of the Muddy River, Mother Brook, the Charles River, and Saw Mill Brook (see Vegetation [Section 4.4] for further description of wetland resources).

AQUIFER RECHARGE AREAS

Aquifers are areas beneath the surface of the earth that contain water, whether composed of permeable rock or unconsolidated materials such as gravel, sand, silt or clay. If they are uncontaminated and of sufficient yield, aquifers serve as a source of drinking water for people throughout the world, as well as here in Massachusetts.

In Boston, high and medium yield aquifers are found in two limited locations. Both types are found in West Roxbury along the Charles River, where open spaces uses, such as Cutler Park, Millennium Park, the Rivermoor Urban Wild, Havey Beach, the West Roxbury High School athletic fields and marsh, and cemeteries dominate the landscape. Some residential, commercial, and industrial uses are also located in this area.

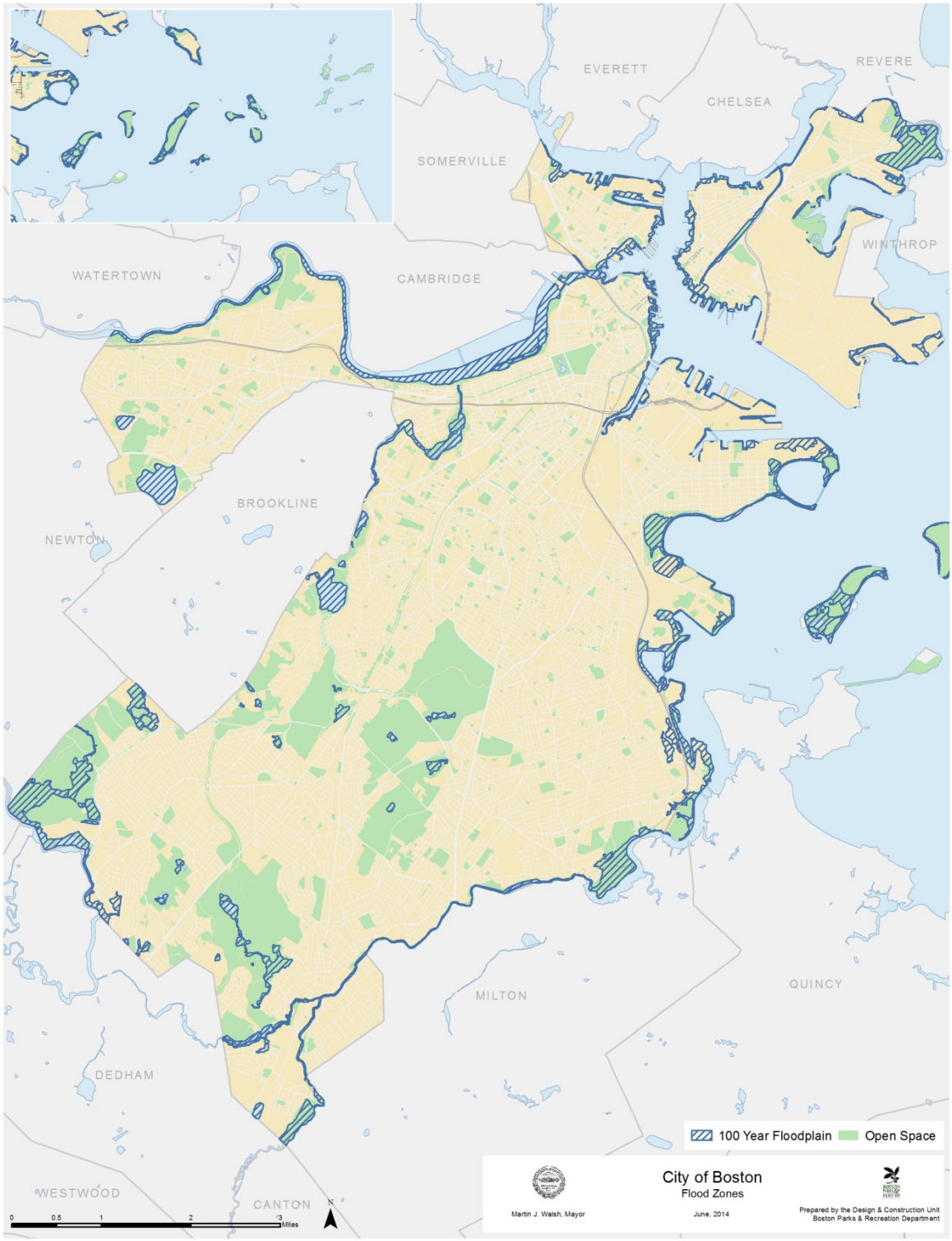
The second area is associated with the Fowl Meadows Area of Critical Environmental Concern (ACEC) in Hyde Park, at the southernmost tip of the city. Most of this medium yield aquifer is within the Fowl Meadows ACEC. Some of this aquifer lies within parklands held by the Department of Conservation and Recreation. Other portions are overlain by a residential area. One large portion is overlain by a warehouse complex.

Most of metropolitan Boston, and especially the city of Boston, is dependent on the DCR-MWRA regional system of water supply, which is based on surface water reservoirs located at great distances from Boston. Therefore, aquifer recharge area protection is not a critical issue for drinking water supply for this community. However, should the city desire at some point in the future to extract groundwater for non-drinking water supply purposes, development over these recharge areas may become an issue worth some consideration. The fact that much of these high and medium yield aquifers found within Boston's city limits are located in areas with some form of protection from development will help future generations, should the need ever arise.

FLOOD HAZARD AREAS

Areas with a greater chance of severe flooding are generally known as flood hazard areas. For purposes of federal and state law and policy, they are more specifically known to be areas where there is a 1% annual chance of flooding (aka the "100-year floodplain" or "FEMA Zone A"), or a 1% annual chance of flooding and an additional hazard associated with storm waves for coastal areas (aka "100-year floodplain" or "FEMA Zone V").

The city wide map titled "Flood Zones" shows the location of both FEMA Zones A and V. These areas tend to be associated with major freshwater or coastal surface water bodies, such as Boston Harbor, Dorchester Bay, the Charles River, the Neponset River, and the Muddy River. The Flood Zones map also shows open space in the city, and one can see that these areas often overlap. Major exceptions tend to be found along coastal areas, such as the downtown, East Boston, Charlestown, South Boston, and Dorchester waterfronts. Flood hazard areas not within designated open spaces are found in some smaller inland areas in East Boston, West Roxbury, Hyde Park, and the Kenmore sub-neighborhood.


EVERETT
REVERE
CHELSEA
SOMERVILLE
WINTHROP
WATERTOWN
CAMBRIDGE
BROOKLINE
NEWTON
MILTON
QUINCY
DEDHAM
WESTWOOD
CANTON
0 0.5 1 2 3 Miles
N
100 Year Floodplain
Open Space
City of Boston
Flood Zones
Martin J. Walsh, Mayor
June, 2014
Prepared by the Design & Construction Unit
Boston Parks & Recreation Department

Many of the flood hazard areas are found within protected open spaces, ensuring that development in these areas, if any, will be limited. In those flood hazard areas not within open spaces, protected or not, such sites are typically highly developed. Whatever redevelopment takes place in such areas will be the subject of the state Wetland Protection Act and other laws affecting development in flood hazard areas. Flood hazard mapping is periodically revised to reflect changing flood risk factors such as sea level rise. Such a map revision is currently underway at the time of this writing.

With much of the coastline within such flood hazard areas, the Chapter 91 regulations mandating open space and public access at the water's edge can help reduce flood impacts and provide public access and use along the water's edge, a highly valued recreation resource. The City, through its planning agency the Boston Redevelopment Authority (BRA), has developed municipal harbor plans that cover such areas as the downtown, Fort Point Channel, East Boston, and South Boston waterfronts in accordance with Chapter 91 and Coastal Zone Management policies. These plans and associated policies work with applicable regulatory review processes to ensure that development in coastal areas does not harm the environment, and is resilient in the face of coastal flooding.

The BRA also has a waterfront planning unit that seeks to extend the open space system known as Harborwalk along all the coastal shoreline of Boston (except in working waterfront areas including Logan Airport and Designated Port Areas). They are assisted by the City's Conservation Commission which encourages public access along the water's edge as part of its approvals, and by non-profit groups such as the Boston Harbor Association and Save the Harbor/Save the Bay. These groups advocate for more waterfront public access in various forums, such as development review processes or participation in such forums as the Metropolitan Beaches Commission.

Section 4.4:

Vegetation

INTRODUCTION

The natural vegetation of Boston is chiefly influenced by the city's geographic position along the Atlantic coast, the presence of landforms resulting from glaciation, and a long history of human land use and manipulation of native habitats.

UPLAND VEGETATION

Forested Uplands

The Boston area, like most of eastern Massachusetts, lies in an area generally described as the Appalachian oak-hickory forest zone. This forest type occurs from southern Maine, throughout southern New England, south to Georgia at higher elevations, and west to western New York. Red, white, and black oaks, with lesser densities of pignut, shagbark, bitternut, and mockernut hickories are species found in the plant communities that dominate the Appalachian oak-hickory forest zone. Other trees commonly found are white ash, black cherry, black birch, hophornbeam, and red maple. Numerous species of shrubs also occur. Among the most common are lowbush blueberry, maple-leafed viburnum, witchhazel, flowering dogwood, and beaked hazelnut.

In the Boston area, the oak-hickory forest is mixed with patches of other forest types found in adjacent northern and southern regions. Elements of the northern hardwood forest, such as sugar maple, eastern hemlock, yellow birch, and American beech can be found in Boston's forested areas, especially on north and west facing ridges. These species are generally prevalent throughout northern New England and southeast Canada. Conversely, areas in the city with well-drained, sandy soils and southeast exposures support woodland species more typical of Cape Cod and other coastal areas, such as pitch pine, scrub oak, and sweet fern. White pine is a

ubiquitous tree species throughout the region, frequently occurring in abandoned pastures and other open, sunny locations.

Given the long history of industrial and residential development within Boston, it is not surprising that natural forests and other native plant communities occur today in remnants and small patches. The largest forested area remaining in the city is the 466-acre Stony Brook Reservation in Hyde Park, Roslindale, and West Roxbury. Other significant forested areas are Allandale Woods (100 acres, West Roxbury), Hancock Woods (55 acres, West Roxbury), Sherrin Street Woods (25 acres, Hyde Park), the Wilderness (100 acres, Franklin Park), Olmsted Park (50 acres, Jamaica Plain), Brook Farm (120 acres, West Roxbury), parts of the Arnold Arboretum (Jamaica Plain), and sections of several Boston Harbor Islands.

Boston's forests provide a range of recreational, scenic, and ecological benefits. They are the city's lungs, cleansing the air of carbon dioxide and producing oxygen. Summer temperatures are up to ten degrees cooler in city forests, helping to mitigate the warming effects of urban development and activity. They also help control stormwater and filter pollutants from urban runoff. Healthy forest communities are essential for preventing excess sedimentation of waterways, wetlands, storm sewers, and catch basins by stabilizing erodible soils and steep slopes.

Many of Boston's forested areas are open to the public providing both formal and informal environmental education opportunities to schoolchildren, families, and adults. Recreational activities, such as hiking, trail running, cross country skiing, wildlife viewing and tracking, and nature photography offering city residents and visitors the unique opportunity to experience and observe nature up close within the confines of an urban environment.

Though many of these areas are publicly owned and protected from outright development, they still suffer from a host of problems. Some, such as the Stony Brook Reservation, have been fragmented by the construction of parkways, creating more edge habitat, less interior habitat, and interrupting established wildlife corridors.

The habitat value of all forested areas is seriously degraded by the prevalence of non-native, invasive plant species. These plants were

either purposely or accidentally introduced to the area and, because of their tolerant and hardy nature, have become major threats to the sustainability of native forest ecosystems. Among the most destructive non-native invasive plants in Boston forests are Norway maple, Japanese knotweed, European buckthorn, multiflora rose, Asiatic bittersweet, and Japanese barberry. In addition, people sometimes subject forested areas in Boston to direct abuse. Severe littering, illegal dumping, vandalism, and trampling by foot and vehicles are chronic problems in many urban forests.

Serious pests, blights, and diseases currently threaten several tree species. Most notable is the marked decline of the eastern hemlock caused by an insect parasite, the wooly adelgid More recently, in 2014, the Emerald Ash Borer has been found in Suffolk County, placing another important canopy tree species at risk for decline. This discovery, along with the early detection in 2010 and successful containment from 2011 to 2014 of the Asian Long-Horned Beetle, have raised public awareness about threats to the City's tree canopy and overall environmental health. Conservation through public ownership by itself is insufficient to protect Boston's forests from degradation. Funding, staffing, and active, hands-on management is also required to ensure the long term sustainability of Boston's forests. Non-native, invasive plants need to be controlled, eroding soil needs to be stabilized and revitalized, and native species of trees and shrubs must be planted in order to restore a healthy forest ecosystem. Early detection, control, and monitoring of invasive plants, pests, blights, and diseases must play a larger role in parks management. In addition, activities that damage the forests – illegal dumping, fires, uncontrolled mountain biking, and off-road vehicles – must be curtailed, while beneficial and productive recreational and educational activities are promoted. With so little of Boston's original forest remaining, it is of paramount importance to maintain the remaining forests to maximize the benefits they provide and ensure that they continue to function as viable ecosystems for future generations.

It bears mentioning that the global warming phenomenon will affect plant hardiness zones. The effect of rising temperatures alone could negatively affect the sustainability of some native species. Global warming could encourage the growth of invasive plant species and pests, diseases, and blights that also would negatively affect some native species' sustainability.

Non-Forested Uplands

Non-forested uplands, primarily meadows, are a dwindling resource in Boston. Often a remnant of past agricultural use, virtually all meadows and pastures throughout the city have been subject to intense residential and commercial development. Most of those not developed have been left to grow into shrubby thickets and early successional forests dominated by non-native, invasive plant species.

Meadows and pastures provide critical habitat to many species of plants and wildlife that are rarely found in Boston and are increasingly uncommon throughout the northeast. These habitats offer great scenic value, breaking up the monotony of dense residential areas and providing expansive views of the city, Boston Harbor, and the surrounding landscape. Boston's meadows are frequently found atop hills and other steep slopes subject to erosion problems. Viable, healthy meadow plant communities are thus important to stabilize vulnerable soil.

Significant upland meadows today can be found in the Arnold Arboretum, Franklin Park, the Boston Nature Center, Calf Pasture, the Walter Street Tract, Allandale Farm, and on several Boston Harbor Islands. Most of these sites are current or former agricultural or horticultural sites. Turf grasses and opportunistic wildflower species of Eurasian origin are dominant. Farmers during the 17th and 18th centuries deliberately or accidentally introduced these species and turf grasses.

Because of the suppression of natural wildfires and the disappearance of farming practices such as haying and grazing, meadows now require regular intentional maintenance to sustain their open, pastoral character. Mowing is the most common method of maintenance; however in many cases mowing is done too frequently to allow for the development of a diverse meadow plant community. Such areas are generally devoid of any habitat value. To maximize floristic diversity and ecological value, most meadow habitats should be mowed only once per year, at the most, in the late summer.

The acreage of meadow found in Boston increased substantially in 2000 with the opening of Millennium Park, a new park atop the former Gardner Street landfill in West Roxbury. This 100-acre park includes over 70 acres of grassland comprised of both native and Eurasian grass species.

In addition, the Parks Department through its Urban Wilds Initiative conducts selective, low-impact mowing regimes at several meadows throughout the city's urban wilds and other natural areas. Community groups and other volunteers have also been involved in introducing native meadow plants, such as goldenrod and aster, and controlling non-native, invasive plant species at many sites.

WETLAND VEGETATION

Freshwater Wetland Vegetation

As throughout all of Massachusetts, Boston has lost a substantial percentage of its original freshwater wetlands to development. Intense filling and subsequent construction has occurred in the extensive marshes once found along Stony Brook, Bussey Brook, and the upper Charles River. Isolated wetlands, bogs, vernal pools, and small ponds have been filled for residential development. Remaining wetlands have been affected by changes to hydrology as streams have been buried and diverted to storm sewers.

Wetlands serve a vital function for the city. They help to store, control, and cleanse stormwater run-off, a function that becomes increasingly important as additional impervious surfaces are created. They also provide essential habitat for a wide array of wildlife (see Wildlife section, below).

Several distinct plant communities are present in freshwater wetlands in Boston. Forest wetlands – such as red maple swamps and floodplain forests – are typified by large trees, such as red maple, willows, basswood, green ash, silver maple, and a diverse shrub layer of dogwoods, alder, winterberry holly, viburnums, and swamp azalea. An outstanding remnant of the southern New England floodplain forest, a rare community type recognized by the Massachusetts Natural Heritage Program, occurs along the Charles River shoreline of Millennium Park in West Roxbury. Other significant forested wetlands are found in the Stony Brook Reservation, Brook Farm, Sherrin Street Woods, and Leatherbee/Hancock Woods.

Non-forested wetlands – marshes, shrub swamps, and wet meadows – are dominated by shrubs, such as buttonbush, highbush blueberry, dogwoods, and elderberry, along with an extremely diverse collection of grasses, grass-like plants, and herbs typified by cat-tails, water willow, pickerel weed, arrow arum, bulrushes, and sedges. Typical marshes are found at Allandale Woods, West Roxbury High School, Brook Farm, along the West Roxbury stretch of the Charles River, and the Boston Nature Center.

Coastal Wetland Vegetation

Coastal wetlands, primarily salt marshes in Boston, were once the most dominant plant community within the city. Thousands of acres occurred along the harbor shoreline and up into the estuaries of the Charles, Chelsea, Mystic, and Neponset Rivers. Over the past 350 years, these salt marshes have been lost to filling, alterations to hydrology, pollution, and other drastic changes to the shoreline. Today only about 400 acres of salt marsh remain. These are primarily found at the DCR's Belle Isle and Neponset River Reservations in East Boston and Dorchester, respectively, and at Massport's Wood Island Marsh in East Boston.

Salt marshes comprise one of the richest and most biologically productive ecosystems on Earth. The precisely balanced cycles of tide, sedimentation, and decomposition all contribute to the production of up to ten tons per acre per year of vital nutrients, minerals, and organic material to nearby aquatic and terrestrial habitats. Healthy salt marshes support dozens of animal species. Some species (ribbed mussel, salt marsh dragonfly, fiddler crab, for example) are restricted to this habitat for the duration of their lives, while other animals (sharp-tailed sparrow, mummichogs, meadow vole) use salt marshes for breeding or feeding but can also be found in other habitats.

Overwhelmingly dominated by salt marsh cordgrass and salt meadow grass, salt marshes also protect sensitive, low-lying coastal areas from flooding and other damage resulting from strong storms. They are vital to the maintenance of clean water in Boston Harbor. Other plants adapted to withstand the unique physical conditions in and around salt marshes include marsh elder, black rush, spike grass, glasswort, and sea lavender.

Because they often form the interface between surface waters and groundwater on the one hand, and developable or developed uplands on the other, both coastal and freshwater wetlands are particularly susceptible to the deleterious effects of urban development. Public ownership alone is insufficient to protect them and preserve the vital functions they provide. All of the wetlands occurring in Boston are degraded to a certain extent. They have been at least partially filled or drained, have received either too much or too little water, have been subjected to pollutants, and have been invaded by non-native, invasive plants that have out-

competed the native species. The most destructive non-native plants in Boston wetlands are giant reed (*Phragmites australis*) and purple loosestrife.

The City of Boston is pursuing a number of programs to restore some natural functions to the city's degraded wetlands. The prime example of this is the restoration of the Muddy River and Back Bay Fens. This project, estimated at $43 million, aims to remove years of accumulated sediment from the Muddy River and restore a diverse native wetland plant community along its banks, now dominated by a dense infestation of giant reed. In East Boston, two major remediation and salt marsh restoration projects have recently been completed. Condor Street Urban Wild, completed in 2003, resulted in the removal of hazardous materials, the creation of a healthy salt marsh, upland meadow, pier, sculpture, as well as pathways, benches and scenic overlooks for habitat and passive recreation uses. Two years later in 2005, the Belle Isle Coastal Preserve project culminated in the remediation and restoration of a previously degraded salt marsh, the reconnection and re-integration of land within the vast DCR Belle Isle Marsh Reservation, and the construction of a trail segment for the future East Boston Greenway extension.

RARE SPECIES

Given the history of scholarly study in the Boston area, it is not surprising that the city's natural areas were well-traveled by knowledgeable botanists and naturalists during the 19th century and the city's flora well documented. The Massachusetts Natural Heritage and Endangered Species Program (MNHESP) lists several dozen rare plant species that are known to have occurred in Boston. Currently threatened plant species still present in Boston include Pale Green Orchis, Long's Bulrush, and Britton's Violet.

Without a doubt the vast majority of rare plant species habitat is long gone in Boston, but isolated occurrences may still exist in a few locations. In 2003, the New England Wildflower Society conducted botanical inventories at selected urban wilds in Boston. These inventories noted two potentially rare species that are listed by the MNHESP on their "watch" list. These species are Black Oat Grass (*Piptochaetium avenaceum*) and Violet Bush Clover (*Lespedeza violacaea*).

CULTURAL COMMUNITIES

As one of the oldest cities in the U.S., Boston has a very long tradition of agriculture and horticulture. At one time, the majority of what is now the city was comprised of farmland. Jamaica Plain, Mission Hill, Dorchester, Roxbury, and Hyde Park were all intensely farmed into the early 20th century, providing food and supplies to the burgeoning industrial and commercial center in central Boston. Pieces of this activity still remain. Allandale Farm in West Roxbury and Brookline is the lone remaining working farm in Boston. It is planted with vegetables, fruit, hay, and cover crops that are sold at the farm's retail stand.

The Arnold Arboretum, managed by Harvard University on land owned by the Parks Department, is a world-famous facility with a collection of trees and shrubs from around the globe. Its lilac collection is particularly renowned. The site also contains several expansive, naturalistic meadows and unmanicured woodlands that provide excellent wildlife habitat and give visitors a sense of the area's pastoral history. The 25-acre Bussey Brook Meadow Urban Wild is one of the few areas within the Arboretum that is truly managed as a natural area.

Section 4.5: Fish and Wildlife

INTRODUCTION

Approximately half of Boston's 7,100 acres of open space, about 3,500 acres, is comprised of land that provides important habitat for a large number of plant and animal wildlife species. These areas are made up of reservations, beaches, urban wilds, portions of parklands, sections of the Boston Harbor Islands, campus areas, and privately-owned land. The diversity of these areas and the correspondingly diverse plant communities found at each support an abundant collection of both native and non-native animal species.

FISH

The city's most diverse habitat for fish is Boston Harbor. This is probably one of the few habitats in Boston that supports a generally native wildlife population. It is also a major recreational resource for sport fishing. The commercial aspect of fishing, though integrally tied to the historic economic development of Boston, is almost completely limited to charter boats and other activity supporting sport fishermen. The most significant fisheries in Boston Harbor are striped bass, winter flounder, cod, mackerel, bluefish, and monkfish. Other important species are pout, hake, dogfish, menhaden, and killifish. The clean-up of Boston Harbor has greatly improved the habitat for all marine wildlife, though populations of several fish species are still imperiled by over-fishing and degraded habitats. Good access for onshore fishing is found at Castle Island, Long Island, Harbor Point and along the Dorchester and East Boston shorelines.

Shellfishing was at one time a mainstay of Boston's economy for both European settlers and native peoples and remains an important cultural artifact of the city's maritime past. Unfortunately, Boston's shellfish beds have been officially closed for many years. Abundant populations of clams, mussels, quahogs, and to a lesser extent, oysters, are still found within Boston Harbor. However, water quality has still not improved to the level required for state officials to allow their consumption, except for those found

in certain small beds in Dorchester Bay and Constitution Beach Bay. Shellfish in those beds can be harvested with the proper license and made fit for human consumption with post-harvest cleansing at a shellfish purification facility.

Sport fishing also occurs on several of Boston's rivers and ponds such as Scarborough Pond, Chandler Pond, Turtle Pond, the Charles River, and most notably Jamaica Pond. The Commonwealth stocks Jamaica Pond with hatchery-raised trout and smallmouth bass. Native species found in Boston's ponds include golden shiner, bluegills, pumpkinseed, chain pickerel, and American eel. These populations have suffered from generally poor water quality throughout the city and the introduction of non-native species such as carp, bass, trout, and goldfish.
The Charles River still supports seasonal migrations of some anadramous fish (species that generally live in salt water and return to freshwater for breeding), most notably Atlantic herring and American shad. A sighting of blueback herring was made in 1996 at the southern end of Leverett Pond.

One state-listed rare species of fish occurs in Boston, the three-spined stickleback. This small, inconspicuous fish lives in a small pool in the Olmsted Park area. The species occurs commonly in marine habitats, but freshwater populations are rare in New England. The Boston population is the southern-most freshwater occurrence and the only one in Massachusetts.

BIRDS

During the course of one calendar year, more than 200 species of birds can be seen within Boston. This great avian diversity stems from Boston's location on the Atlantic Flyway migration corridor and the diverse collection of habitats found within the city limits. Boston Harbor and its associated estuaries, salt marshes, beaches, and mud flats support numerous species of waterfowl, shorebirds, and seabirds. Forested areas and wetlands are home to a wealth of resident songbirds and dozens of species of neotropical migrants in the spring and fall. Meadows and other open areas attract raptors and owls.

Birdwatching is an increasingly popular recreational activity in urban areas as more people discover the great array of birds found even in the midst of extensive development. In the Back Bay Fens area of the Emerald Necklace alone, over 170 species of birds have been documented by local birders, all within the shadows of Fenway Park and the Hancock Tower. At the Boston Nature Center in Mattapan, naturalists have documented approximately 150 species of birds. Other important and well-documented habitat areas for birds are the Arnold Arboretum, the Belle Isle Reservation, Franklin Park, and the Stony Brook Reservation. In June, 2007, during the first year of the Massachusetts Breeding Bird Atlas II, a pair of Hooded Warblers was confirmed nesting in Franklin Park, the first such breeding in the Commonwealth in half a century. Urban natural areas provide important, valued habitat for birds, other fauna, and wild plant species.

The Massachusetts Natural Heritage Program lists six species of rare birds that have nested in Boston: Vesper Sparrow, Common Tern, Least Tern, Barn Owl, Peregrine Falcon, and Upland Sandpiper. Currently, the Upland Sandpiper is listed as endangered, the Grasshopper Sparrow is listed as threatened, and the Least Tern and Common Tern are listed as of special concern. In addition, several state-listed rare species, such as Pied-billed Grebe and Piping Plover, have nested in towns adjacent to Boston and could just as easily nest within the city boundaries. Though not listed by the state as a rare species, Wild Turkeys have returned to the city after an absence of many years. In addition, several Boston Harbor Islands host nesting colonies of egrets and herons. Given the colonial and sensitive nesting habits of these birds, these rookeries are of great regional significance.

The city also contains significant wintering habitat for several important bird species. The most famous examples of this are the Snowy Owls and other birds of prey that spend most winters along the runways at Logan Airport. This phenomenon has been well documented by researchers at the Massachusetts Audubon Society with the cooperation of Massport.

Falling partly within the limits of the City of Boston are three Important Bird Areas (IBAs). Important Bird Areas have been identified and designated in more than 130 countries in order to focus attention on the significance of protecting critical bird habitats. The Massachusetts Audubon Society (MAS or the Society)

has taken the lead in identifying IBAs in Massachusetts. The Massachusetts IBA program may be viewed online at http://www.massaudubon.org/our-conservation-work/wildlife-research-conservation/statewide-bird-monitoring/massachusetts-important-bird-areas-iba. The three IBAs falling partly in the city of Boston are Belle Isle Marsh, the Boston Harbor Islands National Recreation Area, and the Mystic River Watershed. The Society has urged that any public open space within these areas be managed in a manner compatible with the goals of the IBA program.

Several species of birds, both native and non-native, have recently grown in population size to be considered public nuisances. The Common Pigeon, for example, was developed from the European Rock Dove and introduced into this country as a domesticated bird, but many of these birds escaped and formed feral populations. Today the pigeon is always found in association with human habitations and almost universally regarded as a serious pest.

Other non-native bird species, such as the House Sparrow, European Starling, and House Finch, are also abundant in Boston and wreak havoc among populations of native birds. Humans introduced all of these species to North America. These non-native species have grown to a population size where they outcompete native species for food, nesting sites, and other resources. Canada Goose and American Crow, both native species, have also experienced recent population explosions, causing a variety of problems among other native bird populations.

MAMMALS

Like the rest of eastern Massachusetts, Boston is experiencing rapid and dramatic changes to its resident wild mammal population. A combination of factors – explosive residential development in the suburbs, intentional and inadvertent creation of forested wildlife corridors, and the continued habituation of animals to human activity, among others – has caused the sighting of species traditionally associated with remote wilderness areas to be an increasingly common occurrence within the city.

White-tailed deer, rarely seen within the Route 128 beltway only 20 years ago, are now year-round residents in Boston. They and signs

of their presence – tracks, scat, antler rubbings, and browse – are frequently seen in Franklin Park, the Arnold Arboretum, Allandale Woods, and near Millennium Park, among other locations. As the presence of deer has become more common, concern will develop over the possible impacts deer may have on public and private lands and public safety. Shrubbery browsed by deer, the perceived increase in Lyme Disease, and the potential for deer-car collisions all contribute to the public's eventual intolerance for large populations of deer in dense residential areas.

Coyotes have also made a dramatic comeback to eastern Massachusetts, after being almost completely extirpated by a government-sponsored eradication program during the 19th century. Coyote sightings are now commonplace throughout the state. Sightings in various areas of the city, such as along the Neponset River, have become more common in recent years.

Small mammals adaptable to humans and human settlements, such as raccoons, possum, striped skunk, and cottontail rabbits, abound throughout the city, in both developed and undeveloped areas. Less conspicuous mammals, such as mice, voles, shrews, and moles, though rarely seen, are also common in natural habitats.

OTHER VERTEBRATES

Reptiles and amphibians, commonly grouped as herpetiles, are Boston's most imperiled group of animals, and their presence and species composition are frequently used as ecological indicators to gauge the overall health of an ecosystem. Common Massachusetts species found in Boston include green frog, bullfrog, painted turtle, red-eared slider (non-native), snapping turtle, garter snake, red-backed salamander, and two-lined salamander. Though these species are common elsewhere, their occurrence in Boston is sporadic at best, with only scattered records existing in a few neighborhoods. The Massachusetts Natural Heritage Program lists the Blue-Spotted Salamander as a species of special concern in Boston. In addition, two state-listed rare herpetiles occur in West Roxbury. Common Massachusetts species that should occur in Boston but have not been recently documented include milk snake, black racer, Northern-water snake, ribbon snake, American toad, wood frog, and spring peeper (NOTE: Spring peepers are present at the Gladeside I Urban Wild). Significant herpetile habitats are

found in the Stony Brook Reservation, the Brook Farm Reservation/Millennium Park area, and Allandale Woods.

INVERTEBRATES

Insects and other invertebrates are also commonly used indicators of ecosystem viability, particularly for aquatic ecosystems. Preliminary studies of benthic macroinvertebrates conducted by the Parks Department at Chandler Pond, Scarborough Pond, Wards Pond, Willow Pond, and the Muddy River have shown very low species diversity, thereby confirming the poor water quality of these water bodies.

Section 4.6:
Scenic Resources & Unique Areas

SCENIC LANDSCAPES

Boston has many scenic and significant landscapes that define the city's character. The most extensive landscape type is the waterfront. Whether along Dorchester Bay, the Inner Harbor, Belle Isle Inlet, the Mystic, or the Chelsea, saltwater-oriented landscapes form much of the basis for Boston's attractiveness.

Freshwater-oriented landscapes, such as the Neponset, Mother Brook, Bussey Brook, Scarborough Pond, and Chandler Pond also have great scenic charm. The two most notable scenic landscapes based on fresh water are the Charles River Reservation and the Emerald Necklace. In the midst of a densely developed urban area, these green corridors provide a visual and recreational respite. As envisioned by Frederick Law Olmsted and Charles Eliot, the views they afford, and the opportunity to stroll away from streets and through naturalized and recreational landscapes, provide relief from the hectic pace of urban life.

Some parklands developed on former landfills provide scenic landscapes themselves as well as the opportunity for viewing scenic vistas. Pope John Paul II Park along the Neponset in southern Dorchester provides views of the Neponset Estuary, including extensive estuarine wetlands. Millennium Park in West Roxbury forms a prominent hill along the banks of the Charles, a unique landform in the valley of a mature, meandering river. It provides vistas, especially to the west, that some have said are more typical of views from hilltops in rural Central Massachusetts. Of course, the exception is the view to the northeast, which shows the top of the glass Hancock Tower peeking over a wooded skyline.

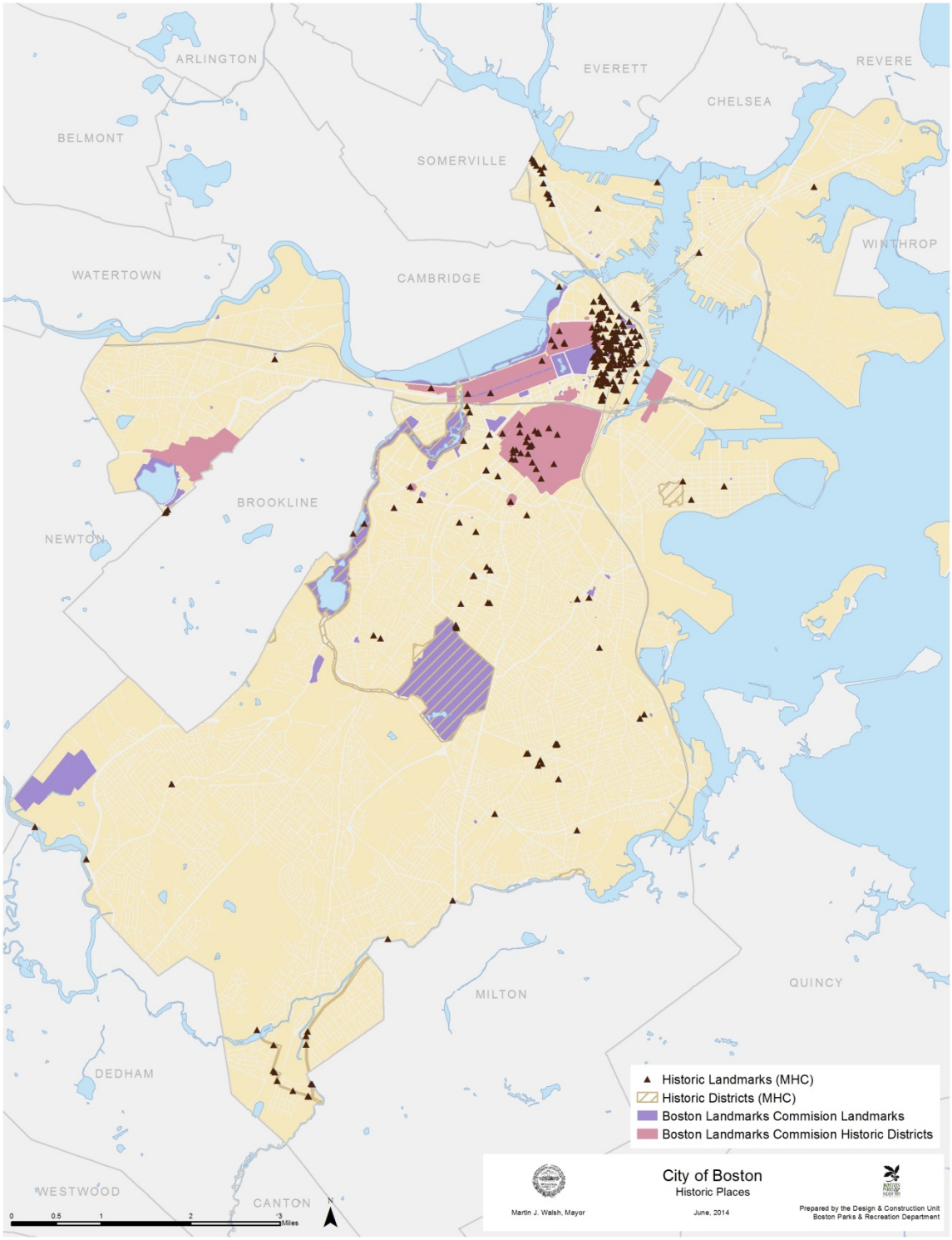
GEOLOGIC FEATURES

Geologic features are described elsewhere in this section. The one geologic feature most appropriate for discussion in this particular section is Roxbury Conglomerate, also known as Roxbury Puddingstone, the State Rock of Massachusetts. This

particular bedrock unit is unique to the Boston Basin, yet quite prevalent within the Basin. Its presence as a rock outcrop is seen occasionally in parts of the city, oftentimes because of the expense of blasting it to provide room for development. It forms a prominent feature in some parks and natural areas/urban wilds, such as Franklin Park, Allandale Woods, Hancock Woods, and Stony Brook Reservation. Such outcrops are natural play areas for children, who love to climb them.

CULTURAL AND HISTORIC AREAS

Boston has numerous properties designated as historically Significant, as well as entire districts so designated. Much of the Emerald Necklace is so designated as well as several other parks. The protection of such cultural and historical resources has become City policy and a facet of our character and our strategy for redevelopment of neighborhoods, commercial areas, and parklands. A map has been included in this plan that shows the extensive designation of districts and sites throughout the city. These designations offer some degree of protection with a review process if federal or state monies, approvals, or licenses are required. Preservation of these areas not only protects the cultural heritage of Boston, but also maintains the visual character of the city.


ARLINGTON
EVERETT
REVERE
CHELSEA
BELMONT
SOMERVILLE
WINTHROP
WATERTOWN
CAMBRIDGE
BROOKLINE
NEWTON
MILTON
QUINCY
DEDHAM
WESTWOOD
CANTON
0 0.5 1 2 3 Miles
N
Historic Landmarks (MHC)
Historic Districts (MHC)
Boston Landmarks Commision Landmarks
Boston Landmarks Commision Historic Districts
City of Boston
Historic Places
June, 2014
Martin J. Walsh, Mayor
Prepared by the Design & Construction Unit
Boston Parks & Recreation Department

AREAS OF CRITICAL ENVIRONMENTAL CONCERN (ACECs)

The Massachusetts Department of Conservation and Recreation (DCR) administers the Area of Environmental Concern (ACEC) program in order to identify, inventory, and ensure careful stewardship of the Commonwealth's outstanding natural resource areas. The City of Boston contains portions of three ACECs – Rumney Marshes, Neponset Estuary, and Fowl Meadow/Ponkapoag Bog.

The Rumney Marshes

According to DCR's Office of Natural Resources, the U.S. Fish and Wildlife Service has characterized the Rumney Marsh ACEC as one of the most biologically significant estuaries in the state. The area includes approximately 1,000 acres of highly productive salt marsh, tidal flats, and shallow channels. The Belle Isle Marsh in East Boston is wholly included in the Rumney Marsh ACEC and is comprised of 275 acres of salt marsh, salt meadow, and tidal flats, providing critical wildlife habitat, flood storage, and water quality improvement functions. All of the Belle Isle Marsh is publicly owned by the DCR, except for small parcels owned by the Town of Winthrop and the City of Boston-owned Belle Isle Coastal Preserve, formerly known as Belle Isle Fish Company Urban Wild.

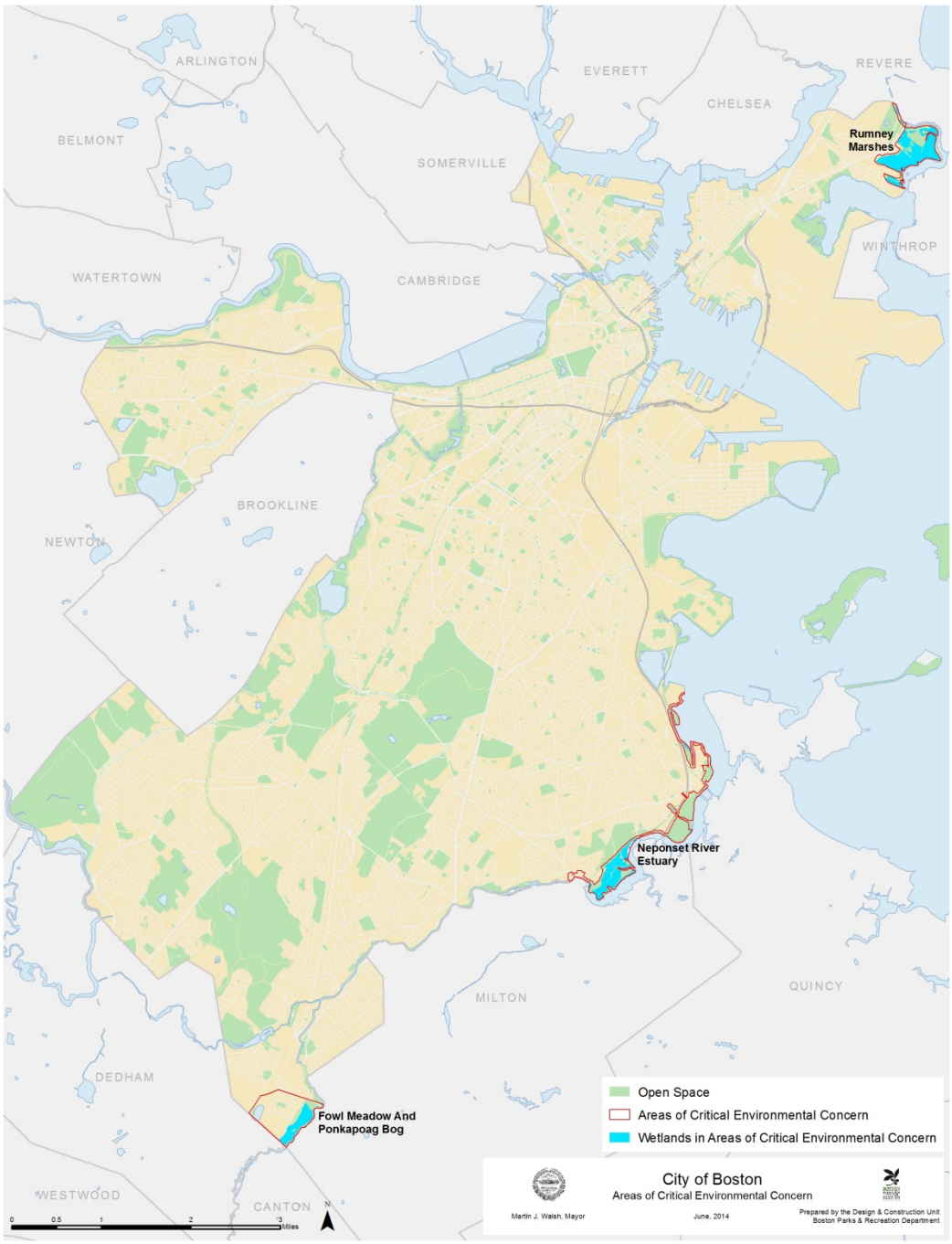
The Neponset Estuary

The Neponset Estuary ACEC extends from the mouth of the Neponset River to the Lower Mills Dam, which separates the tidal and freshwater sections of the river. About 435 acres of the 1,260-acre ACEC are located in Boston with the remainder located in Milton and Quincy. The Neponset Estuary provides valuable habitat for anadramous fish species, including smelt and blueback herring. Most of the open space along the Boston side of the estuary is owned by the DCR, providing a variety of public open space and recreational opportunities. The DCR's Lower Neponset River Reservation Master Plan provides a vision for the long-term development of these properties.

The Fowl Meadow/Ponkapoag Bog

The Fowl Meadow/Ponkapoag Bog ACEC is also located along the Neponset River, from the Readville section of Hyde Park and through the towns of Canton, Dedham, Milton, Norwood,

Randolph, Sharon, and Westwood. Large areas of the 8,350-acre ACEC are part of the DCR's Blue Hills Reservation. This ACEC protects habitat for at least 13 rare species, several aquifers and public water supplies, floodplains, and wetlands associated with the Neponset and its tributaries. In Boston, Sprague Pond and the privately-held Sprague Pond Lakeside Access Area are located within the ACEC.


ARLINGTON
EVERETT
REVERE
CHELSEA
BELMONT
SOMERVILLE
Rumney Marshes
WINTHROP
WATERTOWN
CAMBRIDGE
BROOKLINE
NEWTON
Neponset River Estuary
MILTON
QUINCY
DEDHAM
Fowl Meadow And Ponkapoag Bog
WESTWOOD
CANTON
0 0.5 1 2 3 Miles
N
Open Space
Areas of Critical Environmental Concern
Wetlands in Areas of Critical Environmental Concern
City of Boston
Areas of Critical Environmental Concern
Martin J. Walsh, Mayor
June, 2014
Prepared by the Design & Construction Unit
Boston Parks & Recreation Department

Section 4.7: Environmental Challenges

INTRODUCTION

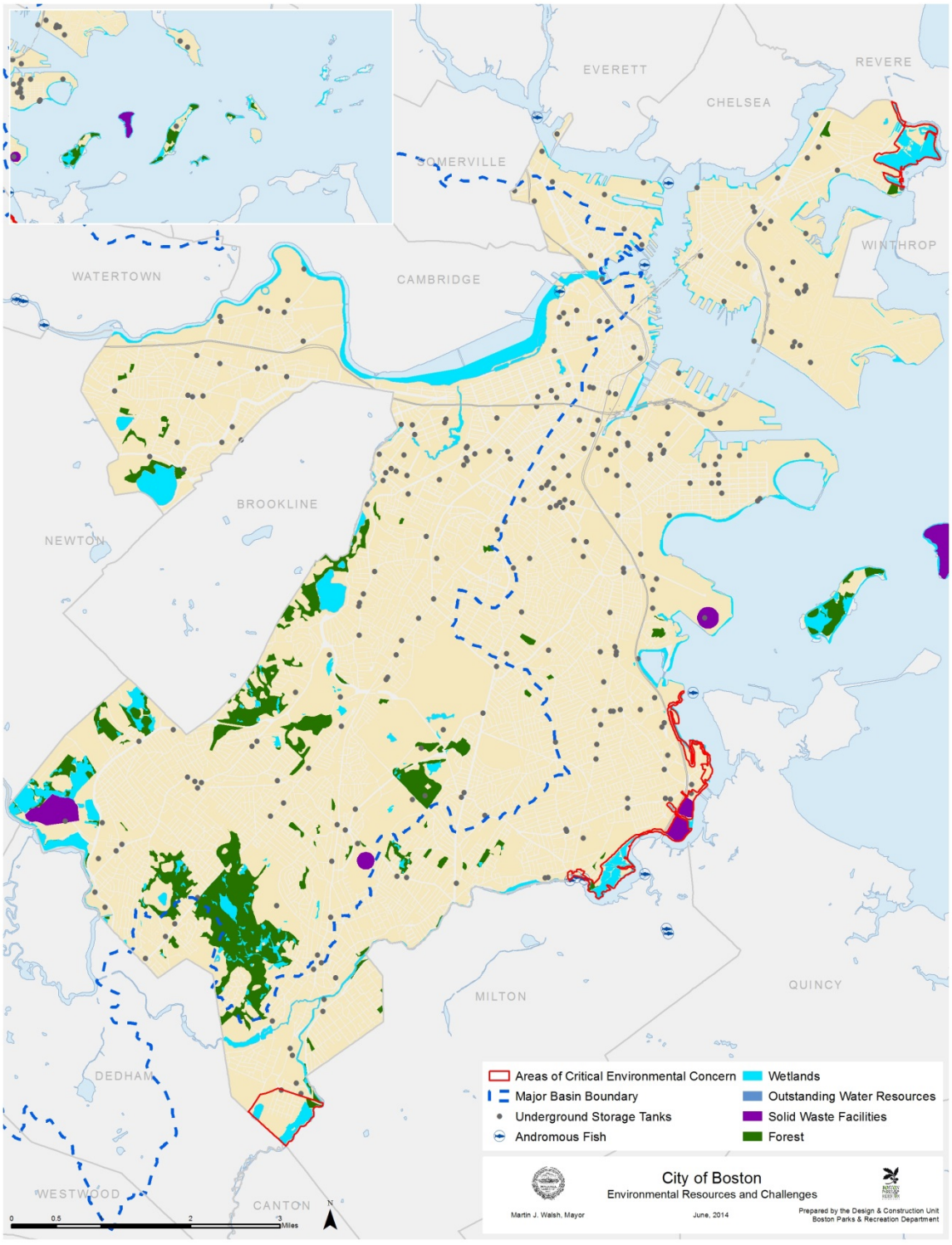
Boston's intense land use can pose threats to several different components of the environment. Most reflective of an environment's health is its water quality. Threats to water quality include hazardous waste sites, landfills, and sewer discharges. While these factors threaten water quality, water itself poses a threat to the landscape. Flooding, erosion, and sedimentation threaten both the constructed and natural landscapes of Boston. Recognizing and planning for these different threats is essential for the protection of both Boston's and the region's environment.

The preservation and expansion of Boston's green spaces contribute to both climate mitigation and adaptation. Green spaces keep the city cooler in summer, thereby reducing the urban heat-island effect (black pavement and other urban structures absorb more solar energy than grass and trees). This reduces the amount of electricity (and associated greenhouse gases) needed for air conditioning and reduces the risks of more frequent heat waves posed by climate change. Greenery also increases the amount of groundwater recharge, thereby lowering flood risks.

HAZARDOUS WASTE SITES

As of January 2014, there were 137 hazardous waste sites in the city of Boston. This figure represents a snapshot of conditions at a particular time. This is due to the nature of identifying hazardous waste sites. It is important to understand what a hazardous waste site is and the threats it may impose to the environment.

A hazardous waste site is an area in which a hazardous substance has been released into the ground. The most common hazardous waste released is petroleum-based. Therefore, the most common hazardous waste site is one that has a land use associated with motor vehicles. This may be a gas station, service garage, or junkyard. Leaking underground tanks are responsible for a


EVERETT
REVERE
CHELSEA
SOMERVILLE
WINTHROP
WATERTOWN
CAMBRIDGE
BROOKLINE
NEWTON
MILTON
QUINCY
DEDHAM
WESTWOOD
CANTON
0 0.5 2 3 Miles
N
Areas of Critical Environmental Concern
Major Basin Boundary
Underground Storage Tanks
Andromous Fish
Wetlands
Outstanding Water Resources
Solid Waste Facilities
Forest
City of Boston
Environmental Resources and Challenges
Martin J. Walsh, Mayor
June, 2014
Prepared by the Design & Construction Unit
Boston Parks & Recreation Department

substantial amount of contaminated sites. These tanks commonly hold fuel oil for homes and businesses, or gasoline for service stations. Other typical locations of hazardous waste include dry cleaners, which use harsh chemicals, and industrial land uses which use various chemicals in manufacturing or processing. Once released into the ground, pollutants may migrate towards ground and surface water resources. If the contaminated soil is exposed to the air (not covered by concrete or asphalt) the pollutant may vaporize causing unusual odors and harmful vapors. Physical contact with contaminated soil may cause skin irritation. Because of these threats to human health and the environment, remediation or cleansing of contaminated soils is necessary.

The Commonwealth's Department of Environmental Protection (MADEP) is responsible for enforcing laws that require remediation of contaminated sites (primarily MGL Chapter 21E, aka the Massachusetts Contingency Plan, or MCP). The 137 sites in Boston are those that are either considered to be of highest priority for clean up, and therefore require MADEP permitting, or where classification is unconfirmed or not yet determined, so that uncertainty exists as to the risk involved. This situation indicates that the level of contamination has not yet been determined for many of these sites. Therefore, many of these sites may not be seriously contaminated, making remediation a financially feasible possibility for the restoring and reusing of many sites across the city.

LANDFILLS

Boston has several areas that have operated as landfills, dumps, or waste transfer stations. Boston does not currently have an active landfill. Former landfills include the Spectacle Island and Gardner Street landfills. Both landfills have undergone a capping and reuse process that has resulted in both the safe containment of waste and the production of open space.

The Gardner Street landfill was Boston's most recently active landfill. The landfill's 75-acre site is located on the banks of the Charles River in West Roxbury. The landfill's operation began in the 1930s, and was closed in 1980 but not capped. In an uncapped state, the landfill had contaminated surface runoff and groundwater flow, posing a threat to the water quality of the

nearby Charles River and its associated wetlands and groundwater resources. In 1997, capping began first with excess material from the Central Artery Project to better shape the landfill's final contours, then with covering the waste with a geotextile (plastic) layer and a layer of clay. With the completion of the capping project, the construction of a major 105-acre park – Millennium Park – began. Dedicated in 2000, this park under Parks Department management features several athletic fields, passive recreation areas, a canoe/kayak launch on the Charles River, six miles of paths, grasslands, and nature study areas.

The Spectacle Island landfill, active until the 1950s, was located on Spectacle Island in the Boston Harbor. In an uncapped state, the dump presented a threat to water quality in the Boston Harbor due to its close proximity to the water. Capping of this landfill was completed with material from the Central Artery Project. This capping prevents contaminated runoff and infiltration from rainfall. Upon completion of the landfill capping, these 105 acres of primarily passive parkland, a major attraction within the Boston Harbor Islands National Recreation Area, was then created. With the completion of the visitor's center, the walking paths, and a swimming beach, the park was opened to the public in 2006. The Parks Department and the state Department of Conservation and Recreation jointly manage this park.

Another pair of capped landfills that now contribute to Boston's usable open space are the Hallet Street and Neponset Avenue Landfills. Owned by the DCR, the landfills, totaling 57 acres together with the abutting Neponset Drive-In site, had been a largely vacant site located east of the Southeast Expressway along the Neponset River. It is included in the Lower Neponset River Reservation, which was the subject of a Master Plan prepared in the mid-1990s. The Department of Conservation and Recreation closed and capped the landfill, and developed a park over it, called Pope John Paul II Park. This park opened in 2000 with active and passive features as well as improvements for better access to the water for Bostonians and other visitors.

The other closed landfills in Boston are at Columbia Point in Dorchester along Dorchester Bay where UMass Boston and housing uses are found, and the Barry Quarry in Hyde Park, which is also known as the Oak Lawn Driving Range.

EROSION/SEDIMENTATION

Pavement or structures cover a large percentage of Boston's surface area. This, in combination with an extensive stormwater drain system, minimizes most land erosion, yet also contributes to localized erosion problems both by increasing surface run-off volume and speed, and by concentrating flows at specific discharge points. Channelized streams and ocean walls, with varying results, have historically controlled erosion along the city's waterways. Erosion also occurs in areas that are undeveloped and not served by storm drains. In association with chronic erosion and uncontrolled run-off in Boston's open spaces, deposition of sediments has posed a threat to areas such as the Back Bay Fens and Muddy River system. The Muddy River is an area of intensive sedimentation within Boston (and Brookline). Large deposits of sediments are concentrated along the Riverway and Back Bay Fens sections of the Muddy River. The Muddy receives a large volume of inorganic sediment from storm runoff caused by the intense urbanization within the river's drainage basin. Urbanization is associated with impervious surfaces that speed the delivery of water to the river channel and result in larger and quicker peak flows. These increased peak flows transport large sediment loads that are dumped upon reaching low energy environments (i.e., slower moving waters contained in broader, shallower channels) such as the Muddy River.

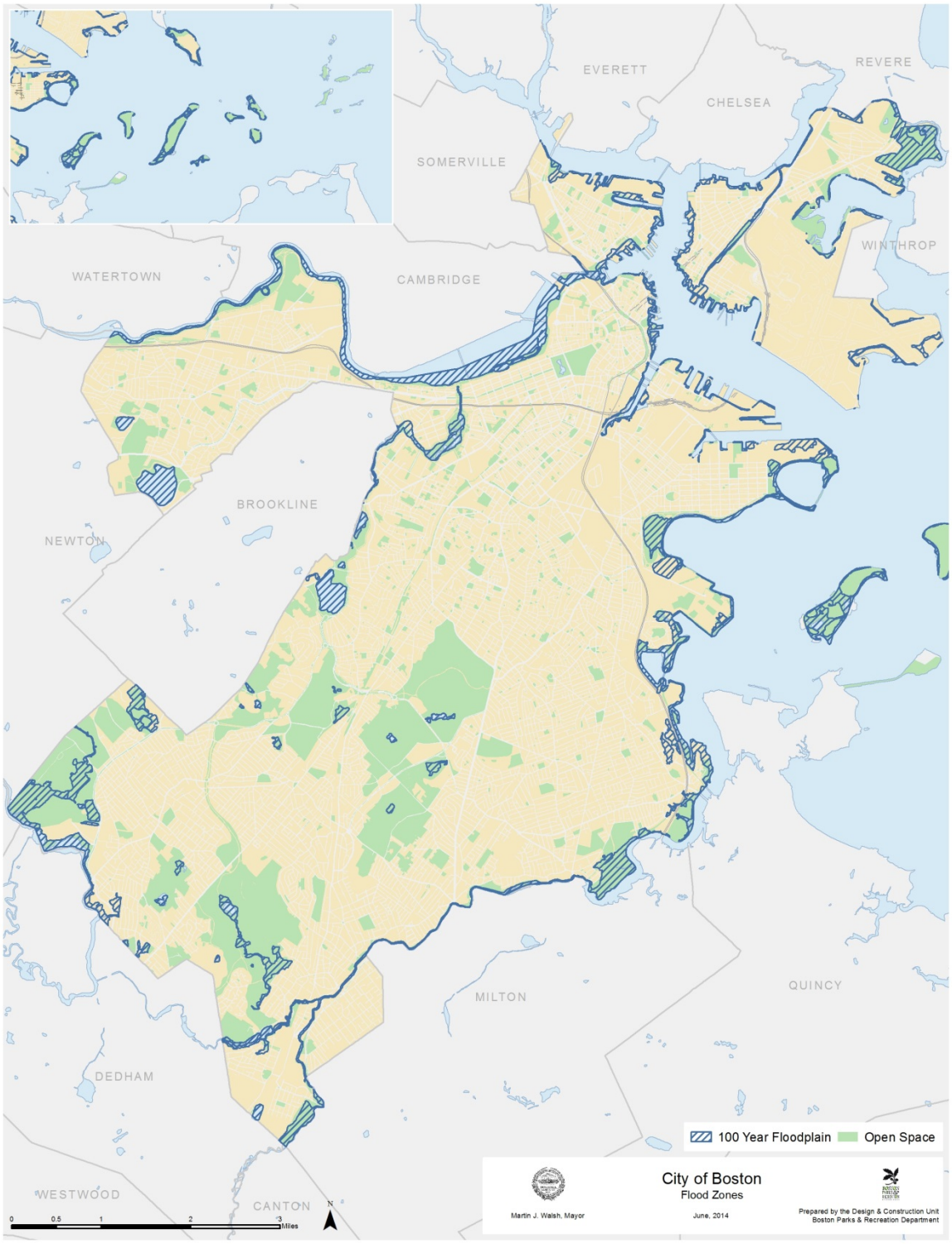
Construction of the Charles River Dam in 1910 prevented tidal flow into the Muddy therefore decreasing salinity and preventing flushing of river sediment. This river sediment has remained along the Muddy's banks, creating point bars that contribute to the proliferation of the non-native, invasive Phragmites australis aka giant reed. Phragmites is a very tall freshwater grass species, with robust, hollow stems and dense, tasselling flower heads. These plants can be seen flourishing – up to 20 feet tall – along the banks of the Muddy. Phragmites contributes to sedimentation of the river by trapping sediment, which then encourages further Phragmites growth. While the Phragmites trap sediment, pollutants chemically bound to the sediment seriously degrade water quality in the river. Pollutants found in sediment include trace metals, inorganic nutrients, and organic compounds.

FLOODING

Boston is served by an extensive stormwater drainage system of dams, berms, and seawalls that have been designed to prevent flooding. However, changing weather patterns, coupled with aging infrastructure, will soon begin to strain the system. Annual precipitation is expected to increase by 5%-8% by 2050, and 7% to 14% by 2100 according to the 2011 Massachusetts Climate Adaptation Report. In addition, the National Oceanic and Atmospheric Administration anticipates sea levels in Boston to rise by up to 2.2 feet by 2050 and up to 6.86 feet by 2100.
But we don't need to wait for the future to witness the impact storms can have on our region. Recent major storms in 2007, 2010, 2012 and 2013,caused substantial flooding in both coastal and inland neighborhoods.

In April of 2007, the Patriot's Day Storm caused $30,000 in damage due to coastal flooding. During the major storm of March 2010 the City of Boston broke the record of 11 inches of rain set in 1953. Major flooding was experienced over much of southern New England. The MBTA's Green Line D branch was hindered by a sinkhole that washed out a trolley track. Storm surge reached 6.5 feet. From December 2010 through February 2011, southern New England, including the City of Boston, saw a series of winter storms that led to record snowfall for the season. Boston snowfall total was over 70 inches, more than 45 inches above the average for that time of year. Heavy snow, combined with rain led to numerous collapsed roofs, downed trees and utility lines and flooding problems throughout the City.

On October 29 and October 30, 2012, Hurricane Sandy, a hybrid storm with both tropical and extra-tropical characteristics, brought high winds and coastal flooding to southern New England, including the City of Boston. Sandy made landfall near Atlantic City, New Jersey on October 29, 2012 as a category 1 hurricane. Sustained wind speeds of 41 mph and gusts to 62 mph were reported at Logan International Airport. Seas built to between 20 and 25 feet just off the east coast with a storm surge generally about 2.5 feet to 4.5 feet. Luckily, storm surge peaked at 4.57 feet in between high tide cycles, and as a result only moderate coastal flooding occurred within Boston. If the peak surge had hit five


EVERETT
REVERE
CHELSEA
SOMERVILLE
WINTHROP
WATERTOWN
CAMBRIDGE
BROOKLINE
NEWTON
MILTON
QUINCY
DEDHAM
WESTWOOD
CANTON
0 0.5 1 2 3 Miles
N
100 Year Floodplain
Open Space
City of Boston
Flood Zones
June, 2014
Martin J. Walsh, Mayor
Prepared by the Design & Construction Unit
Boston Parks & Recreation Department

hours earlier at high tide, the city would have experienced severe flooding.

The Blizzard of 2013 (aka Winter Storm Nemo) occurred on February 8th and 9th of that year, and produced moderate to major coastal flooding, most notably during the time of the high tide Saturday morning along the Massachusetts east coast. The 5th largest snow accumulation ever recorded of 24.9 inches occurred at Logan International Airport.

The City of Boston anticipates working with the Commonwealth of Massachusetts on planning for climate adaptation for the parks along the coast in light of the predicted increased flooding and sea level rise in the foreseeable future. While city parks like the Condor Street Beach, the East Boston Greenway, Umana School Park, LoPresti Park, Porzio Park, Charlestown Naval Shipyard Park, Ryan Playground, Barry Playground, Little Mystic Access Area, Menino Park, Langone Park, Puopolo Park, Christopher Columbus Park, Long Wharf, Children's Wharf Park, L Street Beach, and McConnell Park will be affected by more frequent and intensive salt water inundation, state parklands along the coast in Boston are more numerous and larger in size. As city and state parklands are often located side-by-side, an integrated system of adaptation is advised. Of course, there are areas under the control of entities like the National Park Service, Massport, and private parties such as Harborwalk that will like be affected by coastal flooding and its aftereffects, and would best be integrated into a common regime of adaptation policies and practices

Flooding in the Fenway/Longwood area has resulted from flooding in the Muddy River system. High water levels in the Muddy River can occur as a result of intense surface runoff from storm events, high water levels in the Charles River, and the nearly level gradient of the Muddy River in the Fenway area. These high water levels impede discharge from the Stony Brook Conduit, thus causing it to surcharge. The conduit carries stormwater, brookflows, and combined sewage from West Roxbury, Hyde Park, Roslindale, Jamaica Plain, and Roxbury.

SEWAGE DISCHARGE

Approximately 380 million gallons of effluent (treated sewage) are released into Massachusetts Bay each day. Sewage from Boston and outlying communities is treated by the MWRA at the Deer Island Sewage Treatment Plant. The volume discharged is roughly equivalent to the combined flow of the Charles, Mystic, and Neponset Rivers. The Deer Island treatment facility now also treats sewage that is pumped under the Harbor from the former Nut Island treatment plant in Quincy. The Deer Island treatment plant is the second largest in the nation. It uses two phases of treatment, primary and secondary. Primary treatment separates the sewage by allowing sludge (primarily human waste) to settle from the water. Secondary treatment uses microorganisms to consume the remaining human waste and toxic chemicals. The effluent is then disinfected with chlorine and is 90% free of human waste and 70% free of toxic chemicals. It is released from the facility via a 9.5-mile 24-foot diameter deep rock tunnel. At its end, the tunnel diffuses the effluent into Massachusetts Bay where ocean currents mix and further dilute the effluent. This largely minimizes the impact of treated wastewater on Boston Harbor.

The most prominent point source pollution in Boston is discharge from combined sewer overflow systems (CSOs). Combined sewer overflow systems collect both sewage and surface water runoff from rainfall and snowmelt. During wet weather conditions, surface runoff causes sewer lines to overload. To prevent this overload from backing up into streets or basements, designated overflow discharge points are located along Boston Harbor and the Charles and Muddy Rivers. Due to the various sources of CSO discharges, many pollutants may be present. These pollutants include fecal coliform bacteria, suspended solids, nutrients, metals, and floatable material. Discharges containing such pollutants create potential health impacts near areas such as swimming beaches and shellfish beds.

Substantial efforts have been made by the MWRA to reduce CSO discharge. Among these efforts is the expansion of the Deer Island Treatment Plant, which treats 89% of total overflow during an average rainfall year. An additional 6% of that overflow is treated by CSO treatment facilities that provide screening and disinfection of overflows. This accounts for treatment of 95% of discharges.

Upon completion of further CSO improvements in the near future (anticipated by August 2015), the MWRA expects to treat 99.6% of overflows from combined sewer systems.

WATER QUALITY

Water quality data is available for Boston's larger water systems. These water systems include Boston Harbor, the Neponset River, the Charles River, and the Muddy River. Water quality data primarily used for this plan was obtained from a 2002-2006 Charles River Watershed Water Quality Assessment Report and the 2004-2008 Boston Harbor Watershed Water Quality Assessment Report produced by the MADEP.

Chelsea River

Locally known as Chelsea Creek, this river flows through a highly urbanized watershed dominated by industrial and commercial uses. Flowing from the mouth of Mill Creek between Chelsea and Revere past the northern edge of East Boston to the confluence with the Boston Inner Harbor, it has been officially classified as a Designated Port Area, where water-dependent industrial and commercial uses are favored. Most of the petroleum for this region, and therefore the oil tanker traffic, travels through this river, which has been dredged to a depth of 38 feet. Besides use by private enterprises, the City of Boston and Massport store road salt piles on its banks, and CSO discharges to the river are allowed under the approved MWRA CSO Facilities Plan.

Given such uses, it is no surprise that the EPA in 2001 stated that the creek "is one of the most polluted tributaries of the Boston Harbor. Sediments are contaminated by years of polluted runoff from the adjoining industrial areas, from shipping and from sewer outfalls." While the MADEP officially classifies the Chelsea River as Class SB_{CSO}, where fish, wildlife, and primary and secondary contact recreation are favored, and have good aesthetic value, their 1999 Boston Harbor Watershed Water Quality Assessment Report stated "non-support" for these uses due to oil and grease, toxicity, foul taste and odor, poor color, trash and debris, turbidity, various metals, priority organics such as unionized ammonia, and low dissolved oxygen (DO). It is on the MADEP 2004 303(d) list of impaired waters, due to priority organics, unionized ammonia,

organic enrichment/low DO, pathogens, oil and grease, taste, odor and color, turbidity, and objectionable deposits.

The first direct public access to the Chelsea River from East Boston was developed when the City, through the Parks and Recreation Department and the Urban Wilds Initiative, constructed a combined hazardous waste remediation and urban open space reuse project at the Condor Street Beach urban wild. The public is now allowed to come to the water's edge to view the river and its industrial traffic and views. This creates more "eyes" on the resource, so that any activity adverse to the health of the river can be observed by the public. A portion of the site is now a restored coastal wetland.

Mystic River

Flowing past the northern edge of Charlestown to the confluence at the northern end of Boston Inner Harbor, much of the Mystic River banks in Charlestown are classified as a Designated Port Area. With mainly industrial and commercial uses on both sides of the river, a channel depth of 40 feet for industrial and commercial shipping, and CSO discharges allowed under the MWRA CSO Facilities Plan, the Mystic shares many of the characteristics of the Chelsea River, and has the same MADEP surface water quality classification, SB_{CSO}.

Just like the Chelsea River, the Mystic is on MADEP's 2004 303(d) list of impaired waters, for a variety of causes, such as metals, other inorganics, priority organics, unionized ammonia, organic enrichment/low DO, pathogens, oil & grease, taste, odor, and color.
Their 1999 Boston Harbor Watershed Water Quality Assessment Report stated "non-support" for fish consumption, and shellfishing, due to priority organics. During summer months, due to organic enrichment and low DO, the river is on "Alert Status" as regards aquatic life. Due to elevated pathogen counts during wet weather, the Mystic is assessed as partial support for primary and secondary contact recreation.

The MWRA CSO Control Program has installed a CSO storage tunnel in Charlestown near Barry Playground that has helped reduce CSO discharges.

The only public access to the Mystic River in Charlestown is from Ryan Playground, where the Parks Department recently installed a shoreline boardwalk, and at the Schraffts Center, which has a boardwalk installed as a result of the state-mandated Chapter 91 and the BRA-mandated Harborwalk requirements.

Inner Harbor

The Boston Inner Harbor consists of the Chelsea Creek and Mystic River Confluence, the Upper Inner Harbor, Fort Point Channel, the Lower Inner Harbor, and the Reserved Channel. Land uses along the shores of the Inner Harbor included not only industrial and commercial, but also residential and recreational. Thanks to the clean-up associated with the start of secondary treatment at Deer Island and the disposal of effluent via a 9.5 mile outfall tunnel into Massachusetts Bay, clarity has improved and certain microorganisms now survive to cause faster deterioration of wooden pier pilings. The MADEP has classified the Inner Harbor as SB_{cso} waters.

While the SB_{cso} classification allows for fishing, due to public health concerns MADEP's 2004-2008 Boston Harbor Watershed Water Quality Assessment Report does not support fish or shellfish consumption for fish or shellfish caught in the Inner Harbor. Aquatic life and primary and secondary contact recreation are supported, although aquatic life is subject to "Alert Status" due to wet weather dischardes, discharges from Municipal Separate Storm Sewer Systems (MS4), and industrial point source discharge. It is on the 2008 Integrated list of Waters in Category 5 -- Waters Requiring a Total Maximum Daily Load (TMDL) for priority organics and pathogens.

Pleasure Bay

Part of the Olmsted-designed waterfront recreation area on the South Boston shoreline, Pleasure Bay is mostly enclosed, with flow restricted to two channels between Castle and Head Islands. A beach stretches for two-thirds of its shoreline, with the other third of its shoreline a pedestrian causeway linking Castle and Head Islands. Its use is primarily recreational, but the watershed generates urban storm runoff and storm sewer discharges. It is classified SB Shellfishing (Restricted).

Fish consumption is not supported, per the 2004-2008 MADEP report. Support with alert status is given for primary recreational

contact with full support for secondary contact. The water body was not assessed for aquatic life or aesthetics in this report. Pleasure Bay is also on the 2008 Integrated list of Waters in Category 5- Waters Requiring a Total Maximum Daily Load (TMDL) for priority organics and pathogens. In 2013, Pleasure Bay was closed for one day.

Dorchester Bay

Stretching down from Head Island along the South Boston beaches to Columbia Point, then southward past Savin Hill to the mouth of the Neponset River and out to Thompson Island, Dorchester Bay's watershed has a mix of industrial, commercial, residential, and recreational uses. Thanks to the MWRA CSO Control Program, which included a large scale sewer separation project in Dorchester managed by the BWSC, CSO discharges to Dorchester Bay are being reduced, with water quality improving. The surface water quality classification for Dorchester Bay is SB Shellfishing (Restricted), and it is listed on the 2008 Integrated list of Waters in Category 5- Waters Requiring a Total Maximum Daily Load (TMDL) for priority organics and pathogens. The 2004-2008 MADEP report does not support fish consumption due to PCBs and other contaminants in fish tissue and shellfish, nor does it support primary contact due to discharges from municipal separate storm sewer systems and unspecified urban stormwater. Support is given for secondary contact recreation, and support with alert status is given for aquatic life. and partial support to primary and secondary contact recreation due to pathogens from CSO discharges. Progress is being made in the improvement of water quality for primary contact recreation. In the 2006 season, Tenean Beach was posted against swimming for a total of 19 days, Savin Hill Beach for a total of five days, Malibu Beach for a total of five days, Carson Beach for a total of 14 days, M Street Beach for a total of eight days, and City Point Beach for a total of 12 days. For the 2013 season, conditions improved, with Savin Hill Beach not subject to any closure, Malibu Beach closed for three days, Carson Beach for three days, M Street Beach for two days, and City Point Beach for one day. On the other hand, for 2013, Tenean Beach was closed for 24 days.

Outer Harbor

Water quality for Boston Outer Harbor and the Harbor Islands within Boston city limits typically meets water quality standards for bacterial contamination. The 2004-2008 MADEP report

supports aquatic life and primary and secondary contact recreation in this surface water body. Fish consumption is not supported, nor is shellfishing for most of this area. The 2008 303(d) list includes the Outer Harbor (here called "Boston Harbor") as a water requiring a TMDL due to priority organics and pathogens.

Still, thanks to regulatory action and the needs of the Central Artery/Tunnel project for a disposal site for tunnel-displaced soils, the old landfill at Spectacle Island was capped, providing an opportunity for the construction of a passive recreation area on the island's surface. With pathways, a dock, and beaches, this recently opened park provides spectacular water views of the harbor and surrounding lands.

One piece of evidence for the cleanliness of the Outer Harbor waters is the fact that for the Spectacle Island beaches, only two days in 2006 were posted against swimming, and for Lovell's Island beaches, there were no days in 2006 posted against swimming. In the 2013 season, the Spectacle Island beaches and the Lovell's Island beach were not subject to any closure.

Winthrop Bay/Orient Heights Bay

This bay, lying between East Boston and Winthrop, receives a considerable amount of stormwater discharge from Logan Airport. CSO discharges were eliminated in the late 1990's through a sewer separation project completed by the BWSC. The 2004-2008 MADEP report indicates support for aquatic life and secondary contact recreation. Excessive pathogen levels have caused the bay to remain on the 2008 303(d) list of impaired waters. In the 2006 season, Constitution Beach was posted against swimming for a total of 16 days. For the 2013 season, this beach was posted for five days.

Neponset River

Per the 1999 Boston Harbor Water Quality Assessment Report, MADEP has reviewed this river in four segments that appear in whole or in part within Boston city limits, three segments representing portions of the Neponset mainstem, and one segment representing the Mother Brook, a tributary to the Neponset.

The most upstream Neponset mainstem segment is eight miles long, from the confluence with the East Branch in Canton to the confluence with Mother Brook in Hyde Park. Approximately the

two most downstream miles are within Boston city limits, north of the point where the boundaries of Dedham, Canton, Milton, and Boston meet.

Portions of this segment, including some portion of the segment within Boston, are within the Fowl Meadow/Ponkapoag Bog ACEC. Many portions of the banks in this segment are owned by the DCR as part of the Neponset River Reservation, with some of these parklands developed for land-based and water-based recreation.

This segment is classified as Class B Warm Water Fishery surface water quality. The 1999 MADEP report assesses conditions in this segment to be in partial support of primary and secondary contact recreation, while fish consumption is in non-support due to elevated PCB levels in certain fish. The 2004 MADEP 303(d) list of impaired waters includes this segment due to metals, priority organics, organic enrichment/low DO, oil and grease, pathogens, turbidity, and objectionable deposits.

Mother Brook is the first canal dug in the United States. Its original purpose was to increase flow to the Neponset to help drive the mills along its length, but its current purpose is to provide flood water diversion from the Charles River watershed. Its length, from its headwaters at the diversion of the Charles River in Dedham to the confluence with the Neponset in the Hyde Park neighborhood of Boston, is 3.6 miles. A mix of land uses, from parkland to residential to commercial to industrial, are found along its banks. The DCR owns a considerable amount of the shore along its banks, but the main public access to this river segment is in Hyde Park at its Mill Pond impoundment.

This segment is classified as Class B surface water quality. The 1999 MADEP report assesses conditions in this segment to be in partial support of primary contact recreation and aquatic life, while secondary contact recreation is in full support. The 2004 MADEP 303(d) list of impaired waters includes this segment due to nutrients, organic enrichment/low DO, flow alteration, pathogens, taste, odor, and color.

The Neponset mainstem segment just downstream starts at the confluence with Mother Brook and ends at the Milton Lower Falls Dam. For most of this length, the southern banks are within Milton

town limits, while the northern banks are within Boston city limits. The land uses nearby are residential, with some industrial and commercial, but generally urbanized. While much of the banks are in DCR hands and are wooded, they are often narrow and steep. Some limited public access to the river through these lands has been developed in recent years.

This segment is classified as Class B Warm Water Fishery surface water quality. The 1999 MADEP report assesses conditions in this segment to be in non-support of primary and secondary contact recreation due to pathogens, while fish consumption is in non-support due to elevated PCB levels in certain fish. This report puts aquatic life in the segment on "Alert Status" due to historically contaminated sediments. The 2004 MADEP 303(d) list of impaired waters includes this segment due to metals, priority organics, organic enrichment/low DO, oil and grease, pathogens, and objectionable deposits.

The most downstream segment of the Neponset mainstem is estuarine, flowing from the Milton Lower Falls Dam to the mouth of the river at the confluence with Dorchester Bay. Portions of the southern and eastern banks are within Milton town and Quincy city limits; the northern and western banks are within Boston city limits. A variety of land uses, including estuarine wetlands and former landfills, can be found on its shores. The landfills have been capped and made into a state park, Pope John Paul II Park, and most of the wetlands are under DCR management. A path for walking, bicycling, and other linear-oriented recreation has been established near the banks on lands primarily controlled by DCR.

This segment is classified as Class SB, Shell Fishing (Restricted) surface water quality. The 1999 MADEP report assesses conditions in this segment to be in non-support of primary and secondary contact recreation due to pathogens, while fish consumption is in non-support due to public health concerns. The 2004 MADEP 303(d) list of impaired waters includes this segment due to priority organics, organic enrichment/low DO, pathogens, turbidity, and objectionable deposits.

Remnants of the large shad, river herring, and rainbow smelt fisheries still return to the Neponset River. The US Army Corps of Engineers and the Massachusetts Riverways Program are now engaged in a feasibility study to evaluate alternatives for fish

passage at the Walter Baker (Milton Lower Falls) and Tilestone and Hollingsworth dams along the river, as well as to examine opportunities for channel improvements and habitat restoration.

The BWSC sewer separation project in Dorchester has led to the elimination of CSO discharges to this segment of the Neponset, helping to improve conditions during and following wet weather events.

Charles River

While most Bostonians and folks from eastern Massachusetts know the Charles as the water body flanking much of the northern edge of Boston's city limits, it also flanks a portion of the southwestern edge of the city in West Roxbury. While much of the banks along this stretch are protected parklands and wetlands, some proximate land uses to these banks are industrial, commercial, and residential in nature. The 2002-2006 Charles River Watershed Water Quality Assessment Report produced by the Massachusetts Department of Environmental Protection (MADEP) includes this portion in the 23-mile segment of the Charles from Chestnut Street in Needham to the Watertown Dam in Watertown.

A major effort to improve water quality in this section of the Charles was the capping of the Gardner Street Landfill (now known as Millenium Park) in West Roxbury. Supported by City of Boston capital improvement funds and the State Revolving Fund (SRF), this $14 million capping project was assisted in part by the use of soils displaced by the Central Artery/Tunnel Project. The capping thus prevents water from infiltrating the underlying landfill, thus preventing contaminated discharges and runoff reaching the river itself or its nearby tributary, Sawmill Brook. A multi-use park has been built on its surface, and serves to provide a use to protect the surface of the cap. The park includes the state's first canoe launch designed for handicapped accessibility, funded in part by the state Public Access Board. This park has thus provided a means for the public to access this stretch of the river for secondary contact recreation. Such recreational use of surface waters promotes watershed awareness, a necessary component to help change the public's behavior toward best management practices at the individual level. Such individual practices include cleaning up pet waste, discouraging feeding of waterfowl, and proper disposal of waste motor oil and household hazardous wastes.

This segment is classified as Class B, Warm Water Fishery surface water quality. The 2002-2006 MADEP Report indicates non-support for all categories for this segment. The 2008 MADEP 303(d) list of impaired waters includes this segment due to priority organics, nutrients, organic enrichment/low DO, pathogens, noxious aquatic plants, turbidity, and exotic species.

The Sawmill Brook is a 2.7 mile tributary to the Charles River that begins in southernmost Brookline, then travels through residential areas of southernmost Newton, through cemeteries, wetlands, and parklands in Boston before its confluence with the Charles at Millennium Park. The 2002-2006 MADEP Report indicates support for aesthetics only for this segment. The 2008 MADEP 303(d) list of impaired waters includes this segment due to other organics, organic enrichment/low DO, pathogens, noxious aquatic plants, and other habitat alterations.

Again, thanks to the capping of the Gardner Street Landfill and the development of the surface for Millennium Park, the water quality will improve in the lower reaches of Sawmill Brook over time.

The most downstream segment of the Charles River mainstem runs from the Watertown Dam in Watertown 8.6 miles to the Science Museum Dam in Boston. Due to the Science Museum Dam and the Charles River Dam downstream, this segment of the Charles is lake-like in nature. Its highly urbanized watershed contrasts to the DCR parklands along much of its banks in this segment. Historically, CSO discharges, urban stormwater runoff, and the contributions from tributaries such as the Muddy River and the Millers River have degraded water quality in this section. The 2002-2006 MADEP Report indicates non-support for aquatic life, fish consumption, and primary and secondary contact recreation for this segment. The 2008 MADEP 303(d) list of impaired waters includes this segment due to priority organics, metals, unknown toxicity, nutrients, organic enrichment/low DO, pathogens, oil and grease, taste, odor, and color, turbidity, noxious aquatic plants, and unknown causes.

The EPA has been working with the MWRA, the BWSC, and the Charles River Watershed Association (CRWA), and many other partners on its Clean Charles Initiative. Through negotiations, settlements, and joint projects, these partners have been able to

achieve significant improvements to the number of days this segment of the Charles River can be used for primary and secondary contact recreation. One of the chief efforts is the MWRA CSO control program in this area, which will achieve 99.5% reduction in CSO discharges to this segment from 1995 levels. Other efforts include the elimination of illegal cross-connections that contaminate municipal storm sewers that drain to the Charles or its tributaries, and negotiations and settlements with individual producers of discharges to the Charles. Public education to keep fertilizers, automotive care products, household hazardous wastes, excessive runoff, and – particularly for bacterial contamination reduction – pet and wildlife waste from entering the Charles has started to become an important strategy toward improving the Charles' water and recreation quality.

Gains have already been seen, as the EPA declared the Charles water quality in 2006 to be "B+" in terms of reductions in pathogens that affect primary and secondary contact recreation. The EPA noted that based on CRWA data, this Charles segment met the boating pathogen water quality standard 90% of the time, and the swimming pathogen water quality standard 62% of the time. 2006 was the third consecutive year of the Charles earning a "B+" grade. As a result, an officially sanctioned community swim event took place in July 2013 near the Hatch Shell in the Charles River Basin.

Muddy River

The Muddy River is a tributary to the Charles that forms the "backbone" for three of the Olmsted-designed Emerald Necklace parks, Olmsted Park, the Riverway, and the Back Bay Fens. While almost all of its banks are parkland, the river drains a highly urbanized watershed. Transportation corridors, such as State Route 9, the Massachusetts Turnpike, and commuter rail tracks cross the river.

The 2002-2006 MADEP Report indicates non-support for aquatic life, fish consumption, and primary and secondary contact recreation for this segment. The 2008 MADEP 303(d) list of impaired waters includes this segment due to priority organics, metals, nutrients, siltation, other habitat alterations, organic enrichment/low DO, pathogens, oil and grease, taste, odor, and color.

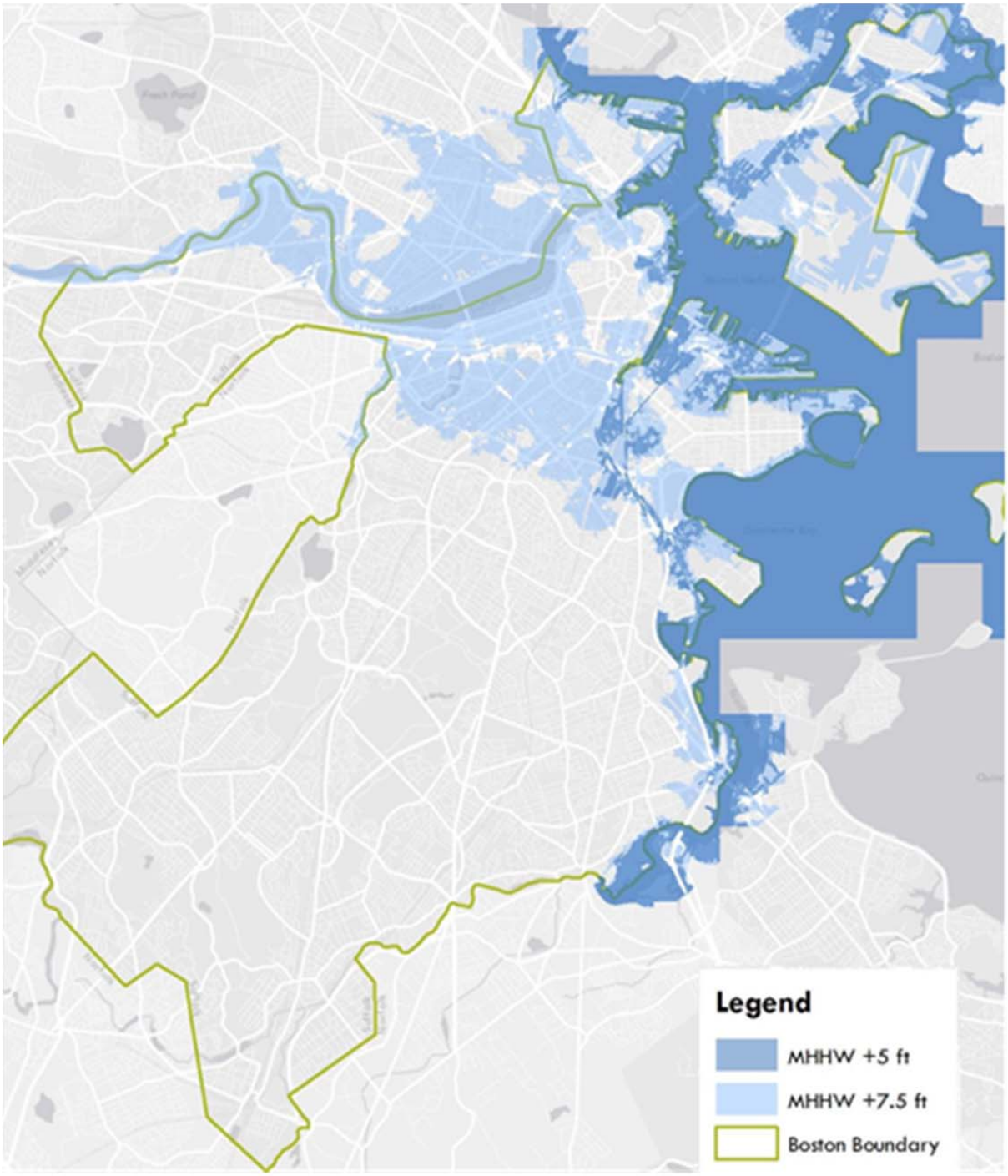
The Muddy River's flow is lake-like, as it has been affected for much of its length by the Charles River Dam impoundment. With historical CSO discharges, and ongoing urban stormwater discharges to the river, it has been highly impacted by sedimentation. This has consequently reduced the flood flow capacity of the river. The Army Corps of Engineers is currently undertaking an effort to daylight the Muddy River to improve flood control and water quality, as well as enhance riparian and aquatic habitat.

CLIMATE CHANGE, MITIGATION & ADAPTATION

Background

According to "Climate Ready Boston: Municipal Vulnerability to Climate Change:"

- 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.
- Rainfall 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. 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.
- 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.



Projected Inundated Areas Due to Sea Level Rise

Environmental Inventory & Analysis

Benefits of Mitigation/Adaptation for Open Space

- Enables parks and landscapes to adapt to and remain resilient in the face of climate change
- Creating parks can be an efficient means of addressing flood control.
- Well designed, constructed and maintained landscapes can help sequester carbon dioxide.
- Landscapes can also reduce ambient temperatures by provide shading and evaporative cooling.

Helps reduce energy use

Considerations

- Quantifying the benefits of individual parks in city-wide mitigation and adaptation can be challenging.
- It will be difficult to predict all of the impacts of climate change, particularly regarding flooding and extreme weather events, especially whether changes in precipitation levels will hinder, alter, or even enhance natural vegetation growth.
- Storm frequencies and flooding levels anticipated due to climate change may exceed existing codes.
- Higher costs of more extensive infrastructure may be difficult to justify.
- While trees sequester carbon and large trees sequester markedly more carbon than small trees, the effect of carbon sequestration of the trees in the city of Boston is insignificant compared to the amount of carbon being produced.
- When new open space cannot be created to mitigate the effects of climate change, existing open space may be perceived by some as "unused" land that should be consumed to solve the pressing problems of the day without recognizing its intrinsic value as open space.

Priorities

The Parks and Recreation Department will continue to modify its schedules and procedures as timeframes and conditions warrant. We have identified these areas as our current high priority issues in relation to climate change:

- Improve storm water retention capacity in all of our parks. Working with the Boston Water & Sewer Commission to invest in infrastructure to reduce storm water run-off and retain water on site to reduce flooding hazards and provide

irrigation for trees and plants. This can be achieved by use of rain gardens, retention basins, irrigation systems, permeable paving systems and less soil compaction.

- Working with the Boston Public Health Commission, develop educational materials and a campaign directed to park users regarding the health risks of mosquitos (EEE and West Nile Virus currently) and high exposure to sunlight. Can utilize permitting system to outreach to athletic and special events groups and schools. Continue to work with schools and others about potential schedule changes that may be required.
- Replace or increase tree canopy on sidewalks and open spaces to reduce heat island effect. Continue to survey health and level of tree canopy with new survey information and continue to direct resources for replanting and arbor-care as needed to ensure shade.
- Reduce energy consumption for field lights and fountains by upgrading energy efficient systems and equipment.
- Use tools being developed by the Environment Department to incorporate sea-level rise considerations in the analysis of identifying new projects.
- Evaluate the need to use plant and turf species used in parks that are adapted to warmer/more severe climates.

Policies

Street Tree Planting
Species of trees may have to change to adapt to heat, drought, pests and wind. Vulnerable trees may pose safety risk. As a result, BPRD will continue to review scientific research and continue to revise planting plans have for disease such as Cankor Stain which is killing London Plane trees.

Similar adjustments may have to be made to counteract increases in pollen, which have effect on air quality

Park Planting Plans
Species of plants and turf may have to change to adapt to heat, drought, and wind. There may be an increased need for inclusion of irrigation and drainage systems.

Storm Water Retention/Flooding in Parks
Some open space may be needed to retain stormwater on site as required and where appropriate to mitigate flooding elsewhere. Parks and other open spaces are potential drainage areas in dense neighborhoods. Other uses of these spaces are negatively affected if they are flooded. BPRD will first need to assess alternatives and then the infrastructure of each park for vulnerability before determining what, if any, action is required.

Workforce Safety
Increases in heat create dangerous health risk to employees working outdoors. BPRD may need to review schedules and modify times for its maintenance workers.
Athletic Permits
Increases in heat and heat waves create dangerous health risk for athletics and exercise. BPRD may need to review schedules and potentially extend hours. This may result in additional costs for lighting of fields.

Construction Work
Increase in heat and heat waves create dangerous health risk for contractors. BPRD may need to review current contracts and adjust days and hours as required.

Power/Telecommunications Outages
Increased demand for power to cool buildings may affect electricity availability resulting in blackouts, brownouts or selective shutting down of non-critical systems during peak usage times.

- Lighted fields, street lighting, fountains, irrigation systems within parks could be affected. Scheduling issues will arise. BPRD must consider backup systems within parks where feasible and improve communication network for permit holders.
- Administrative systems shutdown and lack of payroll or accounts payable may limit our ability to purchase goods and services. City-wide back-up systems will need to be considered.
- Enhancement of workforce backup systems for communication may be needed. Assess radios and phones and upgrade where necessary.

Coastal Flooding
Parks located near harbor or rivers may see increase in flooding creating negative impacts on plantings and make parks unusable for long periods. Accommodating additional drainage may be needed in designs, as well as using hardy coastal plant materials and locating utilities in safe locations. New parks and other open spaces subject to storm surge and wave action may need to have wave breakers integrated in their designs.

STRATEGIC PRACTICES

Objective
Anticipate changes at park sites and surrounding areas that may result from climate change. Determine strategies to mitigate and adapt to the effects of climate change while promoting the long term resilience of parks and landscapes.

Planning

Conduct a citywide climate change impact survey for park areas

- Identify park sites and other landscaped amenities that are vulnerable to:
  - Sea level rise
  - Damage from violent storms
  - Invasive species and pests
  - Landscape succession
  - Temperature related impacts
  - Saltwater intrusion

- Give special attention to waterfront landscapes, geographically exposed landscapes, and sites with a history of flooding.
- Evaluate presence of invasive species as climatic conditions change.
- Determine strategies for increasing the resistance and resilience of specific park and landscape assets.
- In areas that have high risk for future flooding, consider developing adaptation plans to offer protection and increase resilience.

- Consider how natural areas or constructed landscapes along waterways could serve as buffers to surrounding inhabited areas.
- Assess potential for new and expanded disease vectors and their habitats in parks and natural landscapes.

Develop climate adaptation plans for vulnerable existing parks and landscapes

- Hard Infrastructure
  - Drainage
  - Utilities
  - Asphalt design and materials
  - Pile and pier design
  - Fixed playground structures
- Assess site's risk of flooding due to 50 and 100 year storms or larger.
- Examine maps that predict floods and coastal erosion hazard areas.
- Use flood estimates for larger design storms and account for increased intensity of storms.
- Keep abreast of updates to flood projections.
- Determine acceptable levels of risk for the site.
- Consider how flooding events would impact the site: Pay particular attention to sensitive features including buildings, ornamental plantings, large trees, storage areas, and historic assets.
- Determine if any of the following practices will offer increased protection:
  - Engineering solutions such as regrading and stormwalls
  - Altered plantings
    - Salt-tolerant species
    - Inundation-tolerant species
    - Hearty species
  - Stormwater best management practices
  - Management / maintenance changes
  - Increasing tidal wetland coverage in coastal locations.

- Determine strategies for remediating damaged landscape features, including fallen trees and invasive species.
- Identify the most effective site adaptation measures and create an adaptation plan for the site that could either be undertaken incrementally or as part of future work plans.

Assess and seek to enhance the carbon capture and storage potential of landscape and soil features

- Seek to increase understory planting wherever possible to increase biomass.
- Assess the greenhouse gas liabilities of different strategies for dealing with dead or dying trees.

Design

Conduct a climate impact assessment for new parks and landscapes

- Determine future risks related to climate change and opportunities for mitigation.
- Determine acceptable levels of risk for the site.
- Consider exceeding requirements for storm frequencies and sizes.
- Consider onsite stormwater management strategies.
- Consider how the site could aid in citywide adaptation to climate change.
- When possible, engage the public (residents, stakeholders, local environmental groups) in climate impact assessment.

Design to minimize risks related to climate change

- In site planning, locate sensitive site features in locations that are less prone to flooding.
- Create absorbent landscapes and utilize onsite stormwater management.
- Select species that can tolerate the anticipated range of temperatures, rainfall patterns, and potential inundation from sea level rise.
- In situations where inundation may become a problem, utilize species that tolerate intermittent flooding and are less sensitive to salt water.
- Select trees with special care, especially along waterfronts.
- Use proactive park design as an opportunity for public education on flooding: Explain anticipated changes and how the park is planned for long term viability.
- Design landscapes to provide canopy cover, shading, and evaporative cooling in order to reduce the urban heat island effect.