UMASS AMHERST

History and Heritage Lecture

A History of Boston's Water System

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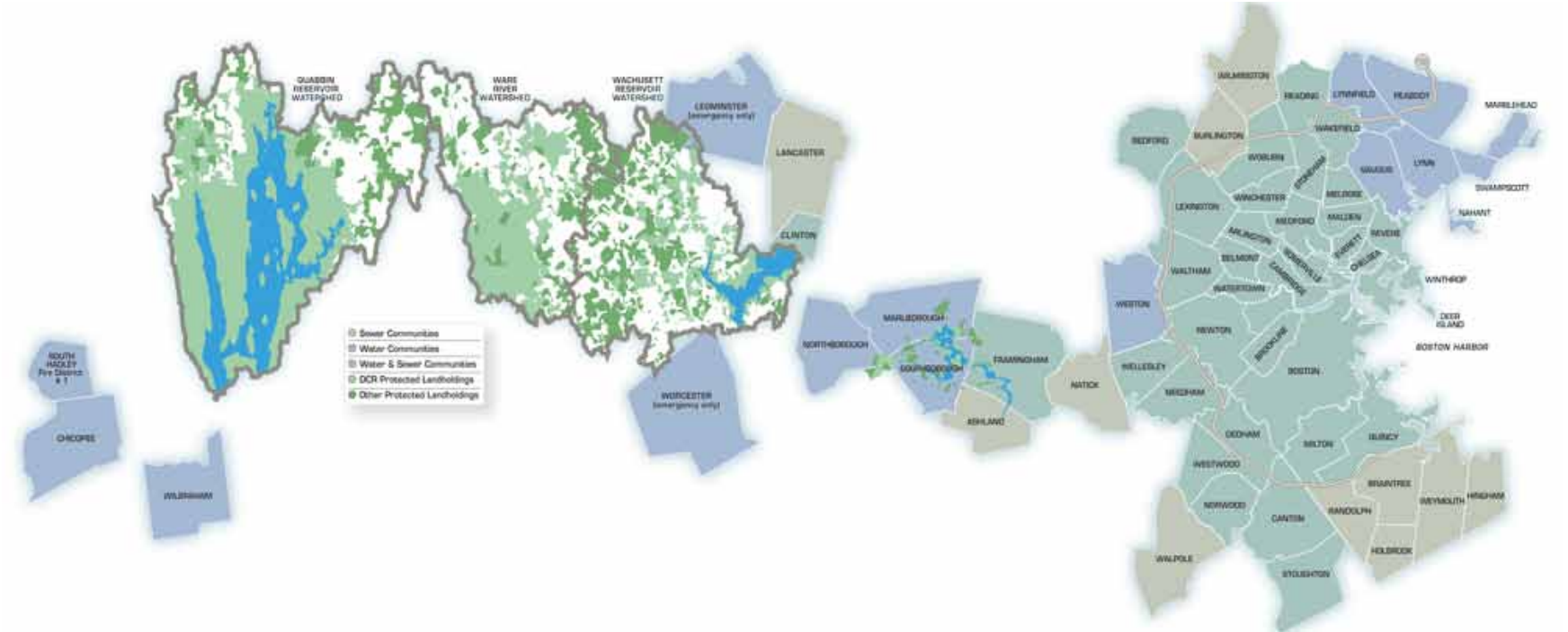
Executive Director

April 3, 2014

About MWRA

MWRA Service Area

- MWRA provides wholesale water and wastewater services to over 2.5 million customers in 61 communities
- On average, MWRA delivers an average of 200 million gallons per day to its water customers, with a peak demand of 350 million gallons
- MWRA collects and treats an average of 350 million gallons of wastewater per day, with a peak capacity of 1.2 billion gallons



Make-Up Of MWRA Service Area

- 51 communities that get water service
- 43 communities that get sewer service
- Of those, 30 get both water and sewer

  - 39 Towns
  - 20 Cities
  - 1 Fire District

  - 37 Boards of Selectmen
  - 20 Mayors
  - 3 Council Presidents

Governance

The MWRA is governed by an 11-member Board of Directors

Three Gubernatorial Appointees	
Secretary of Energy & Environmental Affairs	Co-terminus with Governor
Resident of Connecticut River basin	Co-terminus with Governor
Resident of Merrimack River basin	Co-terminus with Governor
At least one of these members must be a minority.	
Three Advisory Board Appointees	
Elected by the Advisory Board	3-year term
Elected by the Advisory Board	3-year term
Elected by the Advisory Board	3-year term
Three City of Boston Appointees	
Appointed by Mayor of Boston	Co-terminus with Mayor
Appointed by Mayor of Boston	Co-terminus with Mayor
Appointed by Mayor of Boston	Co-terminus with Mayor
Two From Communities That Host Major Facilities	
Appointed by Winthrop Council President	4-year term
Appointed by Mayor of Quincy	Co-terminus with Mayor

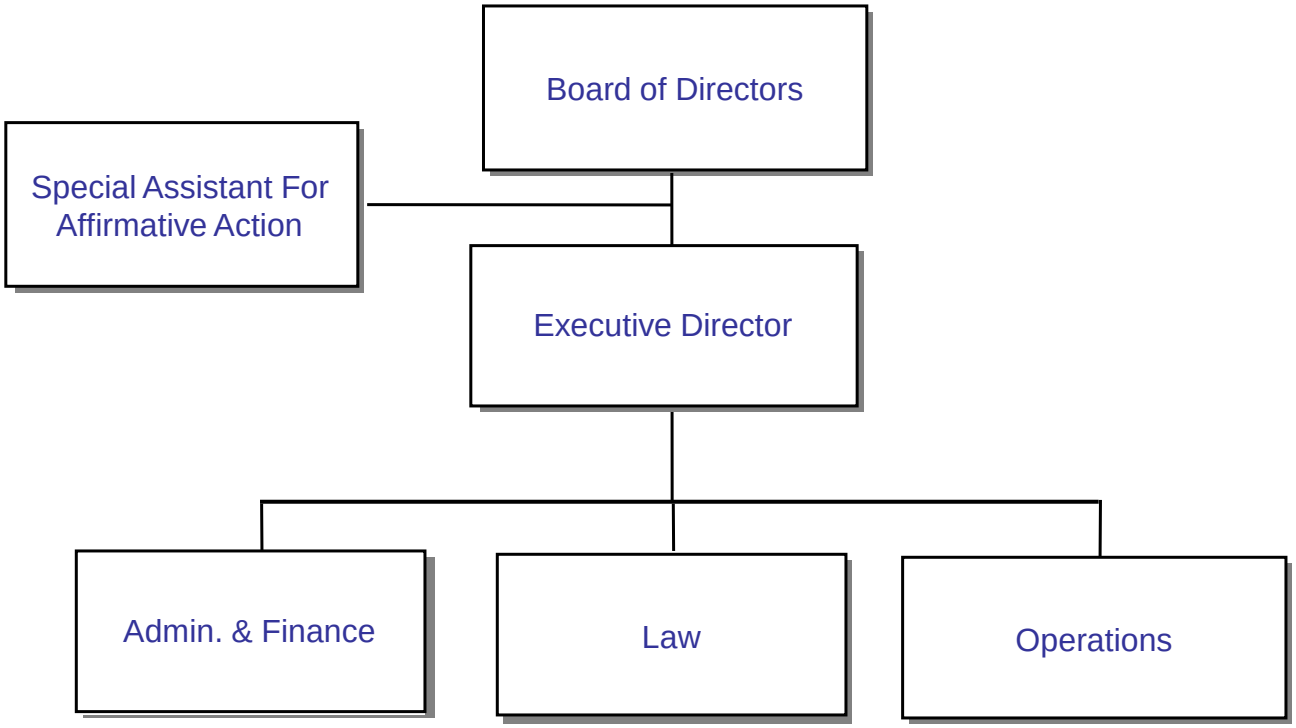
MWRA Advisory Board

- The MWRA Advisory Board was created by the Legislature to represent the interests of MWRA service area communities

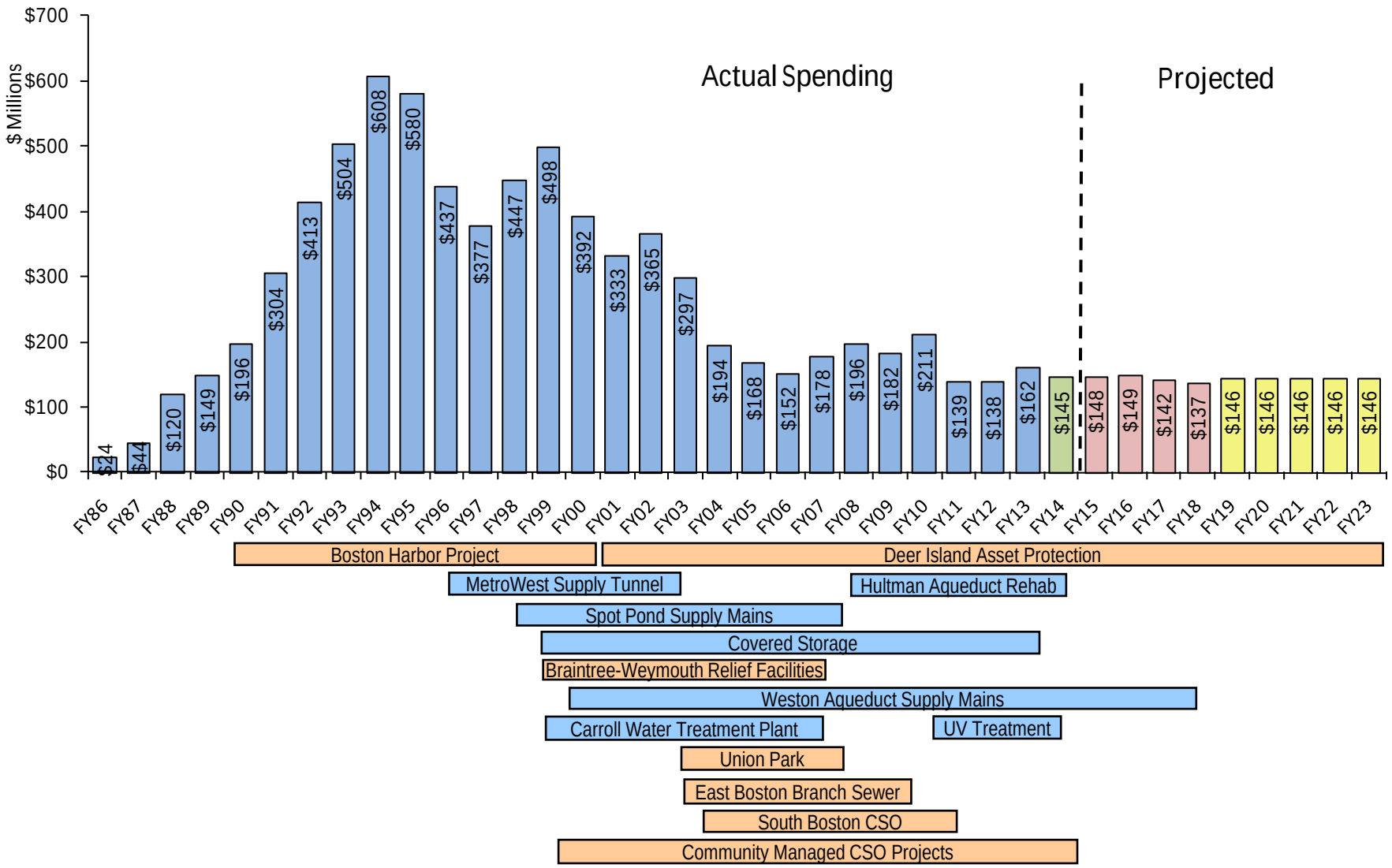
- Its members include the chief elected official and a designee from each of the 60 cities and towns serviced by the MWRA

- The Advisory Board
  - reviews and comments on MWRA budgets
  - appoints three members to the MWRA Board of Directors
  - serves as a liaison between the communities and the MWRA

Organizational Make-up

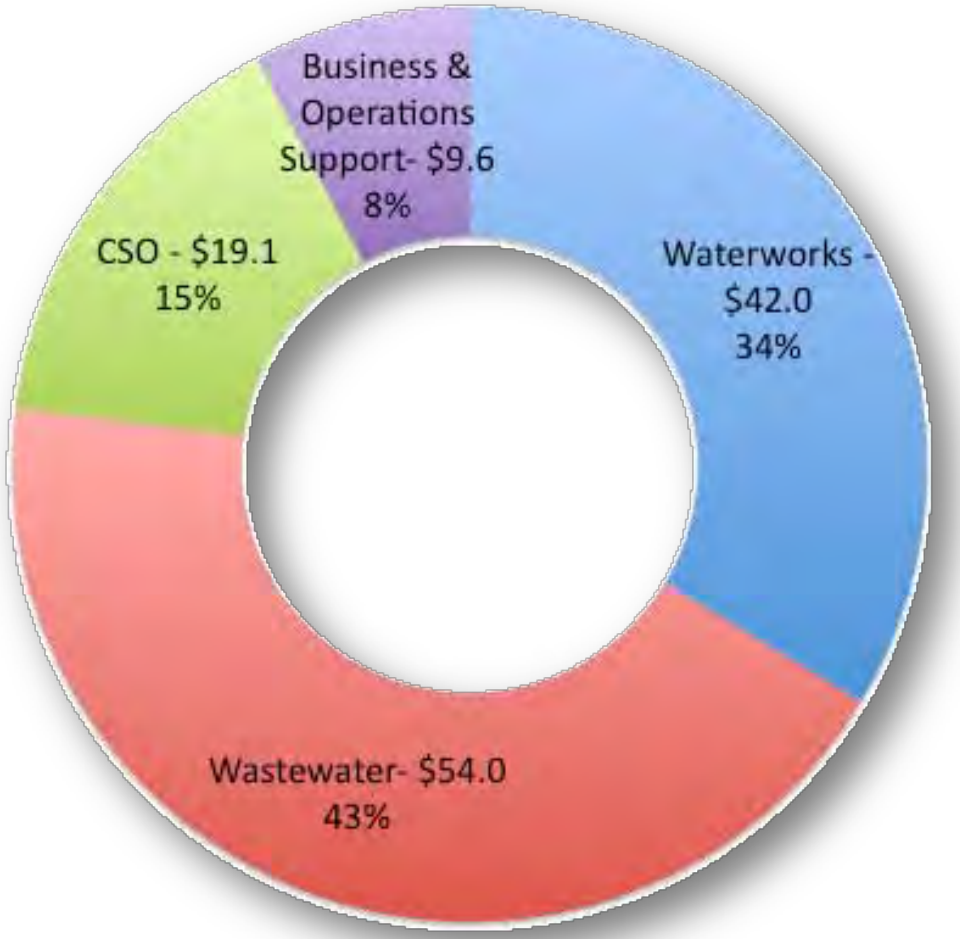


MWRA Has Invested $7.1 Billion In The Water And Sewer Systems



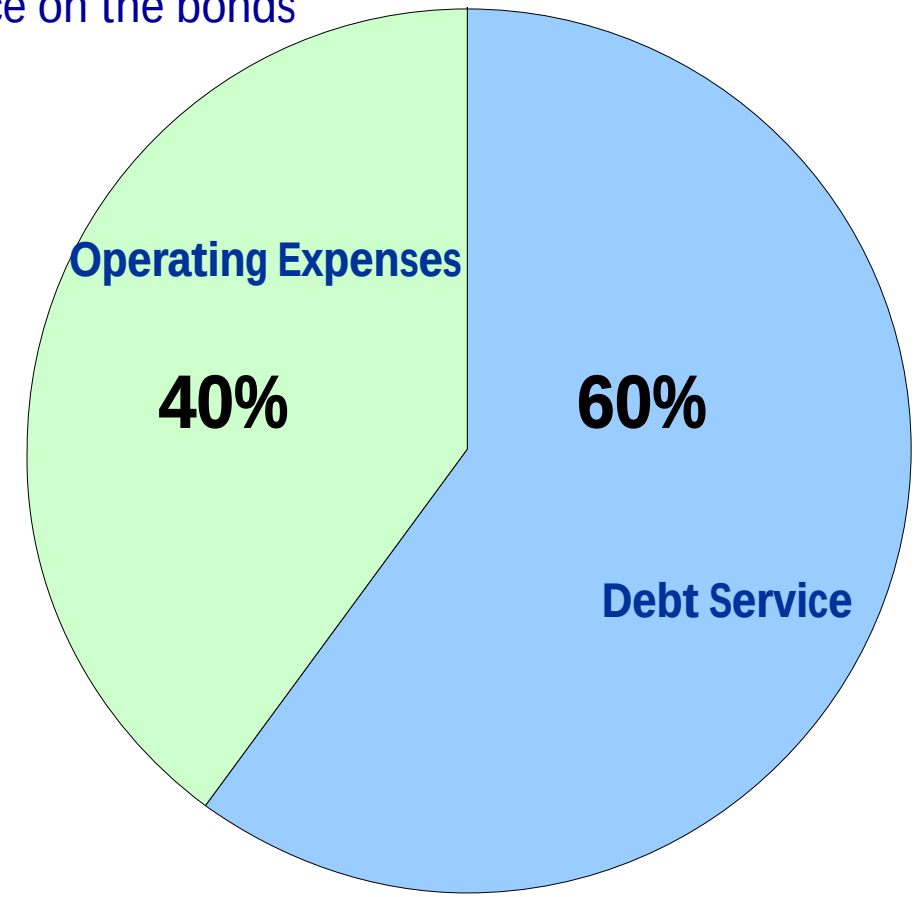
MWRA's Capital Improvement Program

- Proposed spending for FY2014 – FY2018 Cap period is $787.1 million
  - FY2014: $117.0 million
  - FY2015: $124.6 million
  - FY2016: $145.9 million



MWRA's Current Expense Budget

- MWRA has an annual operating budget of $658 million
- Over 60% goes to debt service on the bonds



History of Boston's Water System

1623: The Beginning - Founding Of Boston

- The first settler to enjoy a drink of water on Shawmut Peninsula – Reverend William Blackstone
- He came to the Plymouth Colony in 1623 and migrated to Shawmut to live a life of solitude in the area that is now Louisburg Square
- Reason why Massachusetts Bay Colony picked the site – Blackstone offered the **"Great Spring"**

The “Great Spring” Was Fenced

- The Great Spring is commemorated by a plaque on Spring Lane

1645 map of Boston with houses and key locations

1652: The “Conduit” –First Water Works In The Colonies

- Several families in the Dock Square area formed the first Corporation in the American Colonies to build and use the “Conduit”
- It was the first use of wooden pipes, house services and a terminal reservoir. It provided water for fire fighting and consumption

1796: Privatization Fills A Need

- People clamored for better water
- Entrepreneurs filled the need by bringing water from Jamaica Pond using wooden logs
- Laommi Baldwin Sr. served as engineer to the Jamaica Pond Aqueduct Corporation

FOR SALE,
THREE SHARES in the
BOSTON AQUEDUCT.
The value of this property may be ascertained by the following facts:—The quantity of water which can be brought into Boston by the Aqueduct, is sufficient for the use of twenty four hundred families, which at eight dollars annually, would give a dividend of one hundred and ninety-two dollars per share. Apply to
JOHN MARSTON.

WANTED IMMEDIATELY,
3000 PINE LOGS.
ANY perſon inclined to contract for the laſe and delivery of Three Thouſand Yellow Pine, or *Hackmatack* GREEN LOGS, for the uſe of the BOSTON AQUEDUCT, will pleaſe to apply to
John Marſton,
Secretary Aqueduct Corporation.
Boſton, July 15, 1799.

WOODEN PIPE LAID FROM JAMAICA POND.

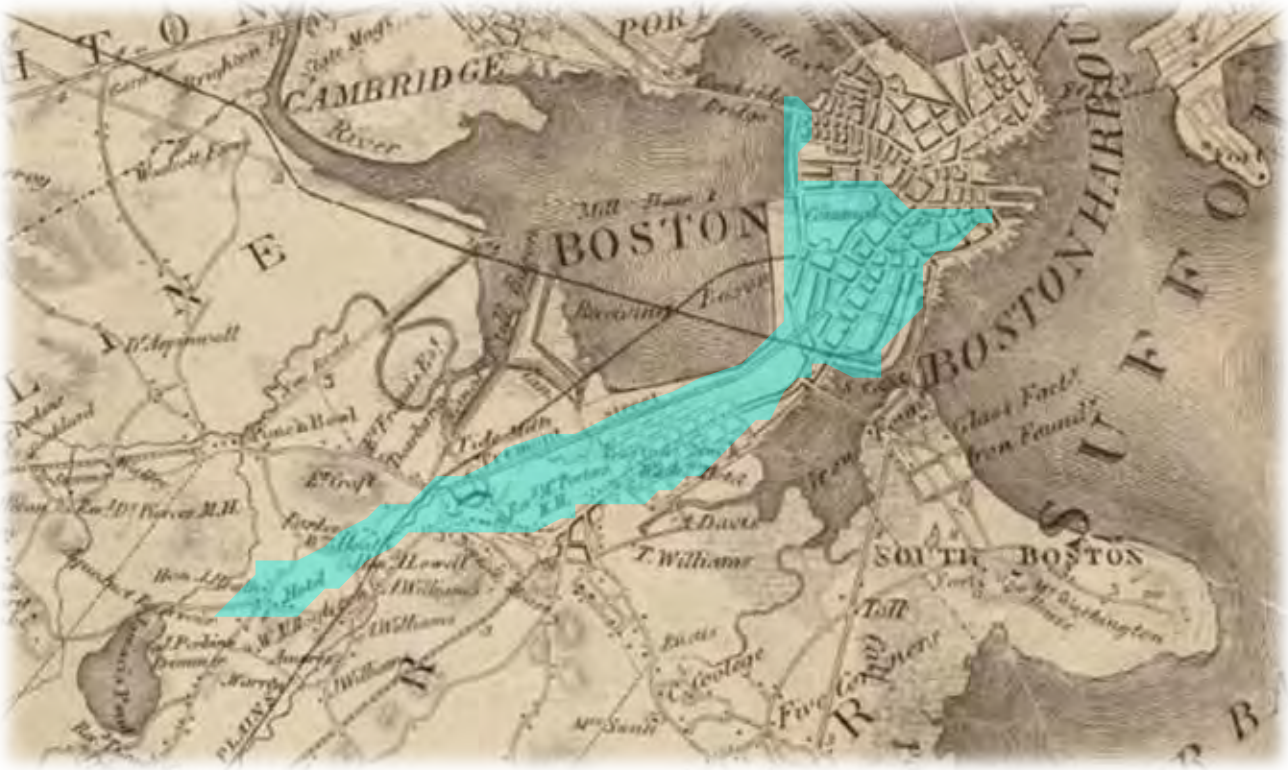
Why Jamaica Pond?

- It's the only nearby water body
- It's elevation is 60 feet above sea level, which allowed gravity flow to most of Boston. Steam pumping was still unproven in 1796

Who Was Served?

- This was strictly for paying customers and for places that were low enough. Customers were served in Roxbury and the low areas of the peninsula including to the Mass General Hospital area on the west and Fort Hill on the east

- Beacon Hill and the North End were not served



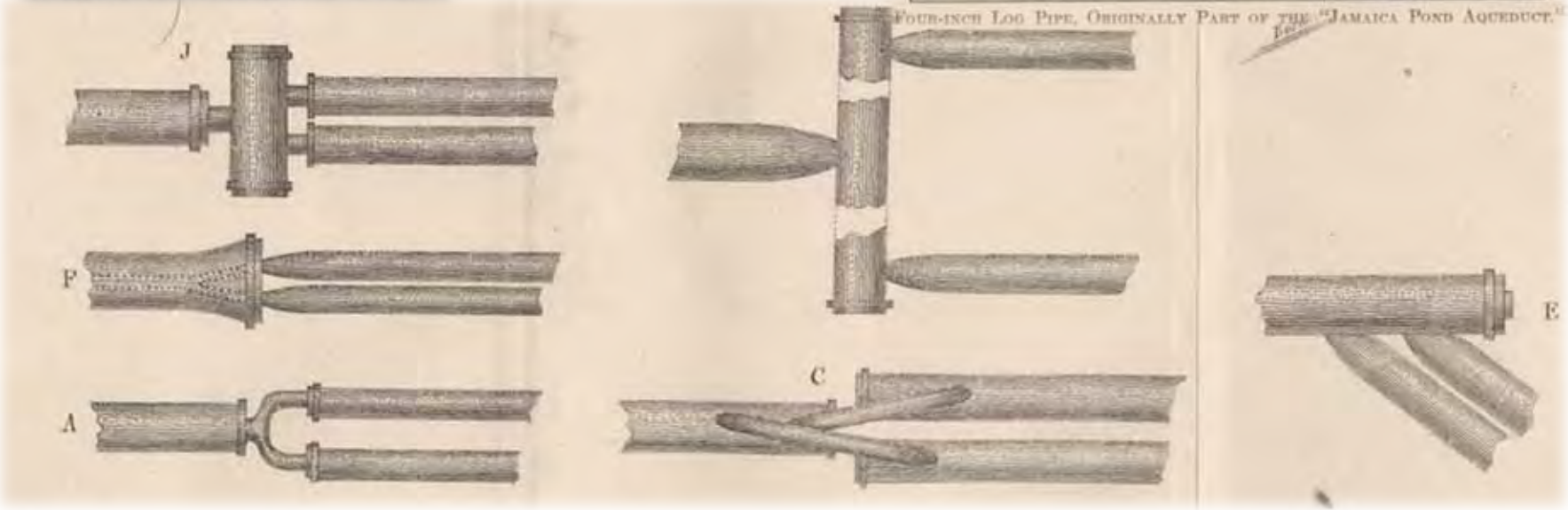
How Was The Service?

- Pressure was minimal, enough for slow delivery, but not enough to burst the pipe
- They quickly found that wood rots, leaks and splits
- Wooden pipes were retired from service when the 1848 municipal system was installed

A water stop – early version of a valve

Details Of Aqueduct Corporations Pipelines

Service connections were usually lead pipes but fire fighting access was drilled and refilled with wooden plugs (fireplugs)



Without fittings, joining multiple pipelines together became a creative exercise

1801: Philadelphia Becomes The First City To Be Supplied By Steam Pumps

- This was the second attempt at pumping, Benjamin Latrobe had an earlier unsuccessful attempt

- Graf's steam pumps worked reasonably well for several years, then a deadly boiler explosion and the cost of fuel resulted in rethinking the pumping do be done hydraulically by water wheels

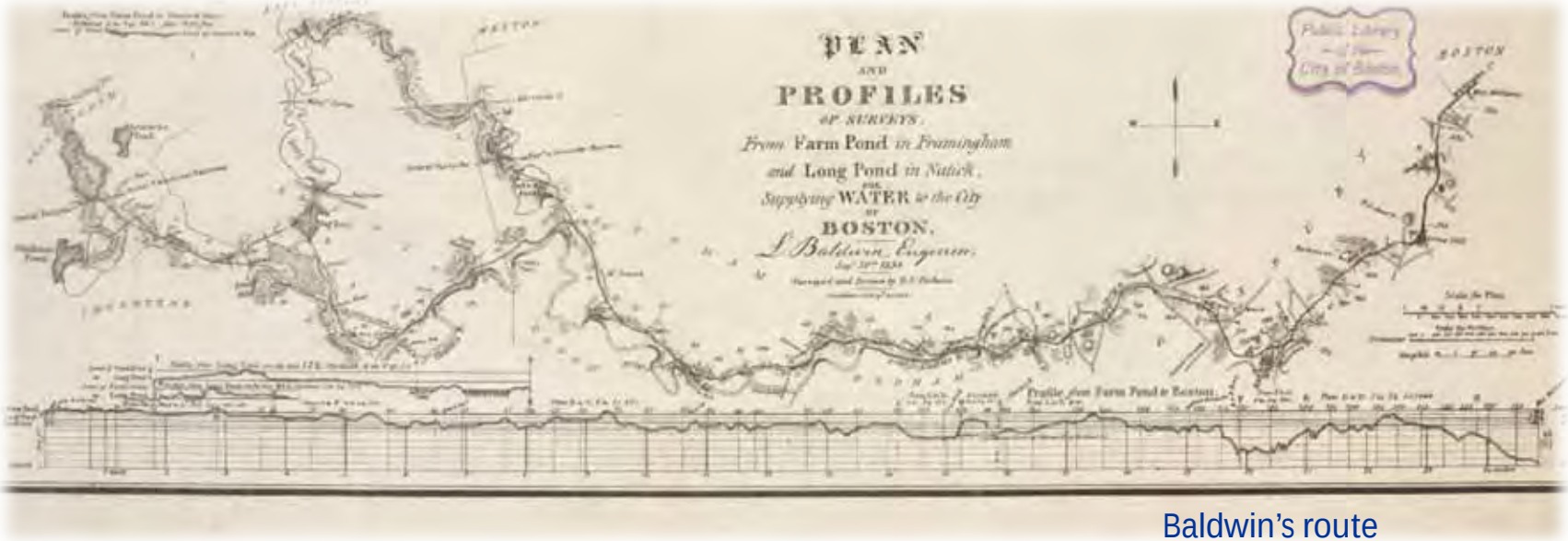
The eventual Fairmount Water Works

1820s: Boston's Need For Municipal Supply

- It became apparent to all that Aqueduct Corporation was not adequately solving the water supply problems of a growing city
  - By the 1820s, Philadelphia had become a shining example of a municipal water supply solution
  - Wells and cisterns are dangerously close to sewage and pollution with greater public dissatisfaction
- Josiah Quincy led the push for a municipal solution, but was confounded by factions that favored their own solutions, partly with a profit motive in mind

1830s: The Controversy

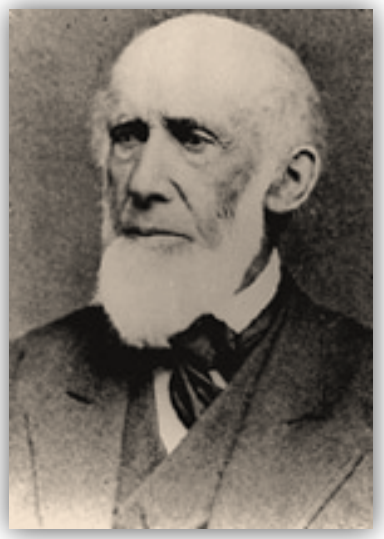
- Inventor Daniel Treadwell was chosen to review choices and recommended pumping from the Charles River at Watertown
- Others pushed the use of Spot Pond and the Mystic Lakes
- Loammi Baldwin Jr. was hired and recommended use of Long Pond in Natick. It was the most costly solution but offered long-term advantages. Water quality was a consideration and this started the trend of finding the upland sources with protected waters



Baldwin's route

1840s: Building Boston's First Municipal System

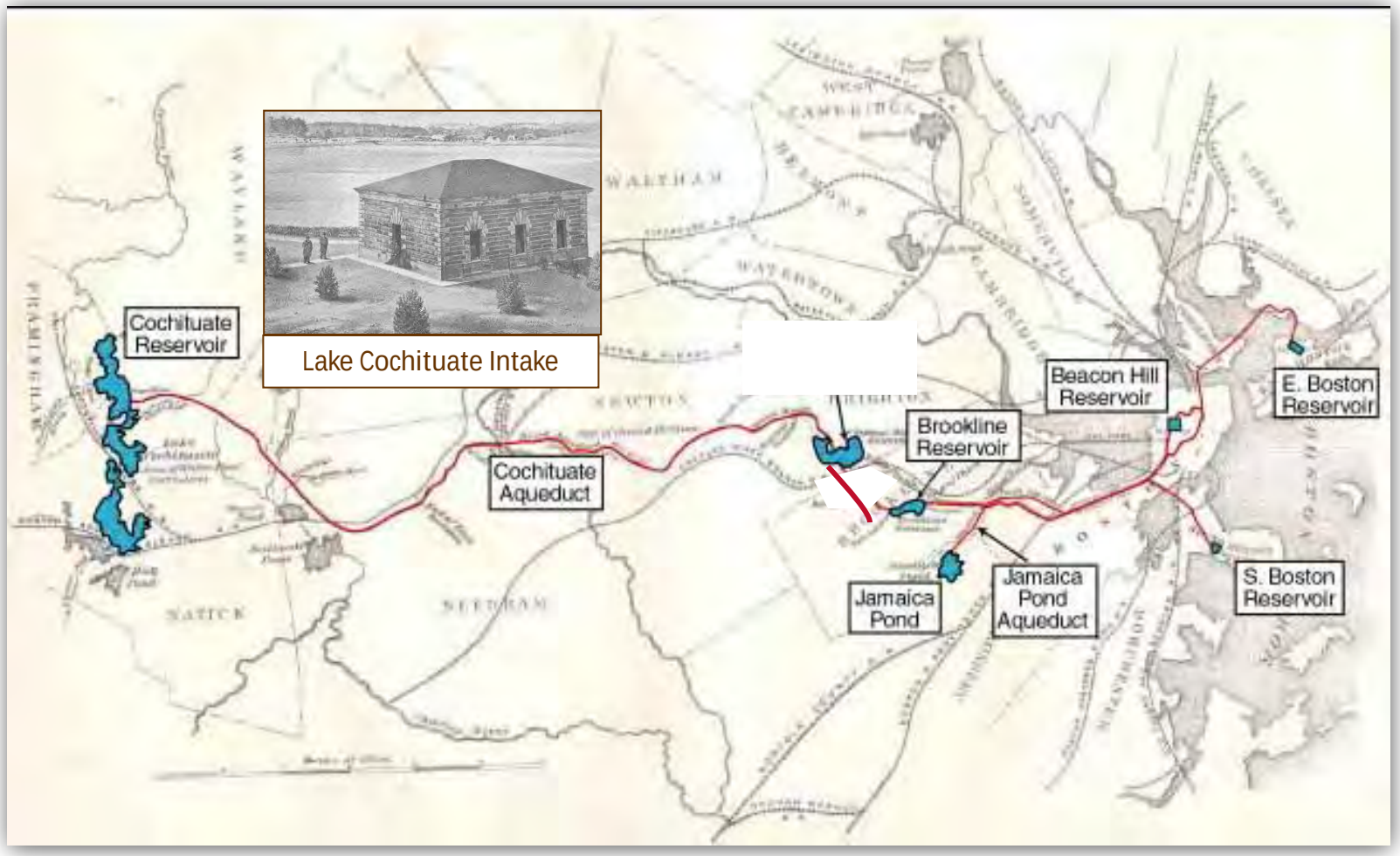
- Controversy continued into the 1840s
- The owners of the now defunct Middlesex Canal offered to sell it to Boston as a water source, a dubious offer at best
- John Jervis, the Engineer for New York's Croton supply, was brought in to be the ultimate expert. He had learned his engineering building a portion of the Erie Canal
- He concluded that the choice of Long Pond was the best and political support was successfully rallied to endorse the plan
- Work began in 1845



John Jervis

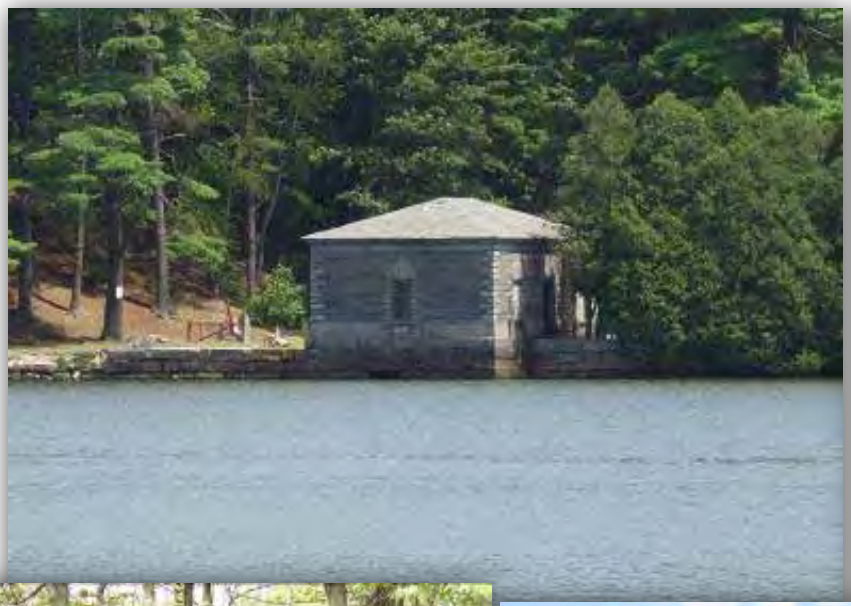
1848: The Result – The Boston Water Works

- Long Pond was renamed Lake Cochituate Reservoir
- The system flowed by gravity through a series of distribution reservoirs



1848: Water Celebration On Boston Common

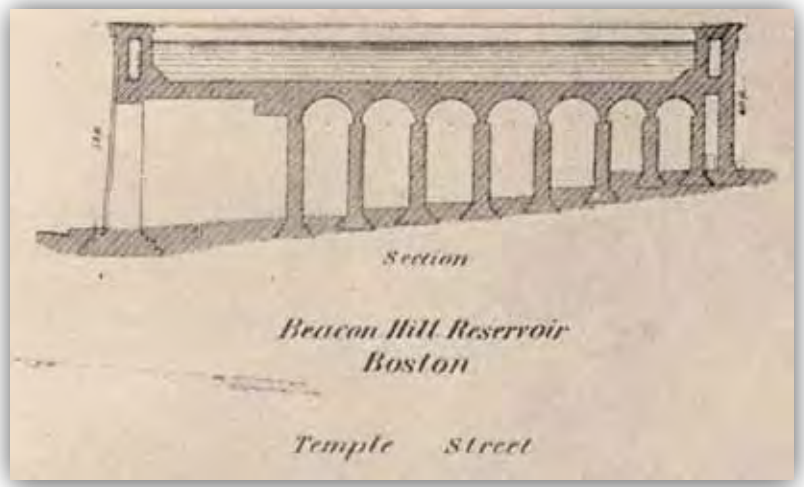
Today's Remnants Of The Old Cochituate System



Cochituate System: Old Brookline Reservoir, End Of Cochituate Aqueduct, Gatehouse

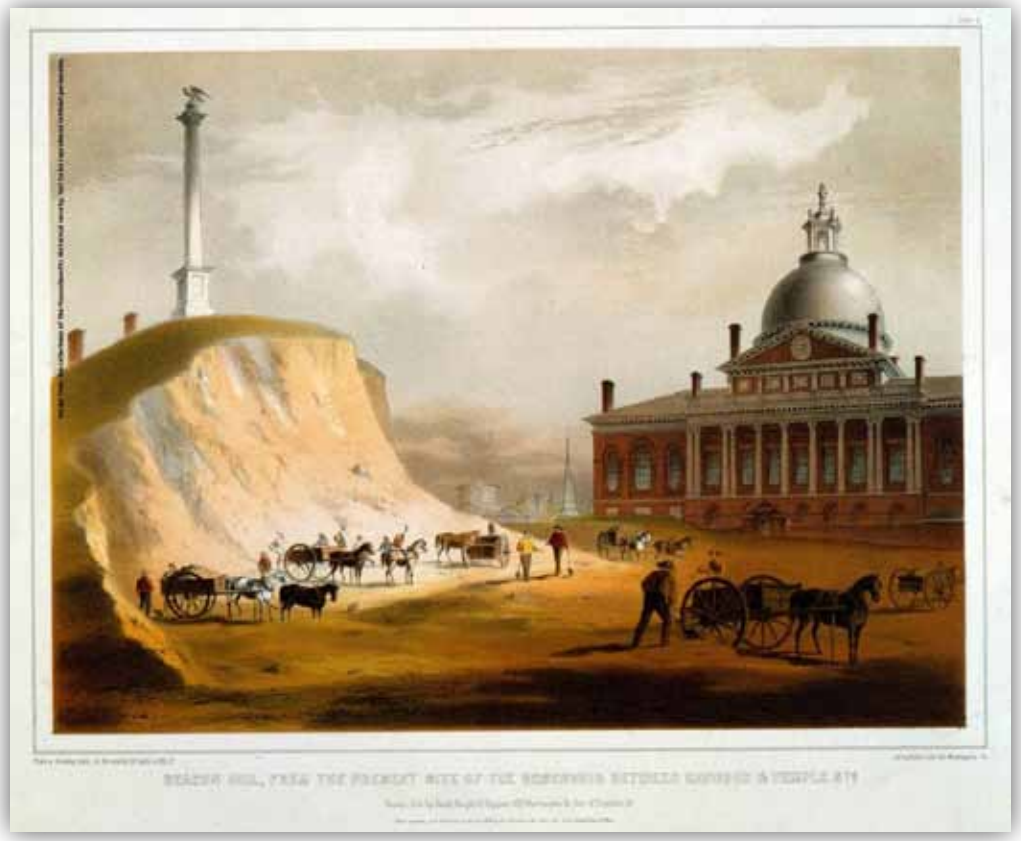
1848: Beacon Hill Reservoir

- Built as an elevated tank, only the top 20 feet held water in a lead sheet lined masonry structure
- It was demolished in 1880 to make way for the State House extension



Removing The Top Of Beacon Hill To Build The Reservoir

- The original top of Beacon Hill, behind the State House was too high for the planned reservoir and had to be lowered.
- The excavated soil went to fill the old Mill Pond



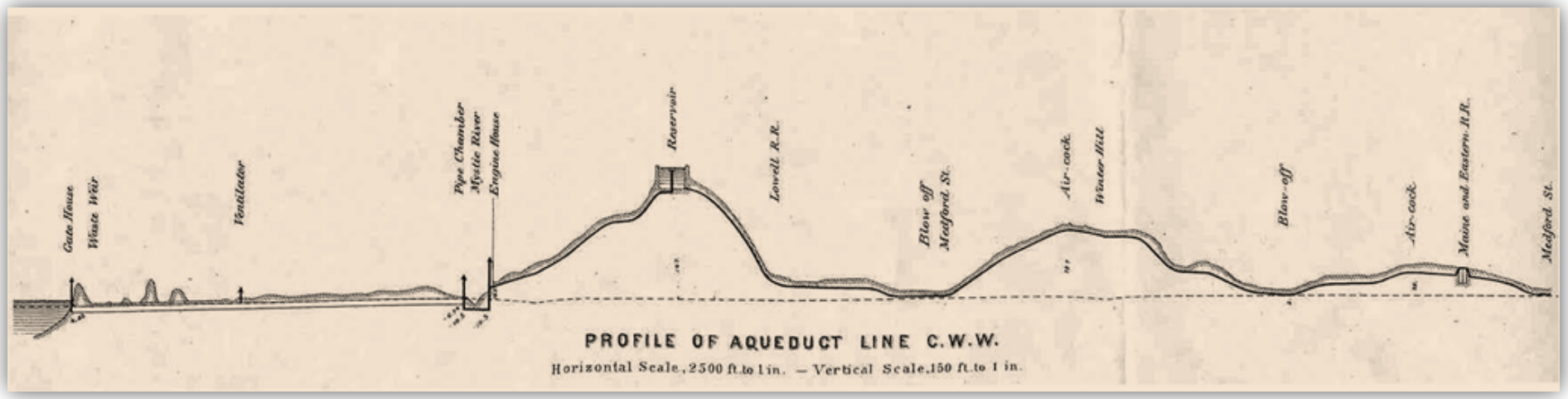
The view from Derne Street before leveling

The Granite Plaques Were Recently Found In A Boston Water & Sewer Work Yard

- They are now on display at the Waterworks Museum at Chestnut Hill

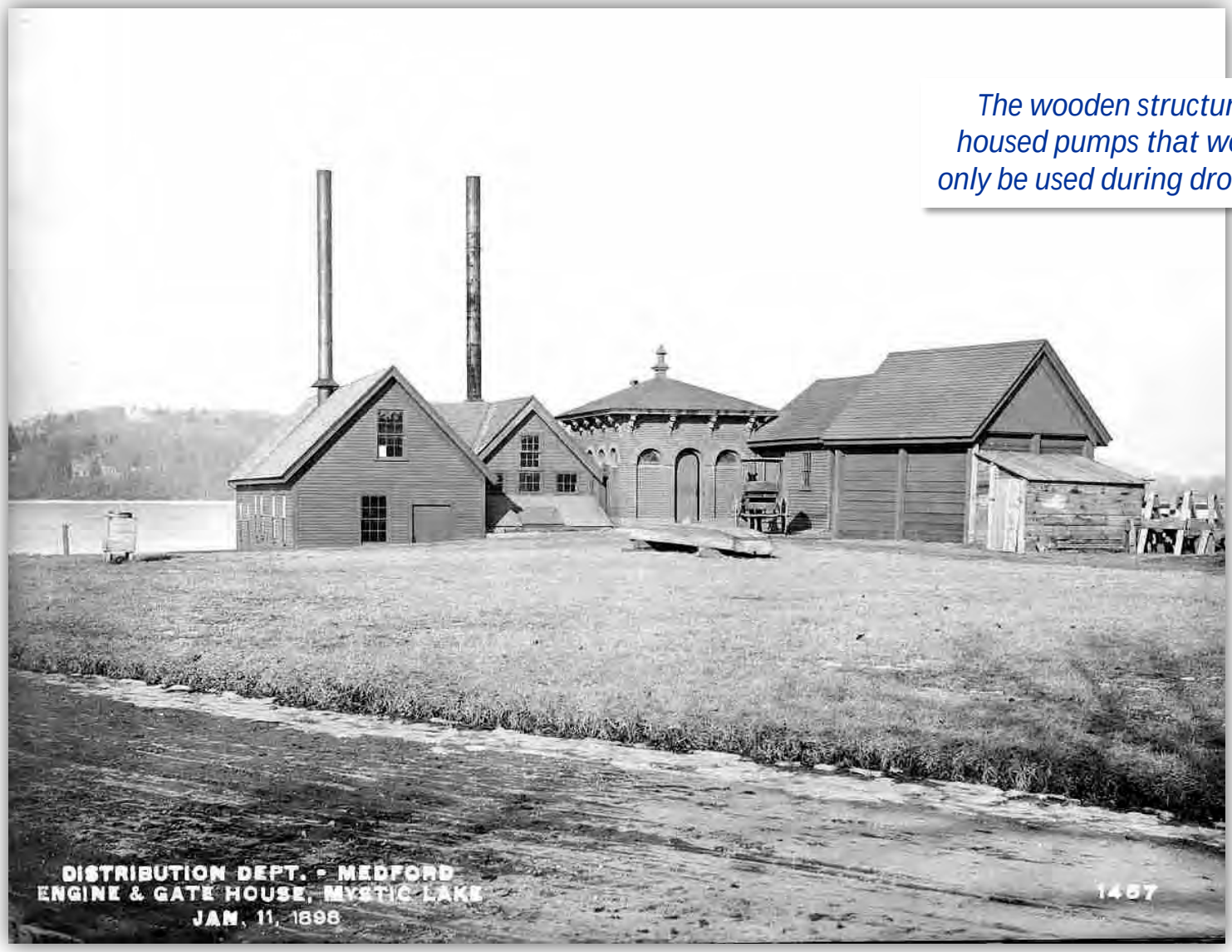
1861: Mystic System For Charlestown

- In the 1860s, the City of Charlestown had decided to take Mystic Lake for its water supply
- By 1864, the upper lake was dammed
- Water flowed by gravity to the Mystic Pumping Station and was pumped up to the Tufts Reservoir
- Charlestown now had enough water to meet its own demand and supply other communities



Mystic Lake Dam

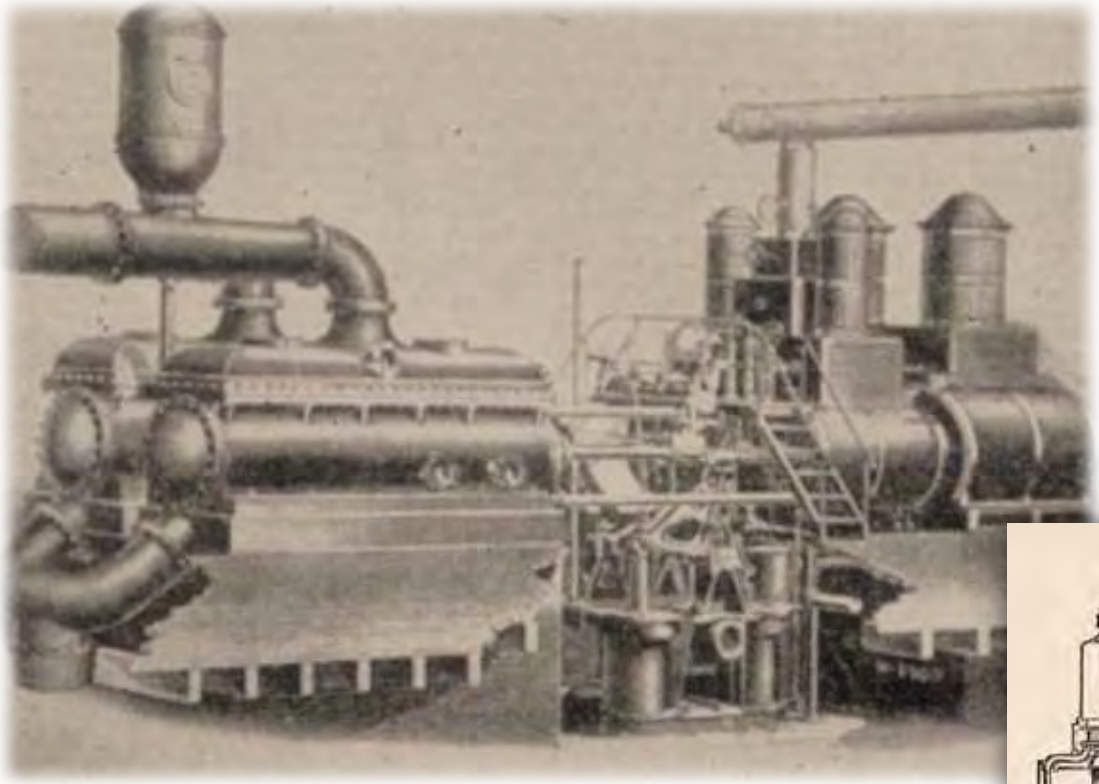
Mystic Lake Engine And Gate House



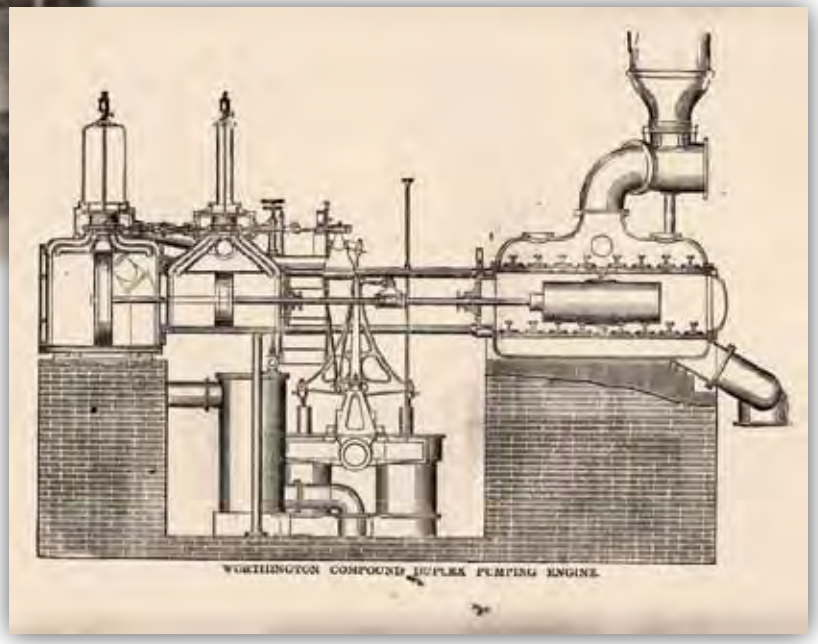
The wooden structures housed pumps that would only be used during droughts

Mystic Pumping Station In Somerville

Mystic Pump Station:
First Worthington Compound Duplex Pumps In The Country

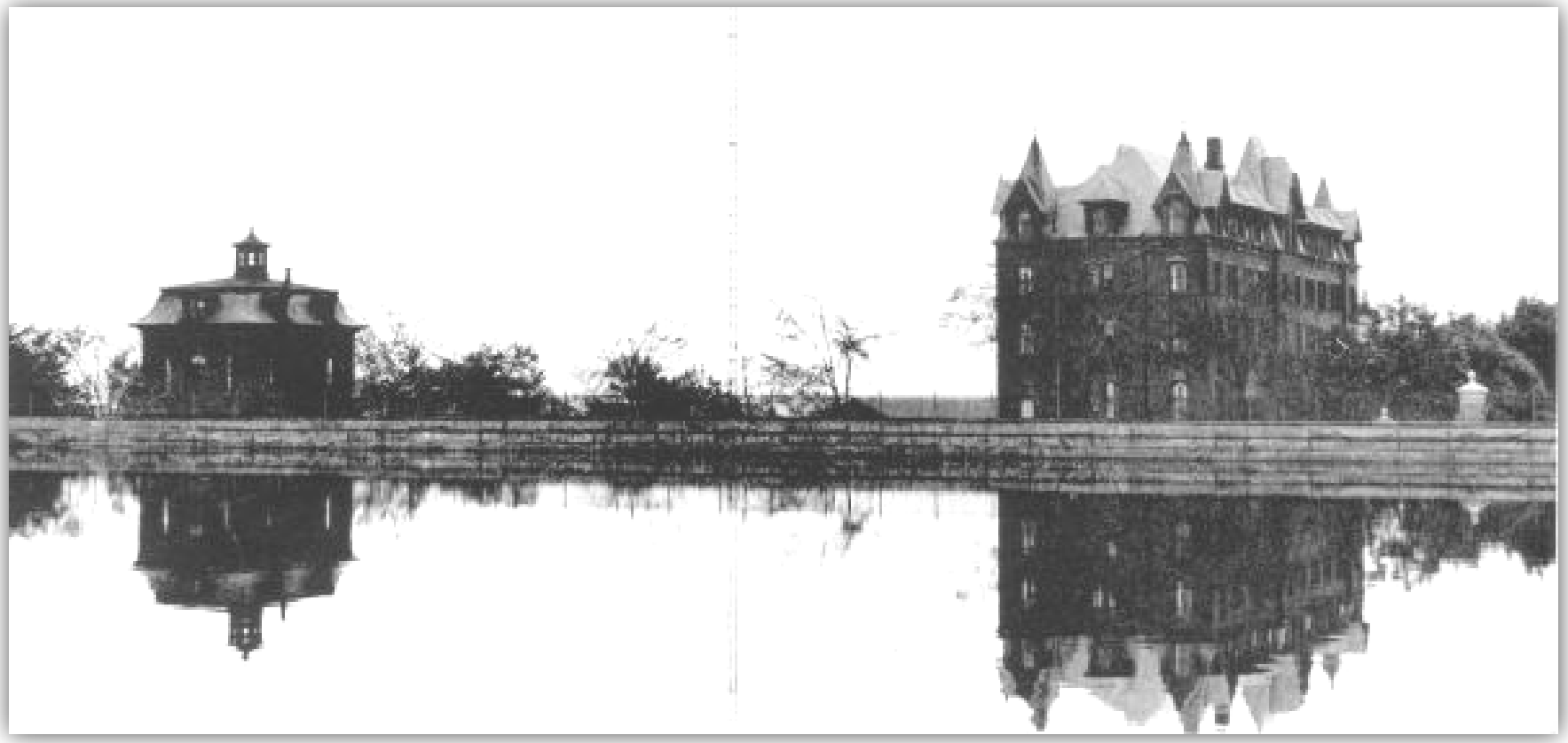


This Worthington pump model became a national standard



Mystic Reservoir At Tufts College

Mystic Reservoir At Tufts College



The site is now occupied by dorms

Remnants Of The Mystic Water Works Today: Upper Mystic Lake Intake And Pump Station

1860s: Boston Water Works Needed A New Distribution Reservoir

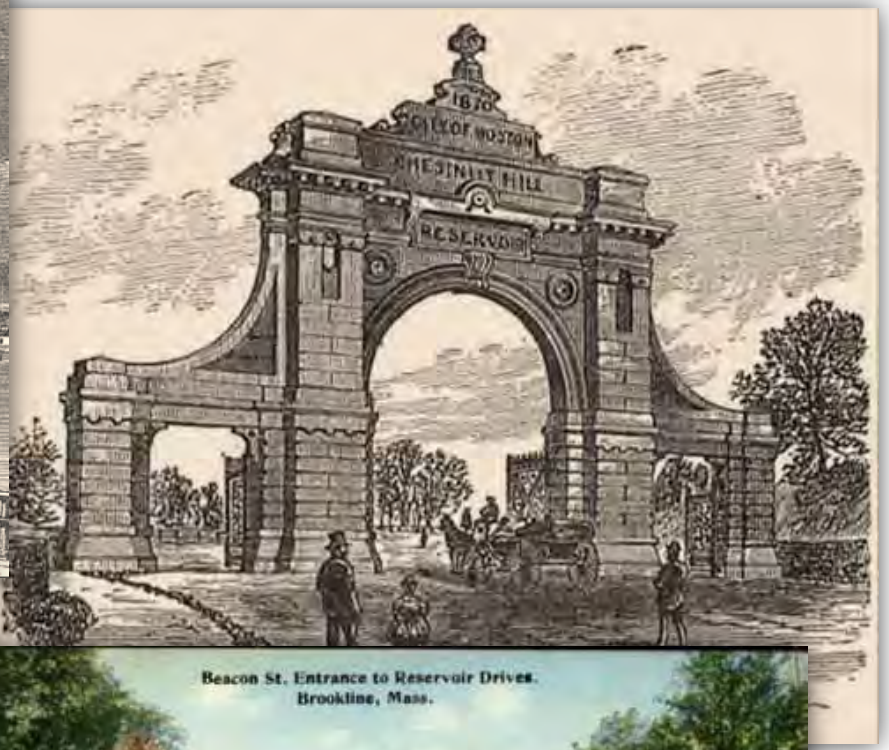
- Lake Cochituate began having difficulties supplying in dry summer months
- The Cochituate Aqueduct experienced a significant break in 1859
- Brookline Reservoir storage was limited and was dropping by 25% during high use periods. Depletion affected distribution system pressure
- Boston Waterworks decided that a new distribution reservoir is needed near the end of the Cochituate Aqueduct at Brookline Reservoir

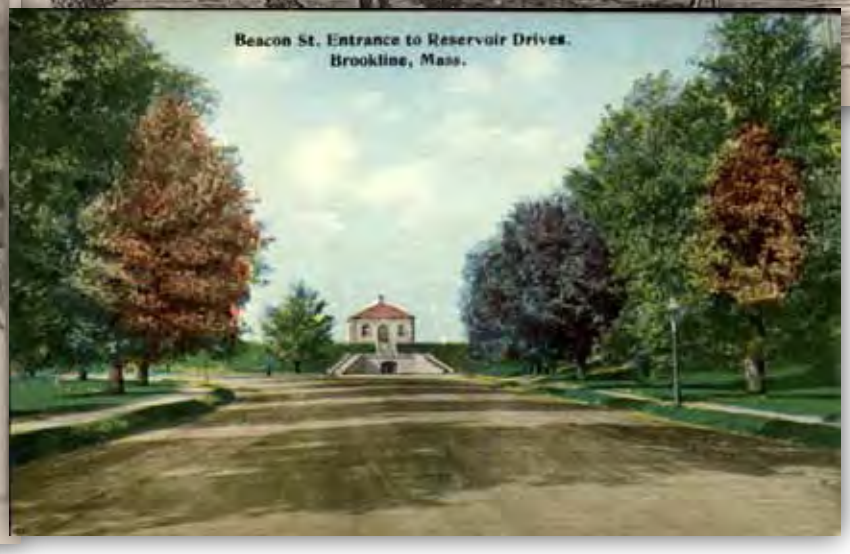
1866-8: Construction Of The Chestnut Hill Reservoir

- Beacon Street was relocated
- Stumps were pulled and large rocks removed
- A force of up to 750 men worked the site for 2 years
- An earthen dam was built and Gatehouse 1 was built

1867: Chestnut Hill Bradlee Basin Was Put In Service
1868: Lawrence Basin

Scenes From The Chestnut Hill Reservoir Grounds





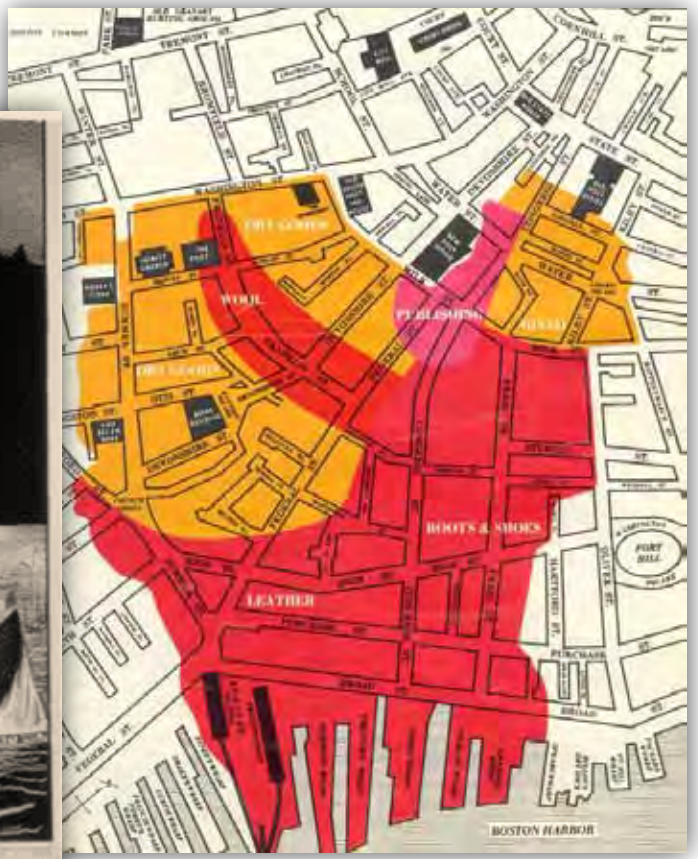
View Of Lawrence Basin With Bradlee Basin And Pump Stations In The Distance

1870: Roxbury Standpipe

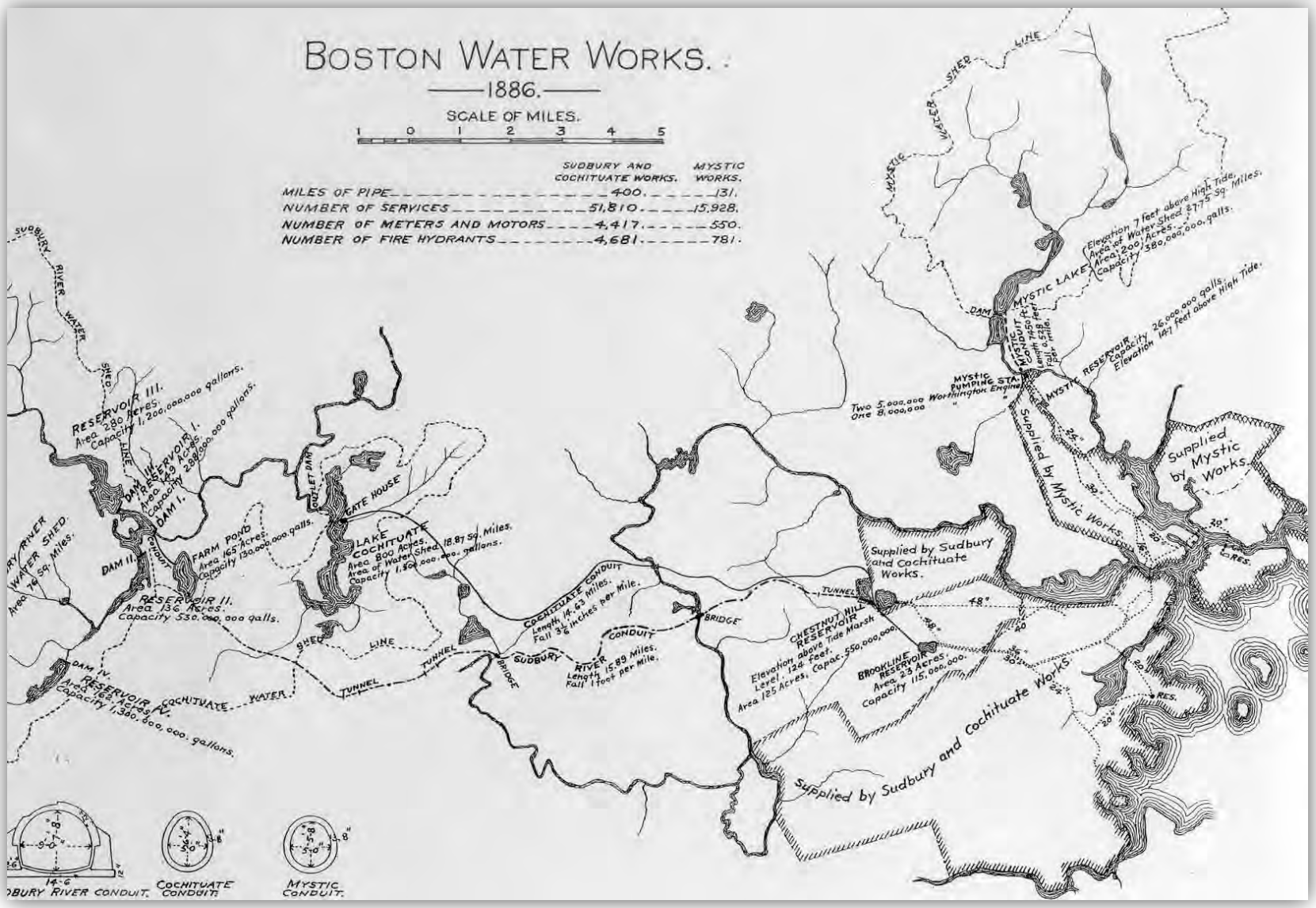
- The standpipe was a 5-foot diameter iron plate tank inside a masonry structure, it took over the role of supplying Beacon Hill and Dorchester Heights, as well as supplying Roxbury Heights

1872: The Great Fire

- Undersized pipes and low pressures hindered the firefighters
- Many distribution improvements followed including another reservoir, larger pipes and more hydrants



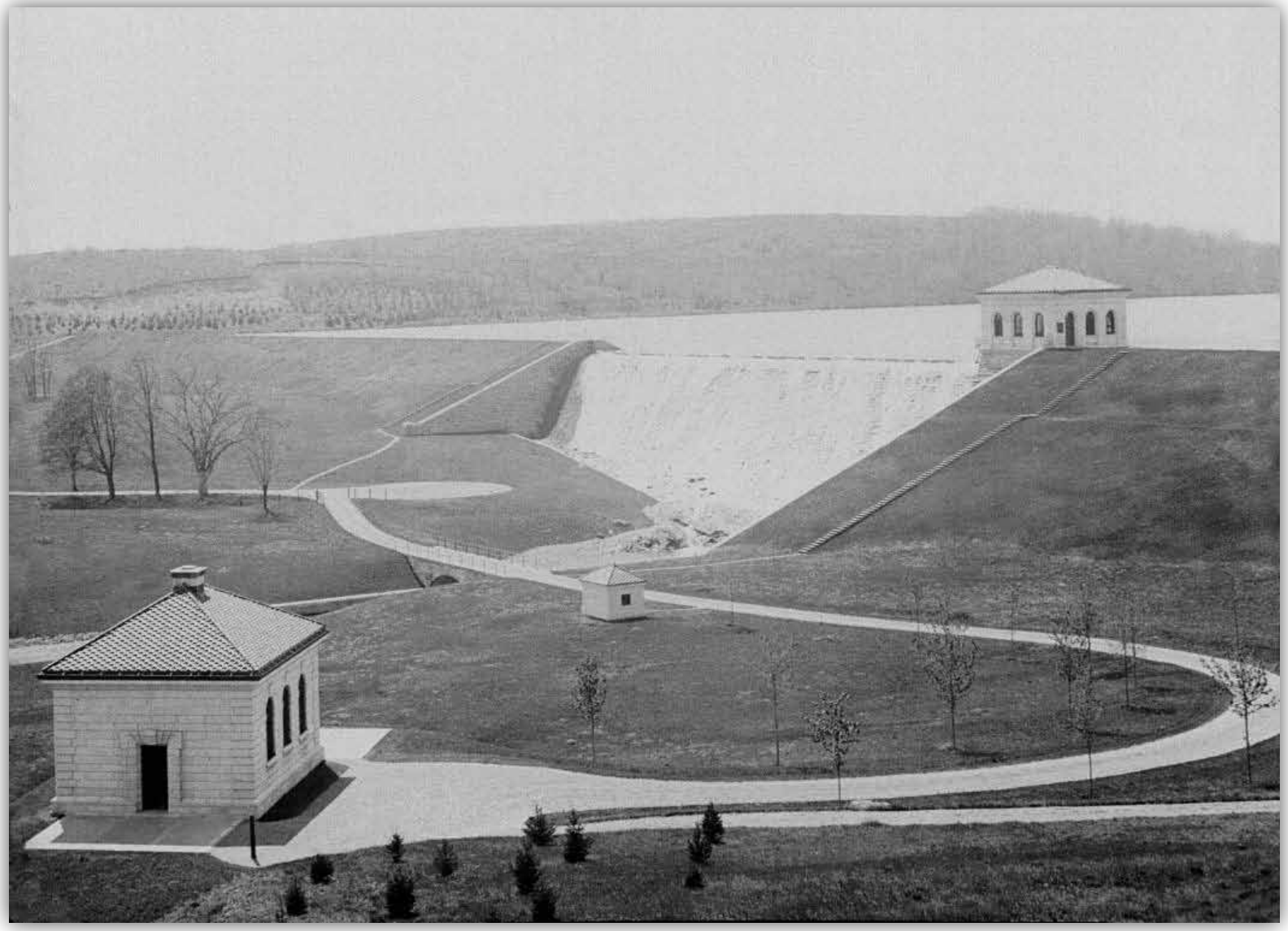
1870s: Boston Water Works Adds The Sudbury System And Inherits Charlestown's Mystic Works After Annexation



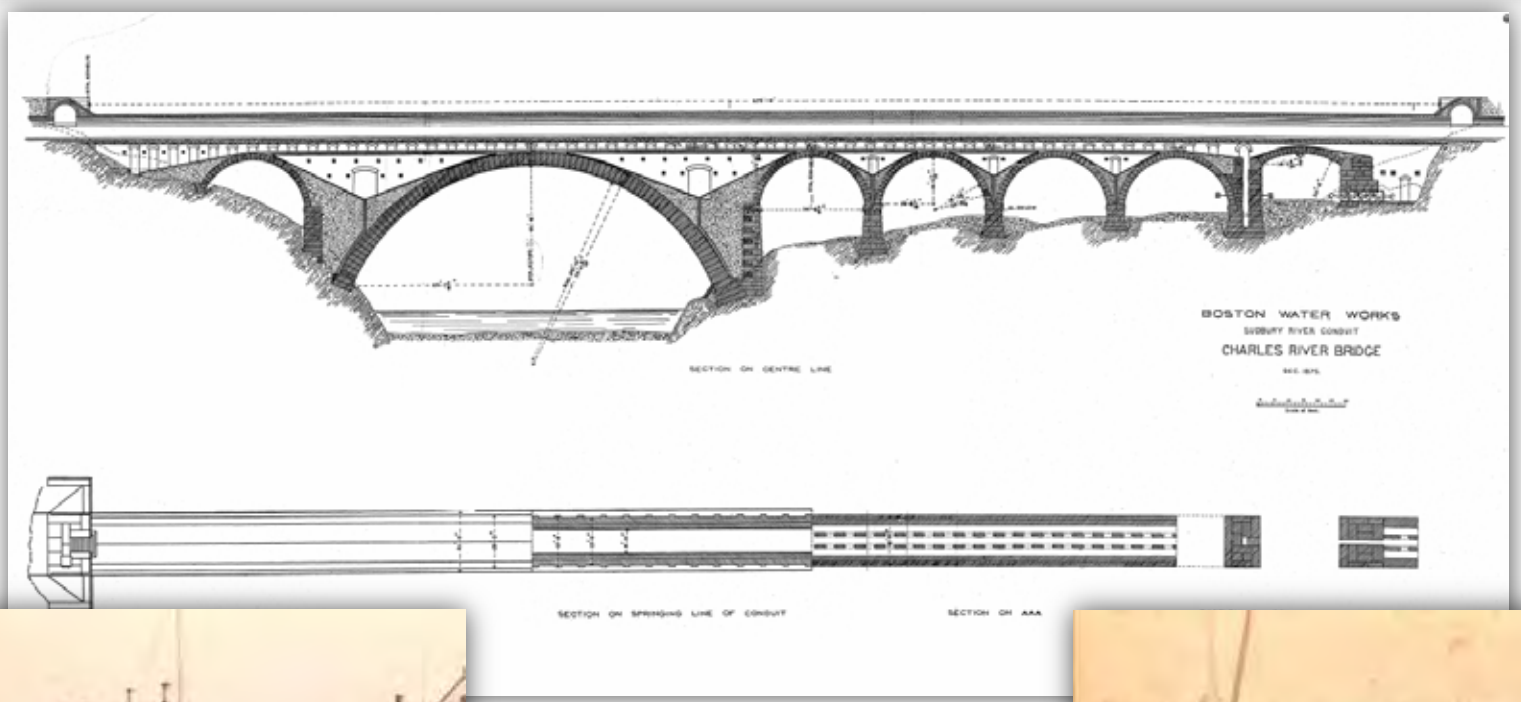
1878: The Sudbury System

- In 1878, the Sudbury River, 18 miles from Boston, was diverted through the Sudbury Aqueduct to the Chestnut Hill Reservoir
- To do this, a series of small reservoirs were built
- Reservoirs 1, 2 and 3 were done quickly to augment the system during the ongoing drought
- In all, 7 reservoirs were built

1898: The Fayville Dam And The Sudbury Reservoir Were Completed



Sudbury Aqueduct – Building Echo Bridge Arches

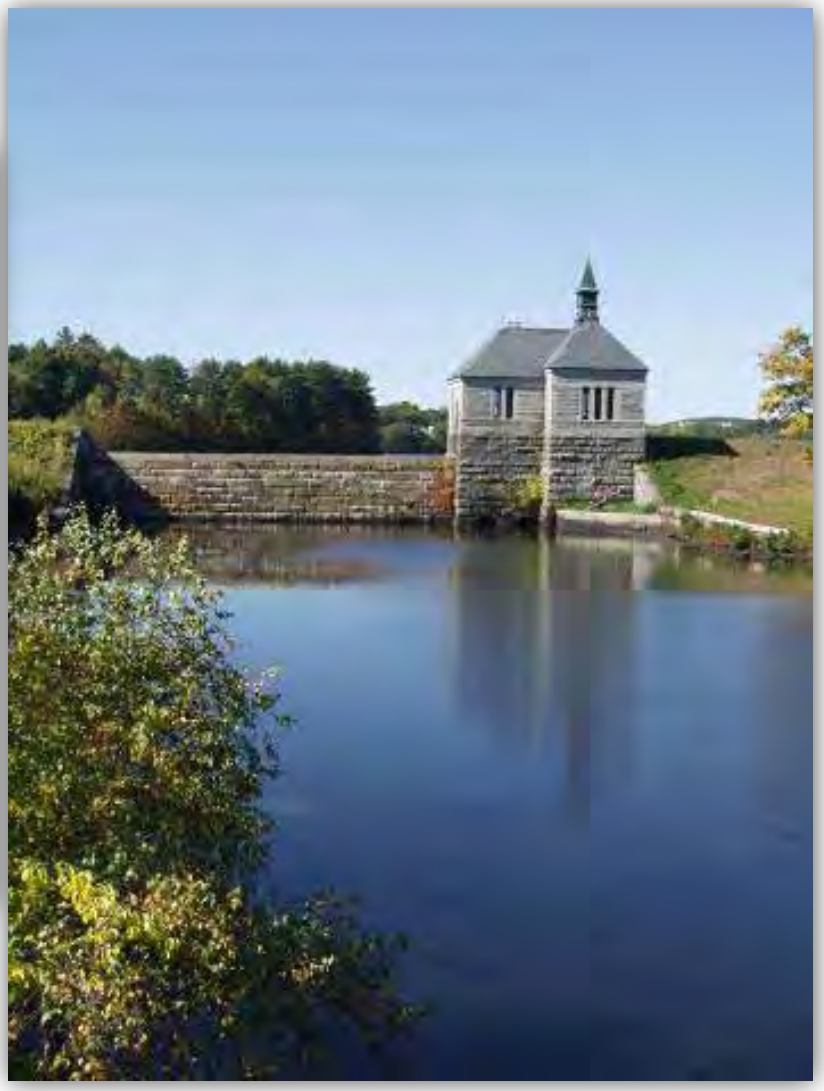


Sudbury Aqueduct

The Farm Pond Gatehouse in Framingham, the aqueduct literally crossed the pond

Reservoir 1 in Framingham – Beginning of Sudbury Aqueduct, Farm Pond Gatehouse

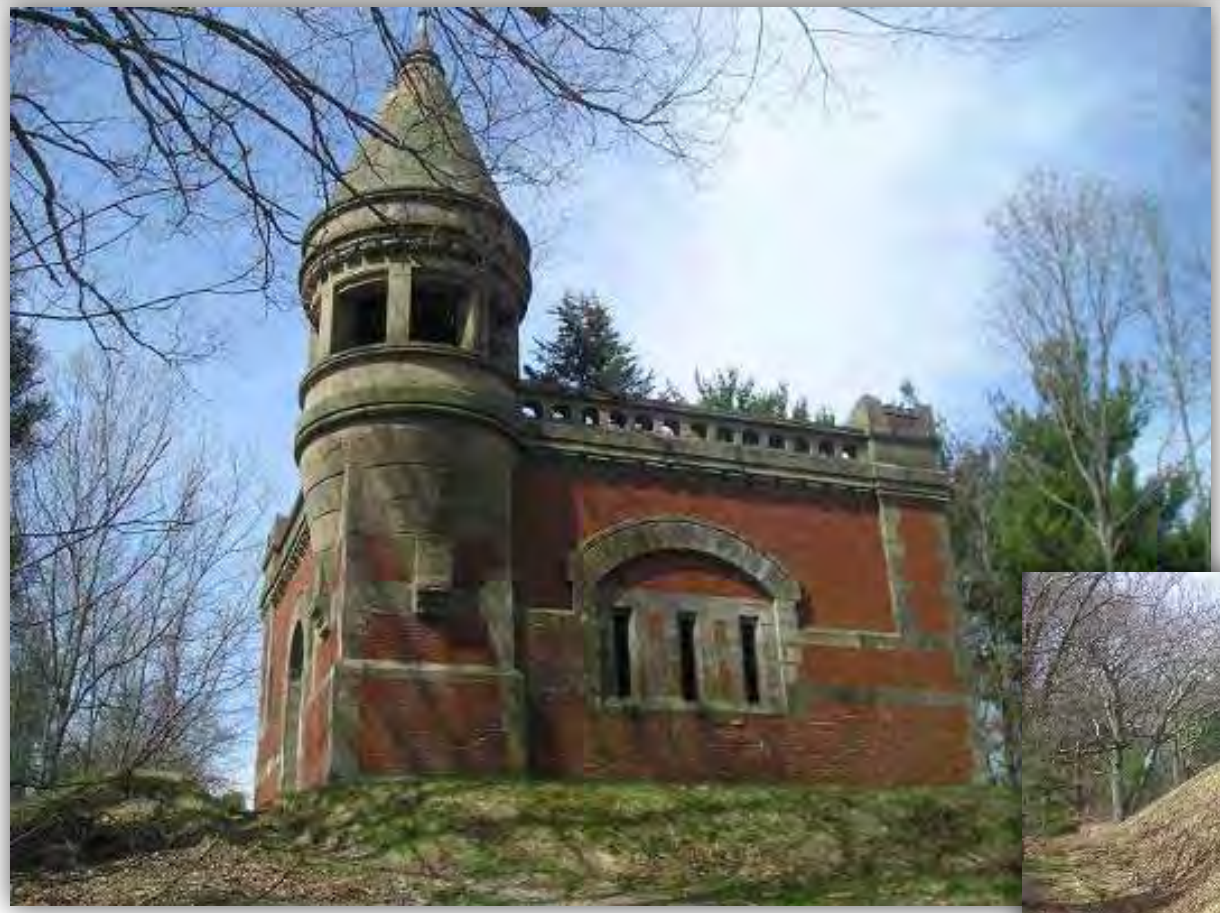
Reservoirs 2 And 3 In Ashland/Framingham



Sudbury Reservoir

Sudbury Aqueduct Bridges – Echo Bridge, Waban Arches

East And West Gatehouses – Rosemary Brook Siphon Of The Sudbury Aqueduct In Wellesley

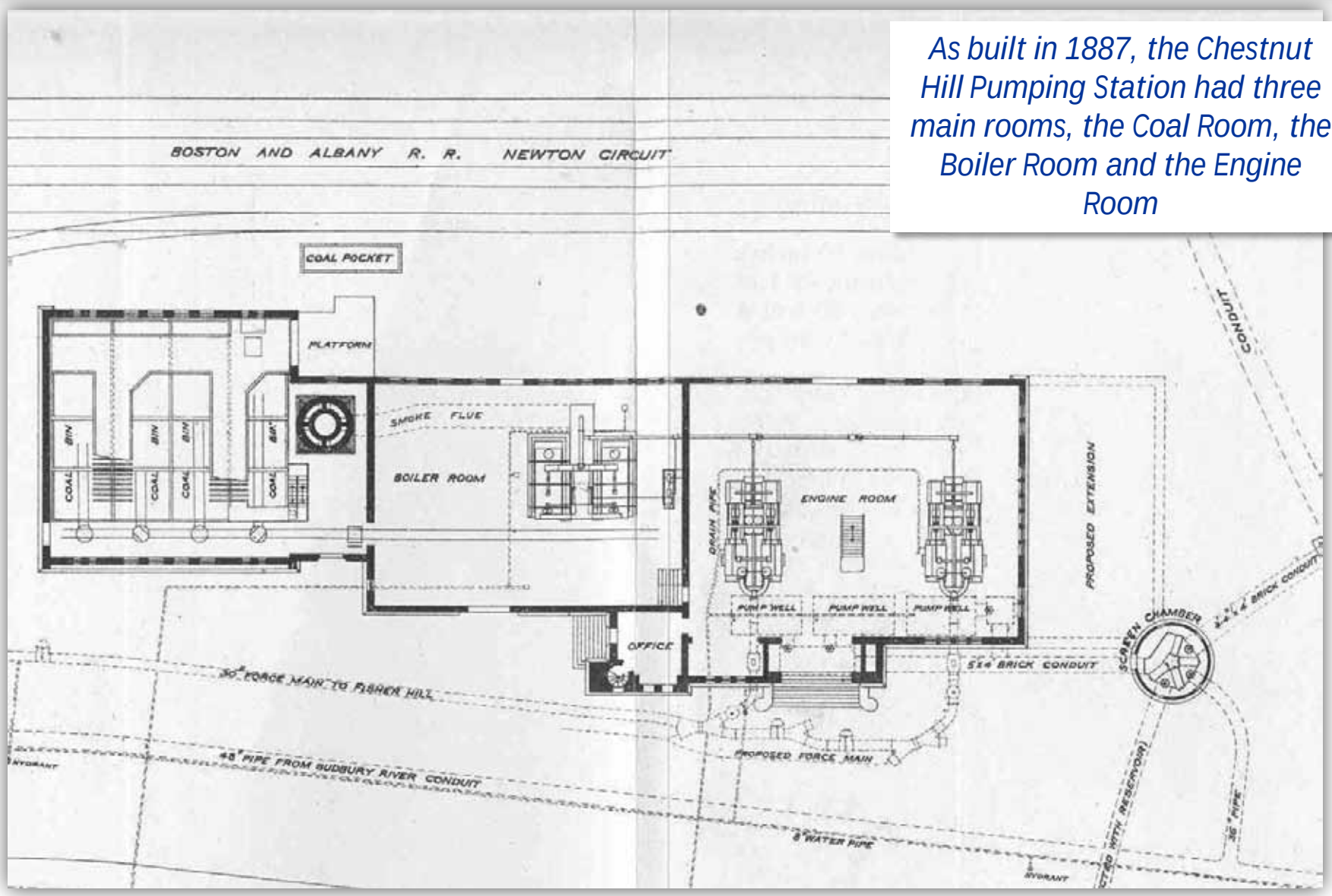


Sudbury Aqueduct Terminal Chamber – At Chestnut Hill Reservoir

1887: Chestnut Hill Pump Station

CHESTNUT HILL PUMPING STATION.

1887: The Original Chestnut Hill Pump Station



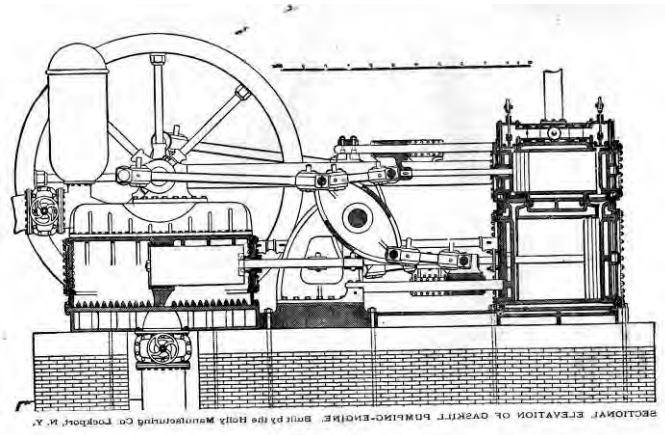
As built in 1887, the Chestnut Hill Pumping Station had three main rooms, the Coal Room, the Boiler Room and the Engine Room

Feeding Coal To The Boilers

The Original Pumps At The High Service Building

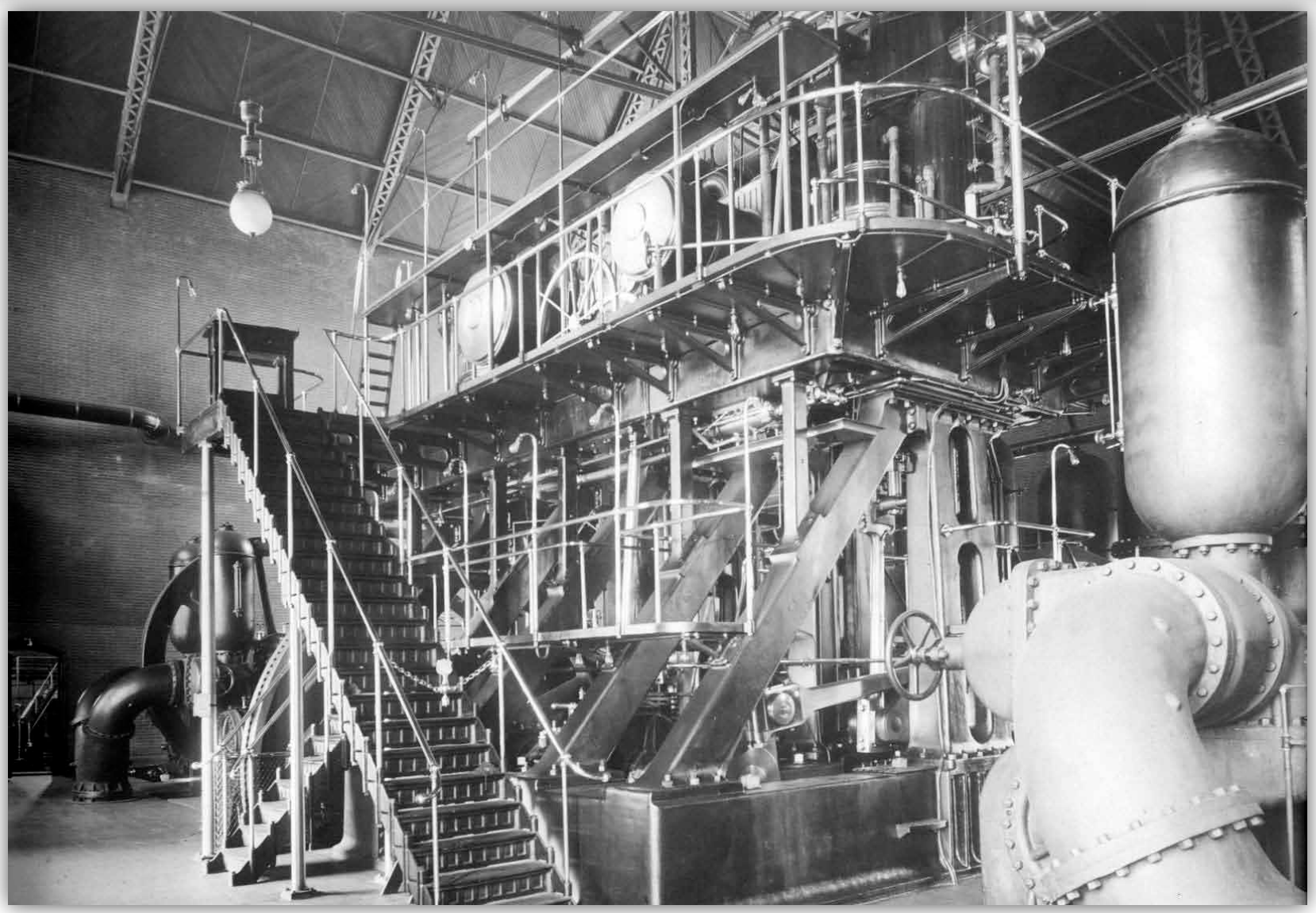
- When Boston Water Works began construction, they awarded the pump contract to Worthington as a no bid contract as they had done before
- Boston Finance stopped the contract and forced a public bid
- When the pumps were bid, Holly-Gaskill won and furnished the two pumps
- The Holly-Gaskill engine was a premium engine for its day and the first horizontal compound duplex to include a flywheel to smooth its motion

Holly-Gaskill Compound Duplex

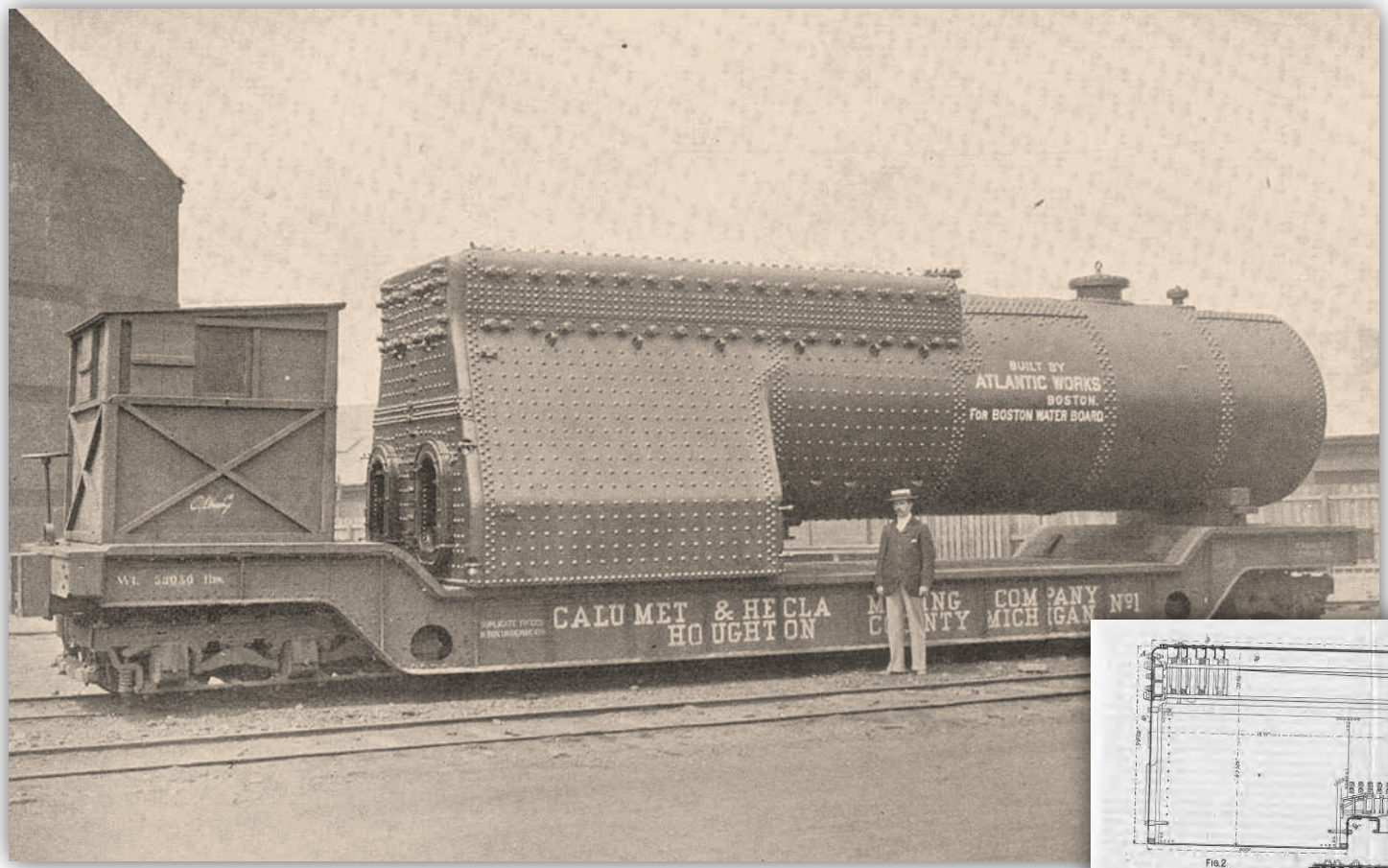


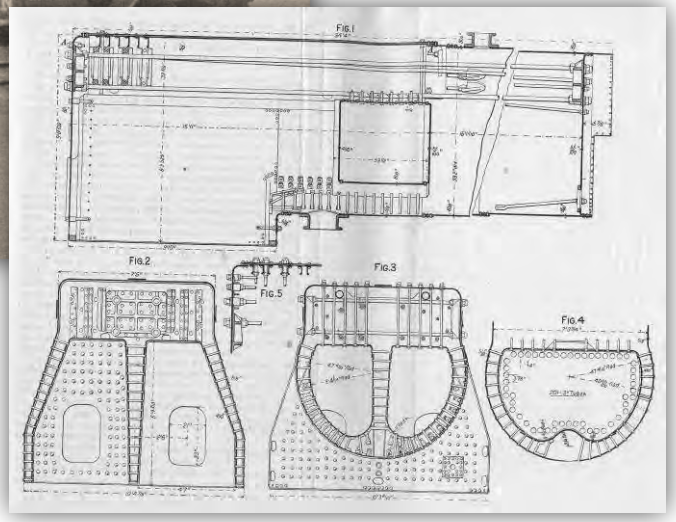
Holly-Gaskill Cutaway

1895: The Leavitt Engine Squeezed In Between The Holly-Gaskills



1895: New Boiler For Leavitt Engine



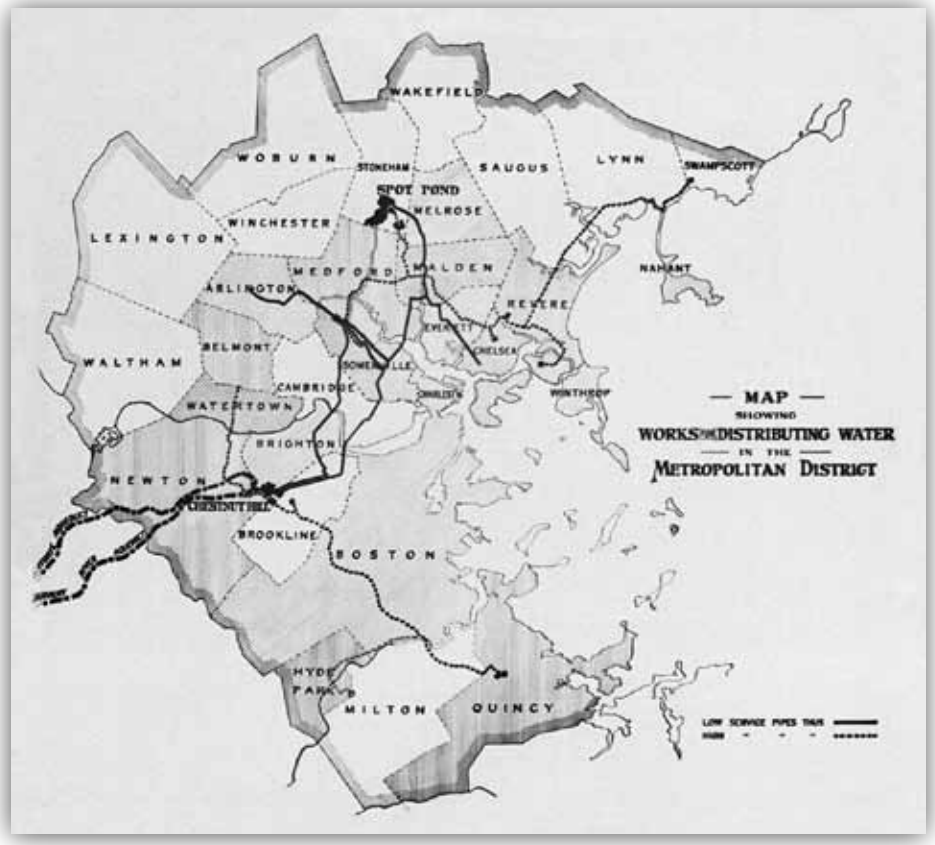


1890s: Boston Needed More Water

- By the early 1890s, Boston's water supply was deemed unsafe and inadequate, as were other community supplies surrounding Boston
- Governor Russell proposed a water district including the development of a large water supply for a number of communities
- In 1895, the Metropolitan Water Act called for the taking of water from the south branch of the Nashua River, the Boston Waterworks at Chestnut Hill and Spot Pond
- This system would supply water to the cities and towns within 10 miles of the State House that wanted it

1895: Creation Of The Metropolitan Water District

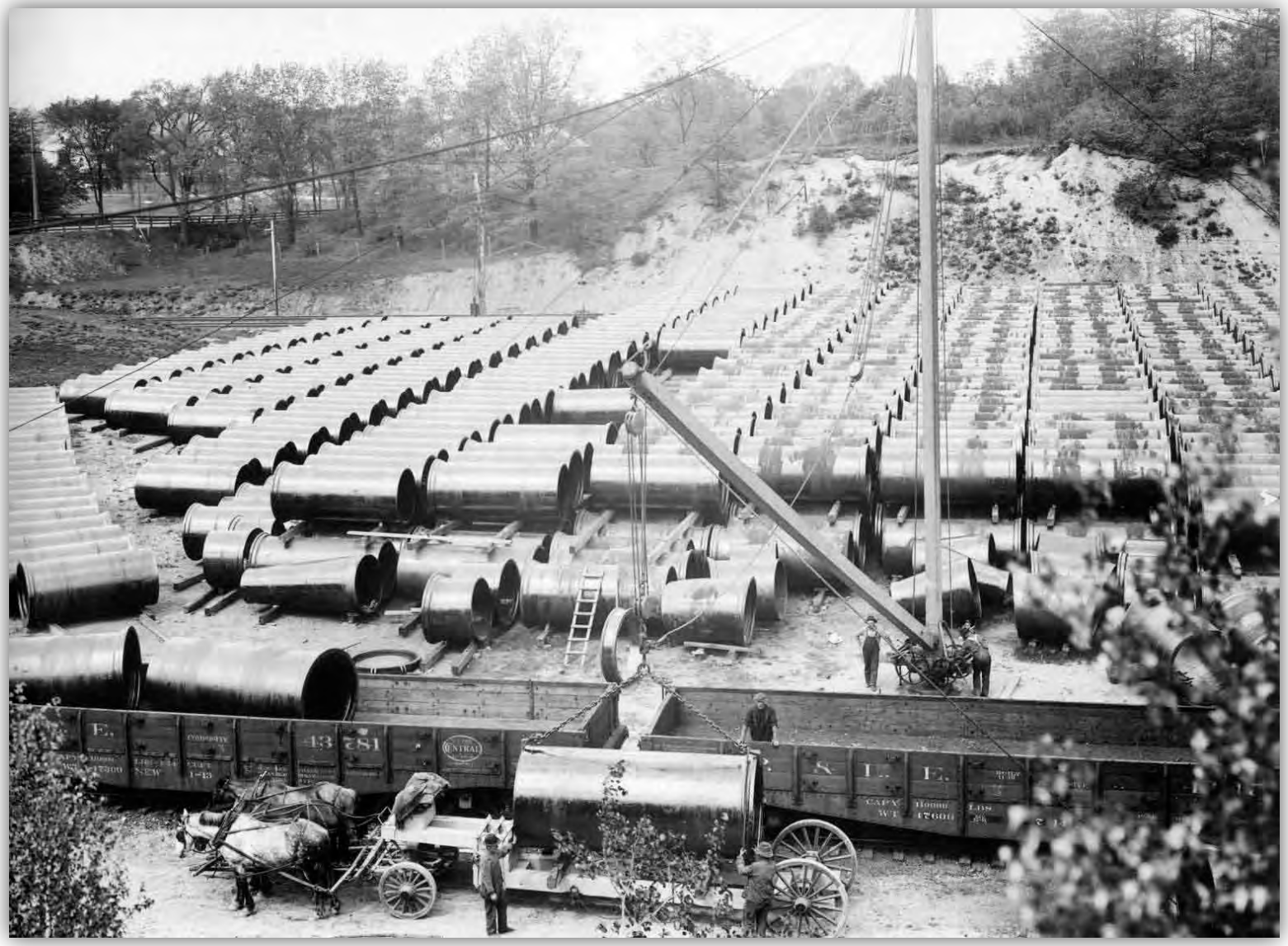
- After reviewing water supply needs in all metro area communities, a District of 13 far-flung communities is formed
- More communities join in subsequent years
- Boston's sources and facilities outside the city (including Chestnut Hill) are sold to MWW



1895: Connecting The 13 Communities

- The Metropolitan Waterworks' Plan to serve the District was very pumping intensive
- Chestnut Hill was a hub
- After delivery from the aqueducts, Chestnut Hill High Service PS would pump south to Boston, Milton and Quincy
- Chestnut Hill Low Service would supply the low parts of Boston and relay water to the north side and Spot Pond
- Spot Pond PS would deliver to high service water to north side communities

1898: Building The Metropolitan Pipe Network



Crossing Rivers

Going Under The Harbor

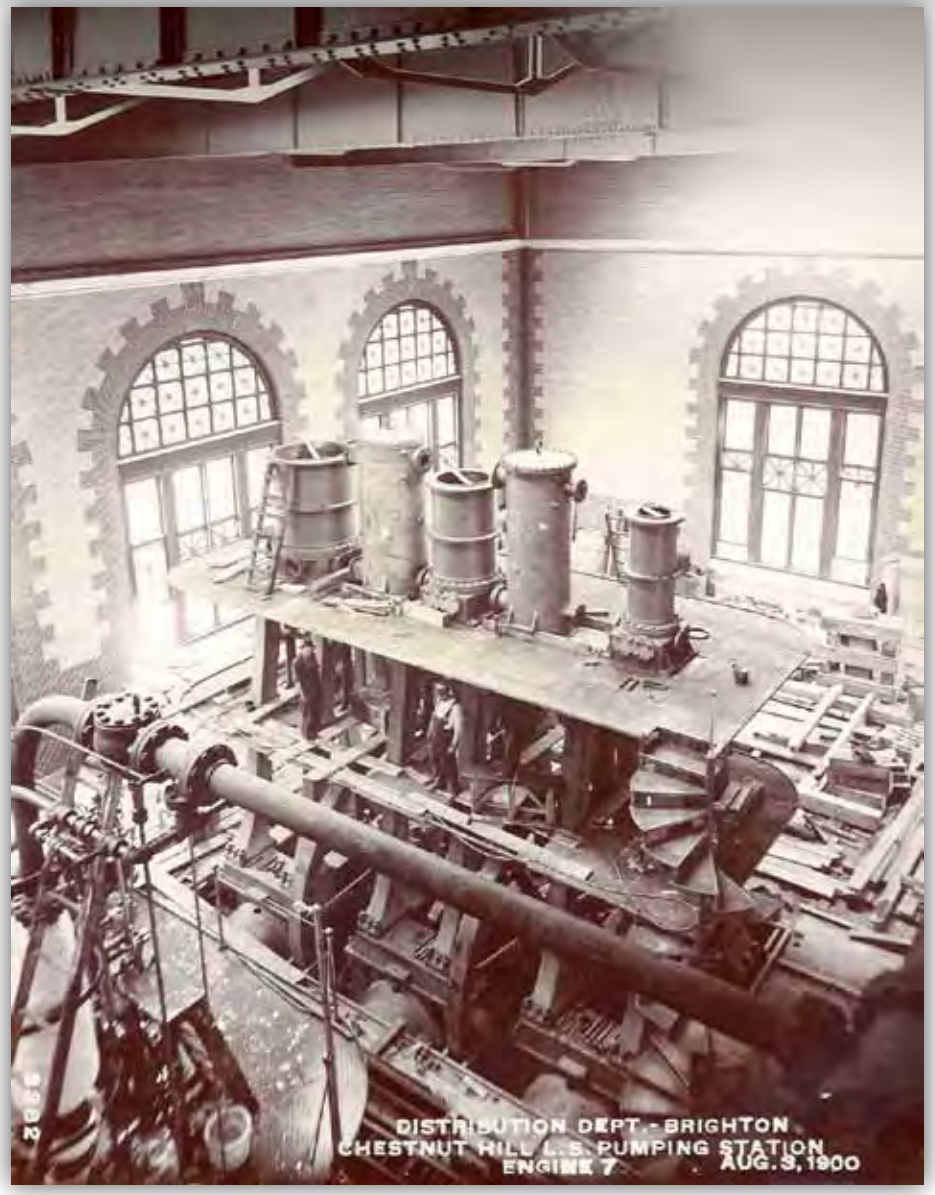
Moving The Base Plate For The Spot Pond Steam Engine

Laying Large Pipes With Minimal Tools

Pump Foundations At The Low Service Pump Station

The Low Service Pump Station Takes Shape

Setting One Of The New Holly Triple Expansion Pumps



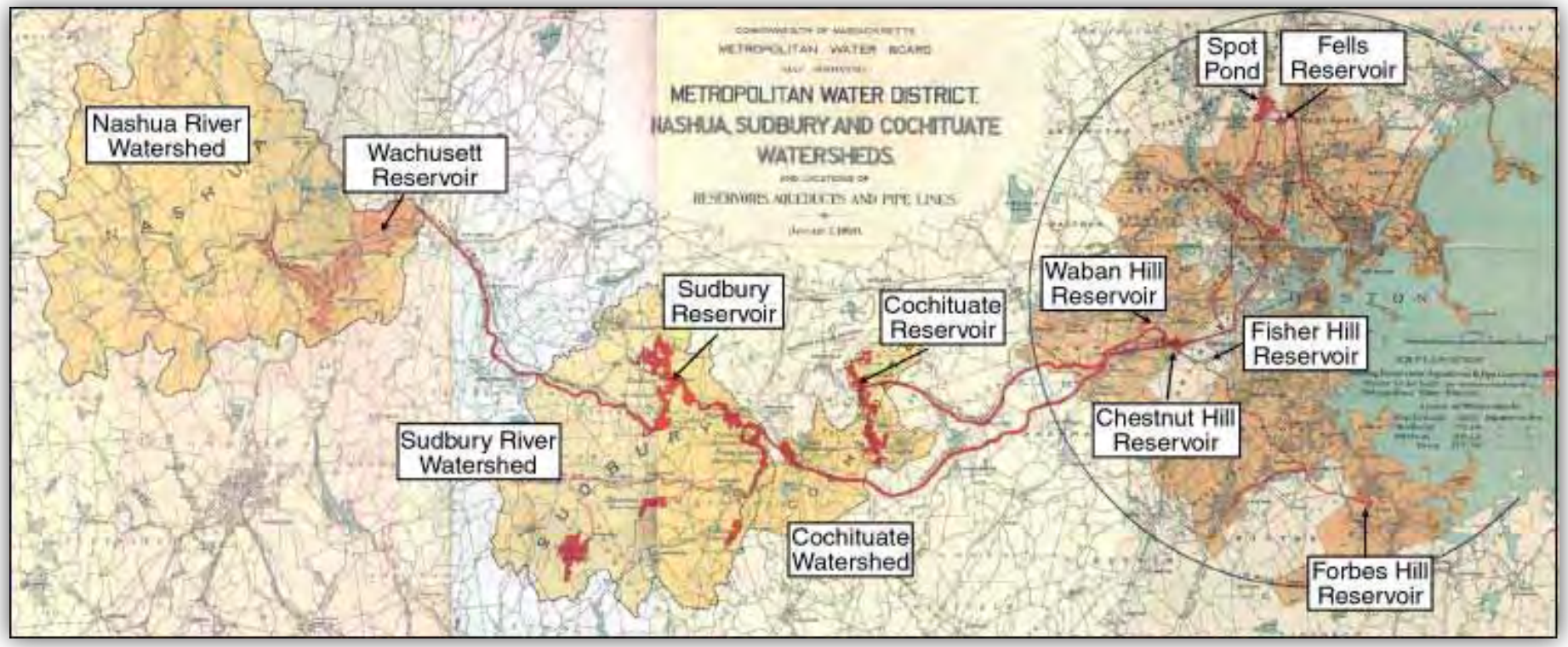
Low Service Vertical Boilers

The 3 Completed Holly Pumps In The Low Service

The New Metropolitan Water District Looks For Water

- Frederick Stearns of the MA Dept. of Public Health led the source augmentation planning
- Sources as far away as Lake Winnepesaukee were considered but the Nashua River was the clear choice
- During his review, Stearns identified the Swift River as a logical future source
- In 1895, the Metropolitan Water Act called for the taking of water from the south branch of the Nashua River
- This system would supply water to the cities and towns within 10 miles of the State House that wanted it

1895: Another Step West



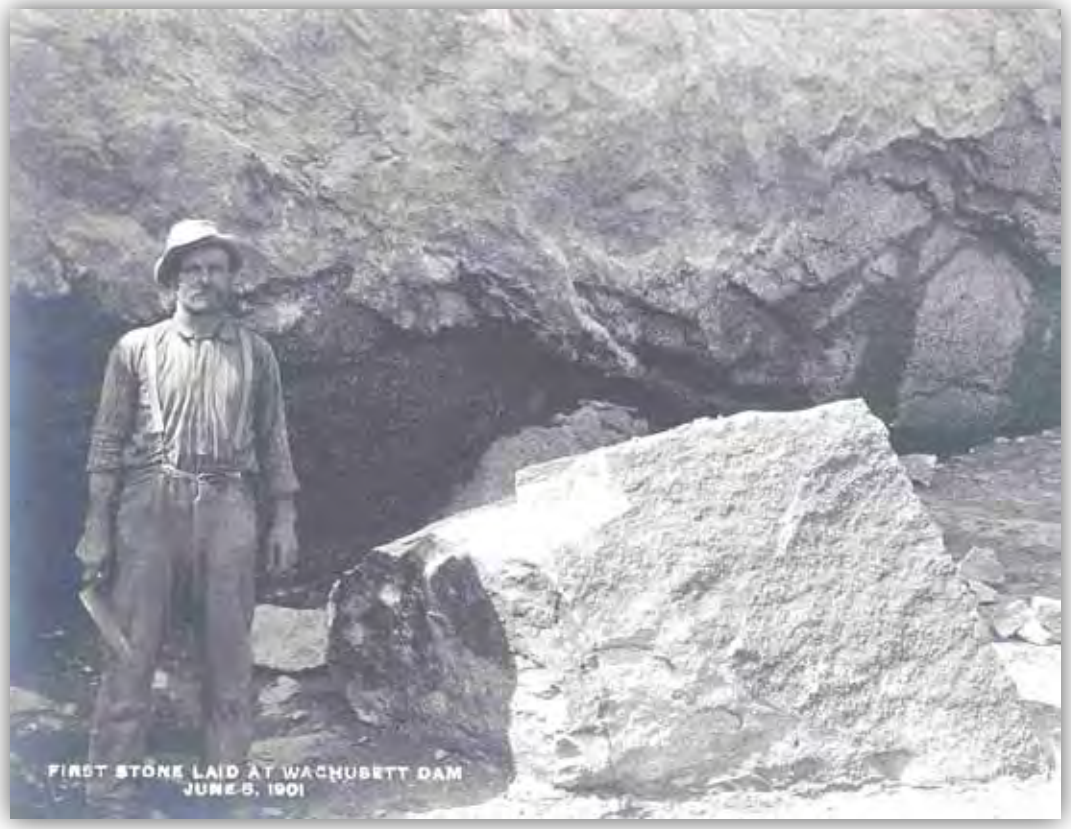
1895: Clinton (Before Wachusett Dam)

Few people were displaced in Clinton but several other towns and villages were displaced in the upper reaches of the reservoir. The impact was significant.

1897: The Wachusett Reservoir

- Chief Engineer Frederick Stearns planned a water source that would be gravity-operated and not require filtration

- In 1897, the site was chosen - the Nashua River was impounded by the Wachusett Dam, 38 miles from Boston



The Wachusett Reservoir

- At the time it was constructed, the Wachusett Reservoir was the largest man-made water supply reservoir in the world

- Its 65 billion gallons supplied
  118 million gallons per day

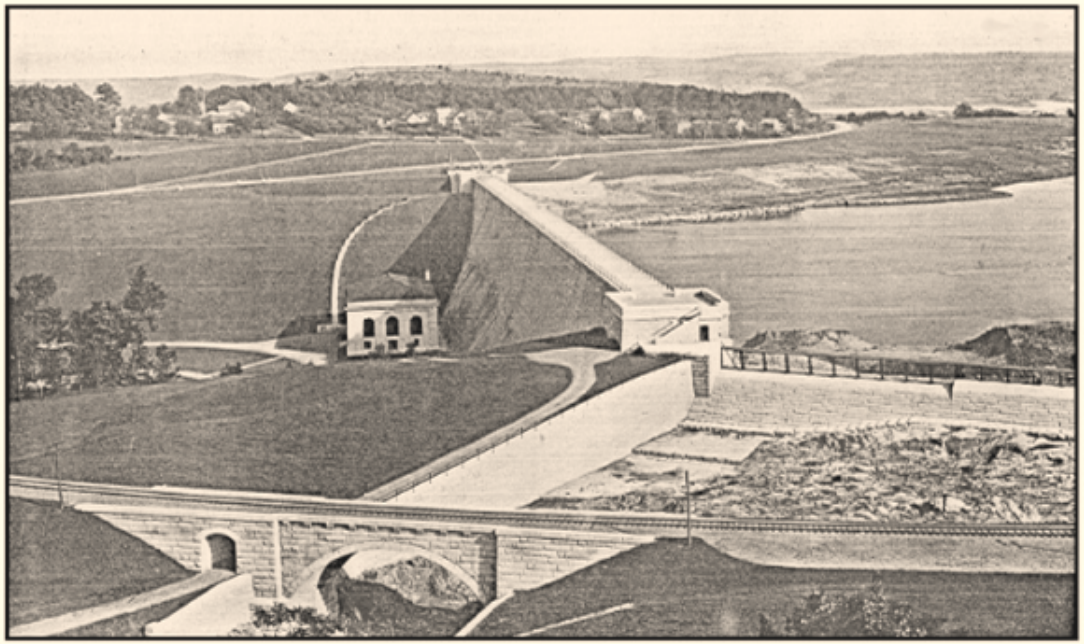
The Wachusett Reservoir

- 6.5 square miles were flooded in the towns of Boylston, West Boylston, Clinton and Sterling

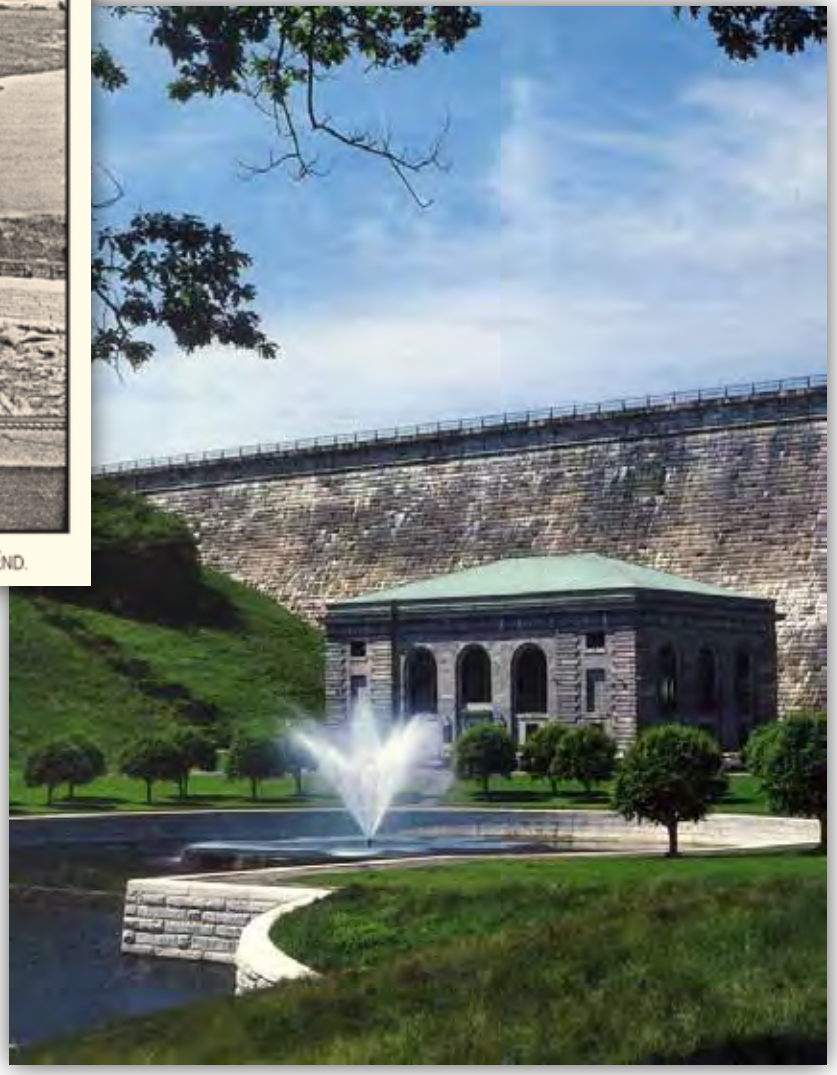
- Work was completed in 1905 and the reservoir filled in May 1908

- Water was conveyed by the Weston Aqueduct to the Weston Reservoir and then by pipeline to Chestnut Hill and Spot Pond

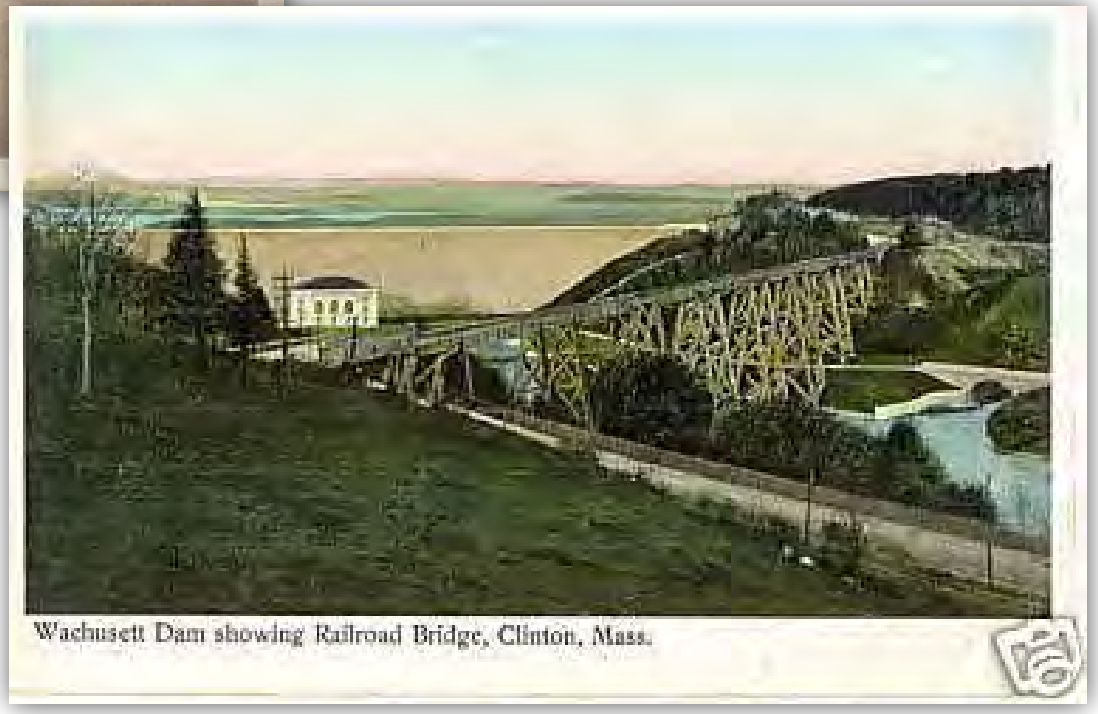
The Completed Wachusett Dam



WACHUSETT DAM WITH RAILROAD ARCH BRIDGE, WASTE WEIR AND BASTION AT NORTHWESTERLY END.



The Completed Wachusett Dam



The Wachusett Aqueduct

- Once again, the use of gravity flow allowed the water to be transported by aqueduct without pumping
- The Wachusett Aqueduct was connected to the Sudbury system, which would then relay the water to the District by using the new Weston Aqueduct and the old Sudbury Aqueduct

Major Figures Of The Period

Frederick Stearns – The architect of the creation of MWD, national authority on water supply and construction of major civil works

Dexter Brackett – The leading distribution system engineer of his day, he helped develop national standards

Desmond Fitzgerald – The leading authority on water sources and water quality of his day, his experiments helped protect consumers

Stearns Hosting A Tour Of Panama Canal Engineers, A Project For Which He Consulted

Trivia Question:

- What do these four towns have in common?

  Dana

  Enfield

  Greenwich

  Prescott

The Quabbin Reservoir

1920s: Once Again, The Metropolitan District Needed More Water

- In 1919, the Metropolitan District Commission was created by an act which consolidated responsibility for water, sewage and parks into one agency
- The MDC and the Department of Public Health were appointed to Joint Board by the legislature to study water supply needs
- The Joint Board made projections for the period 1920 - 1970 and determined current water supply would be inadequate by 1930
- In 1922, the Joint Board recommended the addition of the Ware River and the Quabbin Reservoir to the MDC water supply system

The Quabbin Reservoir

- Construction of the Quabbin required the impoundment of the Swift River and the takings of four towns

- The Quabbin Reservoir, 60 miles from Boston, was another source that could be gravity-operated and not require filtration

Enfield

The Quabbin Reservoir

- Construction of the Wachusett-Colebrook Tunnel (now the Quabbin Tunnel) began in 1926, carrying surplus flow from the Ware River to the Wachusett Reservoir
- In the 1930s, the Tunnel was extended to the Swift River
- This two-way tunnel carries flows east and west, depending on time of year
- In 1936, construction of the reservoir began

Moving a house from Greenwich

The Quabbin Reservoir

- The reservoir was filled with water from the Swift River and the Ware River
- Filling began in 1939 and was completed in 1946
- At the time, the 412 billion gallon reservoir was the largest man-made reservoir in the world

Road still visible beneath surface of water

Last Days Of The Valley - On The Eve Of Moving Out

3 Views Of The Valley – Before, Cleared, Flooded

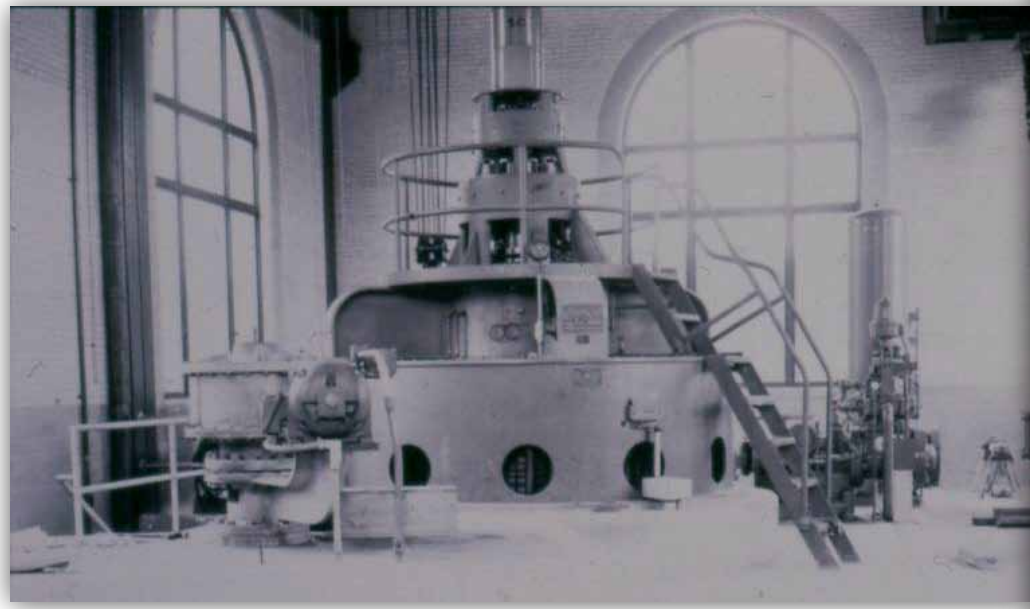
Quabbin's Winsor Dam Constructed By Hydraulic Fill Method

- Soil for the earth dam was quarried and mixed with water to make a slurry, then pumped up and discharged from pipelines along the edge of the rising dam. The water would seep away and the soil would build up the dam.

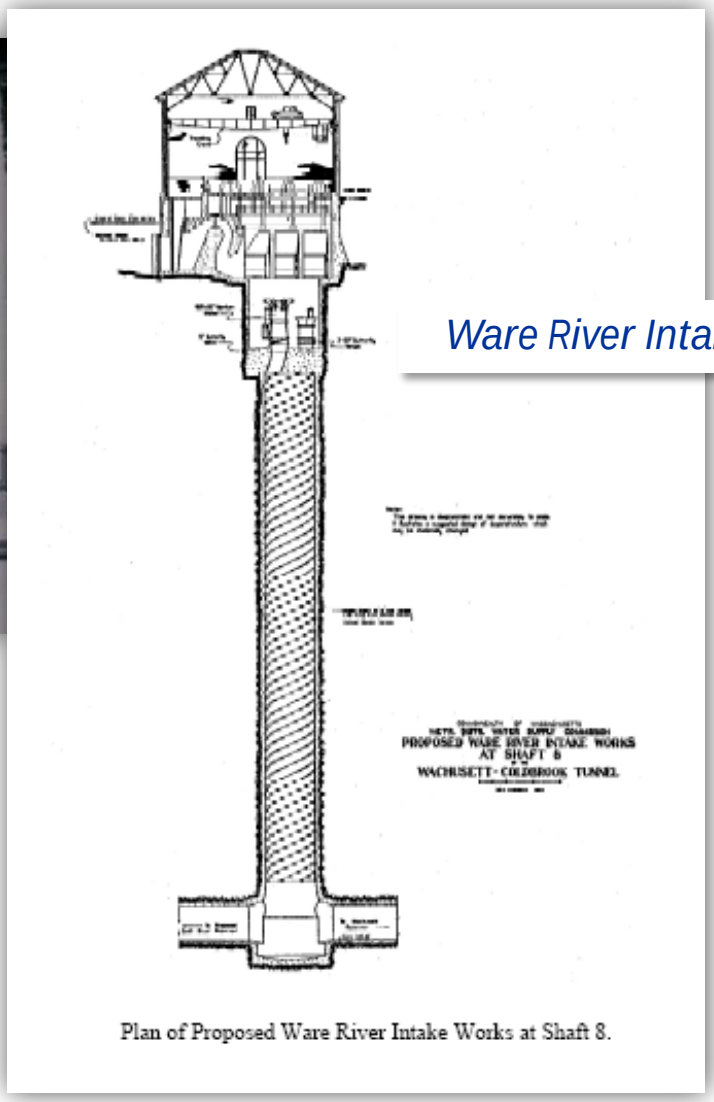
The Completed Winsor Dam

1930s: Building The Quabbin Aqueduct

Quabbin Aqueduct Structures



Oakdale Hydro-electric generator

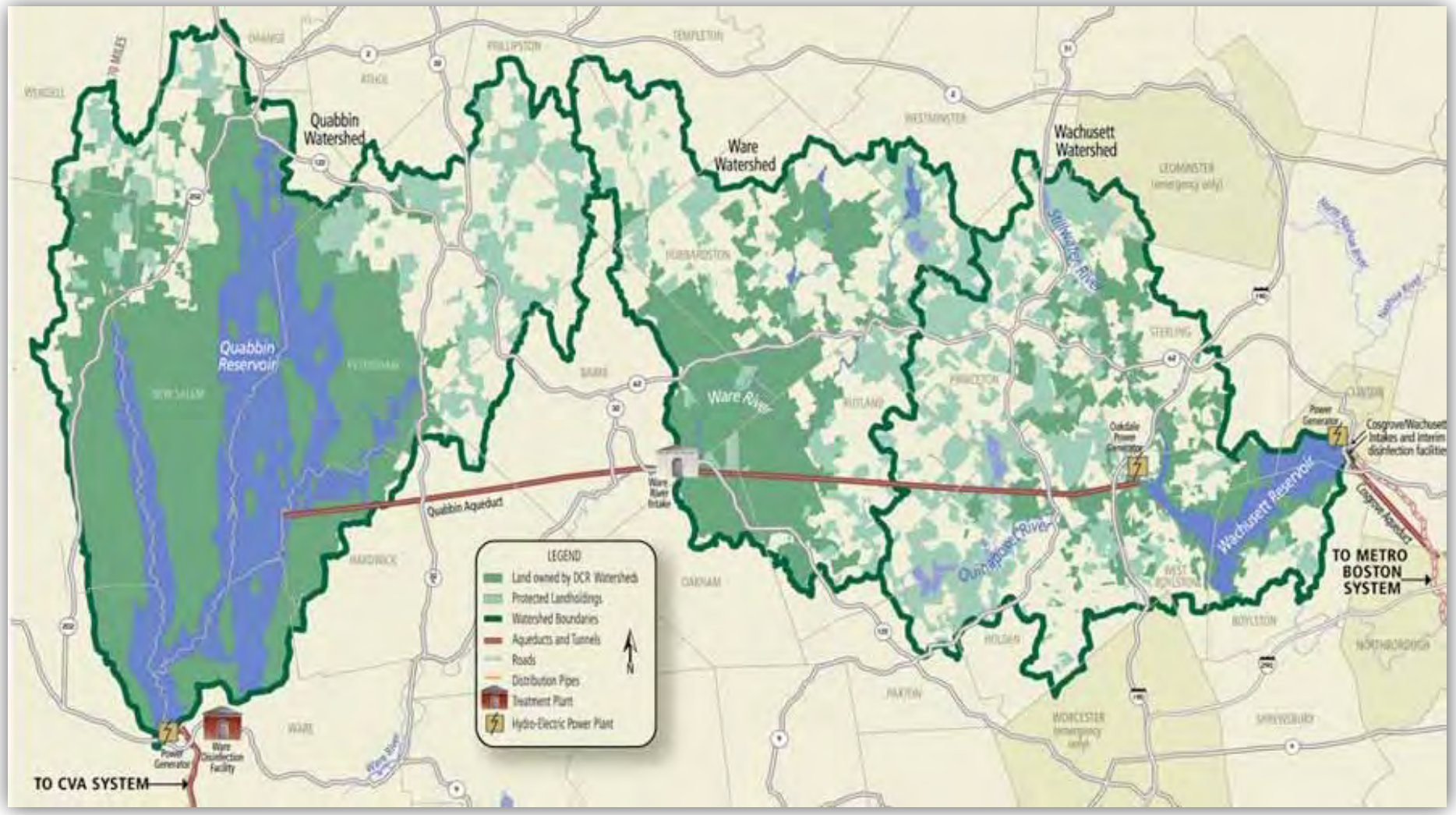


Plan of Proposed Ware River Intake Works at Shaft 8.

Ware River Intake

Ware River Intake

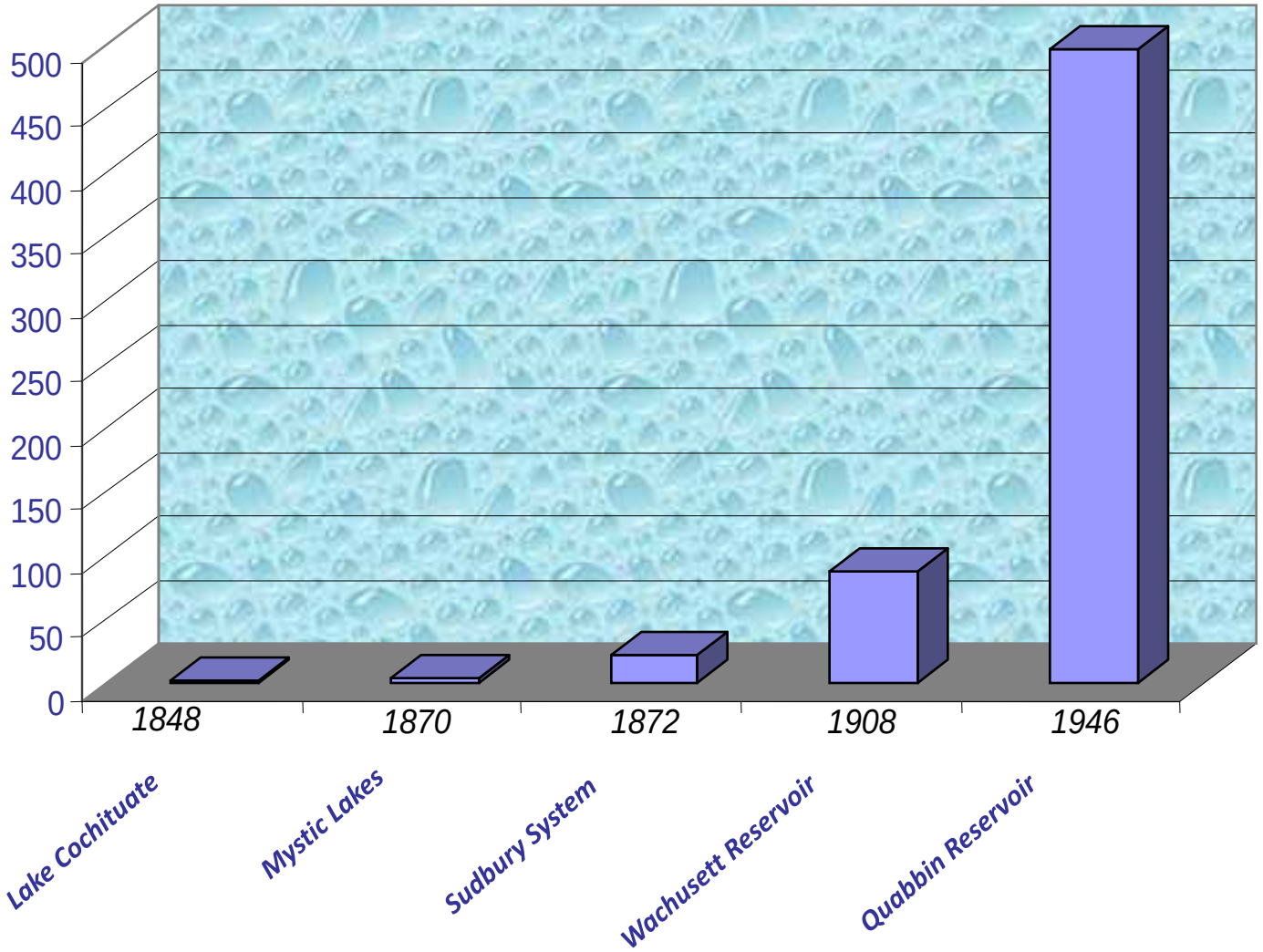
Water Can Flow East Or West



You Couldn't Do It Today

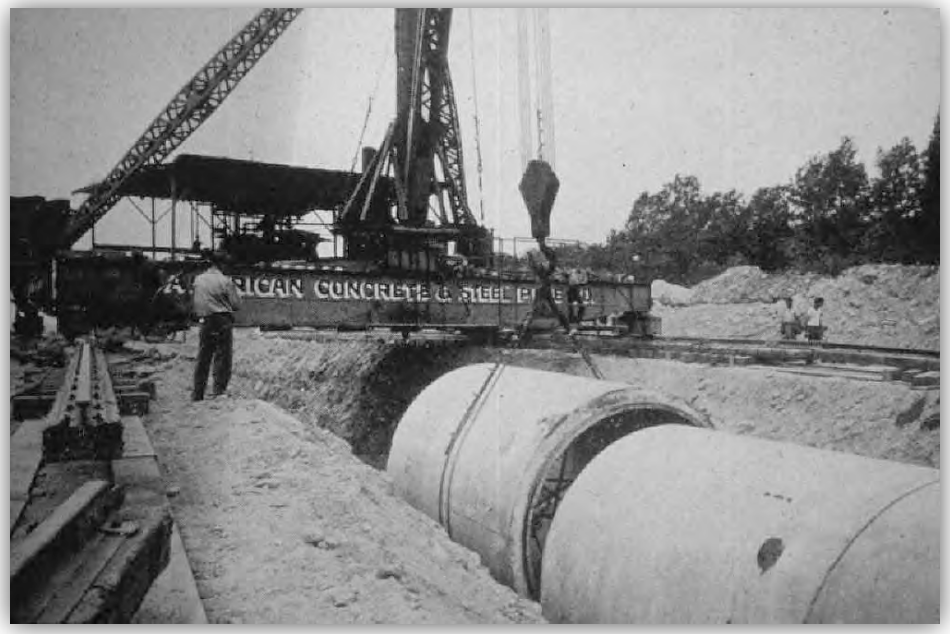
- 4 towns removed and legally dissolved
- 39 square miles flooded
- 2,000 residents relocated
- 1,000 buildings destroyed
- 34 cemeteries relocated
- 81,000 acres purchased for $9.6 million
- $53 million total project costs
- 26 lives lost during construction

Cumulative Water Supply Capacity



The Pressure Aqueduct System

- In 1936, the Legislature approved the construction of a two high-pressure aqueducts to deliver water to the greater Boston area
- The two aqueducts would carry water from the Wachusett Reservoir to the new Norumbega Reservoir in Weston
- One barrel of the aqueduct system - the Hultman Aqueduct - was completed
- But work on the second barrel did not resume after World War II
- Until 2003, 85% of Boston's water supply was provided without redundancy



1950: Norumbega Reservoir

- Norumbega Reservoir was built to work with the Hultman Aqueduct to provide High Service pressure without pumping throughout the entire service area
- The southern part of the system still needed Chestnut Hill pumping until Dorchester Tunnel was completed

1960s And 1970s: More Tunnels (City Tunnel, Wachusett Marlborough Tunnel, Dorchester Tunnel)

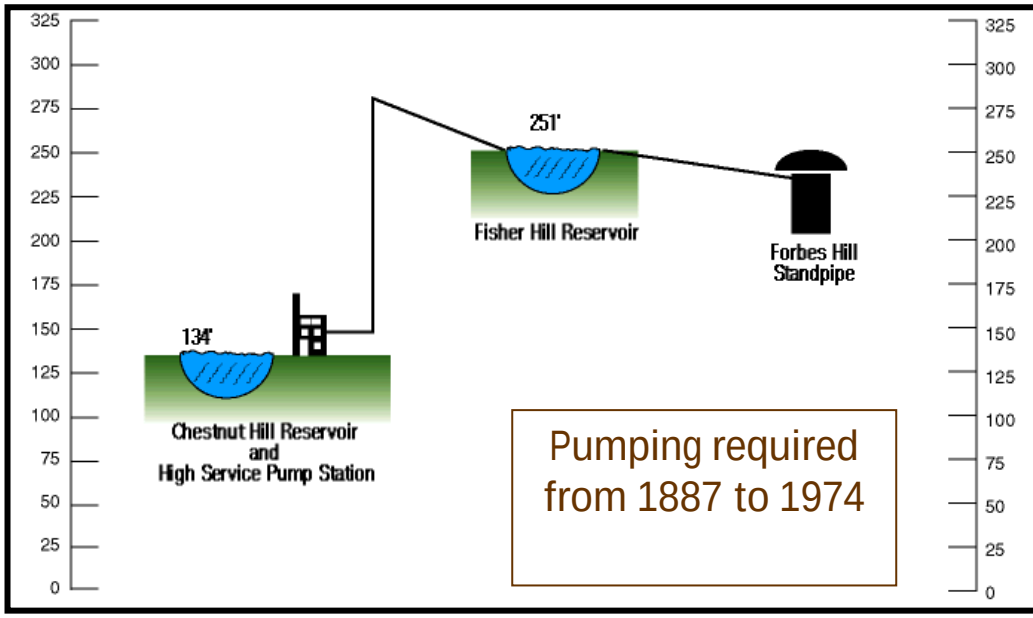
- Tunnels were used to bring better pressure deeper into the distribution system
- Through 1976, all tunnels were done by drill and blast methods

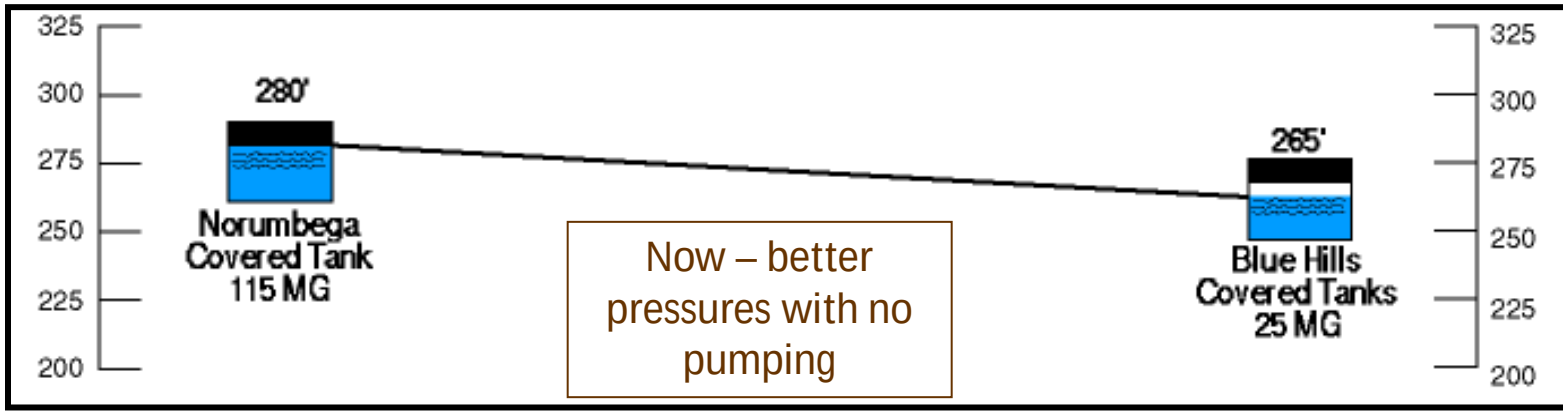
Repairs To Dorchester Tunnel

- After retirement of the Chestnut Hill High Service PS in 1974, leaks were found that needed major repairs
- Three 35 million gallon per day gas turbines were installed to serve during the shutdowns needed for repairs
- One was installed in the basement of the High Service PS and two were installed in the Low Service by removing old Engine 12, the 40 million gallon per day Holly engine to make space for the gas turbines

Effect Of The Completed Dorchester Tunnel

- What once required pumping was now possible by gravity supply from a tunnel
- This greatly improved energy efficiency
- Chestnut Hill pumping stops in 1974 (except during Dorchester Tunnel repairs





Release Of Chestnut Hill Buildings For Redevelopment

- In 1974, the Dorchester Tunnel replaced the need to pump to the Southern High at Chestnut Hill. The steam pumps were then retired
- When leaks appeared and there was a need to go back onto pumping for a period of 2 years, 3 gas turbines were added (2 in the Low Service Building and 1 in the High Service Building) specifically to get through the shutdowns needed for repairs
- The last active use of the 3 gas turbines was in the spring of 1980. These pumps then became the companion to emergency use of the Sudbury Aqueduct when needed for a major tunnel system failure
- The buildings fell into neglect since they were no longer actively used

The Chestnut Hill Emergency Pump Station Replaces The Gas Turbines

This station has the same capacity as all of the pumps in the High Service station but is in a much smaller underground space

The High Service Building Is Now Home To The Metropolitan Waterworks Museum

Rebuilding the Sewer System

Meanwhile, On The Sewer Side

- In 1884, the Boston Main Drainage System was constructed to divert sewage from 18 cities and towns to Moon Island where it was held for release with the outgoing tide

- And by 1919, sewage pollution forced the closure of several harbor clam beds

The “New” Treatment Plants

- By the early 1970s two “new” treatment plants were obsolete, in disrepair and unable much of the time to provide the level of primary treatment they were designed for

- Rapidly expanding demand caused sewage volumes to exceed the capacity of both plants

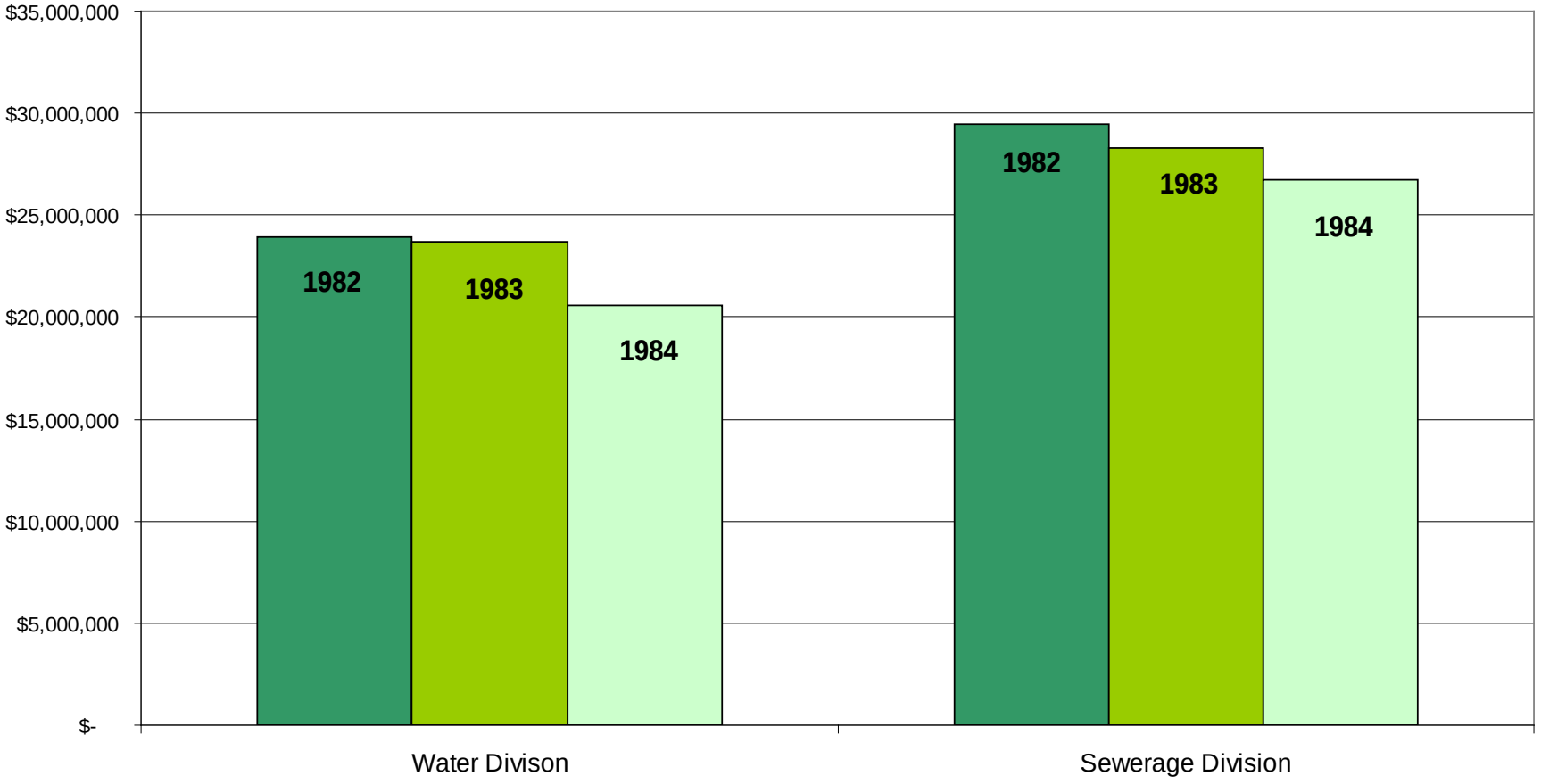
- The inability of the system to meet increased demand, combined with the less advanced level of treatment provided, was a major cause of harbor pollution

The Outlook Was Not Much Better For The Water System

- The $53 million dollars spent on the Quabbin Reservoir in the 1930s was the last major investment in the system
- Thousands of miles of aging pipelines were leaking millions of gallons of water
- No plans were in place for upgrades to carry the water system into the next century
- And the Northeast Drought of the late 1960s cast doubt on the adequacy of existing sources

MCD Appropriations Were Declining

- Appropriations by the legislature were on the decline, which in turn led to staffing reductions, which in turn led to the deferral of much needed repairs



Violation Of The Clean Water Act

- In December 1982, the City of Quincy filed a civil suit against the MDC and other state agencies claiming that the Massachusetts Clean Waters Act had been violated as a result of discharges of untreated and partially treated sewage from Nut and Deer Island

Report Of The Special Master

- Superior Court Judge Paul Garrity appointed a Special Master to investigate the allegations in the state court action

- "The Report of the Special Master Regarding Findings of Fact and Proposed Remedies" documents the inability of the existing MDC sewerage system to adequately protect the waters of Boston Harbor. Major problems included:
  - Inadequate design at Nut Island, which made it impossible to provide optimal primary treatment
  - Inadequate capacity to handle the total amount of wet weather flows
  - Functional capacity less than design capacity


Harbor of shame

Hub waterway 'dirtiest in U.S.'

A New Agency Had To Be Created

- In June 1983, the Conservation Law Foundation brought its own suit in federal court, alleging among other things that the MDC's sewage discharges violate the Clean Water Act

- A comprehensive bill was ready for consideration by the legislature in the spring of 1984

- But over the summer, progress was slowed as lawmakers, regulators, lawyers, environmentalists and citizens wrangled over the details

- The Judge brought the process to a head by declaring a moratorium on new sewer hookups

And The MWRA Was Created

- In 1985, MWRA assumed responsibility for the water and sewer infrastructure serving greater Boston, and to end the pollution of Boston Harbor from obsolete treatment plants
- MWRA was created as an independent authority charged with raising its revenue from ratepayers, bond sales and grants
- MWRA had to establish wholesale water and sewer rates to cover all costs, including a massive capital program to repair and upgrade the systems
- MWRA was also charged with promotion and enforcement of water conservation and planning for the future
- In compromise with Western and Central Massachusetts, MDC retained watershed management, but MWRA covers costs

A National Environmental Success Story

- The Deer Island Treatment plant serves 43 communities in eastern Massachusetts
- About 360 million gallons of wastewater is treated at every day, with a peak capacity of 1.2 billion gallons
- Treated wastewater is discharged 9.5 miles out into the deeper waters of Massachusetts Bay

Deer Island Plant Continues To Perform Well

- Deer Island awarded the National Association of Clean Water Agencies Platinum Award for the last 2 years for violation-free operations, after 5 consecutive Gold Awards

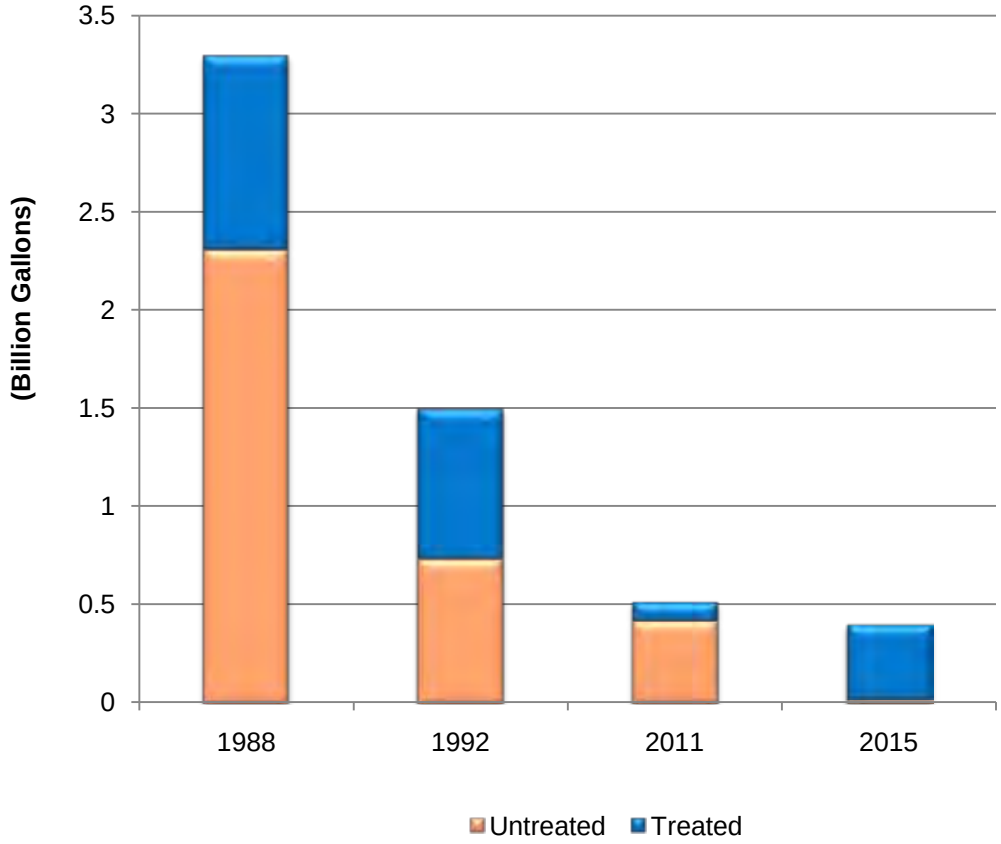
Combined Sewer Overflow Control Program

- Five communities - Boston, Brookline, Cambridge, Chelsea and Somerville - have combined sewer systems that connect to MWRA's sewer system

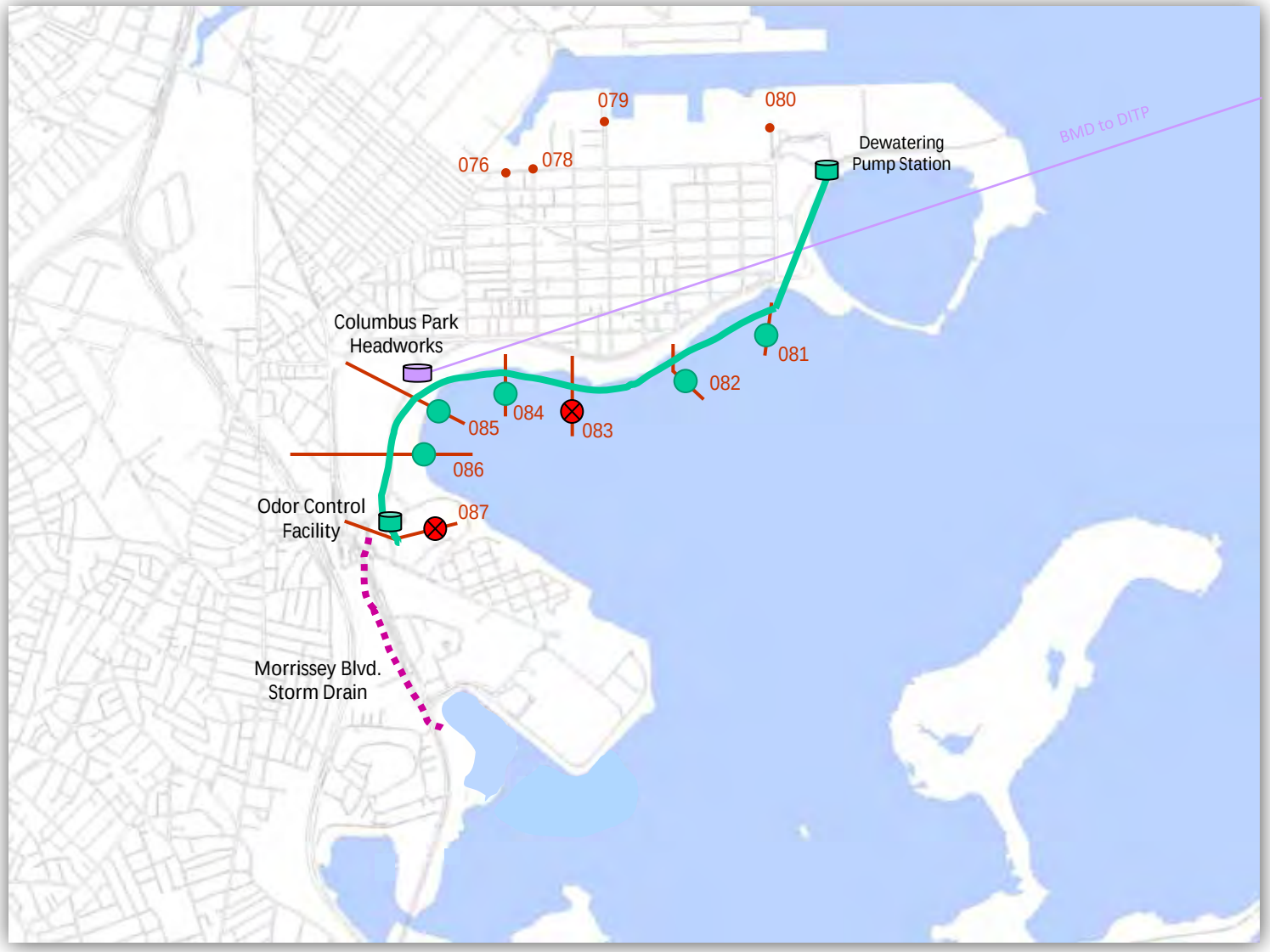
- Boston Harbor, the Charles, the Mystic and the Neponset Rivers are subject to overflows of combined stormwater and sewage during heavy rains

Annual CSO Volume Has Been Reduced Dramatically

- 32 of 35 projects have been completed to date
- Annual CSO volumes have already been reduced by 2.7 billion gallons
- By 2015, 93% of the remaining CSO flows will be treated



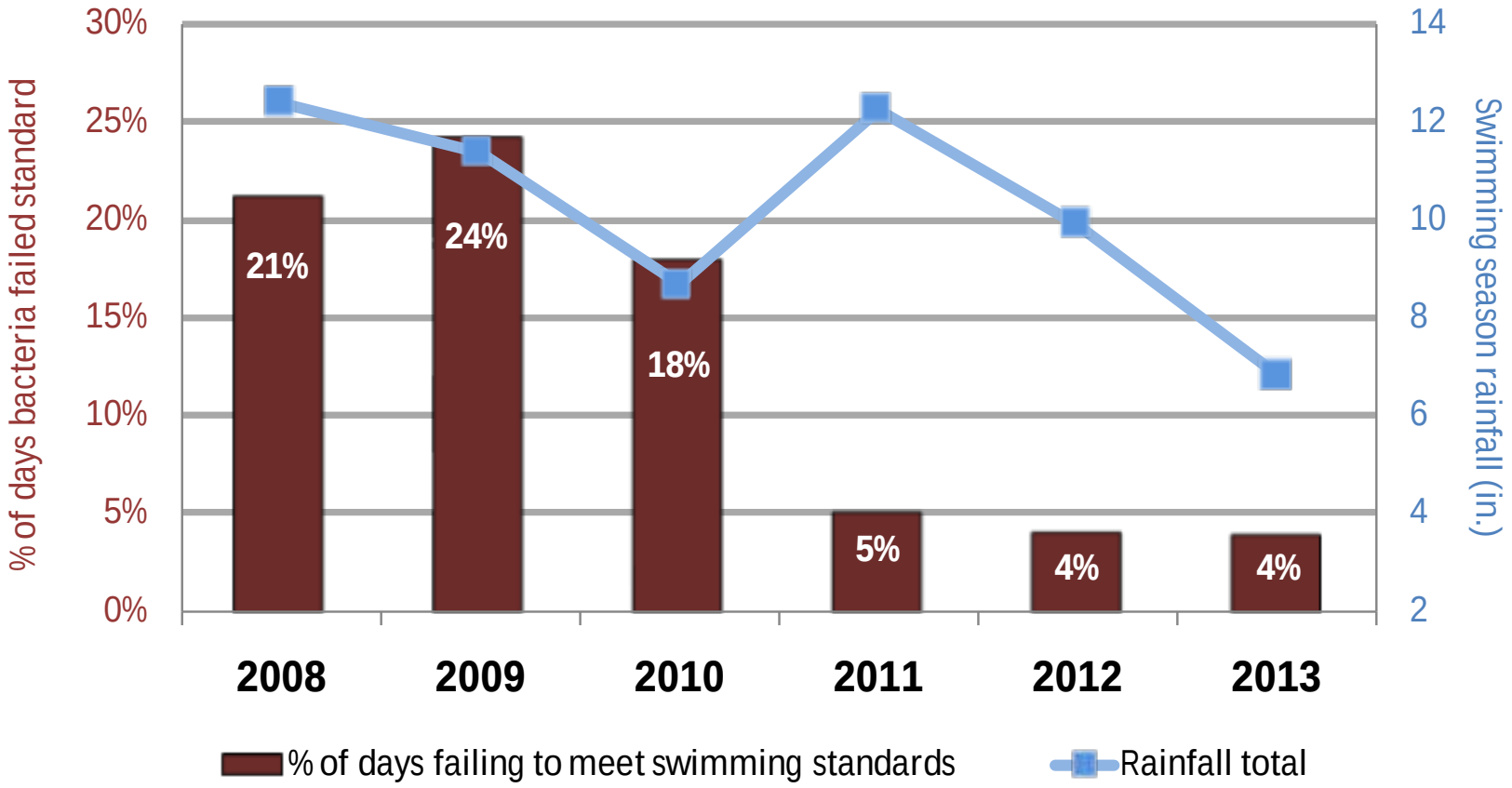
Largest Project: South Boston CSO Storage Tunnel



South Boston Tunnel Mining Completed In August 2008

Project Substantially Complete May 31, 2011

Less Frequent High-Bacteria Beach Days, Despite More Rainfall



In Cambridge, An Innovative Stormwater Wetland

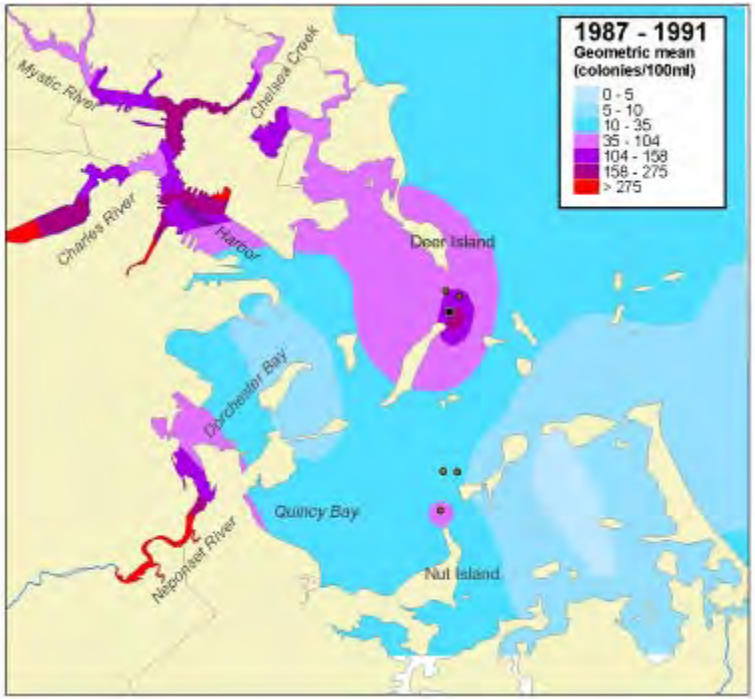
Dramatic Improvements In Wet Weather Water Quality

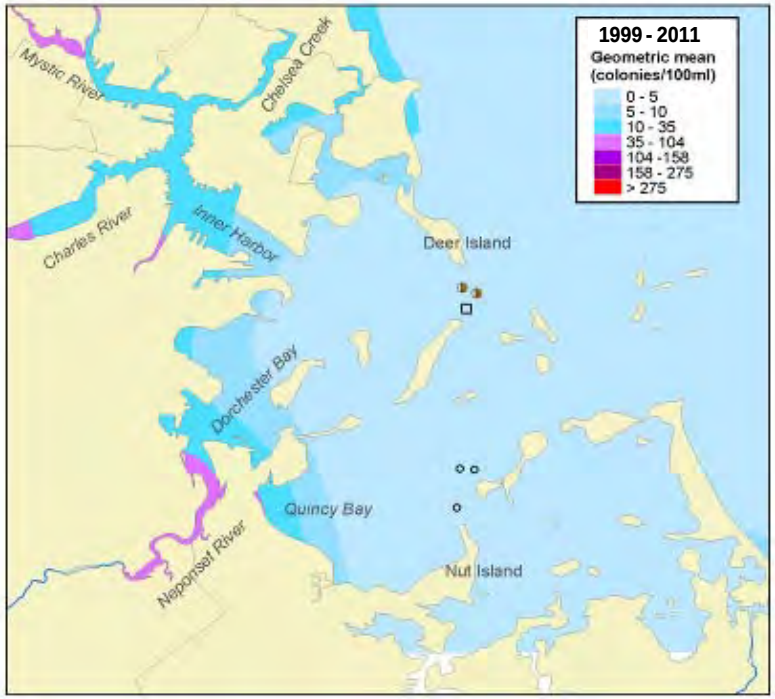
1987-1998 (Before Secondary Treatment and South System transfer)

Elevated bacteria around outfalls, rivers, Inner Harbor, shoreline

1999 - 2011 (After Secondary Treatment and New Outfall)

Most of Harbor well within swimming criteria, most remaining problems in rivers





The lighter the blue, the better

Modernizing the Water System

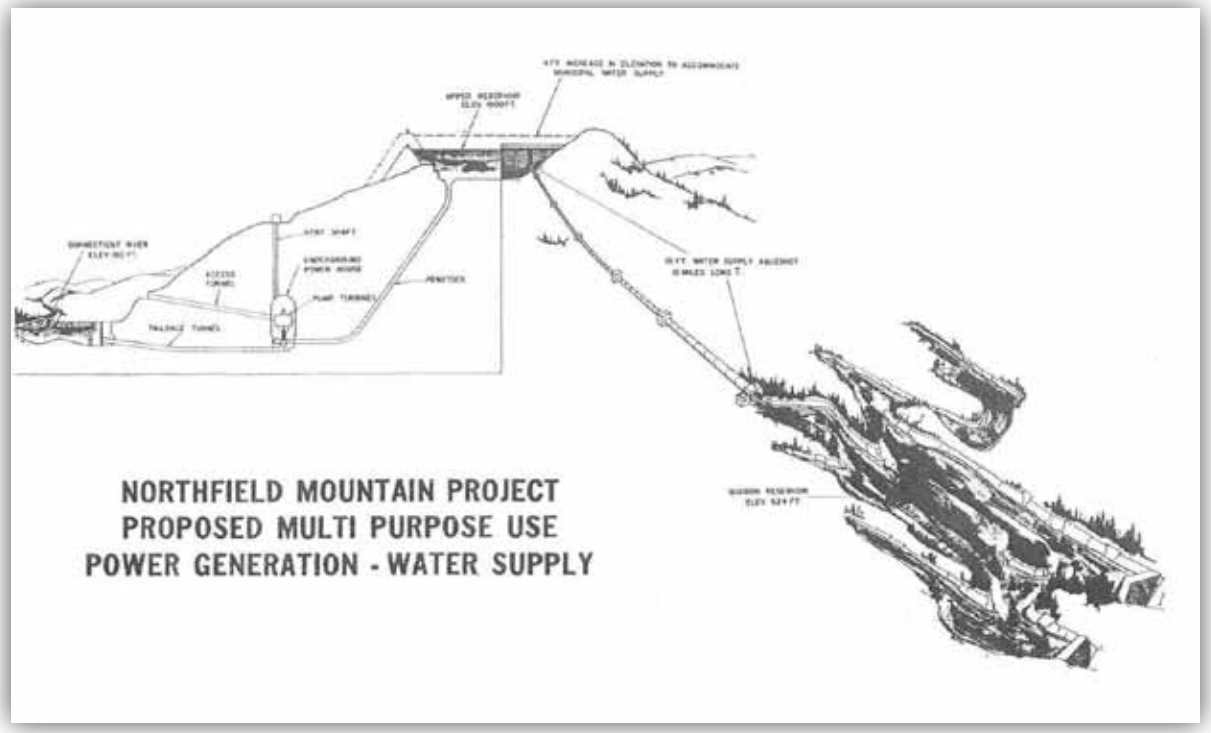
Demand Exceeded Safe Yield

- With the construction of new sewer facilities well underway by the mid-1990s, the focus shifted to the renewal of the water system

- By the early 1970s, demand exceeded safe yield – and continued to do so for 20 years

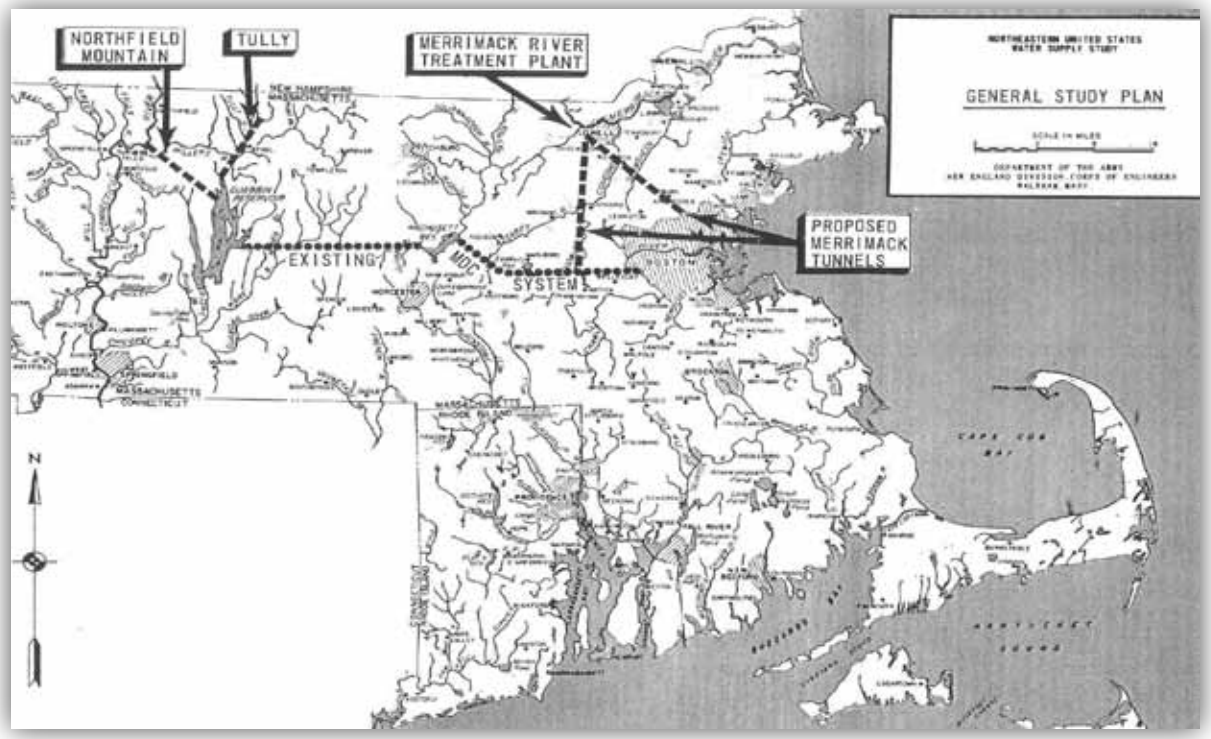
Studies For Northfield Mountain Project

- Studies for the Northfield Mountain Project continued throughout the 1960s
- The project included a pumped-storage facility using water from the Connecticut River



Studies For Northfield Mountain Project

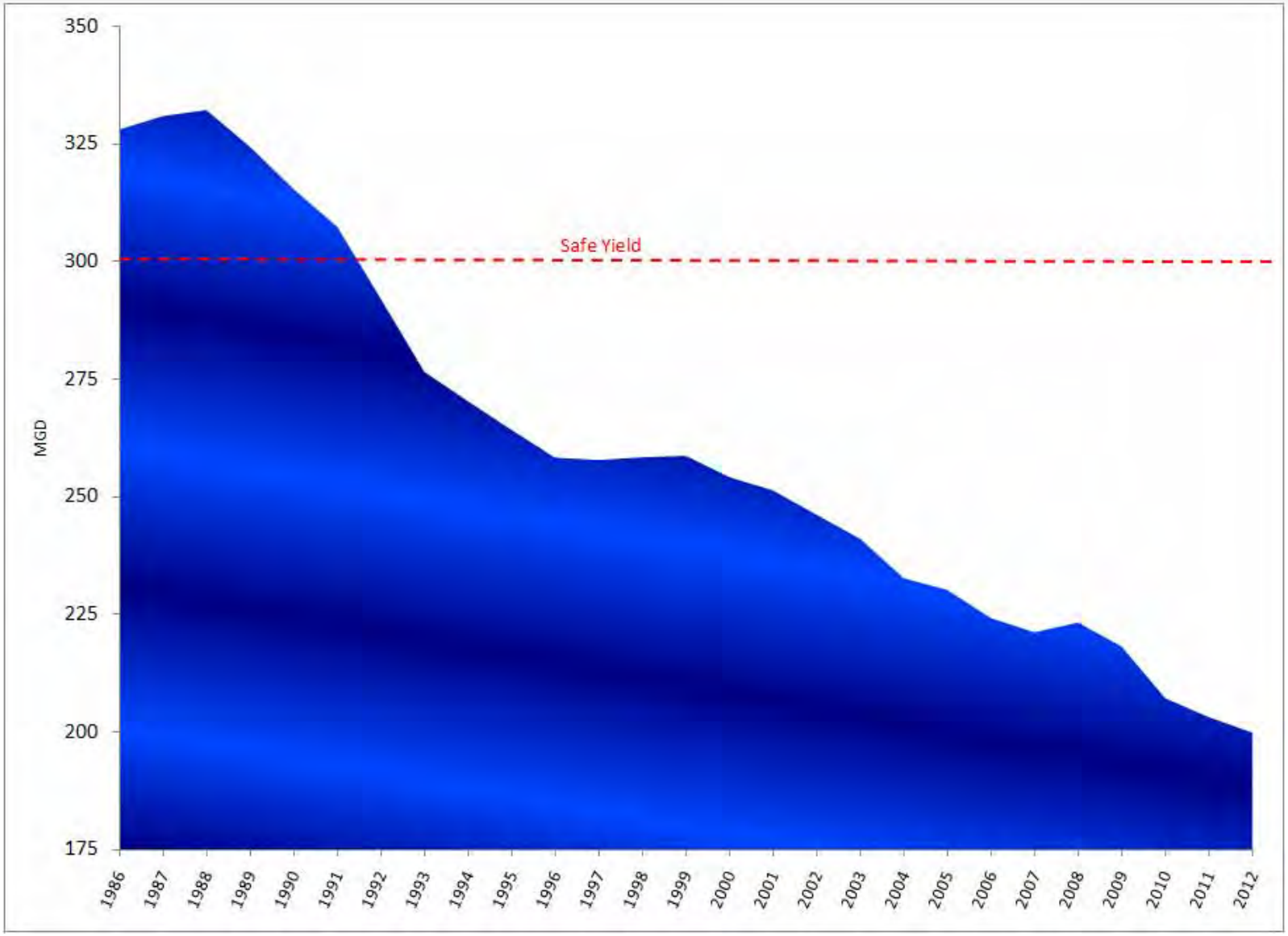
- The Northfield Project was a proposal for skimming Connecticut River spring flood flows and diverting them into the Quabbin Reservoir.
- The measure was authorized by the legislature in both 1967 and 1970



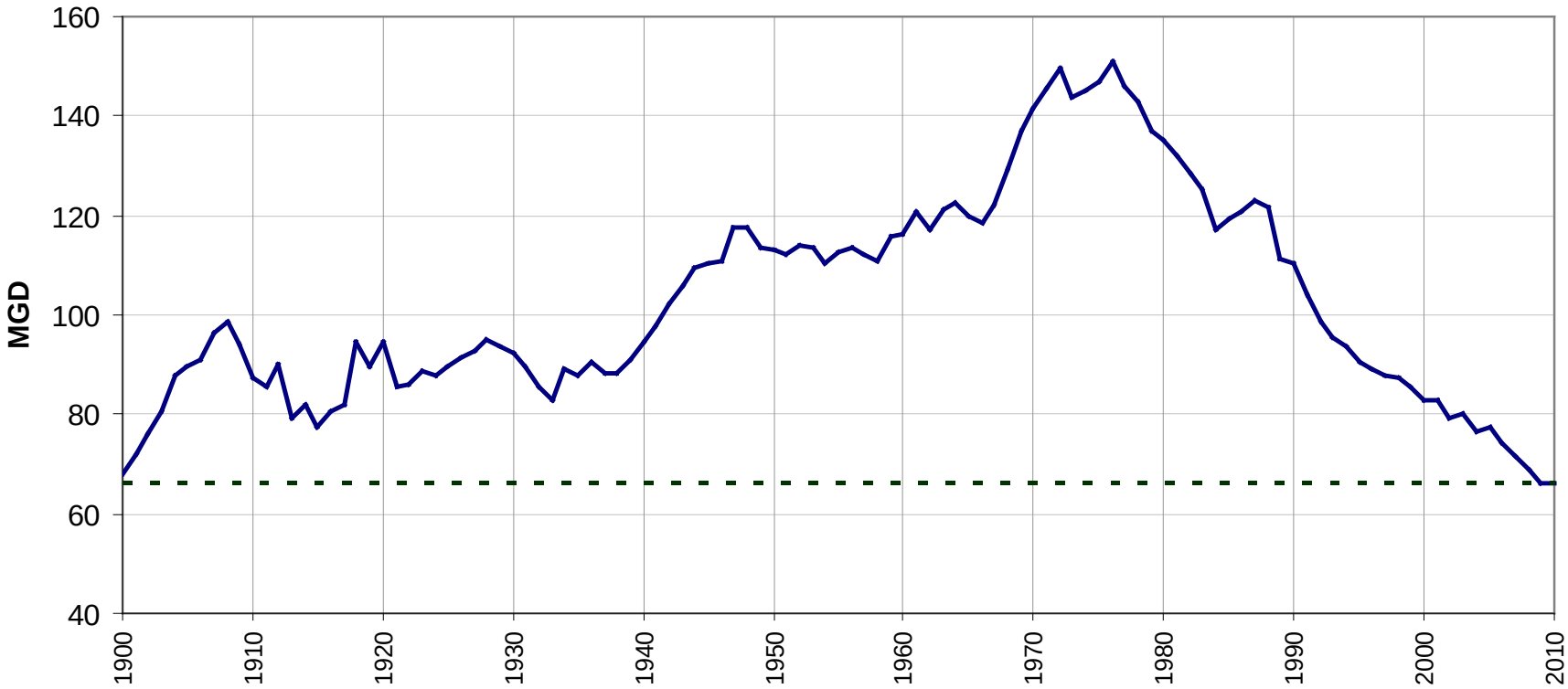
MWRA Demand Management Programs

- A free one-time leak detection survey (1988-1990) of 6,085 miles of community pipes detected 30 mgd of water loss in community systems. Repairs were subsequently undertaken
- In 1991, MWRA's leak detection regulations were put in place, requiring communities to complete leak detection surveys every two years. Communities may use MWRA's contractor
- 5 mgd of water loss in MWRA system detected and corrected 1987-1990. All MWRA distribution pipes (286 miles) checked annually for leaks and repairs made promptly
- Rehabilitation of MWRA distribution pipelines for water quality has added benefit of reduction of pipeline leakage

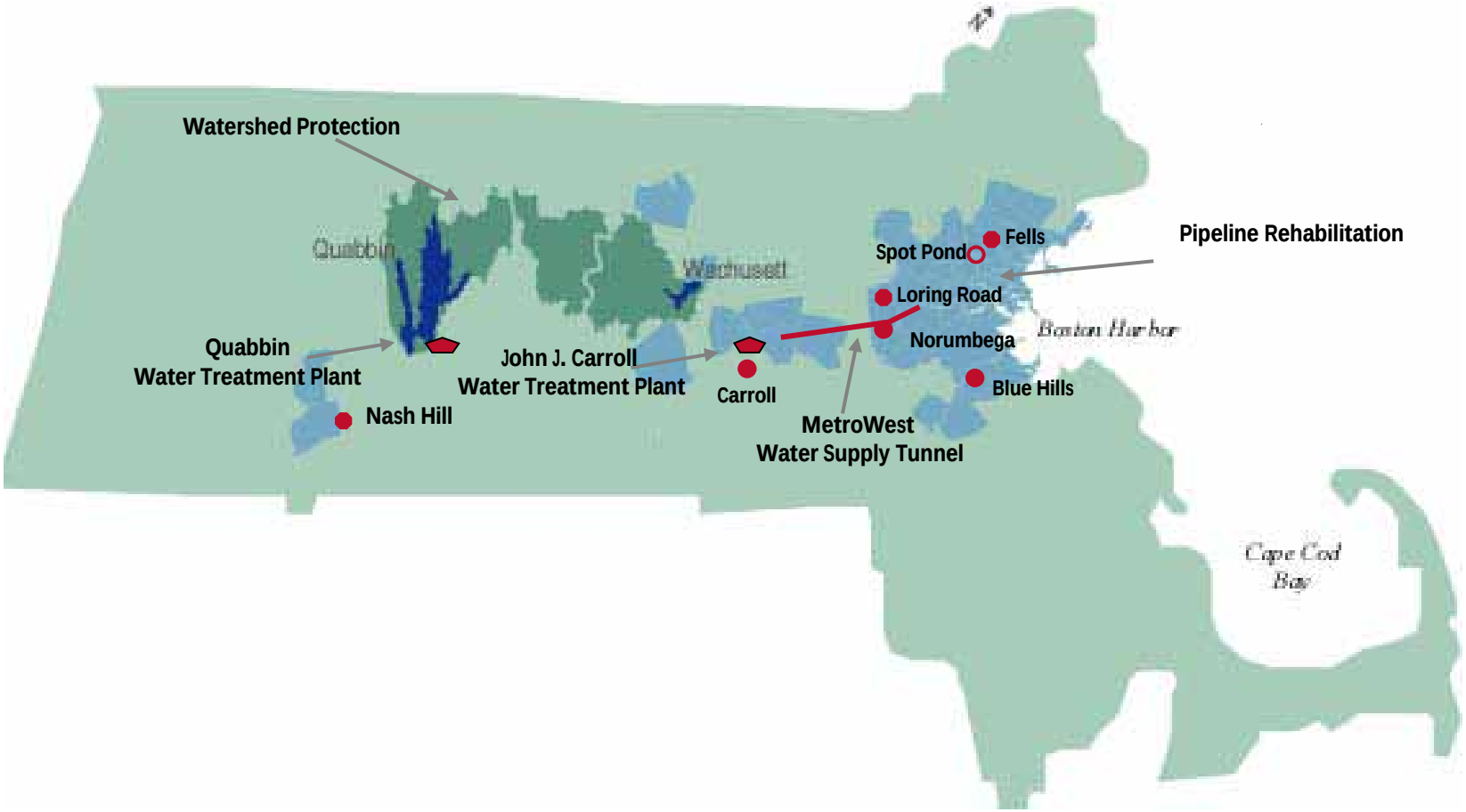
Water Conservation Measures Worked



In Fact, Boston's Usage Is At A 110-Year Low



Now It Was Time To Upgrade The Water System



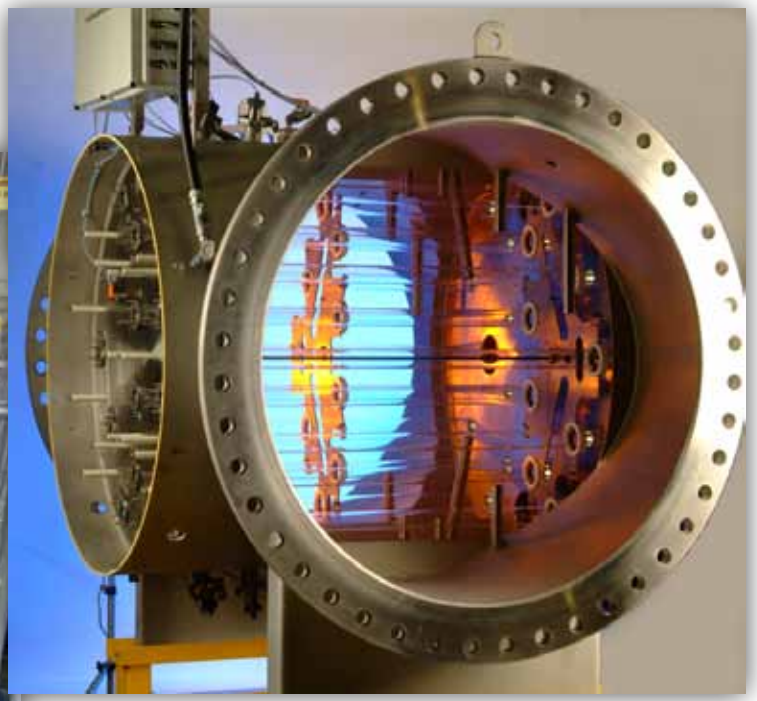
John J. Carroll Water Treatment Plant

- Completed in July 2005
- Treatment Processes:
  - Ozonation for primary disinfection
  - Corrosion control
  - Chloramination for secondary disinfection
  - Fluoridation

Addition Of Ultraviolet Light Disinfection

- Unfiltered systems must have two primary disinfectants, one of which must achieve *Cryptosporidium* inactivation

- UV facilities at the Carroll Treatment Plant are on-line as of Tuesday, April 1, 2014



MetroWest Water Supply Tunnel

- The MetroWest Water Supply Tunnel was brought on-line in November 2003
- By March 2004, the Tunnel was being fully utilized allowing the shutdown of the Hultman Aqueduct for repair

Hultman Aqueduct Rehabilitation

- In 2013, for the first time since originally planned in the 1930s, the Metropolitan Water System has full redundancy for the Hultman Aqueduct from Marlborough to Weston

Covered Storage Projects

- MWRA is building seven new covered storage tanks to replace all open reservoirs
- Six are completed and on-line

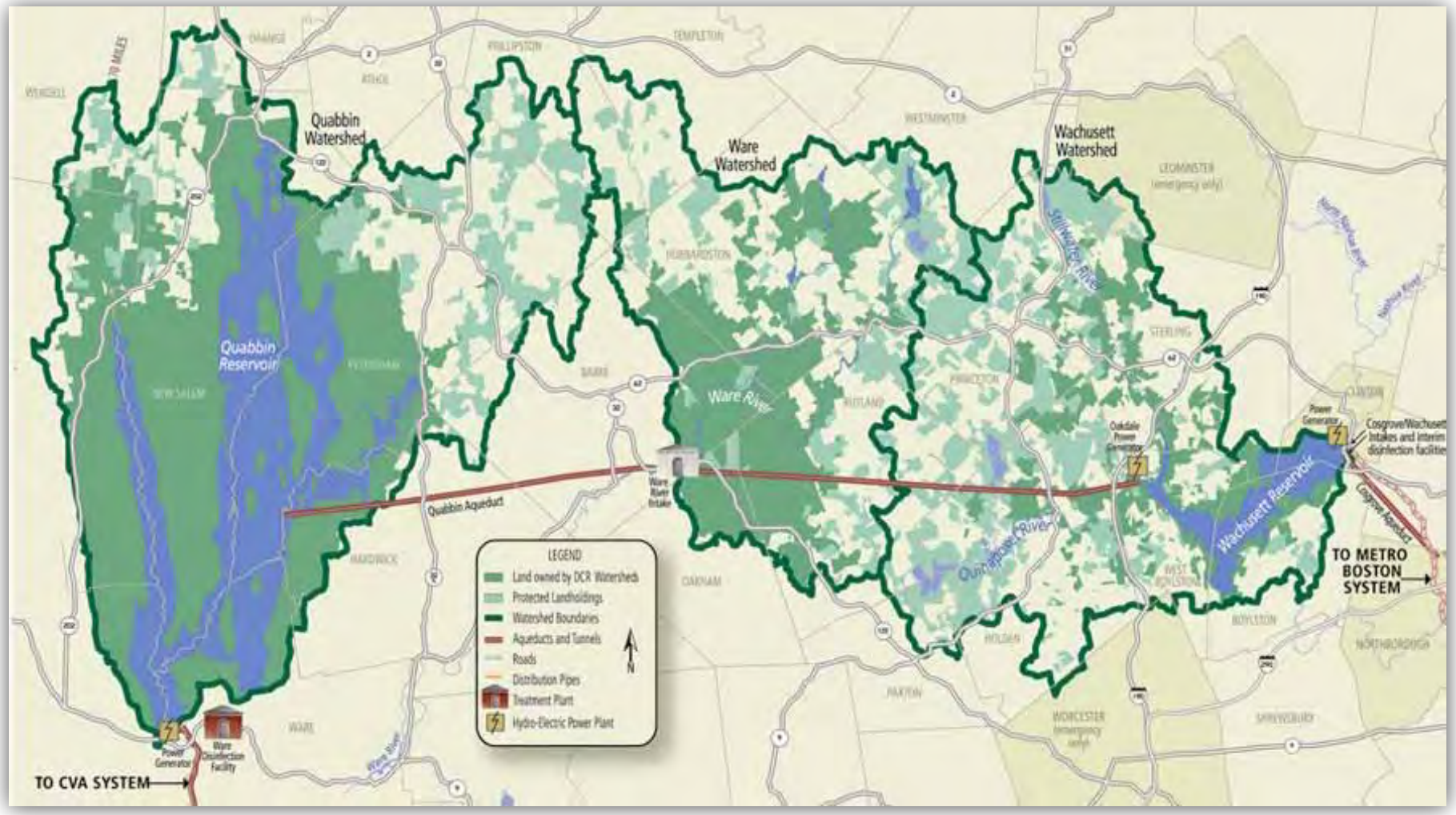
Norumbega Covered Storage Facility

- The tank was completed in May 2004
- It provides 115 million gallons of storage for metropolitan Boston

Spot Pond Storage Facility

- 20-million-gallon buried water tank
- Redundant pump station to supply 20 communities
- Construction 73% complete

Aggressive Watershed Protection Program

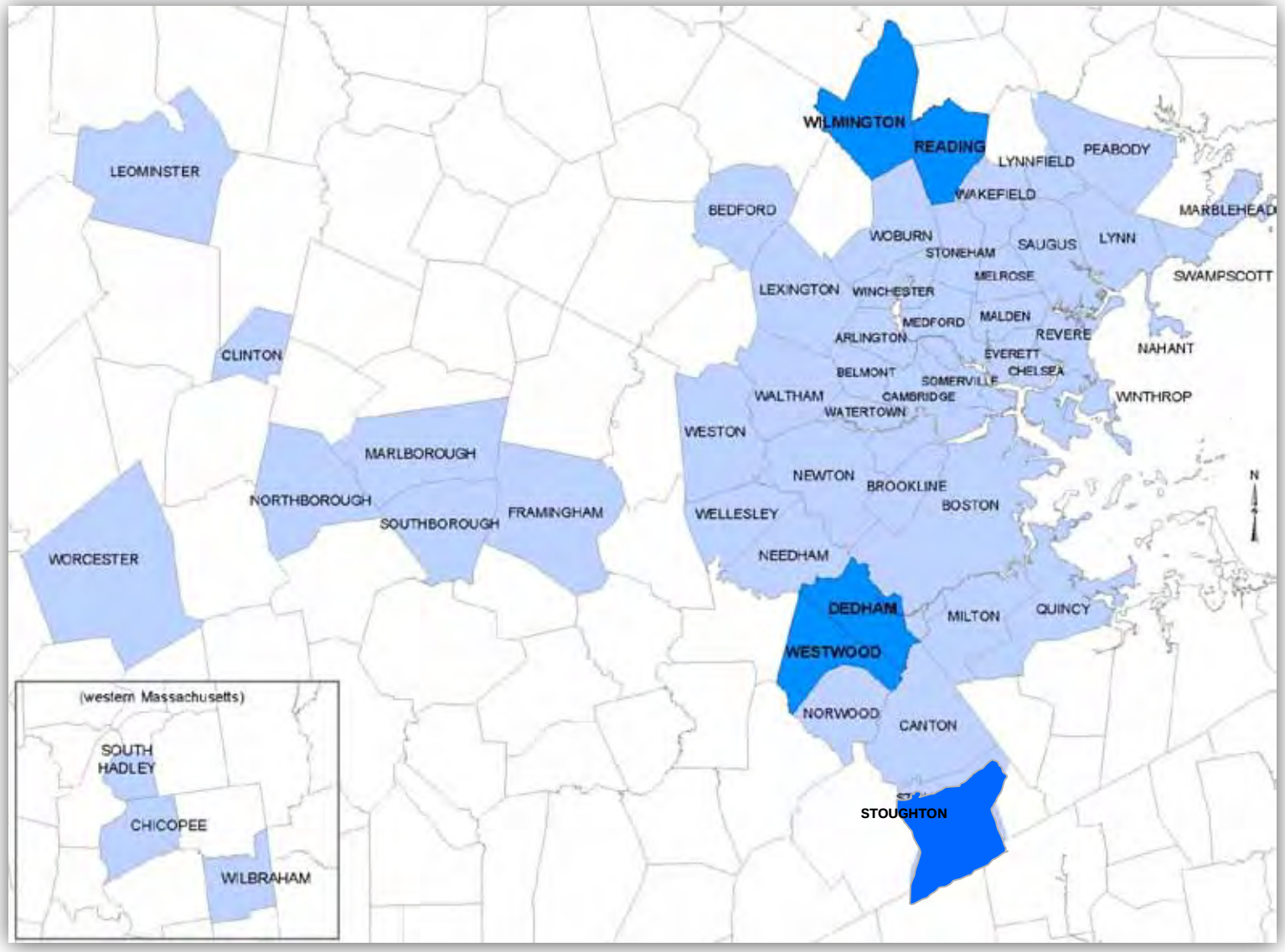


Water Supply Protection Trust

- A water supply protection trust was created by Chapter 149 of the Acts of 2004
- Provides a more efficient mechanism for MWRA's funding of the Office of Watershed Management, under the Department of Conservation and Recreation

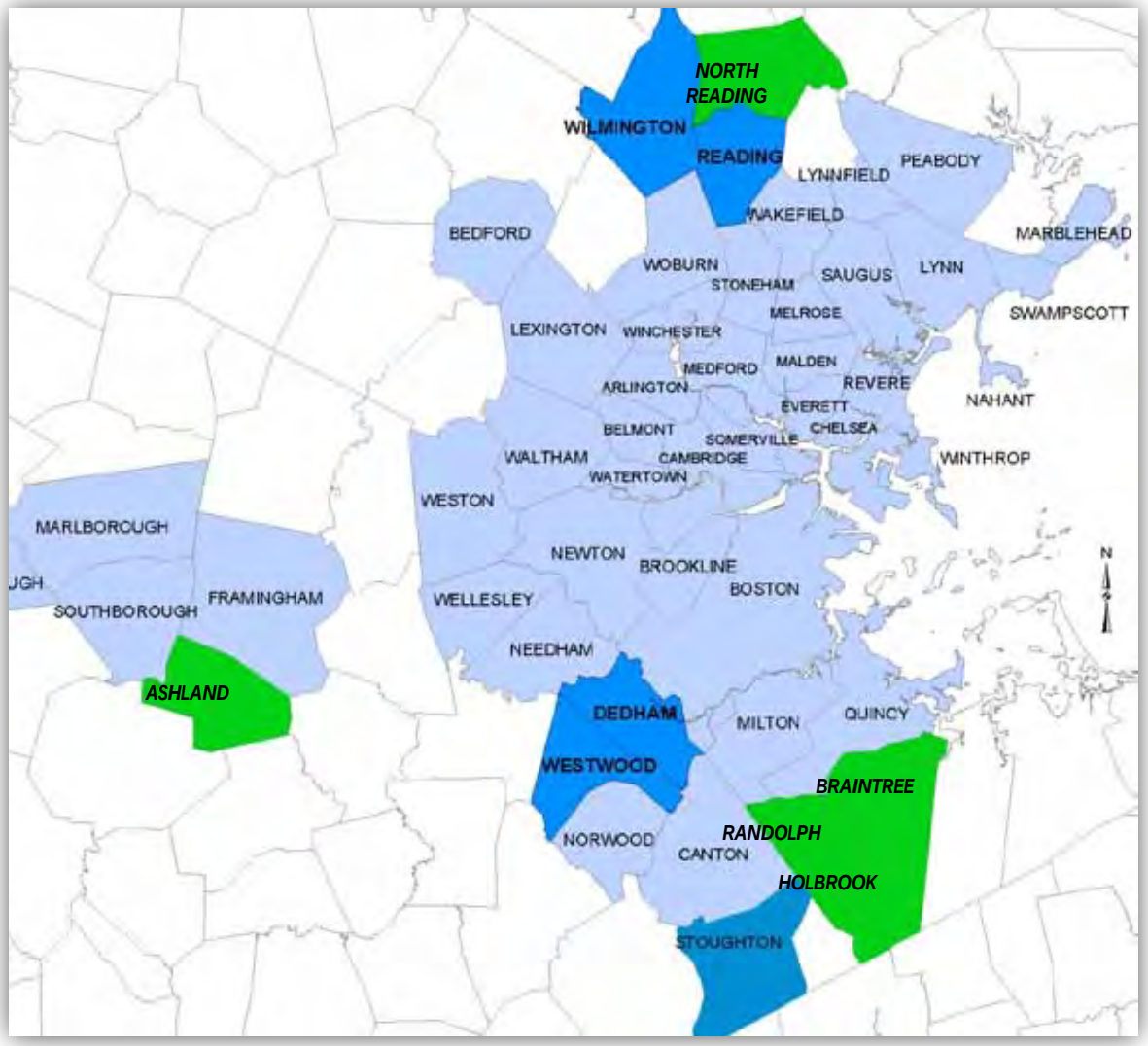
Water System Expansion

Water Use Continues to Decline, Despite Communities That Have Recently Joined



Potential System Expansion

- MWRA talking to several communities about joining the water system



MWRA Water System Expansion

- Some rate relief, as well as environmental benefits to stressed river basins, could be offered if additional communities joined the system

- To frame these and other parameters for a revised system expansion process, MWRA's Board of Directors engaged in a facilitated discussion in spring 2010 with opinion leaders who can influence regional water resources policy in the Commonwealth

- Discussions are ongoing

MWRA Water Service Area And Potential System Expansion

Future Demand For Drinking Water Has Been Assessed

- MWRA Water Management Act Registration 312 MGD
- MWRA Practice Safe Yield 300 MGD
- MWRA Five-Year Average Demand 207 MGD

Renewable Energy At MWRA

The Deer Island Treatment Plant

- Deer Island is one of the largest electricity users in the Northeast
- Deer Island currently self-generates 26% of its electricity needs and
- More than half of the Island's energy demand is provided by on-site, renewable generation

Methane Utilization At Deer Island

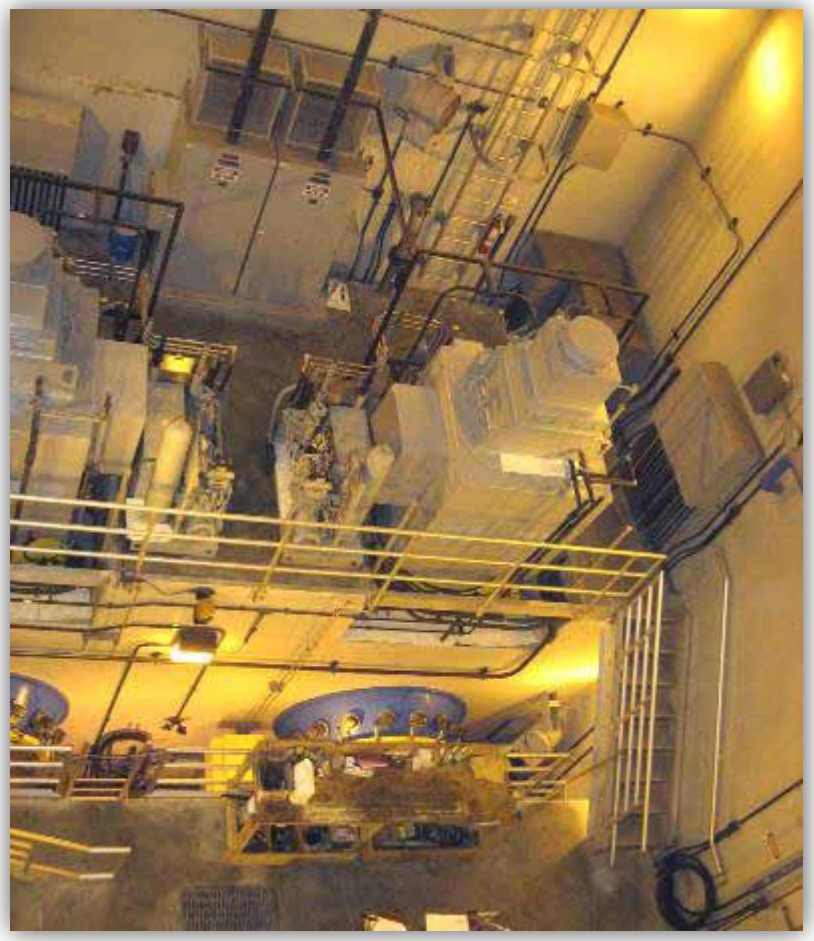
- Deer Island utilizes 97% of the methane generated to power a steam turbine generator for Plant heat and hot water
- Avoid purchase of about $15 million in fuel oil

Deer Island Steam Turbine Generator Upgrade Underway

- Recently installed
- Will produce an additional 5.5 million kWh per year (on top of current 28 million kWh)

Hydroelectric Power At Deer Island

- 2 hydroelectric generators at Outfall shaft
- Generate 5.8 million kWh



Solar Power At Deer Island

- 100 kW photovoltaic system completed in May 2008
- Generates 105,000 kWh

Solar Power At Deer Island

- 180 kW photovoltaic system completed in February 2010
- Generates 105,000 kWh

Solar Power At Deer Island: Power Purchase Agreement

- Solar through Power Purchase Agreement partially funded through ARRA
- Total Installation of 450kW
  - Grit roof – 220kW
  - Parking lot ground – 230kW

Carroll Water Treatment Plant Solar

- 496kW ground mount system will generate 616,000 kWh/yr
- Fully funded through ARRA

Hydroelectric at Loring Road Covered Storage, Weston

- Generator installed in November 2010
- Generates 1.2 million kWh per year
- Fully funded through ARRA and MassCEC

First Two Wind Turbines On Deer Island

- Two, 190-foot turbines installed in August 2009
- Generate 2 million kWh per year

FloDesign Turbine at Deer Island

- Experimental 100 kW unit
- 33% more efficient than blades
- Fully funded by FloDesign

Charlestown Wind Turbine

- Installed in October 2012
- 1.5 megawatt turbine
- 364 feet to top of blade
- Will generate 3.7 million kWh per year
- Fully funded through ARRA