Metropolitan District Commission
Water Supply Study and
Environmental Impact Report-2020

TASK 18.20: A HISTORY OF THE DEVELOPMENT OF THE METROPOLITAN DISTRICT COMMISSION WATER SUPPLY SYSTEM

Submitted to:
Metropolitan District Commission

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INTRODUTCTION

Boston, one of the oldest cities in the United States, has one of the oldest public water supply systems, dating back to 1652. The system was developed and expanded incrementally in response to the growing needs of the city throughout the industrial revolution and into the twentieth century. The water supply system was also one of the first in the nation to be integrated into a metropolitan system, with the formation of the multi-municipality Metropolitan Water District in 1895, a forerunner of the Water Division of the Metropolitan District Commission (MDC). Today, three sources in central Massachusetts provide water to 44 communities through the MDC's Water Division. The Quabbin and Wachusett Reservoirs, and the Ware River, combine to provide a safe yield of approximately 300 million gallons per day (MGD) to the MDC system. Since the formation of the metropolitan system, two major water supply studies have been undertaken, in 1895 and 1922, to evaluate future water needs and plan for system expansions. These historic water planning studies in many ways parallel a third major study now in progress. These three studies all include projections of population and the consequent future demand for water. as well as analysis of various alternatives to meet the projected demand.

BOSTON' S EARLY WATER SUPPLY

Boston was settled in 1630 on the Shawmut peninsula. The earliest source of fresh water was a spring near the Boston Common. By 1652 this source was insufficient. A map recording the ownership of properties from the 1640's shows 208 homes in Boston at that time. A “Water Works Company” was incorporated to construct a 12 foot cistern (a wooden tank to store water) near today's Haymarket district, and a conduit. Later, additional cisterns were added to increase the supply for Boston's residents, counted at 7,000 in a 1690 census.

By 1795, increased population was exhausting the existing water supplies, and water was sought from beyond the confines of the Shawmut peninsula. The Jamaica Pond
Aqueduct Company was created to bring water from Jamaica Pond in Roxbury to Boston. The water was conveyed by four pitch log pipes with three to four inch diameters over a distance of about five miles. This is one of the earliest instances in the Country of one town seeking domestic water from sources lying within another community.

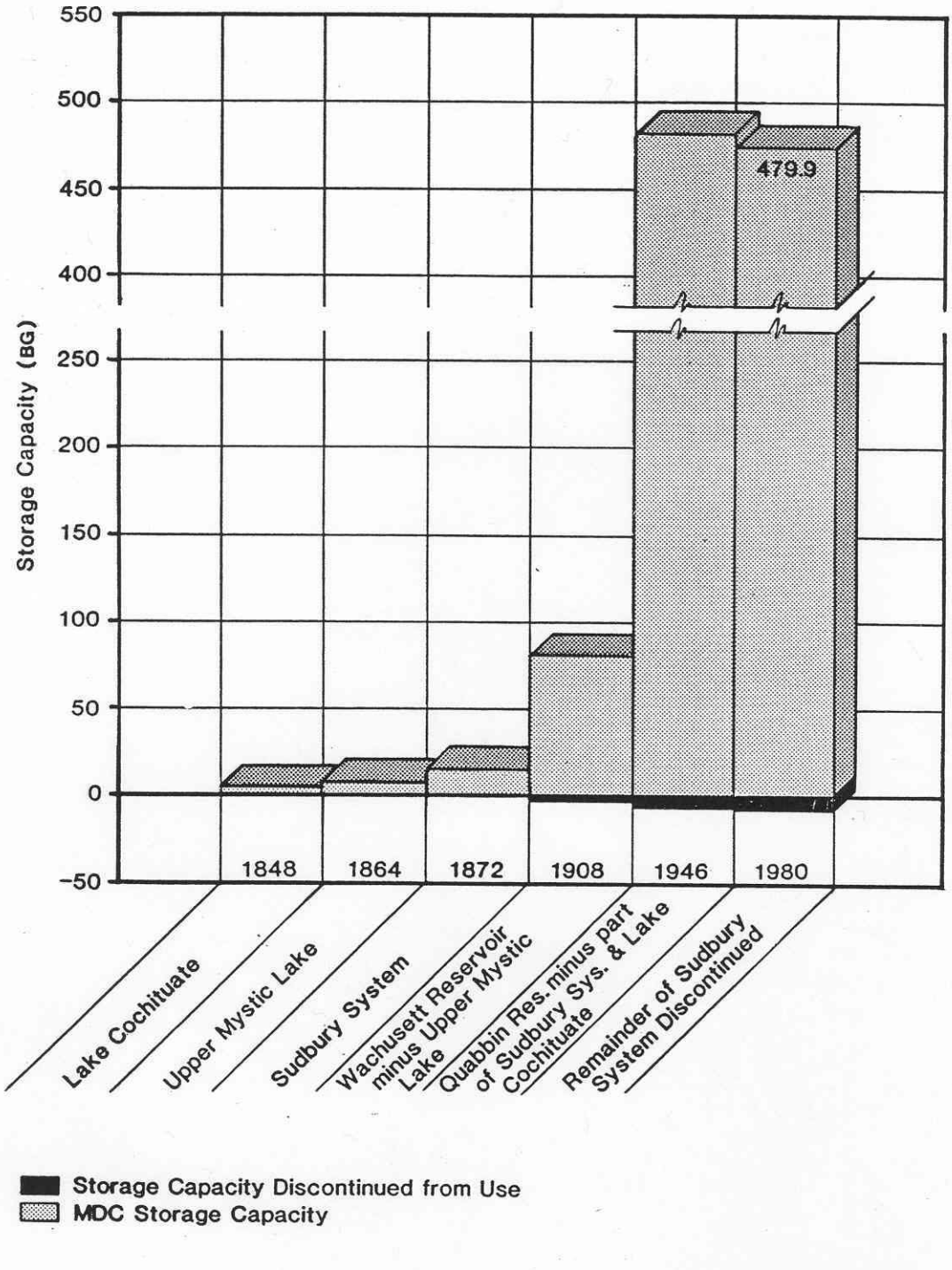
Cistern, circa 1600's

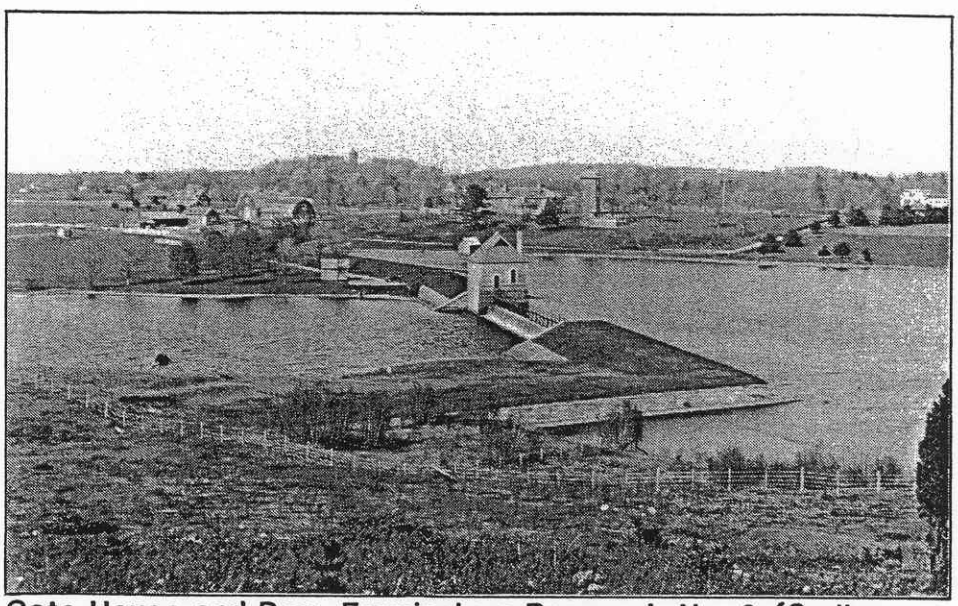
In 1795 when the Jamaica Pond source was developed, Boston's population was 19,000. By 1850 it had increased to 180,000. This growth, together with increased industrial and fire protection needs, stimulated the development of the first publicly owned water supply system in Boston. In 1846, after ten years of controversy over public versus private ownership, the Massachusetts state legislature approved a bill authorizing Boston to take water from Lake Cochituate in Wayland. The first water from Lake Cochituate flowed into the Frog Pond on the Common in 1848 at a dedication ceremony which drew 100,000 people to Boston Common. Cochituate, with its 17 square miles of watershed, two billion gallons of storage, and yield of ten million gallons per day, became the cornerstone of later Boston and MDC water supply systems. (See Table 1 and Figure 1).

Throughout the second half of the 19th century, the population of Boston and neighboring communities continued to grow rapidly, and it was soon apparent that even Lake Cochituate's water would be inadequate. In 1872 the Sudbury River Act authorized the City of Boston to take water from the Sudbury River. Between 1872 and 1898, seven reservoirs were constructed on the north and south branches of the Sudbury River, adding 62 square miles of watershed and over 19 billion gallons of storage to the system.

In 1870, the Mystic Lakes system in Winchester, Medford, and Arlington, which had been developed by Charlestown, was added to the Boston system when Charlestown was annexed.

Figure 1.
Boston/MDC Cumulative Reservoir Storage Capacity, 1850–1980





Gate House and Dam, Framingham Reservoir No. 2. (Sudbury System) (1910 Photograph)

Table 1. Chronology of Development of Boston and MDC Water Supply Sources

Year	Water Supply Development	Developer	Reported Yield MGD	Storage (bg)	Watershed sq. mi.
Before 1652	Spring on Boston Common	-	-	-	-
1652	Cistern and Conduit	Water Works Co.	-	-	-
1795	Jamaica Pond	Aqueduct Co.	-	-	-
1848	Lake Cochituate	City of Boston	10	2	17
1864	Upper Mystic Lake	Charlestown	30	2	28
1872-98	Sudbury Reservoirs (7)	City of Boston	42	19	62
1908	Wachusett Reservoir	MDC	105	67	109
1940	Quabbin Reservoir and Ware River	MDC	160	412	186

THE METROPOLITAN WATER DISTRICT

At the turn of the century, population and per capita water use were increasing rapidly, and before the last Sudbury reservoir was completed, the legislature had already directed the state Board of Public Health to study the future water needs of the metropolitan Boston area and recommend the development of new sources to meet those needs. The Board also considered the idea of forming a Metropolitan Water District (MWD) consisting of most of the

towns and cities within a ten mile radius of the State House in Boston. In recommending the formation of this pioneering metropolitan water supply agency, which was later incorporated into the Metropolitan District Commission, the Board wrote that

> "investigations and estimates show that an additional water supply can be furnished by combined action at much less cost than by independent action, particularly if existing works are used to avoid duplication."(l)

Thus the Metropolitan Water District was established by Chapter 488 of the Acts of 1895, and it included Boston, Belmont, Chelsea, Everett, Malden, Medford, Melrose, Newton, Revere, Somerville, and Watertown. These were joined by Arlington, Lexington, Milton, Nahant, Quincy, Stoneham, Swampscott, and Winthrop between 1897 and 1909.

THE 1895 BOARD OF HEALTH STUDY

The Board of Health's landmark 1895 study laid the groundwork for the creation of the MDC and its growth to the present day. The study established the policy of augmenting metropolitan water sources from protected upland watersheds with abundant supplies of clean water, a policy followed by the Metropolitan Water District and later, the MDC. These sources generally were to be found outside the metropolitan area. After projecting population and water needs to the year 1930, the Board recommended construction of Wachusett Reservoir to augment the existing sources: Lake Cochituate and the Sudbury Reservoirs. The reservoir was to be constructed by flooding parts of four towns near Worcester (Clinton, Sterling, Boylston and West Boylston). In considering alternative water sources from the Charles River to the Deerfield and Westfield River, the plan laid out the basic blueprint for system expansion for the next century. Looking beyond Wachusett, which the study estimated would be insufficient to meet demand as early as 1915, the Board of Health concluded:

> "The very great merit of the plan now submitted is to be found in the fact that this extension of the chain of the metropolitan water supplies to the valley of the Nashua will settle forever the future water policy of the district, for a comparatively inexpensive conduit can be constructed through the Valley of the Ware River, and beyond the Ware River lies the Valley of the Swift"(2)

Clearly the Board of Health was looking ahead nearly half a century to the next major additions to the system. But the Board looked even beyond that day, saying:

> “in a future so far distant that we do not venture to give a date to it, are portions of the Westfield and Deerfield Rivers capable, when united, of furnishing a supply of the best water for a municipality larger than any now found in the world."(3)

One of the reasons the Board was looking so far ahead was that population growth had been quite rapid and was projected to continue through the end of the planning period (1930).

Population Projections 1895-1930

The Board's population projections for the period 1895 to 1930 are shown in Figure 2. These projections were for the 26 cities and towns within a ten-mile radius of the State House which were legally eligible to join the Metropolitan Water District. In fact, only 20 of these towns joined the MDC during the 35 year planning period.

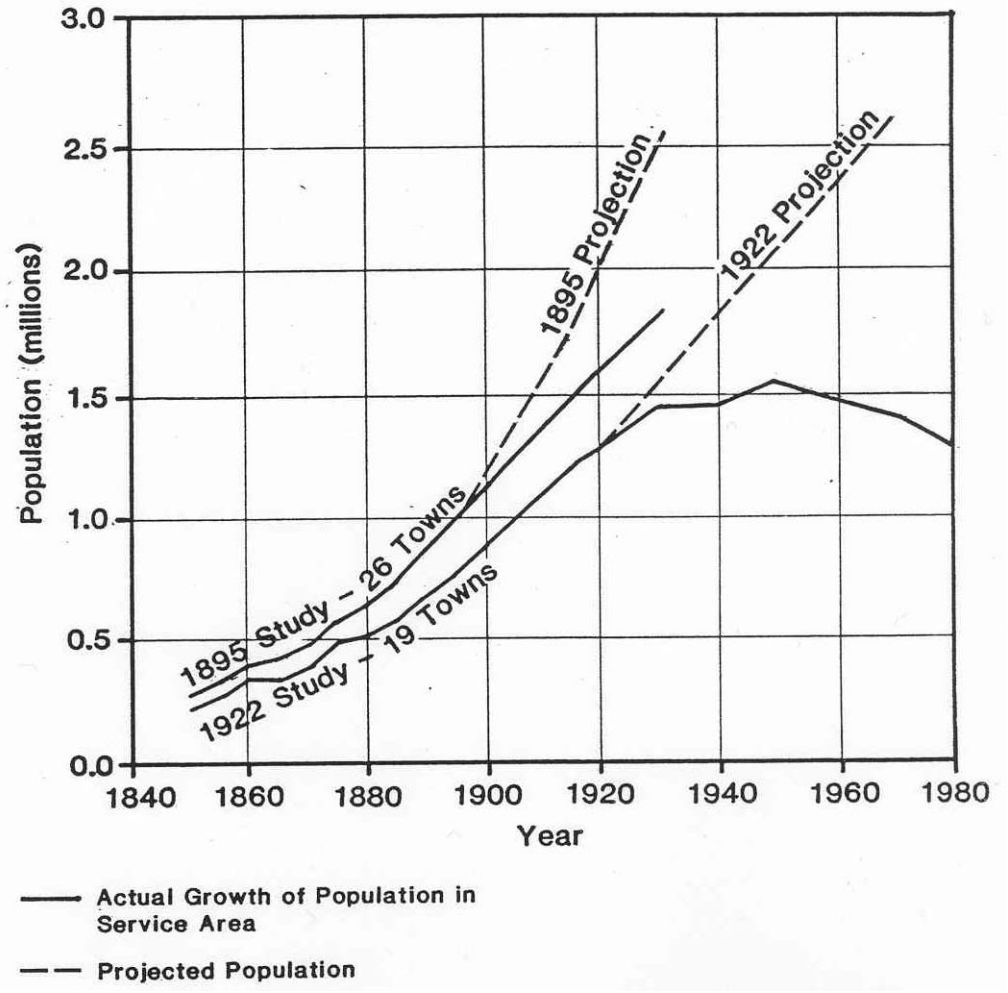
The method used to derive the population projection seems to have been simple straight line projection. The Board wrote:

> "we have not deemed it necessary or advisable to busy ourselves with the insoluble problem of the probable future increase of the population in and about Boston. We have assumed that growth will go on as it has gone on during the last quarter of a century"(4)

The Board looked at the historic growth of other large cities as they had approached and exceeded a population of about one million to determine if its assumptions were reasonable. The Board found that New York, London, Berlin, and Philadelphia had all continued to grow steadily after reaching the one million mark, and therefore assumed that Boston would continue to do the same.

Using this assumption, the Board estimated that the metropolitan population would increase about 2.7 percent per year, doubling to 2 million by 1920 and reaching 2.5 million by 1930. However, stricter immigration laws and World War I caused the population to grow at a considerably slower 1.7 percent per year, so that by 1930 the 26 towns had a population of 1.8 million, 28 percent less than projected. Also, not all of the eligible towns had joined the Water District; by 1930 the Water District's antecedent, the MDC, included only 20 towns, with a population of 1.5 million. See Figure 2 for actual population growth in the 19 towns included in the 1922 study.

Figure 2.
MDC Population and Projections 1895–1930 and 1925–1970



These population projections were a major component of the water demand projections made by the Board, which were subsequently affected by other important factors.

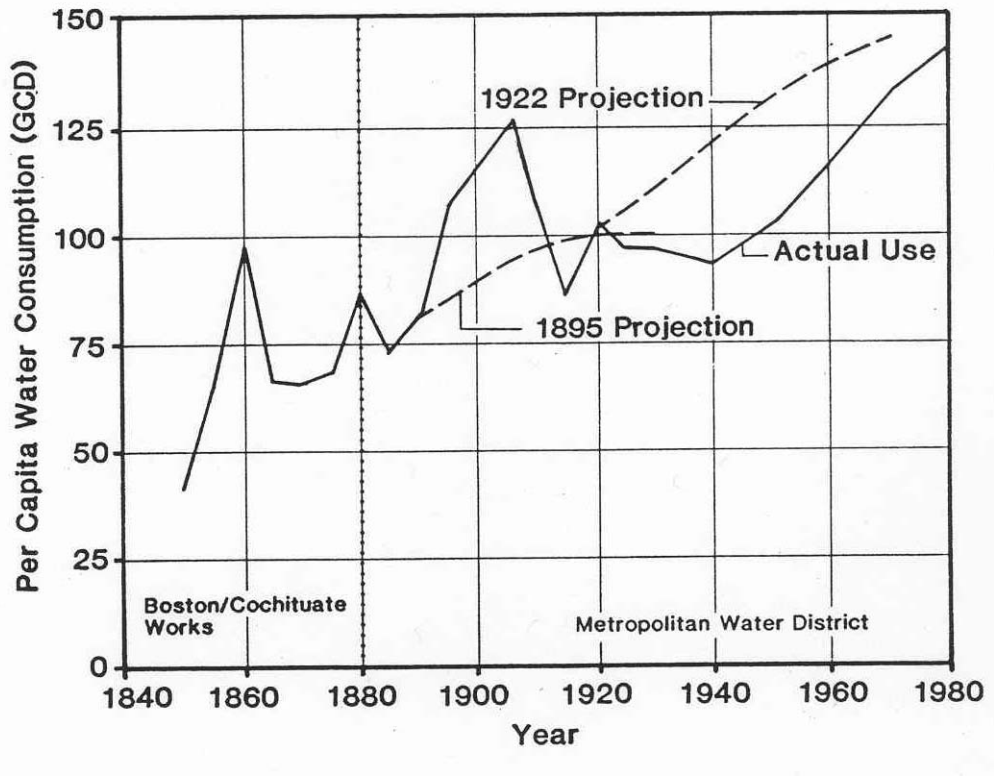
Water Demand Projections 1895-1930

Having predicted a large increase in the MDC's service population, the Board also foresaw a substantial increase in water demand in the district.

The Board found that per capita water use in the district towns was 83 gallons per capita per day (GPCD) in 1893, and estimated that this would rise to 100 GPCD by 1920 and remain at that level through 1930 (See Figure 3). In fact, per capita water consumption rose much more rapidly in the first ten years of the planning period, then fell off sharply in the next ten years due to the widespread introduction of metering. Per capita use grew from 83 GPCD in 1893 to 127 GPCD in 1907. In that year, a law was passed requiring universal metering, with an increment of five

percent of all services to be metered each year. Between 1907 and 1915, per capita water use fell 24 percent to 95 GPCD. Thereafter, growth in water use resumed at approximately the same rate as before the 1907 legislation. But the introduction of metering had caused an eight year reversal of the growth of per capita use, and this had a pronounced short-term effect on total water use in the district.

Figure 3.
Boston/Metropolitan Water District Per Capita Water Consumption

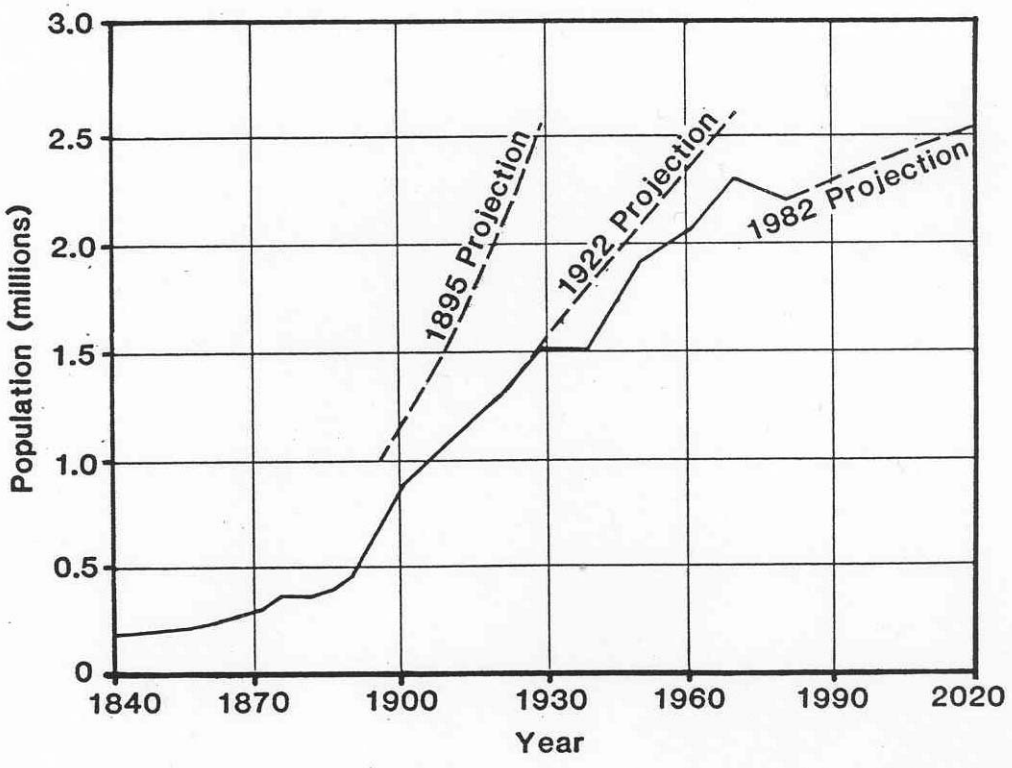


The combination of slower than projected population growth due to immigration laws and World War I, (See Figure 4) together with less than projected per capita water use due to metering, led to an actual water use which was 43 percent less than the Board of Health had projected by the end of the planning period in 1930 (See Table 2).

Table 2. Water Consumption, 1895–1930

YEAR	PROJECTED BY BOARD OF HEALTH (MGD)	ACTUAL CONSUMPTION (MGD)
1895	84	69
1900	103	98
1905	125	120
1910	148	116
1915	173	105
1920	198	131
1925	224	134
1930	252	143

Figure 4.
Historic and Projected Service Population, 1850–2020



The Board also looked at the components of water use, and used metering data from Boston, Newton, Brookline, Fall River, and Worcester to estimate the amount of water used for domestic, industrial, and public purposes and the amount wasted. The Board's estimates of water use by sector are presented in Table 3, along with a breakdown of 1980 water use by sector. The categories used in the two years are not exactly comparable, because public and industrial water use are not broken out in 1980, and "unaccounted-for" in 1980 includes more than just the "waste" of 1895.

Table 3. Breakdown of Water Use by Sector, 1895 and 1980

1895		1980	
USE SECTOR	PERCENT OF WATER USE	USE SECTOR	PERCENT OF WATER USE
Domestic	35	Domestic	38
Industrial	35	Nondomestic	34
Public	5		
Waste	25	Unaccounted-for	28

Unaccounted-for Water and Leakage

As indicated above, the Board estimated that 25 percent of the water delivered to the system was "wasted." Of this water the Board wrote:

> "in the quantity wasted I do not include water which is lavishly used, but only that which is either negligently or willfully permitted to escape from the pipes or otherwise with out performing any useful service."(5)

Earlier efforts at leak detection and repair in Boston's Char1estown district had yielded promising results. In 1880, devices called Deacon meters, which register the flow in the mains, were installed in a residential area. The meters showed a daily per capita use of 58.5 gallons, and a rate of use between one and four a.m. of 37.5 GPCD, indicating significant leakage. After inspection and repairs of street mains and house fixtures, the daily rate was lowered to 37.7 GPCD, and the night rate dropped to 15.8 GPCD, a savings of 35 percent in the daily consumption. By extending this leak detection effort to the greater part of the city, per capita demand was reduced from 91.8 GPCD in 1883 to 71 GPCD in 1884 - a savings of 22 percent. From these results, the Board estimated that leakage amounting to about 15 GPCD was unavoidable, and leakage over this amount was preventable. The efforts of 1880 had recovered about 21 GPCD in leakage.

While the Board endorsed the idea of reducing demand by repairing leaks, there was no suggestion that there be any effort to reduce the amount of water actually consumed. To the contrary, the Board wrote that:

> "no small share in the improved state of the public health may be traced to the greater cleanliness which inevitably results from a practically unlimited freedom in the use of water."(6)

It is obvious that the Board recognized the progress being made in curtailing disease and other health problems due to improved sanitary conditions. Showers, baths, indoor toilets, and washing machines were once considered true luxuries.

Alternative Water Supply Sources

Perhaps the most far reaching aspect of the 1895 Board of Health study was its evaluation of water supply sources available for the MWD. Nearly every surface water source in the Commonwealth east of the Housatonic River Basin, as well as sources in New Hampshire and Maine, were considered. The Board singled out three alternatives for more detailed study: the south branch of the Nashua River, the Merrimack River, and Lake Winnepesaukee, New Hampshire. The Board also considered a number of supplemental sources which could be used in the more distant future. The sources were evaluated according to yield, location, engineering, cost, and water quality. The findings of the Board are discussed below and summarized in Table 4.

Table 4. 1895 Evaluation of Water Supply Alternatives

1895 ALTERNATIVES	Yield mgd	Watershed Area (sq.mi)	Distance to Boston (mi.)	Cost $ (millions)	Water Quality Color (Std.Units)	Water Quality Population per sq. mi
Nashua R.	105		34	19.1	0.40	69
Merrimack R.	65+	4097	25	17.5	0.34	31
L. Winnipesaukee		360	77	34.5	0.01	35
Assabet R.	28	34	30	0.6	0.36	60
Assawompsett	36	62	36	----	0.28	36
Charles R.	73	156	15	----	0.86	179
Deerfield R.	---	454	89	----	0.40	21
Ipswich R.	29	53	16	----	1.36	72
Saugus R.	---	----	--	----	1.16	709
Sebago L.	---	500	104	----	----	---
Shawsheen R.	20	34	18	----	0.89	123
Squannacook R.	---	76	41	----	----	---
Swift R.	200	185	64	----	0.38	30
Westfield R.	---	179	93	----	----	---
Ware R.	71	99	51	6.1	0.75	32

Nashua River. The Board's recommended alternative, the Nashua River, was estimated to yield 105 million gallons per day (MGD) at a cost of $19 million. This came to 10 percent more than the Merrimack River alternative, but the Board deemed that the extra expense was warranted because of the superior water quality of the Nashua. Wachusett Reservoir, with 63 billion gallons of storage, was estimated to cost $9 million, which was the least expensive reservoir built to date on a per gallon basis. (See Table 5). The reservoir was designed to be much larger than actually needed in order to collect available runoff in the watershed. This would increase the time of storage of water in the reservoir which would allow natural processes to improve the quality of the water, an alternative to water treatment. The board estimated that $4 million, or nearly half of the cost of Wachusett, could be attributed to building the reservoir larger than necessary and removing soil from the basin to protect water quality.

Table 5. Cost of Reservoir Storage

Sudbury River Reservoirs	Reservoir Number	Capacity (MG)	Cost per MG
Framingham	No. 1	.280	$918
Framingham	No. 2	.530	$879
Framingham	No. 3	1.080	$388
Ashland	No. 4	1.400	$581
Hopkinton	No. 5	7.438	$336
Whitehall	No. 6	1.530	$566
Reservoir		**Capacity (MG)**	**Cost per MG**
Wachusett		63.068	$144

The Board noted that the advantages of the Nashua River were that the watershed was relatively unpopulated, had little agriculture or industry, and little future growth was likely; that the water quality was good enough that treatment would not be necessary and that the option to expand the Metropolitan Water Supply System to include the Ware River and the Swift River, if required, was available.

Merrimack River. The Board declared that the Merrimack River could supply a nearly unlimited quantity of water, but that the quality of the water was unacceptable for use as a source in the metropolitan system. In the days before sewage treatment plants, most sewage was released to rivers and streams untreated, and the population of a watershed was taken as an indicator of the extent of pollution of a water body. The Board cited the fact that over 130,000 people lived upstream from Lowell, and noted that earlier State Board of Health reports had concluded that a very high death rate from typhoid fever had resulted from the use of unpurified Merrimack River water. Because of the population and other pollution sources on the Merrimack, the Board concluded that treatment would be necessary. This was incompatible with the long standing policy of using protected upland sources without treatment, rather than polluted sources which require treatment, in order to avoid potential health risks. The Board stated its viewpoint on treatment when it wrote:

> "there is still a chance that the preparation may be unscientific and the management unintelligent."(7)

Accordingly, the Merrimack River was ruled out as a source of water supply despite the fact that it would cost 10 percent less than the Nashua.

Lake Winnipesaukee. The third major alternative considered by the Board was Lake Winnipesaukee in New Hampshire. This

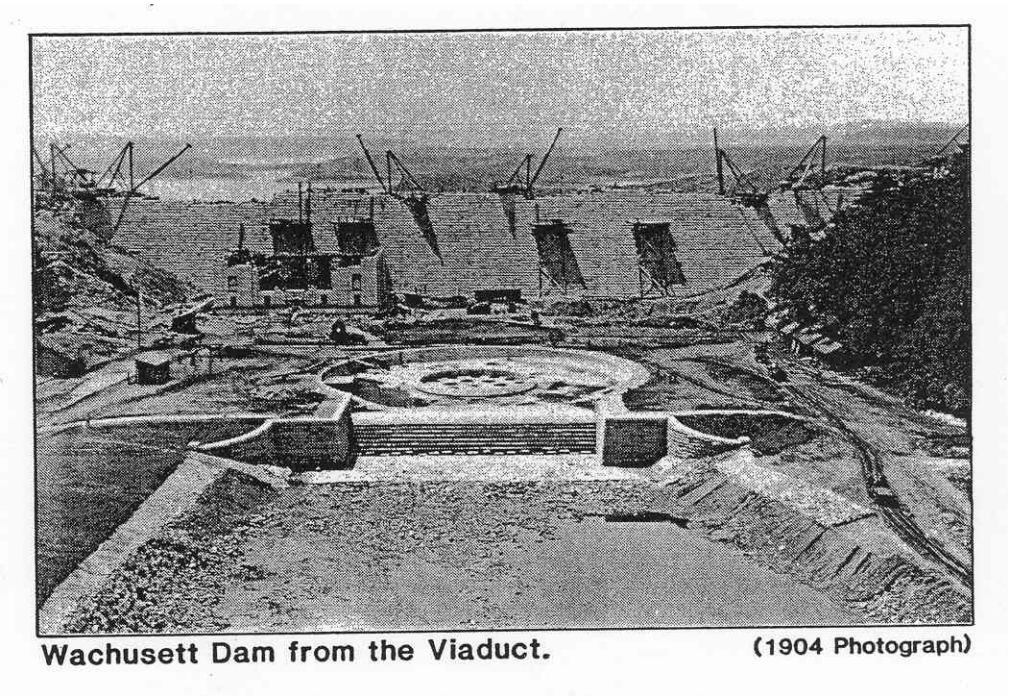
alternative was not recommended because of its great cost and because of the problems of using an out-of-state source. Most of the estimated $34 million cost of the project was associated with pipes, aqueducts, and tunnels to bring the water 77 miles to the Boston area. It was thought that New Hampshire would not allow such a large diversion of water out-of-state, and that New Hampshire would not allow Massachusetts to enforce the necessary controls in the watershed to insure a pure supply of water. The Board also noted that pollution in Lake Winnipesaukee had been increasing due to a growing summer population on the lake.

Supplementary Sources. The Board also considered supplementary sources which could be used when the Nashua was no longer adequate. Chief among these sources were the Ware and Swift Rivers, which were actually developed some 45 years later, and the Assabet River, which was not developed. A map in the 1895 report even shows the outline of the present day Quabbin Reservoir and a proposed tunnel alignment connecting it to the Ware River and proposed Wachusett Reservoir. Other supplementary sources considered but not recommended include the Charles River, the Shawsheen River, the Ipswich River, Assawompsett Pond, Sebago Lake (Maine), the Squannacook River, the Deerfie1d River, and the Westfield River. Sources which were classified as "not worthy of investigation", for the most part due to poor quality, included the Connecticut River, the Millers River, the Quabog River, the north branch of the Nashua River, the Blackstone River, the Taunton River, the Concord River, and the Neponset River. Because of their distance from Boston, the Board also ruled out the Deerfie1d and Westfield Rivers "except in connection with the Swift River, if that source should ever need to be supp1emented in the far distant future" (Massachusetts State Board of Health, 1985).

THE ESTABLISHMENT OF THE MDC

When the Metropolitan Water District was formed in 1895, its eleven cities and towns had a population of 750,000 and a water demand of 70 million gallons per day (MGD). Existing sources could supply about 83 MGD, but demand was growing so rapidly that this would be inadequate in several years. When Wachusett Reservoir was finished in 1908 it was described as the largest reservoir in the world, and the safe yield of the system nearly doubled to 155 MGD. But by then the District had grown to 19 cities and towns with a population of about 1,000,000 and a water demand of 128 MGD. At that rate of growth (85% increase since 1895), the new source on the Nashua River was in danger of being depleted in less than ten years. The 1907 legislation, which required all water to be metered, had the temporary

effect of reversing the growth in water demand which had gone on unabated since the 1880's. Demand declined from 120 MGD in 1905 to 105 MGD in 1915. Thereafter it began to increase rapidly again, and had reached 131 MGD by 1920. (See Table 3 above)



Wachusett Dam from the Viaduct. (1904 Photograph)

After World War I, it became apparent that Wachusett Reservoir would need to be augmented soon if this rate of growth continued. In 1919 the Legislature commissioned another major study of water supply needs and alternative sources. In that same year, the Metropolitan District Commission (MDC) was created by an act which consolidated responsibility for metropolitan water, sewage, and parks into one agency. The new MDC and the Department of Public Health were appointed to a Joint Board by the Legislature to study water supply needs.

THE 1922 JOINT BOARD STUDY

The Joint Board's report, issued in 1922, recommended the addition of the Ware River and Quabbin Reservoir to the MDC water supply system. The Joint Board reviewed the 1895 report of the Board of Health and found that its recommendations were still sound, although its population and water use projections had been high. The Joint Board made its own projections for the period 1920-1970, and concluded that Wachusett Reservoir, then only 14 years old, would be inadequate to meet the increasing demands of the metropolitan water district before 1930. In fact, the demand on the district's supplies did not exceed the yield

of Wachusett Reservoir until 1942. By that time Quabbin was completed and ready to meet the following three decades of nearly uninterrupted growth in water consumption in the MDC service area. This growth in demand was the result of population growth, higher per capita water use, and the addition of a number of towns and cities to the MDC.

Population Projections 1920-1970

In projecting future population growth, the Joint Board assumed that the rate of growth would be about two-thirds of what it had been in the previous thirty-year period.

The Joint Board's population projections are summarized in Table 6 and Figure 4. Assuming an average annual growth rate of 1.46 percent, the Joint Board projected the 19-town MDC service area to more than double its population during the fifty-year planning period, growing from 1.25 million in 1920 to 2.59 million in 1970. Instead, the population of the 19-town area grew at a more moderate rate from 1920 to 1950, then declined from 1950 to 1970, ending the planning period at 1.42 million. This actual net

Table 6. MDC Population – Projected and Actual – 1920–1970

YEAR	1922 PROJECTION 19 MDC TOWN STUDY AREA	ACTUAL POPULATION 19 MDC TOWN STUDY AREA	MDC SERVICE AREA NUMBER OF TOWNS	MDC SERVICE AREA ACTUAL POPULATION
1920	--	1,252,903	19	1,252,903
1925	1,383,880	---------	20	---------
1930	1,518,370	1,449,709	20	1,497,199
1935	1,651,360	---------	20	---------
1940	1,784,750	1,461,881	20	1,511,667
1945	1,919,330	---------	20	---------
1950	2,051,670	1,539,963	27	1,879,450
1955	2,187,080	---------	33	---------
1960	2,321,570	1,468,530	38	2,026,608
1965	2,458,000	---------	40	---------
1970	2,589,970	1,417,804	42	2,292,093
1980	--	1,277,841	44	2,178,072

growth of 180.000 represents an average annual growth rate of 0.25 percent, and resulted in a 1970 population which was lower than projected by over one million people (or 45 percent). After 1970, the population of the original 19 MDC towns continued to decline, and by 1980 it stood at 1.28 million, just slightly above the 1920 population of 1.25 million.

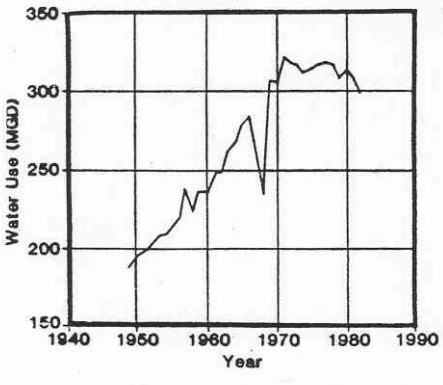
While the population of the original 19 MDC cities and towns did not grow as rapidly as projected, the service population of the MDC did increase more rapidly, as the number of cities and towns supplied by the MDC more than doubled, from 19 to 42. (See Table 7). Towns in the metropolitan area began growing rapidly after World War II, partly due to increased suburbanization. When the water supplies of the new suburbs became insufficient, they found it necessary to look to the MDC. By 1970, the population of the 42 MDC-supplied cities and towns was 2.29 million, which was only 11 percent lower than the Joint Board's projection of 2.52 million based on 19 cities and towns. Growth of the MDC service area, rather than population growth, resulted in a 1970 service population which was close to the fifty year projection made in 1922.

Table 7. Chronology of Growth of MDC Service Area

Date of Supply	Community	Date of Supply	Community
1895	Boston	1946	Saugus
1895	Belmont	1946	Winchester
1895	Chelsea	1946	Framingham *
1895	Everett	1947	Chicopee *
1895	Malden	1948	Wilbraham *
1895	Medford	1949	Cambridge
1895	Melrose	1949	Waltham
1895	Newton		
1895	Revere	1951	Clinton *
1895	Somerville	1951	South Hadley *
1895	Watertown	1951	Marblehead
1897	Quincy	1954	Needham
1898	Winthrop	1954	Northborough *
1898	Nahant	1954	Norwood
1899	Arlington	1957	Lynnfield
1901	Stoneham	1957	Marlborough *
1903	Lexington	1957	Peabody
1903	Milton	1957	Wakefield
1909	Swampscott		
1925	Brookline	1960	Southborough *
		1963	Weston
* Non-members supplied by the MDC.		1964	Leominster *
		1966	Worcester *
		1967	Canton
		1972	Woburn
		1974	Wellesley

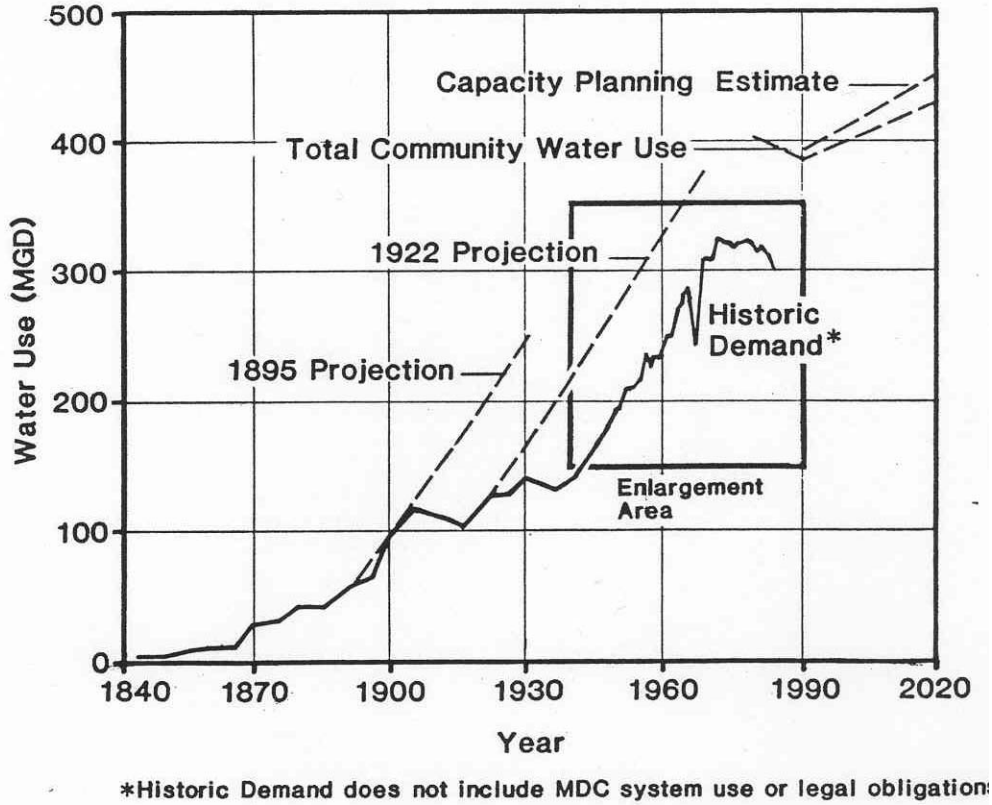
Water Demand Projections 1920-1970

Consumption of water in the MDC service area did not increase as rapidly over the planning period as the Joint Board had projected. While the Board had projected that daily water use would increase nearly three-fold, from 130 mgd to 378 mgd, demand actually reached 306 mgd in 1970, 19 percent lower than projected. During the first ten years of the planning period, demand grew more slowly than projected. During the depression of the 1930s, demand showed no net growth. Starting in 1940, demand began to grow at a rate equal to that of the 1922 projection, and sustained this rapid rate of growth for the next 30 years, until the end of the planning period in 1970. Had this rate of growth been sustained throughout the planning period, the Joint Board's projection would have been realized; however, the slow growth of the 1920s and the depression of the 1930s delayed the start of rapid growth of water use for 20 years until 1940. (see Figure 5).



Annual Demand Since 1940

Figure 5.
Boston/MDC Water Use and Projections 1850–2020



*Historic Demand does not include MDC system use or legal obligation

It is interesting to note that the average annual increase in water use during the 1940 to 1970 growth period (5.4 MGD/year) was very close to the rate of increase assumed in both the 1922 projection (5.2 MGD/year) and the Board of Health projection of 1895 (4.8 MGD/year) (see Table 8). Such a rate of growth occurred only during the first decade of the 1895-1930 planning period, however, and occurred during the last 30 years of the 1920-1970 planning period. Because of the intermittent periods of slow growth and declining water use, the average annual growth for the entire 1895-1970 period was 3 mgd per year.

Table 8. Comparison of Water Use Growth Rates

PERIOD OF GROWTH	AVERAGE ANNUAL INCREASE MGD/YEAR	
	PROJECTED	ACTUAL
1895-1930	4.8 (1895 Projection)	1.7
1920-1970	5.2 (1922 Projection)	3.5
1940-1970		5.4
1895-1970		3.0

The Joint Board's water use projection was based on assumptions about both population growth and growth in the per capita use of water. The Joint Board found that per capita water use in the MDC was 105 GPCD in 1920, and projected that after 1925, per capita use would increase by an average of one gallon per capita per year over the planning period, reaching 123 GPCD by 1970. The Board offered several reasons for this increase, including:

(1) An ample supply of pure water is available.
(2) The standard of living is improving, including better housing, more plumbing fixtures, and new uses such as "swimming tanks".
(3) Industrial water use is increasing.
(4) The "daytime population" of Boston (i.e.commuters who live outside the area served by the MDC) is using a larger amount of water.
(5) Small water leaks are not economical to repair.
(6) No further savings could be expected from metering since the MDC is nearly fully metered.
(7) Heat, drought, and excessive cold cause marked variations in water use.

(8) The cost of water is low compared to its value.
(9) Water pressures are increasing as buildings get taller.

The Joint Board's estimate of 123 GPCD in 1970 was one of the most accurate projections made by the early water studies; actual per capita water use in 1970 was 133 GPCD, only 8 percent higher than the Joint Board's estimate of fifty years earlier.

Having found that the demand on the MDC system was 130 MGD in 1920 and was projected to exceed the safe yield of 155 MGD in about 1928, the Joint Board recommended new supply sources to augment the system.

Conservation and Demand Management

Although the Joint Board of 1922 did not consider conservation and demand management as an alternative to supply augmentation or even as a discrete topic, there are numerous references to leakage, metering, water rates, and conservation throughout the report, which can be interpreted as a sense of the Joint Board's attitude toward the topic.

The Joint Board echoed the policy of the earlier Board of Health study, which held that waste through leakage should be limited, but that the public should be supplied with all the water it needed. The Joint Board wrote,

“While we firmly believe that waste should be restricted and thrift encouraged, we also add that the public water supply should be ample for all reasonable needs, and that the actual use of water in the interest of improved health conditions should be encouraged.” (8)

The Joint Board concluded that with 75 percent of the services in the district metered, no further reduction in water use would result from metering:

> “The Metropolitan District is now in the position where the slack has practically all been taken out by the introduction of meters, and no other remedy for reducing consumption can be applied except rationing of water. This, of course, is impossible, and the only known solution is to be found in an increase of the supply.”(9)

The Joint Board recognized that leakage resulted in a significant loss of water in the system. It estimated that 25 percent or more of the water delivered to the system was

not accounted for by the meters. The Board thought that much of this loss of water was due to domestic leakage.

> "A very large proportion of the water supplied to American cities is wasted through careless use or lost through leaks.
>
> "The losses through leakage occur in part in the distribution mains...leaks from the plumbing fixtures within the houses are even more important, and metering has been found to be a partial check on these household leaks...inspection of house fixtures and leakage surveys help to keep down consumption, but even this is only partially successful."(10)

While the Joint Board recognized that a significant amount of water was lost to leakage in the metropolitan system, the Board doubted that much of that leakage was economically recoverable. On this the Board wrote,

> "...the preventable loss of water in this way is probably not great, and it is likely to persist and to become more or less constant even with the most efficient inspection practical."(11)

Nevertheless, one of the Joint Board's recommendations was that efforts to prevent leakage should be continued.

As for pricing water to encourage conservation, the Joint Board stated that this, also, was not very effective.

The Joint Board also considered the use of non-potable water by industry from sources such as the Charles, Neponset, and Mystic Rivers, and ground water. The conclusion was

> "there is little to expect in the way of water supply from... loca1 sources for industrial uses, and it is likely that the draft of water for such uses from the metropolitan system will become greater as time goes on."(12)

<u>Alternative Water Supply Sources</u>

The Joint Board of 1922 considered many of the same water sources that the Board of Health had studied in 1895, and reached similar conclusions. After considering eastern Massachusetts sources such as the Charles, Shawsheen, Ipswich, and Merrimack Rivers and Lake Assawompsett, as well as out-of-state sources such as Lake Winnipesaukee and Sebago Lake, the Joint Board recommended developing the

Ware and Swift Rivers for the metropolitan water system, which was the recommendation of the Board of Health some 27 years earlier. The Joint Board ruled out the local sources for similar reasons - quality and adequacy of supply - and the out-of-state sources were again considered not feasible for economic and political reasons. The Nashua River reservoir had opened the way to further upland sources in central Massachusetts, and could serve as a link to Connecticut Valley sources such as the Ware and the Swift.

The Joint Board made one alteration to the 1895 plan for the Ware River development. Whereas the Board of Health had envisioned an impoundment on the Ware which could yield 71 MGD, the Joint Board recommended only a diversion of flood flows, with no storage, which would yield 33 MGD. The diverted Ware River water could be transmitted either east to Wachusett Reservoir or west to Quabbin for storage.

The Joint Board agreed with the Board of Health that the Swift River project "should be approved as the logical extension of the water supply system." The Ware and Swift development would double the MDC's safe yield from 155 MGD to an estimated 320 MGD, and increase storage over six-fold, from 81 billion gallons to over 500 billion gallons. It is clear that Quabbin Reservoir's 412 billion gallons of storage is much larger than needed to collect runoff from the watershed of the Swift River. In fact, three reservoir sizes were considered by the engineers who designed Quabbin: 215, 318, and 412 billion gallons, which correspond to reservoir elevations of 500, 515, and 530 feet above mean low water in Boston Harbor. The largest of these options seems to have been chosen for two reasons: to allow for maximum storage time for water quality purposes, and to allow for storage of water from additional sources that might be developed in the future. The Joint Board specifically recommended supplementing Quabbin with water from the Millers River, which had not been recommended by the Board of Health. The Westfield and Deerfield Rivers, which had been recommended for future use by the Board of Health in 1895, were ruled out by the Joint Board because of their distance and because they were needed by local communities within their basins.

The Joint Board had also considered the use of groundwater, but concluded that this source was not adequate to meet the needs of the district. The Joint Board wrote:

> "...the geologic formation of eastern Massachusetts is such as to preclude the possibility of obtaining an adequate supply of water...the idea that there are

great underground streams or great underground reservoirs in this part of the country is pure fiction."(13)

The Joint Board made another conclusion:

"Wherever attempts have been made to obtain large ground water supplies at any one place, the quality of the water has suffered."(14)

And so, with the recommendation of the Joint Board, the process of developing Quabbin Reservoir was set into motion.

Recommendations of the Joint Board

The Joint Board's major recommendations are summarized below:

1. Build the Ware River diversion;
2. Build the Swift River project (Quabbin Reservoir);
3. Filter the South Sudbury and Cochituate system for use when needed as a reserve;
4. Continue efforts to "prevent leakage and waste of water to conserve the present supply to the greatest extent possible"; (15)
5. "Local supplies within the 10-mile radius should be developed to their economical limit, using filtration if necessary, but keeping in mind the possibility of their ultimate abandonment."; (16) and
6. Consider the formation of regional water supply districts in the following areas:
   (a) Southeastern Massachusetts - Fall River, Taunton, and New Bedford;
   (b) Northeastern Massachusetts - to develop the Ipswich River;
   (c) Merrimack Valley - to develop new sources other than the Merrimack River; and
   (d) Connecticut Valley - to develop the Westfield River.

However, not all the members of the Joint Board concurred in these recommendations. The objections were outlined in a Minority Report which was published along with the Joint Board's report.

The Minority Report

One member of the Joint Board, James A. Bailey, representing the Metropolitan District Commission, took exception to some of the findings and recommendations of

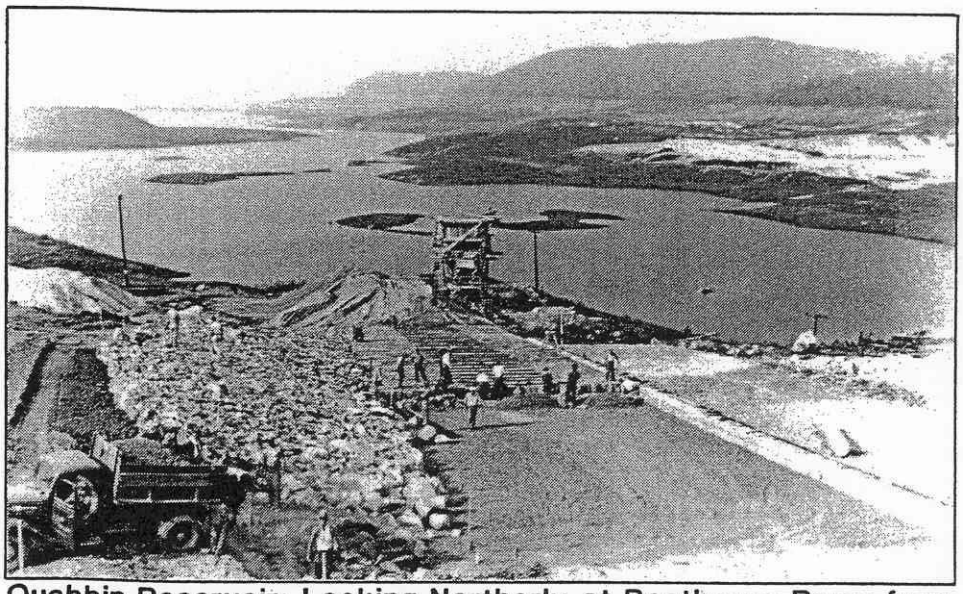
the Joint Board's report, including the district's need for additional water, and the savings possible through conservation. Mr. Bailey pointed out that population in the district had not grown nearly as fast as had been projected by the 1895 report (it had fallen a half-million short, or 30 percent less than projected); that population would continue to grow more slowly due to a low post-war birth rate and legal curbs on immigration; that due to metering, per capita use should not exceed 100 GCD in the next decade; and that given the above, the present supply should last until 1935, rather than the Joint Board's estimate of 1928.

Mr. Bailey believed that every effort should be made to reduce waste before the district sought new sources of supply. He also made a break with both the Joint Board and the earlier Board of Health study in advocating voluntary conservation on the part of consumers:

> "...no one can reasonably doubt that 10 gallons waste per person daily can be eliminated for a brief period, in case of urgent necessity, by a people who survived gasless Sundays, heatless Mondays, and rationed sugar, to each of whom 90 gallons of water daily would still be vouch-safed."(17)

Mr. Bailey's dissent was seized upon by opponents of the Quabbin proposal in subsequent legislative battles. The opponents' alternative plan was dubbed the "Bailey plan". However, after much debate, the legislature finally adopted the "Goodnough" or Joint Board Plan with the passage of the Ware River Act (Chapter 375 of 1926) and the Swift River Act (Chapter 321 of 1927). The passage of the legislation did not end the controversy, however. The State of Connecticut filed suit against the Commonwealth of Massachusetts, claiming that the diversion of water from the Connecticut River would have adverse impacts on stream flow, navigation, power generation, agriculture, water quality, and fish life. The case went to the United States Supreme Court, which ruled in favor of Massachusetts.

The Ware River intake works were completed in 1931 and Quabbin Reservoir was completed in 1940 and was finally filled to capacity by 1946. These works doubled the MDC's safe yield, which was estimated to be about 320 MGD at that time. Total storage was increased from 80 billion gallons to about 490 billion gallons. MDC watershed area grew from about 185 square miles to 465 square miles. Soon after Quabbin Reservoir came on-line, Lake Cochitutate and parts of the Sudbury Reservoir system were abandoned or retained only for emergency uses. (See Figure 1 above). The new sources had been completed none too soon; when Quabbin was finished. Wachusett Reservoir was drawn down to only 25 percent of capacity.



Quabbin Reservoir: Looking Northerly at Boathouse Ramp from Winsor Dam. (1939 Photograph)

When the Quabbin Reservoir was completed in 1940, the MDC's service area included 20 cities and towns with a population of 1.5 million and a water demand of 143 mgd. Between 1909 and 1945, only one new town had joined the district, and with this one exception, the growth of the district was entirely due to population growth in the member towns. The population of these 20 member towns reached a peak of 1.55 million in 1950 and has been declining ever since. Since the mid-1940's, the MDC service population has continued to grow, but largely due to the addition of new towns to the system. During this period, many cities and towns experienced problems with the quality or quantity of their local water sources. These problems led a number of cities and towns to seek water from the MDC. In addition, legislative changes caused more towns to become part of the MDC system. The "legally eligible" towns - those which are legally eligible to request membership in the MDC -- grew from 26 to 63 in 1943, with the passage of legislation which extended the area of legally eligible towns from a radius of 10 miles to 15 miles from the State House. Under the legislation, the MDC "shall on application admit to membership...(the) water districts of any...town any part of which is within fifteen miles of the State House which the commission can reasonably supply with water." In 1947, legislation was approved which permitted the MDC to supply nonmember municipalities not eligible for membership on a contractual basis. The same legislation authorized construction of the Chicopee Valley Aqueduct, which brought Quabbin water to Chicopee, Wilbraham, and South Hadley, the first western Massachusetts towns to receive MDC water.

Finally, in 1949 Worcester was authorized to divert a portion of the water from the Wachusett watershed. These policy changes led to a rapid growth in the number of cities and towns served by the MDC. Between 1940 and 1970, the number of MDC-served municipalities increased from 20 to 42 (including non-members), the service population grew from 1.5 million to 2.4 million, and water use grew from 143 MGD to 306 MGD. The drought of the 1960's lowered Quabbin reservoir to 45 percent of full capacity. In 1969, water use first exceeded the system safe yield which has been estimated at 3QO MGD, and use has remained above 300 MGD (reaching 343 MGD including system use, through 1980).

Although a number of new communities are interested in MDC membership and several already use MDC water on an emergency basis, in the last decade (1970-80) only two new towns joined the MDC. The population of the district declined seven percent to 2.2 million, while demand of the user communities fluctuated between 300-320 MGD (not including MDC system use). With demand at or above the system's safe yield, the need for additional water due to drought, supply contaminations, additional towns applying to join the MDC, and changes in regional growth trends has led to the current MDC Water Supply Study and EIR, the third major study after the 1895 and 1922 studies. Many of the same analyses which were performed in the earlier studies must now be repeated in light of changed circumstances and improved methodologies, including population projections, water use projections, environmental impact evaluation of alternative water sources, and recommendations on the best way to meet future water needs.

The issues Mr. Bailey raised in his report are addressed by the current Water Supply Study and EIR in great detail. Water conservation and demand management are a major part of the present study, and more effort is dedicated to this aspect of the study than went into the entire 1922 water supply study.

COMPARISON OF HISTORIC TRENDS WITH THE WATER SUPPLY STUDY AND EIR-2020

Twenty years after the Quabbin Reservoir was completed, the drought of the 1960's highlighted the fact that Quabbin might not be sufficient to serve water needs in the decades to come. Since 1964 three independent studies have projected future water supply shortfalls. In 1969 the U.S. Army Corps of Engineers undertook the "Northeastern United States Water Supply Study" (NEWS) which estimated a potential shortfall of up to 140 MGD in the MDC supply area

by 1990. In 1977 the New England River Basin Commission undertook the "Southeastern New England Study" (SENE) projecting an MDC shortfall of 77 MGD. In 1978 the “Massachusetts Water Supply Policy Study”, conducted by the state's Executive Office of Environmental Affairs, found that a shortfall of 70 MGD was possible by 1990 for communities served by the MDC.

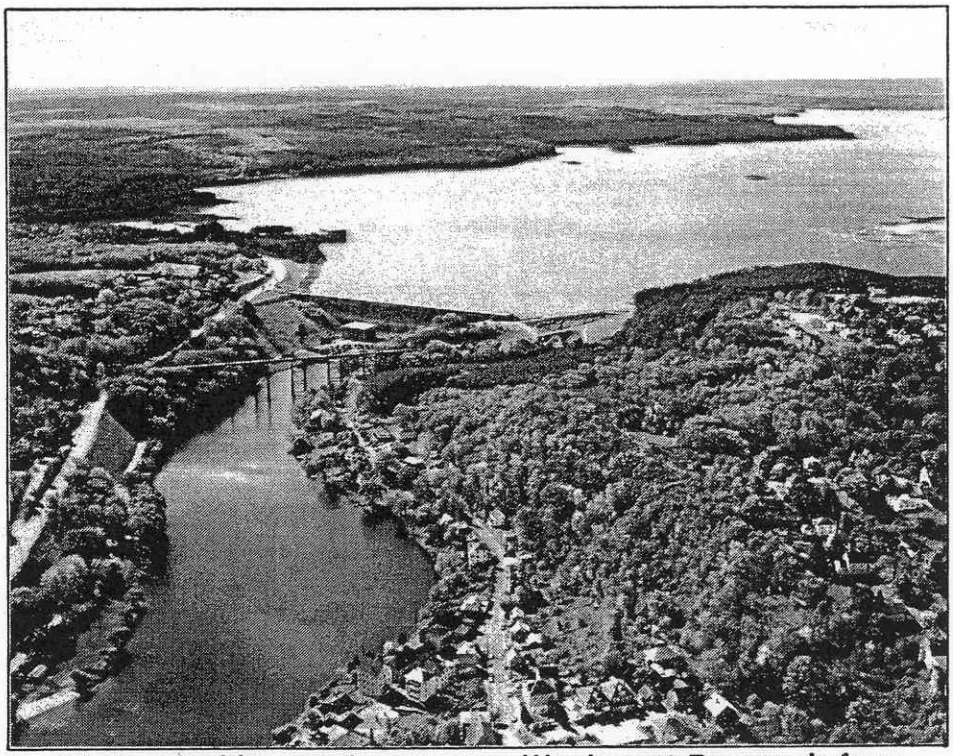
The Northfield Project, a proposal for skimming Connecticut River spring flood flows and diverting them into Quabbin Reservoir, was authorized by the Massachusetts Legislature in both 1967 and 1970.

In 1979 the MDC began an Environmental Impact Report (EIR) assessing the impacts of the Northfield Project and eight other alternatives for meeting future supply shortfalls. The MDC established and funded a Citizens' Advisory Committee which is designed to play a "full and formal advisory role" in the preparation of the EIR. Before Phase II of this study began, the name of the study was changed to the MDC's long-range Water Supply Study and Environmental Impact Report - 2020 to reflect the equal treatment of all nine alternatives and the expanded scope of the project.

Like its predecessors, the current MDC Water Supply Study and EIR includes projections of the future population and water demand of the MDC's service area. However, the methods used to develop these projections are different from those used in the studies of 1895 and 1922. In those earlier studies, projected water use was developed by multiplying projected population by a projected per capita water use factor. The result was a nearly straight-line projection of past water use trends into the future. Because current water use habits and technology differ from the past, the current study projects water demand by using a demand simulation model which projects water use by individual sectors, such as domestic, nondomestic, and unaccounted-for water (See "Task 1 Report - Water Demand Projections"). The demand projections are based on data about population, households, economic activity, changes in water use practices and technology, meter accuracy, unmetered use, leakage and other unaccounted-for water.

Figure 4 shows the current population projections for the MDC, along with historic population trends and the projections from the prior studies. It can be seen that the current population projection assumes a slower rate of growth than either the past projections or the long term historic growth. The average annual growth rate of the current projection is 0.35 percent, compared to 1.46 percent for the 1922 projection and 1.5 percent for the

1895 projection. The actual MDC population increased by 1.14 percent annually from 1895 to 1980. Figure 5 shows the current projected water demand for the MDC. Two components of the projected water demand are shown for comparison. The "total community water use" is the total demand for each of the 44 current MDC users, and it represents a generally slower rate of increase than either the 1895 projection or the 1922 projection. The capacity planning estimate includes the amount of water the MDC now has a legal obligation to supply to present users; an amount to supply potential additional users due to a projected local water supply deficit; an amount to compensate for local sources lost as a result of contamination; and an amount for the MDC system use or water used in the transmission and distribution system. The capacity planning estimate represents an average annual water use growth rate of 2.2 percent. similar to the 1922 projection (2.2 percent) and lower than the 1895 projected growth of 3.2 percent annually.



Aerial view looking southwest over Wachusett Reservoir from Lancaster Millpond

APPENDIX: LEGISLATION RELEVANT TO BOSTON AND MDC WATER SUPPLY

Year and Chapter	Legislation
1846, c. 167	Authorized Boston to obtain water from Lake Cochituate
1861, c. 105	Authorized Char1estown to obtain water from Upper Mystic Lake
1875, c. 80	Created Boston Water Board (assumed control of Mystic and Cochituate Water Works)
1895, c. 488	Created Metropolitan Water District and Metropolitan Water Board (assumed functions of the Boston Water Board)
1901, c. 168	Created Metropolitan Water and Sewerage Board (assumed functions of the Metropolitan Water Board)
1919, c. 350	Created Metropolitan District Commission (assumed functions of the Metropolitan Water and Sewerage Board)
1926, c. 375	Created Metropolitan District Water Supply Commission (constructed Quabbin Reservoir)
1943, c. 543	Permitted communities within 15 miles of the State House to join the MDC
1947, c. 575	Authorized MDC to supply non-member communities and to build the Chicopee Valley Aqueduct
1949, c. 699	Authorized Worcester to divert a portion of the Wachusett Reservoir
1969, c. 704	Established the Executive Office of Environmental Affairs, with the MDC as one constituent element

FOOTNOTES

1. Report of the Massachusetts State Board of Health Upon a Metropolitan Water Supply, February, 1895, House Document No. 500 of 1895, page 148.
2. Ibid., p. xxii.
3. Ibid., p. xxii.
4. Ibid., p. xii.
5. Ibid., p. 169.
6. Ibid., p. xi.
7. Ibid., p. 123.
8. Report of the Joint Board Relative to the Water Supply Needs and Resources of the Commonwealth, January 1922, House Document No. 1550 of 1922, p. 49.
9. Ibid., p. 49.
10. Ibid., p. 13.
11. Ibid., p. 72.
12. Ibid., p. 72.
13. Ibid., p. 21.
14. Ibid., p. 21.
15. Ibid., p. 7.
16. Ibid., p. 7.
17. Ibid., p. 32.

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4. Howe, David W., Quabbin, the Lost Valley, The Quabbin Book House, Ware, Massachusetts, 1951.

5. Kennison, Karl R., “Water Supply Development in Boston, Massachusetts", Journal of the New England Water Works Association.

6. Metropolitan District Commission, A General Description of the Water Supply of the Boston Metropolitan District, Boston, Massachusetts, 1940.

7. Report of the Joint Board Consisting of the State Department of Public Health and the Metropolitan District Commission Relative to Water Supply Needs and Resources of the Commonwealth, House Document No. 1550, Boston, Massachusetts, 1922.

8. Report of the Massachusetts State Board of Health Upon a Metropolitan Water Supply, House Document No. 500, Boston, Massachusetts, 1895.

9. Report of the Metropolitan Water Supply Investigating Commission, House No. 900, Boston, Massachusetts, 1925.

10. United States Supreme Court, Connecticut v. Massachusetts, Summary of Evidence, 1930.

11. Whitehill, Walter Muir, Boston: A Topographical History, Harvard University Press, Cambridge, Massachusetts 1975.