*New York City and metropolitan Boston have been pioneers in protecting their source waters through effective watershed management.*

# Managing Sustainable Water Supplies

## The New York City and Metropolitan Boston Experience[1]

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In the mid-19th century, New York City (only Manhattan Island at the time) and Boston, Massachusetts, faced crises of water quality and quantity due to their locations on saltwater estuaries, their population growth, the pollution of local water sources, frequent fires, and waterborne epidemics. To bring water to urban users, both cities began to develop hinterland facilities to deliver pure fresh water by gravity through a system of impoundments and aqueducts. Both projects were directed by the noted civil engineer John Jervis. New York's original Croton River Reservoir and its 41-mile aqueduct (including the famous High Bridge over the Harlem River) first delivered fresh water to the city in 1842. Boston's Lake Cochituate system, a smaller version of the Croton River project, was completed six years later.

To meet the needs of rapid population growth, rising industrial demand, and the proliferation of household toilets and other plumbing devices, both systems had to be substantially enlarged with the addition of new and more distant water sources. For New York, this meant water from sources across

[1] This article is based partly on the author's participation as a member of the study committee that prepared the National Research Council report, *Watershed Management for Potable Water Supply: Assessing New York City's Approach* (NRC, 2000) and on meetings with city officials during the study. The Boston material is largely based on his experience as a member of the Water Supply Citizens Advisory Committee in the 1980s and the Massachusetts Water Resources Authority website (*http://www.mwra.state.ma.us/*).

the Hudson River in the Catskill Mountains and Upper Delaware River basin (Figure 1). Meanwhile, by the 1890s Boston was drawing water from a series of small impoundments in the nearby Sudbury River watershed along with its Lake Cochituate supply. Under a series of metropolitan-level agencies, the Boston system was further enlarged with the completion of Wachusett Reservoir near Worcester in 1905, followed by the much larger Quabbin Reservoir 65 miles west of Boston in 1946 (Figure 2). Quabbin today provides most of the water supply for metropolitan Boston.

Today, the New York City Department of Environmental Protection (NYDEP) administers the city's sprawling water system, which serves 8 million city residents and another 1 million in nearby suburbs. The Metropolitan Boston system, now administered by the Massachusetts Water Resources Authority (MWRA), a regional agency established in 1985, serves 2.2 million people in 45 cities and towns in eastern Massachusetts.

By the 1990s, both systems faced dual challenges: (1) controlling rising water demand to remain within their respective safe yields; and (2) protecting and improving the purity of water delivered to users. To address the former challenge, both system managers took steps to reduce per capita demand, such as repairing system leaks and instituting household and commercial plumbing codes and retrofit programs, improving metering, and imposing higher water and sewer fees. As a result, both the New York and MWRA systems have dramatically reduced system and per capita demand levels (discussed below).

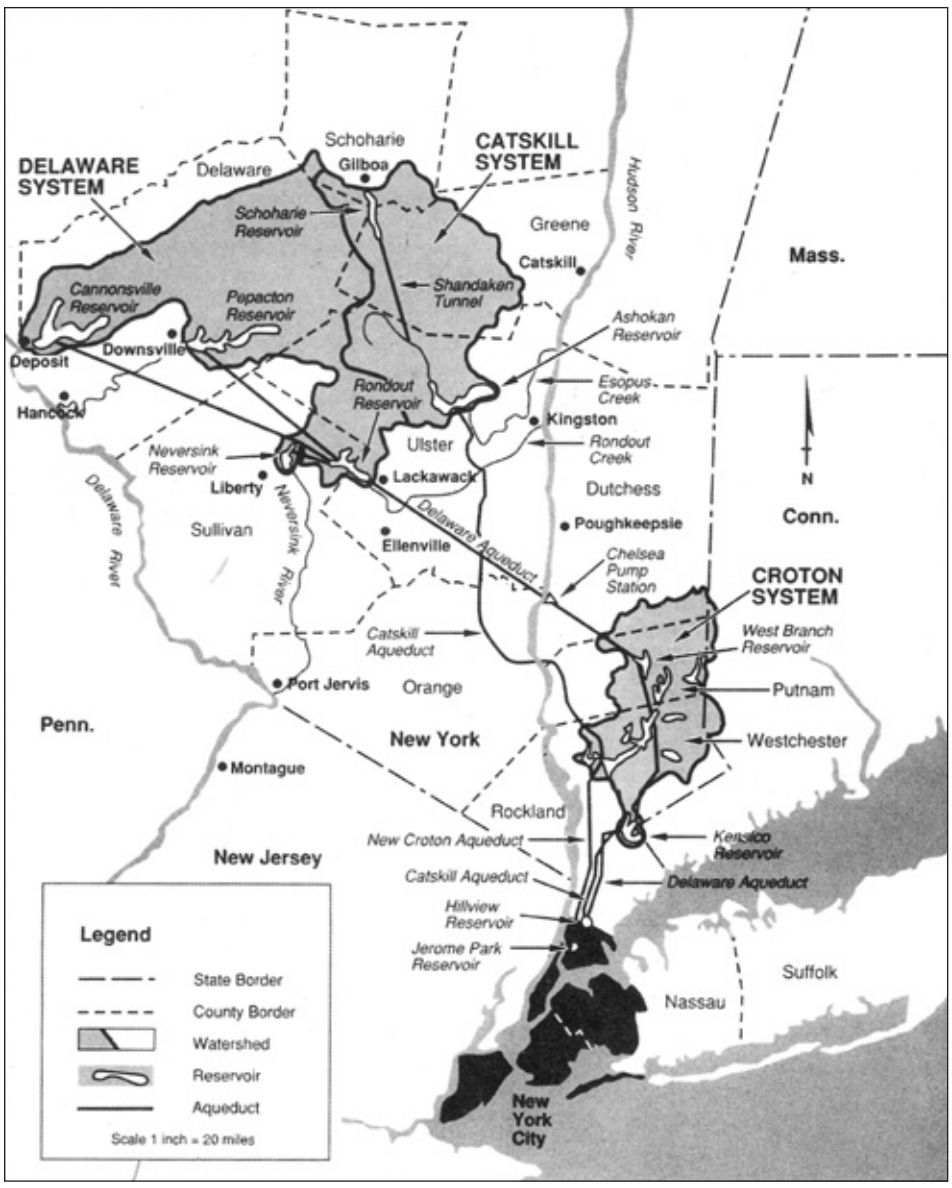


FIGURE 1 Map of the New York City Water System. Source: New York Department of Environmental Protection.

Regarding water quality, both systems have long relied on the purity of their sources in rural watersheds to ensure the healthiness of their raw water. For many years, the water was disinfected with chlorine but was not filtered. However, changing land uses in the source watersheds, as well as new concerns about chlorine by-products and other newly recognized health threats, raised doubts about continued reliance on unfiltered source water.

In 1989, the Environmental Protection Agency (EPA) mandated filtration for drinking water from surface sources. However, a filtration waiver was authorized for large systems that could demonstrate that

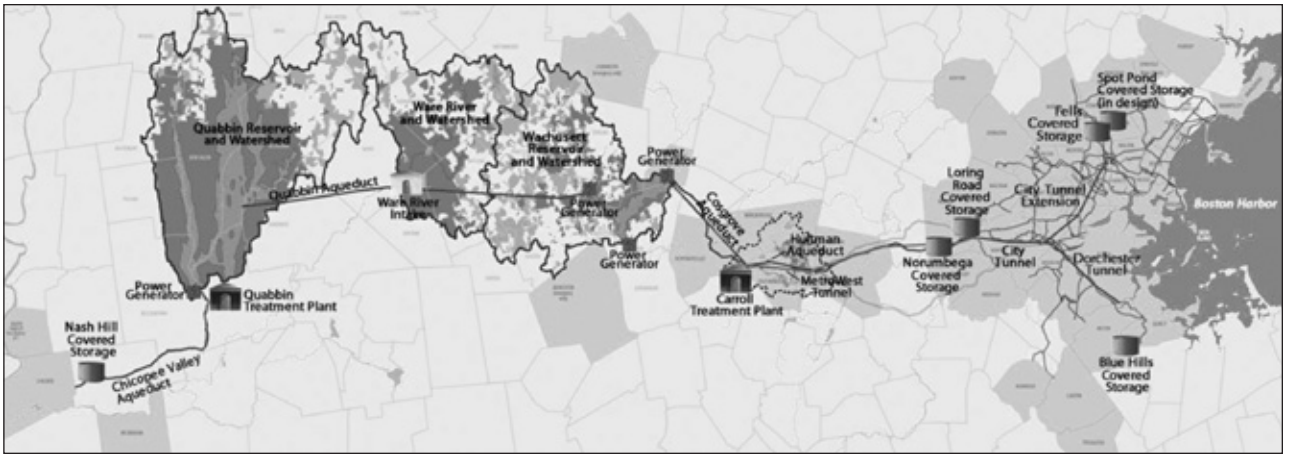


FIGURE 2 Map of the Metropolitan Boston Water System. Source: Massachusetts Water Resources Authority.

they could maintain and improve water quality through nonstructural watershed management. Both the New York City and Metropolitan Boston systems have been pioneers in protecting their sources with watershed management and have qualified for filtration waivers.

Today, a new technology, "hydrofracking," poses a potential threat to the purity of New York's water supply. As of 2011, New York City opposes the extraction by "hydrofracking" of natural gas from the Marcellus Shale, an area that underlies the city's trans-Hudson source watersheds. As of this writing, the state has issued a ban on hydrofracking pending studies by the New York Department of Environmental Conservation and EPA.

### The New York City Water Systems

On July 4, 1842, New York City celebrated the opening of the world's first long-distance urban water supply aqueduct since the Roman Empire. Since 1800, New York's population had quadrupled, from 60,000 to 250,000, and the city was wracked by chronic water shortages, outbreaks of cholera, and recurrent fires. Surrounded by brackish estuaries and with local wells polluted, the growing city turned in desperation to its rural hinterland in search of a reliable source of pure water.

Following the advice of engineer DeWitt Clinton Jr., the city selected a tributary of the Hudson River, the Croton River, which could be dammed at sufficient elevation for water to flow to the city by gravity without pumping. The Croton project, designed by John Jervis, involved a series of engineering marvels for the time: impoundment of a 600-million-gallon reservoir; a 40-mile aqueduct; the "High Bridge" spanning the Harlem River; and distributing reservoirs in Manhattan. The Croton system was enlarged with the construction of a larger dam and expanded impoundment capacity in the 1890s.

With the consolidation of Greater New York City in 1898 to form a five-borough metropolis of 3.5 million people—second only to London at the time—it was imperative that the city develop new water sources to augment the fully developed Croton system before it was tapped out. In addition, suburban development in the Croton watershed was rapidly increasing. Once state authority was granted in 1905, the city began looking farther afield, and in the 1920s it turned to distant upland watersheds across the Hudson River in the Catskill Mountains and the upper Delaware River (the Cat-Del reservoirs) watershed.

By the mid-1960s, most of the city's water was supplied from six major reservoirs in the Catskills and upper Delaware River watershed via two high-pressure aqueducts that plunge beneath the Hudson. East of the Hudson, the 93-mile Catskill Aqueduct and the 110-mile Delaware Aqueduct converge at Kensico Reservoir about 20 miles north of the city in Westchester County. At Kensico, the combined flows are chlorinated, then conducted into the city's two main water tunnels for distribution to the five boroughs. (A third water tunnel has been under construction since the 1970s.)

Today, the Cat-Del reservoirs meet about 90 percent of the water needs of 8 million city residents and another 1 million suburbanites; the other 10 percent is provided by the Croton system. Cat-Del water, which is unfiltered, originates in pure upland sources, a condition that gave rise to the watershed management initiatives described below.

### The Boston Metropolitan Water System

In the 1840s, the city of Boston followed New York's lead and hired Jervis to design and construct its Lake Cochituate Reservoir and a 14-mile aqueduct to deliver pure water. This early source was augmented in the 1870s by a series of small impoundments and transfer facilities in the Sudbury River watershed just northwest of the city. All of these sources were later closed with the development of much larger and more distant sources in central Massachusetts.

In 1893, the Boston system was transferred to a new Metropolitan Water District (later merged into the Metropolitan District Commission along with counterpart sewer and park districts in 1919). The state legislature authorized the MWD to provide water to towns within 10 miles of the State House in Boston (later expanded to 15 miles). This regionalization of the system was motivated in part by the reluctance of suburban towns to being annexed to Boston in order to connect to its water system.

Under the MWD and its successors, the metropolitan water system was greatly enlarged with the completion of Wachusett Reservoir near Worcester in 1908. The much larger Quabbin Reservoir in the Chicopee River Valley (a tributary of the Connecticut River) 60 miles west of Boston was completed in 1939. As shown in Figure 2, water originating in Quabbin flows by tunnel to Wachusett and then through a series of tunnels and pipes to metropolitan Boston.

Today, Quabbin supplies at least 90 percent of the water used by 2.2 million residents and 5,500 businesses in eastern Massachusetts. Like New York's Cat-Del sources, water from Quabbin and Wachusett is not filtered.

### Demand Management

By the 1960s, like other urban water providers, the New York and Metropolitan Boston water systems faced rising demand for water. The safe yield of the New York City system of about 1,400 million gallons per day (mgd) was exceeded regularly, and further increases in demand from population growth, higher per capita usage, and system leakage were likely. In Boston, the safe yield of 300 mgd was also facing shortfalls as additional communities were added to the system, per capita usage rose, and system leakage worsened.

In 1986, New York announced a Universal Water Metering Program to address the city's notorious absence of water meters and the consequent inability to relate water costs to usage. More than 600,000 meters were installed at a cost of $350 million, enabling the city to monitor the use of water and use pricing as a strategy to limit waste and meet increasing demand.

Concurrently, the city embarked on a long-range program of leak detection and repair. In 1990, it launched a pilot water conservation program that offered free leak detection and installation of water-saving plumbing devices, such as water-saving showerheads, faucets, aerators, toilet tank displacement bags, and low-flow toilets. The end result of these measures has been a decrease in the average system demand from about 1.5 billion gallons per day (bgd) in 1980 to about 1.0 bgd in 2009, a decrease in per capita use from 187 gallons per day (gpd) in 1980 to 125 gpd in 2009 (*http://www.nyc.gov/html/dep/html/drinkingwater/droughthist.shtml*).

Meanwhile, MWRA has reduced water demand from 330 millions gallons per day (mgd) in 1985 to about 220 mgd in 2009 (Figure 3). Both systems have thus effectively applied water conservation strategies to live within their available supplies and avert the need to find new sources in the face of economic and environmental constraints.

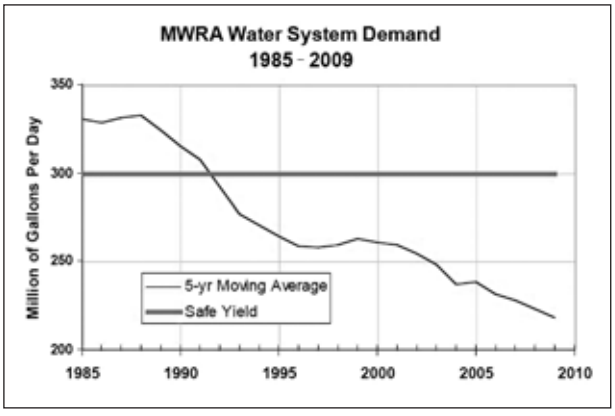


FIGURE 3 Water demand on the Metropolitan Boston Water System, 1985–2009. Source: Massachusetts Water Resources Authority. Available online at *http://www.mwra.state.ma.us/monthly/wsupdat/demand-1985-2010-640.jpg*.

### Watershed Management

The next priority—sustainable watershed management—has put New York City and MWRA in a class by themselves. Since the days of John Jervis, who designed the first stages of both systems, New York and Boston have relied on the natural purity of their hinterland sources, disinfected with chlorine, to provide high-quality water without filtration. In the 1970s and

1980s, public health concerns arose about "disinfection by-products" from the heavy use of chlorine and about *Cryptosporidium* and *Giardia*, waterborne pathogens that might survive chlorination.

In 1986, EPA issued the "Surface Water Treatment Rule," pursuant to the Safe Drinking Water Act (SWDA) of 1974, requiring that public water supplies drawn from reservoirs be micro-filtered to meet higher drinking water criteria and to reduce dependence on chlorination. The rule, however, offered the possibility of a filtration avoidance determination (FAD) for systems that could demonstrate the capacity to protect their source waters from listed microbial agents and chemical pollutants through watershed management. Given extremely high estimated costs of building filtration plants, both New York City and MWRA decided to pursue the watershed management option to qualify for a FAD.

Unlike standard engineering practices, nonstructural watershed management requires the development of a market basket of innovative technical, economic, and legal strategies of unproven effectiveness. EPA required that each system pursue a "dual track" approach, taking preliminary steps in the design process to provide filtration just in case the watershed management track failed.

The challenge was more daunting politically for New York than for Boston. Whereas MWRA was a new regional authority established by the state in 1985 with no history of confrontation with the source watershed region, New York City was viewed by the rural towns in the 1,800 square-mile Cat-Del watersheds as an alien and threatening outsider. Furthermore, anything involving New York City is likely to be contentious!

To explore ways of protecting the city's water supplies with the cooperation, rather than hostility, of local governments in the watersheds, the city in 1995 entered into a complex negotiation process launched with the encouragement of then-governor George Pataki and Robert F. Kennedy Jr. and his organization, Hudson Riverkeeper. After more than two years, the negotiations finally yielded the 1997 Watershed Memorandum of Agreement (1997 MOA), one of the most extraordinary legal agreements in the history of American water resource management. With more than 1,000 pages of text and appendices, the document was signed by representatives of EPA, the state, the city, 46 watershed towns, and 6 environmental organizations, including Hudson Riverkeeper.

The 1997 MOA committed the city to spending more than $1 billion over the next decade on a variety of projects to remediate sources of pollution and promote sustainable economic growth and resource management in the Cat-Del watersheds. (The Croton system was not part of the MOA, and the city is currently building a long-delayed Croton filtration plant pursuant to a court order.)

The MOA addressed a wide range of watershed-protection strategies: (1) land acquisition in the trans-Hudson watersheds; (2) wetlands and buffer protection; (3) wildfowl control; (4) agricultural best-management practices; and (5) upgrades of local sewage treatment plants and septic systems that drain into the reservoirs. Under the MOA's provisions, the city has purchased about 108,000 acres of critical riparian habitat. The Watershed Agricultural Council, established under the MOA, promotes best farming practices to prevent the runoff of chemicals or livestock wastes into local streams. The Catskill Watershed Corporation provides small grants and technical assistance to watershed businesses. Finally, the Watershed Forestry Program promotes sensible management of public and private timberlands.

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In the first decade, the city committed about $1 billion dollars to implementing the terms of the MOA. In 1977, pursuant to this commitment, EPA awarded the city a preliminary FAD, subject to exhaustive monitoring and oversight by the New York Department of Environmental Conservation. Based on the results, the FAD was extended for another 10 years beginning in 2007.

MWRA pursued a similar program under a different legal framework. In place of an intergovernmental agreement like New York's MOA, MWRA relied

primarily on new state watershed management laws regulating wetlands and buffer zones along rivers in the state. The Quabbin watershed was already substantially publicly owned, but certain parcels of private land there and in the Wachusett watershed have been acquired in fee or easement.

EPA Region 1 initially challenged the efficacy of MWRA's watershed management program and demanded in federal court that, under SDWA, all water from the Quabbin/Wachusett system be filtered. This claim was based in part on occasional surges in fecal coliform, which MWRA resolved by sending young employees in boats to chase away waterfowl near reservoir outlets by making loud noises.

MWRA withstood EPA's legal challenge in 2001 and was awarded a filtration waiver, which remains in effect at this writing. In response to concerns about chlorine by-products, MWRA now uses ozone disinfection at its new Carroll Water Treatment Plant in Marlborough, Massachusetts. In addition, several open storage reservoirs have been covered to eliminate contamination from airborne pollutants.

## Hydrofracking

In 2010, a new threat to New York's water supply arose in the form of proposals from energy companies that want to exploit natural gas deposits under portions of the watershed region. According to an article in *Scientific American* of July 2010: "A single vast shale deposit—the Marcellus Formation, stretching from Tennessee to New York—might contain enough natural gas to supply the U.S. for more than 30 years at today's consumption rates" (Fischetti, 2010).

The technology preferred by the industry, known as "fracking," involves extracting natural gas from deep rock strata by injecting high-pressure water mixed with chemicals to fracture the gas-bearing layers. The use of fracking to date in Pennsylvania, Ohio, and elsewhere has contaminated groundwater supplies in some areas and posed serious issues of recovery and safe disposal of the toxic chemicals used in the process.

The potential use of fracking has led to a bitter controversy in New York state, especially in the Cat-Del watersheds. Local citizens yearn for the jobs the industry would create in a depressed economy, while environmentalists and water managers decry the technology's evident risks. *The New York Times* (Sept. 28, 2010) warned editorially that "…carefully regulated drilling in the Marcellus Shale might be feasible, but the state should put the city's watershed permanently off limits. . . . There are simply too many points in the drilling process where toxic chemicals could escape."

On December 11, 2010, outgoing Governor David A. Patterson issued an executive order delaying any permit for fracking in the state until at least July 1, 2011, pending a review of the environmental impacts of the process. As of October 2011, Governor Andrew Cuomo has continued to defer state permits for hydrofracking until the state review has been completed. Meanwhile EPA is conducting its own environmental review.

## Conclusion

Putting aside the ruckus over fracking, the management process established by the 1997 MOA has been remarkably smooth. Issues concerning particular provisions of the MOA have been raised, sometimes emphatically, by the Coalition of Watershed Towns, and the city has tried to promote both environmental and economic progress in the rural watershed region. At the same time, the results have been to restrain water demand and avoid any public health incidents for the past 13 years. Perhaps it is not premature to suggest that "the jury is in"—the New York City watershed management program, and its Metro Boston counterpart, may be declared successful experiments in sustainable urban drinking water management.

## References

Fischetti, M. 2010. The drillers are coming: debate over hydraulic fracturing heats up. Scientific American 303(1): 82–85.

NRC (National Research Council). 2000. Watershed Management for Potable Water Supply: Assessing New York City's Approach. Washington, D.C.: National Academies Press.