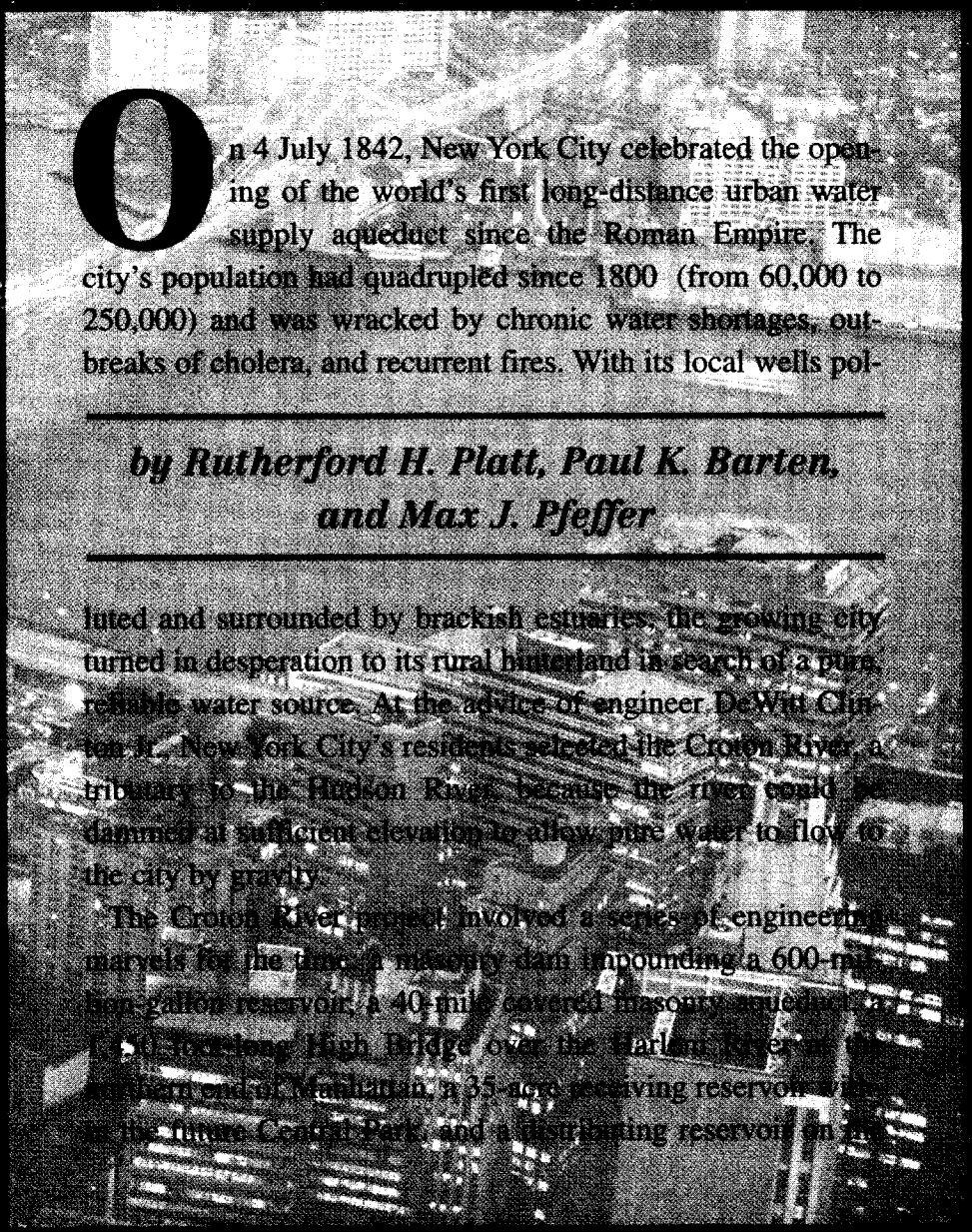
A Full, Clean Glass?

© FOTOMORGANA—THE STOCK MARKET

Managing New York City's Watersheds



On 4 July 1842, New York City celebrated the opening of the world's first long-distance urban water supply aqueduct since the Roman Empire. The city's population had quadrupled since 1800 (from 60,000 to 250,000) and was wracked by chronic water shortages, outbreaks of cholera, and recurrent fires. With its local wells polluted and surrounded by brackish estuaries, the growing city turned in desperation to its rural hinterland in search of a pure, reliable water source. At the advice of engineer DeWitt Clinton Jr., New York City's residents selected the Croton River, a tributary to the Hudson River, because the river could be dammed at sufficient elevation to allow pure water to flow to the city by gravity.

by Rutherford H. Platt, Paul K. Barten, and Max J. Pfeffer

The Croton River project involved a series of engineering marvels for the time: a masonry dam impounding a 600-million-gallon reservoir, a 40-mile covered masonry aqueduct, a 1,450-foot-long High Bridge over the Harlem River at the northern end of Manhattan, a 35-acre receiving reservoir within the future Central Park, and a distributing reservoir on the

present site of the New York Public Library.[1] A decade later, the Croton River project, together with Central Park, reflected the emergence of modern city government armed with new fiscal and administrative capabilities devised by local and state politicians. (The federal government had no role in urban water supply at that time.) It was the prototype U.S. long-distance water transfer project and inspired widespread imitation, first by Boston and later by San Francisco, Los Angeles, and many other cities, including New York itself.

Enlarged between 1885 and 1911, the Croton River system today provides about 10 percent of New York City's water. The other 90 percent is drawn from even more distant sources that were developed between the 1900s and the 1960s cross the Hudson River in the Catskill Mountains and the headwaters of the Delaware River. Five large west-of-Hudson (WOH) reservoirs impound the runoff from nearly 1,600 square miles of rural upland watershed. The Catskill and Delaware aqueducts, extending 92 miles and 86 miles respectively, cross deep beneath the Hudson River by way of high-pressure inverted siphons to deliver water to the city. The two cross-Hudson aqueducts meet at the Kensico Reservoir near White Plains, about 15 miles north of the city. There, water from the two aqueducts mixes and after 15 to 25 days of storage time, is chlorinated and transferred to the Hillview Reservoir, outside New York City, where it is further chlorinated and delivered to the city distribution system via two main water tunnels. (A third water tunnel, now under construction near Boston, is due for completion in 2020 at a cost of $6 billion.) Both the Catskill and Delaware aqueducts are designed to permit bypassing of Kensico in the event that contaminants degrade it. Altogether, the New York City system serves about nine million people in the city and nearby suburbs with a safe yield of about 1.3 billion gallons per day (see Figure 1 on page 11).[2]

On 21 January 1997, New York Mayor Rudolph Giuliani, Governor George Pataki, and a host of governmental and environmental cosigners entered into an epic Memorandum of Agreement (MOA). A product resulting from years of negotiation, the MOA established a legally enforceable compact under which the city would spend up to a billion dollars over 10 years to maintain and protect the high quality of water derived from its WOH reservoirs indefinitely into the future. Its objective is to satisfy the stringent requirements of the federal Safe Drinking Water Act through watershed management rather than by constructing a filtration plant for its WOH sources at even greater expense. The MOA may be viewed as the nonstructural equivalent of the original Croton River project, namely a path-breaking approach to ensuring a reliable and safe water supply that could potentially serve as a model for urban water suppliers across the nation.

Whether or not a system is currently filtered, an aggressive watershed management program, as envisioned in the New York City Memorandum of Agreement, provides an extra barrier against public health threats. Furthermore, source management may reduce the level of necessary water treatment, thereby lowering the threat of disinfection of products from chlorination and other treatment methods.

In February 2000, the National Research Council (NRC)—the research arm of the National Academy of Sciences—released a report commissioned by the New York City comptroller's office that evaluates the scientific and policy underpinnings of the MOA.[3] This article will review the New York City approach to managing its massive water system and summarize the findings of the NRC report.

The Catskill/Delaware Watershed Region

The Catskill Escarpment rises steeply to about 1,500 feet a few miles west of the Hudson River and about 80 miles north of New York City. Elevations reach 3,500 feet in the High Peaks region in the Esopus and Schoharie Creek watersheds, both critical sources of New York water. During the fall and winter when the deciduous trees (mostly red and white oak, beech, red and sugar maple, and various birches) lose their leaves, the horizontal layers of sandstone, shale, and conglomerate layers are clearly visible.

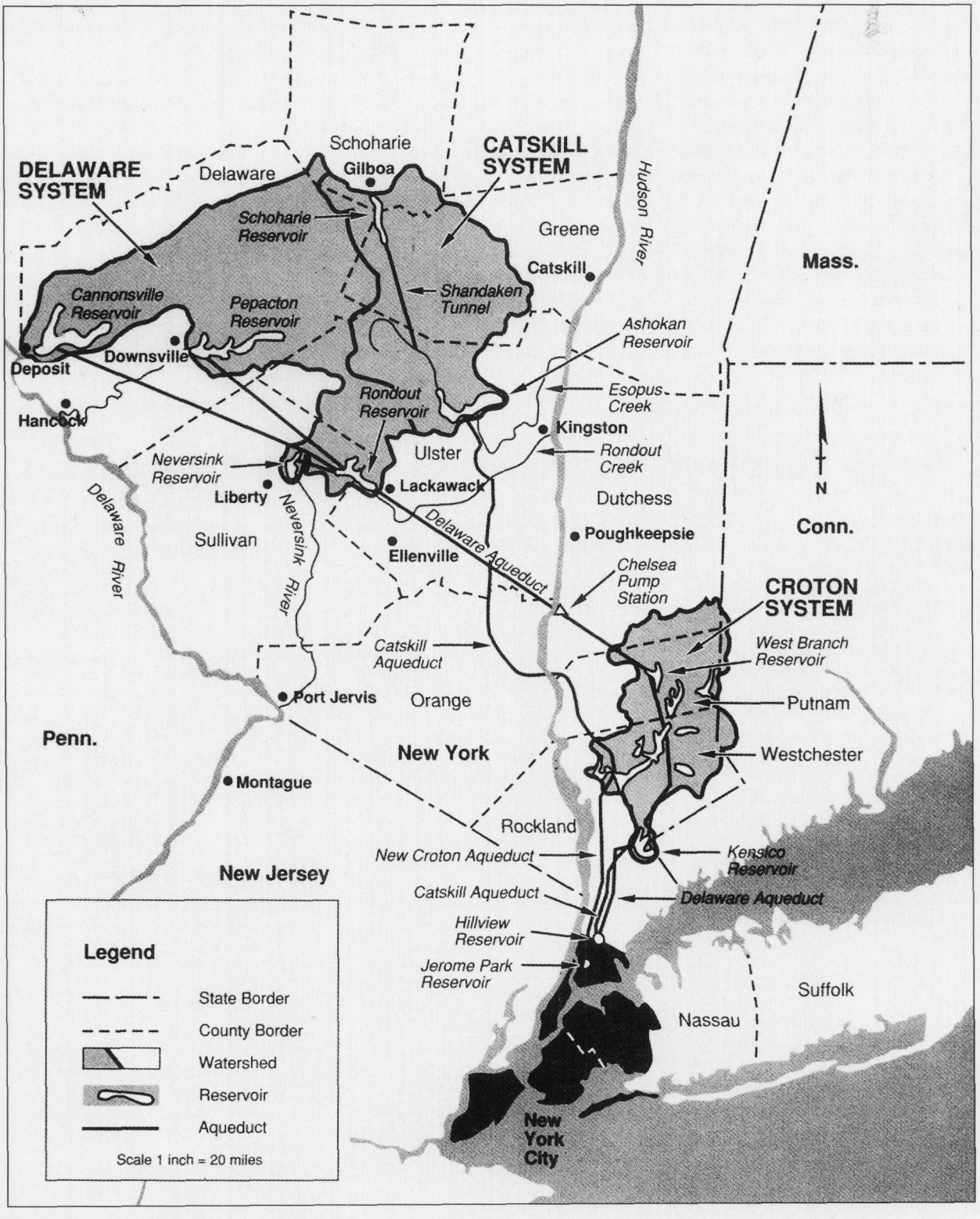
Like much of the Northeast, the Catskill Mountains are covered with a thin veneer of soil derived from glacial till. Rock outcrops and boulder fields are common at higher elevations. The combination of high permeabilities and steep gradients produces rapid rates of lateral subsurface water flow during snowmelt and large rainfall as well as droughty conditions during the growing season. Along lower slopes and in valley bottoms and floodplains, soils have a larger proportion of fine-textured material (silts and clays), but also the soil may contain extensive alluvial sand and gravel deposits.

Continental and maritime air masses influence the region's climate. Frontal systems from the west and north, coastal storms from the south, an occasional northeaster, and summer thunderstorms produce an average annual precipitation of 47 inches. Elevation influences the type and amount of precipitation. The snowpack typically forms in late November and persists through mid-winter thaws until melt occurs in March or April. Rain-on-snow and snowmelt floods can be the largest and most destructive stormflow events in the region. In addition to snowmelt, large rainfall that occurs after leaf-fall but before the period of snow accumulation, may produce high flows. Thunderstorms can produce a rapid streamflow response during the growing season. In sum, while precipitation is relatively uniform in quantity and timing throughout the year, water use by plants regulates total annual streamflow volume during the growing season. Hence, annual stream flow is often dominated by a few, large dormant season events.

Demand Management

The Northeast drought of the early 1960s confronted New York, Boston, and

Figure 1. New York City's water supply system



SOURCE: New York City Department of Environmental Protection.

other mid-Atlantic coastal cities with the prospect of severe and chronic water shortages. In the tradition of past water development, proposals were made to augment the existing system with further withdrawals from the Hudson River above the salt front and elsewhere. But development of further hinterland sources of water to meet projected water deficits of U.S. cities in the 1970s faced both environmental and fiscal obstacles.[4] Enhanced concern for protecting free-flowing rivers along with their fisheries and recreational values made construction of new dams politically unpopular. In Denver, for example, the Two Forks Dam, long proposed by the Denver Water Board, was vetoed by the U.S. Environmental Protection Agency (EPA) in 1991 under Section 404(c) of the Clean Water Act to protect a popular salmon fishing stream.[5] A proposal prompted by the Northeast drought in the early 1960s to divert water some 90 miles from the Connecticut River Basin to metropolitan Boston via the Quabbin Reservoir in central Massachusetts was successfully blocked by basin residents, who persuaded Boston area water managers to pursue aggressive demand management instead of diversions (see the box below).[6] In southern California, where expansion of long-distance water transfers has been stymied for decades, demand management has also been embraced: "By 2010, water conserved through increased efficiency of water use in southern California will constitute the largest single source of additional water."[7]

Like these and other urban areas where new water sources were out of reach, New York City in the 1980s turned to water demand management to avoid predicted shortfalls. Its first effort was to remedy a pervasive absence of water meters through a Universal Water Metering Program announced by the mayor in 1986. The city installed more than 600,000 meters at a cost of $350 million. When completed, New York will be able to monitor water use and

Water Supply Management in Metropolitan Boston

Boston and New York City have followed remarkably similar trajectories in developing and managing their urban water supplies. Founded in the 17th century on deep-water harbors amid brackish estuaries, each settlement relied for two centuries on meager springs and wells. By the early 19th century, each city faced a water crisis aggravated by rapid population growth, epidemics, fires, and contamination of local sources. Following New York's lead in developing the Croton River system, Boston employed the same civil engineer, John Jervis, to design a project to import water from a new reservoir, Lake Cochituate, located 20 miles west of Boston, via a 20-mile tunnel. This system was greatly enlarged with the construction of the Wachusett Reservoir, which lies on the urban fringe of Worcester, Massachusetts, in 1908 and the Quabbin Reservoir in central Massachusetts in the 1930s (believed to be the world's largest water supply reservoir today). But in contrast to New York City, which retains control over its far-flung system, the Boston system has been managed regionally since 1895, first by the Metropolitan Water District established that year, then by the Metropolitan District Commission (MDC) starting in 1919 and, since 1985, by the Massachusetts Water Resources Authority (MWRA) in cooperation with MDC. The New York system today is approximately four times larger in terms of safe yield (1,300 versus 300 million gallons per day) and population served (10 million versus 2.5 million).

MWRA was created primarily to build a massive sewage treatment facility for Boston Harbor in response to a court order, but it is also charged with ensuring adequate quantity and quality of water supplied to 46 cities and towns in the Boston metropolitan area. Like New York, MWRA first concentrated on demand management through system leak repairs, free plumbing retrofits, higher water fees, and public education. Since 1988, MWRA has reduced per capita water demand by at least 16 percent, an achievement cited as an internationally significant success in sustainable water resource management.[1]

New York and metropolitan Boston also share the distinction of providing clean unfiltered water to huge populations. Both seek to convince the Environmental Protection Agency (EPA) that they can satisfy the Surface Water Treatment Rule through watershed management rather than filtration. But farming and urbanization on private lands within source watersheds threaten to degrade reservoir water quality in both systems. Boston's Quabbin Reservoir, whose watershed is nearly 80 percent under public ownership, has received a filtration avoidance determination (FAD) from EPA. But all Quabbin water must pass through the Wachusett Reservoir, whose watershed is still predominantly privately owned. EPA has not awarded a FAD for Wachusett and sued MWRA and the state in March 1998 to require a filtration plant to be constructed at the outlet of Wachusett. However, under a 1992 consent agreement with the state in which EPA previously concurred, MWRA is pursuing watershed management for Wachusett while simultaneously designing the plant (the dual track approach also used by New York). Key elements of the Wachusett Watershed Protection Plan include septic system upgrades, sewage treatment expansion, nonpoint source pollution control, land acquisition, replacement of underground storage tanks, and harassment of nesting geese by crews in rubber boats making loud noises to reduce fecal coliform levels. In 1992, the state legislature adopted the Watershed Protection Act (Massachusetts General Law 1992, Chapter 36) that mandates setbacks for new development along reservoirs and their tributaries.[2]

1. S. Postel, *Last Oasis: Facing Water Scarcity* (New York: W.W. Norton and Company, 1992).

2. D. P. Hutchinson, "A Setback for the Rivers of Massachusetts? An Application of Regulatory Takings Doctrine to the Watershed Protection Act and the Massachusetts River Protection Act," *Boston University Law Review* 73, no. 1 (1993): 237–270.

employ pricing as a strategy to limit waste and demand increase.

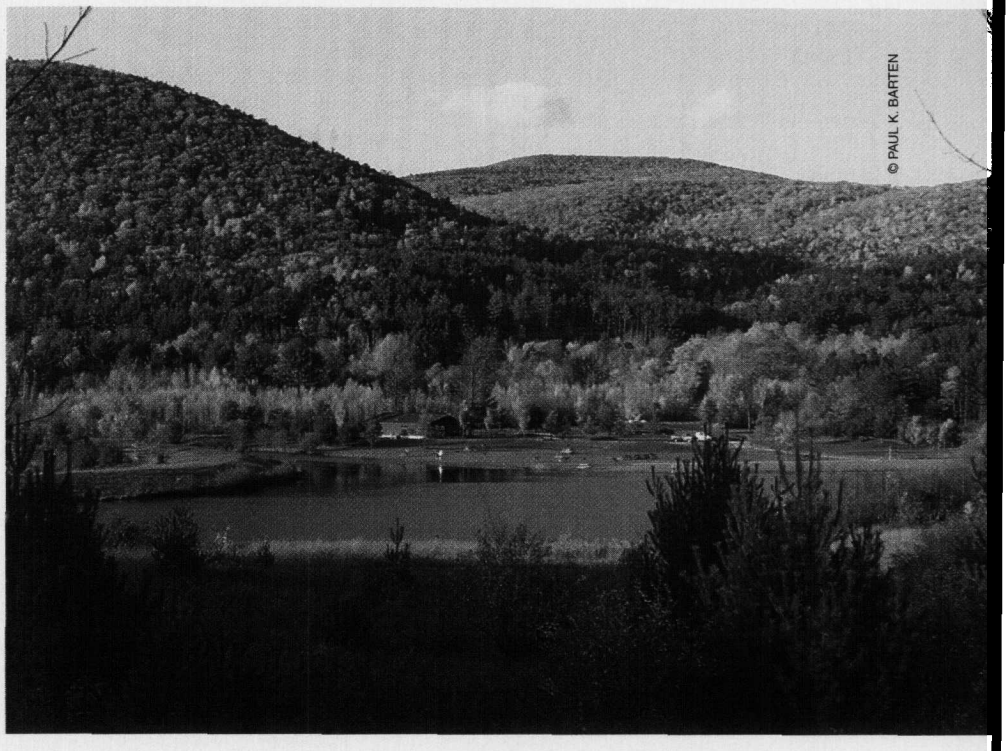
In 1991, the city launched a pilot water conservation program to stem rising demand. The program offered free leak detection and installation of water-saving plumbing devices such as low-flow showerheads, faucet aerators, toilet tank displacement bags, and low-flow toilets. These services were provided to 10,000 one-to-three family homes citywide. Since 1993, a larger scale water conservation program has conducted leak detection for tens of thousands of homes and apartments. The city has provided an expanded range of water-saving showerheads and toilet devices, new outreach and public education, and energy conservation in cooperation with the electrical utility. It has also developed an ongoing audit of leakage as a basis for estimated long-term benefits from subsidized water conservation measures. By 1995, in-city average demand had dropped to about 1,300 million gallons per day (mgd), down from 1,400 mgd, approximately equal to the system's safe yield. Much greater savings are anticipated from continuation of leak detection and plumbing retrofit efforts, including replacement of about one-third of the city's toilets with 1.6 gallon-per-flush units, down from 7 gallons per flush.[8]

Average daily demand served by the New York City water supply system declined from 1546.8 mgd in 1990 to 1449.3 mgd in 1995.[9] While the latter figure was still higher than the estimated system safe yield of 1,290 mgd, the city's demand management program clearly stemmed rising demand.[10]

Watershed Management

With the quantity of water reasonably adequate for the near future, New York City water managers in the early 1990s began to focus on protecting the quality of the city's existing sources. Like Boston, San Francisco, and several other cities, New York has relied on the natural purity of its hinterland sources, along with chlorine disinfection, to provide high-quality water without filtration. During the 1990s, that modus operandi was challenged by national public health concerns about disinfection byproducts and microbial pathogens, among other threats.[11] EPA's 1989 Surface Water Treatment Rule (SWTR), adopted pursuant to the Safe Drinking Water Act of 1974 as amended in 1986,[12] introduced two important metrics of treatment effectiveness. The first is log removal of microbial pathogens, which refers to a decrease in an organism's concentration by a factor of 10. The second was called CT—the product of disinfectant concentration (C) and contact time (T) as the control parameter for disinfection.[13] The SWTR mandates filtration of public surface water supplies unless the system manager can demonstrate that it will "maintain a watershed control program which minimizes the potential for contamination of *Giardia* cysts and viruses in the source water."[14] New York and Boston are seeking to avoid the need to provide filtration by pursuing watershed management programs that would qualify for an EPA filtration avoidance determination (FAD).[15]

In 1998, New York City signed a consent decree for siting, design construction, and operation of a filtration plant for its smaller Croton River water system located east of the Hudson River amidst the city's rapidly developing northerly suburbs.[16] The decree was the result of a lawsuit filed jointly by the United States and New York State alleging that the city was in violation of an earlier EPA demand for filtration of Croton water. For its much larger WOH sources, estimated costs of filtration range between $3 billion and $8 billion for construction and up to $300 million in annual operating costs. To avoid these costs and to maintain its presently high water quality, the city opted to pursue the watershed management option with the goal of earning a FAD from New York State and EPA. In November 1991, the New York City Department of Environmental Protection filed an application for a FAD. In response, EPA convened an expert panel to review the

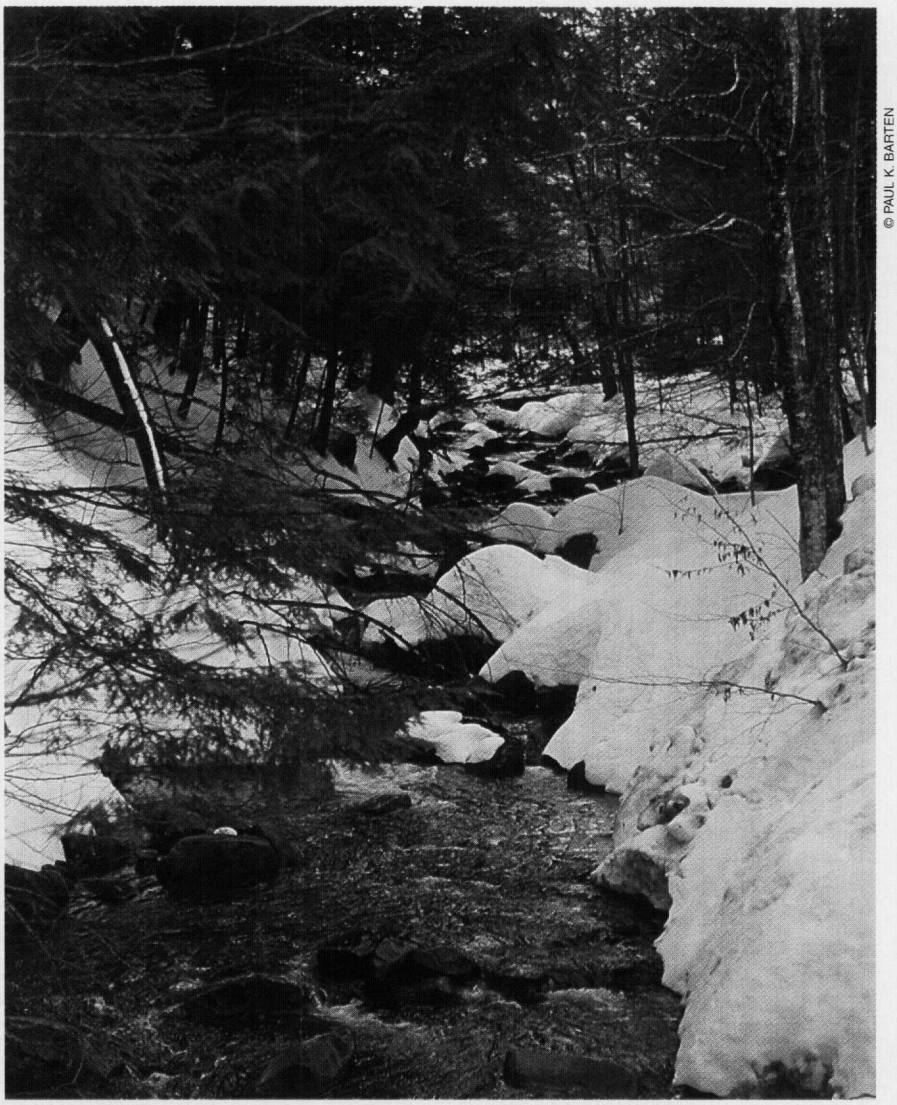


The Little Beaver Kill is a tributary of the Esopus Creek, part of the Ashokan Reservoir. The lake is in Wilson State Park and was formed by damming the kill.

city's request. In April 1993, the panel, chaired by Daniel Okun of the University of North Carolina, issued a report urging that both filtration and watershed management were needed to protect the New York City water system.[17]

A major obstacle to the city's meeting EPA's conditions for filtration avoidance was the opposition of upstate interests to any expansion of the city's influence or control over land use in the WOH watersheds.[18] At the time, New York City owned only about seven percent of the land area of the WOH watersheds, mostly the reservoirs and their immediate shorelines. State and conservation organization ownership controlled another 20 percent of the watershed land area, leaving three-fourths of the WOH watersheds in private ownership, mostly devoted to agriculture and forestry. The region is scattered with sparsely populated towns and hamlets that have not shared in the economic boom enjoyed by metropolitan New York, which has long been regarded as a "1,000 pound gorilla" in the region. Opposition to the city in the watershed region represented a culture of resistance much like the one that developed in the Owens Valley in California, in opposition to water diversion by and to the city of Los Angeles.[19] This culture of resistance was based on shared knowledge about the watershed and common values, norms, and attitudes about the local community and the environment.

In particular, the city's first attempt to comply with the Surface Water Treatment Rule through new watershed regulations and land acquisition proposed in the early 1990s aroused the wrath of watershed interests who feared stifling economic development, a drop in property values, and an eroding local tax base.[20] The Coalition of Watershed Towns was formed in 1991 to represent about 30 WOH watershed towns.[21] The long-simmering animosity between the city and watershed communities came to a head in late 1993 when New York filed an application for a state water supply permit, including plans to acquire 10,000 acres in the watershed, and submitted to EPA a Long-Term Watershed Protection and Filtration Avoidance Program for the Catskill/Delaware system.[22] Uncertainty over the city's intent to use eminent domain to gain control of the land and the perception that it was shifting the costs of watershed protection to upstate communities resulted in the deterioration of relations between New York City and upstate communities. the Coalition of Watershed Towns filed suit to prevent the city from implementing its filtration avoidance plans, citing economic burdens on watershed residents expected from restrictions on the use of privately owned land. It claimed that the city would benefit almost exclusively from environmental measures in the countryside to protect drinking water supplies. The lawsuit led to an impasse in efforts to reach a compromise between New York City and the upstate communities about a watershed management plan.[23]



The Panther Kill is a tributary of Noodland Creek in the Ashokan Reservoir. The deep snowpack and stony substrate are typical of mountain streams.

In the face of this stalemate, EPA and other interested parties urged the state to intervene to bring the interested parties to the negotiating table. In May 1995, newly elected Governor Pataki ordered his chief counsel to mediate negotiations between the city, the Coalition of Watershed Towns, and EPA. Six months later, they reached an historic Agreement in Principle that embodied New York City's agenda for watershed protection and met the coalition's demand for fairness. While recognizing the city's need to acquire additional land and to regulate potential sources of contamination within the watersheds, the agreement also allowed for spending $350 million on infrastructure improvements and sus-

tainable economic development programs in watershed towns and counties.[24] Negotiations continued to hammer out the finer details of the Agreement in Principle, finally culminating in the signing of the 21 January 1997 Memorandum of Agreement.

The 1997 Watershed MOA

Signatories to the landmark 1997 Memorandum of Agreement included New York City, New York State, EPA, the Coalition of Watershed Towns, some 40 watershed communities, and five conservation organizations—the Catskill Center for Conservation and Development, the Hudson Riverkeeper, the Trust for Public Lands, the Open Space Institute, and the New York Public Interest Research Group. In signing the MOA, the parties accepted the updated watershed rules and regulations, and EPA extended the filtration avoidance determination to 2002. As summarized below, the MOA launched an ambitious program of watershed management to protect WOH reservoirs from potential contamination at a cost to city water ratepayers of approximately one billion dollars over 10 years.

The MOA is a vast and complex document with text and attachments comprising about 1,000 looseleaf pages. Essentially, it specifies a long list of sticks and carrots, the former to protect the city's water sources and the latter to placate the watershed communities. As listed in the box on this page, the major water protection activities include land acquisition, watershed regulations, and upgrading wastewater and agricultural facilities. The city is obligated to commit $250 million during the next 10 years to acquiring up to 355,000 acres in WOH watersheds through willing buyer-seller purchase (eminent domain will not be used). Regulations limit the location of specific water quality threats within the watersheds, including hazardous substances, petroleum storage tanks, wastewater treatment facilities, landfills, junkyards, and pesticides. New impervious surfaces of any kind (buildings and pavement, among others) are not permitted within 100 feet of any water course or wetland, or within 300 feet of a reservoir.

Land Acquisition

Land acquisition is a key element of the city's watershed management program. Land may be acquired by the city in fee simple title or through conservation easements. Easements are to be held by the city (or conceivably by a land trust or other intermediary) in perpetuity. Implementation of the Land Acquisition Program is authorized under a state water supply permit that is valid for 10 years and renewable for another five years. Continuation of this water supply permit is contingent upon the city meeting financial and other obligations under the MOA.

The program is voluntary, operating under a willing buyer/willing seller principle. Furthermore, the MOA provides that all land acquisition occur in consultation with affected towns and villages. This consultation extends to recreational uses of lands acquired by the city. The Land Acquisition Program is designed to provide reasonable opportunities for growth in and around existing population centers. The MOA allows localities to exclude certain kinds of parcels from acquisition to preserve community character.

Another concern of watershed residents was the potential loss of tax revenues on lands purchased by the city. Under the agreement, New York will pay taxes in accordance with the assessed value of the properties acquired and agreed not to challenge the initial assessed value of the parcels purchased, provided certain conditions are met. Recently enacted state legislation requires the city to pay taxes on land under conservation easements.[25] The city has promised not to transfer city-owned land to tax exempt entities. Table 1 on page 17 summarizes the criteria and solicitation goals for various types of watershed land.

Key Elements of the New York City Watershed Management Strategy

- Water Quality Monitoring and GIS System
- Public Health Monitoring
  - active disease surveillance
  - microbial risk assessment
- EPA-Mandated Water Quality Protection Initiatives
  - Total Maximum Daily Load Program
  - Phosphorous Offset Pilot Program antidegradation policy
- Land Acquisition and Comprehensive Planning
- Wastewater Treatment
  - sewage treatment plant upgrades
  - septic system upgrades
- Setbacks and Buffers Along Reservoirs and Tributaries
- Best Management Practices to Control Nonpoint Source Pollution
  - Watershed Agricultural Program
  - Watershed Forestry Program
  - stormwater pollution prevention plans
- Watershed Partnership Programs
  - Watershed Protection and Partnership Council
  - Catskill Watershed Corporation
  - Catskill Fund for the Future
- Dual Track Approach (design filtration plant, in case it is needed, while pursuing watershed management program)
- Investigative Studies and Modeling

Catskill Watershed Corporation

The Catskill Watershed Corporation (CWC) is a not-for-profit corporation established by the Memorandum of Agreement to administer programs for the Catskill and Delaware watersheds. The corporation includes members from WOH communities as well as representatives of state and city government. During the next 15 years, CWC will oversee the expenditure of $240 million in city funds for infrastructure, economic development, conservation, and education in watershed communities. A total of $59.7 million is earmarked over 15 years for the Catskill Fund for the Future, a program that supports responsible, environmentally sensitive economic development. In addition, $75 million is set aside for environmental infrastructure, such as construction of new wastewater treatment plants. Finally, more than $80 million will be provided for other projects or activities to enhance water quality (see Table 2 on page 18).

© PAUL K. BARTEN

A spring snowmelt in a small New York City watershed tributary. Snowmelt floods can be destructive events in the region.

CWC's administration of these programs provides an institutional basis for more integrated watershed protection and development. In addition to these CWC programs, the New York Department of State operates a Master Planning and Zoning Awards Program to assist towns and villages in the development of environmentally sound master plans, zoning standards, and capital investment plans. That agency also operates a "one stop shop" that assists watershed residents in determining what permits are required for various types of regulated activities.

The Watershed Agricultural Program

In response to farmers' hostility to the 1990 proposed watershed rules, the city and state established an ad hoc task force on agriculture. The recommendations of this task force provided the basis for the Watershed Agricultural Program (WAP) that was eventually incorporated into the MOA.[26] The WAP is administered by a grassroots organization, the Watershed Agricultural Council (WAC) composed of farm, agribusiness, and environmental leaders. Since 1993, the primary role of the council has been to review and approve efforts on individual farms to improve the water quality of surface and groundwater resources.

WAP reflects five principles of pollution abatement. These include regulatory relief for an affected industry that does not compromise environmental and public health goals; farmer leadership and local administration; public-private and urban-rural partnerships involving industry, government, and academic stakeholders; the precautionary principle (better to err on the side of caution); and scientifically based risk assessment.[27] WAP began in 1992 as a two-year pilot program, involving 10 farms, to develop an environmentally sound approach to farm management.

A cornerstone of the WAP is the Whole Farm Planning Process involving farmers, New York City, watershed governments, the state and federal governments, and the agriculture support infrastructure. Whole farm plans are strategies for controlling potential sources of pollution on individual farms in the watershed. For those farmers who decide to participate in WAP, the process begins with an assessment of the farmer's own goals for the land (e.g., motivation to farm, time horizon, and possible changes in production). The current physical and economic attributes of the farm are inventoried and water quality problems identified. The planning team then develops a list of best management practices (BMPs) to address these environmental concerns compatibly with the farmer's goals. BMPs include a combination of structural, managerial, and behavioral changes to address typical environmental problems. The recommended BMPs are proposed to the local Soil and Water Conservation District and WAC for approval.

As of December 1999, 229 Whole Farm Plans (WFPs) were created and approved by the Watershed Agricultural Council, with 311 farmers participating. Between 1994 and 1999, the city provided $32.5 million for WAP, of which $19.7 million was devoted to construction of best management practices. By

late 1997, the Watershed Agricultural Program had recruited 297 farmer participants, completed 155 WFPs covering 55,550 acres, and implemented 755 BMPs. The types of BMPs implemented were designed to reduce various types of contaminants, especially the pathogens *cyptosporidium* and *giardia*. Cornell University research has found that livestock contribute these protozoans, underscoring the importance of managing manure on farms.[28] Nutrients, especially phosphorus, have also been targeted as priority pollutants in the watershed. Both manure and imported fertilizers contain phosphorus that can reach nearby water bodies after application to fields.

Table 1. Land acquisition framework in the Catskill and Delaware watersheds

Priority Areas	Definition of Area	Minimum Acreage	Solicitation Goals (acres)
1A	Sub-basins within 60-day travel time to distribution near intakes	1	61,750 (1A and 1B)
1B	Sub-basins within 60-day travel time to distribution not near intakes	5	
2	Sub-basins within terminal reservoir basins but not within priority areas 1A or 1B	10	42,500
3	Sub-basins with identified water quality problems not within above priority areas	10	96,000
4	All remaining sub-basins in nonterminal reservoir basins	10	155,000

SOURCE: New York City Memorandum of Agreement, 21 January 1997.

The Ongoing MOA Debate

The 1997 Memorandum of Agreement did not satisfy all critics of New York's approach. The 1993 Okun report and articles ensuing from it continued to urge that filtration and watershed management were needed. The National Resources Defense Council (NRDC) participated in the MOA negotiations but did not sign the agreement, arguing that it "includes significant loopholes both in the rules and in the land-buying effort."[29] One of the biggest weaknesses, according to NRDC attorney Eric Goldstein, is that the plan "allows an unlimited number of new sewage plants to be built in most of the Delaware and Catskill watersheds, a concession that could indirectly spur more growth and pollution."[30] NRDC has continued to oppose development and road construction within the immediate watershed of the Kensico Reservoir in Westchester County, through which all Catskill and Delaware water passes. Robert F. Kennedy Jr., on behalf of Riverkeepers (a signer of the MOA), charged in a *New York Times* op-ed column that the New York Department of Environmental Protection was failing to enforce the regulatory provisions of the MOA, particularly in the Croton River watershed.[31]

The MOA's leading skeptic, in the aftermath of the 1997 signing, was New York City comptroller Alan G. Hevesi, who questioned many aspects of the agreement and threatened to withhold city funds for implementation of the program. Among his concerns were the potential for watershed economic development payments to foster activities that harm water quality, the need for long-term oversight by EPA, and mid-course evaluation of the MOA progress. He also expressed doubt, in sympathy with NRDC, about the scientific justification of the Memorandum of Agreement. By April 1997, Hevesi, with his considerable leverage, negotiated a number of revisions to the MOA to achieve better science, better accounting, and prolonged involvement by EPA.[32] The need for better science was addressed in a city-funded contract with NRC's Water Science and Technology Board to conduct a two-year study of the scientific merits of the MOA—namely, will it work?

The National Research Council Report

In July 1997, the National Research Council formed a 15-member interdisciplinary committee to review the New York City Watershed Management Strategy. The New York City comptroller's office asked the committee to examine a number of issues involving the MOA, including the use of setback distances to protect bodies of water from nonpoint source pollution, the Total Maximum Daily Load (TMDL) program, siting and technology requirements for wastewater treatment plants and septic systems, the phosphorus offset program, the enhanced monitoring program, and antidegradation policy.[33] The ensuing report, released in late 1999 and published in February 2000, contains 93 recommendations and conclusions in relation to the following components of the watershed system:

- water quality monitoring (8)
- geographic information systems (GIS) (3)
- waterborne disease surveillance and public health protection (7)
- microbial risk assessment (3)
- land acquisition (4)
- land use planning (6)
- total maximum daily loads (TMDLs) (8)

- Phosphorus Offset Pilot Program (8)
- U.S. and N.Y. antidegradation policies (5)
- dual track approach (filtration plant design and watershed management) (5)
- Watershed Agricultural Program (9)
- Watershed Forestry Program (5)
- Stormwater Pollution Prevention Plans (5)
- riparian buffer zones (9)
- wastewater treatment (septic systems and treatment plants) (8)

The committee summarized its findings in four overarching conclusions. In many cases, they pertain not only to the New York City system but also to other municipal water supplies, large and small, filtered and unfiltered.

The first conclusion noted that the New York City watershed management program should place importance first on microbial pathogens, second on organic precursors of disinfection byproducts (DBPs), third on phosphorus, and fourth on turbidity and sediment.

As noted earlier, EPA's Surface Water Treatment Rule emphasizes the protection of water consumers from microbial pathogens. Because of the interrelationship of these organisms—disinfection byproducts (DBPs), phosphorus, and suspended particulate matter—the operation and management of a reservoir system can be a complex and daunting task. The New York City system uses chlorine disinfection to control pathogens. When chlorine kills microorganisms, it also comes in contact with organic carbon and produces DBPs such as trihalomethane, a carcinogen. Phosphorus is usually the nutrient that limits primary production (algae and aquatic plant biomass) in freshwater systems. Therefore, when phosphorus loading increases plant biomass (organic carbon), it simultaneously increases the concentration of DBP precursors. To further complicate the situation, turbidity (a standard measure of inorganic and organic suspended particulate matter) can mask or shield pathogens absorbed to the surface of sediment particles and reduce the effectiveness of chlorine disinfection. Add more chlorine, produce more DBPs—so the cycle continues. Clearly, the identification and control of pathogen, nutrient, and sediment sources (e.g., failed septic systems, stormwater from developed areas, and so forth) is the critical first barrier in an unfiltered water supply system.

The second conclusion of the NRC committee is that the concept of balancing watershed rules and regulations with targeted support of watershed community development is a reasonable strategy for New York City and possibly other water suppliers.

New York City's commitment of financial resources to environmentally sensitive economic development in the Catskill region (via the Catskill Watershed Corporation) is an equitable exchange for more stringent land use planning and regulation imposed under the MOA. An analysis of census data shows the rate of population growth in the region is limited. Therefore, the committee expects the combination of comprehensive planning, enhanced environmental regulation, directed development (by sector and site), and improved wastewater treatment stipulated by the MOA will help to maintain high source water quality. To impose a moratorium on land and resource use would reignite the legal battles averted by the MOA.

The committee feels that the MOA adequately considers both private property rights and the economic, social, and political concerns of watershed residents. The imposition of setbacks along surface waters draining to the city's reservoirs is similar to measures employed in Massachusetts and other states to protect water quality and riparian habitats, and to alleviate flood damage. The committee recommends that property owners be encouraged through appropriate incentives to manage buffer areas adjoining streams to control streamwater pollution. Although the owner is not compensated, setbacks apply to only a narrow strip that

Table 2. Major Catskill Watershed Corporation Partnership west-of-Hudson programs

Partnership Program	Funding ($ millions)
Sewage Treatment	75.0
Catskill Fund for the Future	59.7
Stormwater Fund	31.7
Septic Rehabilitation and Replacement	13.6
Sand/Salt Storage Facilities	10.25
Sewer Extensions	10.0
Good Neighbor Payments	9.76
Stormwater Retrofits	7.62
SPEDES Upgrades	5.0
Catskill Watershed Corporation	3.5
Stream Corridor Protection	3.0
Tax Consulting Fund	3.0
Alternate Design Septics	3.0
Public Education	2.0
Forestry Management Program	0.5
Economic Development Study	0.5

SOURCE: New York City Memorandum of Agreement, 21 January 1997.

probably would not be developed and has no public access. Thus, it is likely that the MOA setback regulations would be upheld as reasonable and limited restraints on private property if challenged in court.

As its third recommendation, the committee encourages New York City and all other water suppliers to be receptive to the possibility of additional water treatment options.

If EPA issues more stringent rules and regulations pertaining to allowable concentrations of microbial pathogens and disinfection byproducts, New York City and other unfiltered water suppliers may be unable to consistently meet targets with current infrastructure. Therefore, an optimal combination of watershed management (pollution prevention), coagulation/filtration, and disinfection will be needed. Because of the inherent complexity and substantial time requirements (5 to 15 years) for design, permitting, and construction of water filtration plants and the concurrent need to enhance, or at least sustain, watershed management programs, a dual (parallel versus sequential) track approach is sensible and conservative. A multiple barrier approach has been advocated for almost a century. The optimal number, type, and effectiveness of barriers have been, and will continue to be, a subject of study and debate. (This principle of "multiple barriers," of course, applies to all water systems, not just the New York City system.)

Lastly, the committee recommended that New York City should lead in efforts to quantify the contribution of watershed management to the overall risk reduction from waterborne pollutants.

Although watershed management is an essential component of any progressive water supply system, its direct contribution to risk reduction is difficult to quantify. The effectiveness of a filtration plant can be quantified for a range of operating conditions by measuring influent, internal, and effluent concentrations. By contrast, the spatial and temporal variation of watershed, climatic, and pollutant loading characteristics present substantial challenges for research and management. Nevertheless, a strategic combination of field measurements, laboratory analyses, and simulation modeling can help focus and refine watershed management efforts. Laboring under the need to maintain a filtration avoidance determination from EPA, the New York City Department of Environmental Protection and allied organizations have made progress toward these elusive goals. As some of the largest water suppliers in the United States, their continued leadership will benefit thousands of water suppliers and millions of people without the means to replicate this work.

Conclusion

The 1997 New York City Watershed Memorandum of Agreement, which outlines an ambitious and path-breaking program of source water protection, is a unique document in the history of water resource management. The MOA provides for an extraordinary financial and legal commitment from New York City to prevent existing and potential contaminants from reaching reservoirs; to monitor a broad range of water quality and drinking parameters; to conduct new research on public health and water quality; and to promote sustainable economic development and social well-being in the Catskill/Delaware watershed communities. The program it advances, like its sister program for metropolitan Boston, is a model for other public water suppliers. The goals and means of watershed management are essential whether or not New York ever turns to filtration. Indeed, systems that are now filtered, or will be filtered in the future, will find pollution control through watershed management indispensable to the cost-effectiveness of filtration. Now the proof of the pudding is in the eating: Will the city adhere to the rigorous set of commitments and funding outlays that the 1997 Memorandum of Agreement envisions?

Rutherford H. Platt is professor of geography and planning law at the University of Massachusetts at Amherst. He is involved in federal, state, and local programs concerning management of land and water resources and is author of *Disasters and Democracy: The Politics of Extreme Natural Events* (Island Press, Washington, D.C., 1999). He can be contacted at platt@geo.umass.edu. Paul K. Barten is associate professor of forest resources at the University of Massachusetts at Amherst. He focuses on forest and wetland hydrology and forest management in the United States and Canada. He cochairs the Quabbin Science and Technical Advisory Committee for metropolitan Boston. He can be contacted at pkbarten@forwild.umass.edu. Max J. Pfeffer is associate professor of sociology and faculty associate at the Center for the Environment at Cornell University. He focuses on environmental sociology, especially on the organization of watershed and protected area management. His ongoing projects include the Susquehanna River Basin, the Cerro Atul Meambay National Park in Honduras, and La Amistad International Park in Costa Rica. He can be contacted at mjp5@cornell.edu.

NOTES

1. N. F. Blake, *Water for the Cities: A History of the Urban Water Supply Problem in the United States* (Syracuse, N.Y.: Syracuse University Press, 1956); and C. H. Weidner, *Water for a City* (New Brunswick, N.J.: Rutgers University Press, 1974).

2. Hazen and Sawyer/Camp, Dresser, and McKee, *The New York City Water Supply System* (New York: Hazen and Sawyer/Camp, Dresser, and McKee, 1997).

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

4. R. H. Platt, "The 2020 Water Supply Study for Metropolitan Boston: Demise of Diversion," *Journal of the American Planning Association* 6, no. 2 (1995): 185–197; and R. H. Platt and V. L. Morrill, "Sustainable Water Supply Management in the United States: Experience in Metropolitan Boston, New York, and Denver," in D. Shrubsole and B. Mitchell, eds., *Practicing Sustainable Water Management: Canadian and International Experiences* (Cambridge, Ontario: Canadian Water Resources Association, 1997), 292–307.

5. C. J. Woltemade, "Environmental Impact Mitigation Under the Clean Water Act and the National Environmental Policy Act: The Case of the Two Forks Dam," *Water Resources Bulletin* 27, no. 2 (1991): 293–302.

6. Platt, note 4 above; and S. Postel, *Last Oasis: Facing Water Scarcity* (New York: W. W. Norton & Company, 1992).

7. B. Dezigielewski and D. B. Baumann, "The Benefits of Managing Urban Water Demands," *Environment*, November 1992, 6–11, 35–41.

8. W. S. Nechamen, S. Pacenka, and W. Liebold, *Assessment of New York City Residential Water Conservation Potential* (New York: N.Y.: Department. of Environmental Protection, 1995).

9. Hazen and Sawyer/Camp, Dresser, and McKee, note 2 above, page 11.

10. Significant population increase in the present service area is unlikely. During the 1970s, New York City lost 900,000 inhabitants, leaving 7.0 million city residents in 1980. With the improvement in the city's economy and an influx of new migrants, the city's population in 1990 stood at 7.3 million. Because the water system formerly served 8.0 million (prior to the demand management program), there is no reason to foresee any problem with meeting the expected demand of the city itself. Nor is it likely that the existing suburban user communities, which in 1995 aver-

aged 123 mgd in demand, will significantly increase in population or water usage. These are mostly older communities that are largely built out. While some intensification of residential development may occur through replacement of single family homes with higher density development, the net effect on the city's water system should not be significant. However, a probable source of increased demand on the New York City system would arise from the expansion of its service area to include communities and population currently served by other sources. This could occur if present sources become contaminated or insufficient to meet the needs of areas within potential reach of the city's distribution system (with installation of necessary connectors). Three possible areas of future shortfalls are Long Island, especially Nassau County; portions of Westchester or Putnam counties within reach of the city's aqueducts; and northern New Jersey.

11. National Research Council, *Watershed Management for Potable Water Supply: Assessing New York City's Approach* (Washington, D.C.: National Academy Press, 1999, forthcoming), 17.

12. P.L. 93-523, codified at 42 USCA Secs. 300f et seq.

13. National Research Council, note 3 above, page 80.

14. 40 Code of Federal Regulations (CFR), Sec. 141.71(b)(2).

15. In 1997, EPA published proposed amendments to the Surface Water Treatment Rule to regulate disinfection byproducts (DBPs) and *Cryptosporidium* to be phased in over several years. Federal Register 62, no. 212 (1997): 59388–58484.

16. The Croton River system filtration plant has been delayed by "not in my backyard" (NIMBY) objections and other problems, and the Justice Department in 1995 sued the city to force it to move ahead on that project.

17. Expert Panel on New York City's Water Supply, report, April 1993. The panel was strongly concerned about high levels of coliform in the city's critical Kensico Reservoir. Subsequent low-tech bird harassment there effectively eliminated the problem by shooing away geese. (The same method is practiced at Wachusett Reservoir in the metropolitan Boston system with excellent results.)

18. J. Schneeweiss, "Watershed Protection Strategies: A Case Study of the New York City Watershed in Light of the 1996 Amendments to the Safe Drinking Water Act," *Villanova Environmental Law Journal* 9 (1997): 77–119; and C. M. Finnegan, "New York City's Watershed Agreement: A Lesson in Sharing Responsibility," *Pace Environmental Law Review* 14 (1997): 577–644.

19. M. Reisner, *Cadillac Desert: The American West and Its Disappearing Desert*, (New York: Penguin Books, 1986).

20. Schneeweiss, note 18 above.

21. A 1905 state law gave broad power to the city over its upstate watersheds, including the right to enter private property without permission to inspect land use activities.

22. K. A. Stave, *Water, Land, and People: The Social Ecology of Conflict over New York City's Watershed Protection Efforts in the Catskill Mountain Region, New York* (New Haven: Yale University Graduate School, 1998).

23. M. J. Pfeffer and L. P. Wagenet, "Planning for Environmental Responsibility and Equity: A Critical Appraisal of Rural/Urban Relations in the New York City Watershed," in O. Furuseth and M. B. Lapping, eds., *Contested Countryside: The Rural Urban Fringe of North America* (Brookfield, Conn.: Ashgate, 1999).

24. Platt and Morrill, note 4 above, page 299.

25. New York State Real Property Tax Law, Title 4-A, "Assessment and Taxation of Watershed Easements Acquired by or on Behalf of the City of New York for Watershed Protection Services," and Title 5, "Assessment Procedures." This legislation provides that New York City pays taxes on all watershed protection easements. In addition, property owners paying taxes that do not take into account the watershed easements are entitled to reimbursements equivalent to any taxes paid by the city for the easements.

26. J. McLeod, "A Critique of Whole Farm Planning: Implications for Watershed Management," M.S. thesis, Department of City and Regional Planning, Cornell University.

27. Watershed Agricultural Council, *Pollution Prevention Through Effective Agricultural Management* (Walton, N.Y.: Watershed Agricultural Council, 1997).

28. H. O. Mohammed, S. E. Wade, and S. L. Schaaf, "Risk Factors Associated with *Crytosporidium Parvum* Infection in Dairy Cattle in Southeastern New York State," *Veterinary Parasitology* 83 (1999): 1–13; and S. E. Wade, H. O. Mohammed, and S. L. Schaaf, "Epidemeologic Study of Giardia SP. Infection in Dairy Cattle in Southeastern New York State," *Veterinary Parisitology*, 2000, in press.

29. A. C. Revkin, "A Billion-Dollar Plan to Clean the City's Water at Its Source," *New York Times*, 31 August 1997, A27.

30. Ibid.

31. R. F. Kennedy Jr., "Why New York's Water Supply Still Isn't Safe," *New York Times*, 14 November 1998.

32. A. C. Revkin, "City Comptroller Signs Off on Deal to Protect Water," *New York Times*, 8 April 1997, A1.

33. L. Ehlers, "New York City's Watershed Management Strategy," *WSTB Newsletter*, October/November 1999, 3.