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Watershed protection for a world city: the case of New York

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Abstract

New York City's water supply system provides 5 billion liters/day to 9 million people from unfiltered surface sources. Since the early 1990s, the city has avoided federal requirements to filter its drinking water for public health purposes. Filtration avoidance stems from an unprecedented experiment in watershed management that has significant effects on land use in rural source regions. This article examines the historic transformation of the institutional apparatus of New York's water supply system and the land-use implications of its watershed protection program. Emphasis is placed on the multiple stakeholders who negotiate disparate interests concerning water supply, economic development, and environmental stewardship.

Keywords: Water supply; New York City; Watershed management

Introduction

The New York City water supply system is a fascinating subject for geographers and urban and regional planners. In technological and political terms, the system is a testament to successful urban development planning on a massive scale. Without an abundant and reliable source of pure, clean water, the city would not have been able to attain such phenomenal growth over the last two centuries. A complex network of reservoirs, aqueducts, tunnels, and pipes supplies about 5 billion liters of water daily to over 9 million consumers in the City of New York and several suburban counties. Although the system functions remarkably well, it does have its problems. Much of the infrastructure is aged, over 100 years in some instances, and in need of maintenance and repair. Although the yield of potable water is more than adequate for such a large population, concerns have been raised during the last 10–15 years as to the ability of the city to maintain water quality. Threats to water quality, both present and projected, have provoked a spate of activity to renovate the system's infrastructure and reorganize its management.

One remarkable aspect of New York's water supply system is the fact that it is one of the few of its size in the United States to provide water from an unfiltered surface source. Although federal regulations require most municipal suppliers to filter drinking water from surface sources in order to protect public health, the City of New York has so far avoided the significant investment associated with filtration. The city has done so by convincing the United States Environmental Protection Agency (EPA) that it has put in place a watershed management program that can safeguard public health from waterborne disease. This program has numerous implications for land use in the upstate watershed regions. In light of the concerns regarding water quality, this article explores the implications for land use in the watersheds that stem from changes in how the system is now managed and regulated.

The article is organized into four sections. The first section sketches a brief history of the New York City water supply system in the context of the significant transformation it has undergone from a centralized, technocratic waterworks operation to a complex institutional apparatus for integrated watershed management. The second section introduces the regulatory and management schemes that are in place to protect water quality. The third section describes a number of key land-use mechanisms in the city's long-term watershed protection plan. The last section discusses the constraints and opportunities for watershed stakeholders that flow from these mechanisms.

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From waterworks to watersheds

The history of New York's water supply system is recounted in many interesting publications (Galusha, 1999; Hall, 1993; Koeppel, 2000; Steuding, 1995; Weidner, 1974), and one cannot help but be impressed with the architectural, engineering, and political achievements reflected in its creation. In the early 19th century, New Yorkers endured grave social and economic losses as a result of devastating fires and cholera epidemics that compelled city leaders to embark upon an ambitious project to improve what was then an inadequate mix of public and private water supplies. Construction of the original Croton Dam, located on the Croton River some 65 km north of the city (Figs. 1 and 2), and the remarkable aqueduct that first brought Croton water to New York in 1842, ushered in an era of technocratic, centralized control over municipal waterworks. For well over the next 100 years, city politicians and engineers, backed by the New York State Legislature, presided over the construction of an expansive system designed to quench the thirst, safeguard the health, and assure the vitality of a rapidly growing industrial metropolis (Table 1).

While expanding its water supply system, the City of New York acquired the political and financial clout required to tap this most essential of natural resources from the far reaches of its rural hinterland. Accounts of the socioeconomic impact of this expansion on upstate communities (Galusha, 1999; Stave, 1999; Weidner, 1974) detail a situation characteristic of what Steinberg and Clark (1999) refer to as a critical water resource conflict narrative. This narrative describes the nature of social relations between a powerful and "superior" place, i.e., the city, and how it "dominates, disrupts, and extracts resources from a subordinate place", i.e., the countryside, by "physically uprooting its population, flooding its land, and destroying the livelihoods of its people" (Steinberg and Clark, 1999, p. 477). Although the authors point out that circumstances surrounding the critical water resource conflict narrative are often quite complex and nuanced, the case of New York City's historic quest to secure a reliable and plentiful source of water underscores the essential, longstanding, and sometimes contentious dynamics of water supply and urban development (Blake, 1956; Havlick, 1974; Swyngedouw et al., 2002).

At the close of the 19th century New York was firmly positioned as the nation's leading commercial and industrial center, and in 1898 the city expanded its territory and population by incorporating all five present-day boroughs into one political entity. Consequently, City Hall suddenly found itself with an even larger water supply challenge than the one it encountered several decades earlier. The challenge was met in part by an act of the State Legislature in 1905 that provided for the establishment of the New York City Board of Water Supply (Weidner, 1974). Significantly, the Board was granted powers to secure private land outside city limits by eminent domain, and it used them effectively to expand the water supply infrastructure first in the Catskill Mountains and later in the Delaware River watersheds (Fig. 3 and Table 1). Gandy (2002, p. 45) describes these developments in the context of "an emerging political ecology of power [that] linked the city to an ever greater swathe of upstate land as part of a giant metabolic urban system". His organic analogy echoes Swyngedouw and Kaika's (2000, pp. 567, 577) notion that cities represent a "process of [the] urbanization of nature" in which there is "perpetual [and contested] metabolic socioecological change".

Access to and control over the relatively unspoiled upstate watersheds in the early 20th century allowed the city to postpone dealing with emerging concerns about water quality degradation in the older Croton system and instead concentrate on the technical and engineering tasks of expanding its hydrological footprint to tap more distant yet cleaner sources of water. It would take almost the remainder of the 20th century before the parameters of this political ecology evolved to alter the "power geometries" between city and countryside driving the socioecological changes that attend the urbanization process (Swyngedouw et al., 2002). In the meantime, city politicians and engineers supervised one of the world's most impressive waterworks projects ever undertaken.

Recent changes in the political ecology of urban water supply in the United States derive in part from the enactment of landmark environmental legislation in the 1970s. With respect to drinking water, the key federal law is the Safe Drinking Water Act (SDWA) of 1974 which established national standards for public water supply systems (Dzurik, 1996; Melosi, 2000). Contemporary environmental laws and regulations, together with a new emphasis on integrated, watershed-level ecosystem management (Foran et al., 2000; Ruhl, 1999), have altered the circumstances under which New York City manages its water supply. Given certain environmental, political, and financial imperatives, the city is no longer in a position to rely on system expansion or technical engineering solutions alone to provide potable water that meets legally mandated quality standards. Its power to act with the backing of the state has been curtailed by the imposition of a new paradigm that forces the city to negotiate in a far more complex institutional arena with a much larger number of stakeholders representing quite diverse interests. As Gandy (2002, p. 68) points out, "in the place of a relatively centralized, ossified, and nonparticipatory regulatory system, the watershed is now overseen by a complex and dynamic jigsaw puzzle of different interest

Fig. 1. New York City water supply system.

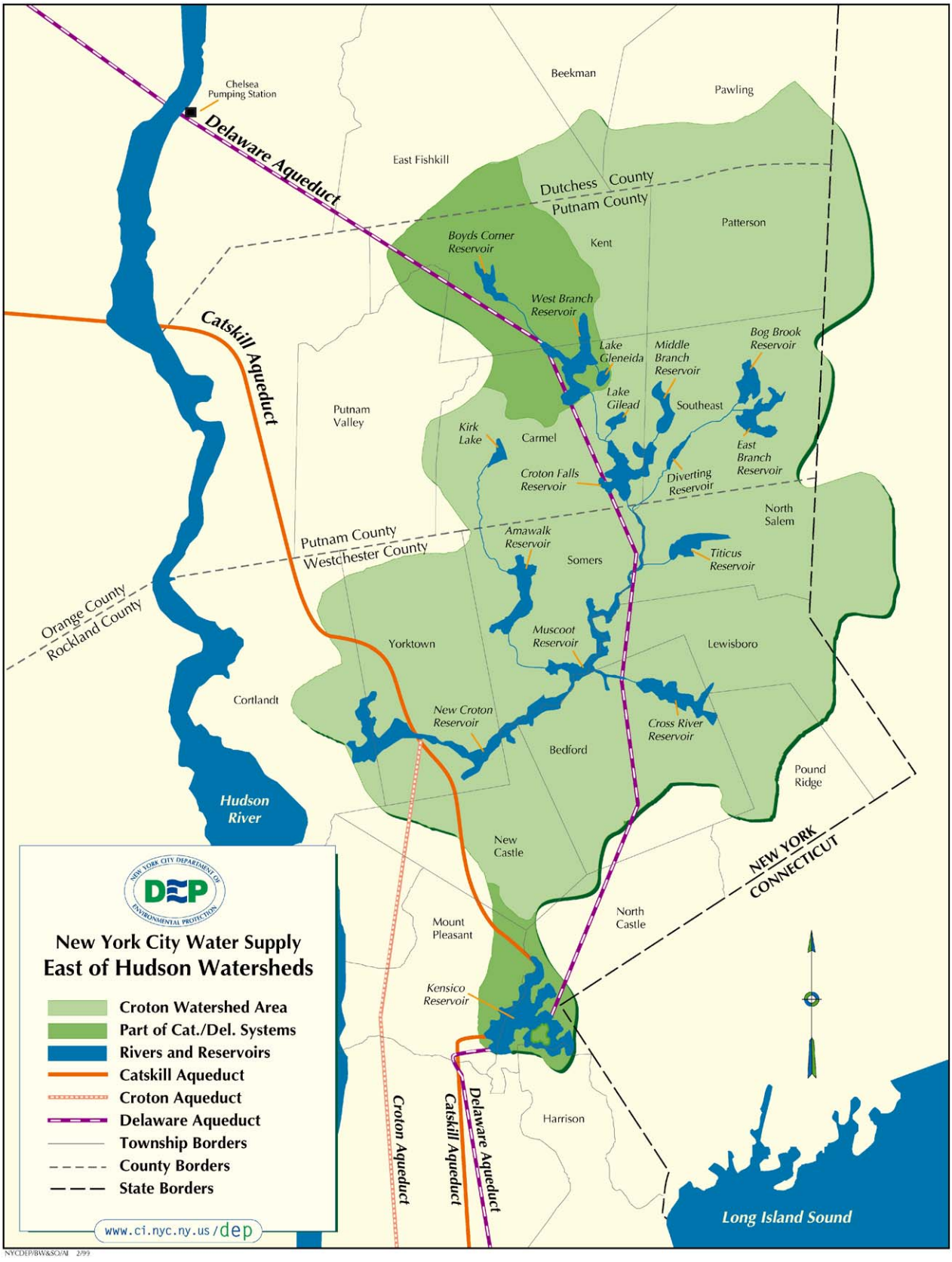

Fig. 2. Croton watershed.

Table 1
New York City water supply watersheds

Watershed/ Reservoir	Date in service	Drainage basin (km^2)	Storage capacity ($10^6 m^3$)	Percent of daily supply	Permanent population in 1990[a]	Population per km^2	Land use (% of total land area)
Croton system		967.1	331.4	10	132,000	136	Croton watershed
12 Reservoirs[b]	1842						Agriculture 6%
3 Controlled lakes	to						(including 250 agricultural operations: nurseries,
	1911						greenhouses, horse farms & silviculture)
							Residential 40%
							Industrial/Commercial 10%
							Private and public recreation 14%
							Undeveloped 30%
Catskill system		1479.0	558.4	40	36,000	24	Catskill/Delaware watersheds
Ashokan	1915	665.7	484.2				Agriculture 5%
Schoharie	1926	813.3	74.2				(including about 350 dairy & livestock farms)
							Forests 68%
Delaware system		2616.0	1233.6	50	45,000	17	Residential 17%
							Industrial/Commercial/Government 1%
Cannonsville	1964	1165.5	366.1				Vacant land 9% (mostly abandoned farmland)
Neversink	1954	240.9	134.2				
Pepacton	1955	963.5	543.9				
Rondout	1950	246.1	189.4				
Other reservoirs[c]							Kensico basin
Kensico	1915	34.4	115.8		5500	160	Residential 29%; Industrial/Commercial 20%;
Hillview	1915	n.a.[d]	3.4				Open space[e] 39%; Undeveloped 12%
Jerome Park	1905	n.a.[d]	3.0				

Source: Data compiled by author from Marx and Goldstein (1999), NRC (2000), NYCDEP (2000), WAC (2003), and Westchester County Department of Planning (1999).

Notes:

[a] Data are for population within watershed boundaries. Permanent population in the Croton watershed can be assumed to have risen significantly as US Census Bureau reports a 14.1% increase in Putnam County's population between 1990–2000, and over 50% of the watershed's land area lies in this county. DEP recently estimated Croton watershed population at 190,000 (NYCDEP, 2003). In Catskill/Delaware watershed counties, average population change-over the same period is closer to the state average of 5.5%. Some sources report seasonal population in the Catskill/Delaware watersheds, including tourists and second homeowners, is as high as 200,000 (NRC, 2000, 5).

[b] Water stored in two reservoirs, Boyd's Corner and West Branch, is primarily received from and continues through the Delaware aqueduct rather than being allowed to flow through the interconnected Croton System. Although physically located in the Croton watershed, these reservoirs and their sub-basins are effectively part of the Catskill/Delaware system (see Fig. 2).

[c] Storage and balancing reservoirs located outside the three principal watersheds. Kensico and Hillview receive Catskill/Delaware water and Jerome Park receives Croton water before entering the city's distribution system.

[d] Hillview and Jerome Park reservoirs are concrete-lined structures with no drainage basins.

[e] Includes potentially developable properties such as land belonging to private clubs, public and private institutions, and public non-park land (Marx and Goldstein, 1999).

groups ranging from upstate lumber companies to city-based ecologists''.

Since the early 1990s, the city agency responsible for the water supply system—now the Department of Environmental Protection (DEP)—has confronted major challenges to its traditional role of hydraulic engineer par excellence. Today, the DEP finds itself having to assume a broader set of responsibilities that also require it to be an effective real estate agent, land manager, regional economic development planner, and environmental educator. In plotting strategy to secure and maintain filtration avoidance status under the SDWA for the large majority of the water supply that originates in the Catskill/Delaware watersheds, as discussed in the next section, the DEP has been criticized by real estate, construction, commercial, homeowner, and environmental organizations for being either too severe or too lax in the implementation of its new watershed regulation and stewardship responsibilities. As Pfeffer and Wagenet (1999) explain, both the City of New York and various stakeholders in upstate watershed communities are rediscovering the inextricable linkages that bind rural and urban regions together in mutually dependent, although not always mutually beneficial, relationships. According to Gandy (2002, p. 65), ''the dilemma facing the city is whether filtration can be avoided for the Catskill/Delaware system without undermining regional development for some of the poorest communities in upstate New York''. Responses to the challenge of implementing effective and equitable strategies to meet

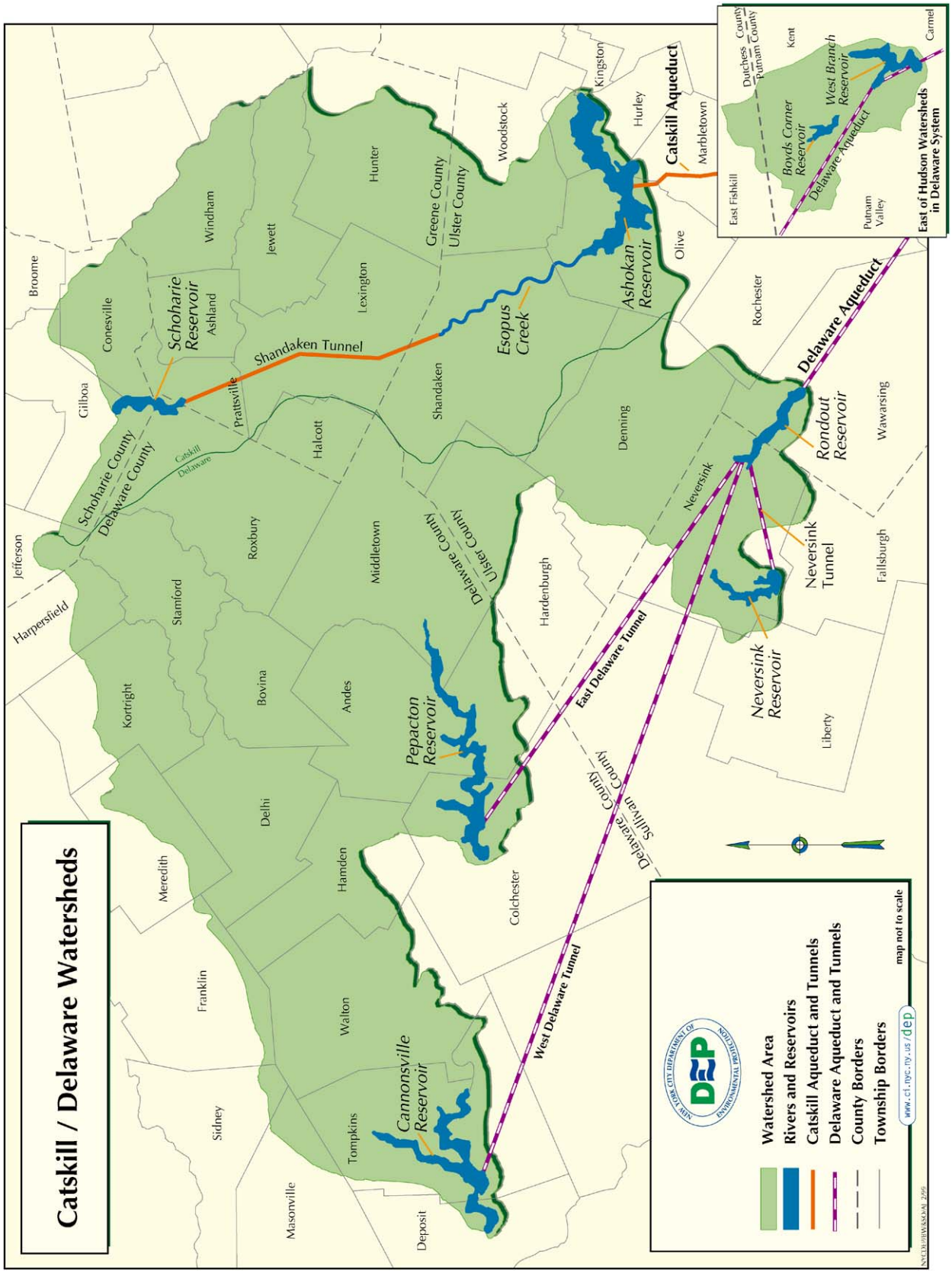

Fig. 3. Catskill/Delaware watersheds.

Table 2
Major provisions of the 1997 MOA

Provision	Programmatic components	Funds committed
Land acquisition	Purchase undeveloped lands deemed hydrologically sensitive for water quality purposes in the three watersheds. Land acquisition is sought on both fee simple and conservation easement bases.	$250 million for the West-of-Hudson watersheds (with possible extension to $300 million). $13 million from New York City and $7.5 million from New York State for the East-of-Hudson watershed.
Watershed rules and regulations	New legislation to work in conjunction with existing state and federal regulations to protect water quality in NYC watersheds in regard to the following activities: • Wastewater treatment plants • Subsurface sewage treatment systems • Stormwater controls • Hazardous substances and wastes • Petroleum products • Solid waste disposal • Agricultural practices • Pesticides and fertilizers • Pathogenic materials • Snow-melt materials	
Watershed protection and partnership programs	Provides for watershed-wide cooperation and planning. Establishes the Watershed Protection and Partnership Council and the Catskill Watershed Corporation. Programs include: • New sewage treatment infrastructure • Regional economic development planning • Stormwater pollution prevention programs • Septic system rehabilitation and replacement • Sand and salt storage facility improvements • Stream bank stabilization programs • Public education and outreach activities • Watershed Agricultural Program • Watershed Forestry Program	$240 million for West-of-Hudson programs; $70 million for East-of-Hudson programs. $60 million Catskill Fund for the Future, an economic development "bank" for environmentally sensitive projects in the West-of-Hudson region. $35 million for Watershed Agricultural Program

Source: Compiled by author from NRC (2000), Budrock (1997), NYCDEP (2001a) and personal communication, DEP Land Acquisition Program, May 2003.

both economic goals and environmental responsibilities are now unfolding for all to observe as city and countryside engage in a natural resources planning experiment of unprecedented proportion.

Filtration avoidance and the memorandum of agreement (MOA)

Although never acted upon because cleaner, more distant water sources together with chemical treatment obviated further consideration at the time, concerns about water quality degradation in New York's Croton watershed led some officials to advocate for filtration as early as the late 1800s (Iwan, 1987; Gandy, 2002). Remaining dormant for the better part of a century, the question of whether New York City's expanded water supply requires filtration was revived when the EPA promulgated the 1989 Surface Water Treatment Rule (SWTR) under the SDWA. The SWTR established new criteria for filtration and disinfection treatment processes of public water supplies obtained from surface sources to protect public health from pathogens such as *Giardia* and viruses (NRC, 2000). For suppliers whose treatment regimes did not include filtration when the SWTR came into effect, the EPA has the discretion to issue a filtration avoidance determination (FAD) which provides relief from the requirement to install filtration technology if the supplier demonstrates that water quality criteria can be met without filtration (USEPA, 2002). In addition to New York, only nine other major cities in the United States currently obtain their water supply from surface sources under the provisions of a filtration waiver.[1]

[1] Of the 235 public water suppliers serving populations greater than 100,000, the 10 with filtration waivers are New York City, New Rochelle (New York), Yonkers (New York), Syracuse (New York),

Filtration avoidance is now a major preoccupation of the New York City DEP. Since the early 1990s, the city has faced federal and state pressure to build filtration facilities based on assumptions that its aging water supply infrastructure, together with development trends in the watershed, will eventually compromise drinking water quality and perhaps endanger public health. For the portion of its water supply that originates in the West-of-Hudson Catskill/Delaware watersheds, the city has so far managed to obtain a series of filtration avoidance determinations from the EPA, including a recent renewal through 2007 (USEPA, 2002).[2] The FADs allow the city to avert having to invest in a Catskill/Delaware filtration facility, estimates for which run to approximately $US 6 billion for design and construction and $US 300 million in annual operating expenses (Hu, 2000; NRC, 2000). In large part, continued filtration avoidance for the West-of-Hudson systems is based on an ambitious watershed management plan outlined in the 1997 MOA, a document signed by the City and State of New York, the EPA, 73 local municipalities and eight counties in the watersheds, and five environmental organizations.

The MOA is a landmark in the history of the New York City water supply system, and it is difficult to underestimate its significance and the contentious, yet ultimately successful negotiation process it represents. The MOA process dates from 1990 when the DEP released draft land-use regulations intended to satisfy requirements for filtration avoidance under the EPA's SWTR, provoking a strong response from the West-of-Hudson upstate communities (Berger, 1995). Recalling the bitter history of the city's quest for water at the beginning of the 1900s, and troubled by uncertainty as to whether the DEP would again seek to invoke powers of eminent domain to acquire land in the watershed, upstate communities were concerned about the impact the city's new regulations might have on local economic development and land-use control (Stave, 1999; Pfeffer and Wagenet, 1999). Once again, residents feared that their communities would bear the costs of assuring New York City's clean water supply while gaining very little in return for their trouble.

The MOA outlines a broad array of measures to protect the quality of water in the city's Catskill/Delaware watersheds. It does this through a three-pronged approach that includes a land acquisition program, new water supply rules and regulations, and a suite of watershed protection and partnerships programs (Table 2). The protection and partnership programs include a number of mechanisms through which the city agrees to invest substantial resources in the upstate communities not only for direct watershed protection measures, but also for environmentally sensitive economic development (Platt et al., 2000; NYCDEP, 1999). This investment represents an explicit recognition on the part of New York City that just compensation to rural communities for the opportunity costs associated with implementing more stringent watershed regulations is imperative if it seeks long-term water supply protection and filtration avoidance (Pfeffer and Wagenet, 1999).

In a comprehensive analysis of New York City's watershed management plan, a National Research Council committee highlights two major strategies, viz. structural and nonstructural, for water quality protection. Structural strategies, such as wastewater treatment facilities or pollution control best management practices (BMPs), are geared toward mitigating pollution from extant sources in a watershed while nonstructural strategies are designed to prevent or reduce potential pollution discharges from future sources (NRC, 2000). Examples of nonstructural approaches include land acquisition, buffer zone designations, conservation easements, and zoning ordinances. Whereas structural strategies involve mostly physical or technical approaches to watershed management, nonstructural approaches concern institutional and policy arrangements that are closely related to land use and economic development planning. Although it provides for certain structural interventions, the MOA emphasizes implementation of nonstructural approaches to water quality protection that have a direct bearing on land use policy in the New York City watersheds. The pursuit of water quality protection through such measures requires careful consideration of the potential costs and benefits to various stakeholders with interests in the region.

Land use implications of watershed management

Since a complete review of the suite of nonstructural strategies for watershed management is beyond the scope of this article, attention here is focused on several major mechanisms directly related to land use policy. Foremost among these are land acquisition, conservation easements, setbacks and buffer zones, and land trusts. What follows is a general description of the rationale behind each strategy. Details of the implications of these mechanisms are discussed in the last section of the paper.

(*footnote continued*)
San Francisco (California), Tacoma (Washington), Seattle (Washington), Portland (Oregon), Portland (Maine), and Boston (Massachusetts). New Rochelle and Yonkers tap into New York's Catskill/Delaware system. (Personal communication, NYC Watershed Office, EPA Region 2, New York City, February 2003; MDC, 2003.)

[2] In 1997, the federal government sued the city for failure to move forward with filtration of the East-of-Hudson Croton portion of the water supply in accordance with the SWTR (USEPA, 1997). Now under a court order to proceed with Croton filtration, the city is presently engaged in a politically charged debate over where to site the eventual water treatment facility (Purnick, 2003).

Land acquisition

Compared to most of the other large urban systems in the United States that obtain water from surface sources under a filtration waiver, the City of New York owns a relatively small proportion of land within its water supply watershed.[3] Prior to the 1997 MOA, the city owned only about 6% of the land (approximately 25,225 ha) in the West-of-Hudson Catskill/Delaware watersheds, with 42% of this total attributed to the land submerged under the reservoirs. Of the remaining West-of-Hudson lands, 74% is in private ownership and 20% is owned by the State of New York (NRC, 2000; USEPA, 2000).

The MOA stipulates that the city will actively seek to increase its landholdings within the watershed by soliciting the purchase of undeveloped parcels deemed hydrologically sensitive, i.e., where there is a significant threat of water quality degradation. The city is authorized to purchase land outside its municipal borders under a water supply permit issued by the New York State Department of Environmental Conservation (USEPA, 2000). A prioritization scheme is in place to guide the acquisition process, based primarily on proximity measures to reservoirs, watercourses, and distribution system intakes, together with slope and potential land-use characteristics. Acquisition can take place through either the purchase of fee simple interest in land or in the form of various types of conservation easements. The acquisition of undeveloped land, to be held as such in perpetuity, is seen as one of the most effective strategies the DEP can employ to protect the water supply from the threat of future degradation.

A significant element of the land acquisition plan as set forth in the MOA is an agreement by the city to purchase land only on a voluntary, willing buyer–willing seller basis, and at fair market value as determined by an independent appraiser. The city's assurance that it will not acquire land through condemnation and eminent domain, which it has the power to do under New York State health law, is considered by many as the decisive concession that brought all parties to finally sign the MOA (personal communication, NYCDEP general counsel, March 2002). Naturally, however, as will be discussed below, this concession affects the city's ability to bring more land under its control. Under the MOA, the city agreed to solicit for purchase 143,745 ha of land over 10 years in the Catskill/Delaware watersheds, committing $US 250 million to do so (NRC, 2000). The 10-year solicitation goal is ambitious, representing approximately one-third of the total land area of the Catskill–Delaware watersheds and about two-thirds of the land area that is deemed eligible for acquisition under the terms of the MOA, respectively (USEPA, 2000). The city also seeks to acquire land in the more developed and hydrologically sensitive Croton watershed, and has committed $US 13 million for this purpose (NYCDEP, 2002a).

Conservation easements

As an alternative to outright fee simple purchase of land, the New York City DEP offers watershed landowners the opportunity to sell some of their property's development rights under the terms of a conservation easement (NYCDEP, 2001b). Conservation easements are designed to appeal to landowners who may not wish to sell their property outright, but who would be interested in deriving some financial and tax advantages by forgoing certain use rights on a portion of their land. Easements allow landowners to retain rights to limited types of activities, for example passive recreational use and forestry under approved management plans, while restricting other uses that could jeopardize water quality such as expansion of impervious surfaces. Landowners retain all rights to sell or otherwise transfer the associated "fee" property. The city pays landowners a purchase price for the development rights, determined by an independent appraiser, that is equivalent to the difference in the land's value before versus after the easement comes into effect. The city also pays assessed property taxes on the proportional value of the easement relative to the full value of the property. The DEP's goal here is of course to promote water quality protection by increasing the land area over which it can control potentially threatening development in hydrologically sensitive areas. Recent data indicate that the agency has acquired, or has under contract to acquire, over 1800 ha in conservation easements as of May 2003.[4]

In the agricultural sector, where farming and forestry figure prominently in the economic base of the West-of-Hudson Catskill/Delaware region, a separate conservation easement program was initiated in 1999 under the auspices of the Watershed Agricultural Council (WAC), a nonprofit agency that assists the agricultural

[3] See footnote 1. Some examples of land ownership in other major water supplies include: Seattle and Portland (Oregon) where all watershed land (nearly 37,000 and 26,500 ha, respectively) is publicly owned and tightly controlled (SPU, 2003; City of Portland, 2003); Boston where the water supplier owns about 27% of its watershed area [land area and reservoir surfaces] (MDC, 1999); and San Francisco, with 85% of the water supply derived from watershed lands located in Yosemite National Park where conventional development pressures are obviously minimized (SFPUC, 2003).

[4] Unless otherwise specified, all data reported here on acquired land area, whether in fee simple purchase or conservation easement, were current at the time this article was submitted for publication and provided via personal communication courtesy of the director of the NYCDEP Land Acquisition Program.

community with implementation of economically viable watershed protection practices. Under the provisions of the Agricultural Conservation Easement program, watershed farmers who participate in the WAC's Whole Farm Planning process are eligible to sell development rights on land they own, which provides cash income to the farmer and in turn helps to preserve open space and protect the water supply (WAC, 2001). As of May, 2003, the DEP reports having approximately 1375 ha under agricultural easements.

Setbacks and buffer zones

Setbacks and buffer zones act to put a certain distance and/or an active barrier between pollutants, such as chemical-laden runoff from impervious surfaces or agricultural land, and watercourses that are tributary to the drinking water supply. A setback is simply a measured distance, usually specified in local zoning ordinances, that separates the site of a potential source of pollution from any nearby waterway deemed sensitive for water supply purposes. A riparian buffer zone, on the other hand, is an area of land, usually a vegetated strip of some determined width, adjacent to a watercourse and purposefully designed to act as a physical barrier or filter where contaminants from tainted runoff are either stored or transformed before the water is discharged into a stream, lake, reservoir, or wetland area (Nieswand et al., 1990; Whipple, 1993). Buffers, particularly ones in their naturally vegetated state, play a significant role in mitigating adverse impacts on water quality due to development activity. They also play an important role in attenuating the erosive and polluting effects of stormwater runoff, a major problem in the New York City watersheds.

On agricultural lands, buffers are promoted through the Conservation Reserve Enhancement Program (CREP), co-sponsored in part by the US Department of Agriculture and New York City DEP through the WAC (WAC, 2002a). The CREP is designed to establish riparian buffer zones by compensating farmers who agree to temporarily "retire" environmentally sensitive cropland on their property. The CREP works by making long-term (10–15 years) annual rental payments to farmers for the portion of their land enrolled in the program, and reimbursing them for BMPs such as livestock fencing, vegetation plantings, and the development of alternative on farm water sources. The program also targets landowners in forested areas and forest products businesses to enlist their participation in developing riparian buffers, particularly in active logging areas (NYCDEP, 2001a). Since 1998, the CREP has enrolled about 400 ha in stream buffers, translating into approximately 480 km of buffered watercourses (NYCDEP, 2002b).

Land trusts

A land trust is "a nonprofit legal entity established under state law that buys, manages, and occasionally sells or leases interests in undeveloped real estate" (NRC, 2000: 286). It is often used to preserve open space for uses such as public recreation, wildlife habitat, wetland preservation and flood control, agriculture, or some other natural resource use (Whittaker, 1999). Most land trusts are managed by small, private, local grassroots organizations. Nationally, the land trust movement in the United States is represented by The Trust for Public Land (TPL) which, among other projects, focuses attention on the connection between land conservation and watershed protection (TPL, 1997, 2000). In the case of the New York City watershed, the TPL, a signatory to the MOA, has helped to acquire over 280 ha of land in the Catskill/Delaware watersheds and almost 325 ha in Putnam County in the East-of-Hudson watershed (NRC, 2000).

The creation of a Catskill/Delaware land trust is among the recommendations made by the National Research Council in its assessment of the New York City water supply system (NRC, 2000). The NRC noted, as has the EPA, that current DEP land acquisition and management procedures often tend to be unduly cumbersome and time-consuming, and that land trusts may be able to work more flexibly and expeditiously to help place undeveloped land under protected status. Although the national TPL is already involved in the New York City watershed, the NRC recommendation encourages more involvement on the part of local land trusts, perhaps working under the auspices of the Catskill Watershed Corporation, a nonprofit agency established under the MOA to implement and manage watershed protection programs in the West-of-Hudson region. Indeed, there are a number of local organizations already involved with various land trusts in the Catskill region. However, the degree to which these organizations work in a coordinated fashion to advance the goal of watershed protection is unclear. Curiously, the DEP's long-term watershed protection plan is silent on the issue of collaboration with land trusts. As discussed below, the land trust concept, while having certain advantages for land and water conservation, also presents certain challenges and disadvantages that may make its application to watershed protection on a large scale somewhat problematic.

Discussion

Although the provisions of the 1997 MOA have enormous potential to protect water quality and promote environmental conservation, efforts to attain these goals must take into consideration their inherent

Table 3
Land acquisition in the Catskill/Delaware watersheds[a]

Date	Solicitation goal (ha)	Contracts closed (ha)	Contracts pending (ha) (%)	Success rate[b]
November 2001	109,410	7213	6457[c]	12.5
By priority area[d]				
1A/1B	26,904	9572	1494	20.0
2	17,135	4697	723	15.3
3	24,957	1112	2635	12.4
4	40,414	2434	1594	6.4
May 2003	123,887	33,338	5531	15.4

Source: Compiled by author from Tables 2.2, 2.3, and 2.5 in NYCDEP (2001a), and personal communication from DEP Land Acquisition Program, May 2003.
Notes:
[a] November 2001 data represent land acquisition status at end of Year-5 of the 1997–2002 FAD as reported in DEP's application for FAD renewal submitted to the EPA in December 2001; updated May 2003 unpublished data courtesy of DEP Land Acquisition Program.
[b] DEP defines success rate as contracts closed + contracts pending/solicitation goal.
[c] The 11 ha discrepancy in the contracts pending total for November 2001 (6457) and the sum of contracts pending by priority area (6446) is reportedly due to exclusion of agricultural easements in the priority areas not tabulated in Table 2.5 of NYCDEP (2001a). Contracts closed total for priority areas does not equal November 2001 total due to rounding.
[d] Priority area definitions:

1A/1B: Sub-basins within 60 day travel time to distribution system near intakes/not near intakes
2: Sub-basins with terminal reservoir basins not within areas 1A and 1B, but linked directly to distribution system (these include the Ashokan and Rondout Reservoirs)
3: Sub-basins with identified water quality problems not in areas 1A, 1B or 2
4: All remaining sub-basins in non-terminal reservoir basins

costs to local communities. In these matters, financial and social equity concerns deserve due consideration, particularly in cases where historical animosities can possibly derail well-intentioned proposals. Finding ways to successfully negotiate solutions to watershed management problems that are mutually beneficial to both the City of New York and diverse stakeholders in the upstate communities is one of the most interesting aspects of the experiment in environmental stewardship now taking place in New York City's watersheds. The following discussion considers the land-use mechanisms outlined above in the context of the constraints and opportunities they entail for water supply protection and the socioeconomic vitality of watershed communities.

Although the city's land acquisition program has shown progress toward the goal of protecting water quality, there are some concerns about the pace of acquisition and the long-term implications for the future economic well-being of watershed communities. These concerns revolve primarily around issues such as the distinction between solicitation and actual acquisition of land, and the all-important question of property taxes. Although actual land acquisition (i.e., ownership) is not stipulated in either the MOA or the FAD—only the solicitation to purchase is required—the EPA does consider progress in concluding purchase contracts a strong indicator of the city's overall performance in watershed protection. In its 2000 mid-term evaluation of the 1997–2002 FAD, the agency criticized the city for delays in closing on land it has under purchase contract and recommended that the DEP work to streamline the acquisition process (USEPA, 2000). There are any number of reasons for such delays, including flagging interest on the part of landowners or bureaucratic obstacles such as defects in land titles, that preclude closing on purchase contracts before they expire. Nevertheless, the city has endeavored with due diligence to meet the solicitation goals spelled out in the MOA and was indeed able to certify in its December 2001 application for FAD renewal that it had met all solicitation milestones at that time (NYCDEP, 2001a). While acknowledging this progress, one must also recognize the distinction between simply soliciting a landowner's interest in selling land and ultimately placing land under city ownership for long-term watershed protection.

An analysis of the city's progress to date with land acquisition reveals the complicated process involved in securing ownership and the tentative nature of reporting on such progress. For example, as of November 2001, DEP data indicated that a total of 109,410 ha had been solicited for purchase through the fifth year of the 1997–2002 FAD, representing 100% of the solicitation target at that time (Table 3). Of this total, 13,670 ha, 12.5% of the solicitation target, were either acquired or under

purchase contract. The DEP refers to this figure as its "success rate" in land acquisition. More recent figures from the DEP Land Acquisition Program indicate that, as of May 2003, the success rate climbed to 15.4%.[5] Significantly, success rates are higher in the more hydrologically sensitive areas of the acquisition priority scheme, reflecting concerted effort to obtain land in vulnerable locations close to the distribution system. Indeed, in one particular case the DEP achieved remarkable progress with 38% of solicited land area under ownership in the high priority West Branch basin located in a part of the East-of-Hudson Croton watershed through which passes one-half of the city's daily supply delivered from the West-of-Hudson Delaware watershed. Impressive gains in the West Branch basin notwithstanding, the general conclusions one can draw about land acquisition at the present time are necessarily tentative because of the constantly changing status of various parcels under negotiation, the lag time between signing and closing on purchase contracts, and the ongoing nature of the program itself. At best, current data offer only a snapshot in time of program results, and more conclusive determinations must wait until the end of the initial 10-year MOA planning horizon in 2007. In the meantime, observers would do well to acknowledge that reporting on progress in land acquisition is dependent on how, where, and when one defines success.

The complicated nature of land acquisition for water quality protection continues to stir passionate debate among watershed stakeholders. In the early 1990s prior to the MOA, the city's plans to acquire more upstate land aroused staunch opposition in watershed communities. Events led a coalition of several townships to challenge in court what they perceived to be an imminent attack on constitutionally protected rights against the taking of private property without just compensation if the city were to exercise its power of eminent domain (Pfeffer and Wagenet, 1999; Stave, 1999). More recently, at the city end of the pipeline, the condemnation versus willing-seller debate resurfaced once again, suggesting that some quarters would still prefer to take a more aggressive stance on acquisition. At a June, 2002, New York City Council Environmental Protection Committee hearing to discuss the EPA's proposed reauthorization of the Catskill/Delaware FAD, a council member from Manhattan demanded to know why the federal agency simply does not insist upon actual acquisition milestones instead of mere solicitation goals, proffering her opinion that such targets should have been built into the 1997 FAD in the first place (Lopez, 2002). In response, EPA representatives reminded the Committee that the MOA/FAD process stipulates that the city will endeavor to acquire land only on a willing buyer–willing seller basis. The exchange helped to remind observers of the contested nature of land acquisition in the watershed. Indeed, what would the establishment of "deliverable" acquisition milestones in effect be saying to upstate watershed communities about the city's agreement not to employ the tools of eminent domain?

Taxes are another issue that can complicate land acquisition efforts. Under the terms of the MOA, New York City is acting in good faith by purchasing land and conservation easements at fair market value and paying taxes on the acquired land or the apportioned development rights. Uncertainties remain, however, over the impact lost development rights might eventually have on local communities as more undeveloped land becomes property of the City of New York to be left undeveloped and hence in a lower tax category (NRC, 2000). In a region with a relatively small economic base, and where real estate taxes are an important component of local government revenue, many municipalities have legitimate concerns about potential losses to future revenue streams through unrealized property and other taxes. There are also reservations about the potential loss of future business and employment opportunities that could stem from arrested development in the region. In recognition of these issues, the MOA provides for a number of financial mechanisms, such as the $60 million Catskill Fund for the Future—an economic development "bank" that supports environmentally sustainable projects in West-of-Hudson watershed communities—to help mitigate the costs associated with maintaining land in an undeveloped state.

Tax considerations are also important in cases where land preservation is achieved through acquisition by land trusts, whose nonprofit status relieves them of tax obligations. As Whittaker (1999) points out, land preservation schemes often involve tradeoffs with implications for local finances and social equity. For example, although lower tax revenue for local municipal coffers due to land preservation can increase the tax burden among other property owners, preservation also has the potential to enhance land values and, consequently, tax revenue by protecting the aesthetic qualities of open space that many property owners find attractive, especially in rural areas located within easy reach of large cities.

In addition to the tax considerations, land trusts raise several other important issues when considering their advantages and constraints as tools for watershed protection. It has been noted that given their private, nonprofit status, land trusts are often able to take action on land preservation unencumbered by the multiple levels of bureaucracy that large government entities such

[5] DEP reports land as "acquired" even if closings on purchase contracts are still pending. Based on land acquired only after contracts closed, the success rates in November 2001 and May 2003 would have been 6.6% and 10.9%, respectively.

as the New York City DEP must navigate. As suggested by the NRC (2000) study, land trusts have the capacity to act swiftly in the negotiating process, and can either hold land themselves, or play the role of a temporary steward or guardian for governmental agencies that may be either ensnared in bureaucratic red tape or unable to authorize immediate spending for land preservation. This flexibility may also prove useful in instances where land parcels are particularly small, typically less than 4 ha, which in the case of the New York watershed makes them ineligible for purchase by the city unless they are located in a high-priority zone such as a reservoir's outlet to the distribution system (Budrock, 1997). Local land trusts may also prove successful given the shared commitment many of their supporters have to the quality of the immediate environment in which they themselves usually live. On the other hand, assuring a sustainable management presence on the part of local land trusts may be complicated by the sometimes atomized or ephemeral nature of some of these organizations (Whittaker, 1999).

As mentioned above, setbacks and buffer zones provide opportunities for water quality protection and, as with the other land-use mechanisms discussed here, they may also present problems in terms of prohibiting or spatially constraining certain types of development. Although subject to considerable wrangling in the negotiation of local building and zoning laws, in the context of potable water supply, setbacks have been shown to have positive implications for protecting public health (Yates and Yates, 1989). Buffer zones, although not regulatory measures in the same way that setbacks are, act as de facto setbacks to all development that might occur within a given distance of a stream or other body of water. The voluntary, cooperative spirit in which the Watershed Agricultural Council's Conservation Resource Enhancement Program engages Catskill-area farmers has helped make this buffer zone program a success. Initial feedback from farmers is reported to be positive (WAC, 2002b). The program has also helped to avoid protracted legal battles of the likes known to arise when government imposes land-use restrictions on private property without due compensation, moving some landowners to claim violation of their constitutional rights. So far, the CREP appears to have struck an important balance between recognizing reasonable compensation to landowners who forego production on buffers and promoting public responsibility for protecting the essential common good of clean water. Like the DEP's land acquisition program, however, the long-term success of this program remains to be seen. It will be interesting to monitor the outcome of these conservation incentives when the 15-year "retirement" rentals begin to expire.

At face value, buffer zone management for water quality protection does appear to be a practical and cost-effective "win–win" proposition. This is particularly the case where buffer zones are used in conjunction with other land-use BMPs that help to control nonpoint (i.e., diffuse) sources of pollution. Since scientific analysis of the effectiveness of buffers to mitigate waterborne contamination of various pathogens indicates that performance is contingent on factors such as slope, soil moisture, and surface roughness, buffer strips that act as transitional filter zones between land-use activity and water bodies are likely to perform best when supported by BMPs in the adjoining active use zone (NRC, 2000). In fact, some researchers have noted that buffer zones themselves should not be seen as substitutes for the establishment of BMPs in the adjacent upslope area (Nieswand et al., 1990). In the Catskill/Delaware watersheds, livestock fencing, tree plantings, rotational cropping and grazing schedules, animal waste and agrochemical storage facilities, and alternative water source development are all examples of positive corollaries to the setback effect derived from on-farm buffer zones. Similar strategies, such as appropriate harvesting, road construction, and runoff control techniques, are being employed as adjuncts to riparian buffers on forested lands.

Conclusion

Given the rising concern over the last two decades about water quality nationwide, the City of New York finds itself under immense pressure to reconcile a difficult dilemma: protect public health via a complex, preventive watershed management approach that maintains water quality at the source, or be prepared to make major investments in water quality remediation by constructing a massive filtration and water treatment facility. As demonstrated in this paper, the city is aggressively pursuing the proactive watershed management approach in which land use policy plays a central role in providing the public with a safe and reliable water supply. In the process, strategies and practices are being developed to attempt to balance watershed protection with community development and preservation, and state powers with the rights of private landowners. A major challenge in this effort is convincing a wide variety of stakeholders that the dual goals of economic development and sustainable water quality are ultimately intertwined.

The 1997 Memorandum of Agreement is an experiment in taking shared responsibility for watershed protection. Working together with numerous partners, the City of New York and its Department of Environmental Protection have fashioned an impressive long-term plan to manage and protect the high quality water supply enjoyed by millions of people in the nation's largest city. The recent renewal by the US

Environmental Protection Agency of its filtration avoidance determination for the New York City water supply demonstrates that the city takes watershed protection seriously. This is both a testament to the innovative and cooperative efforts of a wide variety of watershed stakeholders, and a reminder of what is possible when committed individuals and agencies strive to achieve effective, forward-looking environmental stewardship.

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