Contents

EXECUTIVE SUMMARY

The *Final Report* provides a detailed analysis of the proposed Public Surface Water Supply Protection Act of 2003. For the past 12 weeks, Team Watershed evaluated New York City's Catskill/Delaware Watershed policy in terms of its scientific worth and efficacy.

The final report is a culmination of our collective efforts to identify the impetus for legislation, the proposed solution, the scientific aspects of the problem, and, most importantly, the relationship between science and the solutions proposed in the Public Surface Water Supply Protection Act.

The report discusses the following:

History of New York State's Watersheds

This section of the report offers an overview of New York City's public water supply-from the construction of the first public well in 1677 up through the present. National and state regulations governing water quality protection, population growth and alternative water quality-control options are also discussed in this section to provide the reader with a context for understanding the Public Surface Water Supply Protection Act as a political, economic, and resource conservation tool.

How a watershed provides clean water to NYC residence

The proposed Public Surface Water Supply Protection Act aims to protect New York City's mains water source, the Catskill/Delaware Watershed, the source of 90% of the City's water, from any activity or use that could disrupt or damage the natural filtration process. To recognize the importance of this mandate, one requires a basic knowledge of the natural filtration process. Therefore, this section of the paper explores the science of watershed filtration.

Challenges and threats to providing clean water to NYC residents

Protecting the Catskill/Delaware Watershed from potential threats is a great challenge both scientifically and politically. The Public Surface Water Supply Protection Act is a legislative attempt to mitigate these threats. In this section we'll examine the point and non-point sources of pollutants, and the scientific challenges posed by these pollutants**.**

Legislation to protect Catskill/Delaware Watershed

New York City received a Filtration Avoidance Determination (FAD) for the Catskill/Delaware Watershed in 1997. To keep the FAD, the City must protect the watershed from potential threats, particularly, pathogens, effects of development, pesticides, and sedimentation runoff. New York City is already implementing two programs to protect the watershed: land acquisition and the subsidization of local best management practices. This section introduces and evaluates the protective framework proposed in the Public Surface Water Supply Protection Act. This act adds a third element to watershed protection: the establishment of buffer zones.

Advantages and disadvantages of the Public Surface Water Supply and Protection Act

The Public Water Supply Protection Act requires buffer zones to be established around every feeder stream in the Catskill/Delaware Watershed Management Area. This section of the report defines a buffer zone, describes the science behind buffer zone filtration, and discusses the advantages and disadvantages of buffer zones as the primary means of watershed protection in contrast to other protective models. This discussion will also include cost and quality comparisons between ecological protection and New York City's other protective option of a $6 billion filtration plant.

Scientific Issues and debates surrounding NYC's watershed protection proposal

There is little debate concerning the importance of watershed protection; however, there are varying opinions on how to accomplish this protection; and this raises questions concerning the effectiveness of the legislative solutions proposed by the Public Water Supply Protection Act. Thus, this section discusses the scientific debates surrounding the watershed's slope, width of the buffer zones, the type of vegetation found within and adjacent to the buffer zones, and surrounding land uses.

Measuring the success of watershed protection as proposed in the Act

The Public Surface Water Supply Protection Act's success will be determined by the legislation's ability to effectively protect the watershed from potential threats. The success will be measured scientifically (through water sampling tests) and politically (via local enforcement of the mandates and permit system). This section provides suggestions as to how to evaluate the success of the Public Surface Water Supply Protection Act.

Conclusion

The conclusion provides details of water management case studies from around the United States. Information in this section can be used for comparison with New York's watershed protection program with similar programs throughout the nation. By examining the successes and failures of other programs, the City of New York can perfect its water quality protection plan in the Catskill/Delaware watershed to ensure it is as comprehensive and successful as possible.

HISTORY OF THE NEW YORK STATE WATERSHEDS

Providing water to one of the largest, most densely-populated cities in the world is a challenge. Maintaining a high standard of water quality is an even greater challenge. From New York City's founding in the mid-1600s through to the present, residents and community leaders have found innovative ways to provide our ever-increasing population with abundant, clean water. Throughout this section, we will be discussing public drinking water supplies.

There's Never Enough Water

Prior to 1677, Manhattan residents relied on shallow, privately-owned wells for all of their water needs. By the late 1600s, the City's rapid population growth and dwindling shallow water supply necessitated government intervention and in 1667, the City built its first public well in front of the old fort at Bowling Green. By 1776, the well system could no longer support the city's 22,000 residents. In response, the city constructed its first reservoir in Lower Manhattan on the east side of Broadway between Pearl and White Streets, where "water was pumped from wells sunk near the Collect Pond (located east of the reservoir) and from the pond itself, and was then distributed to residents through hollow logs laid in the principal streets" (NYC DEP, 2004). Throughout the early 1800s, additional reservoirs were constructed throughout Lower Manhattan. However, by 1830, the population density and numerous industries had polluted the barely-sufficient water source prompting the City to begin supplementing the water supply with "cisterns and water drawn from a few springs in upper Manhattan" (NYC DEP, 2004).

By 1842, city officials realized that the current water supply could not sustain the rapidly expanding metropolis and, after looking into several alternatives to increase supply, the City decided to impound water from the Croton River (in present-day Westchester County) and to construct an aqueduct to carry water from the Old Croton Reservoir into the City (NYC DEP, 2004). The Old Croton Aqueduct transported about 90 million gallons of water to the City's distribution reservoirs (located at 42nd and 86th streets) each day. Neither reservoir is currently in use. The City continued to construct new reservoirs throughout the 1800s, the most notable being Boyds Corner (1873) and Middle Branch (1878) both of which are located in the Croton Watershed. In 1883, a commission was formed to build a second aqueduct from the Croton watershed. New York City's need for additional water was so great that the New Croton Aqueduct opened in 1890, while still under construction. The Croton Watershed is still a vital New York City water source, supplying 10% of the City's total drinking water.

The Board of Water Supply and the Catskill/Delaware Watershed

In 1905, the New York State Legislature created the Board of Water Supply to preserve water quality and establish a water resource system capable of providing New York State residents with consistent, high quality water. Around this same time, New York City decided to develop the Catskill region as an additional water source (NYC DEP, 2004). The Board of Water Supply approved the Catskill System project and actually began impounding water from Esopus Creek and Ashokan reservoir, two of the four watersheds in the Catskills. The Board also constructed the Catskill Aqueduct, completed in 1915, to carry water from the Catskills into the city. The Catskill System was completed in 1928 upon construction of the Schoharie Reservoir and Shandaken Tunnel. New York City's Department of Water Supply, Gas and Electricity is responsible for operating and maintaining the Catskill system (NYC DEP, 2004).

The Delaware System came under New York City's control in 1928 after the City received Board approval to appropriate the upper portion of Rondout Watershed and Delaware River tributaries (only those located in the State of New York). Although the system was approved in the late 1920s, it didn't begin operations until 1931. After New York City announced its plan to cipher water from the tributaries to the City, the State of New Jersey, which also relies on water from the Delaware System, filed a federal law suit against the City and State of New York. That case went all the way the United State's Supreme Court and, in May 1931, the court "upheld the City's right to augment its water supply from the headwaters of the Delaware River" (NYC DEP, 2004). In 1937, construction began on the Delaware System and culminated with the completion of the Cannonsville Reservoir in 1964. Collectively, the Catskill/Delaware Watershed System includes nineteen reservoirs and three controlled lakes with a storage capacity of approximately 580 billion gallons (NYC DEP, 2004).

Regulating Water Quality

Since the 1980s, a series of federal laws have been passed to regulate and protect water quality nationwide. In 1986, Congress passed the Safe Drinking Water Act (SDWA), to protect the water quality and prevent groundwater contamination (O'Leary, 1999). Under the SDWA, States are responsible for ensuring that their water meets the standards set by the Environmental Protection Agency (EPA). The Surface Water Treatment Rule of 1989 took quality control one step further by requiring "filtration of surface water supplies unless specific filtration avoidance criteria are met" (EPA 2004). The SDWA also established Maximum Contaminant Levels (MCLs) for turbidity, *Giardia lamblia*, and enteric viruses, and provided a list of approved water quality testing methods (EPA 2004). Only those systems that are able to demonstrate compliance with the "stringent source water quality criteria, meet the inactivation (contact time) requirements, and maintain an effective watershed control program obtained an avoidance to filtration" (Hitchcock, 2004). The Catskill/Delaware Watershed was one of the few watersheds in the nation to receive a filtration waiver; a filtration waiver was not granted to the Croton Watershed because it failed to meet the strictest water quality standards.

In 1997, New York City and New York State negotiated the Watershed Memorandum of Agreement with the EPA, Region II to ensure long-term watershed protection. As part of the Agreement, New York City received a 10-year land acquisition permit to purchase lands situated in the Catskill/Delaware Watershed; New York City currently owns more than 103, 000 acres of undeveloped land in the watershed (Hu, 2004). The MOA also states that New York City also must help to establish the Catskill Watershed Corporation (CWC), a non-profit organization that funds the "construction of new, centralized sewage systems and extension of sewer systems to correct existing water quality problems; stormwater management measures; environmental education; improved storage of sand, salt and de-icing materials; and stream corridor protection projects" (NYC DEP, 2004). As part of the Agreement, New York City committed $240,000 million to CWC-approved water quality protection projects. The MOA also created the

Catskill Fund for the Future, a $60 million economic development fund established to promote watershed-friendly development projects in areas west of the Hudson River. Finally, the Agreement established stricter standards for watershed protection including: "standards for the design, construction and operation of wastewater treatment plants; and set design standards and setback requirements for septic systems" (NYC DEP, 2004). The Agreement also "requires the implementation of stormwater control measures for a variety of commercial, residential, institutional and industrial projects" (NYC DEP, 2004). On May 6, 1997 the EPA granted New York a Filtration Avoidance Determination (FAD) for the Catskill/Delaware Watershed. The waiver was granted five days after the MOA took effect; the FAD was renewed in 2002.

The proposed Public Surface Water Supply Protection Act was introduced to the Senate in 2003, shortly after New York City received its FAD renewal. Like the 1997 MOA, the proposed Public Surface Water Supply Protection Act seeks to establish greater protection for the Catskill/Delaware Watershed by creating a watershed management area.

A watershed management area is defined as: "any lands that are held and utilized for the purpose of preserving and protecting the water quality of a public surface water supply, or any principal feeder stream or secondary feeder streams" (Public Water Supply Protection Act, 2003).

Public surface water supply is defined as: "any public water supply reservoir or any other surface water body with a water supply intake that is constructed, owned, operated, or maintained in whole or in part for the purpose of providing water for human consumption and which is identified by the [D]epartment" (Public Water Supply Protection Act, 2003).

As previously mentioned, the Croton Watershed did not receive a filtration waiver thus, the city must now spend $1 billion to construct a filtration plant. If the Catskill/Delaware Watershed fails to comply with FAD standards, the City will be required to build a $6 billion dollar filtration plant. Clearly, New York City has a great economic, ecological, and political incentive for preserving the Catskill/Delaware Watershed.

HOW A WATERSHED PROVIDES CLEAN WATER TO NEW YORK CITY RESIDENTS

A recurring theme pervading modern environmentalism is the inherent economic service value natural ecosystems provide. Though human populations benefit from environmental services, general ecosystem health is often left out of key decision-making processes. These environmental services are often measured by the amount of financial resources it would take society to perform the same function on its own. In the case of the Catskill/Delaware watershed, this amount approaches $6 billion. In an effort to preserve the valuable resource of clean, safe drinking water, it is important to understand the complex parts of the natural processes involved in cleaning our water.

The majority of the Catskill/Delaware region is mountainous and forested, with agricultural land use comprising about 10% of the area. The soil contains moderate levels of organic matter (0.6 – 6.2 %) (US EPA, 2001). This natural reserve of forest, as well as an accompaniment of soil with adequate carbon levels, allows the Catskill/Delaware watershed to have good conditions for precipitation filtration. The potential problems that threaten this areas natural state revolve around its steep slopes and the surrounding area's encroaching development. To combat these detriments, the proposed Public Surface Water Supply Protection Act establishes buffer zones around the feeder streams to the area's public surface water. The buffer zones allow the natural attenuating processes of soil, vegetation, and organisms, to filter out inorganic, organic, and heavy metal pollution that runs off the surface of the land during precipitation events.

Buffer Zone Function

The buffer zones specified by the Act have spatial dimensions from the bank of feeder streams that go back 300-feet from primary streams and 200-feet for secondary streams (see Legislative Summary for more information). When the water table is less than 3 feet from the surface beyond the required distance, the buffer zone is specified to extend to a vertical height that reaches 3 feet above the water table. Spatial dimensions alone do not give buffer zones their functional value. Buffer zones are comprised of varying types of soil, vegetation, and microorganisms that, by working in concert, lead to a final water supply that is clean and safe for drinking. By setting a standard footage of area to be preserved back from the banks of streams, these buffer zones give the land enough time and space to carry out its natural filtration process before precipitation enters as runoff to the main surface water supply.

Most studies agree that a standard of at least 100-feet is needed for buffer zones to be effective. (NCRS Planning and Design Manual, 2004) The reasoning behind the Public Surface Water Supply Protection Act's implementation of 300/200-foot buffer zones has not been clearly stated, but standard practice bases buffer zone dimensions on the topography of the area.

Buffer zones are riparian areas that provide filtration through natural attenuation and serve as the last line of natural defense for precipitation making its way downhill into streams. (EPA, 2001) Figure 1 is a typical example of a buffer zone model developed provided by the Stormwater Center. Precipitation runs first through the *outer zone*. This outer zone is the farthest from the bank of the stream and should be the first to come in contact with any substantial development. It usually consists of natural vegetation that functions as sediment filter and to slow down the speed of stormwater runoff. (NCRS Panning and Design Manual, 2004)

Following this zone is the *middle zone*, usually the largest of the subzones [between 50-100 feet]; this area should ideally consist of mixed tree species and other vegetation. This zone is where most of the precipitation is allowed to filter down into the soil. (NCRS Panning and Design Manual, 2004) Developments, like bike paths or walkways are still allowed, but should be minimal, according to the Act.

Finally, there is the *streamside zone*, which is the last zone before any remaining water can enter the stream. Under perfect conditions, it would be most beneficial to water quality if *no measurable runoff* enters the stream after entering this zone. Stream entrance of water should happen at the interface of the bank with groundwater inflow. This zone has large, shady trees that serve both to maintain bank integrity (especially during floods) and also to shade the water (to keep it cool in the summertime). These are all idealized conditions, and should be worked towards when designing or conserving riparian areas. (NCRS Panning and Design Manual, 2004)

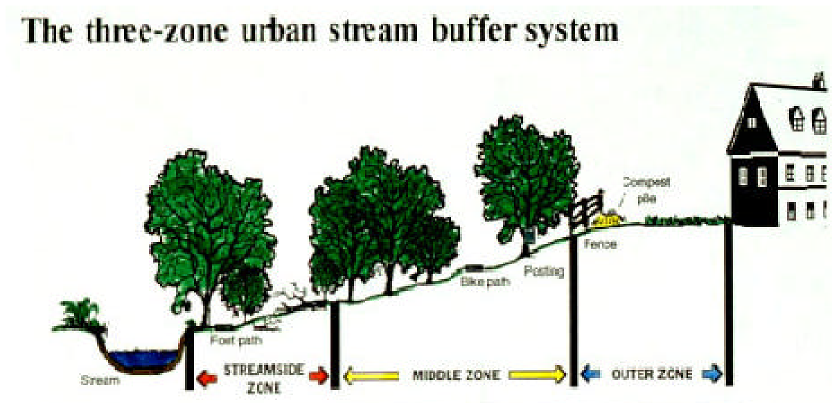

Figure 1. Three Buffer Zone Model Source: http://www.stormwatercenter.net/

While the buffer zone provides a main way to slow precipitation entrance into streams, it also serves the function as a *chemical absorber.* Soil and organisms are primarily responsible for filtering potential contaminants. On the molecular level, soil particles, comprised largely of decomposing organic carbon, allow the dissolved pollutant chemicals in the runoff to adsorb to their surface, thereby taking them out of the water. In soils which typically have a high pH, dissolved heavy metals can precipitate out of the solution and also adsorb or form complexes with the soil molecules. (Brown et al, 1999)

Both plants and animals, which feed from the soil, also play a role in taking out unwanted chemicals. Agricultural byproducts, like nitrogen and phosphorus, are required by plants for growth. When they absorb water from their roots, chemicals such as nitrogen and phosphorus in the water are absorbed through the roots as well. Some hazardous chemicals also get absorbed, and bioaccumulated in the plant tissue, rendering the filtering runoff more clean. (Virginia DOF, 2004)

There are also a number of microbial bacteria that digest potentially dangerous organic chemicals, releasing CO_2 and water as byproducts. The species *pseudomonas aerugnosa* for example, is able to digest petroleum in runoff. This bacterial degradation is especially helpful when organic chemicals that accrue on impervious cover surfaces runoff into the soil, but are effectively filtered out. (Byl et al, 1999)

The net effect of these processes should result in clean water being discharge into streams through ground- and surface-water interfaces along stream banks. It is important to note, that effective buffer zones will be different in every area. Soil type, microbial species, and vegetative cover all vary geographically and temporally. All these factors must be considered when designing, protecting, or restoring riparian watershed buffers.

In addition to fixed-width buffer zones, there are variable width buffer zones which allow for the width to be customized depending on vegetation, soil, type, and slop. However, variable buffer zones are difficult to implement. Some scientists in Taiwan have determined an effective length and depth of soil needed for buffer zones along prominent river on the island. In doing so, they employed a number of mathematical equations and diagrams to determine the optimal design of the buffer zone. The potential drawback to this method however, is its relative complexity and the need for a large number of measurable variables. (Lin et al., 2002)

CHALLENGES AND THREATS TO PROVIDING CLEAN WATER TO NYC

To get a better understanding of the scientific challenges that the Public Surface Water Supply Protection Act is attempting to overcome, it is first necessary to describe the dynamics of the Catskill/Delaware watershed (a map of this watershed can be seen below in Figure 2).

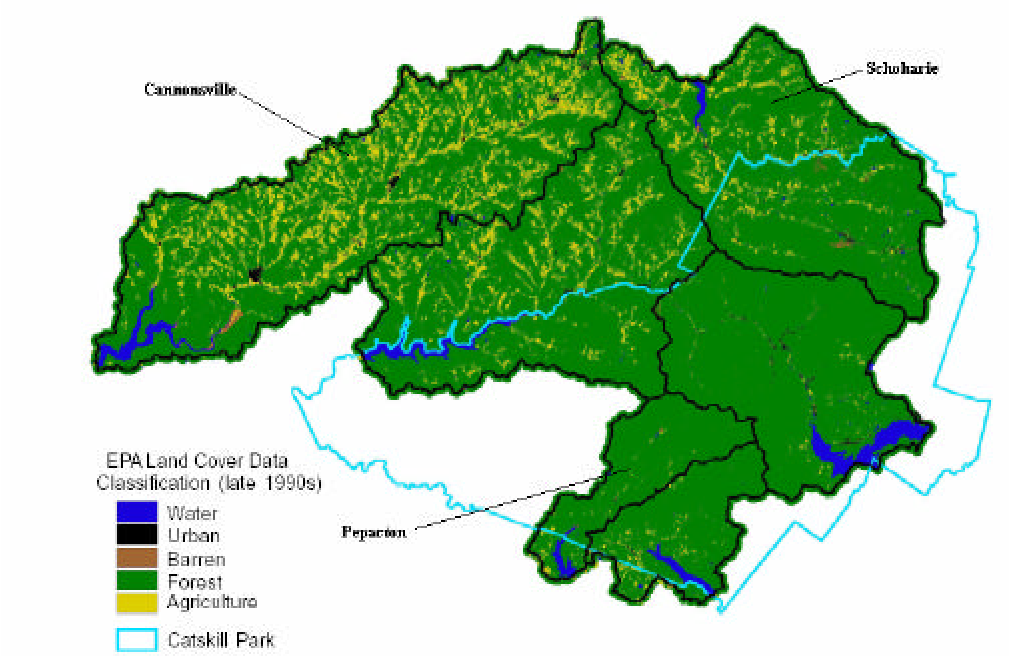

Figure 2. Land cover/use for Catskill/Delaware Watershed *(Mehaffey et al., 2001.)*

Forests dominate the Catskill/Delaware area and consist of hardwood, deciduous, and coniferous trees. The largest amount of human development occurs in the northwest area. Some of the more common human activities in this region include agriculture, ski hills, private lawns, golf courses, and quarries. Agriculture makes up 10 % of the watershed area, with dairy farming being the most common activity. There are also fruit orchards and wineries in the southeastern part of this watershed. Tourism in the watershed is mainly located in the southeast of Catskill Park area, which is drawn on the map in blue. Tourism brings with it several concerns to the watershed most importantly, development and road construction. Currently there is approximately 2,500 miles worth of roads that are evenly-distributed throughout the Catskills, most of which run parallel to the streams in the watershed. The population within the watershed has been steadily increasing, from 53,000 residents to 63,000 between 1970 and 1995; this is a 20% increase and indicates a fairly substantial growth in the area.

In terms of water quality, the northwest has the highest averages of fecal coliforms, nitrogen, and phosphate concentrations, but these averages are still within state guidelines. Restricting development and growth would be necessary to better protect the watershed. Areas where there is increased pollution due to human development are Cannonsville, Schoharie, and Pepacton. According to Mehaffrey et al. (2001), as long as residential and agricultural development can be restricted, the watershed's water quality can be maintained.

Next, looking into the potential problems as well as the science behind these problems, we will examine issues associated with agriculture, development, pathogens, and the water supply. As previously mentioned, the majority of farms in the Catskill/Delaware watershed are dairy farms. A typical environmental problem associated with dairy farming is that of water contamination from fecal matter, which could contain waterborne pathogens that are harmful to animals and humans (NYC DEP, 2004). Fecal matter is of major concern to water quality and health; it is also regulated by the Environment Protection Agency.

To kill or control pests and weeds, farmers use pesticides and herbicides; these dangerous materials pose a threat to fish and animal populations, and threaten human life if it is consumed in drinking water (USGS, 1997). Other agricultural uses include fertilizers which provide nutrients to crops; fertilizers contain large concentrations of nitrogen and phosphorous which can compromise water quality by increasing eutrophication in the water and reducing dissolved oxygen levels, leading to fish kills and damaged ecosystem health (University of New South Wales, 2000a). Vegetation type and planting practices in agricultural fields may also affect water quality as native (and naturally-filtering) vegetation may be removed to make room for monocultures. Native plants are important because they serve as land surface shelter to prevent soil erosion and also limit runoff. Monocultures however, increase runoff because they are planted in rows, rather than randomly, and the type of vegetation may not be the best for protection of the watershed. Erosion may also be resultant of the slope of the land as the Catskill region has a *k* factor of 0.3% or higher, which can lead to high erosion potential (Mehaffey et al., 2001).

Many of the potential problems in the watershed that come with agriculture are also associated with increasing development, specifically residential, growth. An example of this is the fecal matter and nutrients that can make their way to the water from sewer and septic tanks. Pathogen contamination becomes a major issue here as leaking can lead to E. coli, Giardia lamblia, and Cryptosporidium getting into the water system (NYC DEP, 2004). Pesticides and fertilizers used in lawn care can also increase water contamination due to nutrient runoff. Commercial areas, such as resorts, golf courses, and parks, can also bring about similar types of contamination.

Increased development would require more roads to be built. The concern with building more roads is that they are a non-point source for water pollution. It is more difficult to regulate the runoff from a road then from a home, farm, or factory. Therefore, an increase in roads would increase non-point source pollution, such as heavy metals, petroleum hydrocarbons, herbicides, pesticides and other nutrients. Roads are also a part of impervious cover or impermeable cover, which does not allow for natural filtration of water through the ground surface (Figure 3). Figure 3, shows that as the percentage of impervious cover increases, the percentage of runoff increases and inversely the percentage of infiltration decreases. Impervious cover increases runoff, sedimentation, and soil erosion (University of New South Wales, 2000b).

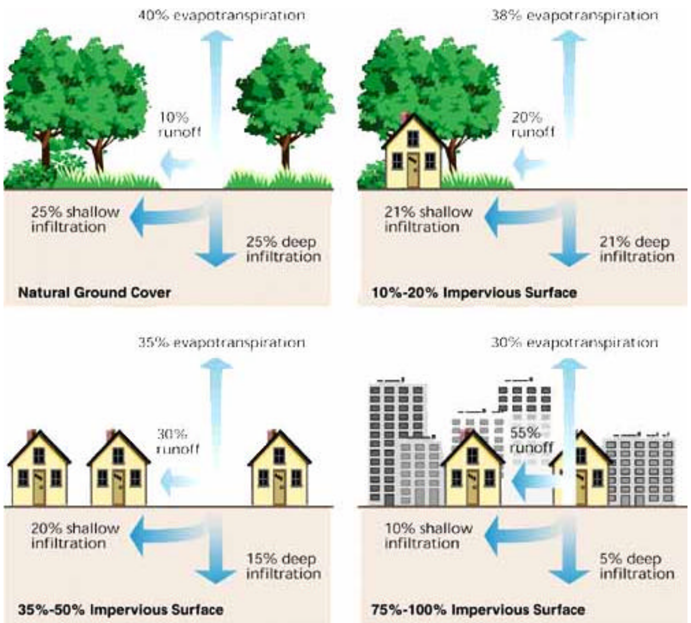

Figure 3: Relationship to impervious cover and surface runoff. (*Dickson Conservation District, 2004)*

Threats from development and agriculture can lead to an increase in pathogens into the water source. Pathogens are indicators of poor water quality and fecal matter contamination due to an increase in development. Three pathogens that should cause concern if found in a water system are: *E. coli, Giardia lamblia, and Cryptosporidium. E. coli* is naturally found in water systems and is not usually a health threat in itself, but it can be used to determine whether other potentially harmful bacteria may be present. There is a strain, O157:H7, which can be found in water contaminated with sewage or agriculture waste. This strain can cause an intestinal infection or even be fatal to immuno-compromised individuals (NYC DEP, 2004). The EPA-regulated concentration of E. coli states that no more than 5% of the samples tested should be positive for E. coli in a month. Samples collected in the New York City watershed were averaged at 3% in 2003 (US EPA Office of Water, 2003).

Giardia lamblia and *Cryptosporidium* are both sources of waterborne intestinal diseases in drinking water. The source of these contaminants is fecal matter from sewage or agriculture. The EPA requires 99% removal of both Giardia and Cryptosporidium and the New York City water supply meets this regulation (EPA Office of Water, 2003).

The last area of concern is the treatment process of the water that New York City gets from the Catskill/Delaware watershed. The process is listed as follows: chlorine is used to treat for pathogens, fluoride is used to treat for the prevention of tooth decay, orthophosphate reduces the release of metals, sodium hydroxide raises the pH and reduces the corrosiveness of the water. The main concern with the treatment process is the occurrence of halocytic acids and therefore it is important to consider them in water quality analyses. Halocytic acids are chemicals formed in drinking water when chlorine used for water treatment reacts with organic matter naturally found in water. The amounts of these acids vary from day to day. New York State has a disclaimer saying that these acids may cause cancer with long-term exposure, but there is uncertainty about what concentration levels would cause this and how much long-term exposure is needed.

The EPA separates halocytic acids into either dichloroacetic acid or trichloroacetic acid, but New York City measures both acids together. In conlusion, the concentration of halocytic acids in New York City water is still under EPA guidelines (U.S. EPA, 2002).

LEGISLATIVE SUMMARY

The Public Water Supply and Protection Act proposes a framework for protecting the Catskill Delaware Watershed against harmful activities and pathogens by creating a permit system and establishing buffer zones around all water bodies feeding into or contained within the Catskill/Delaware watershed. Enactment of the proposed legislation will allow local governments to regulate activities and development within watershed management area.

Defining the Problem and Establishing a Goal

Prior to the proposal of the Public Water Supply and Protection Act, no city or state legislation existed to regulate activities or development within the Catskill/Delaware Watershed. The city had previously created policies to subsidize those residing in the watershed area and implemented an aggressive land acquisition program. . This proposed legislation adds a third dimension to this watershed protection program, the creation of buffer zones to protect water sources. The proposed Act is vital to sustainable, effective watershed protection for many reasons: it defines key terms; identifies the problem (too much point and non-point runoff); prescribes needed actions (to reduce point and non-point source pollution entering our public supply); and establishes a goal (to prevent contamination of our water supply from point and non-point source pollution). Specifically, the Act mandates the city to: "to establish and maintain undeveloped land surrounding the watershed" (NYC has been doing this through its established Land Acquisition Program); and "to establish and maintain undeveloped land around the public water supply and feeder streams (Public Water Supply Protection Act, 2003)."

Proposed Solutions

The Public Surface Water Supply Protection Act proposes to mitigate threats by instituting a permit system and establishing buffer zones around primary and secondary streams and around all reservoirs located within the watershed management area. Buffer zones protect our water supply from runoff, sedimentation, fertilizers, and pesticides. Permits, the second part of the solution, provide local governments with jurisdiction over all water bodies within their township; this jurisdiction includes the power to regulate activities and development within the watershed management area and to enforce compliance.

Under the Public Surface Water Supply Protection Act, local municipalities are required to establish a buffer zone around every primary and secondary feeder stream within the Catskill/Delaware watershed management area. The type of buffer zone needed to effectively protect a water source differs with respect to slope and topography around an individual watershed or stream. Therefore, this amendment provides buffer zone options and a distinct set of criteria for each type of water source. The buffer zone standards set forth in the legislation are as follows:

Primary Feeder Streams: a buffer zone is an area of land including the bed of the stream and extending outward 300-feet from the high water shoreline[1] or to a line where there is at least three feet of soil above the water table.

Secondary Feeder Streams: a buffer zone is an area of land including the bed of the stream and extending outward 200-feet from the high-water shoreline or to a line where there is at least three feet of soil above the water table.

The proposed Public Surface Water Supply Protection Act allows municipalities within the watershed management area to introduce stricter standards than those put for in the Bill. In the event that municipalities exercise their option to increase watershed protection, the stricter standards will supersede anything set forth in the amendment.

Permits, the second part of the proposed solution, establish a regulatory system to control activity and development within the buffer zones. Under the permit system, any individual residence or business located within the watershed area must apply for a permit before building, installing, or introducing any land-based activity that could potentially endanger the watershed. Applicants for development must state their "intended activity (e.g., installing a septic tank, building a deck, extending their farm land, etc); the manner in which activity will be preformed to maximize the minimum environmental impact; why the activity is essential to the operation and maintenance of the water source or why the activity is an essential recreational use; and finally, why prohibition of the activity would result in practical difficulties or economic injury (Public Water Supply Protection Act, 2003)." Applicants must provide a processing fee with their application; this fee is determined by the individual municipalities. According to the legislation, applications will only be approved if they can show that the proposed activity will "not measurably increase the flow of pollutants into the watershed management area" or disturb the natural filtration process. Applicants must also demonstrate that the consequence of prohibiting the proposed activity is greater than the public purpose sought by its prohibition.

What activities are permitted and prohibited inside a buffer zone?

The proposed Public Water Supply Protection Act allows "any activity essential to operation and maintenance of the watershed (Public Water Supply Protection Act, 2003)" to occur inside a buffer zone. Activities listed as essential within the amendment include "the selective thinning of trees, bushes, and shrubs, and the construction and maintenance of water dependant structures (ramps, docks, and piers) and footpaths". The legislation also permits limited use of the buffer zone and watershed area for public recreation. Local governments have the authority to determine which activities are acceptable. Currently, hunting, fishing, and hiking are allowed in both Ulster and Delaware Counties; Delaware County also permits boating. The Act offers the state the

[1] High water shoreline: "reservoir's shoreline at 100% capacity or in a surface water body with a water supply intake, the line on the shore established by fluctuations of water and indicated by physical characteristics such as clear, natural line impressed on the bank, shelving, changes it the character of soil, or other appropriate means that consider the characteristics of the surrounding areas, or that line that at which land adjoins the water of lakes, ponds, rives and streams at the annual average high water level."

option of granting "statewide general permits in lieu of granting approvals on a case-by-case basis for activities deemed essential (Public Water Supply Protection Act, 2003)."

Under this legislation, any activity that disturbs the level of water or the water table is prohibited. This includes: "the removal, excavation and/or dredging of soil; alteration of the water table by damming, draining, obstructing, or diverging; and dumping debris or other substances into the water." Other prohibitions are construction activities, paving, removing or altering plant life, on-site sewage drainage field or septic systems, and any other activity that could produce or exacerbate the potential for point and non-point source pollution.

Legislative Gaps

The Act provides a comprehensive solution for watershed protection however there are some areas of concern, namely the three-foot buffer zone options and allowing pre-existing activities and structures to remain within the buffer zone.

As previously mentioned, the Act provides buffer zone options: the zone extends a specified distance from the water line or "to a line where there is at least three feet of soil above the water table" (Public Water Supply Protection Act, 2003). The latter option concerns environmentalists because it fails to establish a minimum distance at which activity or development is prohibited. For example, if the local municipality wants to construct a new road that is three feet above the water table but only 20 feet from the high-water-shoreline, is it permissible? Logic tells us that such development would increase runoff and negate the legislative intent. However, there is no provision within Act that address this issue and therefore it could become a point of contention in the future.

The second point of concern for environmentalists is with the legislation is that it grants existing development immunity from the proposed regulations. This includes pre-existing structures and/or activities and those that received a permit prior to this legislation's enactment. Grandfathered-in activities include commercial golf courses and agriculture sites, both of which lead to increased pesticide, herbicide, and fertilizer runoff (see Challenges and Threats section). Structures that grandfathered in include:

- Solid waste facilities, junk yards, and landfills located within 250-feet of a watercourse and within 1000-feet of a reservoir;
- Impervious surfaces such as paved roads, sidewalks, driveways, roads, and parking lots within 100-feet of water course, and within 300-feet of reservoir;
- Petroleum storage tanks, gasoline tanks, waste oil tanks, diesel tanks, fuel oil tanks within 100-feet of a watercourse and within 500-feet of a reservoir;
- Tanks between 185- and 1100-gallons located within 25-feet of a watercourse, and within 300-feet of a reservoir;
- Septic Systems that do not meet NYS Codes, Rules and Regulations (most of the septic systems were installed prior to 1991);
- Hazardous Substance Storage Tanks located within 100-feet of a watercourse and within 500-feet of a reservoir (Delaware County, 2004).

All grandfathered-in infrastructure and activities must register in their county's *Non-Compliance Regulated Activity* directory before the amendment takes effect.

Additional measures required in the Public Surface Water Supply Protection Act

The Act requires New York City and local municipalities to take additional watershed protection measures aside from creating buffer zones and establishing a permit system. These measures include "establishing and maintaining undeveloped land surrounding the watershed (since 1997, New York City has been actively purchasing land through the land acquisition program); implementation of all mandates set forth in this amendment within 120 days of its enactment; the development and distribution of guidance manual; and local enforcement. Those who fail to comply with the regulations will face monetary and/or legal repercussions through orders of compliance, civil action suits, administrative or civil penalties, and temporary and/or permanent injunction.

Overall, the proposed Public Water Supply Protection Act identifies potential threats to New York City's main water source, establishes a goal, and provides a comprehensive framework for meeting that goal and mitigating threats to the water supply.

ADVANTAGES/DISADVANTAGES AND DEBATES SURROUNDING THE ACT

Clearly many advantages and disadvantages exist when it comes to limiting development and letting an ecosystem take its natural course. In terms of the protection of water quality, natural riparian buffers are well-suited to filter out contaminants and prevent foreign materials from getting into the water source (see Buffer Zone Function); this is a strong advantage to environmental health and surface water protection of the Act. A disadvantage to allowing for undeveloped buffer zones in a growing residential/agricultural area is that it may limit urban growth, commercial interest, and, consequentially, economic gain to the area. When considering, though, the significance of a clean source of drinking water that is naturally-filtered and protected, and also keeping in mind the tremendous cost of a human-made filtration system, the benefits of buffer zone creation, as provided for in the Act, become more apparent.

Along with the competing interests of environmentalists/New York City residents (who require safe drinking water) versus developers/some residents of the watershed area (seeking expanded growth or economic gain), several debates exist surrounding details of the Act. The questions that will be examined here are: what is the value of a buffer zone; what are the effects of vegetation surrounding streams; and, how does urbanization change a watershed?

There is a consensus among scientists that the best way to protect a watershed is to prevent development; however, there are a variety of debates associated with the designation and effectiveness of buffer zones. The first question related to this is whether buffer zones should require a uniformed width or vary according to the physical or biological characteristics of the riparian zone. Mixed views exist among scientists as to whether buffer zones should have a standardized width or be customized to the ecosystem. The width of a buffer zone is based on the riparian area needed to control surface runoff, the slope of the land adjacent to the stream, and the type of vegetation on adjoining land. Scientists are trying to develop buffer zone models to mathematically determining the width of a buffer zone to solve this debate considering these factors.

The second issue is determining whether a relationship exists between the proximity of forests to streams in buffer zone protection. A study out of Virginia Tech compared stream-side forested buffer zones versus the presence of a forest. Both studied areas had a 50% reduction of vegetation and a correlating increase in concentration of nitrogen and phosphorus in the streams. Investigators concluded, therefore, that it is not the proximity of the vegetation to the stream but rather the presence of vegetation that leads to enhanced water quality. This study also speaks to increasing contamination levels as vegetation is reduced.

The concern of vegetation loss brings us to the question of how much vegetation can be removed from a buffer zone before water quality is significantly affected. According to the study, buffer zones need vegetation for soil stability and sediment-filtering effects. Both grass and forest buffers can reduce levels of nutrients and sediments from surface runoff, and reduce levels of nitrates from subsurface flows. Grass buffers are more quickly established and, in terms of sediment removal, may offer greater stem density to decrease the velocity of water flow and provide greater surface area for sediments to be deposited. Forested buffers offer the advantage of greater resistance and soil support; they are also not as easily inundated during heavy flooding.

The Public Surface Water Supply Protection Act speaks directly do protecting the watershed from the effects of development and urbanization. This begs the question, how does urbanization change a watershed? Several studies in recent years have shown the urbanization, and the resulting impervious cover, can change how water flows over the surface; this in turn can lead to greater erosion, sedimentation, and runoff to streams which can contain contaminants. As a watershed becomes developed, trees and plants are replaced with impervious surfaces (such as roads, parking lots). These surfaces do not allow water to soak into the soil thus causing an increase in the quantity and velocity of runoff, especially during storm events. The increase in erosion, sedimentation, and runoff all have the potential to severely damage an ecosystem and, importantly, cause adverse effects to water quality within the watershed. Some believe these effects are insignificant and are only loosely related to development, while others draw a strong connection between urbanization and degraded water quality. Herein lies a major portion of the debate surrounding the Act. Questions of this nature are addressed as we discuss how watersheds provide clean water to residents of New York City and we look into buffer zone functions (refer to related sections above).

MEASURING THE PROGRAM'S SUCCESS

Given the proposed developments that threaten to negatively affect the water quality of the Catskill/Delaware Watershed, it will be imperative to set up a monitoring strategy that will observe whether the proposed Public Surface Water Supply Protection Act's buffer zones are effectively maintaining the water quality within the watershed. If water quality were to fall below the levels provided in the EPA's FAD, the City would be forced to construct the $6 billion treatment facility it is seeking to avoid. In order to implement monitoring strategies, the City of New York must regularly perform a variety of water quality tests and measurements.

One way to measure water quality is by my testing for turbidity, or the amount of suspended material in the water. Turbid water is a potential indicator of high levels of pollutants or runoff sediments that would lead to unsafe drinking water supplies. By monitoring streams with high turbidity levels, potential problem streams can be located and changes to buffer zones or protection strategies can be made.

Another major threat to water quality is the presence of pathogens. Scientists monitor whether harmful pathogens, like fecal coliform, giardia lamblia, and cryptosporidium, are below acceptable levels in streams so as not to threaten the health of the public.

Pesticides/herbicides, nitrogen, phosphorus, and other byproducts of agricultural activity must also be measured. High levels of pesticides and herbicides pose significant toxicological health risks to all life, including humans. Alternatively, high nitrogen and phosphorus levels can cause problems with the ecological balance of the streams leading to degraded ecosystem health.

Currently, the Department of Environmental Protection's Bureau of Water Supply maintains 892 sampling stations in New York City that measure for some of the above-mentioned pollutants; in 2003, the department completed 425,500 water sample analyses. (DEP, 2003) By keeping this testing framework in place, New York City is playing a proactive role in terms of protecting the public water supply. If the Public Surface Water Supply Protection Act passes, it will be important for the Department of Environmental Protection to set up a comprehensive baseline measurement of pollutant levels in the Catskill/Delaware Watershed. This will serve as a benchmark through which we can compare future water quality measurements. Furthermore, as development increases and/or new agricultural products are used, it will be necessary for scientists to continually update a toxicological profile of common chemicals used in the Catskill/Delaware watershed and make sure that these are included in water quality tests.

Besides water quality testing, GIS and field investigation techniques are used to study vegetative cover in the watershed as well as changes in the amount of impervious cover will help provide spatial data about the state of the created buffer zone. By keeping track of these factors, scientists can keep track of the general health of the buffer zones as well as make sure the development rules of the Public Surface Water Supply Protection Act legislation are being followed. Special attention must be paid to those properties grandfathered into buffer zones and also to those developments allowed in the buffer zones due to permitting.

There are potential problems that must be addressed when measuring the success of the program. Determining proper testing sites in the watershed is crucial. Since measuring every stream in the watershed will be difficult, scientists will have to determine which streams are at highest risk to runoff or agricultural pollution based on proximity to impervious cover or agricultural tracts. By doing so, both time and money will be saved. Also, scientists must determine the correct monitoring targets for the chemicals they wish to measure in the watershed. If their original baseline estimates are too high or too low, potential problems may be overlooked and pose threats to drinking water or waste financial resources in measuring incorrect levels of pollutants. Similarly, in regard to pathogen testing, there is some degree of uncertainty as to what levels are safe and to identifying pathogens correctly. Setting levels too high may impair public health, but setting levels too low may waste money.

Given that the Department of Environmental Protection already has a substantial water testing program in place for New York City, many of the mechanisms needed are already in place to measure the success of the Public Surface Water Supply Protection

Act, should it be enacted. After a baseline of allowable pollutant levels is developed for the Catskill/Delaware Watershed, only incremental changes in water testing strategies will be needed as the watershed's composition of development changes. With the inclusion of GIS monitoring and consistent field studies of vegetative and impervious cover into the current water testing program, there should be continued compliance with the EPA's water quality standards.

CONCLUSION

In this section, state-specific case studies for watershed management will be discussed in order to provide a comparison to New York City's own watershed management plan. Final thoughts on New York City's Public Surface Water Supply Protection Act will also be offered in this section.

Watershed Management Case Studies

Watershed management is achieved in several different ways, unique to each water system and, more striking, highly variable among states in the U.S. One example of a water monitoring strategy different from what might be seen in the Catskill/Delaware Watershed is called Water Watch and takes place in Alabama. In this program, citizens volunteer to monitor lakes, streams, and wetlands. This program not only teaches residents to learn about water issues and water quality testing, it also allows them to feel more involved in protecting the state's water sources (Auburn University, 1995).

In Arkansas, residents of watersheds are given a Landowner's Guide which provides assistance to private landowners in the conservation and management of Arkansas' wetlands and associated agricultural lands. In this guide, one can find information on voluntary programs and even information on financial assistance for wetland and riparian habitat restoration and agricultural land management suggestions (US EPA, 1995-1996).

In Illinois, Iroquois County employs the Natural Resources Conservation Service's (NRCS) Conservation Reserve Program (CRP) to set filter strips along creeks, stream, and rivers. To get stakeholders, such as farmers and private land owners, involved, the NRCS helps provide $26,000 worth of grass seed in order to create areas that will remove chemicals and sediment, and to benefit local land owners (NRCS, 2000).

Some states have found ways to raise money to off-set the costs of protecting watershed areas. An example of this is at the Indiana Purdue University Center for Alternative Agricultural Systems, which turned productive land into vegetated filter strips by planting pussy willows, red twigged dogwood, and corkscrew willows. After two years, the researchers harvested the branches and sold them to florists for $5,500 per acre (Purdue Agriculture Experiment Station, 1997). Tiburon Golf Course, in Nebraska, holds tournaments to help stimulate discussions between the golfers and the golf course managers about management practices and the golfers also learn about the measures the golf course has taken to preserve water quality, the proceeds go to watershed management and protection (US EPA, 1998). The Audubon Society of New York State has teamed with the U.S. Golf Association to have a similar program (US Golf Association, 1998).

In addition to the above techniques, many states have conducted studies on how buffer zone length and vegetation height influence runoff and sediment yield. Such studies have been conducted in Colorado, Georgia, Illinois, Indiana, Iowa, Maryland, Michigan, Nebraska, and North Carolina. Findings from these studies were similar to hypotheses made based on constructed models. For instance, that forested areas in a buffer zone were more effective in nutrient removal than pasture areas (Lowrance et al, 1983). In a study conducted by Iowa Sate University, it was found that vegetated buffer strips removed on average 26% to 50% of pesticides from runoff of test fields (Wood, 1997). A study in North Carolina looked at four watersheds and the optimal width of riparian forest to protect rivers and streams from runoff. It was determined that there is still effective removal of nitrates for riparian strips as narrow as 16 meters (52.4 feet) (Cooper et al, 1986). It is helpful to see what other states are achieving with watershed protection, not only to stay on top of new technologies, but also copy good models and learn from successes in other states.

(For more information on Case Studies in Water Management, visit the “wet measures” site at http://www.epa.gov/owow/nps/wetmeasures/wetmeasures.pdf, the National Management Measures to Protect and Restore Wetlands and Riparian Areas for the Abatement of Nonpoint Source Pollution).

New York City Watershed Management

New York City has one of the few sources of natural, unfiltered water in the United States. Fortunately, the early leaders of New York City were planning ahead when they sequestered the Catskill/Delaware watershed as the city’s drinking water source. With the Public Surface Water Supply and Protection Act, New York City has the opportunity now to plan for the next 100 years and keep this pristine water source. In order to maintain its quality, we need to control the increasing development pressures and guard against threats such as pesticide/fertilizer pollution, pathogens, sedimentation, and harmful chemical pollution. Therefore, continuous and flexible monitoring is needed to ensure that this water source remains suitable for drinking. If the quality of this water source is not sustained, then the outcome will be a huge financial burden on the city to build a filtration system. Protecting the Catskill/Delaware Watershed by maintaining the health of the ecosystem versus building a filtration system is like maintaining your cardiovascular health to avoid the risk of a heart attack: if you do not take the necessary precautions the consequences are grave and costly.

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