2013

New York City's Water Challenges: History, Politics, and Design

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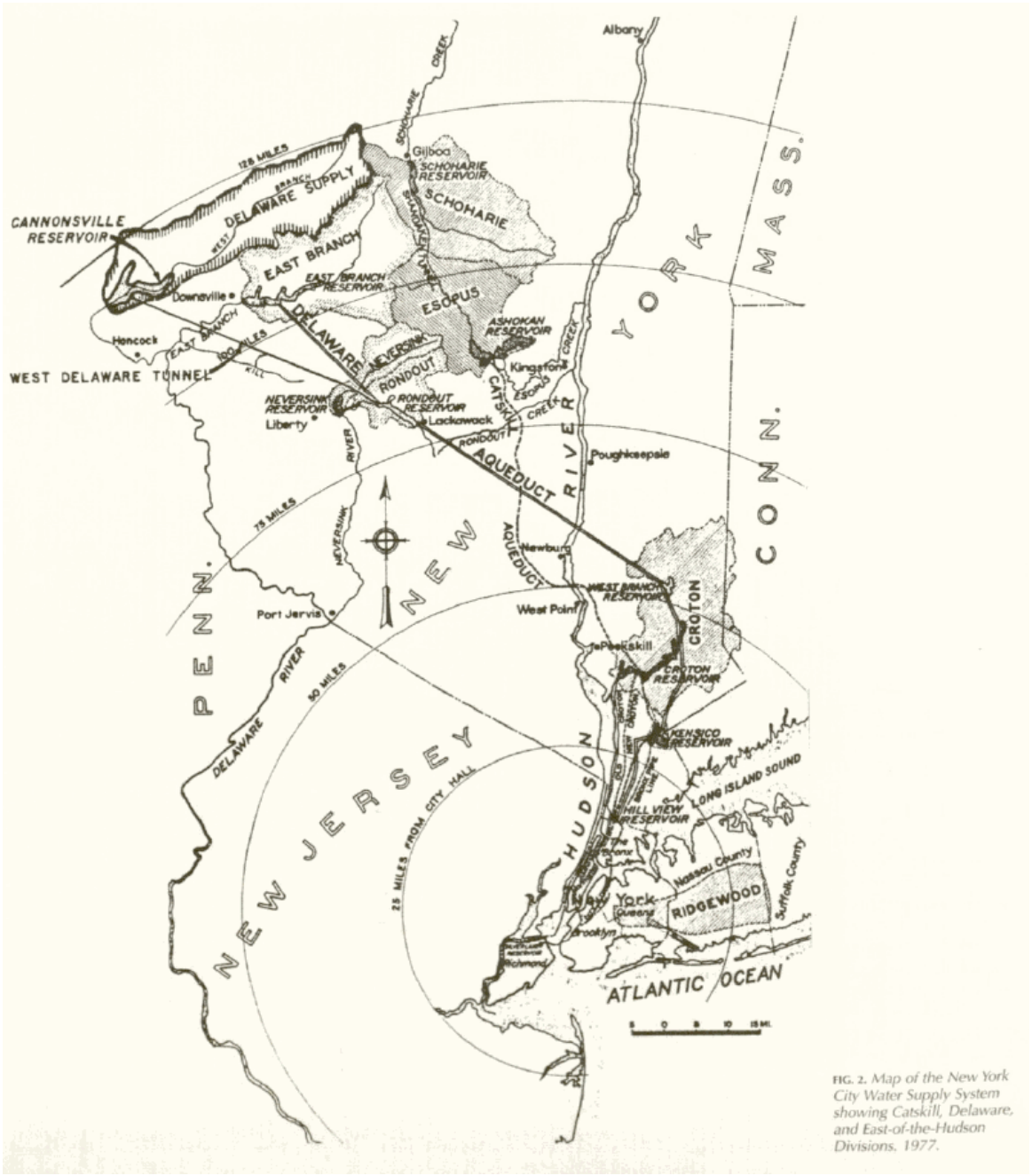

FIG. 2. *Map of the New York City Water Supply System showing Catskill, Delaware, and East-of-the-Hudson Divisions. 1977.*

Abstract

New York City is one of the largest and busiest cities in the world. It is an old city that grew exponentially in size and population since founded and has since needed constant restructuring and construction. Like any large city, water was soon a resource that needed to be harnessed and brought in for health, hygiene, and many other reasons. Considering the geography of the small rocky island, water reservoirs from surrounding areas were an attractive option. Luckily this was a successful plan as the few and small reservoirs on Manhattan were not enough to maintain the enormous city that was growing up around them. New York's water supply is fascinating. Parts of the system are over a century old and others are under construction still. The tunnels, aqueducts, and reservoirs are all sufficient for the stresses of New York but a problem arises when water is on its way out of the city. Sewers are part of an outdated CSO network that regularly spews untreated sewage into the surrounding rivers. There are efforts to make needed changes but what needs to be done and how quickly it will in fact change is another story. New laws, environmental policies, and limited space have made building aqueducts, sewers, water treatment centers, and other necessities harder than in the past. This makes change slow but safe. Water is of the upmost important to every aspect of New York life and it needs to be treated as such.

Introduction

The United States of America is one of the wealthiest, most developed, and powerful countries in the world. Natural resources, food, and water are three vital yet abundant sources of life over which Americans have rarely had to stress. As times and international relations change, prices, trades, and other deals may fluctuate but the general population of the States has always had access to the above and any other necessary commodities. Water is one of the most accessible commodities in the country. Faucets with clean, safe, running water are found in every home and bottled water can be found in lunchboxes nationwide. America has freshwater in every backyard pool, in every refrigerator, and every coffee cup and it is taken for granted daily. The rarity of it in other places is out of sight, out of mind; as is the means by which first world citizens receive and dispose of their water.

To understand the incoming and outgoing water systems that are in place, the struggle of the city, and the progress that has and must be made, it is necessary to study the rich history of New York City and New York State. New York is one of the earliest locations in America to be settled, heavily populated and then go through such a successful and long-lasting population boom. It has served as a port that supplied colonies with goods from around the world, as a welcoming terminal for equally diverse immigrants, and as a flexible and ever-changing international city. Building off of the city's history, other disciplines that help to reveal New York's progress are politics and legal battles as well as the urban and architectural design of the city systems. The economic challenges, and legislative changes

that have come into play in altering New York's water also need to be looked at in order to avoid facing the same challenges.

This paper is organized in a fashion that will facilitate a historical understanding of New York's settlement, early success and failure with water needs, and the slow outsourcing that was needed. It's history will help to explain the right and wrong turns that have been made in the past. The disclosure of general history will then lead into the politics, water system design, and legal battles that were either standing in the way of New York's needs or surrounding areas' rights. Lastly, the fervent design and vision that was required to overcome the struggles the city faced will be elaborated upon. The city needs water, but taking it from elsewhere is often and almost always fought strongly. Throughout the behind the scenes technicalities will be an explanation of the urban growth and development that demanded all of these changes to take place. A chronologic walk through the processes and past actions of the city will incorporate political and design disciplines in hopes to conclude on a positive look to the future.

There will be a focus on the often-overlooked issues that lie within the current sewer system and water pollution that results from it. To conclude this evaluation of New York incoming and outgoing water, the current projects, proposed solutions, and recent advances will be discussed. Current PlaNYC provisions and plans give insight into what is going on and what is to happen to New York in the near future. Also, looking at London's changes to their old CSO sewer systems will allow comparison to New York and see what possibilities can be copied. New York is a massive city with the largest and densest population of any other American city. It is time to make its outdated water meet its modern needs.

The Problem: New York's Long Struggles and Successes in Supplying Water

Modern New York City is full of 8 million first world citizens who use a complex, expensive, and highly pressured system to supply them with monumental amounts of water everyday. Water must be redirected hundreds of miles through aqueducts that cross acres and acres of land just to get the island of Manhattan and other boroughs. Like any other resource, water must be imported to Manhattan because of its location, modern day configuration of skyscrapers and bustling avenues. But as it is being brought into New York, it is being removed from elsewhere. This system of supplying the city is politically challenging, old and tired, and is constantly challenged as the population continues to grow. Likewise, the city's outgoing water poses problems as sewers, drains, and New York's infrastructure is very aged. New York's incoming and outgoing water supplies need a facelift as the population of early NYC quickly outgrew the aquifers and reservoirs that were being built upstate when the need arose in the earliest settlements. Since the developing in Croton, NY in the 19th century, there has been a need for a greater and better-designed way to get water into and out of New York. There needs to be a serious evaluation and rethinking of the way fresh water enters and exits the city.

New York has always put progress first. It is a very old city that has been under construction since the Native Americans sold it. It is constantly being rearranged, dug into, and built onto, all to suit the needs of man. It has been a relationship of abuse and then reconsideration and concern. Reshaping the land to fit the city has been priority over fitting the city to the land. This has been the case with water too. The first settlers and colonists needed water to drink, wash, clean, put out fires, and other common uses that

were being forgot and consequently led to the spread of disease, uncontrolled fire, uncontrollable filth and germs in hospitals, and New York being an all around disgusting settlement. Compared to its southern neighbor Philadelphia, the grand and renowned New York City was very outdated and losing its appeal as well as its citizens. Those who had the means of moving left the city and those who did not have such a luxury stayed in the filthy conditions and likely caught the disease of the year. Eventually the cholera outbreak opened the city's eyes to how desperately change was needed. People needed water rather than alcohol to drink, doctors needed healthier work conditions, firefighters needed the resource to protect the city and even further, there was a massive waste build up had to be dealt with.

New York has never known what to do with its tons and tons of both liquid and solid waste; landfills and incineration have been the most popular but are also extremely environmentally harmful but other options such as better recycling is expensive and waste reduction in general is an idea rooted in the consumers not the government.[1] The collection of garbage and filth directly results in major issues such as the spread of germs, uncontrolled disease, bacteria polluted water that supports the two, the severity of the cholera outbreak, ineffective doctors, growing ghettos, environmental injustice, and a stench that could be smelt from miles away. Looking at the city in terms of natural science, it was an absolute catastrophe, and so much could be mended with proper water supply and removal. Solutions eventually surfaced though. Proposed dams, rebuilding original settlements, and digging around natural and local water sources would all be glimmers of hope for the glorious Gotham.

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[1] Gandy, *Concrete and Clay* (Cambridge, Massachusetts: The MIT Press, 2003), 190.

Crossing state borders, county borders, reshaping land, land property rights, eminent domain, and many other legal hurdles take significant time to work through in order to make the smallest things happen, let alone build aqueducts hundreds of miles long. When water supply systems entering and exiting the city were first built, there were much fewer challenges to deal with because there were much fewer settlements surrounding New York. Land was not owned, bodies of water were not claimed, and people could be bought out and relocated fairly easily in order to reshape the face of landscapes. Today, outsourcing and looking upstate or west of New York is a controversial solution. Further studying of disciplines such as urbanism and its correlation to the local geography unveils the past and present need for the most modern and cutting-edge technology to control water movement through out the New York City.

The lay of the land and what man has done with it is both impressive and somewhat detrimental to the needs of the city. With the build up on the city's surface, much of its water systems and infrastructure has been left in the past. Sewers are nowhere near as advanced or even useful as their neighboring cities. The city's continued growth on top of the already present issues makes them very hard to fix and modernize. While there is ample water in the surrounding areas, New York has needed more and more of it as years have passed. Westchester, Orange, and other more rural counties north of the urban metropolis, are sufficient suppliers to New York but there are still challenges of getting millions of gallons of water to a population hundreds of miles away. The local geography lends itself to support New York's needs but there are still issues of existent urbanization.

The History of Gotham's Water: From Foul to First-Class

New York is one of the most historically rich places in America. The city is known for everything from the culture to the skyline and continually impresses the world in all sorts of ways. The United Nations headquarters shares the same island as the biggest New Years celebration in the country and international corporate business is surrounded by street performers and pigeons. It is one of the most beautiful and bustling cities in the world and was a cornerstone in colonial America. New York State is equally diverse with its mix of farms, waterfalls, metropolises, and a wide variety of geography. The state was settled throughout the Hudson River Valley and was successful in domestic and foreign business. The area developed and started sprouting up cities with healthy populations such as the island of Manhattan. Originally settled at the southern tip, the island was not at all like it is today. There were dense forests, wildlife and game, wetlands, grasslands, and maritime habitats covering the island.[2] Freshwater could be found in small ponds and still bodies on the island and with a small and concentrated population, there wasn't much need for anything larger.

With growth and in the city and the colonies came the need for expansion and more resources to support the settlement. Issues that arose and will be addressed included obviously health and hydration, disease and germs, fire safety, and pure filth. The city's population was growing but so was its pollution and hazards. The earliest supplies of water were wells that sufficed the needs at the time they were built. They were dug when and where they were needed in Manhattan and supplied the small surrounding community.

[2] McCully, *City at Water's Edge* (New Brunswick, New Jersey: Rivergate Books, 2007), Introduction.

Eventually people outgrew the wells and digging more was not an adequate solution. Continuing to sink wells was only furthering issues of sanitation and health because the streets and ground that was being dug up were not sanitary. The quicker the population grew, the quicker buildings popped up and roads got paved and the less runoff could enter the ground. Wells were not being replenished at the rate that they were being drained and when they were it was with dirt and filth collected on the streets. Polluted ground water meant polluted well water and therefore a need to find other means of supplying the city.[3] These wells began causing more problems than benefits. The majority of early New York wells were privately owned by well off citizens who had control over who received water and how much was distributed. Such limits led to racial problems and crimes of theft, arson, and bribery. By the end of the colonial period, there was only one healthy and reliable source of water. The well-known Tea Water Pump was located near the island's Fresh Water Pond and became "became New York's single source of good water".[4]

The Tea Water Pump was one of many wells tapped down into the grounds of Manhattan sometime between the 1730s and 1740s. It was a popular source with an unclear history of who owned it or the commerce that traveled through it. Fortunately this particular well was not a cause of social turmoil and problems like was the case Comfort's well or other "tea water" wells. They were the few sources of clean water and therefore collected people with different intentions. Because of the success of this specific pump, the price of water went up and became more exclusive to the elite. There also had to be city ordinances and regulations put in place to monitor, control, and keep the area safe. Over time, other individual wells became polluted and could only be used for fires or combined

[3] Koeppel, *Water for Gotham* (Princeton: Princeton University Press, 2000), 23, 59.
[4] Koeppel, *Water for Gotham* (Princeton: Princeton University Press, 2000), 31

with alcohol for consumption purposes; the Tea Water Pump was the only suitable source for drinking water left in the city supplying over 3000 homes.[5] It was a success in supplying New York well into the 1790s and could supply enough water to drink and put out massive fires in the same day. Soon however, like all the other wells, pollution and population growth was too much to keep up with. It was a slowly diminishing source that was eventually sold off and taken out of commission for the general publics use and need.[6] The Tea Water Pump fell off the radar at the turn of the century just after the Collect was deemed another disappointment to the city.

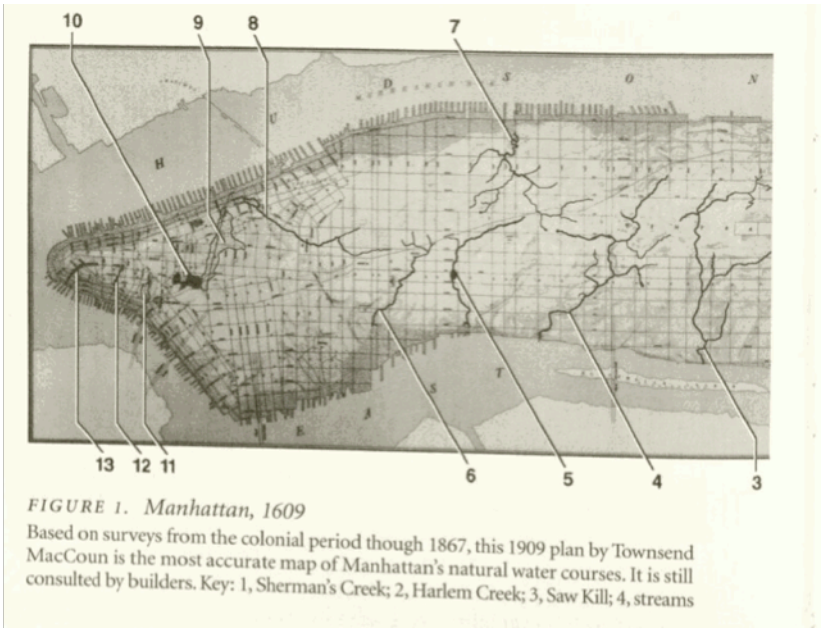
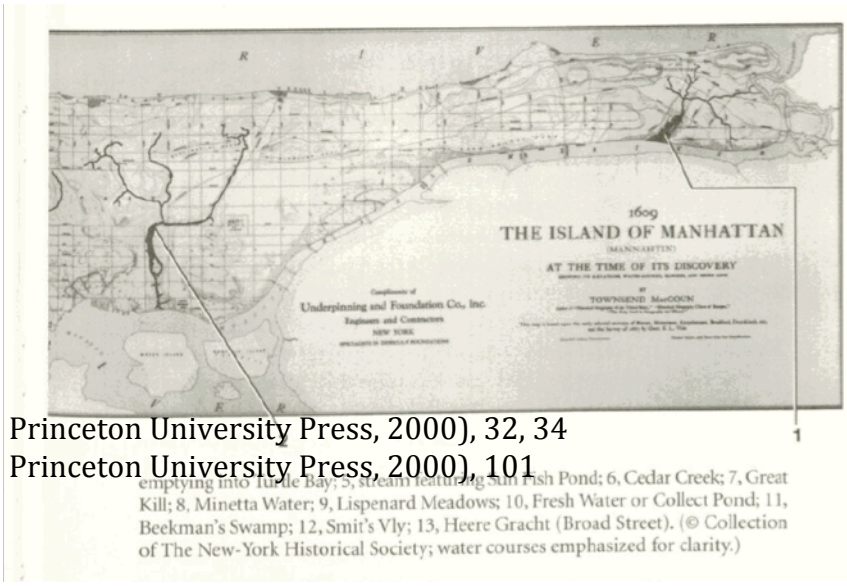


FIGURE 1. Manhattan, 1609
Based on surveys from the colonial period though 1867, this 1909 plan by Townsend MacCoun is the most accurate map of Manhattan's natural water courses. It is still consulted by builders. Key: 1, Sherman's Creek; 2, Harlem Creek; 3, Saw Kill; 4, streams

Right: The two maps detail New York's natural swamps and marshes before they were altered and filled by colonists. The arrow labeled 10 also shows the location of the collect on the southern tip of Manhattan.
Source: Koeppel, Water for Gotham. 8-9



emptying into Turtle Bay; 5, stream featuring Sun Fish Pond; 6, Cedar Creek; 7, Great Kill; 8, Minetta Water; 9, Lispenard Meadows; 10, Fresh Water or Collect Pond; 11, Beekman's Swamp; 12, Smit's Vly; 13, Heere Gracht (Broad Street). (© Collection of The New-York Historical Society; water courses emphasized for clarity.)

[5] Koeppel, *Water for Gotham* (Princeton: Princeton University Press, 2000), 32, 34
[6] Koeppel, *Water for Gotham* (Princeton: Princeton University Press, 2000), 101

The Collect was a seventy-acre pond located near modern day City Hall. It was a less popular but still clean source of water. The Tea Water Pump was ideal but the Collect was a close second choice for a long time.

> "The collect remained the city's more reliable water source into the late 1700s, but in the 1780s it had also become home to a growing number of industries, from tanneries to breweries. In 1785 the *New York Journal* declared the Collect 'a very sink and common sewer,' where both whites and blacks washed their 'cloths blankets and things too nauseous to mention.'"[7]

This small pond turned out to be just another short lived and failed solution to the lack of water in the city. The pollution, overuse, and misuse, of this freshwater was eventually given up on as a healthy solution just like the idea of small private wells. It was used as a public dump for garbage, washbasin, and slowly evolved into an undesirable area filled with lower class citizens, the poor, and immigrants. The area around the Collect became one of the countries first slums with its stenches, swampy grounds, and commercial degradation.[8] By the start of the 19th century, the city started selling off acres of the Collect and the surrounding area. Land was bought up but the polluted swamp was not so popular.

To sell the seventy-acres that was the Collect, the city spent time, money, and carted in tons of dirt to fill the hole in downtown New York. Once that project was completed though, problems continued. Landfill was the simple solution in 1812 but new issues were prominent by 1820. The area became the infamous Five Points neighborhood and was full of crime, tenements, and unstable buildings. Filling the Collect was not done well and led to more unease than progress. Without the Collect to serve and supply the island, there were

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[7] Stradling, *The Nature of New York* (Ithaca: Cornell University Press, 2010), 41
[8] Stradling, *The Nature of New York* (Ithaca: Cornell University Press, 2010), 43

few other water options for Manhattan at the time. There were many plans in order but immediate resolutions were as simple and un-revolutionary as from keg carriers, a few old wells, and drinking tea and alcohol instead of straight water. The use of water kegs was similar to the system of early wells. People ran private businesses of bringing water from upstate lakes, rivers, and reservoirs back down to the city to sell for everyday uses. Those with the resources or enough wealth could simply send their slaves directly to water sources to fill up kegs and bring them back to New York. Through this system though, those retrieving the water were the most at risk for catching diseases such as dysentery from the communal water sources that rarely remained clean for long. The further you went away from the city however, the purer the water, and the healthier the trip and the end result.

While reservoirs, wells, and freshwater was in low supply and high demand, people found other ways to get by with the murky water they had. The simplest and most popular solution of the time was mixing water with alcohol or tea. A technique borrowed from Europeans, using brandy, rum, and other liquor was combined with whatever water was available to make it tolerable. Adding brandy or gin made, or convinced people, that water was safer to drink.[9] New Yorkers drank rarely drank plain water but instead mixed domestic rums, wines, and other spirits they could find. Likewise, tea was used to flavor water and also kill off germs in boiled water. If safe water could not yet be found and abundantly distributed, people had to get creative and make due with what they had.

Sewers: Meeting water needs was only one of the issues troubling New York at the time. Another early obstacle that the original city plans did not incorporate was sewage

[9] Koeppel, *Water for Gotham* (Princeton: Princeton University Press, 2000), 121

and outgoing waste. Manhattan is surrounded by water and composed of bedrock. Millions of years of glacial movement, plate shifts, and changes in the earth's surface shaped the island into what it is today.[10] This consistency of different rock sediments and formations is the backbone and reason for the architecture of the concrete jungle. Natural densities and manmade landfill allows for New York to stand the way it does. However this also makes construction and development more challenging. There were similar formations and rocky texture just north of the city. The state is composed of such solid ground that some saw it impossible to work with. When the Catskill aqueduct system was being built in fact, and engineers and builders decided to dig it under the Hudson River, they were slowed down tremendously by the ground they hit. To reach necessary depths deep enough below the river so as to avoid water, workers had to fight through 200 feet of solid bedrock.[11]

Before sewers were finally dug and utilized, all sorts of waste got left on public and private properties, accumulated on the outskirts of town, and were deliberately dumped into bodies of water to sink or be washed away. The Hudson River served as the single largest sewer pipe that New Yorkers dumped waste into, that polluted runoff drained into, and that industries drained toxic chemicals and products into for decades and even centuries. "As early as 1857 the state had banned the dumping of solid waste into New York Harbor, and later laws forced the city to dump its refuse farther out to sea, decreasing the chance of its floating onto beaches,"[12] but that did not stop people from doing it in the cover of night, upstream, or other illegal means because of the ease and free of charge

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[10] McCully, *City at Water's Edge* (New Brunswick, New Jersey: Rivergate Books, 2007), 1-6.
[11] Bone, *Water Works* (New York: The Manacelli Press, 2006), 135.
[12] Stradling, *The Nature of New York* (Ithaca: Cornell University Press, 2010), 127.

policy. Without sewers, pollution was left to damage the environment. Waste that wasn't dumped was left stationary in the city and bred all sorts of disease and germs. Sewers are an ancient means of keeping a city clean that New York simply did not account for until the end of the 19th century. Even when sewers were finally up to par with the city's excessive waste, they were only designed to relocate the waste, as there were no treatment plants to decontaminate it.

Croton Water Supply: Manhattan was thirsty and there was little fresh-water to be had on the island where population and industry were expanding exponentially. Populations were growing in size and frustration because their health was at risk. City officials had to take action to the many proposals that had been developed in order to keep New York a functioning, thriving, city. Different proposals included damming the Hudson River, tapping the Passaic River in New Jersey, and building a canal from the Bronx River to Manhattan. All of these original ideas fell through however to the idea of diverging and tapping the Croton River.[13] Croton, New York became the first realistic and dependable saving grace for the growing city to the south.

Right: Map of southern Manhattan's Croton water supply
Source: Koeppel, Water for Gotham, 286

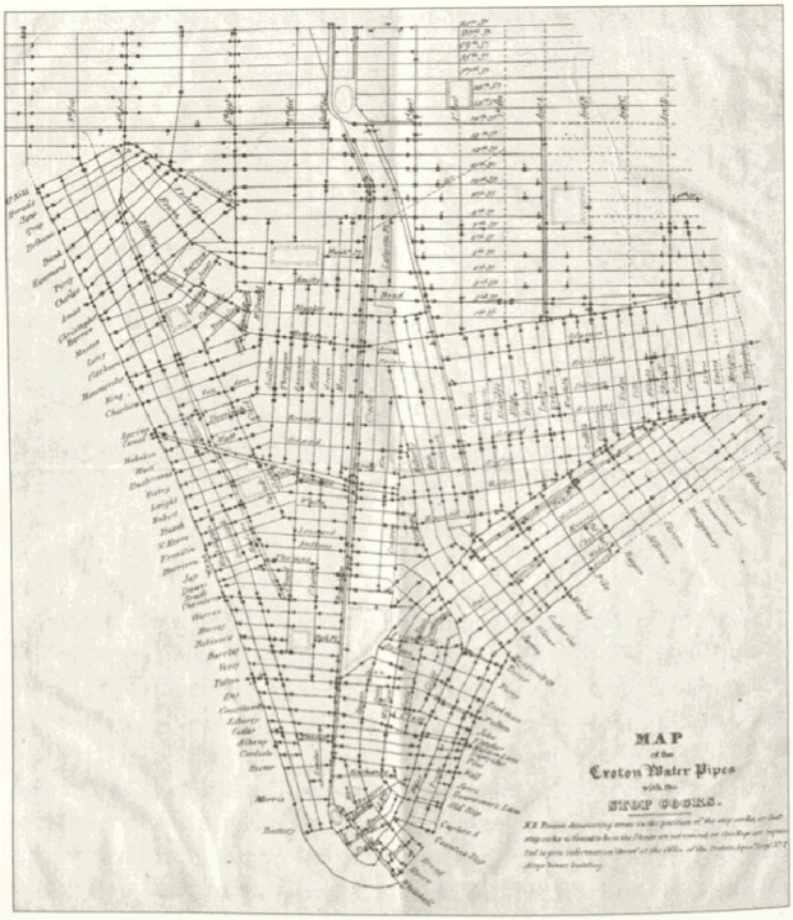

FIGURE 48. Croton water pipe map, circa 1842
This lithograph of the Croton distribution network illustrates the expansion of the city up to its limits at 21st Street. (© Collection of The New-York Historical Society.)

[13] Gandy, *Concrete and Clay* (Cambridge, Massachusetts: The MIT Press, 2003), 29.

The Croton Reservoir was completed in 1842, ten years after the cholera outbreak that not only scared away 100,000 New Yorkers but also took the lives of nearly 3,500. The epidemic was made so much worse because of the lack of water in the city, which really pressured change before tragedy had time to strike again. Politicians stopped putting off the project and hired ex-Army engineer David Douglas to design a system where he saw fit. Damming the Croton River to create a reservoir in Westchester County was decided upon and there was hope to begin construction in 1836. When things were not moving as quickly as needed however, Douglas was replaced with a less educated, less famous, but more qualified, and hands on experienced John Jervis. Jervis spent time working on other projects in the state including the Erie Canal, Hudson and Delaware Canals, and railroads.[14] He may not have had an education from books but he was one of the most qualified men of his time. The Croton reservoir was a success and in the decades that followed its completion, more and more small systems were designed to get water to more New York City doorsteps. As those water mains were connected and built, so were New York's first sewers.

The new Croton Reservoir also had its issues though. The process of connecting water mains was slow and steady but was never successful for poor neighborhoods. Tenement buildings, ghettos, and immigrant communities were still forced to seek out hydrants and cart water back to their homes because those areas were not developed with the technology and luxuries like that of the rich. With issues that arose within city limits, there were also problems with the Croton system in Croton. As New York grew, so did the original reservoir. The Croton system was expanded and a new phase of construction

[14] Stradling, *The Nature of New York* (Ithaca: Cornell University Press, 2010), 70.

began in 1883. There was a new aqueduct, a new dam, and lastly the Croton Falls Reservoir completed in 1911 left the system and infrastructures the most advanced and intricate supplies of water in the era.[15] Eventually the complexities were outgrown and others were constructed in and around the area. The city was slowly draining their local resources and, "by 1900 it had taken essentially all of Croton's water."[16] The latest greatest technology was nice but was also running on fumes. With an estimated 50% of Croton water going to waste through leaks, evaporation, irresponsible consumption, etc., the city saw fit to finally branch north and west toward mountain ranges and rural areas upstate that were plentiful in water and scarce in population in hopes of saving Croton from complete drainage.[17]

Reaching North- Construction and Design of the Catskill and Delaware Water Supply: Reservoirs located upstate were the next step to supplying New York with the water that they needed. Fortunately, while Croton was under pressure and New York was in need of other reservoirs, there were projects well under way. New York City is at the southern most tip of the state and had only one direction to go. They looked north to much less developed areas. The most appealing move was to develop reservoirs or tap into existing sources in the Catskills. The mountains provided hope with their natural, clean, and plentiful supply of water. Although the targeted source was far away, the will power and manpower would soon meet the needs of the country's fastest growing metropolis.

Reaching northward would prove to be a successful but a very long and dangerous process. Those who supported the proposal obviously came out on the winning end but

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[15] Gandy, *Concrete and Clay* (Cambridge, Massachusetts: The MIT Press, 2003), 41
[16] Stradling, *The Nature of New York* (Ithaca: Cornell University Press, 2010), 137.
[17] Bone, *Water Works* (New York: The Manacelli Press, 2006), 109.

also had an almost unfair advantage. One backer was the Ramapo Water Company. They were a group of speculators incorporated in 1897 that managed to weasel through law and legislation, which then allowed them to procure an abundance of land and water rights. With such power, the Ramapo Water Company pushed for the development of a Catskill system.[18] Put in place by the McClellan Act, the Board of Water Supply was another group with unmatched legal power in the initiation and building of the new water supply. The act states that any,

> "Duties of the board as stared by the law were to proceed immediately and with all reasonable speed, to ascertain what sources exist and are the most available, desirable and the best, for an additional water supply of pure and wholesome water… and to prepare maps, plans, estimates, and contracts: to acquire real estate, and other rights and to construct [these waterworks] upon approval of the Board of Estimate and Appeal and the State Water Commission."[19]

The Act allowed New York City to take what water and land they wanted in a sort of far reaching eminent domain manner. The expeditions northward was a land grab relationship where the city took and the watershed communities could do nothing about it; other than Westchester and Putnam Country, New York City had rights to what they wanted. There were communities in the Catskills who fought the city ordinance at the start of the project in the early 1900s. Several months of fighting still led to abandoned homes, two thousand people displaced, but a final decision was made in 1905 to quench the thirst of a city a hundred miles away with the Esopus Creek in the Catskills.[20][21]

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[18] Bone, *Water Works* (New York: The Manacelli Press, 2006), 108.
[19] Bone, *Water Works* (New York: The Manacelli Press, 2006), 111.
[20] Bone, *Water Works* (New York: The Manacelli Press, 2006), 114.

Water from the Catskills: The city first received water from the new Catskill aqueducts in October of 1917. There was a massive celebration to recognize the accomplishments of one of the largest and most revolutionary systems in the world. New York managed to redirect water from the Ashokan Reservoir in the Catskill Mountains over 130 miles south to the metropolis. The project took two decades to complete but was a great success. The Catskill aqueduct travels southeast toward the city, crosss under the Hudson River at Storm King Mountain in Orange County, New York, continues down through Westchester County and then ends at the Hill View Reservoir in Yonkers. This enormous system, incorporated with City Tunnel No.1, would be a lifeline that, "carried 60 percent of the city's water."[22] From Hill View Reservoir, water then travels another 35 plus miles through a network of urban aqueducts and tunnels being tapped all throughout the 5 boroughs of New York until it reaches its final stop on Staten Island at the Silver Lake Reservoir.[23] After the day it got its first sip of water on Jan. 22, 1917, the Catskill Aqueduct would become the most continuously used large aqueduct system in the world. Eventually it was going to need to be relieved of some pressures as well as be shut down at point for repair, but that was years later.

The Catskill Mountains are a rich source of water and were targeted for many reasons. With natural rivers, lakes, ample snow capped hills, there are billions of gallons of fresh water circulating through the area everyday. With a few different options, there is one major Catskill source; "The Ashokan Reservoir alone covers an area of 12.8 square miles, equal to the whole of Manhattan Island below 110th Street, with a capacity of over

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[21] Stradling, *The Nature of New York* (Ithaca: Cornell University Press, 2010), 137.
[22] Bone, *Water Works* (New York: The Manacelli Press, 2006), 184.
[23] Bone, *Water Works* (New York: The Manacelli Press, 2006), 114.

130 billion gallons drawn from a mountainous catchment are of 257 square miles."[24] Another attraction to the Catskills was its elevation. The mountain range is at a much higher elevation than Manhattan, which is nearly at sea level. The simple force of gravity carried much of the water where it needed to go. At certain points along the way there were needs for pressure stations and control valves, especially at the Hudson River crossing and in Westchester, but nature helped the aqueducts' functionality significantly. Pressure existed so long as there was water. A way for man to control the pressure that nature could not was through pipe diameter. The Catskill Aqueduct varied in diameter from 15 feet to 5 feet. Naturally the size shrunk as the pipes got further from the source. Significant room had to be left in the aqueducts for emergency water, but not so much as to foster still water and prevent high pressure and the supply steadily flowing.

Right: Part of the Catskill aqueducts; the size of the water transportation system had to carry billions of gallons per day.
Source: Bone, Water Works, 208

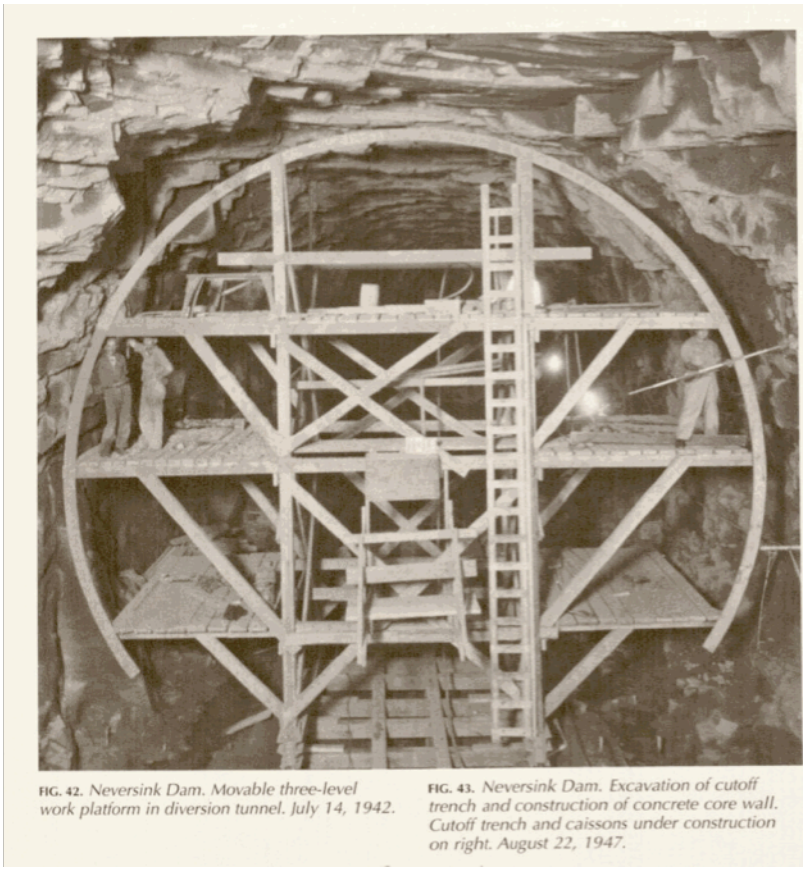


FIG. 42. *Neversink Dam. Movable three-level work platform in diversion tunnel. July 14, 1942.*

FIG. 43. *Neversink Dam. Excavation of cutoff trench and construction of concrete core wall. Cutoff trench and caissons under construction on right. August 22, 1947.*

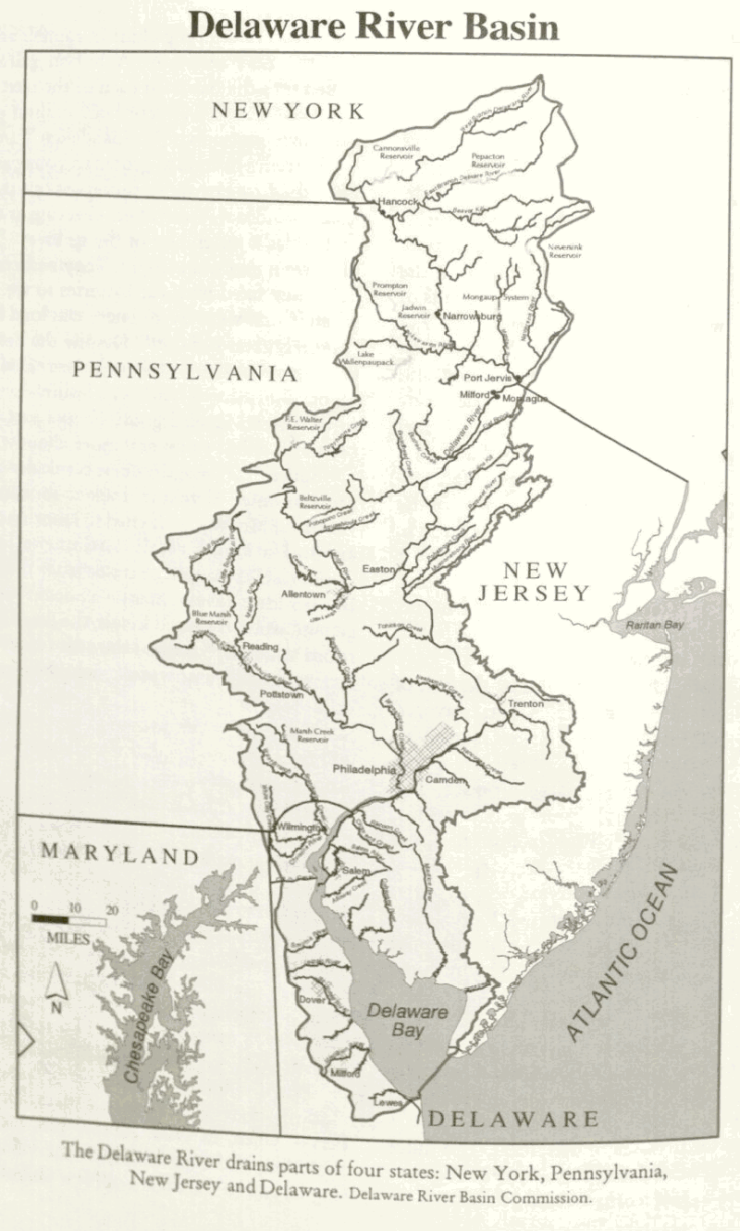
[24] Gandy, *Concrete and Clay* (Cambridge, Massachusetts: The MIT Press, 2003), 47.

City Tunnel Number 2, New York's next project, followed in the footsteps of its earlier model. The second tunnel dug into the city streets worked in much of the same way as the first. Connected to the Hill View Reservoir and created in hopes of supporting the first tunnel system and preventing tragedy if there was ever an issue with it, Tunnel No. 2 delivered water to more parts of Brooklyn, Queens, and Staten Island. It was designed to carry up to 700 million gallons of water per day through its massive, 17-foot diameter pipes. The system was underground like its sister tunnels but was much larger and longer.[25] All 20 miles of Tunnel No. 2 were completed and put into action in 1936, "as the longest continuous tunnel in the world."[26] The world-class tunnel would hold the title until New York outdid itself once more with the completion of the Delaware Aqueduct in the near future.

[25] Galusha, *Liquid Assets* (Fleischmanns, NY: Purple Mountain Press, 2002), 172.
[26] Galusha, *Liquid Assets* (Fleischmanns, NY: Purple Mountain Press, 2002), 174.

***Water from the Delaware River Basin*:** "Overcoming the physical obstacles and community opposition to development of the Catskill System was tough. But the Board of Water Supply was to face an even longer and costlier battle, one that raged all the way to the U.S. Supreme Court, as it tangles with three other states for control of the Delaware River System."[27]

Right: Harnessing the Delaware was so controversial and battled in court because of how intertwined it is in three states
Source: Galusha, Liquid Assets, 166



The Delaware River drains parts of four states: New York, Pennsylvania, New Jersey and Delaware. Delaware River Basin Commission.

[27] Galusha, *Liquid Assets* (Fleischmanns, NY: Purple Mountain Press, 2002), 167.

The Delaware River Basin is a lucrative water source and was appealing for the city of New York, the state of New Jersey, and the Commonwealth of Pennsylvania. The area that would potentially supply any or all of them, spans the entire height of PA, half of the area of NJ, and starts in central NY. It is an enormous area with four reservoirs that are tapped and directed to Westchester, New York before it is distributed throughout the city. The water in those reservoirs was also said to be so pure that it required no treatment. 125 miles away, this water was greatly needed in the Big Apple to contribute to the more than 1 billion gallons needed every day. In combination with the Catskill system, the Delaware would provide ninety percent of New York's water for the next century.[28]

The Delaware system was just as vital as but constructed differently than the earlier Catskill Aqueduct. Because of the composition of the land, crossing state borders, and other details, the engineers and leaders of the new system chose deep-rock tunnels to stretch 170 miles back to their destination. This option was more expensive for the already stressed budget but was ultimately the best choice. By burying the aqueduct below the hydraulic gradient, the entire system would be under pressure and be a better long-term decision.[29] Because of geographic differences from Croton and the Catskills, pressure rather than gravity would be utilized. The underground drilling and tunneling moved at an incredible 140 feet per week, faster than originally anticipated. The system was a straight path from the Rondout Reservoir to the Westbranch Reservoir in Croton. From there water traveled to Kensico and Hill View for collection and specialized distribution.[30]

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[28] Bone, *Water Works* (New York: The Manacelli Press, 2006), 187.
[29] Bone, *Water Works* (New York: The Manacelli Press, 2006), 187.
[30] Bone, *Water Works* (New York: The Manacelli Press, 2006), 197.

The Delaware system was greater and grander than the Catskills and Croton and upon completion was New York's longest system of tunnels and one of the largest projects. It proved to be a great success as it still supplies nearly half of the boroughs' water. It wasn't until the second half of the 20th century that the system would be filled and functional but since then it has not stopped.

Environmental History and Conflict: Water Pollution Problems

The environment has historically always taken a back seat to man's desire to explore, expand, and develop. New York's early water supply construction projects were no different. Worse than that though were the practices of the colonists in Manhattan. With no sewers, no garbage companies, and little knowledge of the damage their pollution could do, early New Yorkers did damage to the area that would take centuries to undo. Disease flourished, ecosystems suffered, and New Yorkers did nothing immediate to fix either. Dumping into the bay, letting animal carcasses and feces lay around, and paving over everything in site led to severe environmental degradation. Swamps were seen as undesirable lands and were filled which eliminated "unhealthful fogs", and reduced the number of mosquito breeding grounds[31] but likewise destroyed flora and fauna, as people built toward the sky and toward the north indefinitely.

A repeated finding in research and in observation is the forceful fitting of nature to man rather than man adjusting to his surrounding nature. The environment was forced to absorb all the runoff, the sewage, the hygienic waste, and absolutely anything that colonists produced because there were no landfills or treatment plants. There was only undeveloped land that could be used for those purposes. Waste grew as time went on. A thriving city went through the industrial revolution and all sorts of factories popped up. With this came tremendous amounts of industrial waste. In the early 1900s, there was an estimated 40 million gallons of raw sewage being dumped per day.[32] In the bay and all around the city, there was little enforcing of the few laws that did protect ecosystems that were being destroyed. One of the first obvious and enormous changes was seen in oysters.

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[31] Stradling, *The Nature of New York* (Ithaca: Cornell University Press, 2010), 41, 43.
[32] Stradling, *The Nature of New York* (Ithaca: Cornell University Press, 2010), 150.

A city once known for its abundance of fresh shellfish, New York now had more areas deemed unsafe than edible. It was estimated that, "fifty thousand acres along the lower Hudson had been rendered unsuitable for shellfish by industrial waste."[33] The only reason this drew any concern though was because commerce and the market was suffering. Oyster populations dropped tremendously which affected other fish species, bacteria counts, and the entire New York Bay area.

New York City's waterways are some of the most damaged in America. Some problems have been long lasting, and others have been repaired or remedied to a degree. Severe damage occurred from industrial waste and companies that dumped straight in to the Hudson and East River. From North of Albany, to the tip of Manhattan, petroleum refineries and chemical plants clustered along miles of riverbanks that were being drenched in toxic chemicals and discharge that was dumped uncontrollably and affected everything from the riverbed to the eagles flying above it. Sources agree that,

> "The scale of pollution in New York waterways during the nineteenth and twentieth centuries was staggering. In 1885, pollution of New York waterways by raw sewage had become so critical that the New York state legislature was compelled to pass an act giving the State Board of Health 'power to protect from contamination by suitable regulations, the water supply of the State and their sources.'"[34]

The board studied and reported on the population of 6 million New Yorkers and their lack of sewers, purification, or any regulation. From the city and the surrounding region, ten million gallons a day of any and everything was being spewed into the once pure water.

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[33] Stradling, *The Nature of New York* (Ithaca: Cornell University Press, 2010), 150.
[34] McCully, *City at Water's Edge* (New Brunswick, New Jersey: Rivergate Books, 2007), 85.

Another environmental issue that presented itself in New York's waterways was humanly altered oxygen levels. Pollution and sewage are broken down and eaten by bacteria that also consume oxygen in the process. Larger quantities of sewage in the water meant more bacteria growth and consumption of it and therefore less oxygen in the water as bacteria thrived. An unnatural lack of oxygen suffocated aquatic plant and animal life and there were massive fish kills, ecosystem loss, and then the cycle continues as it feeds on more dead matter. This vicious cycle flourished in the early 20th century and posed recreational and economic issues. Beaches all around the city had to be shut down, as there was contamination on so many levels. Manhattan had become an island floating in one giant cesspool. All the blue water surrounding the dense lush forests and swamps were gone. Water was sludge and forest was sidewalk. People had done everything in their power to over run nature and redesign it as needed. With no regard to how the earth designed it, New York's "architecture rather than its physical setting" define it.[35]

The Hudson River was one of the most heavily industrialized places in the country. The abundance of space, ease of transporting people and goods, and flowing water used as a dump, made the area perfect to develop along. There was no regulation of waste and everything just flowed away and downstream leaving the source that it came from clean. It accumulated elsewhere and caused problems there. One of these far accumulations and effects was DDT. The widely sprayed pesticide dichlorodiphenyltrichloroethane was extremely successful in mosquito, gypsy moth caterpillar, and other bug control. It killed off invasive species and was a proven deterrent of lice and other pests. DDT was a celebrated solution that was sprayed all over and often. Farms, schools, homes,

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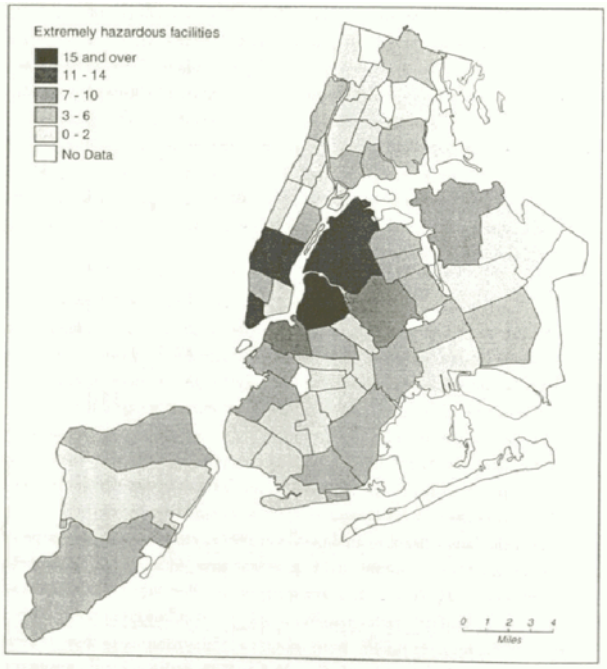
[35] Gandy, *Concrete and Clay* (Cambridge, Massachusetts: The MIT Press, 2003), 23.

playgrounds, stores, and anywhere else that could possibly have bugs utilized this supernatural and health friendly chemical. There were no ill effects on human health so there was no restraint on its use. DDT had atrocious effects elsewhere though. The chemical, if not directly sprayed into, leaked into rivers, steams, lakes, and became so intertwined in the environment that there were effects in every part of the food web. DDT was leached into aquatic plants, and then eaten by fish, which were eaten by larger carnivores, and was causing devastation to New York State environments as well as anywhere else it was widely used. The chemical was slowly phased out but not before legal battles fighting for and against it. Eventually it was banned in the United States only after some species faced extinction.

Right: A map detailing levels of hazardous facilities within the boroughs and Newtown Creek collecting the highest number.
Source: Gandy, Concrete and Clay, 198



5.4 Variations in the distribution of toxic facilities across the 59 New York City community districts. The heaviest concentration marks Greenpoint-Williamsburg.
Source: City of New York Department of City Planning.

Another industry caused damage and extensive pollution at Newtown Creek. The small area in Brooklyn sits on the water and was once a popular commercial and public fishing spot. The location just east of Manhattan but in an inlet made it perfect for oil

companies to import, process, and export. "Refineries dumped unneeded sludge acid into the creek, contributing to the once heavily fished area's ecological collapse. In 1886 the New York Sate Fisheries commission confirmed that Newtown Creek could no longer support fish life."[36] There were many offenders and polluters on the creek. The most harm and long lasting damage however was done by Standard Oil, a company powerful enough to avoid many regulations that others obliged by. The creek is today one of the largest and most continuous oil spills in the world.

[36] Stradling, *The Nature of New York* (Ithaca: Cornell University Press, 2010), 127.

Politics: The Battles Over Rights to Water: New York finally had ample potable water from hundreds of miles away yet its domestic sources and bodies were so polluted people could not swim in, fish, or even stand to smell sometimes. The city had water but didn't know how to care for it or treat the pollution that it was still forcing into it. Up until the second half of the 20th century, there were few laws and legalities regarding the treatment of water and the ones that were in place were rarely enforced. Unless caught and held accountable, companies dumped any and all waste directly into rivers. Unless caught and fined, citizens of New York used streets as garbage pails. And unless draught hit New York, sewers collected all sorts of trash and spewed it, untreated and unfiltered, directly into the rivers when heavy precipitation regularly flooded them causing overflow and release valves to open. The post war era would call for new law and serious evaluation of the sewage system that was not up to par with America's biggest city.

New York faced all sorts of political battles and policy making regarding incoming and out going water. Reservoirs upstate needed to be protected, waste production from homes and businesses needed to be controlled, and there were few departments, people, or concern for it in the past. Development and population booms meant more structure was needed. New York historically was the most powerful city in the state and therefore faced little opposition for most development because it was for the good of the people and public, and both urban and, "residents of the Catskills surely understood that urban growth had led to increased government authority, even in the country side, well away from the crowded city streets."[37] Not only were the Catskills legally overrun by the city but the Delaware River and that water source was the cause of serious legal battles.

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[37] Stradling, *The Nature of New York* (Ithaca: Cornell University Press, 2010), 137.

Right: A post upstate declaring New York City's ownership over the photographed water
Source: Gandy, Concrete and Clay, 67

1.14 Property of New York City: the Neversink Reservoir in 1995.
Source: Photograph taken by Matthew Gandy.

The Delaware Water Shed would potentially feed three states with potable water. New York was one of them and was ready to fight for it in 1923 when the state established a commission specifically for dealing with representatives from New Jersey and Pennsylvania to create a treaty to allocate water to all three. The original treaty proposing 3 billion gallons of water a day to Pennsylvania, and 1.5 billion gallons a day to New York and New Jersey each was not agreed upon. More proposals were produced and shut down for the next five years, as there was not one easy solution to the division of liquid wealth. By 1927 a plan had been decided upon and by 1929, "New Jersey filled its original bill of complaint against the State of New York and the City of New York seeking to enjoin the state and the city from diverting any water from the Delaware River or its tributaries."[38] The struggles continued and the fight over the Delaware made its way to the Supreme

[38] Bone, *Water Works* (New York: The Manacelli Press, 2006), 183.

Court. Eventually a decision was made in favor of New York's original proposal and Justice Oliver Wendell Holmes came to a conclusion that would be repeatedly utilized in future battles over water rights:

> "A river is more than an amenity, it is a treasure. Ur offers a necessity of life that must be rationed among those who have power over it. New York has the physical power to cut off all the water with in its jurisdiction. But clearly the exercise of such power to the destruction of the interest of lower states could not be tolerated. And, on the other hand, equally little could new jersey be permitted to require New York to give up its power altogether in order that the river might come down to it undiminished. Both states have real and substantial interests in the river that must be reconciled as best they may be. The different traditions and practices in different parts of the country may lead to varying results, but the effort always is to secure an equitable appointment without quibbling over formulas."[39]

Right: A sign in Delaware County, New York, shows New York's influence across the state and the displacement people had to deal with.
Source: Bone, Water Works, 179

[39] Bone, *Water Works* (New York: The Manacelli Press, 2006), 183.

Developing the Delaware River to serve and supply New York not only required but also led to many legal developments. Post-Delaware Aqueduct, more reservoirs were proposed in the area. A 37 mile long stretch of land from the Delaware up to Port Jervis was to be dammed and could further be turned into a national park to service 10 million visitors a year. Congress approved in 1962. In 1975 however, enough public opposition to the plan shut it down.

Water from the Delaware River would prove to be a vital resource to all of its bordering states, which had to find a common middle ground for the use and redirection of it. While the fight for development ended and the Delaware aqueduct reached New York, there was still much dissatisfaction with the rest of the area. There was plenty of fresh water to be harnessed but a lack of cooperation between state governments. In 1955, the Delaware River Basin Advisory Committee was formed and led to the Delaware River Basin Commission composed of Governors from New York, New Jersey, Pennsylvania, and Delaware, as well as a federal government representative. This commission was the first of its kind- a combination of state and federal legislation regarding a river basin. The DRBC fostered the communication and mutual exploitation of the basin. It was also a major player in responsible use of the water and conservation efforts following it. In 1992 the commission set standard for household faucets, showers, and toilets, and supported by the federal government, monitors unaccounted-for water. Through these efforts, there is hope to reduce this waste by fifteen percent by the year 2020.[40]

New York won many legal battles to get clean water to the city. The federal government followed the pattern and made legal changes regarding varying pollution and

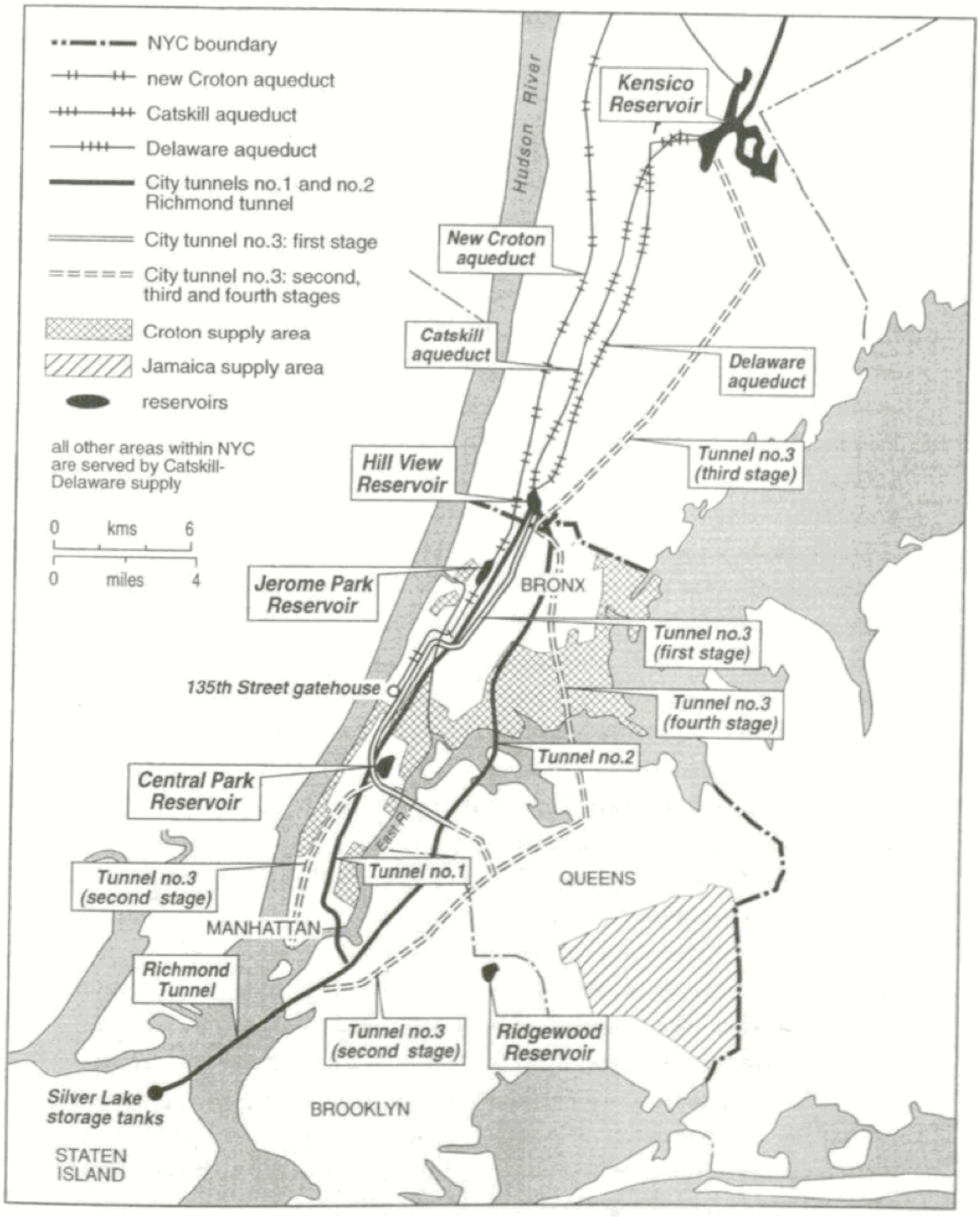
[40] Galusha, *Liquid Assets* (Fleischmanns, NY: Purple Mountain Press, 2002), 195.

protection of water. The Natural Resources Defense Council and the Clean Water Act, created in 1970 and 1971 respectively, were two revolutionary legalities that would help to clean and keep clean the toxic water around Manhattan. For Hunt's Point, and bodies of water across the country, there was now a system of monitoring and forbidding discharge of waste into water. Unless a permit was issued, the Hudson River could no longer be used as GE, Standard Oil, or anybody else's dump.

New York's Modern Water: What's Going on Now

Today New Yorkers depend on three massive tunnels, two major valley reservoirs, and millions of pipes and faucets to get water where it is needed. Tunnel No. 1 and Tunnel No. 2 are very old and have never been shut down for services or inspection. Tunnel No. 3 is a work in progress. The combined systems supply New York with billions of gallons of water a day and are under intense water pressure as well as from citizens of the city that depends entirely on it. With this in mind, it is of the upmost importance that No. 3 is finished on time and starts relieving the stress of the century old tunnels in service now. Designed in four stages or four individual projects, some have been completed and two entire sections remain in progress. The first run was from the Hill View Reservoir southbound into Manhattan and then east into Astoria, Queens. The next section runs through Brooklyn and Queens but also incorporates Staten Island and southern Manhattan. The third part of the massive project will connect the Kensico Reservoir in Westchester to the Bronx and the fourth would flow from Hill View through the Bronx Queens and connect to stage two.

This complex array of underground systems was started in the 1970s and has been under fairly constant construction since. Funding has been an issue and slowed the progress but has not halted it. Tunnel No. 3 calls for no immediate action or use either though. The project is underway in preparation and anticipation of the future unlike the first two. The lack of immediate need relieves some of the pressure off the project but also slows progress.



1.2 New York City water infrastructure.
Source: New York City Department of Environmental Protection.

Above: Map of Tunnel No. 1, No. 2, and No. 3
Source: Gandy, Concrete and Clay, 20

The sewers in New York are a similar story. The systems that lie under the city streets today date back to the 19th century. They are old, not up to par with the pressures the city creates, and they are not world class like much of the rest of the city. New York sewers have always been a mild concern at the bottom of the list of many other immediate issues. By the end of the 20th century however, they were in the spotlight and almost redone. The only thing stopping the city from starting work on the sewer system was the billions of dollars and hours being spent on Tunnel No. 3. If sewer construction were to start, tunnel construction would be stopped. Sewers were also questioned and considered at the end of the century when ocean dumping was outlawed, and construction on Tunnel No. 3 and throughout the city put extra stress on the system.

Combined Sewage Overflow system combines human wastewater and runoff, which only makes it to treatment plants if the sewers are not flooded or overflow with rainwater. With these changes in law and the face of the city, the DEP proposed two options to the DEC: they had to immediately revamp the sewer systems, or cease construction on Tunnel No. 3. Neither happened but a common and somewhat successful settlement was decided upon when the DEC provided a way to drastically reduce human water waste by reducing human use. Leaks were fixed, valves were replaced, and the city developed an unbreakable hydrant lock to stop the millions of gallons of water lost to summer fun.[41] Considering how evolved environmental movements have been in the last three decades regarding other means of waste traffic and management, it is absurd that sewage overflow into oceans is still tolerated. Fresh Kills landfill, the largest in the city, was closed, incinerators were

[41] Bone, *Water Works* (New York: The Manacelli Press, 2006), 225-28.

closed, and ocean dumping was outlawed all by 1990, and while sewage solutions have made positive changes, there is still much work to be done.

New York is currently working on several projects that were set up in the 2007 PlaNYC, which covers everything from the food industry to New York's waterways and water supply. The nearly 200-page document was updated in 2011 and is putting New York above the rest in green cities. Two sections in particular apply to the care, repair, and upkeep of New York's water: Waterways and Water Supply. Both are composed of the city's near and longer term plans for improvements. The first details that are addressed are the remaining 30 billion gallons of CSOs discharged every year and the 14 water treatment plants currently used to handle all of New York's dry weather sanitary waste. The plan continues into 15 major initiatives including everything from habitat reconstruction to expanding the sewer networks. Initiatives 1 and 2 are to upgrade wastewater treatment plants to achieve secondary treatment standards- not just handling particulate matter and large pollution and 2: Upgrade treatment plants to reduce Nitrogen discharge, which is extremely degrading to ecosystems and aquatic life. This will involve projects for reducing up to 50% of nitrogen discharge at Bowery Bay, Tallman Island, and Wards Island Wastewater Treatment Plants as well as new nitrogen reduction technologies at many sites. Newtown Creek is currently the largest of the treatment plants and is due for a $5 billion facelift.[42]

The third initiative in the waterway cleanup project is to complete cost-effective grey infrastructure to reduce CSOs and improve water quality. This will happen by

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[42] New York. The City of New York, *PlaNYC,* Michael Bloomberg. N.p.. 2007. Web. 61-69

improving and updating CSO treatment facilities and building new ones like at Alley Creek in Queens. Next, the city plans to expand the sewer systems. This fourth priority will consist of building some more separate storm water sewers, which will reduce sewer back up and flooding. More rainwater is to be diverted so as not to mix with sewage and cause stress on the system. This in combination with initiative 5 of optimizing the existing sewer systems should reduce and control the excess CSO problems that exist. Initiatives 7: build public green infrastructure projects, 9: modify codes, and 10: provide incentives for green infrastructure all encourage citizen participation to make the city environment greener through concepts like green and blue roofs, permeable pavement, storm-water capturing tree-pits, new building and construction site codes, storm surge plans, and new available technologies for the trade of tax breaks.[43]

These community and publicly interactive initiatives are great policies for the city to enforce. Green roofs to catch water and blue roofs to hold water until the storm surge has passed are simple and proven successful ways to reduce runoff and stop flooding. Permeable pavement like cobblestone is another good plan but it is more controversial. Miles of roads would have to be torn up to make a visible difference and automobile drivers object to bumpy roads; there are alternatives to cobblestone but they are expensive and significant mileage of construction would take months or years regardless. The new building and construction codes seem like a reasonable change though. Many of the proposed or new regulations are based on acreage development. Because it is rare that one company or one developer builds on more than one acre in the concrete jungle, they should not have an issue with the ratio of green needed when developing. The larger sites

[43] New York. The City of New York, *PlaNYC,* Michael Bloomberg. N.p.. 2007. Web. 61-69

however are required to provide certain green space when construction is complete and are only allowed certain amounts of complete pavement, which would add to the city's issues with runoff.

The next segment of PlaNYC is New York's water supply. From the 1800's until now, the city has not stopped improving and altering the water supply that feeds billions of gallons to millions of people every day. While the quality of New York's water is exquisite and surpasses both state and federal standards, there are always improvements to be made. There are currently three massive projects going on to maintain the city's water delivery and quality that also happen to be the three largest water network projects in the world; "the Croton water filtration plant, the Catskill/Delaware Ultraviolet (UV) Disinfection Facility, and City Water Tunnel No. 3."[44] The water supply chapter also provides over a dozen initiatives that the city will and has been working on for years already. The first and possibly the most important is the continued protection of the Watershed Protection Program. New York is currently one of only a handful of American cities that does not have to filter the majority of its surface water. This is an enormous financial benefit and to lose such a luxury to pollution or contamination would cost the city immensely. The projected $462 million Watershed Protection Program will guard against the greatest potential threats as well as involve and utilize surrounding towns, businesses, and communities to keep their environment and surroundings as clean and safe as possible, which will benefit all parties. The program will also replace septic systems and water treatment plants that are near the city's reservoirs to prevent and future potential

[44] [44] New York. The City of New York, *PlaNYC,* Michael Bloomberg. N.p.. 2007. Web.,79

threats. Lastly, the protection plan aims to continuously acquire and buy surrounding lands and properties from willing sellers to prevent development.[45]

The second initiative is very closely linked to the first. "Protecting the water supply from hydrofracking for natural gas," is something that several local, state, and nation groups have been fighting for years. While fracking could serve as a viable source of extracting gas for energy purposes, it is also a toxic, hazardous risk to the entire northeast. The Marcellus Shale and New York's reservoirs overlap and drilling or pursuing to frack could contaminate all of the city's water with chemicals that are completely unstudied and pose unknown dangers to humans and the environment. Following the preventive fracking actions are plans to finish the Catskill/Delaware UV disinfection facility and complete construction of the Croton Water Filtration Plant, which was already underway with electrical and testing of equipment as of April 1, 2013. These two projects will be world class updates to the century old systems and will not only be state of the art but also very pleasing to the public. The roof of the Croton Plant doubles as a golf course and the UV Disinfection Facility will be the largest one in the world.[46]

Initiatives 5 and 6 are repairing the Delaware Aqueduct and connecting the Delaware Aqueduct to the Catskill Aqueduct. These two projects are billion dollar plans that will require the aqueducts to be shut down for several, up to 15, months at a time. While this construction is going on to improve the Delaware system, the city will depend on more water from the Catskill and Croton systems. After the needed Delaware repairs are made, the Catskill and Delaware systems are to be connected in Ulster County, New York. Connecting the two will allow more and cleaner water to be moved from the massive

[45] New York. The City of New York, *PlaNYC,* Michael Bloomberg. N.p.. 2007. Web. 78-83
[46] New York. The City of New York, *PlaNYC,* Michael Bloomberg. N.p.. 2007. Web. 78-83

Delaware watershed into and through the Catskill Aqueduct, which will greaten the capacity of the overall system and the amount of water that can be delivered to the city. This project, originally scheduled to begin in 2012 was pushed back to 2013 and is finally breaking ground. There are a few more major projects like pressurizing the Catskill aqueduct because previously utilized gravity won't work with the new layout of the system and construction plans. There are also dam upgrades and repairs to be made to many parts of the system but all of this construction is not scheduled until the second half of the decade and will likely by pushed back further as the larger projects take longer.[47]

These initiatives are also fairly reasonable and potentially very successful. Watershed protection and fracking prevention are two plans that both the city and citizens of New York should fight for. The environment and natural habitats upstate are not only stunning but also an oasis from the modern day development that is happening across the country. And in the case of frackng, allowing such a dangerous situation as a extraction site anywhere near our water sources, homes, or environment is absurd. It is an incredibly under developed process that may one day be reasonable but right now the amount of un-researched chemicals, accidents that have occurred, and flaming faucets that show up, fracking has no business anywhere near the Delaware River Basin. The other incentives like the Disinfection Facility, Croton Filtration Plant, repairing the Delaware system, connecting the Catskill and Delaware systems, and completing Tunnel No. 3 are all projects that are underway and will eventually, upon completion, be successful means of providing and continuing to feed New York. They are million and billion dollar projects but without them, the city's needs would surpass their supply. The city has done a lot right in the past

[47] New York. The City of New York, *PlaNYC,* Michael Bloomberg. N.p.. 2007. Web. 78-83

regarding water supply but has struggled with water waste. The new sewers and updated treatment plants will remedy this. The repairing of the old aqueducts is slightly overdue but their construction has held up tremendously and the new preventive measures such as Tunnel No.3 and Croton projects are a responsible move for the city's future.

The city has very big plans for their water in the coming years. The century old systems that flow from upstate and west of the city are in for major reconstruction and repairs and inner city workings like the sewer systems and Tunnel No. 3 will be huge improvements to the already world class water. PlaNYC has fallen behind their originally laid out schedule on most of their initiatives, however the effort and commitment toward the future and constant renovation is there and as strong as ever.

Conclusion: More Water for More People

Water has been declared "the last frontier in privatization of the world."[48] Fortunately New York City and State either prohibited that from happening or has since prevented the commercialization of water for the good of the public. In the future, there should be no problems with marketing or the privatization of public water and as New York no longer looks to expand its systems but preserve them instead, there should be few long hard legal battle like there was over the Delaware. The Croton Valley, the Catskill Valley, and the Delaware Water Gap are sufficient sources that just have to be monitored, rationed, and replenished.

New York was built from the ground up like any other city, but few had to go back and lay the foundations after centuries of development. A city cannot survive without water and fortunately Gotham figured out how to import what they needed. The little water that was domestic was disgusting and not suitable for any sort of human uses. Outsourcing proved to be a battle but a success in keeping New York alive. Hundreds and hundreds of miles of aqueducts and tunnels, billions of gallons of water, thousands of acres of land and reservoirs are what make up the complexities of the faucets of Manhattan. The work that was done in the past has since sufficed because of conservation and sustainability efforts. A system with much less sustainability however is the sewers. The pollution that results from an outdated and defective system must be the city's immediate next project.

New York's plans for the future and current projects are going to be a sufficient means of supplying 9 million people the billions of gallons of water that they need. The

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[48] Gandy, *Concrete and Clay* (Cambridge, Massachusetts: The MIT Press, 2003), 72.

most important actions currently are completing Tunnel No.3, updating sewers, and keeping the current reservoirs and water sources clean and protected. There also needs to be a closer monitoring of water used in New York. While many leaks, cracks, and mistakes have been fixed, there is still a tremendous amount of water wasted in New York. There needs to be more meters installed to measure usage so that all of the water going into the city can be accounted for. This will not only encourage people to be more conscience of how much they use and it will allow constant monitoring of any leaks or faults in the system. This is obviously a far reaching wish as it would require serious construction and design changes as well as impose legal supervision to many people who likely don't want it. The design of New York's water system as a whole is very old though so if there are going to be so many changes to the aqueducts and continued construction on tunnels, all for the same general purpose, now is the time to make the changes. Politically it may be a little more difficult to inflict more changes on the people of New York. Legal issues can take years and years to be resolved but when it is in favor of the masses of the city, there should be a hard push for betterments.

The environment has seen better days too but is in much better shape than it was at the start of the last century. Efforts to cleanly repopulate oyster beds, continuous battles over the condition of Newtown creek, and legal statures that are meant to protect the Hudson top to bottom are great strides from where nature was a short time ago. The political battles to get both New York City and its natural environment up to par with the state, country, and world's satisfaction have been difficult as they often pin industry and development against air and water quality; all of the above is needed, but a healthy harmony must come above all. New York's water systems are a beautiful exhibit of man-

made marvels that twist and turn for hundreds of miles under and above ground. It is a testament to America's will power and world-class engineering and construction capabilities. There is no water system in the world that has surpassed its old records and esteem threefold. New York is a great success that spans decades and landscapes and will continue to be altered and developed, in the form of Tunnel No. 3 etc., so long as the boroughs need.

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