WATER-WORKS

THE ARCHITECTURE AND ENGINEERING OF THE NEW YORK CITY WATER SUPPLY

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THE MONACELLI PRESS

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THE RISE TO CROTON

GERARD KOEPPEL

Twenty-first-century New York is arguably the world's capital city. But it was not always so. New York's primacy was not inevitable (nor is it inviolable). When Dutch New Amsterdam became English New York in 1664, the leading colonial city was Boston. Over the next hundred years, New York was outranked in population by two others: Philadelphia and Charles Town to the south. By the turn into the first full century of the new American nation, Philadelphia was the country's largest city, but its supremacy was draining away down the hundred river miles that separated it from ocean shipping lanes. In 1810 New York counted ninety-six thousand citizens, slightly more than Philadelphia. Ten years later, the Erie Canal was under construction, joining the Hudson River to the previously impenetrable continental interior. Two hundred years after its founding, the island settlement by the sea finally emerged as the trade center of the Western world.

In many ways, New York was prepared to take up its mantle as the nation's premier city. In 1811 it began stretching paved fingers up Manhattan from its jumbled southern tip. Replication of Dutch-made disorder—narrow winding streets haphazardly laid—would not do. A state commission led by Gouverneur Morris, a home-grown gentryman and a draftsman of the U.S. Constitution, decided that Manhattan should be a natureless grid of twelve avenues and 155 streets: two thousand similar rectilinear blocks from suburban North (now Houston) Street to the seeming limit of future migration, designated as 155th Street. Manhattan's hills—the Delaware Indian name "Manahata" is thought to mean "island of many hills"—were to be shoved into its valleys. Its many fresh streams, extensive marshes, scattered ponds, and bubbling springs were to be suffocated with pavement and basement floors. Rational order was to transform this continental shard into prized real estate. "[A] city is to be composed principally of the habitations of men," wrote the sure-handed Morris, "and . . . straight-sided and right-angled houses are the most cheap to build and the most convenient to live in."[1] Thus was Manhattan gridded for its glorious future.

As urban settlement pushed north from Houston Street to Washington Square to 21st Street and beyond, the political and social landscape adapted as well. Starting in the late 1790s, control of city and state government shifted from the Federalists (later reborn as Whigs and now Republicans) to the Democratic-Republicans (today's Democrats): from Hamiltonian elites to Jeffersonian merchants, from the manor-born to the Tammany served. In 1804 the state legislature, over conservative objections, significantly expanded city suffrage to all taxpayers. In 1830 the first major city charter revision in a hundred years created modern governance: the Common (now City) Council was split into two houses, each with legislative authority, and the mayor—appointed only since 1821 by the council instead of Albany—was severed from the council and given veto power, subject to majority override. Annual popular elections for mayor began in 1834. Mayoral control of proto-bureaucracy followed, and a city under executive management emerged. And none too soon.

From 1810 to 1840 New York's population more than tripled, adding an average of 7,200 new people a year, many of them poor Irish immigrants. New York turned from an overgrown colonial-age town into a dense industrial city of 330,000. And yet, on the cusp of world dominance, New York was still drinking water as it had in the days of burghers and bouweries: from wells that had always been distastefully hard and brackish but now were extraordinarily deficient and dangerously polluted.

FACING PAGE

FIG. 1. *Old Croton Aqueduct. Cross section. c. 1836. This is believed to be the oldest drawing in the DEP Archive.*

Area of cross section of Masonry of Aqueduct is:

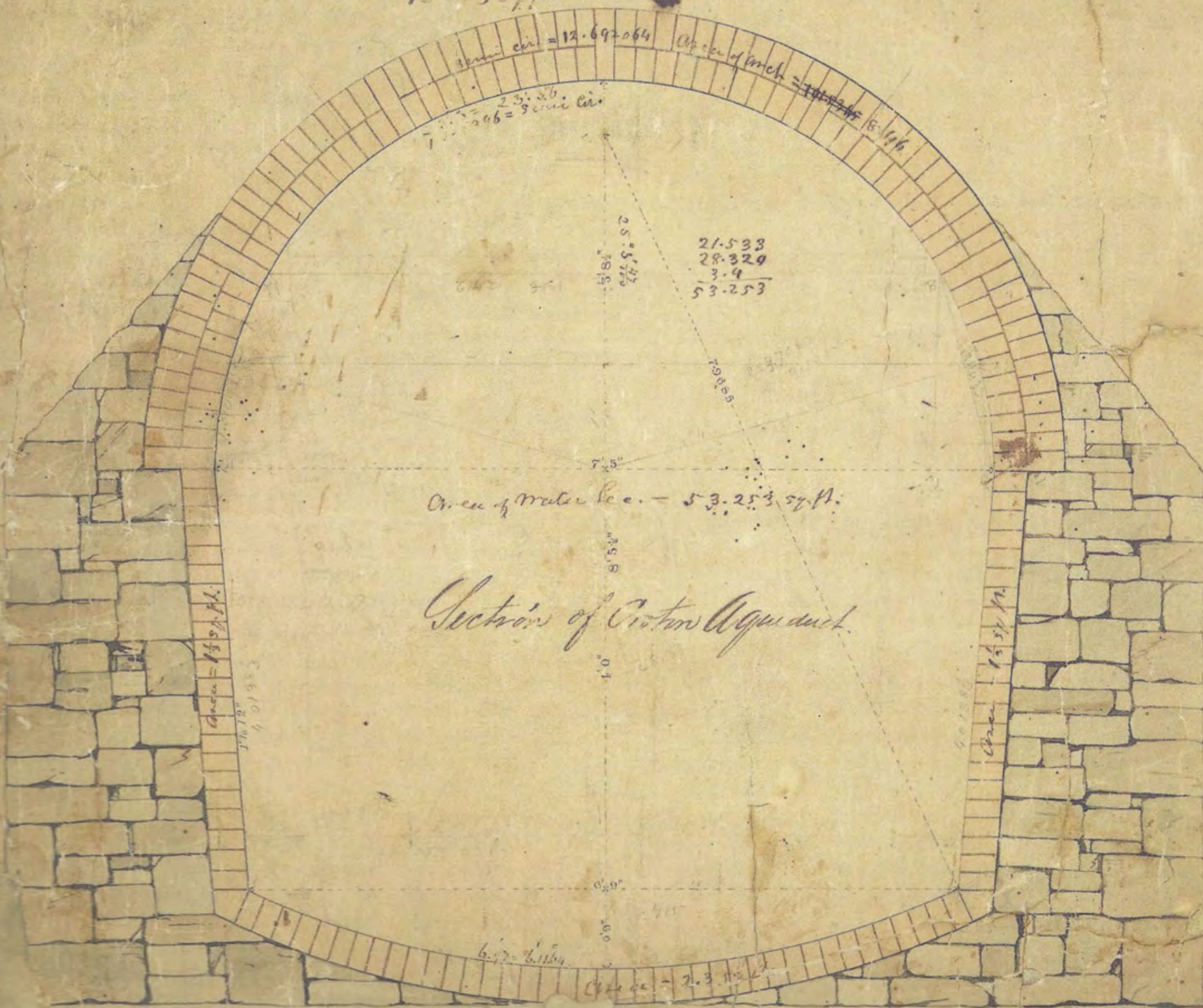
Concrete Masonry = 4.605
Stone walls in sides 1.572
& in foundations 2.690 | 28.867

Brick in Arch, Inside facing 13.658

42.525 sq. ft.

Top 8.46
Sides 2.67
Bot 2.3

See Brick work = 13.43 sq. ft.



53.98 sq ft

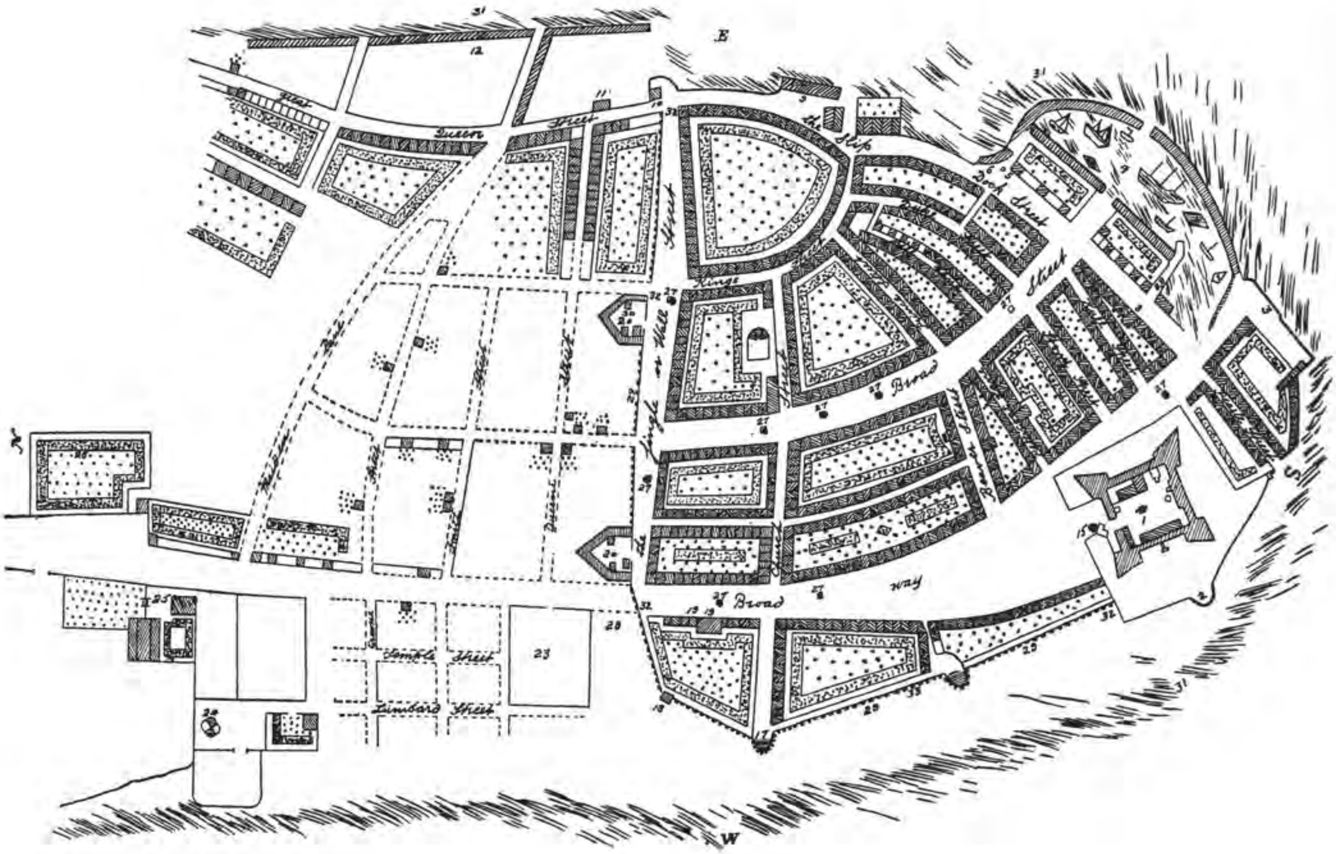


FIG. 2. *Plan of New York, 1695, showing nine public wells below Wall Street. Small dark squares indicate well locations.*

New York's eternal struggle with filth was noted as early as 1697 when Boston physician Benjamin Bullivant took offense to the "nasty & unregarded" streets.[2] Annapolis physician Alexander Hamilton (an intellectual bon vivant, not the later statesman) was the first to record New York's water trouble. "They have very bad water in the city," he observed in his private travel journal during the summer of 1744, after finding excellent and abundant well water in Philadelphia.[3] Swedish botanist Peter Kalm made New York's water a matter of public record a few years later. "There is no good water to be met with in the town itself," he wrote in the widely published account of his North American travels. "This want of good water lies heavy upon the horses of the strangers that come to this place; for they do not like to drink the water from the wells of the town."[4] English clergyman Andrew Burnaby passed the final verdict on colonial New York: "[It] is subject to one great inconvenience, which is the want of fresh water."[5] U.S. Supreme Court Justice and native New Yorker Brockholst Livingston remarked in 1810 on the bodily wastes seeping into wells public and private: "Inhabitants literally in their water [are] drinking a proportion of their own evacuations, as well as that of their horses, cows, dogs, cats and other putrid liquids so plentifully dispensed in the different yards, streets, and alleys."[6] Livingston might have added the noxious leechings from slaughterhouses, tanneries, hatteries, and other industrial waste deposited, along with organic waste, in yards and street gutters. Another generation later, Washington Irving lamented the lack of progress: "It is a pity that so rich and luxurious a city which lavishes countless thousands on curious wines, cannot afford itself wholesome water."[7]

Irving was writing in early August 1832 from the safety of a spa at Saratoga Springs. Having ravaged the world for six years, Asiatic cholera had made its inevitable way to New York, deemed (by former mayor and great diarist Philip Hone) to be a filthier host than any of the cholera-violated cities of Europe and Canada. No one knew that cholera was a bacillus transmitted in waste-polluted water. In 1832 no New Yorker made the medical connection between well water and the waste that infiltrated the wells from the streets and yard privies. Over 3,500 New Yorkers died, nearly one in sixty, the highest cholera death rate among the largest cities of the Western world. One hundred thousand New Yorkers fled, a desertion rivaled only by the patriotic flight from the English occupation during the Revolution. This was no way to run the leading city of the United States.

Wells had figured almost exclusively in the water fortunes and misfortunes of New York for its first two centuries. The Dutch town (confined within a fortified wall that became Wall Street) drank only from private wells, especially those used commercially by a half-dozen brewers. New Amsterdam's wells were shallow and few. The best were lined with wood and had a large bucket suspended from a long sweep. The lack of a well in the fur-trading settlement's fort at the foot of Broadway contributed to Governor Peter Stuyvesant's quick surrender to an English fleet in 1664. There was no way to water his besieged troops, Stuyvesant later explained to New Amsterdam's proprietor, the Dutch West India Company, which found the explanation "very strange."[8]

New York's first water shortage was resolved two years later, when the new English governor sunk a well in the fort "beyond the imagination of the Dutch" who had believed the location unsuited for a well.[9] It was the city's first public well. The second, sunk in 1671 in the rear yard of the Stadt Huys, a tavern turned into City Hall on the East River at Pearl Street and Coenties Slip, was the first stone-lined well. A deep wood-lined well dug in front of the fort in 1689 was fitted five years later with a pump, another first. By then the town boasted nine other stone-lined public wells. They were situated mid-street and systematically ordered, paid for, and maintained. Locations were designated by the Common Council, costs were split between the city and the given neighborhood, and residents were assessed on the basis of their proximity to a local well. Prominent residents were named (and compensated) as caretakers of their neighborhood wells, so that most of these first public wells became identified not by their locations but by the names of their caretakers. The well in Broadway just south of what is now Exchange Place, for example, was known as "Mr. (Francis) Rombout's Well," for the former mayor who owned much of the land along the west side of Broadway. A detailed city plan drawn in 1695 noted thirty landmarks, not the least of which were the public wells in Broadway, Broad Street, Wall Street, Bridge Street, and the fort [Fig. 2]. A hundred and forty years later, hundreds of public wells equipped with brass pumps had been shifted from the center of the streets to curbs and were maintained by the city.

During the generations of water deprivation, there were periods of hope. All revolved around the greatest geographic feature of lower Manhattan: the Fresh Water Pond. Spreading seventy suburban acres across what is now the courthouse neighborhood of Foley Square, the pond in its natural splendor was ringed by wooded hills and fed by clean subterranean springs. Its outlets spanned the island: marshy ground led southeast to a small stream opening onto the East River at what is now Catharine Street, and extensive marshes led northwest along what later became a canal (and then the street of that name), draining to the Hudson River. As the expanding city encroached on this area in the early 1800s, the Fresh Water came to be called the Collect [Figs. 3, 4], a corruption of the Dutch word for *pond—kolk*—and disparagingly emblematic of the pond's increasing collection of rubbish and the occasional murder victim. In the 1810s the pond was landfilled into real estate, with Centre Street roughly defining its longitudinal axis. The pond was never directly tapped for drinking water, but its prodigious springs were the source for three water supplies of varying inspiration and efficacy.

FIG. 3. *Vicinity of Collect Pond showing streets and significant landmarks before and after filling of pond in 1810s.*

FIG. 4. *Collect Pond. c. 1787.*

In the early 1740s, the Tea Water Pump started a six-decade run, ending when the city grew up around it and its sources grew polluted. The pump was located just east of the Fresh Water Pond on a country road that is now Park Row; the exact spot is beneath the grounds of the Chatham Towers apartment complex. The pump was owned by the Hardenbrooks, a family of prominent tanners, and leased to a succession of operators; the well tapped a spring that was for many years deemed the finest for New Yorkers' tea.

The pump got its start after the so-called Great Negro Conspiracy of 1741. The conspiracy was supposedly hatched by slaves and suspect whites at a private well near a Hudson River dock above Wall Street to which leading citizens' slaves were sent to fetch water. New York was ripe for intrigue, due to a combination of economic recession, strained colonial finances—England was warring with Spain—a severe winter, and lingering unsubstantiated rumors about a black plot to poison public wells. The 1741 conspiracy, "exposed" by the spectacular testimony of a sixteen-year-old white servant girl, called for the slaughter of all whites, the burning of the town, and rule by a junta of assorted tavernkeepers, slaves, and prostitutes. Hysterical justice claimed thirty-five lives (all but four black) at the stake and gallows, and dozens of blacks and whites were banished. A new law prohibited blacks from getting water from anywhere but the nearest neighborhood well.

The "conspiracy" turned the Hardenbrooks' suburban well into an entrepreneurial opportunity. Before long, the Tea Water Pump was a concession, its water delivered in casks on horse-drawn carts by city-regulated Tea Water men to customers who could afford the charge. By the early 1770s thousands of households were getting a few pails of water a day for forty-five shillings a year. As fine as the water was, its annual cost equaled a month's earnings for working people, who continued to use the inferior but free street wells. By the early 1800s, the quality of the Tea Water had fallen dramatically and it passed out of use as a regular supply. It was last seen in 1827, trickling from a pipe into a liquor store at what had become 126 Chatham Street.

The inequities and inefficiencies in the water supply of late colonial New York were addressed by Christopher Colles, the first individual clearly identified with New York's water fortunes. Colles hailed from a prominent Anglo-Irish family. Particularly notable is his nephew Abraham Colles, the great surgeon and medical educator of early-nineteenth-century Dublin. Christopher Colles's successes, however, were few. "Had I been brought up to the trade of hatter," he lamented late in a long and ultimately impoverished life, "people would begin to come into the world without heads."[10]

In 1774 Colles proposed New York's first piped water supply, a public enterprise he would both build and superintend. On the outskirts of town he would create a waterworks featuring a deep well, a steam engine, and a large reservoir. A network of hollowed log pipes would be laid through the main streets. Although increasingly distracted by rising revolutionary fervor, the Common Council agreed to the idea and began issuing promissory notes to finance the estimated £18,000 ($45,000) cost [Figs. 5, 6]. That was six times the city's annual revenues and far more than its accumulated debt. The "New-York Water Works" notes were the first paper currency issued by an American city.

Over the next two years, Colles constructed his works on high ground purchased by the city just west of the Fresh Water Pond, at what is now Broadway between Franklin and White Streets. The well was thirty feet wide and twenty-eight feet deep; Samuel Bard, the city's leading scientist, tested its water and deemed it superior even to the Tea Water. Next to the well, Colles built a reservoir that was 165 feet square, with a capacity of two million gallons. Twelve-foot-high vertical interior walls of brick (or stone) were supported by exterior sloping earthen embankments.

The centerpiece of the works was the steam engine that pumped water from the well into the reservoir. At the time there was no working steam engine in America. Twenty years earlier, a large and powerful Newcomen-type engine had been imported in parts from England, where steam engines had long been in use to pump out mines; the imported engine was put into service at the famous Schuyler copper mine in New Jersey but was destroyed by fire early in 1773. Later that year, the newly immigrated Colles designed and built the first American steam engine for a Philadelphia distillery. It was cheaply made and barely worked, but it inspired design improvements for his New York engine. Its major components were cast at the New York Air Furnace, a prominent foundry at the site now occupied by the Woolworth Building.

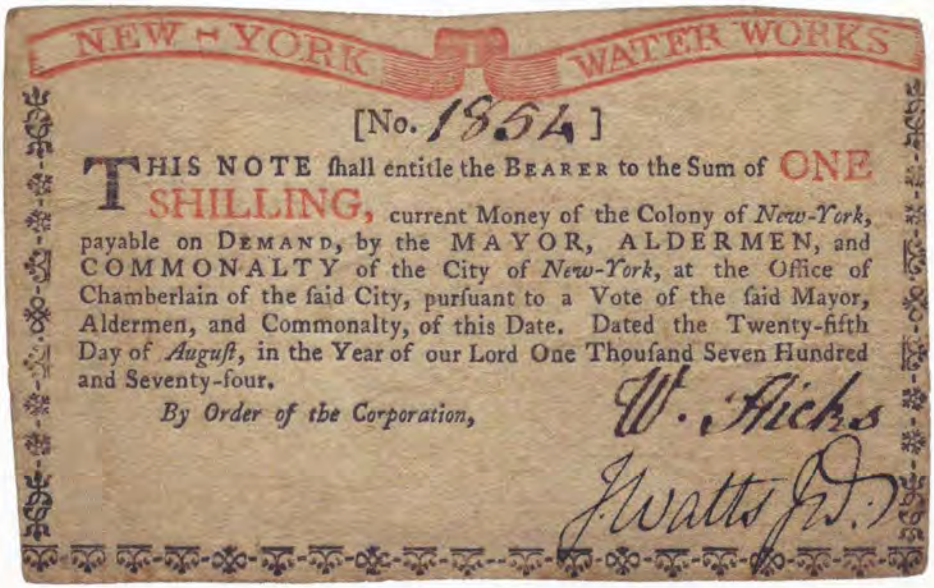
The completed engine was an immediate and fascinating attraction. Few New Yorkers had seen a steam engine in operation. Workers raised a flag on a high pole at the waterworks before tests. Large crowds flocked up from the town to experience this belching, hissing, clanking harbinger of the industrial future. These tests began in March 1776. Six months later, British forces occupied the city. Most New Yorkers, including the patriotic Colles, fled. The New-York Water Works, a "dangerous" example of American ingenuity, was destroyed by British troops. The log pipe distribution network was never laid.

Colles's waterworks (like all of his engineering and scientific projects over the next four decades) amounted to very little, but they inspired many other would-be water purveyors in the years after the revolution. The Common Council, cautious after the failed first effort and harried by the claims of many Colles contractors, refused to sanction any of the numerous plans similar to his. None advanced beyond written proposals. This changed in 1798.

Yellow fever had been a recurring warm-weather plague in New York since 1702, when the mysterious ailment was called a "malignant distemper" and officially blamed on "our manifold sins immorality & profaneness."[11] By the mid-1700s the disease had taken its modern name from the jaundice its victims suffered, but the suspected causative agent had advanced only to miasmas of bad air rising from swamps and foul standing water. Not until the early 1900s was yellow fever conclusively understood as an acute viral disease transmitted by infected mosquitoes. Eighteenth-century New York, with its surrounding swamps and filthy unsewered streets, was a notorious mosquito breeding ground.

In the summer of 1798, two thousand of the city's sixty thousand residents died from mosquito bites they believed to be nothing more than a nuisance. The wisest survivors recognized that filth must be involved. "The present sickness will subside and soon be forgotten," warned editor and public health advocate Noah Webster, "and men will proceed in the same round of folly and vice . . . piling together buildings, accumulating filth, and destroying fresh air, and preparing new and more abundant materials for pestilence, which will continue to assume greater virulence and to prove more destructive to human life, in proportion to the magnitude of our cities."[12]

Webster's newspapers advocated heavily for New York's cleansing. "Get water into the city," demanded one correspondent. "Take the matter into consideration, and resolve every man for himself, to leave no stone unturned to have this grand object of watering carried thro," urged another.



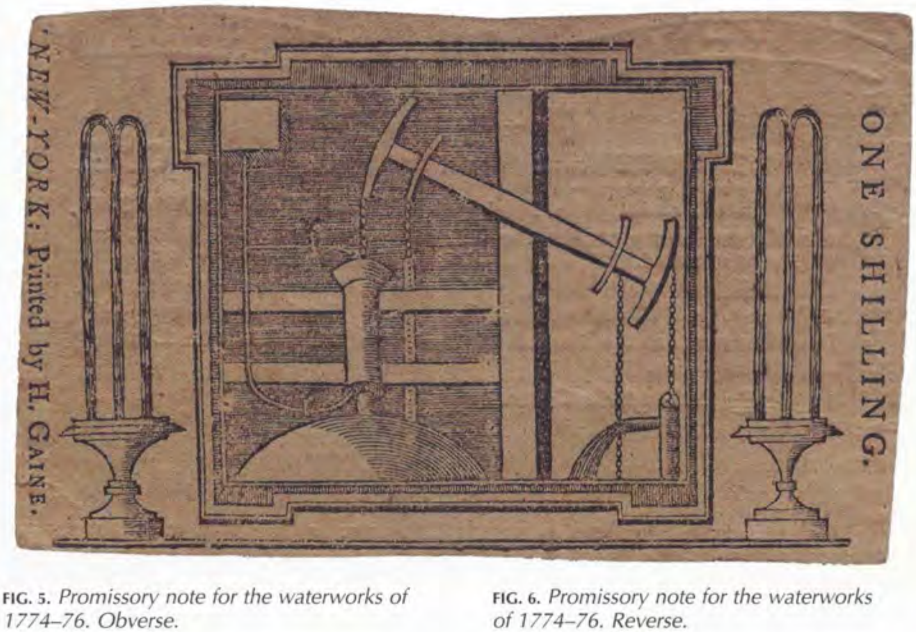


FIG. 5. *Promissory note for the waterworks of 1774–76. Obverse.*

FIG. 6. *Promissory note for the waterworks of 1774–76. Reverse.*

"Then New-York will be as famous as old Rome was, and the other cities may learn from us how to do clean things."[13]

Fever-ravaged New Yorkers were already talking about a cleansing plan offered in July by a Westchester doctor named Joseph Browne. Little did they know what a dirty business it would become.

A surgeon and author of an earlier treatise on yellow fever, Browne proposed that a private company provide water to New York from the pristine Bronx River, which flowed through southernmost Westchester (now part of the Bronx) opposite upper Manhattan. The river would be dammed some fourteen miles from the city and diverted into an open channel to the Harlem River. There, a river-powered pumpworks would raise the Bronx water to a height sufficient for its passage over an embankment across the Harlem River. From upper Manhattan, the water would flow in wooden pipes down to a receiving reservoir five miles north of town, and from there to a distributing reservoir in the city proper. Browne put the cost at $200,000, half of that for a twenty-mile network of distribution pipe. As proposed by Browne, the public-spirited company would guarantee a minimum of 300,000 gallons of water a day; after household allowances of 30 daily gallons, at an average charge of $10 a year, excess supply would be available to the city for street cleaning and firefighting. For investors, Browne calculated a 13 percent return in ten years.

Browne's was the first proposal to water New York from off its island. In that, it was historic. Otherwise, as subsequent developments showed, it was nothing more than a front for the larger designs of Browne's confederate, brother-in-law Aaron Burr.

Finally propelled to action by yellow fever, the Common Council endorsed Browne's Bronx plan but insisted that the city itself, rather than a profit-minded company, do it. The council communicated this desire to its delegation of senators and assemblymen in Albany, where the city's water needs would be decided by the state legislature, meeting in early 1799. The legislature and the council were controlled (though not for much longer) by Federalists; the city's Assembly delegation, however, was headed by Democratic-Republican Burr, who had other ideas.

By the time Burr had completed an extraordinary sequence of manipulations over the ensuing weeks, the legislature chartered a private company as historic as the plan that prompted it. The highlight of Burr's efforts was enlisting political archrival Alexander Hamilton to convince fellow Federalists that the annually elected and perpetually underfunded city government was inadequate to the task of building and managing a water supply. Why Hamilton agreed to get his city's government to change its mind in favor of a private company is an enduring mystery, but Burr was a master at convincing opponents where their best interests lay, and they were invariably his own. In April 1799, "an act for supplying the city of New-York with pure and wholesome water" became law. The Manhattan Company was created, ostensibly to supply New York with water based on Browne's plan, with Burr at the head of the board of directors.

The company was capitalized at $2 million, an unprecedented cash base in those days of few and strictly limited corporations. An obscure clause Burr slipped into the charter late in legislative debate allowed the company to use surplus funds from its water operations for any legal purpose. This was practically revolutionary and soon revealed the true purpose of Browne's water plan and Burr's exploitation of it. Five months after it was created and many months before it supplied any water, the Manhattan Company opened a bank. It immediately thrived as a source of economic and political power for Democratic-Republicans, quickly outpacing the influence of the city's two other banks—the Bank of New York and the local branch of the Bank of the United States—both Federalist-dominated institutions created by Alexander Hamilton. Burr's banking coup is known today as JPMorganChase. To hoodwinked Federalists who had unwittingly supported Burr's endeavor as a water company, the bank was "a greater pestilence than the Yellow Fever."[14] But the water business was even worse.

In order to do banking, the Manhattan Company, under the terms of its charter, had to supply water. It endeavored to do this in as capital-conserving a manner as possible. Instead of throwing money and limited engineering knowledge at the distant Bronx River, the company opted for a

FIG. 7. *The Manhattan Company's Chambers Street Reservoir. 1825.*

waterworks just south of the Fresh Water Pond, by then universally and derisively known as the Collect. In his Bronx proposal of 1798, Joseph Browne had called the Collect a "large stagnating filthy pond" and doubted that the city would "ever seriously think of forcing the inhabitants to drink [its] disgusting water."[15] In 1799, Joseph Browne, appointed at his brother-in-law's behest as the Manhattan Company's superintendent, endeavored to do just that.

Browne oversaw construction of the waterworks between Chambers and Reade Streets. It was built on the Colles model of a quarter-century earlier (the aging Colles actually gave it his blessing) but of dramatically less imagination. A large well was dug, but its water was not submitted to scientific testing. On the brink of the steam age, the company opted for a horse-operated pump to raise the water, initially into a round iron tank 41 feet across and 15 feet deep, set on a 23-foot-high stone foundation. Plans for a grand reservoir were gradually scaled back. Superintendent Browne's initial proposal for a great stone octagon holding a million gallons was replaced by the plan of architect John McComb Jr. (the future builder of today's City Hall) for a 250,000 gallon reservoir. Ultimately, the company board approved a reservoir, likely designed by City Hall codesigner Joseph Mangin, holding a mere 100,000 gallons. New York was then a rapidly expanding city of nearly that many people. The Manhattan Company could not adequately supply them from its tank and its meager reservoir.

The reservoir was not unattractive. It was built of brick and stone on a lot with a fifty-foot front on Chambers Street. Rising twenty feet, the gracefully sloping facade featured a portico of Doric columns surmounted by a statue of Oceanus, recumbent and pouring water from an urn [Fig. 7]. The reservoir was something of a landmark until it was torn down shortly after the Croton Aqueduct came on line in 1842. (The Surrogate's Court building now stands on the site.) The more utilitarian tank had a longer life.

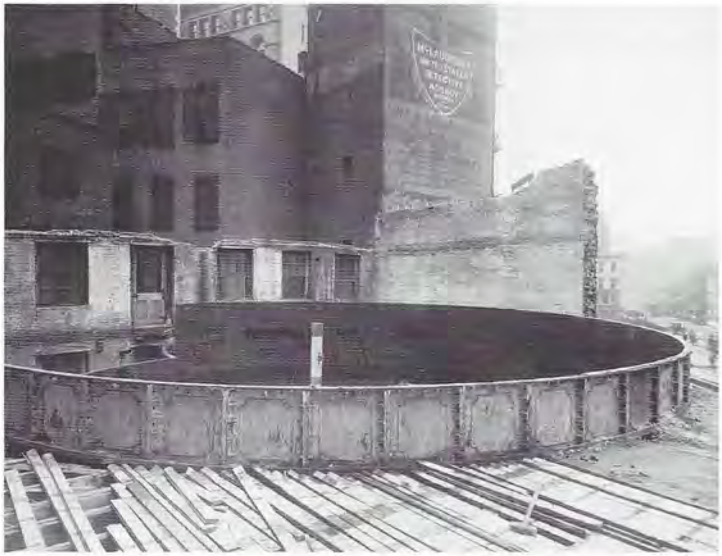


FIG. 8. *Iron water tank of the Manhattan Company, Centre and Reade Streets, during dismantling. July 14, 1914.*

FIG. 9. *Radial arched masonry supports after removal of iron water tank. July 29, 1914.*

Enclosed in a four-story building, it was maintained for generations by the Manhattan Company for fear of losing its charter. During the widening of Centre Street in 1898, the building's eastern wall was torn down, drawing crowds to view the century-old iron tank, into which a bank employee reportedly pumped a bit of water every day, in service to the charter. The tank was tightly reentombed inside a new, curving wall until 1914, when tank and building were torn down and the land was leased to a developer [Figs. 8, 9]. The company's banking business proceeded without incident until the mid-1900s when a merger with the Chase National Bank and a national banking charter legally relieved Aaron Burr's corporate descendant of any water obligations.

After using horsepower to raise its water level, the company eventually moved into the steam age. The company managed to lay some twenty-five miles worth of distribution pipe, initially made of hollowed yellow pine logs of small bore and notoriously leaky. In 1810 the company wanted the city to chop down all its Lombardy poplar trees because their thirsty roots were clogging company pipe; the city responded with a tree protection ordinance. In the 1820s the company replaced some of its wooden pipes with cast iron mains.

For decades after its founding, the Manhattan Company's influential directors and lawyers, mayor and future governor DeWitt Clinton among them, thwarted numerous plans by the city or private interests to develop a proper water supply.

Wary of threats to its banking activities, the Manhattan Company effectively argued that it alone was entitled to supply New York with piped drinking water. In the meantime, these very pipes froze in the winter, clogged in the summer, rarely yielded ample water, and that water never deemed healthy or flavorful. In 1824 botanist David Hosack was among fifteen leading city physicians condemning company water as "highly injurious" to New Yorkers' health.[16] Several years later, a lyrical correspondent to the *New York Evening Journal* derided the "poisonous nature of the pernicious Manhattan water . . . the unpalatableness of this abominable fluid."[17]

If New Yorkers suffered for years with Manhattan Company water, the company disposed of its founder promptly. Having dipped into its bank for $120,000 in unsecured loans—nearly as much as the company had invested in its water operations—Burr was removed from the board in 1802 (when he was Jefferson's vice president). Brother-in-law Joseph Browne was shown the door shortly thereafter. The company's practice of ripping up streets to lay pipe and the bitter negotiations with the city to pay for their repair helped topple Browne from concurrent service as company superintendent and the city's street commissioner. This was certainly one of the era's great conflicts of civic interest.

Yellow fever preyed on New Yorkers for many summers after the Manhattan Company was founded to combat it. Four hundred people died in 1822, the last epidemic. By then, the Collect and its swampy outlets had been filled in for development, serendipitously eliminating a prominent mosquito breeding ground. Ten years later, New York would be ravaged by cholera, the disease that finally prompted a new solution to its water troubles.

In the meantime, the city expanded in length and width, through the island's broad girth between Grand and 14th Streets. Settled areas increased, as did the wood and other combustible structures crowded into them. Increasingly they caught on fire and progressively there was less water to save them. Major fires devastated residential and commercial neighborhoods in 1804, 1811, and 1816; the city suffered an average of twenty fires a year during that period. Spectacular blazes consumed the historic Park Theatre (now the site of J&R Music World) in 1820 and the Bowery Theatre (in today's Chinatown opposite the Confucius Plaza Apartments) in 1828.

It was fire that inspired the city's first public waterworks: not a bold aqueduct from a distant river but a modest works on suburban 13th Street. Begun in 1830, the system, with well, steam-engine, tank, and distributing pipes, is largely forgotten today because the water was undrinkable and used only for firefighting. The 13th Street Reservoir was, however, a great step forward, at least geographically. After the Tea Water Pump and the Colles and Manhattan Company works, the 13th Street Reservoir system was New York's first effort to provide water from somewhere other than the subterranean sources of the Collect Pond. That the pond itself had been filled in nearly twenty years earlier indicates how slowly New York started crawling out from under the Manhattan Company's unfortunate water monopoly.

The 13th Street Reservoir system was the inspiration of Common Council fire committee chairman Samuel Stevens, "Alderman Sam," as he was known, for his long council service. Questioned during council debate about the prospects for water under newly laid 13th Street, Stevens said: "Give us the tank and pipes, and we [will] engage to fill them, if we have to carry the water in quart bottles."[18]

The works were built in 1829 on empty lots purchased by the city on the south side of 13th Street just east of upper Bowery (now Fourth Avenue) [Fig. 10]. Inside an octagonal stone structure, a cast-iron tank, over 40 feet in diameter and 20 feet high, was placed on a 27-foot-high stone base [Fig. 11]. Beside the 250,000 gallon tank, a twelve-horsepower steam engine was installed to raise water from a remarkable well. Dug and blasted over a three-year period, the well eventually reached a depth of 112 feet, mostly through solid rock. The main chamber was 16 feet across, but two broad lateral galleries near the bottom of the well each extended 75 feet, giving a total capacity of 175,000 gallons. The subterranean blasting killed at least three workers, the first examples of that special breed now known as sandhogs to die in the service of New York's public water supply.

By 1833 roughly 12 miles of cast iron mains, with inner diameters from 6 to 20 inches, had been laid. Major north-south lines ran along Hudson Street (and lower 8th Avenue), Broadway, the Bowery, East Broadway, Pearl Street, and William Street. Shorter crossing lines were laid under Waverly Street, Spring Street, Stanton Street, Delancey Street, Grand Street, Canal Street, and Chambers Street. In all, some 150 street hydrants made firefighting water available in portions of all twelve wards out to the city limits at 21st Street.

The partially completed works were officially opened in April 1831. A potentially significant fire several weeks later was put out with 13th Street water, the "most practical evidence of the certain success of this enterprize."[19] Rising 100 feet above what was already high ground, the handsome building presented "a very picturesque object to boats passing through both the East and North [now Hudson] Rivers."[20] This first landmark of the city's public water supply was short-lived. The works were shut down with the advent of the Croton water supply system in 1842, and the distinctive octagonal building and tank were torn down in the early 1850s. The location retains its heritage: for nearly a century, 108 East 13th Street has been a firehouse.

The 13th Street Reservoir system prevented much death and destruction by

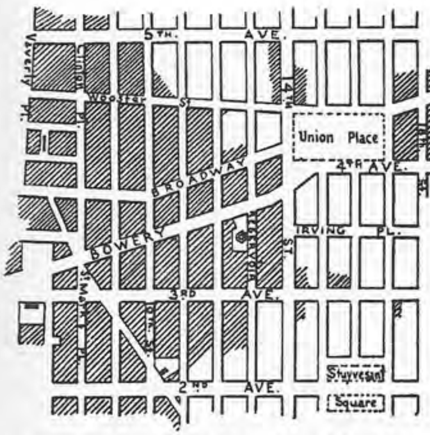


FIG. 10. *Map showing the location of the 13th Street Reservoir between Bowery and Third Avenue in Manhattan.*

FIG. 11. *The octagonal stone structure housing the 13th Street Reservoir.*

fire, but it was unsuited to protecting New Yorkers from epidemic disease, as the cholera epidemic of 1832 quickly proved. Water from local wells, the Manhattan Company, and up-island springs (purveyed, as was the Tea Water, by cart at considerable expense) were insufficient or likely harmful to cholera patients, and no 13th Street hydrants were tapped for health purposes.

The terror of cholera exposed the deficient visions of Stevens, Burr, and Colles before them. The island did not have the water to quench New Yorkers' thirst or cleanse them of disease. The first person to recognize and act on this fact was Myndert Van Schaick, a New Yorker of old Dutch stock. His name appears on no memorials except the New York Marble Cemetery vault where his remains share space with assorted relatives of the Clinton and Hone clans. For the man who brought Croton watershed water to New York City and made both famous for excellent water, his obscurity seems undeserved.

While thousands of prominent citizens died (including Magdelen Bristed, the eldest daughter of John Jacob Astor) or fled, Alderman Van Schaick stayed and witnessed death scenes that horrified him. He (among others) realized that the suffering had something to do with filth and water. Whereas a generation earlier Aaron Burr had manipulated city and state for personal and political benefit after a devastating epidemic, Van Schaick put his efforts to public manipulations for enduring social benefit.

As a Democratic alderman and then a state senator from 1832 to 1835, Van Schaick shaped policy and drafted legislation, guiding its passage and implementation. In 1832 he arranged for a report by DeWitt Clinton Jr., the late governor's son and a rising engineer, which called for the city to tap the distant Croton River.

The Croton River was not unknown to New York water planners. In the early 1820s, the Common Council had hired Erie Canal engineer Canvass White to explore the possibilities of tapping the Bronx, Byram, or Saw Mill rivers; White in turn had hired Westchester surveyor George W. Cartwright to examine the distant Croton River to see if it might be led down to any of these rivers. Cartwright gauged the Croton at 20 million gallons a day—a third of its true capacity—and White discounted it as a tributary source; he also dismissed the Croton as an independent source due to what he perceived to be insurmountable engineering issues. White's report of 1824, like so many before, was filed away and forgotten, until engineer Clinton gave Croton a second look.

The Croton River rises in the low rolling hills of Putnam County and flows in a southwesterly direction, merging with the Hudson River about 40 miles north of New York City. Three main rivulets and many minor streams drain a 375-square-mile area blessed with dependable rainfall (48 to 50 inches per year) and abundant ground water that bubbles up in numerous small springs, brooks, and marshes. Many of the local lakes are fed from underground streams.

Clinton's report proposed that the water be taken directly from the Croton River through a diversion weir to be built near Pine's Bridge, in the lower stretch of the Croton valley about five miles upriver from the confluence with the Hudson River. From the diversion it would head south to New York, flowing in an open canal, much like a simple agricultural irrigation ditch:

> The elevation at Pine's Bridge, by Mr. Cartwright's measurement, is 183 feet above tide. I would propose at this point to sink the bottom of the works below the bed of the stream, to avoid the risk of a dam, and more fully command the whole volume of the water if necessary. Sluices and gates should

be provided and other contrivances to prevent any impurities from the stream passing into the works . . . The elevation of the Croton at Pines Bridge being 183 feet, and the bottom of the work being sunk 6 feet below the bed of the river, it leaves 177 feet; and if the line from that point should descend uniformly 1 1/2 half feet in the mile . . . I have strong confidence in the practicability of delivering it [the water to New York] at 138 feet above tide.[21]

The canal would head west, then south along the southern banks of the Croton River, continuing along the steep and irregular terrain of the east bank of the Hudson. The route would take the water over the valley of Sleepy Hollow and other ravines that drain into the Hudson, turn inland to the east, crossing the Saw Mill River above Yonkers, and then crossing the Harlem River near Macomb's Dam, in the vicinity of what is now Yankee Stadium. (An alternate proposal crossed the Saw Mill River near its mouth at Yonkers and continued directly south to the Harlem River, crossing at the northern extremity of Manhattan Island around Marble Hill at what is now the Broadway Bridge.)

Clinton's vision for the new aqueduct was the first to propose a bridge over the Harlem River, estimated at 138 feet high and 1,000 feet long. Despite objections made by his critics at the time of its release, Clinton's plan was specific, well organized, and based on sound engineering. The overall thoroughness and credibility of his report helped turned the tide of official opinion toward the Croton as the preferable source. Clinton closed his report by calling for minute and careful surveys to help establish and refine the aqueduct line and determine the actual construction requirements.

In 1833 Van Schaick's "pioneer law to the Croton" wisely shifted planning authority from the overmatched city government to five state-appointed commissioners.[22] Van Schaick named the panel, all prominent Manhattanites and good Democrats, led by former Mayor Stephen Allen, a sailmaker turned civic booster. At Van Schaick's behest, the commissioners named military and civil engineer David Bates Douglass to conduct surveys. The West Point graduate and professor had earlier been hired to design the first building for the new college on Washington Square (now New York University) of which Van Schaick was a founder.

While Clinton had proposed a straight diversion from the river, Douglass introduced the idea of building a dam and an associated storage reservoir. The Romans had utilized water storage facilities for their great aqueducts. That concept would come to prevail in New York. The Croton River was reliable, but there would certainly be sustained dry times when the river yield could prove inadequate. A dam could retain a reserve source and get the city through the inevitable droughts impacting the Croton basin. The position of the dam on the river would affect the capacity for collection and storage. If the dam was located too far upriver, the amount of water available in the watershed would be reduced, as many of the watershed streams would enter the river downstream of the dam. But if the dam was located too far downstream the elevation at the reservoir would be too low and could limit the effective ability to deliver and distribute the water by gravity. A balance that would provide an advantage in establishing proper flow would have to be sought.

Van Schaick's 1834 legislation, "An Act to Provide for Supplying the City of New York with Pure and Wholesome Water," gave the commissioners complete authority over all aspects of aqueduct construction and funding (through bond issues), pending approval of their final plan by the Common Council and a public referendum. "Was it not prudent," Van Schaick explained, when the successfully completed project reached its eventual $13 million cost—nearly double the outlay for the Erie Canal twenty years earlier—"that the people should be pledged for the payment of the debt by their own act and deed and by their favorite rule of the majority?"[23]

In April 1835, New Yorkers (that is, those adult males who were entitled to vote) went to the polls to give the Croton project their blessing. Opposition was fierce from spring water suppliers, bored-well drilling advocates, the Manhattan Company (via politically safe anonymous pamphlets), and tax-wary rich and poor alike. Westchester landowners (many of them city dwellers as well) protested the extraterritorial invasion of their peaceable county by a city grown too large to water itself. Despite robust anti-Croton electioneering, memories of the 1832 cholera had been revived by a 1834 recurrence, and the vote came down 17,330 to 5,963 in favor of the plan to claim the Croton's water. Only three of the city's fifteen wards had majorities against the bill: one comprising the formerly separate village of Greenwich which still had good wells and clear springs, and two in the sunken neighborhoods of what is now the Lower East Side, which had the worst wells and the least money but the greatest fear of change.

Lingering opposition went up in smoke eight months later. On the bitter night of December 16, a fire was touched off in a Merchant (now Beaver) Street warehouse. Fanned by a gale, it consumed seven hundred buildings from south and east of Wall Street and Broadway [Fig. 12]. The thermometer read below zero, but the intensity of the flames liquefied copper roofs. The 13th Street Reservoir system, depleted by fires earlier in the week, trickled and froze in its hydrants. Wells and scattered cisterns remained frozen solid. Manhattan Company water goes unmentioned in any account. Property losses from the Great Fire of 1835 were more than $20 million, roughly 10 percent of the city's property value. While the commercial center of the nation continued to smolder three days later, Stephen Allen was named to oversee the rebuilding effort. Allen was already managing the Croton project that would help protect the city from future disasters. But he was growing impatient with the slow pace of his chief engineer's study.

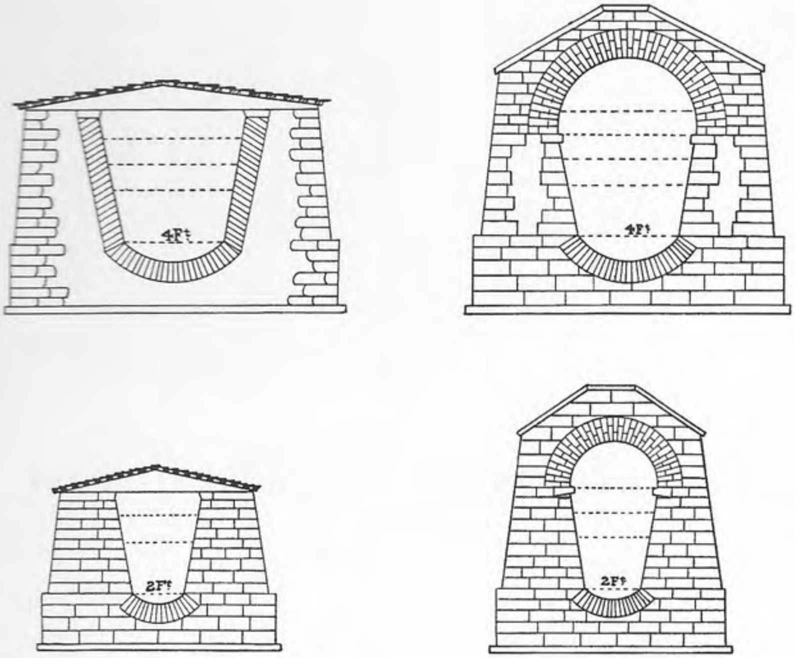
The quantity of water to be delivered was based upon two main assumptions: that the system would ultimately serve 450,000 people (at the time of planning, the population was 225,000), and that each user would require 20 gallons per day.

FIG. 12. *Burning of the Merchants' Exchange. December 16–17, 1835.*

Unlike the aqueducts of the ancient world that often passed through arid or semi-arid lands, the Croton Aqueduct would have to traverse a complex and craggy landform marked by springs, creeks, and deep-cut draws that flooded with every rainfall. To some degree the aqueduct could follow the contours of the land, but in many places ravines would have to be crossed with built-up embankments or open bridges. These crossings would add substantially to the sheer volume of construction for the conduit. Each creek would be routed into a culvert of stone, some one hundred feet long and deep below the hydraulic line of the enclosed structure.

Douglass studied and suggested two alternate routes. He developed specific structural ideas for each of these routes but ultimately settled on a plan where water was to be collected at numerous places in the branches and tributaries of the Croton watershed and taken via iron pipes to a small one acre confluent reservoir at Mechanicsville. The elevation of this basin would be 270 feet above the Hudson River at low tide, a significantly higher point of origin than had previously been proposed. This plan confronted various topological obstacles in moving the water directly south through the high rocky ground that separated the Croton River drainage from the Saw Mill River basin. The route would have required deep cutting and hard-rock tunneling through the rocky ridges, but once through the high ground, the aqueduct could follow a shorter route down the gentle terrain of the Saw Mill River valley. The construction characteristics proposed by Douglass were very close to those ultimately used.

Douglass developed a horseshoe-shaped cross section that had an inverted arch at the base, outward battered masonry walls on the side, and a brick arch cover (or wood roof) over the channel [Fig. 13]. The larger aqueduct section would be four feet wide at the base arch, and the smaller section would be two feet wide at the base arch. Clinton's original plans for the aqueduct proposed an open-cut trench type conduit, but concerns about contamination, freezing and evaporation, and maintenance prompted the decision to enclose the entire aqueduct with a masonry arch. The most typical and characteristic cross section was a brick-lined stone trench with slightly battered



walls separated on the bottom by an inverted, nearly flat arch, and covered above by a semicircular brick arch, made of two thicknesses of brick, measuring 7 feet 8 inches in diameter. This masonry conduit would then be buried in an earthen berm, or would be set into a trenched cut and then covered. In addition to this typical construction, there were several masonry conduits developed to accommodate various geological conditions. These alternates included a stone arch cover and an irregular ovoid cross section that was used in rock tunneling [Figs. 14, 15].

By the fall of 1836, Douglass had completed four years of surveys and design but still hesitated on breaking ground. After increasingly uncivil quarreling, Allen replaced Douglass with John Jervis, an upstate farm boy turned valedictorian of the so-called Erie School of Engineering.

FIG. 13. *Various sections of the first Croton Aqueduct as proposed by Major David Bates Douglass. c. 1835.*

FIG. 14. *Old Croton Aqueduct. Cross sections showing different methods of construction on steep hillsides, inscribed: "This drawing probably made about 1836."*

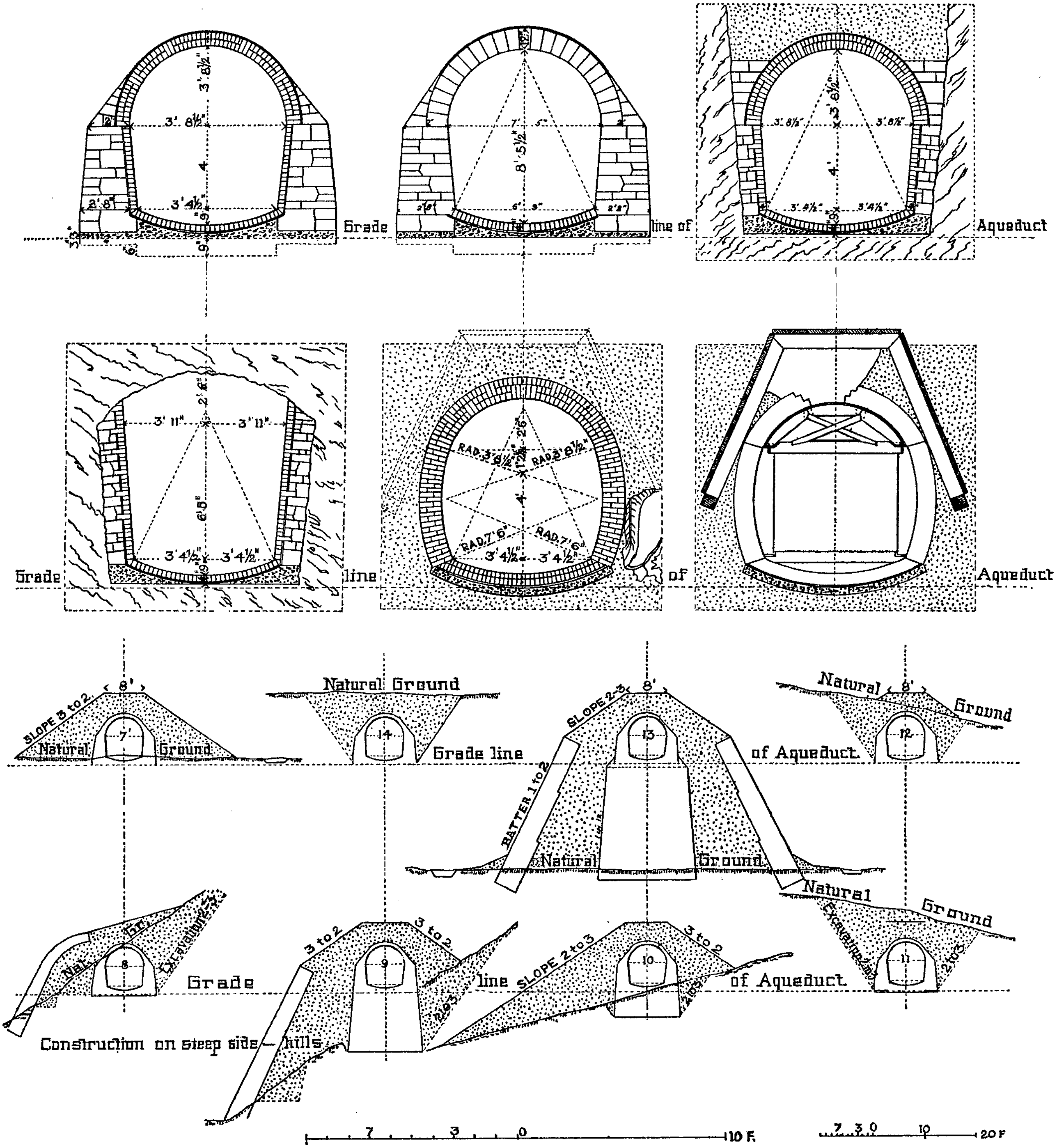


FIG. 15. *Old Croton Aqueduct. Cross sections showing the variety of construction methods in different landscape conditions.*

Whig politicians cried foul: Douglass was a Whig and Jervis a Democrat working on a project run by his political brethren. But Douglass was proving himself a conceptual engineer ("a ripe scholar . . . *and in theory*, well acquainted with the science of engineering" in Allen's public estimation),[24] while Jervis was a proven project engineer with a lengthening resume of railroad and canal work that began with his rise from Erie Canal axeman to chief. In the end, Douglass largely designed the Croton Aqueduct and Jervis built it, with some substantial design modifications and innovations along the way.

As conceived by Douglass and executed by Jervis, New York's great aqueduct started with a 50-foot-high dam 6 miles from the Croton River's junction with the Hudson, making a long natural reservoir of the rugged Croton River valley. Jervis shifted the dam location slightly down-river from where Douglass had staked it, but then paid the price. Heavy snow and rain in early January 1841 caused a flood that breached the mostly completed dam, killing one worker there and two men at a downstream wire mill destroyed by the rolling wall of water, ice, mud, boulders, and uprooted trees. Navigation on the lower Croton was permanently ruined; lawsuits continued for many years. But Jervis ingeniously redesigned the dam, with a stilling basin and a novel S-shaped face that minimized the destructive force of overflowing water and became a standard for American dams [Figs. 16, 17]. Jervis's dam survives, submerged for over a century now in the deeper reservoir created by the towering New Croton Dam.

The original plan for the dam was to have 25 percent of the length constructed as masonry, and the remaining 75 percent as earth embankment. As redesigned after the flood, the dam had an additional 180 feet of masonry. The river bottom was cleared of mud and boulders to reach a stable layer of riverbed. Timber cribs filled with boulders created the aprons upon which the dam rose. The cribs were a combination of elm, pine, and oak, with joints dovetailed and secured with wooden spikes of white oak (treenails), and capped with pine planks. This series of substructures was the armature of the dam. On these, rows of hydraulic stonework were keyed together to resist the great forces of restrained water. The face stone was granite. The profile of the dam allowed water to flow evenly over almost the entire upper surface and not through a restricted weir. On the downstream side of the dam, the stilling basin, or "dead water" pool, was created by a low secondary dam. The pool created a counterforce to the weight of the water backed up by the main dam and minimized the destructive force of the water spilling over the dam.

From the reservoir created by Jervis' dam, diverted river water began a 33-mile run by gravity to the Harlem River. Through the undulating hills and valleys of the lower Hudson Valley, Douglass had painstakingly determined the aqueduct's

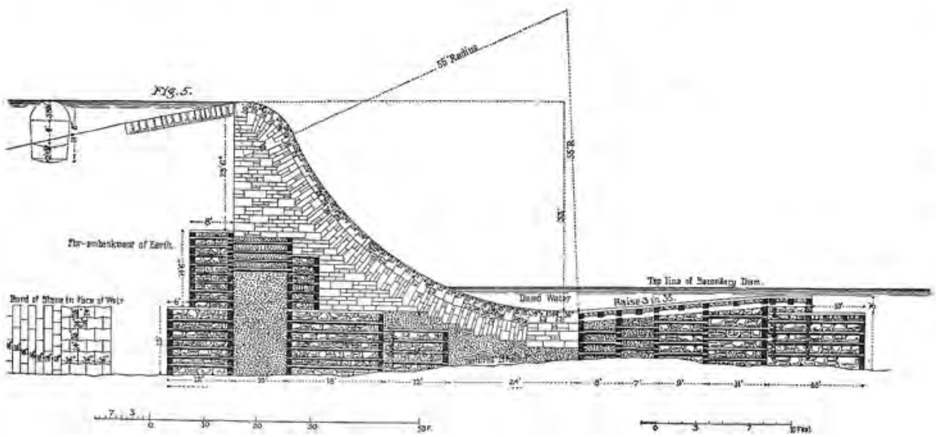


FIG. 16. *Old Croton Dam. Cross section.*

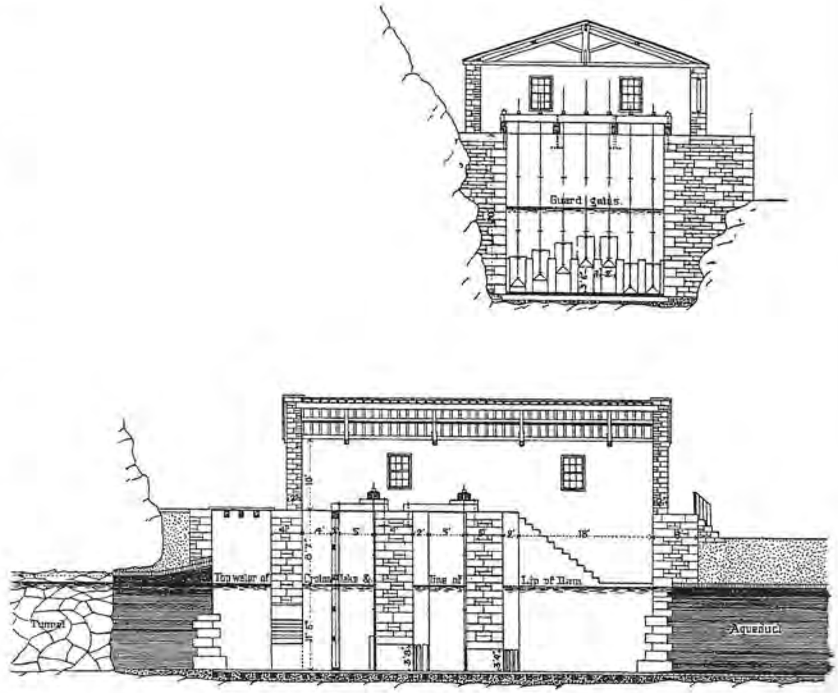
FIG. 17. *Water cresting over the Old Croton Dam. The gatehouse for the New Croton Aqueduct is on the hill at right. c. 1900.*

most efficient route to maintain the required descent of 13 inches per mile. In places, the aqueduct's underground course ran up to 30 feet deep in varied rocks and soils; in others, it passed in dozens of culverts and larger structures over rivers, streams, and hollows [Fig. 19]. Throughout, the basic dimensions were retained: the horseshoe-shaped conduit was just under 7½ feet wide and 8½ feet high. The bottom was a flat inverted arch and the straight sidewalls broadened slightly toward the rounded arch top. (In tunnels passing through rock, the conduit roof was formed by the natural rock; in tunnels deep through earth, the sidewalls were round.)

Jervis acknowledged Douglass' sensible route location and made only small refinements to his conduit dimensions and specifications, but Jervis designed most of the major aqueduct structures along the Westchester route, including the spectacular arched crossing of Sing Sing Kill, which is still standing in what is now Ossining, and the long embankment over the Mill (now Pocantico) River near Sleepy Hollow [Figs. 20, 21]. At the Harlem River, which separates the mainland from upper Manhattan, Jervis nearly met his match.

Douglass, with a taste for the magnificent, had suggested, but not designed, a grade-level crossing of the Harlem River on towering Roman arches, meeting Manhattan at what became 174th Street. At more than 1,400 feet long and 140 feet high, the scale of the bridge would have been unprecedented in America. Jervis, whose tastes ran toward the frugal, designed a pipe siphon on a relatively inexpensive low embankment, with one low arched passage for boats. This plan pleased the cost-conscious commissioners but quickly ran afoul of other interests.

Douglass defenders alleged that Jervis was afraid to build a great bridge. Real estate interests on both shores of the Harlem saw rising values in a high bridge. Shipping interests were outraged at the permanent obstruction to navigation posed by a low arch. And New Yorkers generally wondered why their fine aqueduct should come slinking onto the bold



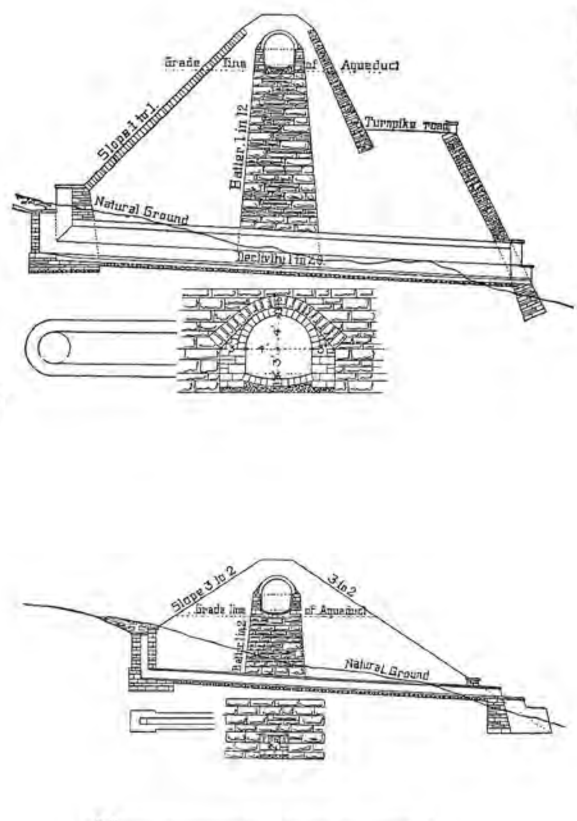


FIG. 18. *Old Croton Aqueduct Inlet gatehouse.*

FIG. 19. *Old Croton Aqueduct Cross sections of culverts.*

highlands of upper Manhattan in a style suited for lesser cities.

Passions became enflamed, especially those of Lewis Gouverneur Morris, grandnephew of the late city grid planner. In September 1838, the young heir to the Morrisania estate on the Harlem River led a strange naval assault on Macomb's Dam Bridge, which had been thrown across the Harlem two decades earlier without a state-mandated draw for river traffic. The dam portion of the wooden bridge, a mile downriver from the proposed Croton crossing, succumbed quickly to boatloads of axe-wielding mariners. The Harlem River was once again open for navigation, especially by Morris and other Harlem River estate owners, and the cause of Harlem navigation was dramatically improved: without Macomb's Dam Bridge, the argument for a river-blocking aqueduct embankment lost support (state courts eventually vindicated Morris for abating "a public nuisance;"[25] the third and current Macomb's Dam Bridge dates from 1895). The legislature soon ordered Jervis to choose between a high bridge or a tunnel.

Jervis knew that the effort to build the world's first underwater tunnel, Marc Brunel's Thames Tunnel in London, was only just coming to completion after fifteen years. The project had caused dozens of deaths and incapacitating injuries, and ran 400 percent over budget. Jervis offered a Harlem River tunnel plan but favored his plan for a multi-arched bridge with an Albany-mandated hundred-foot minimum clearance over the river: a high bridge but one that came in slightly below grade level using a cheaper pipe siphon instead of expensive additional masonry.

The legislature happily opted for the high bridge, a resolution not necessarily unwanted by the original low-bridge advocate: "It was natural," Jervis wrote in his memoirs, "that an engineer should incline to a work that would give prominence to professional character as a work of art."[26]

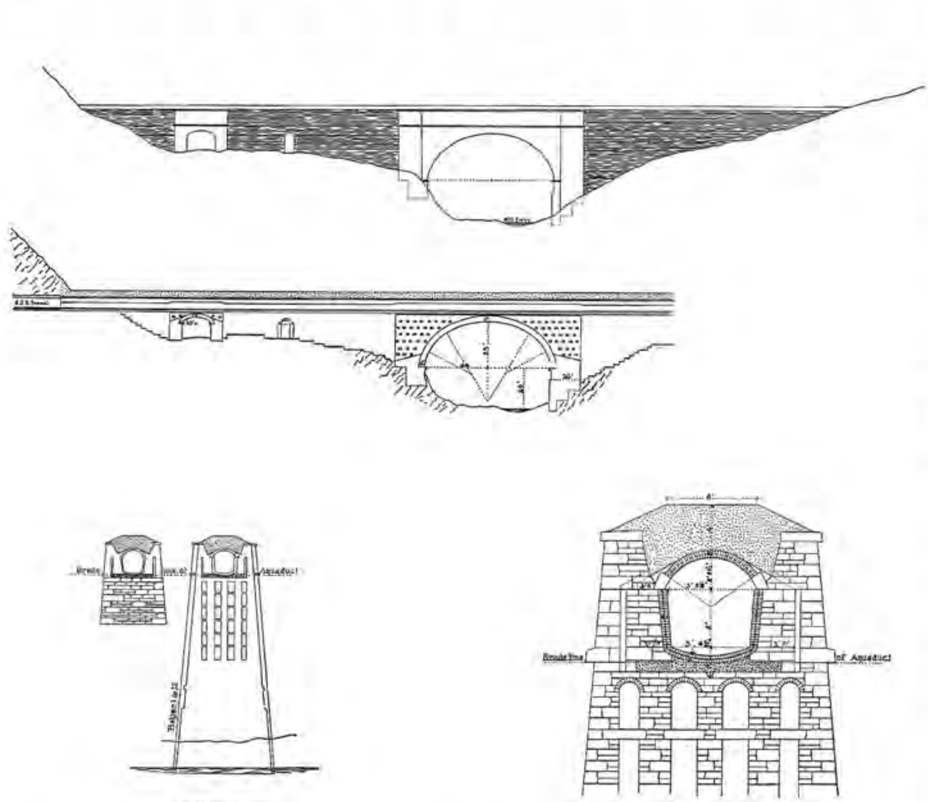


FIG. 20. *Old Croton Aqueduct. Sing Sing Kill Bridge. Elevations and cross sections.*

Not all on Jervis' staff agreed. Twenty-one-year-old assistant engineer Fayette Tower privately condemned a costly high bridge mandated "just for architectural beauty in a place where there is little necesity [sic] for it."[27] Tower soon learned the role of business and politics in engineering and went on to document the Croton Aqueduct in a book of exquisite engravings, including his panoramic view of the bridge that originally offended his youthful idealism.

Croton was built on the organizational model established for the Erie project twenty years earlier: a state-appointed commission hired the engineers who conducted the surveys, prepared the work for competitive bidding in small sections, and oversaw the contractors' progress. The construction had one hundred sections, each averaging less than a half-mile in length. As with the pioneering Erie work, the construction contracts for many sections were won by local farmers or landowners knowledgeable about their particular area, but a substantial number of sections were undertaken by associations of workers who had gained experience on canal projects elsewhere.

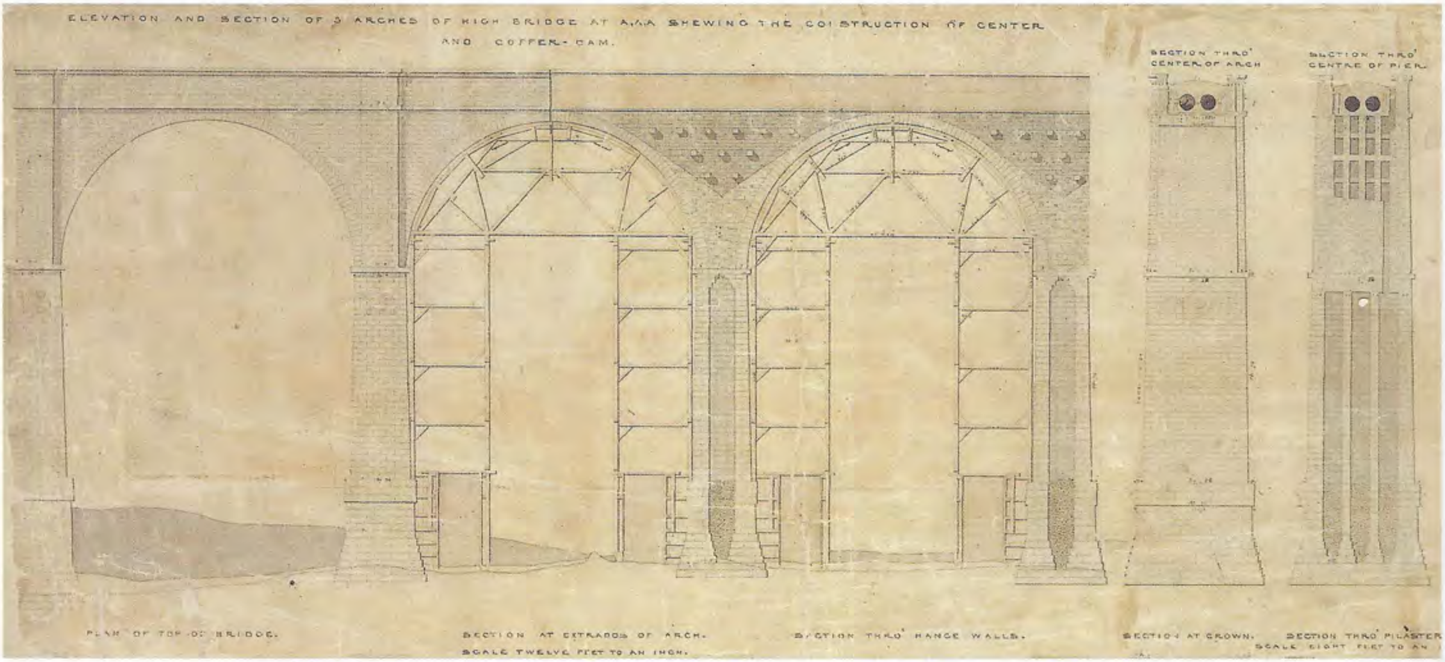
The lead contractor of the High Bridge, for example, was an aspiring capitalist named George Law. In the fifteen years after leaving the struggling upstate farm established by his Irish immigrant father, Law had risen from laborer on various American canal projects to contract winner on several small Pennsylvania canals. Having obtained some wealth and a well-born wife, he moved to New York City to bid on Croton contracts. After winning the contract for the embankment over the Mill River (where he befriended a loquacious local whom he failed to recognize as Washington Irving), Law joined three other veteran Croton contractors to win the High Bridge job with a $755,000 bid. "[A] self-made man [who] worships his creator" and imbued with "a talent for making money out of other people,"[28] Law was soon a Fifth Avenue millionaire, a financier, and owner of steamship, ferry, and railroad lines ranging from New York to California and Panama. He was also an early challenger

FIG. 21. *Old Croton Aqueduct. Ossining Arch (Sing Sing Kill Bridge). July 9, 1913.*

for the White House in 1856 as a Know-Nothing Party candidate. Coarse and reactionary, Law was not popular among New York's established elite, but the Croton project had launched him into the city's broadening upper-middle class.

Most of the workers who labored for Law and other Croton contractors were fresh Irish immigrants. They had fled economic collapse in Ireland only to find the same crisis in America, where the Panic of 1837 (spawned by a burst bubble in speculative canal stocks) was spiraling into a six-year national depression. Croton, financed with $12 million in state bonds issues, which sold initially at impressive premiums but soon at deep discounts, was nevertheless a timely public works project that employed thousands of the otherwise jobless. In good seasons, unskilled Croton laborers happily earned a dollar a day. This was considerably more than the average wage for unskilled labor in the city, and relatively in line with the $75 monthly salary for first assistant engineers. In bad seasons, though, such as 1839 when the commissioners had to pay contractors in discounted city bonds instead of cash, daily wages for laborers dropped to seventy-five cents.

Regardless of the season, workers were always at risk of injury or death. Because workers were hired by contractors, and



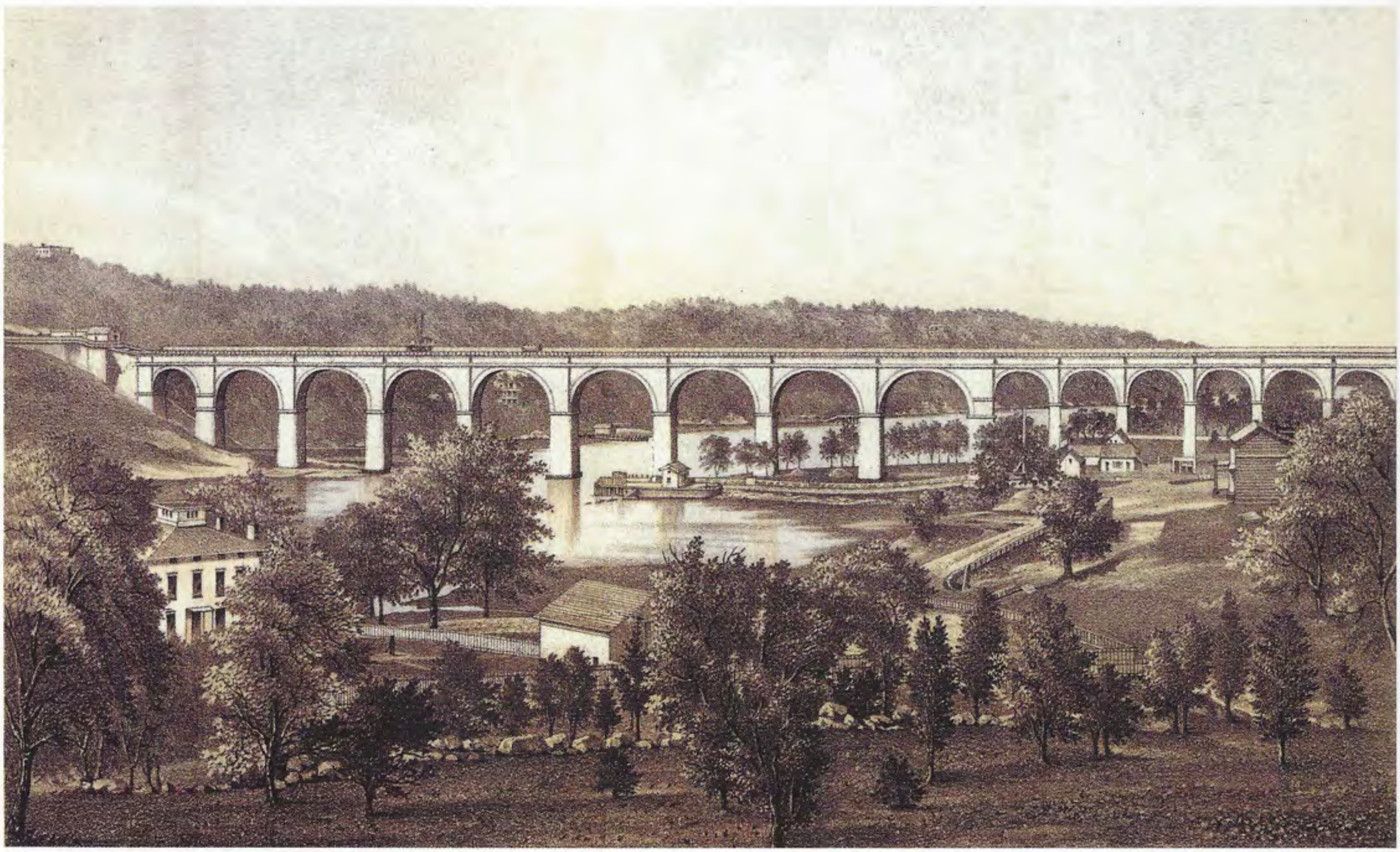


FIG. 22. *High Bridge. Cross sections and partial elevation showing cofferdams and centering for arch construction. c. 1845.*

FIG. 23. *High Bridge. View from mainland, looking up Harlem River.*

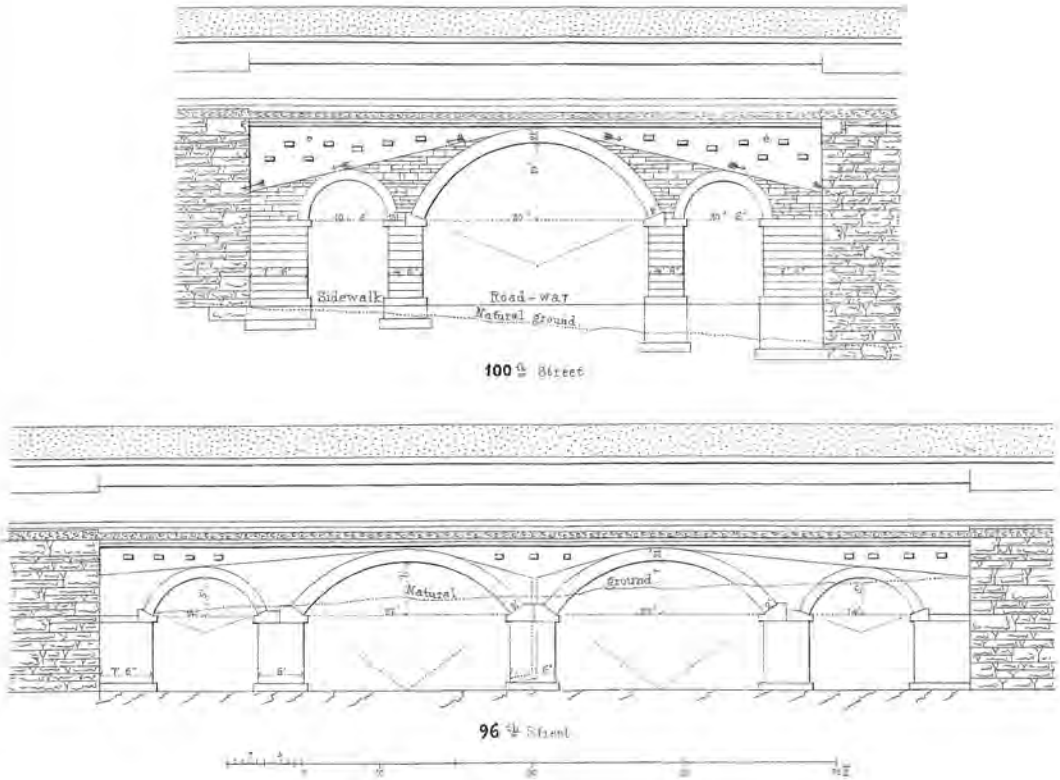


FIG. 24. *Sections of elevated aqueduct through the Clendening Valley showing arched passageways for roads and sidewalks.*

governmental oversight was generations in the future, there is no record of Croton casualties other than the occasional reporting in local papers of particularly gruesome incidents. The imprecise science of rock blasting, especially for the aqueduct's sixteen tunnels, earned the most ink and the least sympathy. On a section near Dobbs Ferry in January 1838, the "unfortunate" Patrick Carr was "negligent of the precaution of keeping a sufficient quantity of water in the hole, and when a part of the covering of the charge was removed, a hissing noise was heard, and in the twinkling of an eye" Carr was blown to bits.[29]

Unsafe on the job, Croton workers were never fully at peace with each other or their employers. Southern ("corkonians") and northern ("fardowns") Irish factions skirmished regularly (and sometimes fatally) along the line, fueled by illicit whiskey consumption. On April 1, 1840, when it became apparent that the prevailing lower winter wage would be continued for the summer season, workers united in full-scale riot. After beating or driving off higher-paid masons, carpenters, and other skilled workers, as well as otherwise content laborers, a thousand Westchester workers—equal to the entire winter crew and a quarter of the usual summer force—commandeered work boats at the Harlem River and invaded upper Manhattan, scattering work crews there. "The Croton War"[30] ended bloodlessly several days later when the city militia, mustered for the first time in long memory, rode north to find the rioters had already dispersed. But spontaneous strikes and violence persisted along the entire line through the month, until it became clear that there were many unemployed laborers eager for work at depression wages.

National economic malaise did not significantly affect progress on the Croton because its bonds, though deflated, did continue to sell. By 1840 much of the work in Westchester was completed, or nearly so, and construction in Manhattan was moving forward.

The piers to support the fifteen arches of the High Bridge slowly rose from the bed of the Harlem River and the low Westchester plain. A pipe siphon on a low embankment would carry Croton water across the Harlem until the bridge's completion in 1848 [Figs. 22, 23].

From the Harlem River, the aqueduct ran underground (in brick conduit, cast iron pipe, and two tunnels) for four miles toward, and then down, the future line of Amsterdam Avenue and, after a gentle S-turn, to just west of today's Columbus Avenue, surfacing dramatically at what is now 102nd Street to cross the Clendening Valley.

Perceived today as merely a shallow dip in the Upper West Side, the valley was the Clendening family farm. By late 1840, a 50-foot-high, 1,900-foot-long arched stone wall supporting a section of brick conduit, lined with iron to prevent seepage damage to the stonework, rose from the bucolic valley [Fig. 24]. The nine arches—three which are 27-feet wide, and

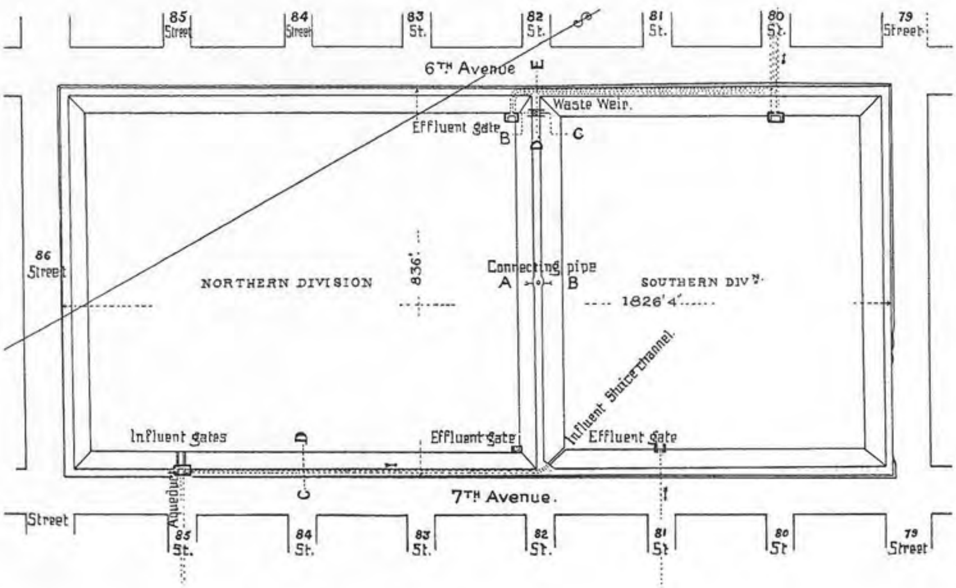
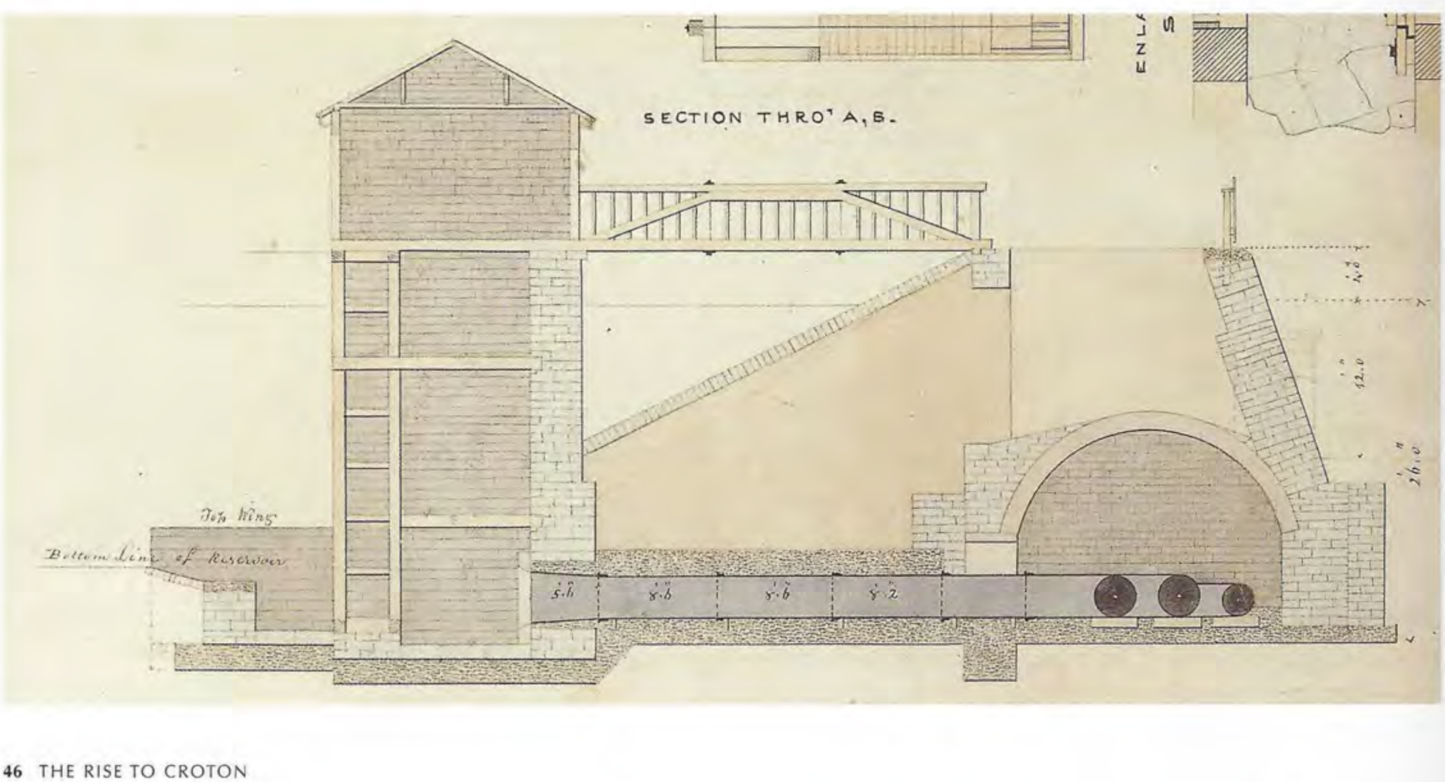


FIG. 25. *York Hill Receiving Reservoir. Plan with intended street layout (before implementation of Central Park plan). c. 1839.*

FIG. 26. *York Hill Receiving Reservoir. Section of effluent pipes and vaults for the north basin. c. 1839.*

flanked by 14-foot-wide arches—represent a bit of city governmental history. When the Whigs gained control of state government in 1840 (for two years), they impaneled a slate of cost-cutting water commissioners (led by old alderman Samuel Stevens) who won a vote by the politically divided Common Council to scrap the planned Clendening arches in favor of a cheaper solid wall. Democrat Isaac Varian responded with the first veto by a New York mayor. Varian explained that not only was the council order beyond the council's authority and a violation of existing contracts, but the unbroken wall it mandated would be a barrier to development. And so a Solomonic compromise was made: a solid wall would rise at the northern and southern ends, comprising half the valley crossing's length, and the partially constructed nine-arched midsection would be completed. Within twenty years, the Clendening farm was gone, and the streets and sidewalks of 98th, 99th, and 100th Streets passed beneath those arches. In the 1870s, development demanded more: the aqueduct section was shifted underground into a



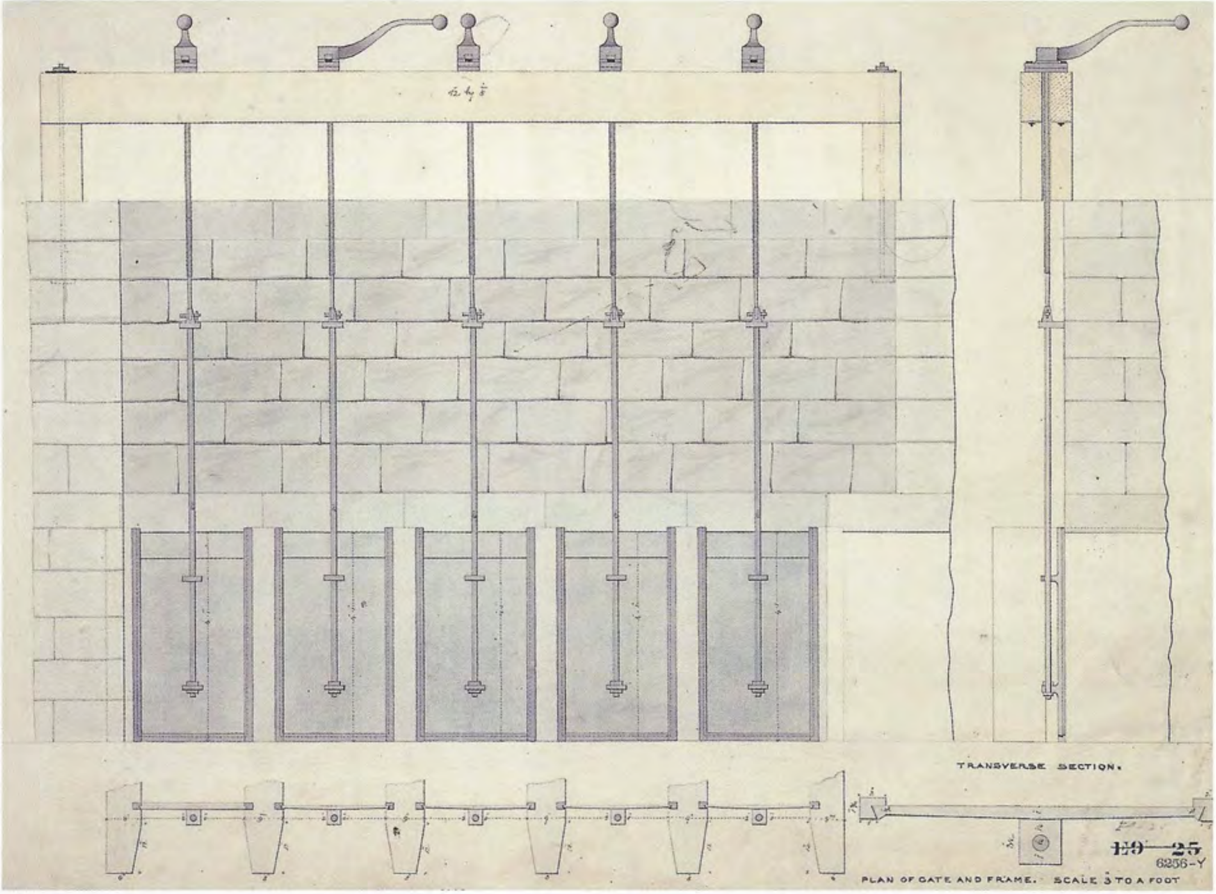


FIG. 27. *Old Croton Aqueduct. Sluice gates at termination of aqueduct at York Hill Receiving Reservoir. c. 1839.*

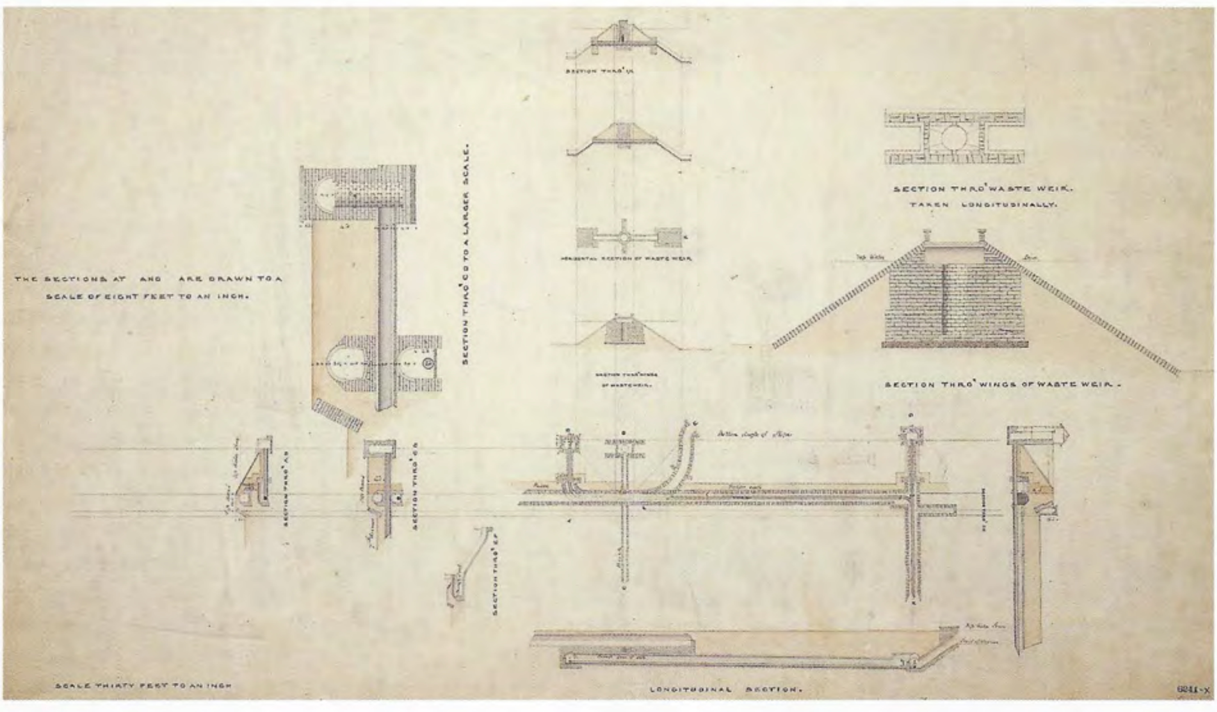


FIG. 28. *York Hill Receiving Reservoir. Sections through waste weir. c. 1839.*

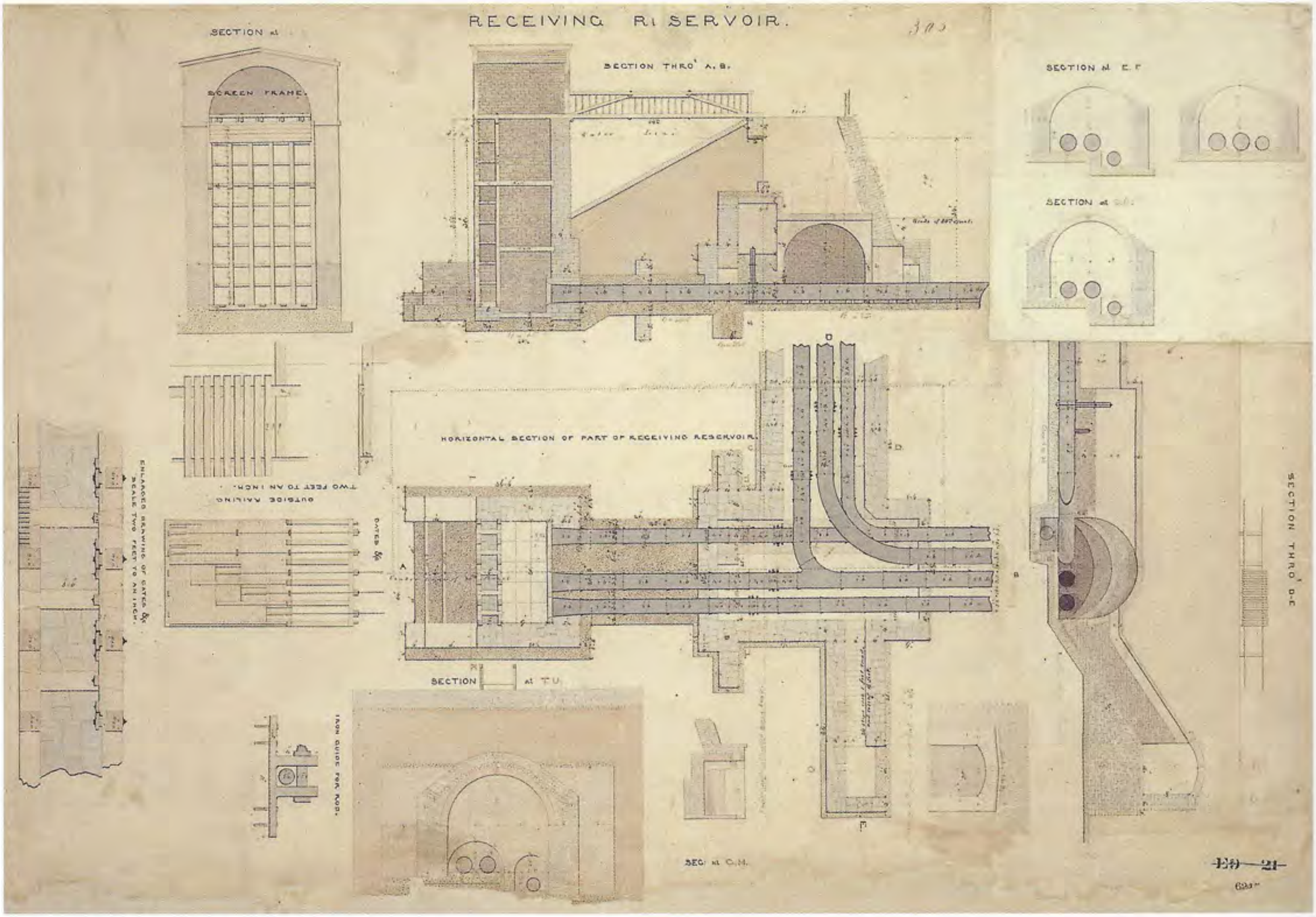


FIG. 29. *York Hill Receiving Reservoir. Details of gatehouse and pipe vaults. c. 1839.*

pipe siphon and the entire valley crossing—the arched central portion and the solid wall blocking 96th, 97th, and 101st Streets—was torn down. Some might say that the valley has never countenanced its development: after its degeneration into a dense region of shabby tenements, 1950s urban renewal delivered the current "banal . . . slab and balcony" high-rise apartments of Park West Village.[31]

From the looming tristesse of Clendening Valley, the brick conduit disappeared for its final underground mile to the York Hill receiving reservoir in rocky, open ground that the 1811 grid plan intended to eventually fill with fourteen blocks bounded by 79th and 86th Streets and Sixth and Seventh Avenues. Twenty years after it was completed, the reservoir was the centerpiece of Central Park—843 urban acres of re-created nature rescued from their fate of becoming part of the 153 blocks of grid (and inspired by Brooklyn's Green-Wood Cemetery, the pioneering exercise in urban pastoralism created in 1838 by displaced Croton chief David Douglass).

The York Hill receiving reservoir was comprised of two linked basins with unadorned sloping stone walls that rose in varying heights above the uneven terrain to maintain a maximum water depth of twenty-five feet [Fig. 25]. With a capacity of 150 million gallons, the receiving reservoir outpaced the storage of the Manhattan Company and the 13th Street Reservoir system three hundred times over [Figs. 26, 27, 28, 29, 30].

York Hill received its first water on the afternoon of June 27, 1842, to the cheers of twenty thousand citizens and the salute of thirty-eight guns. Fayette Tower, who during the past five years had been assigned increasing responsibility for major structures from the dam to the Clendening crossing, was present from early morning, when he took the hand of a distinguished visitor emerging from his exquisite carriage. "His head was bent forward beneath the weight of years and being introduced to one of the contractors for building the reservoir, he turned up one eye towards him and remarked 'I think you ought to make money here.' How characteristic of the man whose thoughts have turned to dollars."[32] Possibly the thoughts of America's richest man, seventy-three-year-old John Jacob Astor, were also turned to the costs of cholera and the approaching tenth anniversary of his daughter Magdelen's agonizing death.

From the receiving reservoir, twin three-foot-diameter iron mains led water south for two miles under the future line of Fifth Avenue to a 20 million gallon distribution reservoir at the provincial intersection of dirt roads, presently Fifth Avenue and 42nd Street. The receiving reservoir was primarily a functional creation; the distribution reservoir, on four acres of Murray Hill a mile north of the city limits, was a showpiece [Fig. 31]. Its massive sloping masonry walls were 45 feet high, towering over new lots, country cottages, and trees that thus far had survived clearing. The exterior was adorned with neo-Egyptian detailing. An iron railing ringed the flat top of the walls, creating a broad public promenade a third of a mile square [Figs. 32, 33]. To all who viewed it from a distance or viewed into the distance from its high promenade, the great reservoir augured the city to come, surging northward to meet, surround, and, by century's end, overwhelm it. When the reservoir was filled to its 36-foot depth, the level of the water was 115 feet above mean tide, and 51 feet below the water level at the Croton Dam 41 miles away.

With cannon booming at sunrise on Independence Day 1842, the water gates into the twin basins of the Murray Hill reservoir swung open. "At an hour when the morning guns had roused but few from their dreamy slumbers, and ere yet the rays of the sun had gilded the city's domes," Fayette Tower, perched on the reservoir parapet, "saw the first rush of the water as [it] entered the bottom and wandered about, as if each particle had

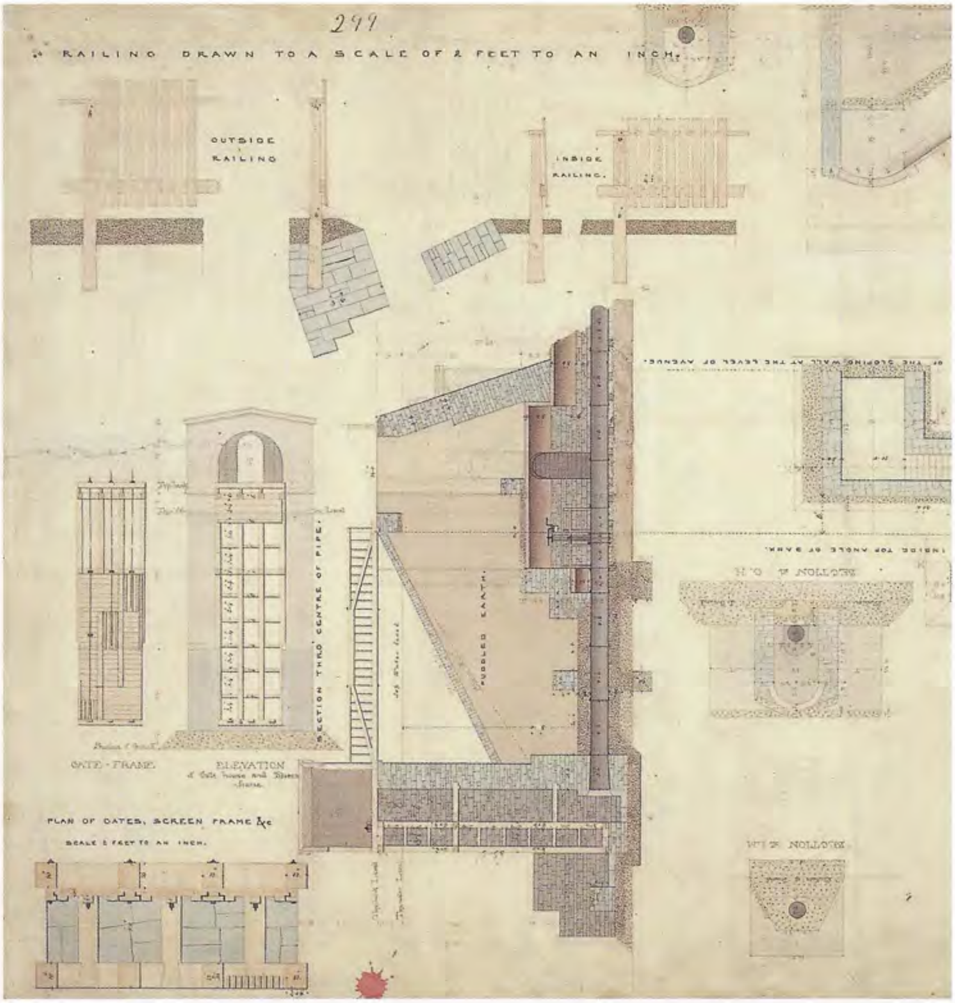


FIG. 30. *York Hill Receiving Reservoir. Cross section of gatehouse and perimeter embankment. c. 1839.*

FIG. 31. *Murray Hill Distributing Reservoir. 42nd Street and Fifth Avenue (future site of the New York Public Library).*

consciousness."[33] Later, the reservoir's bounty was served in cups to twenty-five thousand sweating citizens. By mid-October, hundreds of miles of distribution pipe had been laid, from the Battery to 21st Street, river to river, and spectacular fountains played in City Hall Park and Union Square. "Nothing is talked of or thought of in New York but Croton water; fountains, aqueducts, hydrants, and hose attract our attention and impede our progress through the streets," wrote Philip Hone in his famous diary; "Water! Water! is the universal note which is sounded through every part of the city, and infuses joy and exultation into the masses, even though they are somewhat out of spirits."[34] New Yorkers were out of spirits from six years of economic depression, which had something to do with the fact that few households had engaged a new breed—the Croton plumber—to hook up expensive service pipes. Only two weeks earlier the city officially announced that it would make free and unlimited water available at street hydrants and charge up to $12 a year for private service.

To promote the use of its new abundance, the city threw the "Croton Water Celebration" on October 14, 1842. Tens of thousands of marchers, in groups representing every layer of society, paraded before the population crowded along the winding citywide route festooned with flags and floral displays. Church bells pealed, bands played, artillery fired, and everyone endured a choral society rendition of the seven-stanza "Croton Ode," which opened with:

> Water leaps as if delighted,
> While her conquered foes retire!
> Pale contagion flied affrighted
> With the baffled demon Fire![35]

More lyrically, editor and best-selling writer Lydia Maria Child (chiefly remembered today for her Thanksgiving verse "Over the river and through the wood . . . ") reported to her newspaper readers in Boston: "Oh, who that has not been shut up in the great prison-cell of a city, and made to drink of its brackish springs, can estimate the blessings of the Croton Aqueduct? Clean, sweet, abundant water!"[36]

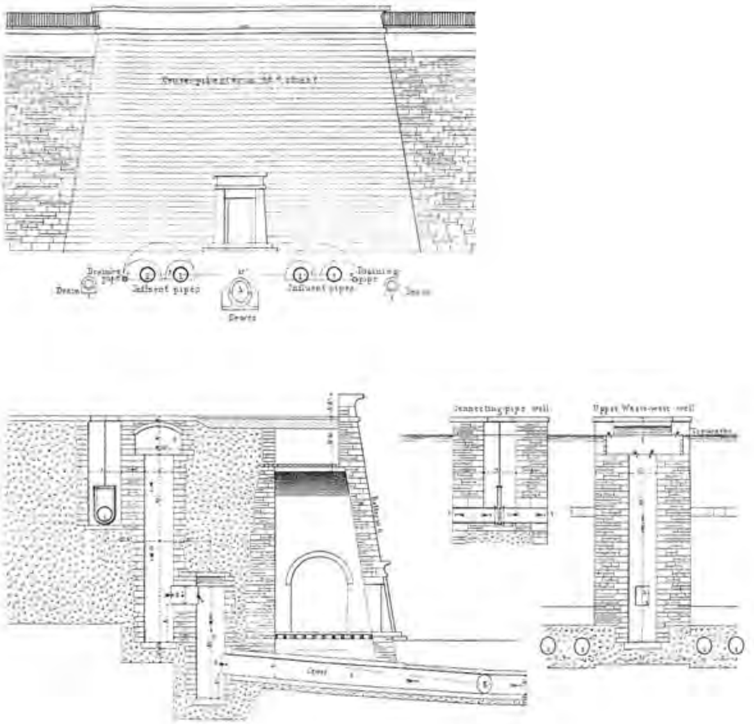


FIG. 32. *Murray Hill Distributing Reservoir. Elevation and cross section details at entry to pipe vaults.*

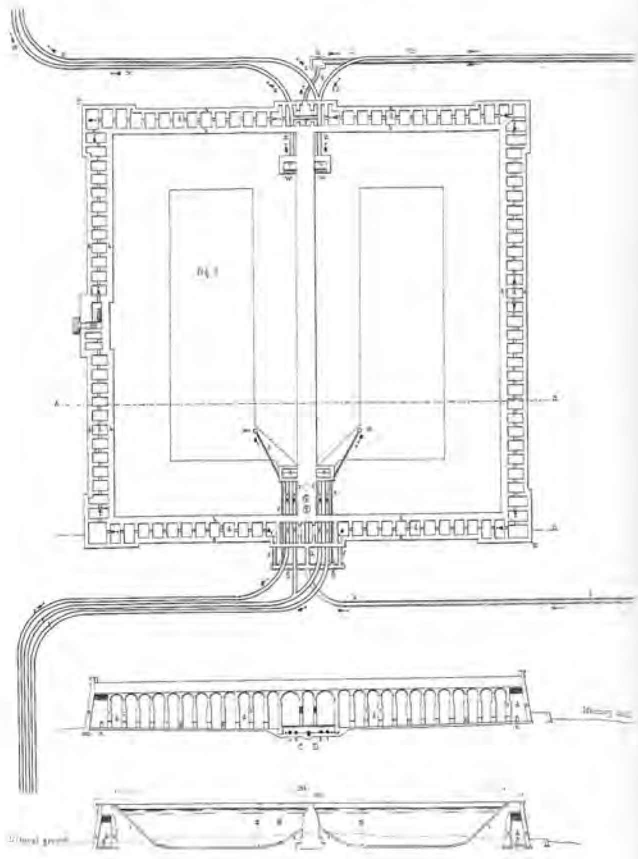


FIG. 33. *Murray Hill Distributing Reservoir. Plan and sections showing vaulted perimeter masonry walls.*

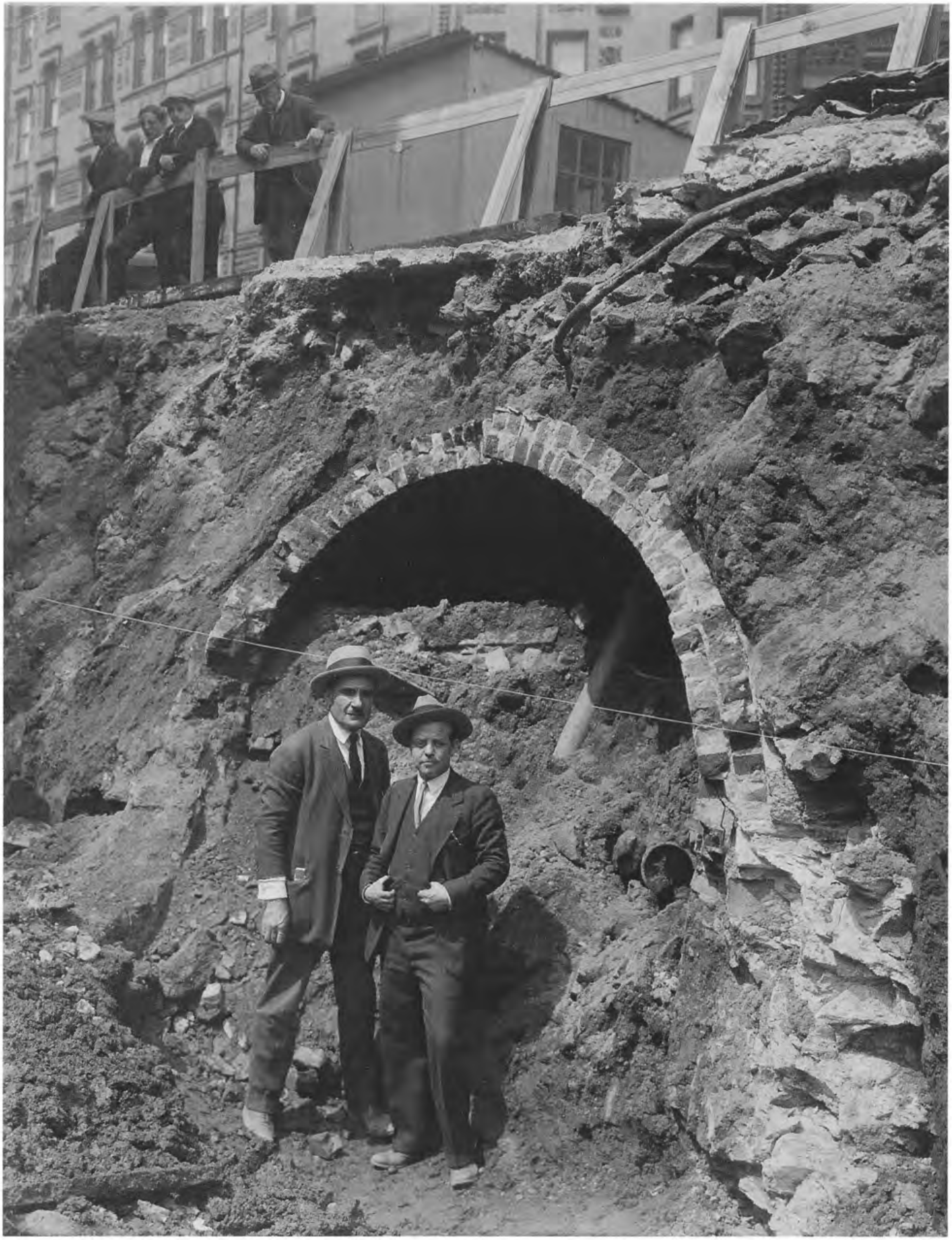


FIG. 34. *Old Croton Aqueduct. Section of aqueduct exposed during building excavation at West 105th Street, Manhattan. May 4, 1928.*

NOTES

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