Chicago's War With Water

ON ITS WAY TO PIONEERING OUR MODERN SEWER SYSTEM, CHICAGO SURVIVED EPIDEMICS, FLOODS, AND COUNTLESS BAD PLANS

BY DANIEL E. Capano

BEFORE THE CANAL ERA, THE PLACE THAT WOULD BECOME known as Chicago barely merited a dot on the map. It was a trading post and fort on the way to St. Louis, the leading city of the West, and the Great Plains beyond. But just twelve miles west of Lake Michigan there existed an ancient geological feature that, with some new technology and an immense amount of labor, would make Chicago into the city of the century. It was a subcontinental drainage divide, a five- to six-foot-high ridge running north-south along what is today Harlem Avenue. On its eastern side, streams and rivers, including the branched Chicago River, drained into the Great Lakes; on the western side, they drained into the Mississippi and the Gulf of Mexico.

Travelers long dreamed of a reliably navigable connection between the two systems, which would tie the country together by water from the St. Lawrence River and Erie Canal all the way to New Orleans. When that connection finally came, in 1848, in the form of the Illinois and Michigan (I&M) Canal, which connected the Chicago and Illinois Rivers and thus linked Lake Michigan to the Mississippi, it instantly turned Chicago into the major transportation hub of the region—and more: The canal attracted so many railroads that by 1857 the city was the country's largest railroad center. But the very network of waterways that brought Chicago wealth also brought a curse, for it proved wholly incapable of handling the sewage of such a rapidly growing city. Escaping that curse would be an almost unending struggle; but the lessons learned
would prove useful in making water safe all over the nation. When the land on which Chicago now sits was acquired from the local Indians, in 1833, it held 150 people; when it was chartered as a city, in 1837, the population had risen to more than 4,000; in 1880 it surpassed 500,000. That explosive growth created increasing water problems. More and more had to be pumped in, and more and more human and animal waste and other effluents had to be disposed of.

Sewage treatment as we know it today was nonexistent. Citizens simply dumped their refuse into shallow privies or the Chicago River, which became black and sluggish with filth. A newspaper account from late in the century complained, “The river stinks, the air stinks. People’s clothing, permeated by the foul atmosphere, stinks. . . . Stink reaches the infinite and becomes sublime in the magnitude of odiousness.” And the problem reached beyond the aesthetic. The river, being on the eastern side of the subcontinental divide, emptied into Lake Michigan, the city’s main source of drinking water. Disease began to reach chronic, if not epidemic, proportions.

Unbelievable as it may seem, people did not yet see the connection between pollution and disease. Typhoid and cholera spread, their incidence spiking whenever heavy rains washed filth from the streets back into the city’s water supply. Between 1849 and 1852 nearly 2,000 people died. Since germ theory was unknown, doctors blamed “death fogs” and immigrants.

Early attempts to eliminate waste and dead animals in public areas actually made the situation worse. Roads were graded toward the river to provide drainage, only to empty even more waste into the river. Where grading was not possible, dead animals rotted in the streets; and rainstorms left fetid, stagnant pools. To make matters worse, the growing meat-packing industry used the Chicago River for fresh water as well as for disposal of slaughterhouse wastes.

In danger of choking on its own sewage, the city experimented. Beginning in 1849, wooden gutters were laid in the streets, but they only carried more pollutants to the already congested river and eventually became clogged themselves. It was obvious that more drastic action had to be taken. In 1855 the city appointed a Board of Sewerage Commissioners, which hired Ellis Sylvester Chesbrough, the city engineer of Boston, to develop an overall plan. Chesbrough’s job was harder. Coastal cities could ultimately rely on the ocean to sweep their sewage away, although getting the waste to the sea in the first place could be difficult. New York at the time had a haphazard system of storm sewers intended to carry storm water to the East and Hudson Rivers. But waste leaked into these ditches from underground privy vaults and frequently clogged the works and created pools of pollution in the rivers at the outflow points; as conditions became dire over the next decades, the city opened its streets to construct a network of underground sewers better suited to carrying waste. Boston in the 1870s began to pipe its sewage to points offshore where the tide was strong enough to carry it away. On the other hand, landlocked St. Louis, which built a network of underground sewers starting in the 1850s, would empty its waste into the Mississippi until the 1960s.

Since nothing so comprehensive as Chicago’s plan had ever been proposed in the United States, Chesbrough went off to study the waste-disposal systems of the great cities of Europe. London and Paris were perfecting covered sewer systems that would empty into the Thames and the Seine, respectively, downstream, so that citizens could draw clean drinking water from above the outlets. Chicagoans, having a large body of clean water close at hand in Lake Michigan, didn’t have to drink from their polluted river, but instead of carrying waste away from the city, like the Seine or the Thames, their river emptied straight into the water supply.

Chesbrough considered four possibilities: building a canal between the
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Chicago River and the Des Plaines River, and then pumping Lake Michigan water into the Chicago River to flush the wastes away (this was the plan that would eventually be adopted in the 1890s); establishing "sewage farms" to turn waste into fertilizer; draining sewage directly into Lake Michigan; or draining most of the city's sewage into a deepened Chicago River and diluting it with a modest amount of lake water.

In 1856 the commissioners chose the last idea, preferring it as easy, fast, and economical if not perfect. They omitted the pumps to bring lake water into the river as expensive and unnecessary. Workers immediately began to install a system of sewers draining directly into the river. These operated by gravity, but most of Chicago was built on ground only one or two feet above the river, so the street level downtown had to be boosted an average of eight feet with fill dredged from the bottom of the river. Eventually 1,200 acres were raised, and all the buildings, trees, and lampposts on them. (A leading contractor for raising buildings was George M. Pullman, who used his profits to establish the Pullman Palace Car Company.) The sewers did draw most of the muck off the streets, but they failed to solve the larger problem. The river, and all the sewage it carried, still drained into Lake Michigan. Deepening its channel only staved off disaster for a while.

The city had already extended its drinking-water pipes 600 feet into the lake and a mile and a half from the river's mouth, but as Chesbrough reported, waste was being pushed farther out into the lake too. Plumes of contaminative sewage frequently overwhelmed the water intakes, particularly during rain.

O CHESBROUGH, NOW HEAD OF THE NEWLY FORMED Bureau of Public Works, decided to draw drinking water from even farther out. To do so, he created a marvel of engineering. Irish immigrants working 16-hour days dug a two-mile tunnel—the longest ever bored at the time—30 feet under the lakebed. When the system was opened, in 1867, water flowed into intake pipes and through a bricked-lined tunnel to a pumping station, and from there to a water tower 154 feet tall. In the meantime, city officials voted to implement one of Chesbrough's earlier suggestions for keeping sewage out of the lake in the first place. In 1867 workers
The Sanitary and Ship Canal trained a generation of engineers, many of whom went on to work on the Panama Canal.

began to deepen the channel of the I&M Canal and install greatly enlarged pumps to force increased amounts of water from the South Branch of the Chicago River into the canal. Now the goal would be not just to provide enough water to fill the canal but to reverse the river’s flow and provide drainage away from the lake.

The new cut opened in July 1871, just months before the Great Fire, and was an immediate success. The Chicago River, now flowing southwest to the canal, slowly began to cleanse itself, and the populace celebrated its triumph over the specter of disease. One resident exclaimed that the river would soon be “clean enough for fish to swim it.” Citizens dared to hope that their water supply would remain pure.

They got their wish for a little more than a year. Then, inevitably, problems began to develop. Springtime flooding of the Des Plaines River, which was connected by the Chicago River by a pumpless canal called the Ogden-Wentworth Ditch, caused the flow of the Chicago River to reverse again, pouring sewage and filth into Lake Michigan. The quality of the drinking water relapsed to questionable at best. Though a dam was built on the ditch a few years later, people still endured all manner of contamination, from the malodorous discharge typical after a heavy rain to live fish and clams clogging their faucets, which led tourists to call the water in the city’s hotels “chowder.”

While Chicagoans worried about the canal, towns downstream suffered because of it. When waste was flushed out of the city down the reversed river, the pollution didn’t disappear, of course; it just went somewhere else. A resident of Morris, Illinois, said, “Ever since that water from the Chicago River was let down into the Illinois River, the stench has almost been unbearable. What right has Chicago to pour its filth down into what was before a sweet and clean river, pollute its waters, and materially reduce the value of property on both sides of the river and canal, and bring sickness and death to citizens?”

 Unfortunately, better solutions would have to wait. In 1871 the Chicago Fire consumed more than 13,000 buildings, and the rebuilding city had little time to address sanitation problems. It was 12 years before another attempt was made to reverse the flow of the river. In 1883 the Chicago government installed even bigger pumps on the canal and built a 12-foot tunnel between the
North Branch of the river and Lake Michigan, equipped with a pumping station for flushing the North Branch in either direction, as conditions required. But these facilities had only a marginal effect on the river’s condition. Most of the plains and wetlands that had once acted as huge sponges absorbing rainwater had been filled in or developed, and storm water now simply ran off into drainage ditches or storm sewers and then into the river, which swelled and scoured the slime into Lake Michigan despite the powerful pumps. In 1879, 30 consecutive days of rain caused a continuous foul discharge from the Chicago, poisoning the water supply.

After the torrent subsided, a citizens’ committee demanded that a “new river” be constructed to solve the pollution problem. It would run 31½ miles between the South Branch of the Chicago River and Joliet, on the Des Plaines, and would accommodate oceangoing vessels. Water pumped from Lake Michigan would dilute the sewage and keep the canal filled. The idea elicited great interest among industrial and shipping interests, but while it was being discussed an event occurred to snap the government out of its reverie.

A storm on August 2 and 3, 1885, dumped more than six inches of water on the city and its surroundings. The already overburdened drainage system was completely overwhelmed. The pumping facilities at Bridgeport were flooded and the river again reversed course, scouring its bottom and banks of accumulated waste and pouring it into Lake Michigan. The black cloud again overtook the drinking-water intake. The storm brought the problem of drainage and sewage disposal to the fore, and in January 1886 the city appointed yet another commission to find a way to protect the public water supply and control the Chicago River.

The commission entertained new proposals to continue dumping sewage into Lake Michigan, establish sewage farms, and increase drainage away from the lake. In the end, it opted to construct a channel much like the “new river” that would permanently reverse the Chicago River’s flow away from the lake. In 1889, after two years of legal and procedural maneuvering, the Illinois legislature created the Sanitary District of Chicago and ordered it to protect the public by draining away wastes.

The effort to dig the Chicago Drainage Canal, which would be renamed the Sanitary and Ship Canal in the 1930s, began three years later, after exhaustive design studies by the project’s first chief engineer, Lyman Cooley. The original design called for the use of the I&M Canal as part of the new channel, but disputes with the I&M commissioners resulted in an alternative channel that left the I&M undisturbed.

Instead, the Drainage Canal ran parallel to the I&M for 28 miles, reaching southwest from present-day Damen Street on the South Branch of the Chicago River in Chicago to Lockport, on the Des Plaines, with an average depth of 24 feet. The canal is wider than either the Suez or the Panama, and it slopes downhill all the way. It carries 10,000 cubic feet of water per second and keeps the current under 1½ miles an hour with a lock structure at Lockport involving seven vertical sluice gates and a horizontal dam shaped like a bear trap. Digging through earth, limestone, and solid rock for nearly eight years, workers moved more than 41 million cubic yards of dirt and rock using new excavation techniques and entirely new types of equipment. Some of the spoil was deposited on Chicago’s lakefront, where it was used to create Grant Park. Like the Erie Canal early in the century, the Drainage Canal trained a

Left: Workers tend to Chicago’s sewer pumps in the 1930s or 1940s. Right: Settling tanks from the same era.
The Chicago River, the first to flow away from its mouth, purged itself, and the city celebrated. Its water supply was safe at last.

On January 17, after the Illinois governor's commissioners heard that Missouri was about to file for an injunction in the U.S. Supreme Court, they assembled hastily and hurried to Lockport. After inspecting the still unfinished Des Plaines riverbed, they approved opening the canal. The governor gave his assent by telephone, the Bear Trap Dam was lowered, and the waters of the Great Lakes surged toward the Mississippi. Since it was now too late for an injunction against opening the canal, Missouri sued to make Illinois shut it down. This required a finding that the canal was a hazard to the health of Missouri's citizens, but a team of bacteriologists from the University of Wisconsin determined that by the time the canal water reached St. Louis, it was harmless.

The Chicago River, now the first ever to flow away from its mouth, purged itself, and the city celebrated. Its water supply was safe at last from the caprices of nature. Newspapers were full of praise for the engineers, the new canal, and its effect on the river. The sight of ice forming in the Chicago was novel to those who couldn't remember its increasingly distant sludge-free past. One spectator predicted, "The water in the drainage canal will be so pure that it will freeze hard. When the canal is finished we shall have a skating course from here to Lockport." And a Lincoln Park resident drew a crowd when he and his son caught two catfish from the Well Street Bridge. "I knew we'd do it," he muttered, "It's only a bullhead, but nothin'
but a bullhead would have anythin’ to do with such a river, anyway.” Watching the ice cakes “move leisurely to the Missis-
pippi,” he said, “it ain’t what it used to be.”

The last phase of the project, the addition of intercepting sewers 6 to 27 feet in diameter, was completed in 1907. Built
along the lakefront beneath the regular sewer grid, they piped storm water away from the lake to pumping stations,
which sent it to the Drainage Canal. That same year, the Drainage Canal was extended another four miles from Lock-
port to Joliet. Two new channels, the 8-mile North Shore
Channel (completed in 1910) and the 16-mile Calumet-Sag
Channel, or “Cal-Sag” (completed in 1922 and soon a major
commercial waterway), drained the North Branch of the Chi-
cago and the Calumet, respectively, and, in conjunction with
the new sewers, ended the emission of waste into Lake Michi-
gan forever.

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ESPITE ITS SKIRTING THE ST. LOUIS INJUNCTION, THE
district’s legal woes dragged on. In 1907 it petitioned
the Secretary of War for the right to divert more from
Lake Michigan into the canal than the 4,167 feet
per second already authorized. (An 1895 commission study
had determined that an increase to 10,000 cfs would lower the
level of the lake by about six inches.) The secretary denied
the petition and subsequently brought suit against the district
to restrain it from diverting more. In 1922 the state of Wis-
sconsin filed suit to stop the diver-
sion entirely, but then in 1925 re-
treated to demanding (together with
Minnesota, Ohio, and Pennsylvania)
that the Sanitary District not divert
water for sewage dilution. In 1926
Michigan and New York joined the
suit. They claimed that the diversion
was interfering with navigation, agricul-
ture, horticulture, and the cli-
mate and violating their water rights.
(In fact, the level of Lake Michigan
is constantly changing for a variety of
reasons.)

In 1930 the U.S. Supreme Court
finally ordered the city to reduce the
canal’s take to 1,500 cfs by 1938.
(The decree did not address the
amount of water Chicago could
pump for drinking.) Chicago obeyed
the new limits, and its river became
filthy and malodorous once again.
In 1954 the district asked for fed-
eral legislation to allow increased
diversion. It failed, and in 1958 six
Great Lake states brought suit to com-
pel the district to return all treated
wastewater to the lake. This could
have been staggeringly expensive. In 1967 the parties agreed
on a decree setting the total allowed diversion, for all uses, at
3,200 cfs.

During the decades of legal wrangling, engineers and sci-
entists had perfected several sewage-treatment techniques that
would at last actually clean wastewater, not just send it south.
British engineers in Manchester developed a process in the
1910s to breed naturally occurring microorganisms in large
aerated tanks for the purpose of digesting wastes. This “activ-
ated sludge” process was tested in an experimental plant in
Maywood, Illinois, in 1921, and experimenters found that the
well-fed bacteria clumped together and sank out of the waste-
water solution quickly. Other experiments showed that sludge
could be separated from the water even more easily by add-
ing ferric chloride, which acts as a coagulant. Chicago applied
both principles in three new sewage-treatment plants built in
the following decades: the Calumet Treatment Plant, completed
in 1922 with a capacity of 358 million gallons a day (MGD);
the North Side works, opened in 1928 with a capacity of 333
MGD; and the Stickney Treatment Works, created in 1949 by
combining two 1930s plants. Stick-
ney is the largest sewage-treatment
plant in the world, with a capacity
of more than 1,200 MGD. In 1955
Chicago’s waste disposal system was
named by the American Society of
Civil Engineers as one of the
seven engineering wonders of
the United States.

The main goal of sewage
treatment is always to sepa-
rate harmful material from the
water that carries it. The typi-
cal wastewater treatment plant
depends as much on gravity as
on chemistry. Wastewater flows
through the various treatment
processes with a minimum of
pumping and electricity. First,
in what is called the primary
treatment stage, raw waste-
water sits in a tank undisturbed
for a certain period, and up to
75 percent of offensive materi-
al is settled out of suspension
merely by gravity. The sludge
falls to the bottom of the tank,
where it is swept into sumps and
pumped to another part of the
plant for treatment. Air is
bubbled through the remain-
ing wastewater, allowing rapid
growth of the beneficial mi-
crobes that do the activated-
After more than a century of being choked with waste, the Chicago River is finally clean enough to row on.

The Deep Tunnel Project will carry billions of gallons of storm overflow hundreds of feet underground to await treatment later.

sludge job. Once they have dined, clumped together, and separated out, the remaining wastewater, now called "mixed liquor," flows into secondary treatment tanks. There more settleable solids are given time to sink to the bottom. The clear water remaining—odorless and free of 95 percent of the solid waste it once carried—is disinfected with chlorine and released into the receiving waters (in Chicago's case, the river system). In many cases, the receiving waters are more polluted than the plant's discharge. And the separated solid waste is put to good use. Chicago removes most of the water, sand, grit, and active-sludge bacteria, and sells what remains as fertilizer or landfill.

Mother Nature can still wreak havoc even on as advanced a system as Chicago's. The city's sewers collect both storm water and wastewater, and a heavy rain can easily double the flow through the collection system and treatment facilities. Downpours in 1954 and 1957 overwhelmed both systems, and waste leaked into waterways and even basements. The beaches were closed, and the public, by now unused to the sight of raw sewage, protested loudly. Overflows became increasingly frequent over the next decade until the federal government in the late 1960s demanded a solution. It happened not a moment too soon. By then waste was draining into the rivers an average of once every four days.

It looked as if the city was facing another spate of costly plant expansions or interminable sewer-system installations. But then the Sanitary District received an elegant proposal that eliminated the need for either. In 1975 crews broke ground for the Tunnel and Reservoir Plan, or Deep Tunnel Project, which is slated for completion in 2010. The system will use 109 miles of tunnels, ranging from 9 to 33 feet in diameter at depths from 150 to 350 feet belowground, to carry storm overflow to reservoirs with a combined capacity of 15.5 billion gallons. When a storm first hits, the old sewer system will operate as usual, taking in both storm runoff and household wastewater. Then as its capacity is exceeded, excess wastewater will drop into the deep tunnel system and the storage reservoirs. By the time the sun comes out, the stored wastewater will be pumping into existing treatment plants.

Today the Metropolitan Water Reclamation District of Greater Chicago, the successor to the Sanitary District, serves more than 5.1 million people. Industrial waste adds the equivalent of another 4.5 million people. In the 170 years since it had a population of 150, Chicago has served as a crucible for modern wastewater treatment. It has had to continuously improve and upgrade its systems, and the results, efficient and safe methods of treatment, are today enjoyed by every city and town in the United States.

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