

New York Harbor Survey Program Celebrating 100 Years

1909 — 2009

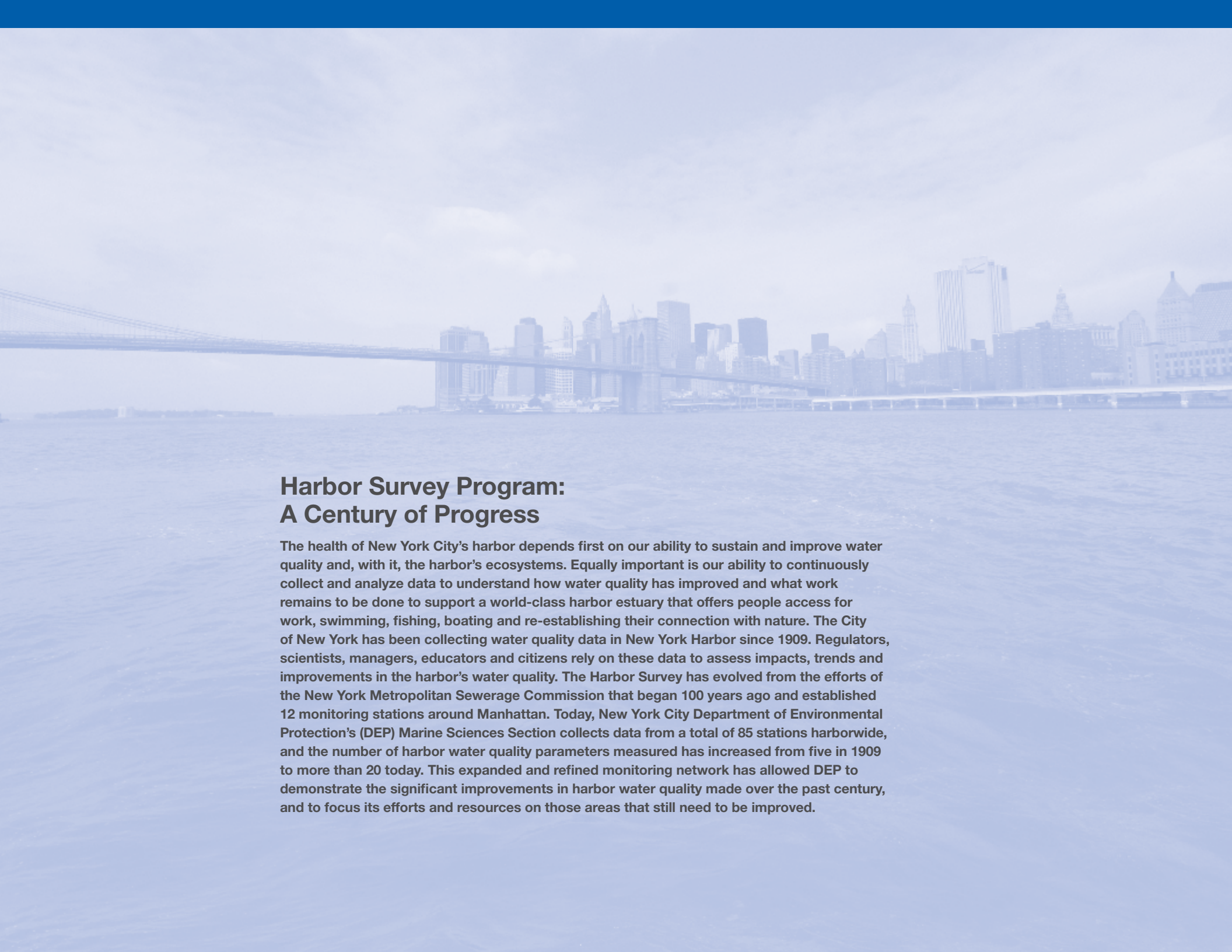


NYC

Environmental
Protection

Michael R. Bloomberg, Mayor
Cas Holloway, Commissioner





Harbor Survey Program: A Century of Progress

The health of New York City's harbor depends first on our ability to sustain and improve water quality and, with it, the harbor's ecosystems. Equally important is our ability to continuously collect and analyze data to understand how water quality has improved and what work remains to be done to support a world-class harbor estuary that offers people access for work, swimming, fishing, boating and re-establishing their connection with nature. The City of New York has been collecting water quality data in New York Harbor since 1909. Regulators, scientists, managers, educators and citizens rely on these data to assess impacts, trends and improvements in the harbor's water quality. The Harbor Survey has evolved from the efforts of the New York Metropolitan Sewerage Commission that began 100 years ago and established 12 monitoring stations around Manhattan. Today, New York City Department of Environmental Protection's (DEP) Marine Sciences Section collects data from a total of 85 stations harborwide, and the number of harbor water quality parameters measured has increased from five in 1909 to more than 20 today. This expanded and refined monitoring network has allowed DEP to demonstrate the significant improvements in harbor water quality made over the past century, and to focus its efforts and resources on those areas that still need to be improved.

New York Harbor Survey Program

Celebrating 100 Years

1909 — 2009



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THE CITY OF NEW YORK
OFFICE OF THE MAYOR
NEW YORK, NY 10007

Water surrounds New York City and the story of our harbor water quality in many ways reflects the history of the City. The Harlem, East, and Hudson Rivers, Jamaica Bay, and the unmatched natural harbor comprised of the Upper and Lower New York Harbor have physically shaped the city and have supported a vigorous maritime trade, industry, diverse ecological communities, and recreation. In so doing, our waterways, as much as any other element of the City, distinguish our people and neighborhoods.

Our Harbor Survey Program has evolved over the last hundred years to reflect the latest techniques and technologies. But for a century its goal has remained the same: to monitor and protect the ecology and vitality of New York City's local waterways. Thanks to the dedication and ingenuity of the nearly 6,000 men and women of the Department of Environmental Protection and its predecessors, I can proudly report that New York Harbor is healthier now than it has been at any time in the last century—and the best is yet to come.

Join me in celebrating a tradition of committed service and rigorous scientific examination by reading this report and learning more about the work we've done and continue to do to protect the health of New York City's harbor waters.

Michael R. Bloomberg
Mayor of New York City



Two-thousand-nine marked the centennial of the New York City Department of Environmental Protection's Harbor Survey Program. After years of neglecting local waterways, reformers were motivated by epidemics of typhoid, cholera and other waterborne diseases to press the City to form the New York Metropolitan Sewerage Commission in 1906. The Commission established the first Harbor Survey Program in 1909 to assess local water quality, and it has become a critical benchmark of the ecological health of New York Harbor. The pioneers you will read about in these pages identified new ways to effectively control wastewater disposal and treatment, and developed techniques to preserve and restore the City's natural environment. The tradition of innovation that gave rise to modern wastewater treatment more than a century ago is more robust today than ever. Working with some of the most talented engineering and construction firms in the world, DEP continues to implement new technologies to improve wastewater treatment and the quality of our harbor waters.

While we still have a long way to go, it is important to reflect on what the City has achieved: New York City's waterways are healthier than they have been in 100 years, and New Yorkers are returning to the waterfront in unprecedented numbers. Better water quality alone does not account for the success, but it is the foundation that has made the reclamation of the City's vast waterfront possible. As the Harbor Survey enters its second century, DEP looks forward to building on that success.

Caswell F. Holloway
Commissioner

Introduction

The first Europeans to arrive on the shores of what would become New York City found a landscape abundant with native flora and fauna and a vast, pristine harbor that reached as far as the eye could see. Though largely undisturbed by the relatively small population of native people, the growing number of newcomers had an impact on these precious natural resources. As they began to settle Manhattan in the early 17th century, little effort was made to protect the surrounding waterways from harm.

solid waste and wastewater were discharged into the harbor without any treatment. The effects of these discharges were not initially apparent due to the harbor's natural ability to assimilate waste; as a result, the city and surrounding municipalities were able to grow without investing in wastewater treatment. However, harbor water quality gradually degraded, eventually becoming inhospitable to New York City residents and aquatic life. In addition, highly unsanitary conditions resulted in cholera outbreaks and other illnesses, and it became imperative that the city find a plentiful supply of clean drinking water. The city found such a source in then sparsely populated Westchester County. The Old Croton Aqueduct, completed in 1842, delivered as much as 50 million gallons of water a day to reservoirs located in what is now Central Park and the site of the New York Public Library on 42nd Street.

Over the course of the next 200 years, the city's population increased rapidly — from approximately 5,000 in 1700 to nearly two million in 1900 — and so did New Yorkers' consumption of water and their generation of waste. Even as underground sewers replaced open trenches that ran down some city streets,

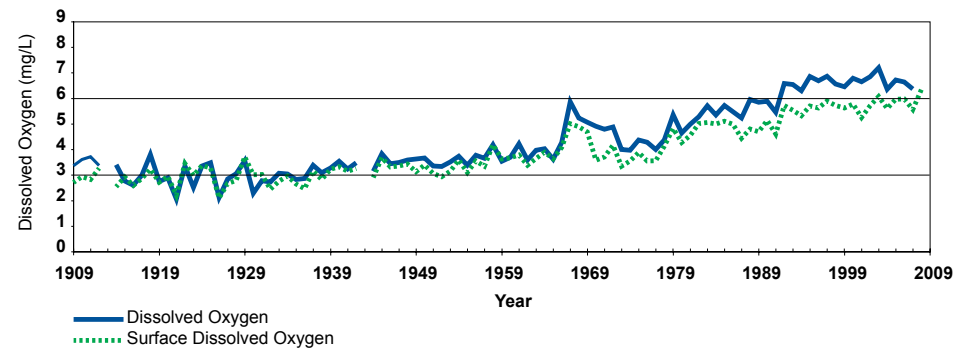


Hattie Bell, the first harbor survey vessel in 1906



Harbor survey vessel Osprey monitors water quality today

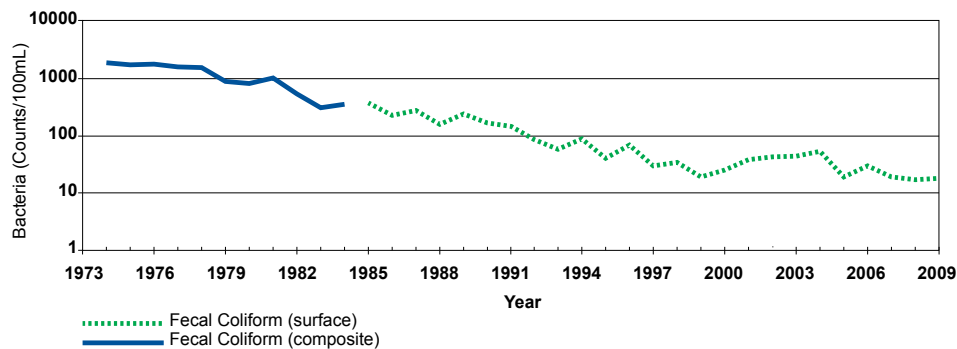
Summer average dissolved oxygen from 1909 to 2009



It was not until the late 1800s that the need for systems to manage and treat solid waste and wastewater became obvious. A little more than a century ago, the city took the first steps to comprehensively manage the treatment and disposal of wastewater and to restore the harbor to its original state. The New York Metropolitan Sewerage Commission (MSC) was established in 1906 to study wastewater discharges and improve sanitary conditions. The MSC conducted the first surveys of harbor water quality, which led to the establishment in 1909 of a full-fledged Harbor Survey Program. This effort helped to identify the location and scale of improvements needed to develop a comprehensive wastewater treatment system, and laid the groundwork for investments in new infrastructure. The sound scientific basis of this work helped to gain public support for the program.

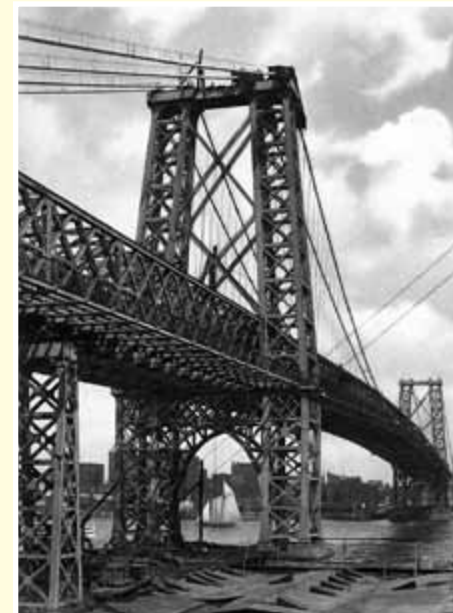
Thanks to these early efforts and to the ongoing work of highly skilled City employees and contractors, harbor water quality has improved dramatically. New York Harbor and other surrounding waterbodies are cleaner today than they have been in 100 years. This improvement is due in large part to the ingenuity of New York engineers and scientists who have pioneered new methods designed to treat the more than one billion gallons of wastewater produced every day by the city's more than eight million residents and visitors. The processes they designed both to maintain a high degree of performance and reduce costs have been adopted around the world. This centennial report celebrates the success of the Harbor Survey Program, and catalogues the progress the city has made throughout the decades.

Summer geometric means of bacteria from 1909 to 2009



Gateway to the World

The stories of New York Harbor and New York City are inextricably intertwined. It is, after all, this open expanse of coastline and inland waterways that welcomed both the first explorers and initial waves of settlers. As the city grew, the harbor's ports served as an economic engine and a gateway for successive generations of immigrants who are the foundation of New York City's strength and diversity.



Construction of the Williamsburg Bridge (1903)

WATERFRONT AND HARBOR OF THE CITY OF NEW YORK

Channels having a depth of 30 feet or
over are colored Blue

1870-1871

Leading the Charge for Clean Harbor Water

Dr. George Soper (1870-1948), a philosopher and sanitary engineer whose wide-ranging passions focused on quality-of-life issues, was among the first to insist on solving the city's waste disposal problems. Recognizing the relationship between the regular dumping of raw sewage, worsening conditions in the harbor and surrounding waterways and growing public health concerns, Soper pushed for sewer construction and treatment of wastewater. He led the New York Metropolitan Sewerage Commission in the early 1900s.

Other notable New Yorkers built on Soper's early efforts. Richard H. Gould, a sanitary engineer active in the 1920s, was among the first to evaluate harbor survey data and to conduct cost analyses to identify locations for wastewater treatment plants. As the first Engineer in Charge of the Sewage Disposal and Intercepting Sewers for the City's Department of Public Works, Gould led a team of city engineers in devising a master plan to protect harbor water quality. A number of sanitary engineering formulas he developed are still used today to monitor and design wastewater treatment plants. He also conceived of a unique design for sedimentation tanks — aptly named *Gould Settling Tanks*, which continue to be used today. In addition to instituting the first activated sludge process in the city, Gould worked with Wilbur Torpey to develop the step-feed aeration process that allowed for the design of treatment facilities that were smaller and less costly to build. This process and design were eventually incorporated into all city wastewater treatment facilities.

Wilbur Torpey, a sanitary engineer, started with the city as a Process Control Engineer, and became Director of Water Pollution Control and a well-known leader in the wastewater treatment industry. He developed a number of wastewater treatment processes with Richard Gould, Martin Lang, and other city engineers. Torpey developed the use of gravity thickeners to reduce the volume of solids removed from wastewater and associated costs. He also created the high-rate anaerobic digestion process, which stabilized the decaying solids removed from wastewater. This process also generated digester gas, which was used to generate electricity and reduce operational costs.

Another New Yorker prominent in the field, Martin Lang, a chemical and civil engineer, also started work for the city as a Process Control Engineer and eventually served as Commissioner of the Department of Water Resources and later as First Deputy Administrator of the Environmental Protection Administration for the City of New York. Lang was also president of the Water Environment Federation. In his early years with the city, he worked alongside Torpey developing techniques to improve wastewater treatment. He helped implement the use of sodium hypochlorite for disinfection at city treatment plants, a practice accepted years later in other municipalities.



Microbiologist at work performing bacteria analysis

First Steps: Confronting Harbor Water Pollution

A century ago, with New York City in the midst of a dramatic period of industrial and commercial growth, residents and business owners began to experience the negative impact of years of untreated wastewater disposal into the harbor. Water quality steadily worsened as the harbor received discharges of approximately 600 million gallons of raw sewage every day. Decomposing waste, industrial pollutants, construction debris, and residential garbage dumped regularly into the waterways made the harbor a noxious eyesore. Visitors complained about these conditions, the Board of Health often closed beaches, and the city's once rich oyster beds were dying.

From the mid to late 1800s, local efforts focused on managing wastewater by installing pipes to convey it to the nearest receiving waters. It was left up to individual boroughs to plan, design and maintain these systems.



Jamaica Wastewater Treatment Plant after an upgrade

By the beginning of the 20th century, numerous sewers discharged untreated wastewater containing a wide array of disease-carrying microorganisms into the city's waterways. To address this public health issue, the City built its first wastewater treatment plants at Coney Island (1886), 26th Ward (1894) and Jamaica (1903). They relied on screening and sedimentation, the "low-tech" processes available at the time, to remove the largest solids from the wastewater flow. These plants treated only a fraction of the city's total wastewater flow, but they did marginally improve the quality of the hugely popular beaches at Coney Island.

The overall situation was so dire, however, that the New York State Legislature established the New York Bay Pollution Commission in 1903 to assess the problem. In 1906, the newly formed New York Metropolitan Sewerage Commission began to report

A Wave of Humanity Flows through Ellis Island

Between 1892 and 1954, roughly 12 million immigrants entered the United States through Ellis Island, arriving on ships from around the globe. Though many of these newcomers continued on to points across the country, many settled here and the city's population grew from 1.5 million to 7.8 million between 1890 and 1960. Along with this massive influx came a need for infrastructure, including water and sewer mains, wastewater treatment plants and new sources of water supply.



The Statue of Liberty National Monument, a New York Harbor symbol of freedom, opportunity and friendship



City workers inspecting 12-foot Bowery Bay sewer



Sewer worker inside the New Street sewer; from Beaver to Wall Street, Manhattan (1928)



Wards Island Wastewater Treatment Plant on the East River

specifically on the sewage and garbage being discharged, and to recommend methods for addressing its impact on the harbor. Led with great commitment and conviction by Dr. George Soper, the MSC produced the first Harbor Water Survey in 1909. This initial survey attempted to define the scope of the harbor's degradation based on data gathered from twelve monitoring stations around Manhattan.

At a time when sophisticated water testing equipment and mathematical computer models were not available, and clear water quality standards had not yet been established, the MSC was challenged to develop a master plan to quantify, investigate and develop solutions to address pollution in the harbor. These solutions had to respond to current conditions and foresee the effects of the continued growth of the city and adjacent communities. Armed with analytical tools that were simple by today's standards, the MSC was able to determine harbor flow dynamics, the effects of harbor pollution, and the maximum amount of pollutants the harbor could absorb. The MSC had the vision to suggest a flexible plan that allowed for potential advances in water pollution control technology and anticipated pollutant load increases. It also chose sites for wastewater treatment facilities that would most benefit the public's health and general welfare.

To determine the harbor's water quality, five different parameters were tested during the early surveys: dissolved oxygen, bacterial count, turbidity, salinity and temperature. Of these five parameters, dissolved oxygen and bacterial count are the most important. Dissolved oxygen is needed by aquatic life to survive. When wastewater is discharged, microorganisms feed on the waste and consume oxygen, depleting dissolved levels. Oysters were one of the first types of aquatic life to disappear from the harbor, since they were not able to move to areas where the dissolved oxygen level was higher.

Bacteria measurement provides an indication of fecal matter contamination and the potential for human illnesses and disease. The MSC's efforts added substantially to the then fledgling field of sanitary engineering. Importantly, the MSC also established that harbor water quality testing is a critical element of a comprehensive, science-based approach to water quality. Many of the MSC's early findings and recommendations were eventually adopted, such as the need for a single governmental agency to plan, design, monitor and regulate wastewater discharges and conveyance systems, to regulate discharges to sewers through a uniform code, to convey sewage to waterbodies with the greatest assimilative capacity and, ultimately, to build treatment facilities.



Water Quality Snapshot #1

In the 1920s, as immigration peaked, the city's population soared. Only a few rudimentary wastewater treatment plants were in operation, and many areas of the harbor were dead zones with less than 1 mg/L of dissolved oxygen, a concentration below the current New York State standards for fish survival. Bacteria concentrations in the Upper Bay were too numerous to count.



Coney Island beach and swimmers (1922)



Local youth cooling off in New York Harbor



Health Department inspector with shellfish advisory

1909

Summer average dissolved oxygen



Summer geometric means of bacteria



The City's Sewers: An Evolving Network Underfoot

New York City's first sewer, a primitive open canal on Broad Street in lower Manhattan, was eventually buried by the English. The system has grown dramatically in the last two centuries along with the city and its population, connecting to ever more sophisticated wastewater treatment facilities as they have come on-line. Today, more than 7,400 miles of sewer mains – some measuring 17 feet wide – safely and invisibly convey storm and wastewater beneath the city's streets.



Sedgwick Avenue sewer construction (1939)

From Assessment to Action

In 1914, the New York Metropolitan Sewerage Commission produced the *Main Drainage and Sewage Disposal Works Proposed for New York City: Reports of Experts and Data Related to the Harbor*, an 800-page report, eight years in the making. It recommended that a special commission modeled on the Board of Water Supply, which was then involved in building the Catskill Aqueduct, supervise construction of the city's wastewater system. With the completion of this report, the MSC was disbanded, but

Dr. Soper continued to push for implementation of a plan to treat the wastewater that was being discharged into the harbor and surrounding waterbodies. By 1920, a plan for treating New York City's wastewater had been drawn up. In 1929, on the eve of the Great Depression, the City consolidated authority for executing the plan in the newly created Department of Sanitation. This new department was made responsible for removing solid waste, installing sewers, and building facilities to treat wastewater.



Main entrance to Bowery Bay Wastewater Treatment Plant



Water Quality Snapshot #2

By 1939, with the Wards Island, Tallman Island and Bowery Bay wastewater treatment plants in operation, harborwide dissolved oxygen levels rose to about 3 mg/L. Water quality in the East River showed signs of improvement due to the increase in dissolved oxygen.

Under the auspices of the Department of Sanitation, between 1937 and 1944, three new wastewater treatment plants were constructed — Wards Island in Manhattan, and Bowery Bay and Tallman Island in Queens. These facilities were designed to reduce pollutants in the Harlem River and in the East River, whose dark and murky waters had some of the lowest dissolved oxygen concentrations in the harbor. During the summer months, dissolved oxygen levels were often zero, which caused unpleasant odors. The city and its waterways benefited from an infusion of funds from the Works Progress Administration (WPA), an ambitious public works program that was part of President Franklin D. Roosevelt's New Deal. The Wards Island plant, located in the middle of the East River, was built to handle flows from the east side of Manhattan and the lower part of the Bronx. The plant came on-line in October 1937 and was the first to use the conventional activated sludge process, a great leap forward in wastewater treatment. A few years later, the activated sludge process was incorporated into the Bowery Bay (1939) and Tallman Island

(1939) plants. During this period, New York, New Jersey and Connecticut established the Interstate Sanitation Commission (ISC) to protect, regulate and set water quality standards for the entire harbor.

While proposals before the 1930s estimated that as many as 38 wastewater treatment plants would be required to serve the city, our nation's entry into World War II left little funding available to expand the system. Treatment efforts slowed considerably at this time, but as the population approached 7.5 million, the city did manage to upgrade the old Coney Island (1942), 26th Ward (1944), and Jamaica (1943) plants. These upgrades helped to protect bathing beaches and improve overall water quality in Jamaica Bay. Together, the new and upgraded plants brought the citywide treatment capacity to 497 million gallons per day (mgd). Throughout this time, the Harbor Survey Program continued and remained focused on measuring dissolved oxygen as the primary indicator of water quality.

1943: The Peak of the Harbor's Activity

New York Harbor was the busiest in the world in March 1943, during World War II, with 543 ships at anchor. At this time, 1100 warehouses with nearly 1.5 square miles of enclosed space served freighters with 575 tugboats. There were also 39 active shipyards, with a staggering inventory of heavy equipment. At this time, New York City was also a manufacturing hub, producing goods — clothing, chemicals, metal products, food and furniture among them — for the war effort and for civilian use around the country and the world.

The Harbor's Role in National Defense

New York Harbor, with its open vistas and strategic setting, has played an important role in national defense and military history. Overlooking the harbor in Brooklyn's Bay Ridge community, Fort Hamilton has served the U.S. military continuously since it opened in 1831 and was a major embarkation center for troops setting sail in World Wars I and II. Located just south of Manhattan, Governor's Island was a military installation for nearly 200 years. It was a critical supply base for army ground and air forces in both world wars. Today it offers New Yorkers a variety of recreational activities — and this year it will become the new home of Urban Assembly New York Harbor School, a public high school that instills stewardship by teaching about the city's waterways.



Verrazano-Narrows Bridge looking west from Ft. Hamilton in Brooklyn to Ft. Wadsworth on Staten Island

The Harbor's Geographic Scope

The harbor consists of nearly 600 miles of waterfront and about 240 miles of shipping channels, as well as anchorages and port facilities, centered on Upper New York Bay. The harbor's main entrance from the Atlantic Ocean lies to the southeast, between Rockaway Point and Sandy Hook; there is another entrance at the outlet of the East River to the northeast. The harbor also extends west to New Jersey, southwest to the mouth of the Raritan River, northwest to Port Newark and north to the George Washington Bridge.



Looking southwest across New York Harbor

The Post-war Era: Renewed Commitment and Growth

Following the Second World War, there was a renewed focus on needed infrastructure enhancements, especially for wastewater treatment. Around this time, the City's Department of Sanitation sought new methods for capturing all wastewater outflows and began to tackle the issue of industrial waste in the harbor. In 1950, the city approved a sewer-use charge, which sought to make wastewater treatment a self-financing enterprise.

By consolidating sewer catchment areas and constructing pumping stations, the city was able to reduce the need for wastewater treatment plants from 38 to 14. With new funding available, between 1945 and 1965, five new plants were built to meet the needs of the growing population of New York City, which was approaching eight million: Hunts Point in the Bronx (1952), Port Richmond (1953) and Oakwood Beach (1956) in Staten Island, Rockaway (1952) in Queens, and Owls Head (1952) in Brooklyn. During this period, the older Bowery Bay (1957), Coney Island (1964), and Tallman Island (1964) plants were also upgraded.

The new plant designs incorporated two types of activated sludge processes, step-feed and modified-aeration, both of which were pioneered in New York City. In the step-feed process, wastewater was added incrementally into aeration tanks to increase significantly the removals of suspended organic solids. While modified aeration achieved slightly less removals, it was less expensive to operate, and fit within a smaller footprint. This was especially important as open space in the city was rapidly dwindling.

The Harbor Survey Program continued to evolve throughout this period. The Survey now had 20 permanent stations (12 in Jamaica Bay and eight in the East River), and several other sites that were monitored periodically. In 1959, the Department of Public Works consolidated the ten separate laboratories that were then responsible for the Harbor Survey into five state-of-the-art labs located in the Jamaica, Bowery Bay, Wards Island, Oakwood Beach and 26th Ward wastewater treatment plants.



Water Quality Snapshot #3

Eleven wastewater treatment plants were in operation by 1952, and harborwide average levels of dissolved oxygen neared 4 mg/L, sufficient for fish propagation. However, with 400 million gallons of raw sewage still being discharged each day, bacteria concentrations remained too numerous to count in many areas of the harbor, including the Hudson River as far north as the Bronx county line.



Final settling tanks at Bowery Bay Wastewater Treatment Plant



Aeration and sludge tanks at Rockaway Wastewater Treatment Plant



Owls Head Wastewater Treatment Plant

1968

Summer average dissolved oxygen



Summer geometric means of bacteria



DEP: A New City Agency Focused on Water Quality

Following in the footsteps of the New York Metropolitan Sewerage Commission and the Department of Sanitation, and consolidating the Bureau of Air Resources and the Department of Water, Gas and Electricity, the New York City Department of Environmental Protection was formed in 1977. In addition to managing the city's wastewater treatment system, today, DEP is responsible for the city's water supply, providing approximately one billion gallons of water each day to more than nine million New York State residents.



Pepacton Reservoir in Delaware County, New York

Growing Environmental Awareness Takes Hold

Throughout the 1960s, as the effects of pollution became increasingly apparent, concern for the environment was on the rise around the nation. In New York City, pollution control efforts were reflected in continued investment in improvements to wastewater treatment. The city began construction of the Newtown Creek Wastewater Treatment Plant in Brooklyn in 1965. This new plant would become the largest in New York City; today it has a treatment capacity of 310 mgd and can handle a maximum flow of 620 mgd. By 1968, 12 wastewater treatment plants were operating in New York City and were capable of treating 1.4 billion gallons of wastewater each day. They removed an average of 65 percent of pollutants from the daily flow, up from between 30 and 50 percent, as measured by the concentration of Suspended Solids and Biochemical Oxygen Demand.

In an effort to capture and treat more sanitary sewage flow during storms, and to prevent combined sewer overflows (CSOs), in 1972 the city began to operate the Spring Creek combined sewer overflow facility, which connected to the 26th Ward Wastewater

Treatment Plant. During this period, the city began to address CSOs, a legacy of older cities like New York with sewers that accept both sanitary and stormwater flows. In dry weather, virtually all of New York City's sewage is treated. During rainfall, however, the added volume of stormwater can exceed the capacity of the combined sewer infrastructure. This can result in untreated discharges from relief structures that are designed to protect the biological treatment process in treatment plants and to prevent sewage backups and flooding. Infrastructure upgrades have enabled the city to increase stormwater capture rates from 18 percent in 1987 to 73 percent today. And New York City is investing heavily to capture billions of gallons of additional CSOs every year.

Water quality standards for the country were about to become significantly more rigorous. Riding a wave of environmental awareness, in 1970 the federal government consolidated in the newly formed U.S. Environmental Protection Agency (E.P.A.) a variety of federal research, monitoring, standard setting and enforcement activities. The country celebrated its first Earth Day in April of the same year.



Water Quality Snapshot #4

In 1970, with the Newtown Creek Wastewater Treatment Plant treating more than 200 mgd, dissolved oxygen levels approached 5 mg/L throughout the harbor. Despite this improvement, more help was needed. More than 170 million gallons per day of untreated sewage were still being discharged into the Hudson River and fecal coliform bacteria averaged more than 2,000 colonies per 100 milliliter samples harborwide.

In 1972, Congress passed the Clean Water Act (CWA). This monumental law established ambitious goals for reducing water pollution and enabling safe recreational use of navigable waterways. The CWA included a major federal public works financing program to help municipalities comply with new wastewater treatment standards and delegated much of the responsibility for setting water quality standards and permit limits to the states, making the New York State Department of Environmental Conservation a critical partner in the City's wastewater treatment program.

Passage of the CWA meant that New York had to upgrade its wastewater treatment plants to achieve secondary treatment standards, which require removal of at least 85 percent of suspended solids and Biochemical Oxygen

Demand and a concentration of less than 30 parts per million in the plant effluent discharge. By 1979, nine of the city's wastewater plants had been upgraded to secondary treatment using the step-feed aeration process. Since enactment of the Clean Water Act, overall investments to improve the quality of New York City's waterways have exceeded \$35 billion.

During this time period, the Harbor Survey Program was expanded dramatically to include a total of 53 monitoring stations. Responding to the CWA's requirements for more comprehensive testing, the Survey's parameters were increased to include measurement of chlorophyll "a" (a plant pigment), silica and nutrients such as nitrogen and phosphorus.



Marine Sciences crew monitors water quality aboard harbor survey research vessel Osprey

1985

Summer average dissolved oxygen



Summer geometric means of bacteria



Restoring the Harbor to Health



Red Hook sludge vessel entering New York Harbor



Red Hook Wastewater Treatment Plant chlorine contact tanks and the East River

From the late 1970s on, spurred by passage of the CWA and federal funding and supported by the growing environmental movement, New York City continued to upgrade and expand its wastewater treatment system. Between 1979 and 1995, the Coney Island and Owls Head wastewater treatment plants were upgraded to full secondary treatment. During this time, the City completed construction of two new treatment plants, the North River plant on the Hudson River in Manhattan (1986) and the Red Hook plant in Brooklyn (1987). With a total of 14 wastewater treatment plants, essentially all of the city's dry-weather wastewater flows were captured and treated for the first time.

The completion of the North River and Red Hook wastewater treatment plants capped years of steady, committed work to clean up New York Harbor and surrounding waterbodies. By 1987, with the end of most raw sewage discharges, bacteria levels dropped in many areas of the harbor by 99 percent, and most open waters in the harbor achieved a level of quality making recreational activities like boating possible.

With waterbodies around the city relatively clean, new water quality challenges came to the fore. For example, it became possible to track down illegal connections to the sewer system that had been obscured by generally poor harbor water quality.

In response to the federal Ocean Dumping Act of 1988, which banned ocean disposal of sludge, New York City had to find alternatives to its previous practices. In addition to a new round of wastewater treatment plant upgrades, facilities were constructed to dewater sludge into a cake-like substance. This substance is taken to a landfill or turned into compost and other soil additives that help retain water and nutrients. Over the long-term, 100 percent beneficial re-use of sludge is the sustainable way to handle this by-product of the 1.3 billion gallons of wastewater that New Yorkers generate every day, and DEP is committed to achieving that goal.

The Harbor Survey Program has also modernized its equipment and methods since the 1980s. Its first dedicated vessel, the Osprey, was commissioned in 1991 to



Water Quality Snapshot #5

By 1987, as both the North River and Red Hook wastewater treatment plants came online, virtually all sewage produced in the city during dry weather was captured and treated.

Dissolved oxygen averaged nearly 6 mg/L and fecal bacteria dropped by 90 percent, marking a significant turning point in harbor water quality. In addition, year-round disinfection with chlorine was now being done at all 14 treatment plants.

handle onboard processing of water samples, making collection much more efficient. During this period, computers came widely into use, enabling the Harbor Survey to analyze and report harbor quality data more efficiently.

In 1909, the Harbor Survey collected data on five parameters at 12 sampling stations. Today, more than 20 parameters, including physical and biological data on the water, current weather and an evaluation of floatables, are collected at 85 stations harborwide. Each year, the Survey reports on dissolved oxygen, bacterial counts and chlorophyll “a” as water quality indicators in an annual report that synthesizes the data collected from approximately eight thousand individual water samples that DEP scientists analyze in two laboratories.



DEP Marine Sciences staff performing field water quality analysis

Nitrogen: New Approaches to a Naturally-occurring Problem

A naturally-occurring component of human wastewater is nitrogen. Although it is not a pathogen and poses no risk to people, high levels of nitrogen can degrade a waterway’s overall ecology by promoting excessive algae growth and reducing dissolved oxygen, especially in warm-weather months. As a result, E.P.A. determined that many municipalities needed to upgrade their wastewater treatment plants to reduce nitrogen discharges.

Most of the treatment plants around the country, including New York City’s, were not originally designed to remove nitrogen compounds. Adding denitrification to the wastewater treatment process presented a particular challenge to DEP. Unlike other municipalities that had ample space to build new batteries of treatment tanks, nearly all of the city’s treatment plants are confined to long-established footprints. Indeed, many plants that were once at the outskirts of the communities they serve now have close residential neighbors. DEP engineers in the 1990s developed the Step-feed Biological Nitrogen Removal (SFBNR) process that uses existing tanks to cut nitrogen. Basic components of this process were installed at five DEP plants, and it proved successful and reliable. SFBNR has become the foundation of the nitrogen upgrades that

are now underway at six DEP plants (Hunts Point, Bowery Bay, Tallman Island, Jamaica, 26th Ward, and Wards Island) and planned for two more (Coney Island and Rockaway).

Recently, DEP began installing additional systems to remove nitrogen from centrate at several treatment plants. Centrate is a nitrogen-rich liquid that is removed from sludge during the dewatering process. Technology developed in the Netherlands that quickly breaks down ammonia nitrogen in a sustainable way, called SHARON, was installed at Wards Island in 2009. In 2010, DEP announced an agreement to improve overall water quality and mitigate marshland loss in Jamaica Bay through a total of \$115 million in investments, including the dedication of \$100 million to install nitrogen control technologies at the 26th Ward and Coney Island wastewater treatment plants in Brooklyn and at the Jamaica and Rockaway wastewater treatment plants in Queens. These investments are in addition to the \$95 million that DEP is already investing to implement nitrogen removal technology at the 26th Ward and Jamaica wastewater treatment plants. In total, DEP will spend more than \$1 billion by 2016 to reduce nitrogen discharges to the harbor by more than 60,000 pounds per day.

Great Developments at Newtown Creek

The Newtown Creek Wastewater Treatment Plant, the largest of the city's 14 plants, is undergoing a dramatic upgrade, part of one of the nation's largest capital improvement projects. The upgrade has included installation of eight 14-story-high, stainless-steel-clad "digester eggs," tanks used for the anaerobic (oxygen-free) decomposition of the solids removed from wastewater. Through this process, bacteria digest organic matter in the sludge and convert it to water, carbon dioxide and methane gas. This plant can treat up to 310 million gallons of wastewater on a dry-weather day, about 18 percent of the city's total, coming from parts of Manhattan, Brooklyn and Queens.

Early in 2010, DEP opened a new microbiology laboratory at the plant which consolidated bacteriological analyses for all of the city's wastewater treatment plants, increased DEP's ability to

compare test results across its facilities and will help the city to achieve the highest levels of pollutant removal and disinfection. It will substantially increase DEP's monitoring and testing capacity to ensure that wastewater is effectively treated and that it has as little adverse impact on our receiving waterways as possible.

Working in collaboration with the surrounding community, DEP oversaw the design and incorporation of the unique Newtown Creek Nature Walk into the plant upgrade, which restores aspects of this industrial area's natural environment, points to its rich history and offers the first public access to Newtown Creek in decades. In 2010, the Visitor Center at Newtown Creek also opened to welcome and educate New Yorkers about the New York City water and wastewater system.



Newly upgraded Newtown Creek Wastewater Treatment Plant



Scenes from Newtown Creek Wastewater Treatment Plant, Visitor Center and Nature Walk

Call of the Wild

As the harbor has come back to health, New Yorkers are returning, too, for recreational activities like boating, hiking, bird-watching and biking. In addition to waterways cleaner than they have been in a century, Gateway National Recreation Area encompasses the Jamaica Bay Wildlife Refuge, a true natural treasure that is home to 300 species of birds, 100 species of fish and hundreds of species of plants — all within city limits.

As late as the 1800s, Jamaica Bay was primarily a wilderness area with 16,000 acres of wetlands. The upland watershed was a mosaic of indigenous woodlands, shrublands, grasslands and freshwater wetland systems that reduced upland runoff and provided an uninterrupted supply of important marsh building sediments. The bay itself was a shallow estuary between three and 20 feet deep that contained extensive and largely contiguous salt marsh systems, oyster reefs and eel grass beds. An array of small tributaries and inlets gently washed over these marsh islands, depositing essential nutrients and fresh sediment supplies. This system was shaped by thousands of years of dynamic natural processes.

Over the last 200 years, however, these natural processes have been disrupted

by significant, human-made alterations that have had profound impacts on the bay's ecological health. These include changes in the depths of ocean and surrounding waterbodies; the removal of natural, freshwater flows; the dredging of Grassy Bay to build John F. Kennedy International Airport and other dredge work; the introduction of wastewater treatment plant and CSO discharges; and hardened shorelines and sea level rise. The extension of the Rockaway peninsula has also played a role in influencing changes in tidal exchange, tidal range and sediment transport. The impacts have resulted in increased nutrient loading and altered tidal flushing patterns that would otherwise help cleanse the bay. While our knowledge about the particular mechanisms that affect the bay's ecology is incomplete, we do know that the most critical and pressing problem at this time is the recent and ongoing disappearance of its once abundant wetlands.

In addition to substantial wastewater treatment plant upgrades, DEP and partners including the City's Parks Department, the Army Corps of Engineers and the State Department of Environmental Conservation have been implementing a number of Jamaica Bay restoration projects to more directly reverse ecological degradation.

These include the remediation and ecological restoration of two inactive hazardous waste landfills (which will restore nearly 400 acres of sensitive lands adjacent to Jamaica Bay), the restoration of tributary basins such as Paerdegat Basin with tidal wetland fringes, coastal grassland and a six-acre Ecology Park that will highlight many of the city's ecological plant communities and the restoration of the Salt Marsh Islands. DEP has already contributed nearly \$6 million to fund salt marsh island restoration work, and has committed an additional \$15 million over the next 10 years.

DEP is also developing a number of aquatic pilot projects soon to be implemented in Jamaica Bay. These include oyster reef, ribbed mussel and eelgrass habitat restoration pilot studies, and the use of unconventional technologies such as Algal Turf Scrubber®, a patented technology that polishes wastewater flows and potentially produces the raw materials for biofuels. Each of these restoration and pilot projects focuses on improving the ecology of Jamaica Bay by restoring degraded lands to productive wildlife habitats, increasing plant biodiversity and providing natural reduction of stormwater through nutrient uptake.



Scenes of Jamaica Bay restoration projects



Curbside plantings beautify the neighborhood and reduce flooding



Green roof and blue roof at PS 118, Queens



Staten Island Bluebelt wetlands

PlaNYC Looks Ahead

Ensuring that New York Harbor remains a vital natural resource for all New Yorkers will require continued investment in our water network infrastructure, ongoing upgrades to our wastewater treatment facilities and finding more natural solutions to cleanse and filter our waterways. DEP has traditionally solved the city’s need for wastewater services with the construction of sewer and treatment plant infrastructure on a large scale, which has led to major improvements in the quality of the city’s waterbodies. Today, however, we have limited space or funds for additional infrastructure.

Mayor Bloomberg’s sustainability blueprint, PlaNYC, provides a framework for holistic, interdependent solutions to make the city a more sustainable and attractive place to live. PlaNYC established a water quality goal to open 90 percent of the city’s waterways to recreation and committed the city to evaluate innovative stormwater management strategies through an interagency Best Management Practices Task Force. The Sustainable Stormwater Management Plan released by that Task Force concluded that green infrastructure was feasible in many areas of the city and could be more cost-effective than certain large

infrastructure projects such as CSO storage tunnels. Consistent with that approach, and expanding on earlier efforts to build ecological systems in the Staten Island Bluebelt, in the upstate drinking water supply watershed and in Jamaica Bay, DEP recently released the NYC Green Infrastructure Plan: A Sustainable Strategy for Clean Waterways. The new plan will utilize green infrastructure to improve the quality of waterways around New York City by capturing and retaining stormwater to reduce sewer overflows.

Green infrastructure uses plants, permeable areas, and other source controls, in a decentralized and integrated network to mimic the pre-development water cycle and to reduce stormwater runoff. DEP has many pilot projects underway, including planting native trees with improved pit design, creating vegetated ditches (swales) along streets and highways and developing and implementing green parking lots that include trees and other plantings to curb runoff. Even better, these green infrastructure techniques can provide other benefits that will make our city more sustainable by making more efficient use of our natural resources and reducing energy costs in the process.



Water Quality Snapshot #6

Today, due to increased capture of CSOs, improvements in wastewater treatment and the elimination of illegal sanitary hookups, fecal bacteria levels are 99 percent below 1970s levels and dissolved oxygen averages more than 6 mg/L harborwide. The majority of the harbor is now safe for boating and similar recreational activities.

DEP is working with the New York State Department of Environmental Conservation, the U.S. Environmental Protection Agency, and the public to implement these techniques for controlling combined sewer overflows. At the same time, DEP is seeking a public consensus about how best to meet the public's need for access to appropriate areas for boating, swimming and fishing in our waterways.

Achieving our goals will require a balance between infrastructure solutions and natural strategies. In all cases, it will involve continuing to build awareness about the challenges New York City faces and how New Yorkers, together, can meet them for future generations.



High school and elementary school students work together to test water quality in the East River



High school interns help to remove trash from the shoreline



2009

Summer average dissolved oxygen



Summer geometric means of bacteria



Glossary of Wastewater Treatment Terminology

Activated Sludge: An accumulation of solid particles produced by the growth of microorganisms in aeration tanks.

Activated Sludge Process: A secondary wastewater treatment process using compressed air and bacteria to speed up the decomposition of wastes.

Advanced Treatment: Any additional treatment done to wastewater beyond secondary treatment.

Aeration: The process of adding air. In wastewater treatment, air is needed to provide oxygen to microorganisms and to keep solids in suspension.

Aeration Tank: The tank where settled wastewater is mixed with return activated sludge and aerated.

Aerobic: Life or natural processes that require the presence of oxygen.

Anaerobic: Life processes that require an environment without oxygen.

Bacteria: Single-celled microscopic organisms.

Bathymetric: The measurement of the depth of bodies of water.

Biochemical Oxygen Demand (BOD):

A measure of the amount of oxygen required by microorganisms to break down organic matter in water.

Biofuels: Fuels produced from renewable organic material such as algae.

Catchment: The area drained by a river or other body of water.

Centrate: The water removed from digested sludge during the dewatering process.

Combined Sewer: A sewer designed to carry both sanitary wastewater and stormwater runoff to wastewater treatment plants.

Combined Sewer Overflow (CSO): Excess amounts of wastewater and stormwater that flow directly into waterways through permitted relief structures in the collection system. CSOs generally occur during heavy rain or snowmelt.

Decomposition: The biological breakdown of organic wastes.

Denitrification: The biochemical process of converting nitrates into nitrogen by bacteria in the absence of dissolved oxygen in water or wastewater.

Dewater: To remove or separate a portion of the water present in sludge. Dewatering reduces sludge volume making it easier to handle and store.

Digestion: The biological decomposition of organic matter in sludge by anaerobic or aerobic microorganisms. This process is performed in a digestion tank.

Disinfection: The final process in wastewater treatment designed to kill the majority of remaining microorganisms in wastewater, including pathogenic (disease-causing) bacteria.

Dissolved Oxygen: The amount of molecular oxygen dissolved in water.

Effluent: Partially or completely treated wastewater flowing out of a wastewater treatment process or treatment plant.

Floatables: Trash that stays on the surface of a body of water or suspended near the surface.

Grit: The heavy inorganic material present in wastewater, such as sand, gravel and cinders.

Influent: Wastewater flowing into a basin, treatment process or treatment plant.

Methane: A major constituent of natural gas that can be used as a fuel. It is primarily produced within the anaerobic digestion process.

mg/L: Milligrams per liter; a measure of concentration of a dissolved substance. A concentration of one mg/L means that one milligram of a substance is dissolved in each liter of water.

Microorganisms: Microscopic animals and plants of simple cell structure that feed on the wastes in wastewater.

Nutrients: Substances, such as carbon, hydrogen, oxygen, nitrogen, phosphorus and sulfur, which are required to support living things.

Nutrient Loading: Quantity of nutrients entering an ecosystem in a given period of time.

Nutrient Uptake: The absorption by a tissue of a nutrient, and its permanent or temporary use.

Parameters: The substance that is the subject of a chemical analysis.

Preliminary Treatment: The removal of rocks, rags, sticks and similar materials which may hinder the operation of a treatment plant. Preliminary treatment is accomplished by using equipment such as bar screens and grit removal systems.

Primary Treatment: A wastewater treatment process using physical methods, such as screening and settling, to remove most of the organics and inorganic solids in wastewater that settle or float.

Pumping Stations: Facilities that contain equipment for pumping fluids from one place to another.

Receiving Water: A stream, river, lake or ocean into which treated or untreated wastewater is discharged.

Sanitary Sewer: A sewer intended to carry domestic wastewater from homes, businesses, schools and other facilities.

Secondary Treatment: A wastewater treatment process using enhanced, natural biological methods to convert dissolved or suspended materials into a form more readily separated from the water being treated.

Sewage: The used water and solids from a community that flow to a treatment plant. The preferred term is “wastewater” since the flow to treatment plants often includes industrial wastewater.

Sludge: Accumulated, settled organic solids which must be separated from the liquid portion of wastewater during the treatment process.

Sodium Hypochlorite: A solution used for disinfection similar in composition to, but stronger than, household bleach.

Storm Sewer: A separate sewer that carries runoff from storms and surface drainage.

Suspended Solids: Solids that either float on the surface or are suspended in liquids such as water or wastewater. These solids are normally measured by filtering in laboratories.

Telemetry: The science and technology of the automatic measurement and transmission of data by wire, radio or other means from remote sources to receiving stations for recording and analysis.

Turbidity: The amount of cloudiness of a normally clear liquid due to the suspension of solid particles.

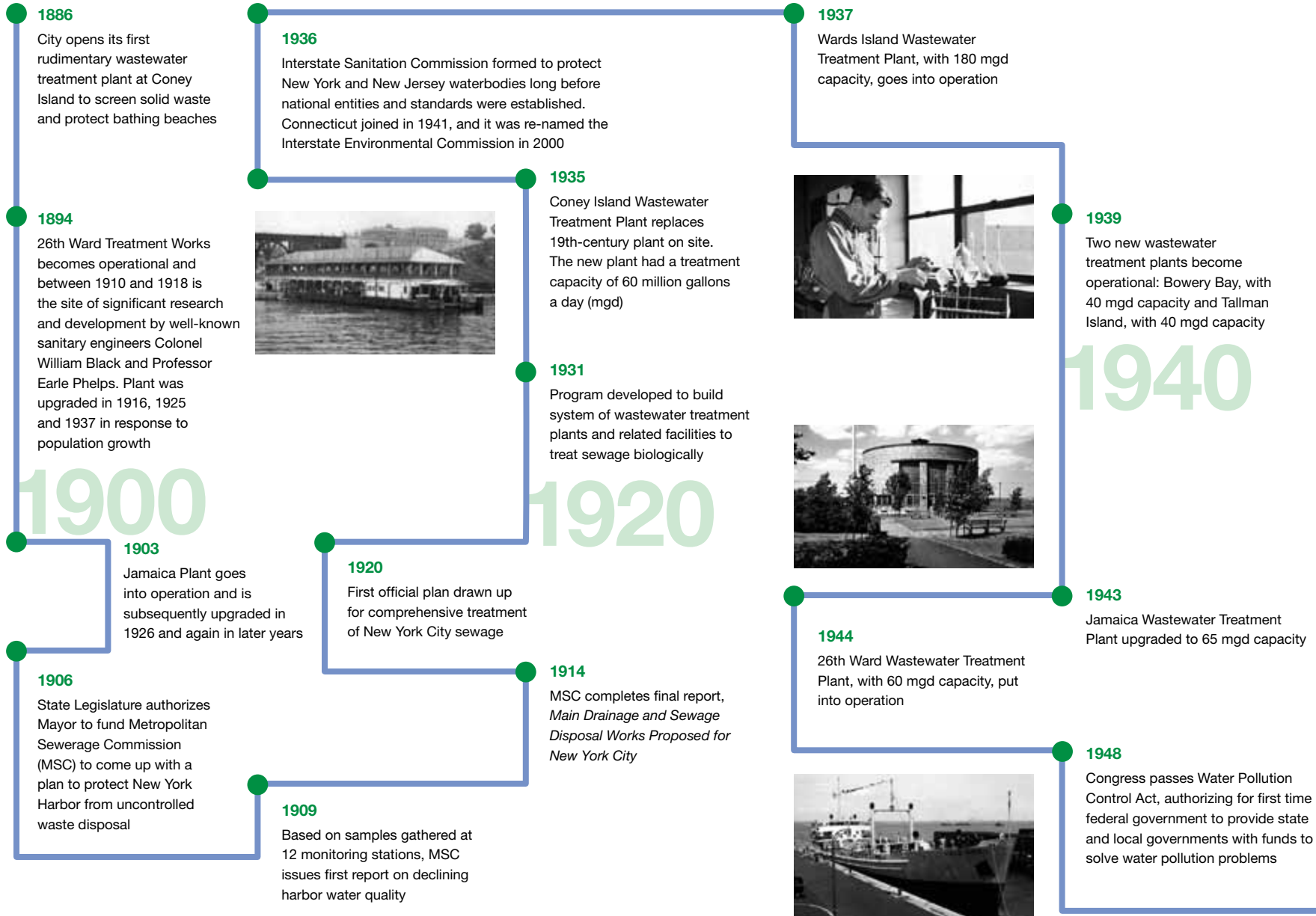
Wastewater: Used water from households and industries and, in combined sewer systems, stormwater that flow to a treatment plant.

Water Quality Indicators: The measurements that are used to determine if water quality is in good condition or not.

Watershed: Land area that drains water to a particular stream, river, lake, bay or reservoir.

Wetlands: Land area predominantly saturated with water, where specific plant and animal communities live; coastal areas that help absorb the forces of flood and tidal erosion to prevent the loss of upland soil.

New York City Harbor Survey Program: Celebrating 100 Years



1980

1972

Federal Clean Water Act enacted by Congress to restore and maintain nation's water and waterbodies. In response, city required to upgrade all 14 wastewater treatment plants to secondary treatment level



1977

NYC Department of Environmental Protection replaces NYC Environmental Protection Administration created in 1968

1986

Citywide Water Conservation program introduced, focusing on household metering, plumbing retrofits, leak detection and raising public awareness through educational initiatives. North River Wastewater Treatment Plant becomes operational with capacity of 170 mgd

2009

DEP Harbor Survey Program turns 100. The Survey has grown from 12 monitoring stations in early 20th-century to 85 at present, and measures more than 20 parameters throughout New York Harbor



1967

Newtown Creek, New York City's largest wastewater treatment plant, goes into service

1960

1956

Oakwood Beach Wastewater Treatment Plant, treating 15 mgd, goes into operation

1953

Port Richmond Wastewater Treatment Plant opens on Staten Island, treating 10 mgd

1987

Red Hook Wastewater Treatment Plant goes into operation with 60 mgd capacity; City rolls out Industrial Pretreatment Program

1988

Federal Ocean Dumping Ban Act becomes law, prohibiting all ocean dumping of sludge by mid-year 1992

1993

DEP introduces Boom and Skim Program to capture floatables in canals and creeks; and Shoreline Survey Sentinel Monitoring Program to identify illegal connections to sewer system and abate dry weather discharges

2007

PlaNYC, created by Mayor Michael Bloomberg, announced on Earth Day, April 22

2004

DEP develops comprehensive Long-Term Control Plans to address combined sewer overflows and its impact on harbor water quality

2000

1952

Three new wastewater treatment plants go into operation at Hunts Point, Owls Head and Rockaway, handling total capacity of 295 mgd



1997

DEP starts annual Enhanced Beach Protection Program to increase levels of surveillance and improve preventive maintenance procedures for critical pumping stations



1998

Telemetry installed at 91 city pumping stations to improve monitoring and communications between these facilities and DEP operators

DEP Commissioners

1977

Robert A. Low

1978 — 1981

Francis X. McArdle

1982 — 1986

Joseph T. McGough

1986 — 1989

Harvey W. Schultz

1990 — 1994

Albert F. Appleton

1994 — 1996

Marilyn Gelber

1996 — 2002

Joel A. Miele

2002 — 2005

Christopher O. Ward

2005 — 2008

Emily Lloyd

2008 — 2010

Steven W. Lawitts*

2010 –

Caswell F. Holloway

* Acting Commissioner



Acknowledgments

Thanks to the efforts of generations of dedicated City employees New York Harbor is cleaner today than it has been in 100 years. There are too many people to cite by name, but we express gratitude to the city agencies past and present — from the New York Metropolitan Sewerage Commission, to the Department of Sanitation to the Department of Public Works and now, through the work of the New York City Department of Environmental Protection. Their monitoring of the city's harbor water quality and the planning, construction and operation of its state-of-the-art wastewater treatment plants and sewer network have steadily raised the standard for harbor water quality in New York City and serve as a model around the globe. We are also indebted to Mayor Michael Bloomberg's visionary PlaNYC, which will guide the city for the future.



NYC DEP

H.S.V. OSPREY

DEP



New York City Department of Environmental Protection
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Non-Emergency Help Call 311