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Technical Communication

Combined Sewer Overflow Abatement: The East River Project

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Abstract. The methodology used by New York City to abate pollution from Combined Sewer Overflows in the receiving harbor waters is presented in a case study for the East River facility planning. The approach integrates water quality studies, facility planning, environmental assessment and public participation. The project suggests construction of three underground storage tanks. Results from the recent water quality survey are summarized and discussed.

Key words: CSOs, East River, urban pollution abatement.

1. Introduction

New York City (NYC) is located within a major estuary, the New York/New Jersey Harbor Estuary, which includes the waters of the New York Harbor and the tidal rivers and streams which flow into the estuary. The East River is a vital waterway of New York City situated east of the Manhattan Island between Manhattan, Bronx, and Queens. It is linked to the Long Island Sound to the east and flows into the Hudson–Raritan Estuary to the south (Figure 1). Written records from the times of explorers Verrazano in 1524 and Hudson in 1609 describe a pristine environment in the estuary. Since the first settlement on Manhattan Island in 1624 the river water quality gradually degraded due to population growth and industrial development. The first sewer in Manhattan was built in 1696 and by the early twentieth century the construction of sewers and treatment facilities was intensified. Systematic river water quality monitoring can be traced back to 1906. These early quantitative measurements of dissolved oxygen (DO), bacteria and nutrients document a steady decline in water quality through the 1920s and 1930s (Parker and O'Reilly, 1991). The growing environmental concerns resulted in upgrades of the wastewater treatment facilities in the early 1970s, construction of new treatment plants in the 1980s, and improved sewerage system operations in the 1990s. In addition many

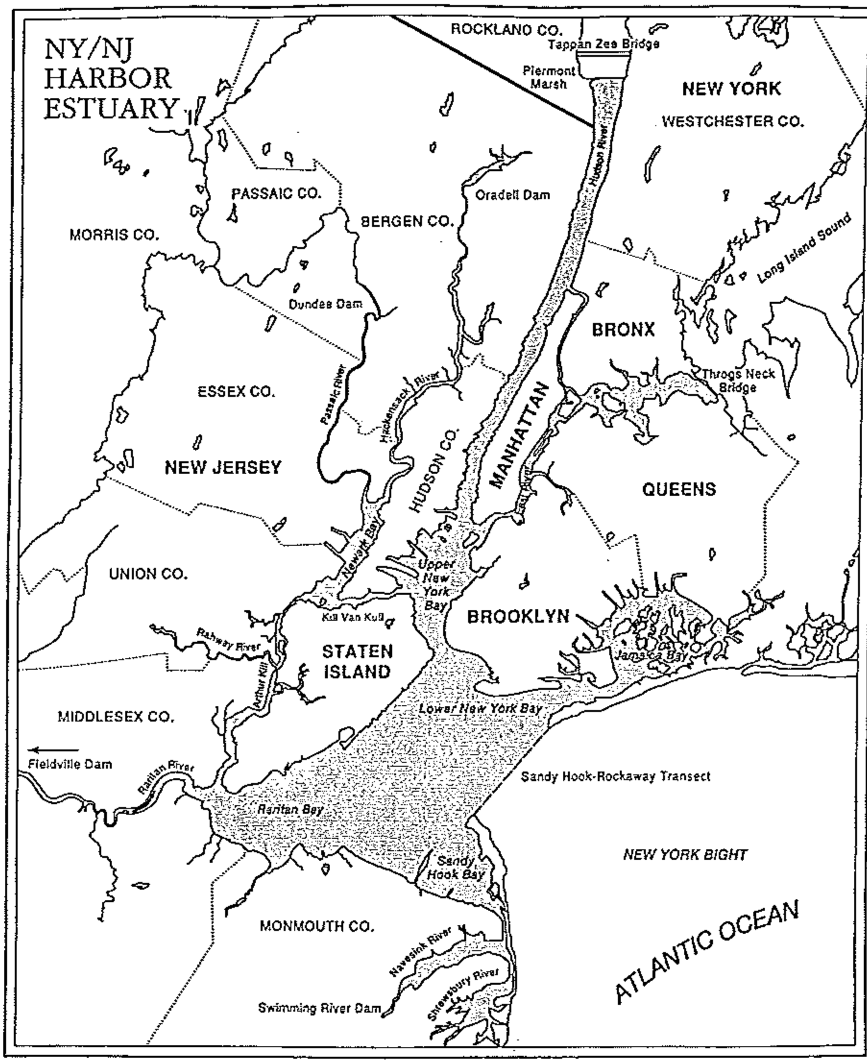


Figure 1. The New York/New Jersey Harbor Estuary.

water quality studies were conducted in the past twenty years by academic and governmental institutions.

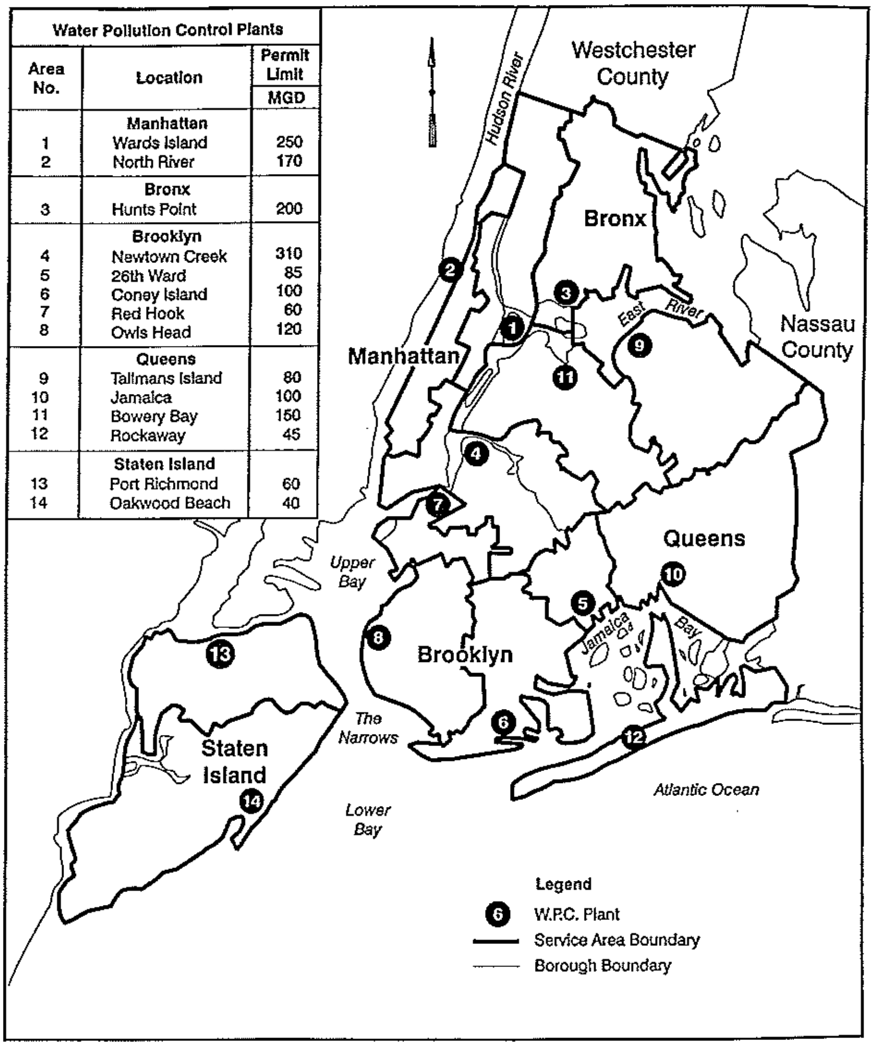
About 80% of New York City's sewers are combined, carrying both stormwater and raw sewage to water pollution control plants (WPCP) for treatment. During and shortly after rainfall events, the flows from these sewers can exceed the capacity of a treatment plant, causing the combined sewers to overflow and discharge untreated combined sewage into local water bodies. The city has long recognized that Combined Sewer Overflows (CSO) affect the water quality of New York Harbor, particularly at tributary bays and inlets. The New York City Department of Environmental Protection (DEP) is conducting a city-wide program to address the problem of CSOs discharging into the tributaries and open waters around New York City. The program is designed to meet the mandate of the Federal Clean Water Act and to comply with New York State Department of Environmental Conservation (DEC) standards for attaining fishable, swimmable waters.

Waste loadings of conventional contaminants in the East River are derived almost exclusively from water pollution control plants and numerous CSO outfalls. Approximately one billion gallons (3.8 billion liters) per day of effluents are discharged directly from WPCPs into the East River (Farrow *et al.*, 1986). It is estimated that municipal and industrial wastewater discharges into the East River amount for substantial fractions of the total conventional pollutant loads within the entire Hudson–Raritan estuary (34% of total nitrogen, 30% of total phosphorus, and slightly smaller fractions of other pollutants) (Mueller *et al.*, 1982).

The Federal Clean Water Act of 1972 legislated specific standards for treatment plants and required 85% removal of conventional pollutants for all plant discharges. As a result NYC had to rebuild or upgrade twelve existing treatment plants, in addition to constructing two new plants (Figure 2). In the 1970's NYC addressed the CSO problem by conducting an area-wide water quality study under Section 208 of the Water Pollution Control Act. This study included water quality computer modeling based on actual monitoring of CSO and its impacts. In 1985 New York State under its State Pollutant Discharge Elimination System (SPDES) required that the City undertake a city-wide CSO abatement program. The objective of this second phase of the CSO program, for which 1.5 billion dollars has been committed by the City, is to develop detailed facility planning for all four area-wide water bodies (East River, Jamaica Bay, Inner Harbor, and Outer Harbor) and construct facilities (Figure 3). The specific objective of the East River Combined Sewer Overflow facility planning project, which began in April 1988, is to improve the water quality of the East River and its tributaries. The paper presents the suggestions of the facility plan that has been developed for this area as well as the water quality studies conducted to support the planning efforts.

2. Project Area

The receiving waters under study are the East River and its tributaries (bays and inlets): the Harlem River, Bowery Bay, Little Neck Bay, Alley Creek, Eastchester Bay, Hutchinson River and Creek, Westchester Creek, Pugsley's Creek, and the Bronx River. The land side study area includes the combined sewers from the drainage areas of four DEP water pollution control plants: Wards Island (Manhattan and Bronx), Hunts Point (Bronx), Bowery Bay (Queens), and Tallman Island (Queens). The drainage areas encompass all of the Bronx, the northern part of Queens, and the northeastern part of Manhattan. They include 27 Community Board districts: Bronx Community Boards 1 to 12; Manhattan Community Boards 8 to 12; and Queens Community Boards 1 to 9 and 11.



Area No.	Location	Permit Limit MGD
	Manhattan	
1	Wards Island	250
2	North River	170
	Bronx	
3	Hunts Point	200
	Brooklyn	
4	Newtown Creek	310
5	26th Ward	85
6	Coney Island	100
7	Red Hook	60
8	Owls Head	120
	Queens	
9	Tallmans Island	80
10	Jamaica	100
11	Bowery Bay	150
12	Rockaway	45
	Staten Island	
13	Port Richmond	60
14	Oakwood Beach	40

Figure 2. The New York City Water Pollution Control Plants.

The hydrodynamics and pollutant transport mechanisms in the East River are quite complex. Jay and Bowman (1975) estimated that the long-term average, net volume flow at a cross section located at Throgs Neck was about 340 cubic meters per second towards New York Harbor. However, short-term estimates of this flowrate showed large variations, ranging from –324% toward Long Island Sound to +182% toward the Harbor compared to the long-term average. They concluded that the net estuarine and dispersive transport in the Upper East River were directed toward the Sound. More recent studies support this statement and conclude that the East River is actually a tidal strait subject to a wide range of physical forcing and variability.

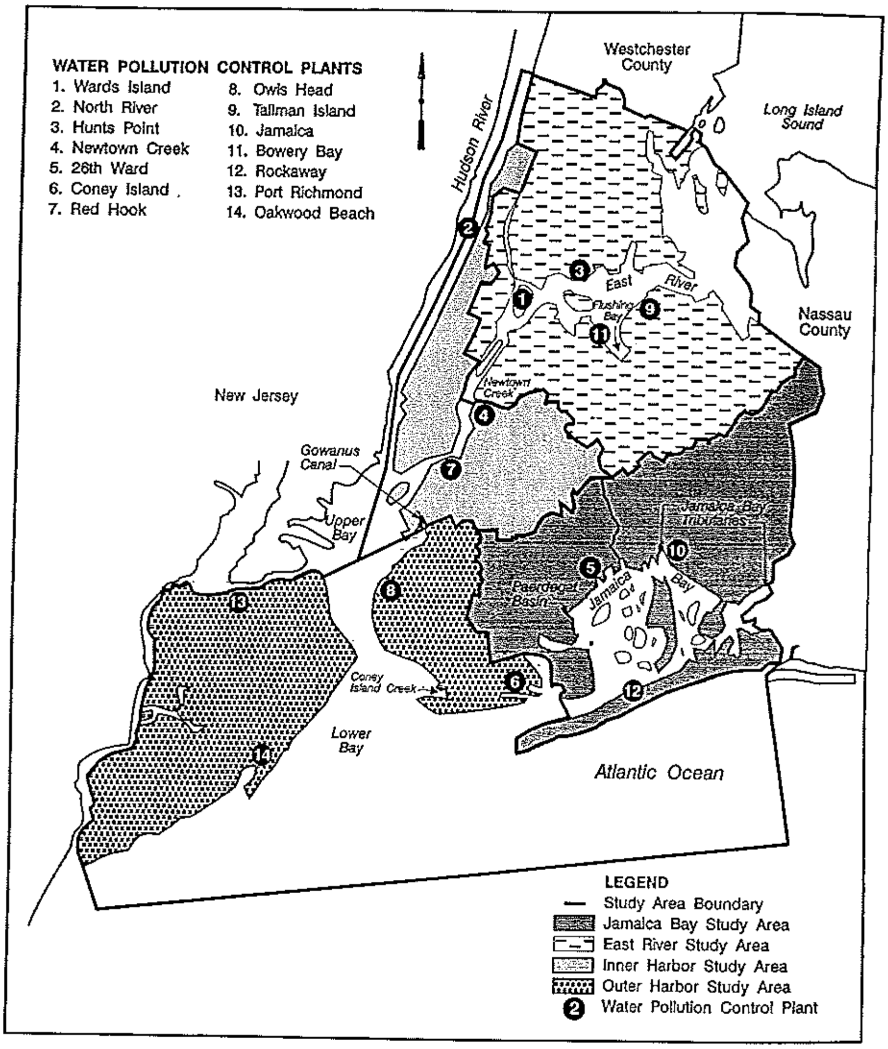


Figure 3. Combined Sewer Overflow Study Area Locations.

The East River study includes four major elements of equal importance:

- water quality study,
- facilities planning,
- environmental assessment, and
- public participation.

A summary of the principal project tasks is provided below.

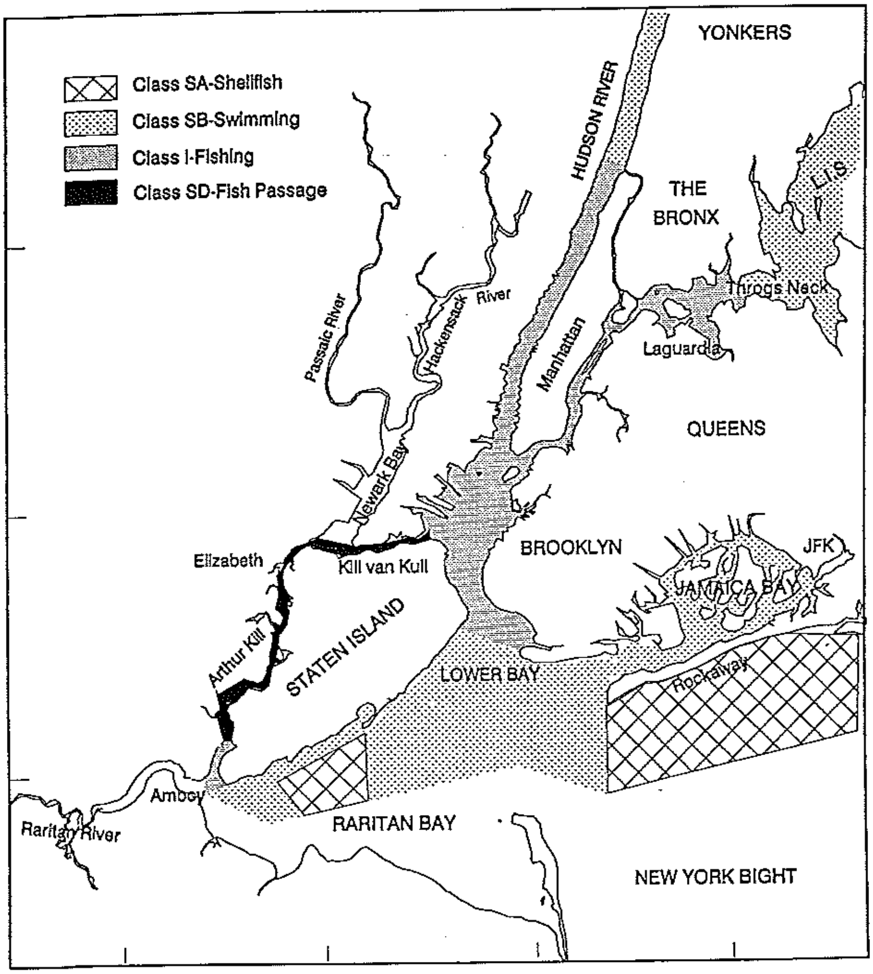


Figure 4. The New York Harbor Water Quality Classifications.

3. Water Quality Study

The water quality study consisted of two tasks:

(1) field sampling and data collection, and
(2) mathematical modeling.

These tasks were conducted to determine the degree to which water quality in the East River and its tributaries meets DEC criteria for dissolved oxygen (DO) and coliform bacteria, and to project water quality improvements that may be expected once CSOs are abated.

NYS DEC generally classifies the waters of the East River system "I" – best intended use fishing (Figure 4). This standard requires a minimum DO level of 4 milligrams per liter (mg/l), with mean total coliform bacteria not exceeding 10,000 organisms per 100 milliliters. The chronic occurrence of hypoxia (DO level less than 3 mg/l) is stressful to marine organisms and causes environmental concern, while near anoxic conditions (DO almost zero) almost always result in resource mortalities and other serious effects. The Long Island Sound and its tributaries (from the Whitestone Bridge to the city limits) are generally classified "SB" – best intended use bathing. This requires a minimum DO level of 5 mg/l, with monthly mean coliforms not exceeding 2,400 organisms per 100 milliliters. Field surveys indicated that most of the East River study area does not consistently meet the criteria for its intended use. It was therefore necessary to investigate possible methods of improving water quality to meet the state-mandated standards.

3.1. FIELD SAMPLING AND DATA COLLECTION

New York City began monitoring water quality in New York Harbor waters in 1909. In modern times a 7 to 14 day sampling frequency was maintained during most summer seasons in the East River. The sampling stations are shown in Figure 5. Contour plots of the surface and bottom summer minimum DO at the ten East River sampling stations from 1970 to 1990 are shown in Figure 6 (Brosnan *et al.*, 1987). Surface DO contour intervals range from a healthy 4.0 to 6.0 mg/l in the extreme western Sound (stations E-8 to E-10) to a near anoxic state in the lower East River (stations E-1 to E-3). The marked increase in the summer minimum DO in stations E-1 to E-7 around 1979 coincides with the completion of the project to upgrade the Wards Island WPCP located near station E-4. A recent pattern of more severe oxygen depletion has emerged since 1986 in bottom waters to the east (stations E-7 to E-10) and this pattern appears to be persisting. Since 1986 hypoxia conditions in the Long Island are documented extending in an area from 65 to 180 square kilometers and lasting from two to three weeks.

The 85th Water Quality Survey of the New York Harbor was performed in 1994 and is summarized in a recent report of NYCDEP (NYCDEP, 1994). Presently, 52 stations are monitored at least bimonthly year-round for a variety of water quality indicators, including: DO, BOD, coliform bacteria (June through September only), nutrients, chlorophyll 'a', phytoplangton, pH, Secchi transparency, light transmittance, total suspended solids (TSS), salinity, and temperature. In general conventional water quality, as indicated by coliform bacteria and DO levels, continues to improve in most areas of NY Harbor. Overall, conditions from 1991–1994 are significantly better than pre-1990 conditions. This is due to construction and upgrading of WPCPs, increased maintenance of sewage systems, increased capture and treatment of CSOs, the ongoing abatement of illegal discharges, and an enhanced industrial pretreatment program.

In particular total coliform concentrations show significant declines from 1968 through 1994 (Figure 7). More recently the decline is over 50% at 35 of 52 stations from 1989 to 1994. Only twelve scattered stations in Jamaica Bay, the East River,

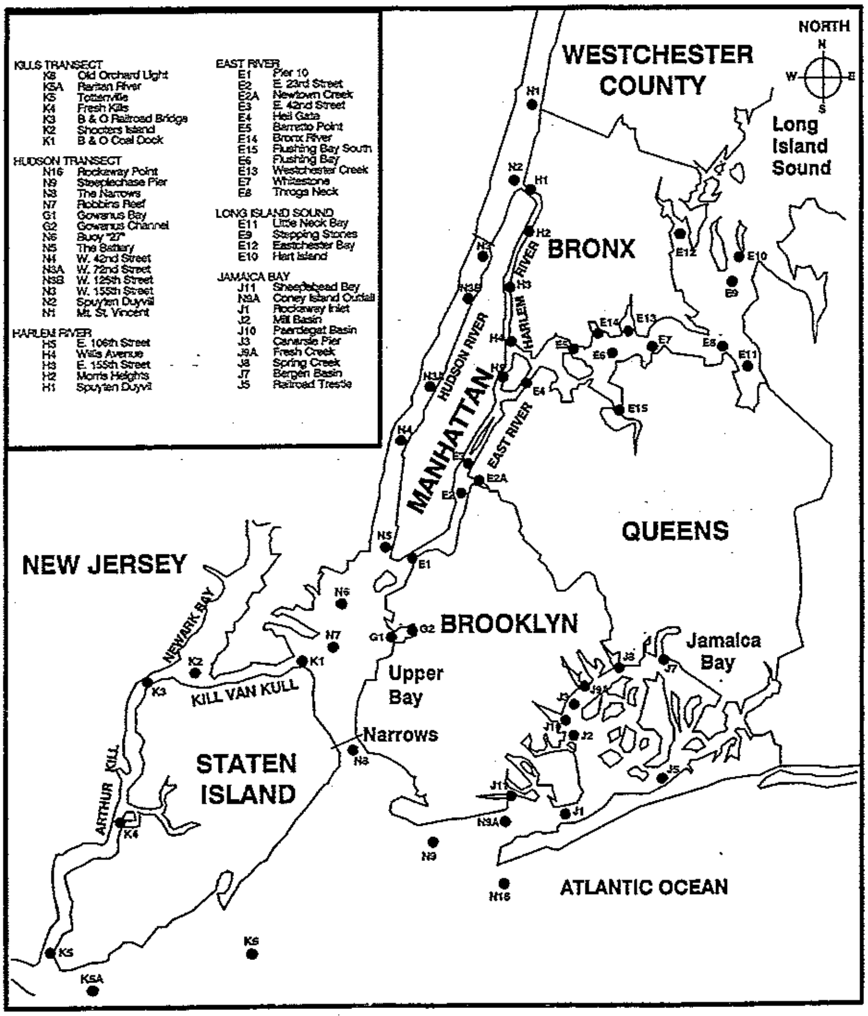


Figure 5. The New York Harbor Survey Sampling Stations.

and the Harlem River exhibited summer geometric average fecal coliform (FC) concentrations in excess of 200 cells/100 ml, which is the NY State primary contact standard.

CSOs have an average FC concentration of 3.5 million cells/100 ml compared to less than 50 cells/100 ml from WPCP effluent. Therefore, an effort has been made in recent years to quantify the effects of precipitation on water quality by sampling during both 'dry' and 'wet' periods. A sampling event is characterized 'wet' if a significant rainfall event occurred in the preceding 48 hours, with 'significant' defined as 0.4 inches (1.02 cm) within 24 hours or 0.2 (0.51 cm) inches within 2 hours. Estimates of TC concentrations during dry and wet periods for

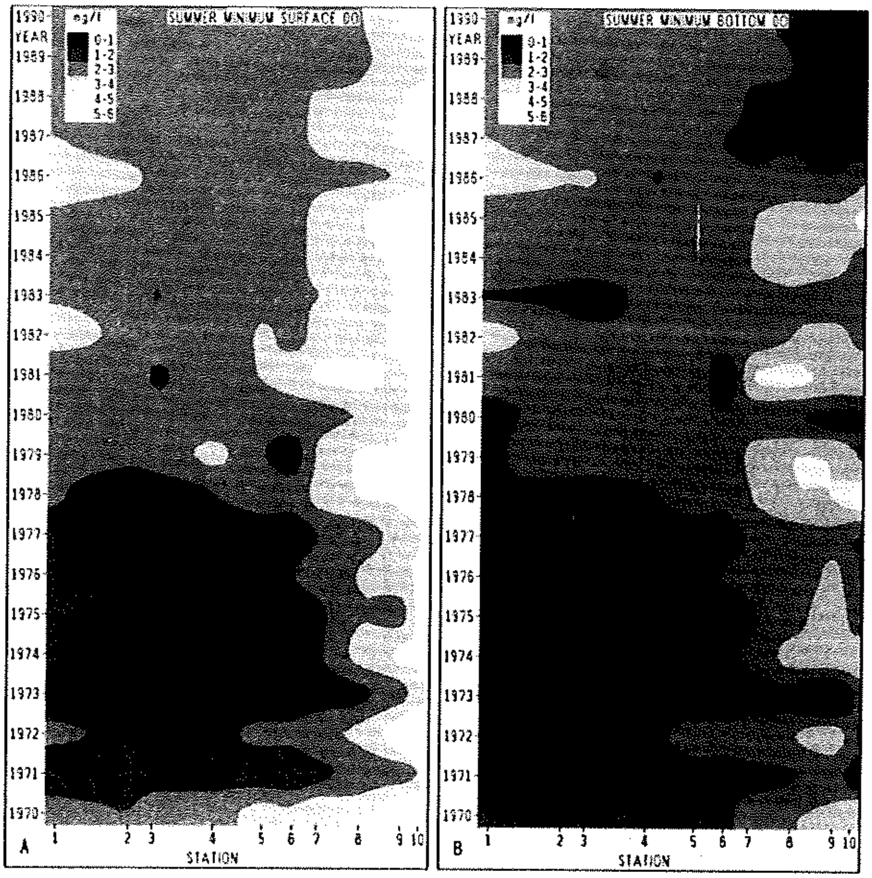


Figure 6. Minimum Summer Surface and Bottom Dissolved Oxygen in the East River (1970–1990) (from Brosnan *et al.*, 1987).

the combined summers of 1987–1989 and 1992–1994 are shown in Figure 8. The summer rainfall during 1987–1989 was 0.7 inches (1.78 cm) per month larger than during 1992–1994. During dry weather in 1992–1994, average TC concentrations met the bathing standards of less than 2,400 cells/100 ml over most of NY Harbor. Exceptions included Flushing Bay and Sheepshead Bay which only met the secondary contact standards during dry weather. During wet weather in 1992–1994 certain areas exhibited short-term increases in TC concentrations after rainfall events. These areas included East River, Harlem River, the Kills, the Hudson River, and the north shore of Jamaica Bay. Coliform levels tend to return to dry weather conditions within one to three days after the rainfall event.

Summer minimum DO concentrations have also improved since the late 1980s. However, in the 1994 survey hypoxia conditions (DO less than 3 mg/l) were recorded at least once at 17 bottom stations and 7 surface stations, that is in a total of 45 out of 959 surface and bottom DO measurements. The lowest DO data were ob-

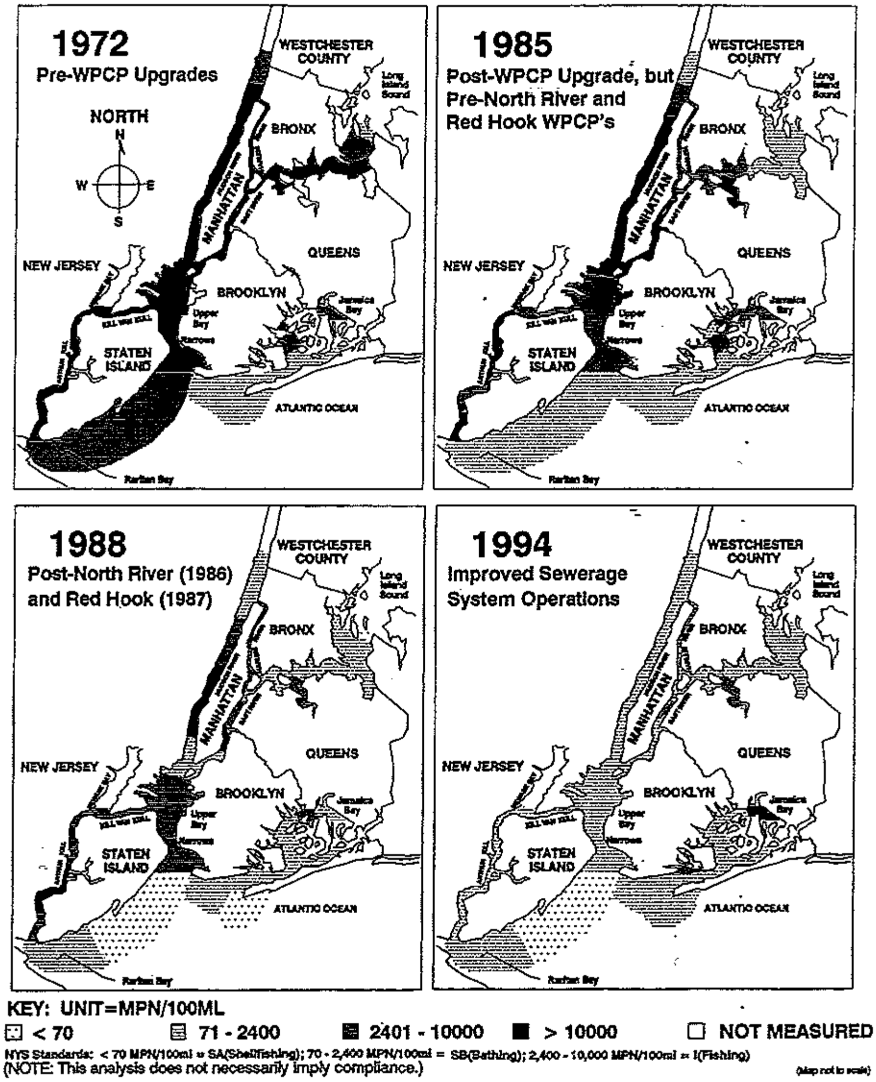


Figure 7. Total Coliform Trends in Surface Waters (Summer Geometric Means 1972–1994).

served in the bottom waters of western Long Island Sound, parts of the Upper and Lower East River and in Jamaica Bay. In several stagnant Jamaica Bay tributaries anoxia was recorded.

Spatial distributions of other water quality parameters (average summer total dissolved inorganic nitrogen, total phosphorus and dissolve orthophosphate, surface average chlorophyll, Secchi transparency etc.) are presented in the NYCDEP survey report. These spatial patterns have remained essentially constant since at least 1986.

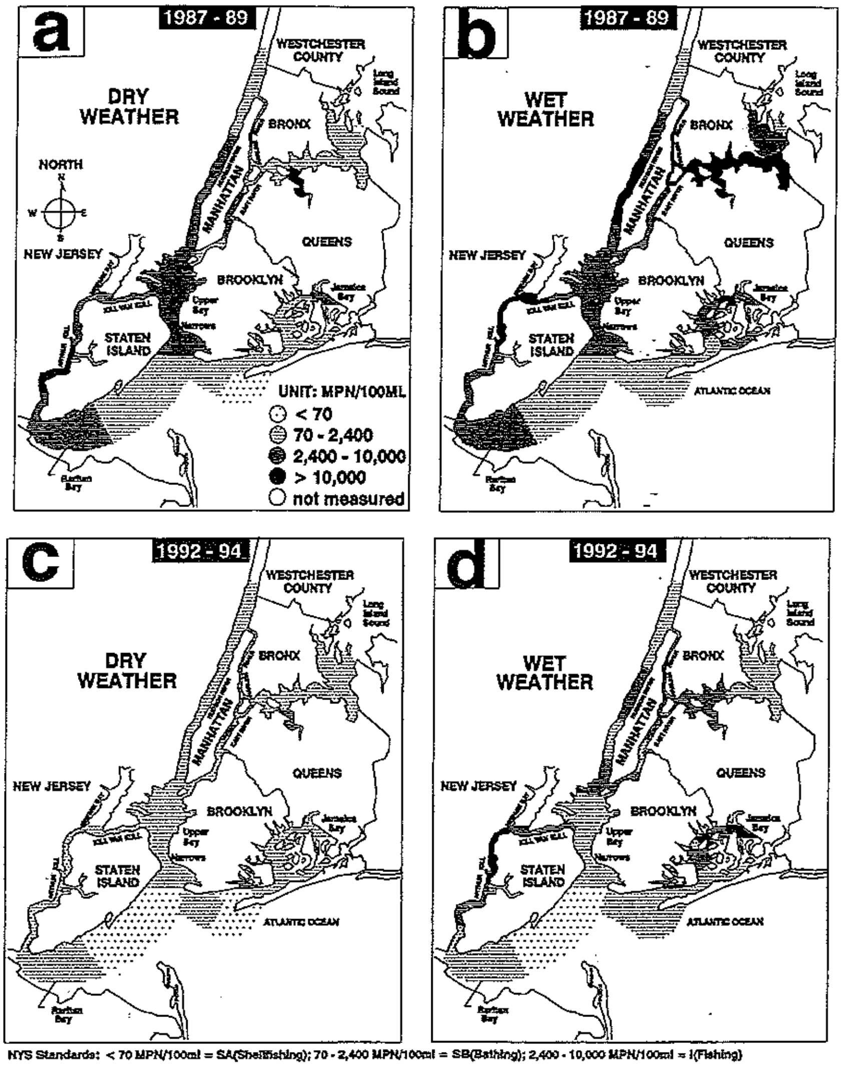


Figure 8. Total Coliforms During Dry and Wet Weather in Surface Waters (Summer Geometric Means 1987–1989 and 1992–1994).

3.2. MATHEMATICAL MODELING

The landside field investigations consist of the following components:

(1) sewer system flow monitoring,
(2) sewer system videotaping inspection,
(3) rainfall monitoring, and
(4) wet weather sewer system sampling.

Sewer systems flows are measured with portable flowmeters during both dry and wet weather at various selected sites. The tidal range in NYC between high and low tide is approximately 6 ft and sewers are submerged during long time periods. Due to this condition flow monitoring is problematic because flowmeters are designed for free discharge, a hydraulic condition that is rare in NYC sewers. Sewers that have potential for in-line storage are videotaped. Weather data are collected by the National Oceanographic and Atmospheric Administration at the three area airports and at the Central Park Station in Manhattan. Average annual statistics indicate that on the average it rains approximately every three days in NYC (time between storms is 76.3 hours). A rain event has duration 6.56 hours and delivers a depth of 0.388 inches (0.99 cm). The yearly average rainfall for NYC area is approximately 44 inches (112 cm). Wet weather sewer sampling is performed to characterize the quality of CSO. Figure 9 depicts the location of all 460 CSOs outfalls of NYC. The major parameters analyzed include coliform bacteria, biochemical oxygen demand, and solids (total and volatile).

Three types of mathematical models were developed and calibrated for the water quality study: (1) a landside model of the sewer system, (2) a hydrodynamic model of the receiving waters, and (3) a water quality model of the receiving waters. Landside models are developed of the sewer system to calculate flows and loads discharged to the receiving waters. These results are fed to the water quality model for calibration and prediction. The landside model is calibrated to flow monitoring data and constituent concentrations. The hydrodynamic model defines the circulation patterns of the receiving waters. The model is three-dimensional with ten vertical layers and calculates advection and mixing terms on an hourly average basis. The results are also fed to the water quality model for calibration and prediction. The hydrodynamic model is calibrated to salinity, tidal height, and current meter data. The water quality model calculates constituent concentration distributions in the water column on a time varying basis. The model is calibrated to salinity, coliform bacteria, BOD, and DO concentrations collected in the receiving waters during both dry and wet weather events. Since receiving water conditions are the result of all pollutant discharges, all pollution loads must be defined for calibration, that is CSOs, stormwater, tributary inputs, municipal discharges, and industrial discharges. A summary of the mathematical modeling approach is provided in a recent report of NYC DEP (NYCDEP, 1995).

The results of the water quality study for the East River are summarized below:

- In the open waters of the East River system, CSOs do not significantly depress DO levels and therefore abatement of CSOs directly discharging into the East River is not necessary.
- DO criteria are not met in the tributaries during the summer, the most difficult season for achieving compliance. CSO abatement will substantially eliminate short-term degradation of water quality caused by rain events in the summer. Severe DO depressions or anoxic conditions will be greatly reduced.

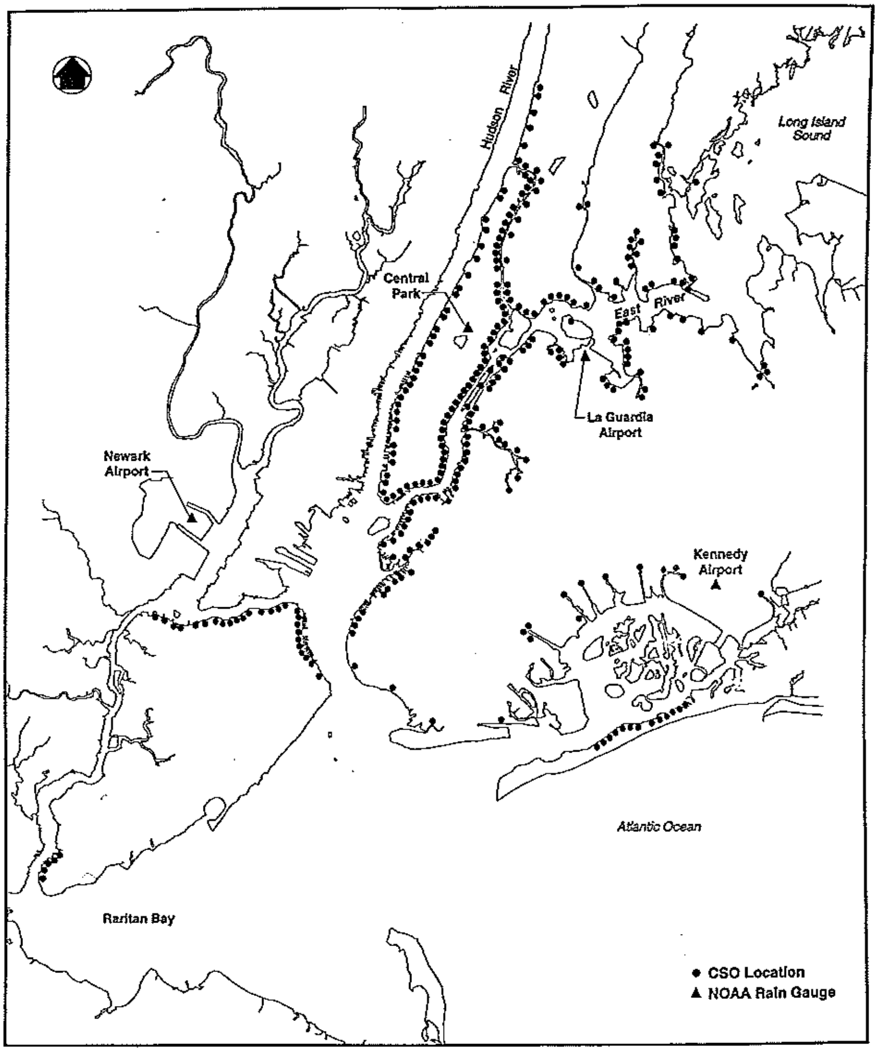


Figure 9. Combined Sewer Overflows and Weather Stations in NYC.

- Monthly total coliform criteria are presently met during average rainfall conditions throughout the study area, except in the Hutchinson River. However, water quality monitoring during substantially wetter than normal periods indicated that DEC standards are violated in the upstream tributary areas of the Bronx, near Parsons Beach in Little Neck Bay, near EdgewaterPark in Eastchester Bay, and in the East River near Ferry Point and Throgs Neck.
- CSOs account for nearly all of the coliform loading within the East River project area. Complete removal of CSOs that discharge into the East River will substantiallly decrease total coliform concentrations throughout the system

and yield compliance with DEC standards during wetter than average rainfall conditions.

- four storage facilities and a storage tank (see next section) are proposed to achieve approximately 25% of the maximum potential DO improvement attributable to complete removal of CSO in the open waters and approximately 70% of the maximum potential improvement in the three tributaries (Bronx River, Westchester Creek, and Hutchinson River).

4. Facilities Planning

The facilities planning effort for the East River and its tributaries has been essentially completed. Its purpose was to identify places where CSOs degrade the water quality and to recommend ways to abate the problem. Facilities planning activities include identification of possible CSO abatement alternatives, screening and evaluation of alternatives, analysis of CSO abatement needs, and development of the proposed facility plan. The plan primarily provides for the design and construction of underground storage tanks. Although it discusses the possible need for disinfection and floatables removal facilities, it does not present specific designs and locations for disinfection facilities or a specific floatables abatement plan.

The facilities planning phase of the East River project was largely based on the results of the water quality study. This study included field sampling, data collection, and modeling activities, which identified the major sources of pollution in the East River and its tributaries, evaluated the existing water quality of the East River system, and determined the degree of CSO reduction needed to meet water quality goals. The facilities planning effort then evaluated potential control and treatment alternatives for meeting the CSO reduction goals.

A summary of the proposed Facility Plan is provided below:

(1) Storage Facilities

Engineering analysis determined that the most feasible and cost-effective solution for improving water quality in the East River and its tributaries is the construction of underground storage tanks. The proposed tanks are designed to capture the CSO before it is discharged to receiving water bodies. After a storm, the stored flow would be pumped out and sent to existing water pollution control plants for treatment. During storms, flows in excess of the plant's capacity would pass through the tank and undergo screening, some settling, and disinfection before discharge into the water body, thereby receiving a degree of treatment.

Site selection for the storage tanks included field surveying; review of aerial photographs, city urban renewal atlases, land use/zoning regulations, and sewer, land use and zoning maps; and consideration of public input. A preferred location was identified as one that combined the technical requirements of adequate open area within good proximity to the overflow line with favorable hydraulic features.

Table I. Characteristics of proposed storage tanks (FPS units)

Storage Facility	Volume (Mgal)	Size (ft by ft)	Depth (ft)	Required Land (acres)	Capital Cost (millions)
Bronx River	10	350 by 120	34.5	1	$53.0
Hutchinson River	7	400 by 100	23.5	1	$44.0
Westchester Creek	12	300 by 270	20	1.8	$75.0
Alley Creek	9	300 by 200	20	1.5	$56.3

Characteristics of proposed storage tanks (SI units)

Storage Facility	Volume (M*l*)	Size (m by m)	Depth (mt)	Required Land (sq m)	Capital Cost (millions)
Bronx River	37.9	107 by 36	10.5	4,050	$53.0
Hutchinson River	26.5	122 by 30	7.1	4,050	$44.0
Westchester Creek	45.4	91 by 82	6.1	7,280	$75.0
Alley Creek	34.1	122 by 61	6.1	6,070	$56.3

Other factors taken into consideration were topography, compatibility with existing and proposed zoning and land use, and minimization of disturbance to the environment and to residential and commercial areas.

The proposed storage tanks will be approximately 20 to 35 feet (6.1 to 10.7 meter) deep. Recommended sites and tank sizes are presented below for each proposed storage facility. A small portion of the facilities will be above ground to accomodate maintenance or office buildings, as well as exhaust ports for odor control systems. After construction, the areas above the tanks will be restored to their previous condition. Possible improvements for future uses atop the tanks include parks, ballfields, running tracks, or other recreational facilities.

The proposed facility plan discusses the need for three storage tanks in the Bronx to improve water quality in the Bronx River, Hutchinson River, and Westchester Creek. In addition, it addresses the possible need for a tank at Alley Creek in Queens. Although a definite determination concerning the Queens storage tank will not be made until additional water quality studies are conducted, the project team has estimated that a nine million gallon (34.1 million liter) tank is likely to be required for significant improvement of water quality in the Creek. The main characteristics of the proposed storage tanks are presented in Table I.

(2) Disinfection Facilities

Disinfection by chlorination of CSOs is DEP's preferred method for preventing impairment of bathing at beaches in the study area. However additional guidance is needed from the New York State DEC and New York City Department of Health before specific designs and locations of proposed facilities can be investigated. Therefore, at present only a conceptual approach towards disinfection stations has been developed. In general the disinfection stations under consideration would operate by diverting combined sewage through an underground tank where sodium hypochlorite would be introduced. After disinfection most of the flow would be discharged by gravity to the receiving water. Any remaining flow would be pumped out either to the receiving water or pumped back to the sewer system for treatment at existing water pollution control plants.

In a worst case scenario disinfection would be necessary at as many as 15 outfalls (7 in the Bronx and 8 in Queens). Peak flow rates at these outfalls range from 1.5 to 225 million gallons (5.7 to 851 million liters) per day during the design rainfall period. The underground tanks would range in size from approximately 1 to 4.5 million gallons (3.8 to 17 million liters) and would require approximately 0.5 to 1.5 acres (2,020 to 6,070 square meters), respectively. All disinfection facilities would include an above-ground building for operation and maintenance activities. The building could range in size from 30 by 30 to 40 by 50 square feet (9.1 by 9.1 to 12.2 by 15.2 square meters). The estimated capital cost for 15 disinfection facilities is $251 million.

(3) Floatable Abatement Facilities

Although one of the objectives of the East River project is the substantial removal of settleable solids and floatables from CSOs, further guidance is needed from state and federal agencies before a specific abatement plan can be developed. In addition, DEP is conducting a city-wide floatables study in order to develop appropriate measures. This study is currently in progress.

Options for the abatement of floatables and settleable solids range from increased street sweeping to storage systems (i.e. tunnels) or end-of- the pipe treatment facilities (i.e. swirl concentrators). Based on preliminary analyses conducted as part of the East River CSO project, two viable abatement options have been identified for future analysis and evaluation: (1) tunnels, which are generally used in areas with numerous, closely spaced outfalls, and (2) swirl concentrators, which are used in areas with widely spaced outfalls. Depending on the level of treatment eventually needed, the east side of Manhattan could be significantly affected due to the close spacing of the outfalls.

Preliminary estimates of capital costs for floatables abatement facilities range from $628 million (swirl concentrators on all outfalls exclusive of those designated for storage) to $2,388 million (tunnels for all outfalls), exclusive of land costs.

5. Environmental Assessment

The environmental assessment process involved a comprehensive evaluation of the abatement alternatives proposed for the East River CSO project. The alternatives were evaluated for their short- and long-term environmental and community impacts, in terms of water quality, recreation, public safety and health, water resources, and economics.

The Environmental Assessment concluded that construction of the storage facilities would not impact wetlands, endangered species, or any historic sites. The principal long-term impact of the project was found to be the commitment of resources. It is estimated that the capital and operation and maintenance costs of the project total $197.2 million (in 1992).

Short-term impacts related to construction of the storage facilities were identified as traffic disruption; displacement of birds (Bronx River site); displacement of ballfields (Westchester River site); loss of trees and grass; dust, erosion, and noise; and aesthetics. These impacts will be mitigated by use of noise, dust and erosion control measures; careful coordination of traffic routing and maintenance and protection of traffic schemes; replanting of trees and regrading and reseeding of grassy areas; and restoration/replacement of disturbed facilities, along with possible development of sites for community use. The Environmental Assessment therefore concluded that the short-term adverse impacts of the project were outweighed by its long-term benefits: improved water quality in the Hutchinson River, Westchester Creek, and the Bronx River; odor abatement; and removal of floatable materials at outfalls being abated by underground storage tanks.

Specific environmental characteristics and impacts of the recommended site for each storage facility were considered. The Bronx River site offers almost no wildlife habitat, although some bird species (rock dove, house sparrow, european starling) may roost or nest in the buildings on the site. The Hutchinson River site has almost no vegetation, and offers little or no wildlife habitat. A fringe of tree-of-heaven is present along the western border of the site. The Westchester Creek site includes a variety of grasses and herbaceous weeds. The open, unvegetated site offers little cover for wildlife. However, a thicket of small trees and shrubs provides cover and a possible breeding habitat for birds (sparrows, house finches, robins). Although removal of trees will eliminate some feeding and possible nesting areas, comparable nearby nesting places are available for birds temporarily displaced by the construction process. Trees are expected to be restored following construction.

6. Public Participation

In order to fully involve the community in all aspects of the project, a comprehensive public participation program has been designed to accompany the technical study effort. This program includes the dissemination of informational project materials through local repositories and direct mailings, as well as ongoing interaction and dialogue through a Citizens Advisory Committee (CAC), public meetings, and informal contacts (e.g. conference calls). This ongoing dialogue is designed to provide the public with up-to-date project information; encourage open and ongoing communication; and facilitate timely receipt of informed public input to be used by DEP in developing a Facility Plan reflecting the highest engineering standards, sound environmental requirements, cost effectiveness, and minimal community impact.

An essential component of the program has been the CAC which was established to serve as a continuous source of public input and to provide outreach and information to interested constituencies. The Committee, which was established in the fall of 1988, has been meeting on a bi-monthly basis to discuss both immediate and long-range issues relating to water quality, alternative CSO abatement techniques and storage tanks. In addition a number of meetings have been held with the Offices of the Bronx and Queens Borough Presidents and affected Community Boards to review alternative sites and to detail the specifics of the proposed storage tanks.

7. Conclusion

The East River CSO abatement facility planning suggests the design and construction of three underground storage tanks in the Bronx, and possibly one underground storage tank in Queens. The precise configuration and physical characteristics of the tanks, diversion structures, conduits and overflow spillways as well as the exact nature of mixing and washdown equipment, and operational procedures will be addressed in detail in the preliminary design phase of the project.

The NYCDEP studies have concluded that there is no single solution to the CSO abatement problem for all areas within the New York-New Jersey Harbor estuary. The ultimate solution to the CSOs problem involves:

(1) construction of storage tanks near the discharge point of large CSOs (15 such points have been proposed); stored overflows will be treated at a later time by treatment at nearby treatment plans,
(2) for storm flows exceeding the capacity of the storage facilities, the facilities themselves will operate as primary treatment plants, with solid and floatable removal and disinfection where necessary; for smaller CSOs floatable removal seems necessary at most locations with disinfection added in certain cases; the abatement of smaller CSOs presents great technological and regulatory challenges due to higher costs and diminished benefits; innovative technologies are needed to address this challenge, and
(3) optimal use of sewer capacity by controlling the quantity and direction of flows.

The city is proceeding with a demonstration project to evaluate the effectiveness of vortex separators for removal of floatables. It is recognized that there can only be a long-term solution to the CSOs problem over a time horizon of 10 to 20 years. In the interim the City continues its very successful efforts to monitor and characterize the quality in the New York Harbor waterways and sediments, to improve operations in the fourteen water pollution control plants, to abate illegal connections to the sewer system, to reduce raw sewage bypassing, to plan and test facilities for CSO abatement, to enforce the industrial pretreatment and pollution prevention, to promote water conservation, and to implement effective biosolids dewatering with nutrient removal.

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