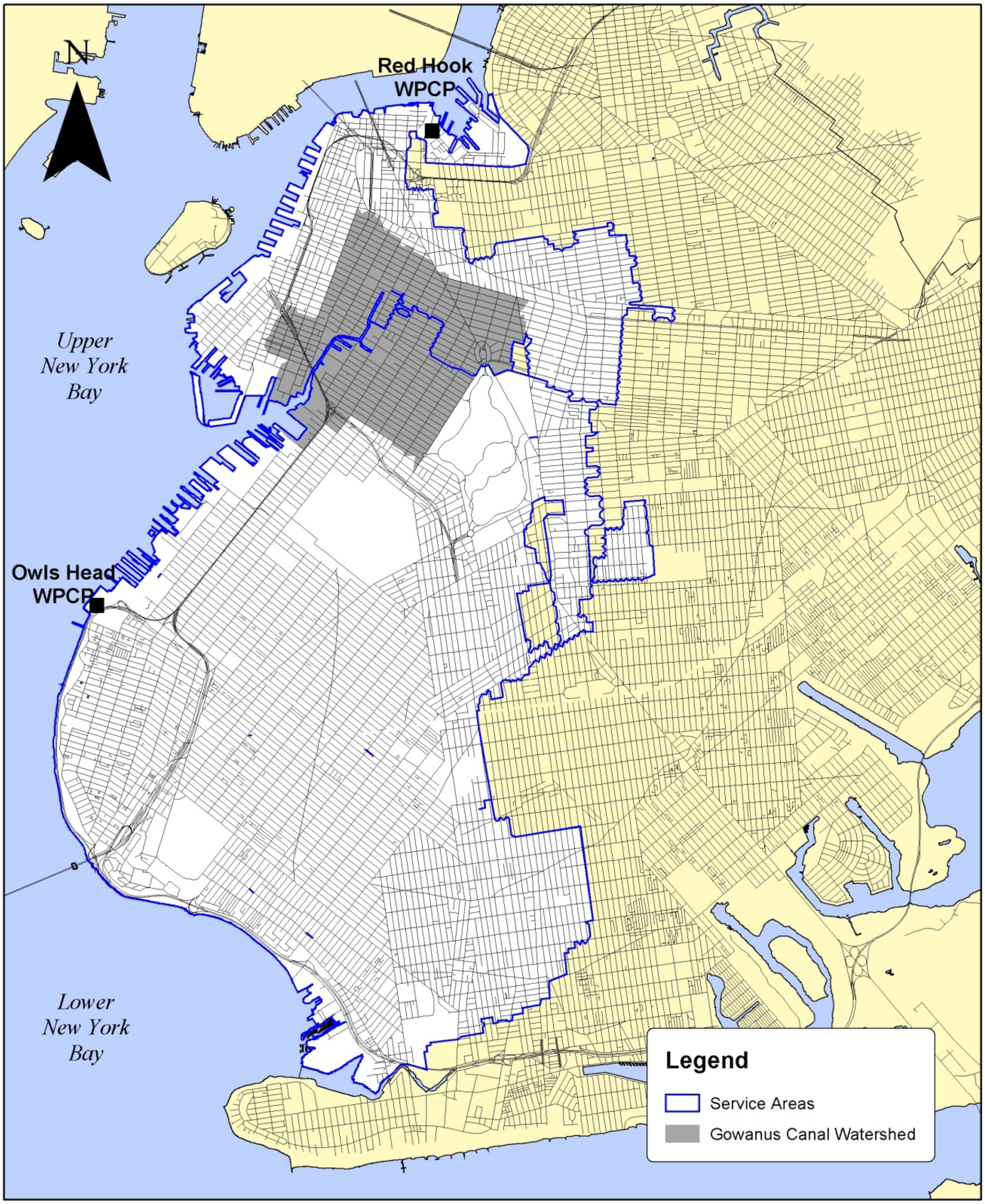
3.0 Existing Sewer System Facilities

The Gowanus Canal watershed consists primarily of sewersheds tributary to two different WPCPs: the Red Hook and Owls Head WPCPs. Figure 3-1 presents the Gowanus Canal watershed in relation to the Red Hook and Owls Head WPCP drainage areas. During significant rainfall events, Gowanus Canal receives discharges of combined sewage via reliefs from the combined sewer system, as well as relatively small discharges of stormwater runoff via storm sewers and direct overland runoff. This section presents a description of the existing sewer system facilities, the collection system, and characteristics of discharges to Gowanus Canal.

3.1 RED HOOK WPCP

The Red Hook WPCP is permitted by NYSDEC under SPDES permit number NY-0027073. The facility is located at 63 Flushing Avenue, Brooklyn, NY, 11205, on a 19-acre site adjacent to the East River and bounded by Flushing Avenue and Navy Street. The Red Hook WPCP serves approximately 3,054 acres of northwest Brooklyn, including the communities of Red Hook, Gowanus, Carroll Gardens, Cobble Hill, Vinegar Hill, Fulton Ferry, Brooklyn Heights, Downtown, Navy Yard, Clinton Hill, Fort Greene, Boerum Hill, Prospect Heights, and Crown Heights. Approximately 137 miles of sanitary, combined, and interceptor sewers feed the Red Hook WPCP.

The Red Hook WPCP began operating in 1987 with a step-aeration design capacity of 60 million gallons per day (MGD), and has been providing full secondary treatment since 1989. Treatment processes include primary screening, raw sewage pumping, grit removal and primary settling, air-activated sludge capable of operating in the step aeration mode, final settling, and chlorine disinfection. Figure 3-2 presents the layout of these treatment processes in a site plan of the WPCP; as shown, these existing processes fully utilize the available space at the site. Figure 3-3 presents a schematic diagram of these same processes. As NYSDEC requires in the plant SPDES permit and in accordance with the Wet Weather Operating Plan (WWOP, see Section 3.1.2), the Red Hook WPCP has a design dry-weather flow (DDWF) capacity of 60 MGD, and is designed to receive a maximum wet-weather flow of 120 MGD (2 times DDWF), with 90 MGD (1.5 times DDWF) receiving secondary treatment. Flows over 90 MGD receive primary treatment and disinfection. The daily average dry-weather flow during 2007 was 30 MGD. During severe wet-weather events in 2007, the WPCP treated 124 to 137 MGD. Table 3-1 summarizes the Red Hook WPCP permit limits.



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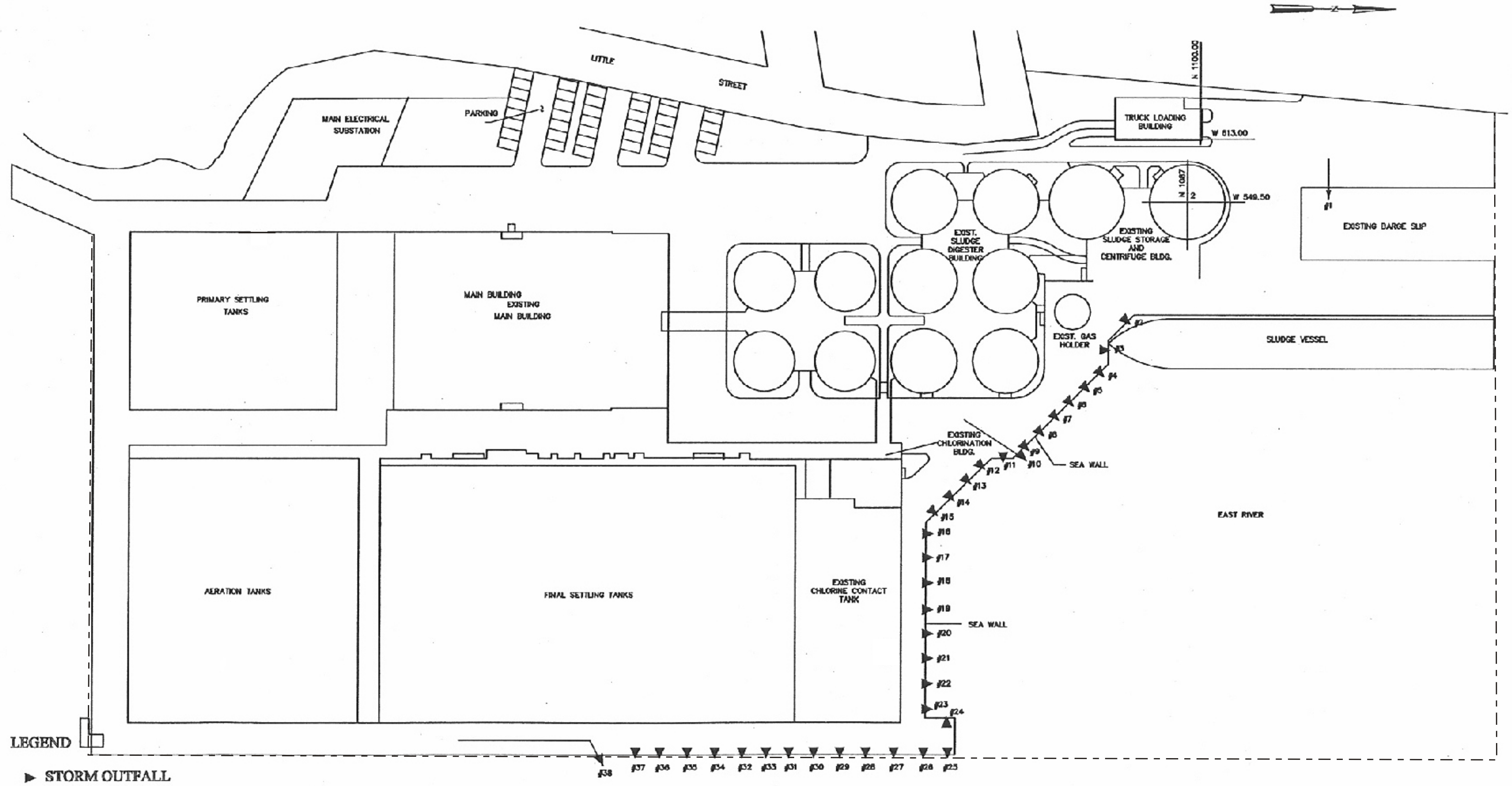
Gowanus Canal Waterbody/Watershed Facility Plan

Gowanus Canal Watershed and WPCP Service Areas

FIGURE 3-1



Red Hook WPCP Process Layout and Site Plan

FIGURE 3-2

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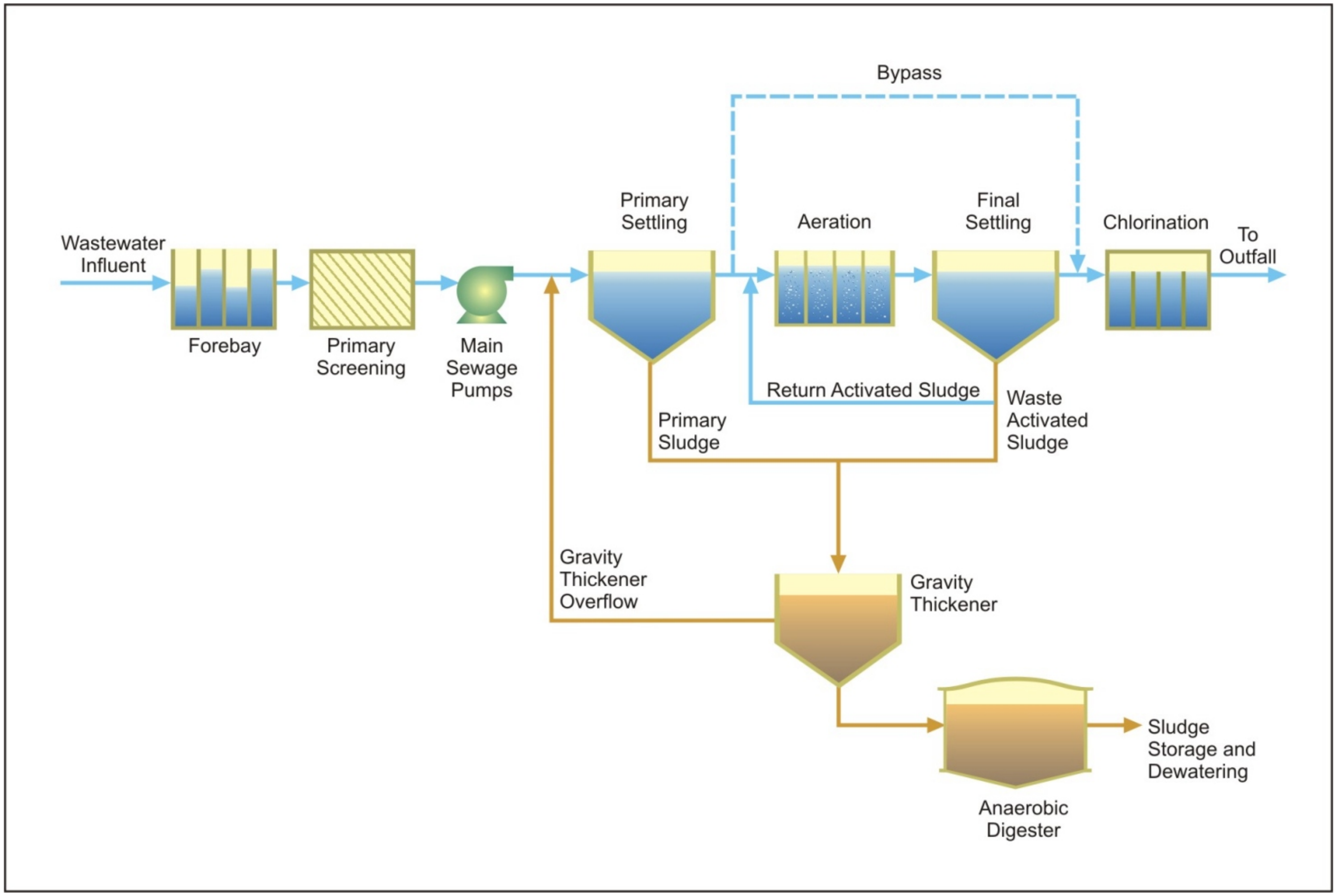

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Gowanus Canal Waterbody/Watershed Facility Plan

Red Hook WPCP Process Flow Diagram

FIGURE 3-3

Table 3-1. Select Red Hook WPCP SPDES Effluent Permit Limits

Parameter	Basis	Value	Units
Flow	DDWF Maximum secondary treatment Maximum primary treatment	60 90[(1)] 120	MGD
$CBOD_5$	Monthly average 7-day average	25 40	mg/L
TSS	Monthly average 7-day average	30 45	mg/L
Total Nitrogen	12-month rolling average	108,375[(2)]	lb/day

(1) 1.5 DDWF (1.3 at HP to protect BNR process as recommended by the WWOP)
(2) Nitrogen limit for the Combined East River Management zone, calculated as the sum of the discharges from the four Upper East River WPCPs (Bowery Bay, Hunts Point, Wards Island, Tallman Island) and one quarter of the discharges from the 2 Lower East River WPCPs (Newtown Creek, Red Hook). This limit is effective through November 2009, then decreases stepwise until the limit of 44,325 lb/day takes effect in 2017.

NYCDEP has examined the feasibility of processing twice DDWF (120 MGD) through the complete WPCP. NYCDEP has found that it is not feasible to route all 120 MGD through the existing secondary treatment portion of the facility due to treatment process constraints, and that it is not feasible to construct new secondary facilities as the WPCP completely occupies the available land at the site (Figure 3-2).

3.1.1 Process Information

Figure 3-3 presents a schematic of the treatment process employed at the Red Hook WPCP. A 102-inch interceptor delivers flow to the Red Hook WPCP. The influent throttling chamber is located at the terminus of the interceptor and is connected to the screening forebay by a 108-inch by 72-inch influent conduit. At the entrance to the conduit, there is a set of stop-log grooves that can isolate the flow to the treatment plant. Downstream of the stop-log grooves is a 108-inch by 72-inch hydraulically operated flow throttling gate used to regulate or shut off flow from the influent chamber. Although high velocities develop as flow is routed under the throttling gate, these velocities dissipate within the influent conduit—prior to entry to the screenings forebay—due to a 90-degree bend and the extensive length of the influent conduit.

At the screenings building, there is a set of stop log grooves in the influent conduit and a 108-inch by 72-inch main influent sluice gate that can isolate the flow into the screenings forebay. Four screening channels connect the screenings forebay to the wet well. Each screening channel has an influent sluice gate and an effluent sluice gate that can isolate the channel when the screen is not needed or in the event that screen or channel repair work is necessary. The screens are 6-feet wide with 1-inch clear spacing and are cleaned with a vertical traveling rake. Each screen is designed to handle 53.3 MGD; however, this capacity can be negatively impacted by heavy loadings of debris. During wet-weather events, plant personnel can flood the screening channels to maximize flow and reach 120 MGD. A set of manually operated velocity-control gates is located in each screen channel, downstream of the screen, to maintain low velocity through the screen.

There are five vertical, centrifugal, mixed-flow, bottom suction, flooded suction main sewage pumps, each rated 30 MGD at a total dynamic head of 50 feet. Each pump draws flow from the wet well via a 36-inch suction line. Discharge from each pump is via a 30-inch line that includes a cone check valve and gate valve. The 30-inch lines connect to a 66-inch discharge line that conveys the flow to the primary settling tank distribution structure. There is a venturi meter on the 66-inch line for flow measurement.

The primary settling tank distribution structure receives raw sewage from the main sewage pumps via the 66-inch discharge line. The distribution structure divides the flow equally to the four primary settling tanks. The four primary settling tanks have a total volume of 3.2 million gallons (MG) and a surface overflow rate of 1,974 gallons per day per square foot (gpd/sf) at average design flow. Each rectangular primary settling tank includes three longitudinal chain and flight collectors and cross collectors.

Primary tank effluent is conveyed to the aeration tanks in a primary effluent channel. During wet-weather events, the plant uses a secondary bypass channel to convey primary effluent to the chlorine contact tanks when the flow into the secondary treatment process exceeds 90 MGD. The bypass gate automatically opens at a plant flow of 90 MGD.

Four 4-pass aeration tanks provide biological treatment with a total volume of 8.8 MG. Four 9,500 standard cubic feet per minute (scfm) blowers provide air to the aeration tanks through ceramic domes. Aeration tank effluent is conveyed to the eight rectangular final settling tanks in an aeration tank effluent channel. The total volume of the final settling tanks is 10.5 MG with a surface overflow rate of 600 gpd/sf at average design flow.

The disinfection system includes two double-pass chlorine contact tanks, three 10,000 gallon sodium hypochlorite storage tanks, four metering pumps, and an automated control system. The two tanks have a total volume of 1.72 MG and a detention time of 20.6 minutes. The chlorine contact tanks are sized such that one tank operating at 120 MGD will provide sufficient contact time (more than 15 minutes) for disinfection. Chlorinated effluent is discharged to the East River via a 96-inch outfall.

Sludge thickening is accomplished by four 60-foot diameter gravity thickeners. Each thickening tank unit has a 10.3-foot side water depth (SWD) and a total surface area of 11,320 square feet. The gravity thickener overflow is returned to the aeration tanks, and the thickened sludge is sent to the digesters. Sludge digestion is accomplished in six 60-foot diameter digestion tanks arranged with a total volume of 4 MG so that three tanks are run as primary digesters, two tanks can be run as either primary or secondary digesters, and one tank is run as a secondary digester.

Two sludge-storage tanks are provided for the storage of digested sludge. Digested sludge is dewatered on site in preparation for final disposal and the centrate is returned to the aeration tanks.

3.1.2 Wet-Weather Operating Plan

NYCDEP is required by its SPDES permit to maximize the treatment of combined sewage at the Red Hook WPCP. The permit requires treatment of flows up to 90 MGD through complete secondary treatment. Further, to maximize combined sewage treatment, the SPDES permit requires flows of up to 120 MGD to be processed through all elements of the WPCP except the aeration basins and the final settling clarifiers. New York State requires the development of a WWOP as one of 14 BMPs for collection systems that include combined sewers. The goal of the WWOP is to maximize flow to the WPCP, one of the nine elements of long-term CSO control planning. NYCDEP has developed a WWOP for each of its 14 WPCPs, and Table 3-2 summarizes the requirements for the Red Hook WPCP, and notes that flows beyond the maximum capacity of the aeration basins and final clarifiers (i.e. over 90 MGD) would cause damage to the WPCP by creating washout of biological solids and clarifier flooding. The WWOP therefore suggests that the facility operate at or near its maximum capacity as designed and configured, and as permitted by NYSDEC. The WWOP for Red Hook, attached as Appendix A, was submitted to NYSDEC in April 2005 as required by the SPDES permit.

3.1.3 Other Operational Constraints

NYSDEC and NYCDEP entered into a Nitrogen Control Consent Order that updated the New York City SPDES permits to reduce nitrogen discharges to Long Island Sound and Jamaica Bay in order to reduce the occurrence of eutrophic conditions and improve attainment of dissolved oxygen numerical criteria. Although the permitted effluent nitrogen load established by the Nitrogen Control Consent Order includes the discharge the Red Hook WPCP, there are currently no plans to implement Biological Nitrogen Removal (BNR) at either facility because the City is meeting its overall nitrogen goals. However, because of ongoing efforts by the Harbor Estuary Program (HEP) for water quality improvements, it is possible that BNR may be required at some point in the future. According to the 1998 NYCDEP Nitrogen Control Feasibility Plan, infrastructure at the Red Hook WPCP does exist in the aeration tanks and froth-control system that would make it possible to operate at basic step-feed BNR, but the plant is not being run in that mode and there are no plans to begin BNR operation.

3.2 OWLS HEAD WPCP

The Owls Head WPCP is permitted by the NYSDEC under SPDES permit number NY-0026166. The facility is located at 6700 Shore Road, Brooklyn, NY, 11220 in the Bay Ridge section of Brooklyn, on a 14-acre site adjacent to the Upper New York Bay and next to Owls Head Park. The Owls Head WPCP serves approximately 13,644 acres in western Brooklyn, including the communities of Bath Beach, Bensonhurst, Bay Ridge, Dyker Heights, Fort Hamilton, Borough Park, Ocean Parkways, Flatbush, Sunset Park, Windsor Terrace, Kensington, Prospect Park South, Gravesend, Prospect Lefferts Gardens, and Park Slope. Approximately 471 miles of sanitary, combined, and interceptor sewers feed the Owls Head WPCP.

Table 3-2. Wet Weather Operating Plan for Red Hook WPCP

Unit Operation	General Protocols	Rationale
Influent Gates and Screens	Leave gate in normal dry weather operating position until plant flow approaches 120 MGD, wet well level exceeds an acceptable level, screen channel level exceeds acceptable level, bar screens become overloaded, or grit removal exceeds capacity. If necessary activate additional screens in order to accommodate increased flow.	To regulate flow to the plant and prevent excessive flows from destabilizing plant performance.
Main Sewage Pumps	Bring extra pumps on line based on wet well water levels. Operate pumps optimally to maintain wet well levels.	To maintain a safe water level in the wet well.
Primary Settling Tanks	Make sure four primary sludge pumps are pumping and back-flush when necessary while watching water surface elevations at the weirs for flooding and flow imbalances. Reduce flow if grit accumulation exceeds the plant's ability to handle it or loss of equipment warrants reduction to keep flow balanced to the primary tanks.	Maximize suspended solids and CBOD5 removal, prevent premature weir flooding, prevent short circuiting, prevent excessive sludge and grit accumulation in individual clarifiers, and maximize scum removal. Sludge blankets need to be kept to minimum levels
Bypass Channel	Open the bypass gate to Parshall flume when the plant influent flow exceeds 90 MGD or if the primary clarifier weirs flood with less than 3 primary settling tanks in service. Open bypass gate downstream of Parshall flume when required.	To relieve flow to the aeration system and avoid excessive loss of biological solids and to relieve primary clarifier flooding
Aeration Tanks	Keep all necessary aeration tanks in step-feed operation and adjust the airflow to maintain a dissolved oxygen greater than 2 mg/L.	To provide effective secondary treatment to storm flows up to 90 MGD.
Final Settling Tanks	Observe the clarity of the effluent and watch for solids loss. If necessary, increase the RAS rate to maintain low blanket levels.	High flows will substantially increase solids loadings to the clarifiers, which may result in high clarifier sludge blankets or high effluent TSS. This can lead to loss of biological solids that may destabilize treatment efficiency in dry weather conditions.
Chlorination	Check, adjust (increase), and maintain the hypochlorite feed rates to provide chlorine residual at determined target of less than 2 mg/l.	Hypochlorite demand will increase as flow rises and secondary bypasses occur.
Sludge Handling	Proceed as normal.	Uninfluenced by wet weather.

The Owls Head WPCP began operating in 1952 and has been providing full secondary treatment since 1995. Treatment processes include primary screening, raw sewage pumping, grit removal and primary settling, air activated sludge capable of operating in the step aeration mode, final settling, and chlorine disinfection. Figure 3-4 presents the layout of these treatment processes in a site plan of the WPCP; as shown, these existing processes fully utilize the available space at the site. Figure 3-5 presents a schematic diagram of these same processes. As NYSDEC requires in the plant SPDES permit and in accordance with the Wet-Weather Operating Plan (WWOP, see Section 3.2.2), the Owls Head WPCP has a DDWF capacity of 120 MGD, and is designed to receive a maximum wet-weather flow of 240 MGD (twice DDWF), with 180 MGD (1.5 times DDWF) receiving secondary treatment. Flows over 180 MGD receive primary treatment and disinfection. The daily average dry-weather flow during 2007 was 86 MGD. During severe wet-weather events in 2007, the WPCP treated 238 to 250 MGD. Table 3-3 summarizes the Owls Head WPCP permit limits.

Table 3-3. Select Owls Head WPCP SPDES Effluent Permit Limits

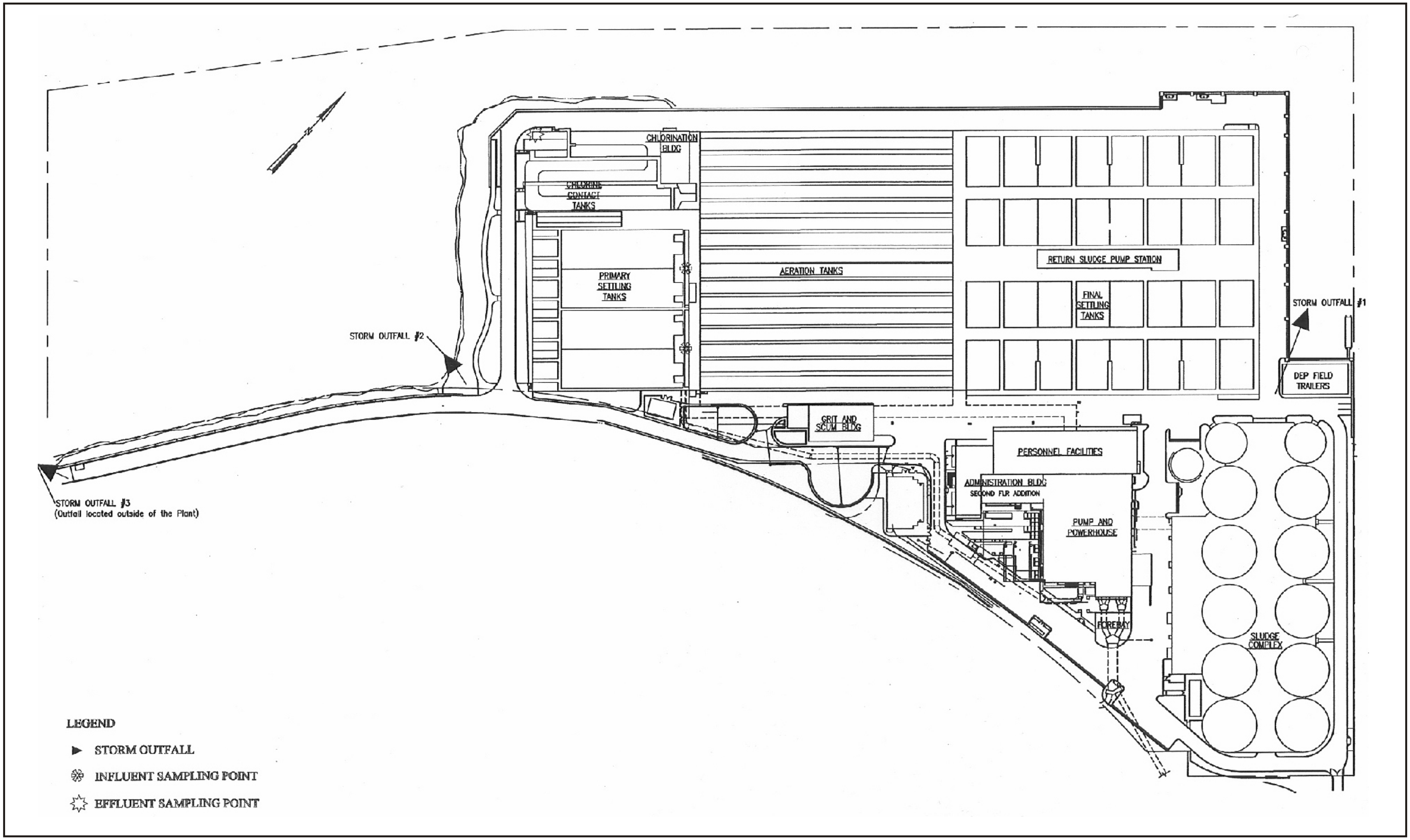
Parameter	Basis	Value	Units
Flow	DDWF[(1)] Maximum secondary treatment Maximum primary treatment	120 180[(1)] 240	MGD
$CBOD_5$	Monthly average 7-day average	25 40	mg/L
TSS	Monthly average 7-day average	30 45	mg/L
Total Nitrogen	12-month rolling average[(2)]	N/A[(2)]	lb/day

[(1)] 1.5 DDWF
[(2)] Limits not applicable to North River, Oakwood Beach, Owls Head, and Port Richmond WPCPs.

NYCDEP has examined the feasibility of processing twice DDWF (240 MGD) through the complete WPCP. NYCDEP has found that it is not feasible to route all 240 MGD through the existing secondary treatment portion of the facility due to treatment process constraints, and that it is not feasible to construct new secondary facilities as the WPCP completely occupies the available land at the site (Figure 3-4).

3.2.1 Process Information

Figure 3-5 shows a schematic of the treatment process employed at Owls Head WPCP. Sewage from the Owls Head drainage area is transported through the north interceptor sewer (150-inch by 96-inch) and the south interceptor sewer (108-inch by 108-inch) which join together at a junction chamber. The plant has a functional Supervisory Control And Data Acquisition (SCADA) system that monitors and/or controls most major processes, including throttling gates, main sewage pumps (speed control only) and the secondary bypass gates. The junction chamber divides the flow from the influent sewer into two forebay branches, each of which contains a forebay sluice gate and a stop-plank assembly at the lowest ends. The forebay sluice gates are used to throttle the flow in the forebay branches. The gates close automatically in the event of a power failure. Downstream of the forebay sluice gates, each of the two forebay piping branches connects to a junction chamber, each of which contains a stop-plank assembly utilized for isolation purposes. Four pipe branches connect to four 80-inch by 180-inch screening channels, each equipped with one hydraulically operated influent sluice gate, a coarse and fine screen set up in series, and a hydraulically operated effluent sluice gate. After passing through the screening channels and the effluent sluice gates, sewage flow enters the wet well, the lowest point in the system.



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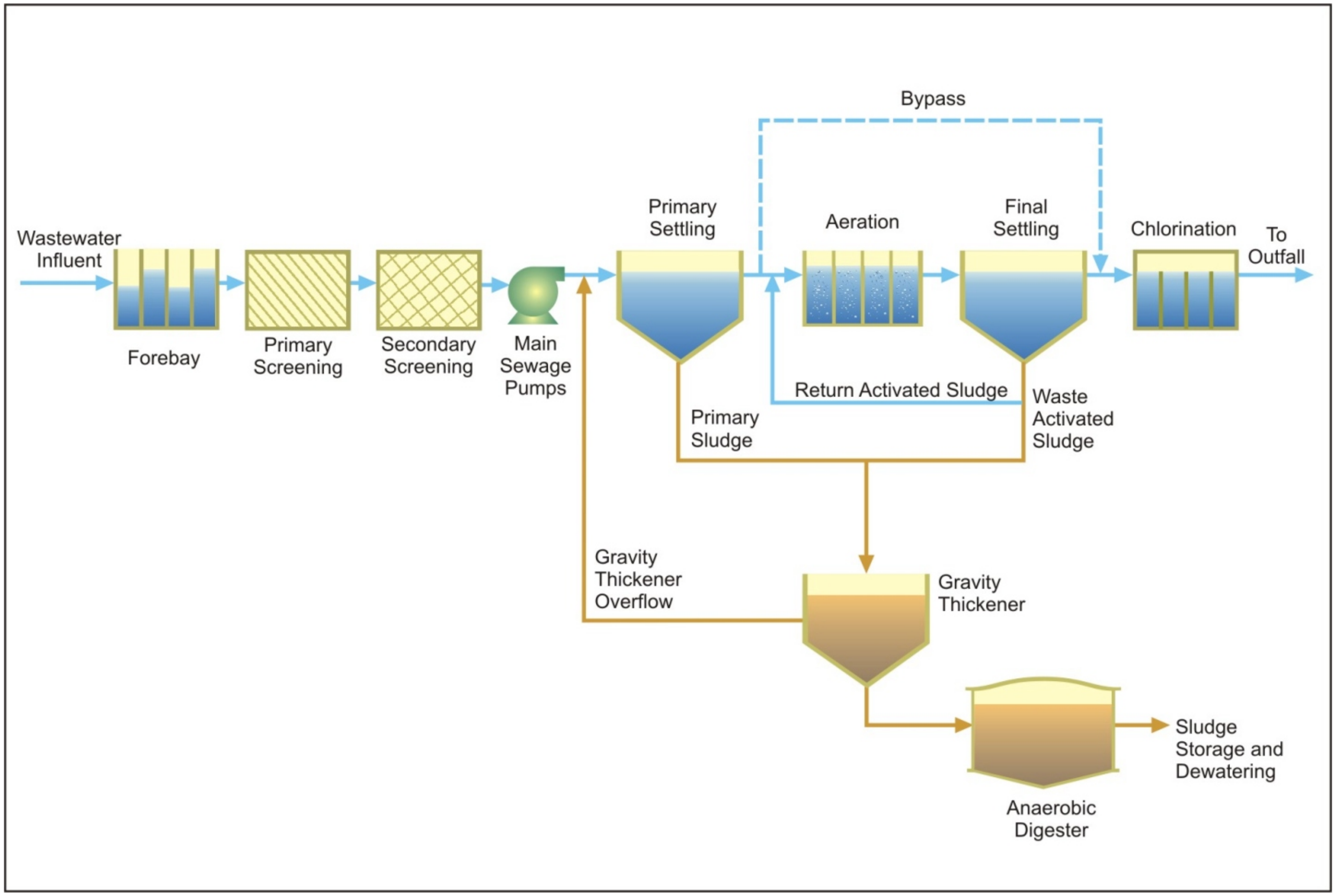
Gowanus Canal Waterbody/Watershed Facility Plan

Owls Head WPCP Process Layout and Site Plan

FIGURE 3-4



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Owls Head WPCP Process Flow Diagram

The screens are reciprocating-rake type, front cleaned, front return, mechanically cleaned bar (climber) screens that were designed for continuous operation. Primary and secondary screens are provided. The primary (coarse) screens have a 5/4-inch clear spacing and the secondary (fine) screens have a 3/4-inch clear spacing. The bar screen rakes elevate the captured screenings to a discharge chute approximately four feet above the opening floor. Screenings are dislodged by a screen wiper and dropped into a cubic yard container and are later transferred to a six-cubic-yard container and eventually picked up and transported to a designated New York City landfill according to a predetermined schedule.

Five 60-MGD vertical centrifugal or mixed flow-type pumps, driven directly by electric motors are available to pump the maximum design flow of 240 MGD with one pump held as a reserve. Each of the five main sewage pumps has a 700-HP electric motor of the wound-rotor induction type, suitable for speed control by varying rotor resistance. The synchronous speed of these motors is 390 rpm at 50 Hz. New main sewage pumps are currently being designed as 85-MGD capacity, with 800-HP and variable-frequency drives. Replacement of the pumps is anticipated to start in 2006. The sewage is discharged from the five main sewage pumps through their respective 42-inch diameter discharge lines to a 90-inch diameter force main that transports the sewage to the four primary settling tanks. The four primary settling tanks have a total volume of 4.8 MG and a surface overflow rate of 2,238 gpd/sf at average design flow. The primary settling tanks are equipped with steel chain and redwood flight sludge-collector mechanisms. Primary tank effluent flows to the aeration tanks through a channel equipped with wet-weather, overflow-bypass weirs.

The plant has a secondary bypass channel to convey primary effluent to the chlorine-contact tanks when the flow into the secondary treatment process exceeds 180 MGD. The capacity of the bypass channels is believed to be around 60 MGD.

Four 4-pass, step-feed aeration tanks are provided for step aeration with activated sludge. The total aeration tank volume is 18.7 MG and four 20,000 scfm blowers provide air through ceramic disc, full-floor coverage, fine-bubble diffusers. Aeration tank effluent flows by gravity to 16 final settling tanks. The collected solids are either wasted to the gravity thickeners or returned to the aeration tanks. The total volume of the final settling tanks is 13.5 MG, with a surface overflow rate of 800 gpd/sf at average design flow.

The plant effluent is disinfected with sodium hypochlorite solution. Sodium hypochlorite is fed with a rotary-feeder/eductor system, with metering pumps provided for prechlorination and backup. Two plug-flow contact tanks with a total volume of 2.5 MG are provided to detain the effluent for 15 minutes at peak flow prior to discharge to Upper New York Bay. An outfall sewer, with two branches and 64 diffusers, disperses the effluent approximately 220 feet into the Bay.

The primary solids are pumped to cyclone degritters to separate the grit from the primary sludge. Scum from the primary tanks is pumped to a scum-concentration tank. Grit and concentrated scum are trucked to a sanitary landfill. Degritted primary sludge is pumped to the sludge-processing complex, where it is mixed with the waste-activated sludge. Combined sludge is screened with mechanically cleaned bar screens prior to gravity thickening in four 80-foot diameter thickeners. Thickened sludge is pumped to four 80-foot diameter, high rate anaerobic digesters with a total volume of 7.2 MG. The digesters are mixed with a pumped liquid mixing system and are heated with external heat exchangers. The digesters are designed to operate in either the mesophilic or thermophilic modes. Digested sludge then flows to two 80-foot diameter gas extractors and eventually is pumped to two 60-foot diameter sludge storage tanks with a total volume of 1 MG. Digested sludge is transported by sludge vessel to the 26th Ward WPCP for dewatering and beneficial reuse. To remove odors, exhaust air from the thickener gallery, screening chamber, sludge-storage tanks, and grit and scum buildings is treated with nine 12-foot diameter, dual bed, activated-carbon adsorption units.

3.2.2 Wet-Weather Operating Plan

NYCDEP is required by its SPDES permit to maximize the treatment of combined sewage at the Owls Head WPCP. The permit requires treatment of flows of up to 180 MGD through complete secondary treatment. Further, to maximize combined sewage treatment, the SPDES permit requires that flows of up to 240 MGD to be processed through all elements of the WPCP except the aeration basins and the final settling clarifiers.

New York State requires the development of a WWOP as one of the 14 BMPs for collection systems that include combined sewers. The goal of the WWOP is to maximize flow to the WPCP, one of the nine elements of long-term CSO control planning. NYCDEP has developed a WWOP for each of its 14 WPCPs, and Table 3-4 summarizes the requirements for the Owls Head WPCP, and notes that flows beyond the maximum capacity of the aeration basins and final clarifiers (i.e., over 180 MGD) would cause damage to the WPCP by creating washout of biological solids and clarifier flooding. The WWOP therefore suggests that the facility operate at or near its maximum capacity as designed and configured, and as permitted by NYCDEC. The WWOP for Owls Head, attached in Appendix A, was submitted to NYSDEC in December 2007 as required by the SPDES permit.

3.2.3 Other Operational Constraints

NYSDEC and NYCDEP entered into a Nitrogen Control Consent Order that updated the New York City SPDES permits to reduce nitrogen discharges to the Long Island Sound and Jamaica Bay in order to reduce the occurrence of eutrophic conditions and improve attainment of dissolved oxygen numerical criteria. There are no effluent nitrogen limitations at the Owls Head WPCP associated with the Nitrogen Control Consent Order. Therefore, there are no plans to implement BNR at the Owls Head WPCP. However, because of ongoing efforts by the HEP for water quality improvements, it is possible that BNR may be required at some point in the future.

3.3. GOWANUS CANAL WATERSHED COLLECTION SYSTEM

The Gowanus Canal watershed covers an area totaling about 1,758 acres in western Brooklyn (Figure 3-1) and represents approximately 4 percent of Brooklyn's total area of about 46,000 acres. The Gowanus Canal watershed is highly urbanized, with approximately 94 percent of the area served by sewers. As shown in Table 3-5, combined sewers service the vast majority of the watershed, with only 2 percent served by storm sewers and 6 percent draining directly to the Canal as non-point source runoff.

Table 3-4. Wet Weather Operating Plan for Owls Head WPCP

Unit Operation	General Protocols	Rationale
Influent Gates and Screens	Leave gate in full open position until pump capacity is hit, screen channel level exceeds acceptable level with maximum pumping, bar screens become overloaded, or grit removal exceeds capacity. Set a third primary screen into operation and set screen rakes to continuous operation in order to accommodate increased flow.	To regulate flow to the plant and prevent excessive flows from destabilizing plant performance.
Main Sewage Pumps	As wet well level rises put off-line pumps in service and increase speed of variable speed pumps up to maximum capacity always leaving one pump out of service as standby.	Maximize flow to treatment plant and minimize need for flow storage in collection system and associated overflow from collection system into receiving waterbody.
Primary Settling Tanks	Make sure four primary sludge pumps are on-line and watch water surface elevations at the weirs for flooding and flow imbalances. Reduce flow if sludge cannot be withdrawn quick enough from the primaries, grit accumulation exceeds the plants ability to handle it, or a primary tank must be taken out of service.	Provide settling for the increased flows.
Bypass Channel	The bypass gate automatically opens or closes to maintain secondary flow at 180 MGD or greater.	To relieve flow to the aeration system and avoid excessive loss of biological solids and to relieve primary clarifier flooding.
Aeration Tanks	Keep at least four aeration tanks in operation and adjust the airflow to maintain proper dissolved oxygen levels.	To provide effective secondary treatment to storm flows up to 180 MGD.
Final Settling Tanks	Balance flows to the tanks and observe the clarity of the effluent to watch for solids loss.	High flows will substantially increase solids loadings to the clarifiers, which may result in high clarifier sludge blankets or high effluent TSS. This can lead to loss of biological solids that may destabilize treatment efficiency in dry weather conditions.
Chlorination	Check, adjust (increase), and maintain the hypochlorite feed rates to provide proper chlorine residual for adequate fecal kill.	Hypochlorite demand will increase as flow rises and secondary bypasses occur.
Sludge Handling	Proceed as normal.	Uninfluenced by wet weather.

Table 3-5. Gowanus Canal Watershed - Summary of Sewerage Categories

Sewerage Category	Drainage Area (Acres)	Percentage of Watershed
Point Sources		
Combined Sewers	1,612	92%
Storm Sewers	42	2%
Non-Point Sources		
Unsewered	104	6%
Total Watershed	1,758	100%

Overall, the collection system associated with the Gowanus Canal sewershed consists of 4 pump stations, 11 active CSO discharges, and 4 storm sewer discharges. The following sections describe the combined and storm sewer systems.

3.3.1 Combined Sewer System

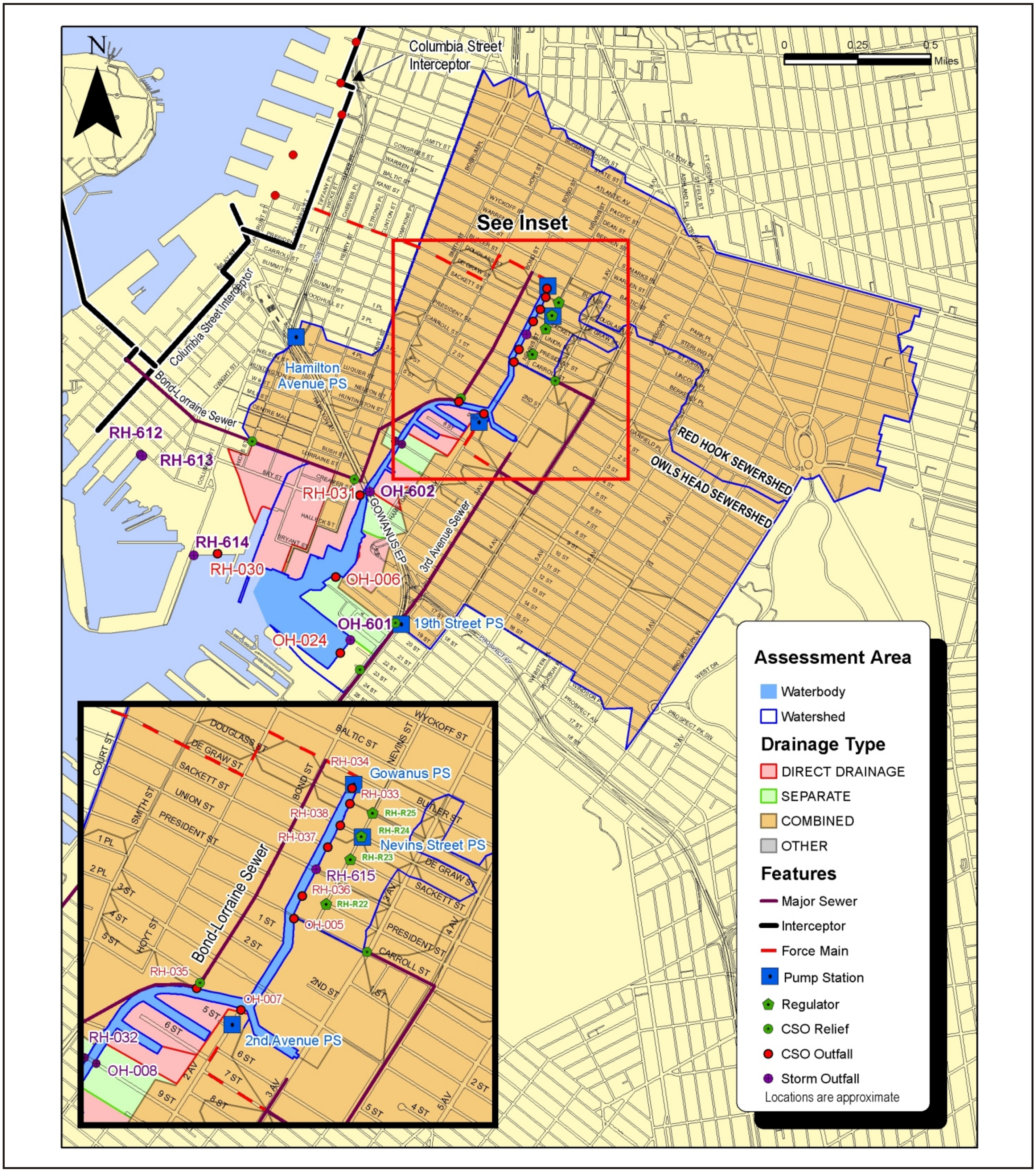
Combined sewers serve about 1,612 acres—92 percent—of the 1,758-acre Gowanus Canal watershed. Figure 3-6 presents the major components of this combined sewer system, including pump stations, force mains, major trunk sewers, regulators, CSO outfalls, and associated area delineations. As shown, the sewershed is comprised of two distinct subareas, one draining to the Red Hook WPCP and the other to the Owls Head WPCP. Combined-sewer discharges in each subarea are addressed in the SPDES permits for the corresponding WPCP (Red Hook: NY-0027083; Owls Head: NY-0026166). The following describes the combined sewer system in each of these subareas.

Red Hook Sub-Area

The portion of the Gowanus Canal sewershed draining to the Red Hook WPCP surrounds the upper reaches of the Canal and includes the area west of the Canal. This drainage area is approximately 933 acres, includes two pump stations, and seven active CSOs.

The Nevins Street and Gowanus Pump Stations operate within the Red Hook portion of the Gowanus Canal sewershed. The Nevins Street Pump Station, built in 1977 and last upgraded in 1980, is located on Nevins Street between Sackett Street and Degraw Street. Serving a drainage area of about 32 acres, this pump station has a capacity of 2.2 MGD. The pump station consists of two 2.2 MGD pumps and is designed so that the second pump is available as a standby to be used if the first pump needs maintenance work. During dry weather, the service area contributes an average sanitary flow of about 0.54 MGD. During wet weather, the pump station receives regulated combined sewer flow from four regulators (R-22, R-23, R-24, and R-25). The pump station conveys up to 2.2 MGD of the combined sewage via a force main to a trunk sewer feeding the Gowanus Pump Station. Excess flow is discharged to Gowanus Canal via outfall RH-038.

The Gowanus Pump Station, located on Douglass Street at the head of Gowanus Canal, was built in 1908 and was last upgraded in 2002. This pump station has a capacity of 20.2 MGD and serves a drainage area of about 657 acres. The pump station consists of five pumps, with a minimum of two pumps running at any given time. During dry weather, the service area contributes a sanitary flow of about 9.5 MGD. During wet weather, the pump station receives unregulated combined sewage flow from most of its drainage area as well as regulated combined sewage flow the Nevins Street Pump Station. Though the Gowanus Pump Station is designed to convey flow to the Columbia Street Interceptor via a force main in the Flushing Tunnel, the NYCDEP has experienced problems with that force main and is now temporarily rerouting pumped flow to the Bond-Lorraine Sewer (described below) via the Butler Street Interceptor. Using this configuration, the Gowanus Pump Station can convey up to about 28.5 MGD (due to a lower head loss versus the design configuration), with excess flows discharged to the head of Gowanus Canal via outfall RH-034. However, the capacity of the Bond-Lorraine Sewer is



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Gowanus Canal Sewershed-Sewer System Components

limited, and this configuration does not provide a net reduction of CSO volume versus the design configuration.

The Bond-Lorraine Sewer is a principal element of the Red Hook portion of the Gowanus sewershed. This 72-inch brick sewer runs from the Gowanus Pump Station southward along the western side of the Canal to Lorraine Street, where it turns west and ultimately connects to the Columbia Street interceptor. In addition to the force-main flow it receives from the Gowanus Pump Station, the Bond Lorraine Sewer also receives flow from combined-sewered areas west of the Canal. The Bond-Lorraine Sewer has two relief points that can discharge to Gowanus Canal via outfalls RH-031 and RH-035. In 2001 and 2004, the NYCDEP conducted sewer cleaning and television inspections of the Bond-Lorraine Sewer (Gannett Fleming, 2004). These inspections revealed sediment accumulations and other pipe restrictions that may limit the sewer's conveyance capacity.

There are a total of seven active CSO outfalls in the Red Hook portion of the Gowanus Canal sewershed. Table 3-6 presents a listing of these CSO outfalls' permit numbers, locations, dimensions, and associated regulators and drainage areas. Field inspections have determined that outfall RH-039 is closed and no longer discharges to the Canal. Field inspections also determined that outfall RH-032 (not shown in Table 3-6), though permitted as a CSO, is not connected to a combined sewer and is actually a stormwater discharge (see Section 3.3.2). In summary, of the nine CSOs permitted to discharge from the Red Hook service area to Gowanus Canal under the Red Hook WPCP SPDES permit (NY-0027083), only seven CSOs are active.

Owls Head Sub-Area

The portion of the Gowanus Canal sewershed draining to the Owls Head WPCP is generally located to the south and east of Gowanus Canal. This drainage area is approximately 679 acres and includes two pump stations, and four active CSOs.

The 2nd Avenue and 19th Street pump Stations operate within the Owls Head portion of the Gowanus Canal sewershed. The 2nd Avenue Pump Station, located at the northern terminus of the 2nd Avenue near the 4th Street turning basin, was built in 1990 and serves a drainage area of 558 acres. The pump station has a 1 MGD capacity that it achieves using one pump; a second pump is available as a spare. During dry weather, its service area contributes an average of 0.6 MGD of sanitary flow. During wet weather, a potential area of up to approximately 558 acres is tributary to the pump station, which conveys up to 1 MGD to the 3rd Avenue Sewer. Excess flow discharges to Gowanus Canal via outfalls OH-007 and OH-005.

The 19th Street Pump station, located near the intersection of 19th Street and 3rd Avenue, was built in 1951. With a rated capacity of 5 MGD, this pump station services separately sewered areas that generate an average of 2.5 MGD of sanitary flow. The pump station has one pump and a spare that is available for maintenance procedures. The 19th Street Pump Station conveys flow to the 3rd Avenue Interceptor Sewer.

Table 3-6. CSO Discharges to Gowanus Canal from Red Hook WPCP Service Area

Outfall Permit Number [1,2]	Outfall Location	Outfall Size	CSO Discharge From	Regulator / Relief Location	Combined Sewer Area (Acres) [4]
RH-031	Creamer St	72" diameter	Bond-Lorraine Sewer Relief	Lorraine St. & Smith St.	70
RH-033	Douglass St.	38"W x 44"H	Regulator R-25	Nevins St. & Douglass St.	5
RH-034	Butler St.	4 barrels, each 163" diameter	Gowanus Pump Station	Douglass St.	657
RH-035	Bond St.	48" diameter	Bond-Lorraine Sewer Relief	Bond St. & 4th St.	88
RH-036	President St.	18" diameter	Regulator R-22	Nevins St. & President St.	10
RH-037	Sackett St.	18" diameter	Regulator R-23	Nevins St. & Sackett St.	7
RH-038	Degraw St.	144"W x 62"H	Regulator R-24	Nevins St. & Degraw St.	10
RH-039 [3]	Douglass St.	38"W x 44"H	Bond-Lorraine Sewer Relief	NA (closed)	NA
Total Combined Sewer Areas (Acres)					**933**

(1) SPDES permit numbers replace "RH" with "NY-0027073."
(2) CSO-permitted outfall RH-032 (not shown) is a stormwater outfall, according to field inspections.
(3) CSO-permitted outfall RH-039 is closed, according to field inspection.
(4) Combined-sewer areas shown for Bond-Lorraine Sewer reliefs represent the incremental drainage area between reliefs.

There are a total of four reportedly active CSO outfalls in the Owls Head portion of the Gowanus Canal sewershed. Table 3-7 presents a listing of these CSO outfalls' permit numbers, locations, dimensions, and associated regulators and drainage areas. Field inspections have determined that an additional permitted CSO outfall, OH-009, is closed and no longer discharges to the Canal. Similarly, the field inspections also determined that another outfall permitted for CSO discharge, OH-008 (not shown in Table 3-7), is actually a stormwater discharge (see Section 3.3.2). The field inspections also revealed an additional relief on the 3rd Avenue Interceptor Sewer at 23rd Street, with an outfall to the lower end of Gowanus Canal at 23rd Street. This location was not associated with a SPDES number prior to April 2006, when NYCDEP and NYSDEC designated this CSO location as "OH-024." In summary, though there are five CSOs permitted to discharge to Gowanus Canal from the Owls Head service area under the Owls Head WPCP SPDES permit (NY-0026166), only three of these—plus a fourth at a previously unknown location—now discharge CSO to Gowanus Canal.

3.3.2 Stormwater Sewer System and Non-Point Source Runoff

Storm sewers serve about 42 acres, or 2 percent, of the 1,758-acre Gowanus Canal watershed. Figure 3-6 presents the stormwater discharge points using the numbering system employed by the NYCDEP Shoreline Survey. As shown, portions of the Gowanus Canal drainage area draining to both the Red Hook WPCP and the Owls Head WPCP contain some stormwater drainage areas. Stormwater outfalls in these areas are presented below.

Red Hook Sub-Area

The Red Hook portion of the Gowanus Canal drainage area contains one active stormwater outfall draining about 2 acres. This outfall was previously designated RH-032 as a permitted CSO, but field inspections determined that it is not connected to a combined sewer and that it is actually a stormwater discharge. As of April 2006, this outfall has been redesignated as "RH-601" to reflect that it conveys stormwater only. Field inspections of stormwater outfall RH-615 determined that this outfall does not receive flows from any area and does not discharge during wet weather or otherwise. Table 3-8 presents the locations, dimensions, and drainage areas associated with these stormwater outfalls.

Owls Head Sub-Area

The Owls Head portion of the Gowanus Canal drainage area contains three active stormwater outfalls draining a total of about 40 acres (see green-shaded areas on Figure 3-6). Table 3-9 lists these outfalls and presents the location, dimensions, and drainage area associated with each. Outfall OH-008 is permitted as a CSO, but field inspections determined that it is actually a stormwater discharge. There are two other documented stormwater discharges from this area.

Table 3-7. CSO Discharges to Gowanus Canal from Owls Head WPCP Service Area

Outfall Permit Number (1,2)	Outfall Location	Outfall Size	CSO Discharge From	Regulator / Relief Location	Combined Sewer Area (Acres) (5)
OH-005	5 ft south of Carroll St. Bridge	42" diameter	3rd Ave Sewer Relief	3rd Ave. & Carroll St.	34
OH-006	19th St. (north side)	36" diameter	3rd Ave Sewer Relief	3rd Ave. & 19th St.	306
OH-007	east of 2nd Ave.	78" diameter	2nd Ave Pump Station	3rd Ave. & 7th St.	339
OH-009 (3)	5th St.	78" diameter	3rd Ave Sewer Relief	NA (closed) (2)	0
OH-024 (4)	23rd St.	42"W x 24"H (Oval)	3rd Ave Sewer Relief	3rd Ave. & 23rd St.	NA
Total Combined Sewer Area (Acres)					**679**

(1) SPDES permit numbers replace "OH" with "NY-0026166."
(2) CSO-permitted outfall OH-008 (not shown) is a stormwater outfall, according to field inspection.
(3) CSO-permitted outfall OH-009 is closed, according to field inspection.
(4) This outfall was recently discovered and was designated "OH-024" in April 2006.
(5) Combined-sewer areas shown for 3rd Avenue Sewer reliefs represent the incremental drainage area between reliefs.

Table 3-8. Stormwater Discharges to Gowanus Canal from Red Hook WPCP Service Area

Stormwater Outfall	Outfall Location	Outfall Size	Stormwater Sewer Area (Acres)
RH-032 (RH-601)(1)	W. 9th St.	12" diameter	2
RH-615	10ft north of Union St. Bridge	8" diameter	0(2)
Total Stormwater Drainage Area			**2**

(1) RH-032 was a SPDES-permitted CSO location, but field inspections determined that this is a stormwater outfall. As of April 2006, this outfall is designated "RH-601."
(2) RH-615 is listed as a stormwater outfall, but field inspections determined that it has no tributary area.

Table 3-9. Stormwater Discharges to Gowanus Canal from Owls Head WPCP Service Area

Stormwater Outfall	Outfall Location	Outfall Size	Stormwater Sewer Area (Acres)
OH-008 (OH-607)(1) OH-008(1)	E. 9th St.	12" diameter	8
OH-601	22^{nd} St.	36"W x 48"H (Egg)	22
OH-602	30ft south of Gowanus Expressway	18" diameter	10
Total Stormwater Drainage Area			**40**

(1) OH-008 is permitted as a CSO outfall but field inspections determined that it is a stormwater outfall. As of April 2006, this outfall is designated "OH-607"

Overland Runoff

Unsewered areas immediately adjacent to Gowanus Canal contribute direct overland runoff during rain events. This overland runoff represents a non-point source discharge to the waterbody from land areas totaling approximately 104 acres. These areas are shown shaded in pink on Figure 3-6

3.4 SEWER SYSTEM MODELING

Mathematical watershed models are used to simulate the hydrology (rainfall runoff) and hydraulics (sewer system flows and water levels) of a watershed, and are particularly useful in characterizing sewer system response to rainfall conditions and in evaluating engineering alternatives on a performance basis. In the hydrology portion of the model, climatic conditions (such as hourly rainfall intensity) and physical watershed characteristics (such as slope, imperviousness, and infiltration) are used to calculate rainfall-runoff hydrographs from individual subcatchments. These runoff hydrographs are then applied at corresponding locations in the sewer system as inputs to the hydraulic portion of the model, where the resulting hydraulic grade lines and flows are calculated based on the characteristics and physical features of the sewer system, such as pipe sizes, pipe slopes, and flow-control mechanisms like weirs. Model output includes sewer-system discharges which, when coupled with pollutant concentration information, provide input necessary for receiving-water models to determine water-quality conditions. The following generally describes the tools employed to model the Gowanus Canal watershed. A more detailed write up describing the calibration of the model-calibration and model-projection process is provided under separate cover in the LTCP WB/WS Landside Modeling Report.

3.4.1 InfoWorks CS™ Modeling Framework

The hydraulic modeling framework used in this effort is a commercially available, proprietary software package called InfoWorks CS™, developed by Wallingford Software of the United Kingdom. InfoWorks CS™ is a hydrologic/hydraulic modeling package capable of performing time-varying simulations in complex urban settings for either short-term events or long-term periods, with output of calculated hydraulic grade lines and flows within the sewer system network and at discharge points. InfoWorks CS™ solves the complete St. Venant hydraulic equations representing conservation of mass and momentum for sewer-system flow and accounts for backwater effects, flow reversals, surcharging, looped connections, pressure flow, and tidally affected outfalls. Similar in many respects to the USEPA's older Storm Water Management Model (SWMM), InfoWorks CS™ offers a state-of-the-art graphical user interface with greater flexibility and enhanced post-processing tools for analysis of model calculations. In addition, InfoWorks CS™ utilizes a four-point implicit numerical solution technique that is generally more stable than the explicit solution procedure used in SWMM.

Model input for InfoWorks CS™ includes watershed characteristics for individual subcatchments, including area, surface imperviousness and slope, as well as sewer-system characteristics, such as information describing the network (connectivity, pipe sizes, pipe slopes, pipe roughness, etc.) and flow-control structures (pump stations, regulators, outfalls, WPCP headworks, etc.). Hourly rainfall patterns and tidal conditions are also important model inputs. InfoWorks CS™ allows interface with graphical information system (GIS) data to facilitate model construction and analysis.

Model output includes flow and/or hydraulic gradeline at virtually any point in the modeled system, at virtually any time during the modeled period. InfoWorks CS™ provides full interactive views of data using geographical plan views, longitudinal sections, spreadsheet-style grids and time-varying graphs. A three-dimensional junction view provides an effective visual presentation of manholes. Additional post-processing of model output allows the user to view the results in various ways as necessary to evaluate system response.

3.4.2 Application of Models to Gowanus Canal

New York City is comprised of 14 independent sewersheds, each having a distinct sewer system model. Because the Gowanus Canal watershed overlaps two different WPCP service areas, two different models were employed for the Gowanus Canal study area: one model for the Red Hook WPCP service area, and a second model for the Owls Head WPCP service area. Each of these models had been previously constructed using information and data compiled from the NYCDEP's as-built drawings, WPCP data, previous and ongoing planning projects, regulator improvement programs, and inflow/infiltration analyses. This information includes invert and ground elevations for manholes, pipe dimensions, pump-station characteristics, and regulator configurations and dimensions.

Model simulations include WPCP headworks, interceptors, branch interceptors, major trunk sewers, all sewers greater than 60 inches in diameter plus other smaller, significant sewers, and control structures such as pump stations, diversion chambers, tipping locations, reliefs, regulators and tide gates. As presented in LTCP WB/WS Landside Modeling Report, these models were previously calibrated and validated using flow and hydraulic-elevation data collected during the Inner and Outer Harbor CSO Facility Planning Projects, as well as more recent data collected in the past several years for facility planning. Field verifications were conducted by the NYCDEP during its Use and Standards Attainment (USA) Project and ongoing facility planning projects to confirm and re-measure system components where data or information gaps existed. All CSO and stormwater outfalls permitted by the State of New York are represented in the models, with stormwater discharges from separately sewered areas simulated using separate models as necessary.

Conceptual alternative scenarios representing no-action and other alternatives were simulated for the design meteorological condition (1988 JFK rainfall) as described below. Tidally influenced discharges were calculated on a time-variable basis. Pollutant concentrations selected from field data and best professional judgment were assigned to the sanitary and stormwater components of the combined sewer discharges to calculate variable pollutant discharges. Similar assignments were made for stormwater discharges. Discharges and pollutant loadings were then post-processed and used as inputs to the receiving-water model of Gowanus Canal, described in Section 4.

3.4.3 Baseline Design Condition for Sewer System Modeling

Sewer-system or "landside" modeling can be an important tool in evaluating the impact of proposed physical changes to the sewer system and/or of proposed changes to the operation of the system. In order to provide a basis for these comparisons, a "Baseline condition" was developed. This Baseline condition generally represents the current state of the watershed and sewer system, with certain exceptions specifically used for planning purposes. For the Gowanus Canal landside model, the Baseline conditions are summarized as follows:

1) Sanitary (dry-weather) sewage flow rates at each WPCP reflect year 2045 projections: 40 MGD at Red Hook and 115 MGD at Owls Head.

2) Wet-weather treatment capacities at each WPCP reflects 2003 conditions: 113 MGD at Red Hook and 235 MGD at Owls Head.

3) The Gowanus Pump Station operates at a capacity of 28.5 MGD and routes flow to the Bond-Lorraine Sewer.

4) Sedimentation levels in sewers are associated with reasonable maintenance.

Establishing the future sanitary sewage flow at the WPCPs is a critical step in the Waterbody/Watershed Planning analysis because the City's CSO-control program relies in part on the capacity of the sewage conveyance and treatment systems to reduce CSO overflows. Increases in sanitary sewage flows associated with increased populations will reduce the capacity available for wet-weather flow, thereby increasing the CSO volumes that need to be accounted for in the planning process. The year 2045 has been selected as the planning horizon for the analyses contained herein. Some 40 years in the future, 2045 was selected as a point in time when CSO facilities currently under construction (Paerdegat Basin and Alley Creek CSO retention facilities) or recently completed (Flushing Creek CSO retention facility) will likely be in need of a major upgrade. For example, NYCDEP recently completed a major renovation to the Spring Creek CSO retention facility after over 35 years of operation. NYCDEP generally finds that it is most cost effective to construct facilities sized in accordance with expected future populations to avoid constructing the facilities larger than necessary to perform the functions expected of them during their natural like cycle. These facilities can then be reconstructed during future renovations depending on the needs at that point in time.

At the direction of the Mayor's Office, the Department of City Planning assessed population growth from 2000 to 2010 and 2030 in a set of projections made for 188 neighborhoods within the City (NYCDCP, 2006). These assessments included general potential future development activity as well as specific development projects, such as the Atlantic Yards project (Section 2.2.3). NYCDEP escalated these populations forward to 2045 by assuming that the rate of growth between 2045 and 2030 would be 50 percent of the rate of growth between 2000 and 2030. NYCDEP used GIS analyses to distribute these population projections among the subcatchments draining to each CSO regulator, and then applied the WPCP-specific, per-capita sanitary sewage flow rate from calendar year 2000 to develop a conservatively high estimate of the expected sanitary sewage flow rates for each subcatchment. Overall, this increase in the dry-weather flow rates to 40 MGD (from 30 MGD in 2006) at the Red Hook WPCP, and to 115 MGD (from 95 MGD IN 2006) at the Owls Head WPCP, properly accounts for the potential reduction in available wet-weather treatment capacity associated with projections of a larger population.

For the same reasons stated above, the wet-weather capacity of the sewage conveyance and treatment systems is another critical factor in the planning process. In this regard, existing conditions were defined as the capacity of the conveyance and treatment systems prior to the development of wet-weather operating plans and infrastructure improvements required by the CSO Consent Order; in short, the capacity of the conveyance and treatment systems in calendar year 2003. The wet-weather capacities shown represent the average of the maximum capacities observed for the top 10 storms during 2003 (HydroQual, 2004b).

In the Gowanus Canal drainage area, an important component of the sewer system is the Gowanus Pump Station. As described in Section 3.3.1, although the station is designed to pump up to 20.2 MGD to the Columbia Street Interceptor, the current operational configuration allows the station to pump up to 28.5 MGD via the short Butler Street force main to the Bond-Lorraine Sewer.

Over time, sedimentation buildup can negatively impact the conveyance capacity of the sewer system. Although the sewer system is generally designed to be self-cleaning, sedimentation buildup can be a problem in locations where the sewage has high solids content and/or where sewer slopes are relatively flat. One such area in the Gowanus Canal sewershed is the Bond-Lorraine Sewer, which the City has cleaned on multiple occasions. To account for the reduction in the theoretical conveyance capacity of this 72-inch-diameter sewer due to sedimentation that occurs despite reasonable cleaning efforts, all modeling analyses herein (Baseline and all subsequent projections) assume a buildup of 15 inches through most of the sewer, and 18 inches upstream of a constriction located at Bond and 5th Street. All other sewers are assumed to be clean.

Meteorological Conditions For Modeling Analyses

As discussed above, the Baseline condition provides a basis of comparison so that subsequent modeling scenarios can evaluate the impact of specific proposed changes affecting the sewer system. Such comparisons dictate that the same meteorological (rainfall) conditions be used in each evaluated scenario. For planning purposes, a rainfall condition that is consistent with the long-term annual average is appropriate and consistent with the federal CSO Control Policy. Long-term rainfall records measured in the New York City metropolitan area were analyzed to identify potential rainfall design years to represent long-term, annual average conditions. Statistics were compiled to determine:

- Annual total rainfall depth
- Annual total number of storms
- Annual average storm volume
- Annual average storm intensity
- Annual total duration of storms
- Annual average storm duration
- Annual average time between storms

A more detailed description of these analyses is provided under separate cover (HydroQual, 2004a). Although no year was found having the long-term average statistics for all of these parameters, the rainfall record measured at the National Weather Service gage at John F. Kennedy (JFK) International Airport during calendar year 1988 is representative of overall, long-term average conditions in terms of annual total rainfall and storm duration. Table 3-10 summarizes some of the statistics for the 1988 rainfall record and the long-term record at JFK Airport. As shown, the aggregate statistics indicate that 1988 is representative of the long-term conditions. With regard to storm intensity, an important factor impacting CSOs, the 1988 value is more than one standard deviation greater than the median, indicating that using 1988 as a design year would provide conservative results with respect to CSOs and their water quality impacts. Another characteristic that makes the 1988 rainfall record suitable as a design year is the fact that it contains critically high rainfall conditions during both a recreational period (July) and a shellfishing period (November).

As a result, the JFK 1988 rainfall record was selected as an appropriate design condition for which to evaluate sewer system response to rainfall. The JFK 1988 record has also been adopted as a design condition by New York Harbor Estuary Program to evaluate water-quality conditions in the New York/New Jersey Harbor Estuary, and by the New Jersey Department of Environmental Protection for CSO performance evaluations.

The potential impact of climate change on future meteorological conditions was not forecast for these planning analyses. However, the NYCDEP is concerned about this issue and is currently investigating how climate change could impact rainfall conditions in the New York metropolitan area. The Long-Term Control Plans will incorporate the ongoing analysis of the potential impacts of climate change on wet-weather operations, CSOs, and ambient water quality.

Table 3-10. Comparison of Annual 1988 and Long-Term Statistics JFK Rainfall Record (1970-2002) [1]

Rainfall Characteristic	Long-Term Statistics (1970-2002)		1988 Statistics	
	Median	Return Period (years)	Median	Return Period (years)
Annual Total Rainfall Depth (inches)	39.4	2.0	40.7	2.6
Average Storm Intensity (inch/hour)	0.057	2.0	0.068	11.3
Annual Average Number of Storms	112	2.0	100	1.1
Average Storm Duration (hours)	6.08	2.0	6.12	2.1

[1] (HydroQual, 2004)

3.5 DISCHARGE CHARACTERISTICS

As indicated in Section 3.4, sewer-system modeling is useful to characterize discharges from the sewer system. Because long-term monitoring of outfalls is difficult and sometimes not possible in tidal areas, sewer-system models that have been calibrated to available measurements of water levels and flows can offer a more complete and useful characterization of discharge quantities. Sewer-system models can also be used to estimate the relative percentage of sanitary sewage versus rainfall runoff discharged from a CSO. This is particularly helpful when developing pollutant loads, since it allows application of different pollutant concentrations for sanitary sewage and runoff instead of a fixed pollutant concentration for combined sewage.

Section 3.5.1 presents information related to the quantity (volume) discharged into the waterbody for the Baseline condition. Section 3.5.2 characterizes the quality (pollutant concentration) developed to assign pollutant concentrations to discharges. Section 3.5.3 summarizes the pollutant loadings discharged to Gowanus Canal for the Baseline condition. Section 3.5.4 discusses the potential for toxic discharges to Gowanus Canal, and Section 3.5.5 provides an overview of the effect of urbanization on discharges.

3.5.1 Characterization of Discharged Volumes, Baseline Condition

The calibrated watershed models described in Section 3.4 were used to characterize discharges to Gowanus Canal for the Baseline condition. Table 3-11 summarizes the results with statistics relating the annual CSO and stormwater discharges from each point-source outfall for the Baseline condition. Approximately 32 percent of the total annual CSO volume to Gowanus Canal is discharged at RH-034, the outfall associated with the Gowanus Pump Station, located at the head of the Canal. An additional 18 percent of the total annual CSO volume is discharged from OH-007, an outfall located halfway between the head of the Canal and Gowanus Expressway/Hamilton Avenue. CSO discharges from RH-034 are calculated to occur during 56 of the 100 rainfall events in the Baseline condition; discharges from RH-035 occur during 75 events.

3.5.2 Characterization of Pollutant Concentrations, Baseline Condition

Pollutant concentrations associated with intermittent, weather-related discharges are notoriously variable. In part for this reason, analyses to characterize discharged pollutants utilized estimates of the relative split of sanitary sewage versus rainfall runoff in discharged flows. Pollutant concentrations for sanitary sewage are attributed to the sanitary portion, and concentrations for stormwater are attributed to the rainfall runoff portion of the discharged flow volumes.

Table 3-12 presents the pollutant concentrations associated with the sanitary and stormwater components of discharges to Gowanus Canal. Sanitary concentrations were developed based on sampling of WPCP influent during dry-weather periods, as described elsewhere in more detail (NYCDEP, 2002). Stormwater concentrations were developed based on sampling conducted citywide as part of the Inner Harbor Facility Planning Study (Hazen and

Sawyer, 1993), and sampling conducted citywide by NYCDEP for the USEPA Harbor Estuary Program (HydroQual, 2005d).

3.5.3 Characterization of Pollutant Loads, Baseline Condition

Pollutant-mass loadings were calculated using the pollutant concentrations shown in Table 3-12, applied to the discharge volumes and sanitary/rainfall-runoff splits provided by the watershed model, as described above. Table 3-13 presents a summary of the annual discharges to Gowanus Canal for the Baseline condition.

As shown in Table 3-13 and summarized on Figure 3-7, CSOs dominate the loadings of biochemical oxygen demand (BOD), total suspended solids (TSS), and total coliform bacteria to Gowanus Canal. Moreover, CSO discharges from the Gowanus Pump Station (RH-034) represent between 45 and 71 percent of the total loadings of these pollutants.

3.5.4 Effects of Urbanization on Discharge

This section describes some of the important aspects of urbanization with respect to the watershed and presents a comparison of the discharge characteristics projected for the pastoral condition relative to the existing, urbanized condition.

The urbanization of the Gowanus Canal drainage area from a pastoral watershed to an urban sewershed is described in Section 2. The pastoral condition featured undeveloped uplands that provided infiltration of incident rainfall and contributed continuous freshwater inputs. Urbanization brought increased population, increased pollutants from sewage and industry, construction of sewer systems, and physical changes affecting the surface topography and imperviousness of the watershed. Increased surface imperviousness generates more runoff that is less attenuated by infiltration processes, and the sewer systems replaced natural overland runoff pathways with a conveyance system that routes the runoff directly to the waterbody—without the attenuation formerly provided by surrounding wetlands. As a result, more runoff is generated, and it is conveyed more quickly and directly to the waterbody. These changes also affect how pollutants are transferred along with the runoff on its way to the waterbody.

Table 3-11. Gowanus Canal Discharge Summary for Baseline Condition [1,2]

Outfall	Discharge Volume (MG)	Percentage of CSO or Stormwater Volume	Number of Discharges [3]
Combined Sewer			
RH-034	121	32.1	56
RH-035	111	29.5	75
OH-007	69	18.4	47
RH-031	35	9.4	33
OH-024	23	6.2	35
OH-006	13	3.3	33
RH-036	1.6	0.4	21
RH-038	0.9	0.2	18
OH-005	0.7	0.2	5
RH-037	0.5	0.1	16
RH-033	0.2	0.1	14
Total CSO	377	100	75
Storm Sewer			
OH-601	10	13.8	66
RH-032	1.5	2.1	38
OH-008	0.1	0.2	10
OH-602	0.1	0.2	3
Overland Runoff	62	83.8	79
Total Stormwater	74	100	79
Total	**452**	**NA**	**NA**

(1) Baseline condition reflects design precipitation record (JFK, 1988) and sanitary flows projected for year 2045 (Red Hook WPCP: 40 MGD; Owls Head WPCP: 115 MGD)
(2) Totals may not sum precisely due to rounding.
(3) Number of discharges reflects minimum modeled threshold flow of 0.01 MGD per 5-minute interval.

Table 3-12. Sanitary and Stormwater Discharge Concentrations, Baseline Condition

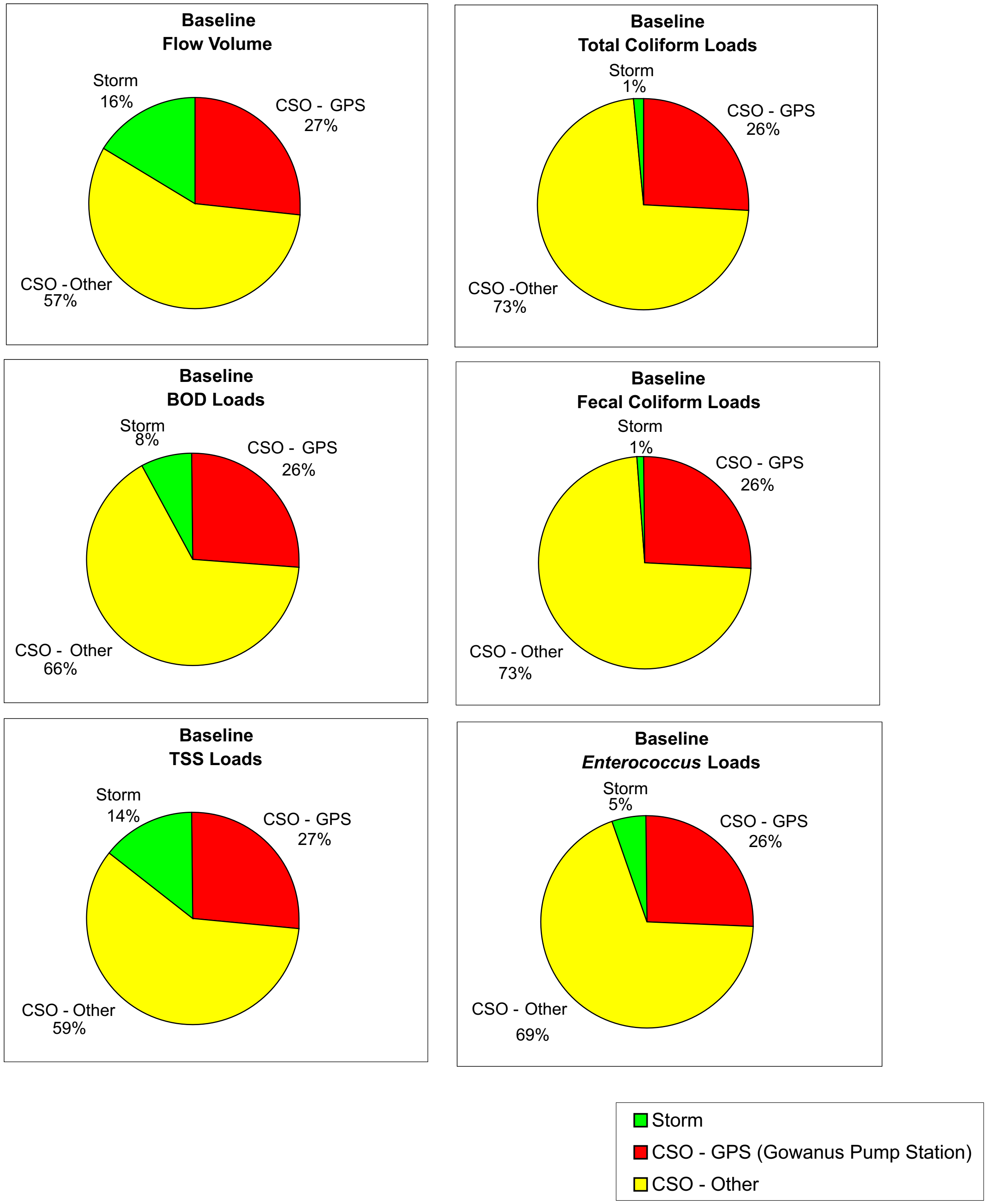
Constituent	Sanitary Concentration	Stormwater Concentration
Dissolved Oxygen, (mg/L)	1.0 mg/L	4.0 mg/L
Biochemical Oxygen Demand (BOD) (mg/L)	120 mg/L [1]	15 mg/L [2]
Total Suspended Solids (TSS) (mg/L)	115 mg/L [1]	60 mg/L [2]
Total Coliform Bacteria (MPN/100mL)	$150x10^5$ [1,2]	$2.0x10^5$ [2,3]
Fecal Coliform Bacteria (MPN/100mL) [4]	$27x10^5$ [1,2]	$0.3x10^5$ [2,3]
Enterococci (MPN/100mL) [4]	$10x10^5$ [1,2]	$0.7x10^5$ [3]

(1) NYCDEP, 2002.
(2) Hazen and Sawyer, 1993.
(3) HydroQual, 2005d.
(4) Bacterial concentrations expressed as "most probable number" of cells per 100 mL.

Table 3-13. CSO and Stormwater Discharge Loadings, Baseline Condition [1]

Constituent	GPS CSO Loading [2]	Other CSO Loading [3]	Stormwater Loading	Total Loading
Biochemical Oxygen Demand (BOD)	31,723 lbs	78,833 lbs	9,321 lbs	119,878 lbs
Total Suspended Solids (TSS)	69,290 lbs	152,631 lbs	37,285 lbs	259,207 lbs
Total Coliform Bacteria [4]	$11.5x10^{15}$ MPN	$31.9x10^{15}$ MPN	$0.6x10^{15}$ MPN	44.9×10^{15} MPN
Fecal Coliform Bacteria [4]	$2.1 x10^{15}$ MPN	$5.7x10^{15}$ MPN	$0.09x10^{15}$ MPN	7.8×10^{15} MPN
Enterococci [4]	$1.0 x10^{15}$ MPN	$2.7x10^{15}$ MPN	$0.2x10^{15}$ MPN	3.8×10^{15} MPN

(1) Loadings represent annual total during Baseline simulation.
(2) GPS CSO loadings reflect CSO discharges from the Gowanus Pump Station (RH-034).
(3) Other CSO loadings reflect all CSO discharges to study area except the GPS CSO loadings.
(4) Bacterial loadings expressed as most probable number (MPN) of cells.



New York City
Department of Environmental Protection

Watershed Loading Comparisons Baseline Conditions

Furthermore, the urbanized condition also features additional sources of pollution from CSOs and industrial/commercial activities.

Prior to construction of Gowanus Canal in the 1840s, the Gowanus Creek watershed consisted of mostly farms and mills that were on the edge of the City of Brooklyn. At that time, the population of the pre-urbanized watershed was likely about 10,000 (roughly 8 persons per acre), based on available information from the U.S. Census Bureau, which estimates that the entire population of Kings County was just over 1 million in 1900, with populations centered outside of the Gowanus area. The Gowanus Canal watershed currently had a population of approximately 108,800 (62 persons per acre) in 2000, based on U.S. Census Bureau information.

Urbanization of the watershed has altered its runoff yield tributary to Gowanus Canal by increasing its imperviousness. Imperviousness is a characteristic of the ground surface that reflects the percentage of incident rainfall that runs off the surface rather than is absorbed into the ground. While natural areas typically exhibit imperviousness of 10 to 15 percent, imperviousness in urban areas can be 70 percent or higher. As presented in Section 2, land uses in the urbanized Gowanus Canal watershed are only about two percent parks; 98 percent of the area's land uses feature rooftops, sidewalks, streets, and paved playgrounds and schoolyards. Overall, the calculated imperviousness of the Gowanus Canal watershed is about 62 percent. This represents a potential increase in runoff of up to roughly six times the pre-urbanized, pastoral condition.

In a pastoral condition, runoff from a watershed typically reaches the receiving waters through a combination of overland surface flow and subsurface transport, typically with ponding and other opportunities for retention and infiltration. Tidal wetland areas previously surrounding Gowanus Creek would have further attenuated wet-weather discharges. The urbanization of the Gowanus Canal watershed reduced infiltration and natural subsurface transport and eliminated all natural streams previously tributary to Gowanus Creek so that there are no longer any continuous freshwater tributaries to the waterbody. Runoff is transported via roof leaders, street gutters and catch basins into the combined and separate sewer system, which then discharges directly to Gowanus Canal since the wetlands have been eliminated. Urbanization has thus simultaneously decreased retention and absorption of runoff during transport and decreased the travel time for runoff to reach the waterbody. When combined with the increased runoff due to increased imperviousness of the watershed, the end result is increased peak discharge rates and higher total discharge volumes to the waterbody during wet weather.

Table 3-14 presents a summary of pre-urbanized and urbanized conditions for the Gowanus Creek and Gowanus Canal watersheds, respectively. The pre-urbanized condition is circa 1840, prior to construction of the Canal, while the urbanized condition reflects current conditions. The table demonstrates how wet-weather discharges, estimated using watershed models with the design-condition precipitation record (JFK gage, 1988), are projected to have increased from the pastoral to the urbanized condition. The total, annual wet-weather discharge in the pastoral condition was approximately 143 MG, compared to 473 MG in the urbanized condition, representing a more than three-fold increase. For the same precipitation record, the maximum discharged volume in a single storm increased by an even wider margin, from 8.8 MG in the pastoral condition to 33.6 MG in the urbanized condition. Instantaneous peak flows increased from 38.6 MGD in the pastoral condition to 246.5 MGD in the urbanized condition—an increase of over six times.

Table 3-14. Urbanization and Effects on Hydrology

Watershed Characteristic	Pastoral[1]	Urbanized[2]
Drainage Area (acres)[3]	1,286	1,758
Adjacent Wetlands (acres)[4]	439	0
Population[5]	~10,000	108,800
Imperviousness	10 %	62 %
Annual Wet-Weather Discharge (MG)[6]	143	473
Top Storm, Wet-Weather Discharge (MG)[6]	8.8	33.6
Peak Runoff Rate (MGD)[6]	38.6	246.5

(1) Pastoral conditions reflect pre-urbanized Gowanus Creek watershed, circa 1840
(2) Urbanized conditions reflect existing Gowanus Canal watershed
(3) Drainage area estimates do not include any wetlands
(4) Wetland area for pre-urbanized condition approximated from historical maps
(5) Population estimates for 1840 (pre-urbanized) and 2000 (urbanized), based on U.S. Census information
(6) Wet-weather discharge estimates generated using watershed model with JFK 1988 precipitation record; includes stormwater

Urbanization has also altered the pollutant character of wet-weather discharges from the watershed. The original rural landscape of forests, fields and wetlands represents pristine conditions with pollutant loadings resulting from natural processes (USEPA, 1997). These natural loadings, while having an impact of water quality in the receiving water, are insignificant compared to the urbanized-condition loadings from CSO and stormwater point sources.

Wet-weather discharges from a combined sewer system contain a mixture of sanitary sewage and urban runoff that is significantly stronger in pollutant concentrations than natural runoff. These pollutants include coliform bacteria, oxygen-demanding materials, suspended and settleable solids, floatables, oil and grease, and others. Table 3-15 presents a loading comparison for TSS and BOD—two pollutants with significant impact on water quality in Gowanus Canal. The loadings are based on the watershed model discharge volumes (Table 3-14) and pollutant concentrations taken from literature sources for pastoral conditions and as determined for existing conditions for the urbanized condition; stormwater concentrations used for the urbanized condition are typically higher than those for a rural or pristine condition. The table demonstrates that urbanization of the watershed has substantially increased pollutant loadings to Gowanus Canal.

Table 3-15. Effects of Urbanization on Watershed Pollutant Loadings

Annual Pollutant Load(1)	Pastoral(2)	Urbanized(3)	Change
Total Suspended Solids (kg/year)	71,500	252,500	353 %
Biochemical Oxygen Demand (kg/year)	17,900	89,600	500 %

(1) Annual pollutant loads reflect watershed model calculations for the design-condition precipitation record (JFK gage, 1988)
(2) Pastoral condition reflects pre-urbanized conditions and natural pollutant concentrations in stormwater
(3) Urbanized condition reflects existing pollutant concentrations found in CSO and stormwater discharges

3.5.5 Toxics Discharge Potential

Early efforts to reduce the amount of toxic contaminants being discharged to the New York City open and tributary waters focused on industrial sources and metals. For industrial source control for separate and combined sewer systems, USEPA requires approximately 1,500 municipalities nationwide to implement Industrial Pretreatment Programs (IPPs). The intent of the IPP is to control toxic discharges to public sewers that are tributary to sewage treatment plants by regulating Significant Industrial Users (SIU). If a proposed IPP is deemed acceptable, USEPA will decree the local municipality a “control authority.” NYCDEP has been a control authority since January 1987, and enforces the IPP through Chapter 19 of Title 15 of the Rules of the City of New York (Use of the Public Sewers), which specifies excluded and conditionally accepted toxic substances along with required BMPs for several common discharges such as photographic processing waste, grease from restaurants and other non-residential users, and perchloroethylene from dry cleaning. NYCDEP has been submitting annual reports on its activities since 1996. The 310 SIUs that were active citywide at the end of 2004 discharged an estimated average total mass of 38.2 pounds per day (lbs/day) of the following metals of concern: arsenic, cadmium, copper, chromium, lead, mercury, nickel, silver and zinc.

As part of the IPP, NYCDEP analyzed the toxic metals contribution of sanitary flow to CSOs by measuring toxic metals concentrations in WPCP influent during dry weather in 1993. This program determined that of the 177 lbs/day of regulated metals being discharged by regulated industrial users only 2.6 lbs/day (1.5 percent) were bypassed to CSOs. Of the remaining 174.4 lbs, approximately 100 lbs ended up in biosolids, and the remainder was discharged through the main WPCP outfalls. Recent data suggest even lower discharges. In 2003, the average mass of total metals discharged by all regulated industries to the New York City WPCPs was less than 39.1 lbs/day, which would translate into less than 1 lb/day bypassed to CSOs from year 2003 regulated industries if the mass balance calculated in 1993 is assumed to be maintained. A similarly developed projection was cited by the 1997 NYCDEP report on meeting the nine minimum CSO control standards required by federal CSO policy, in which NYCDEP considered the impacts of discharges of toxic pollutants from SIUs tributary to CSOs (NYCDEP, 1997). The report, audited and accepted by USEPA, includes evaluations of sewer system requirements and industrial user practices to minimize toxic discharges through CSOs. It was determined that most regulated industrial users (of which SIUs are a subset) were discharging relatively small quantities of toxic metals to the NYC sewer system.

There are five SIUs within the Gowanus Canal watershed. The total permitted flow rate of these SIUs is 0.024 MGD, which corresponds to about 0.2 percent of the 14.1 MGD daily dry-weather flow generated within the watershed, or 0.01 percent of the 1,215 MGD daily dry-weather flow generated City-wide. It can be inferred from these flows that, of the 39.1 lb/day of metals in the City-wide dry-weather flow, less than 0.004 lbs/day of metals are generated in the Gowanus Canal area. Since a portion of the combined sewage generated during wet weather is captured for treatment, the potential metals load to Gowanus Canal from SIUs during wet weather is even smaller. Since no discharge from these sources occurs during dry weather, the daily average (for wet and dry weather) loading is further reduced. As a result of the small scale of this potential source, NYSDEC has not listed Gowanus Canal as being impaired by toxic pollutants associated with CSO discharges. As such, metals and toxic pollutants are not considered to be pollutants of concern for the development of this Waterbody/Watershed Facility Plan.

As discussed in Section 2.3, other potential sources of toxics to Gowanus Canal include some shoreline issues and activities, such as previous accidental fuel spills and currently regulated activities. In addition, as in any industrial waterway, fuel spills directly to the waterbody represent an additional potential source.