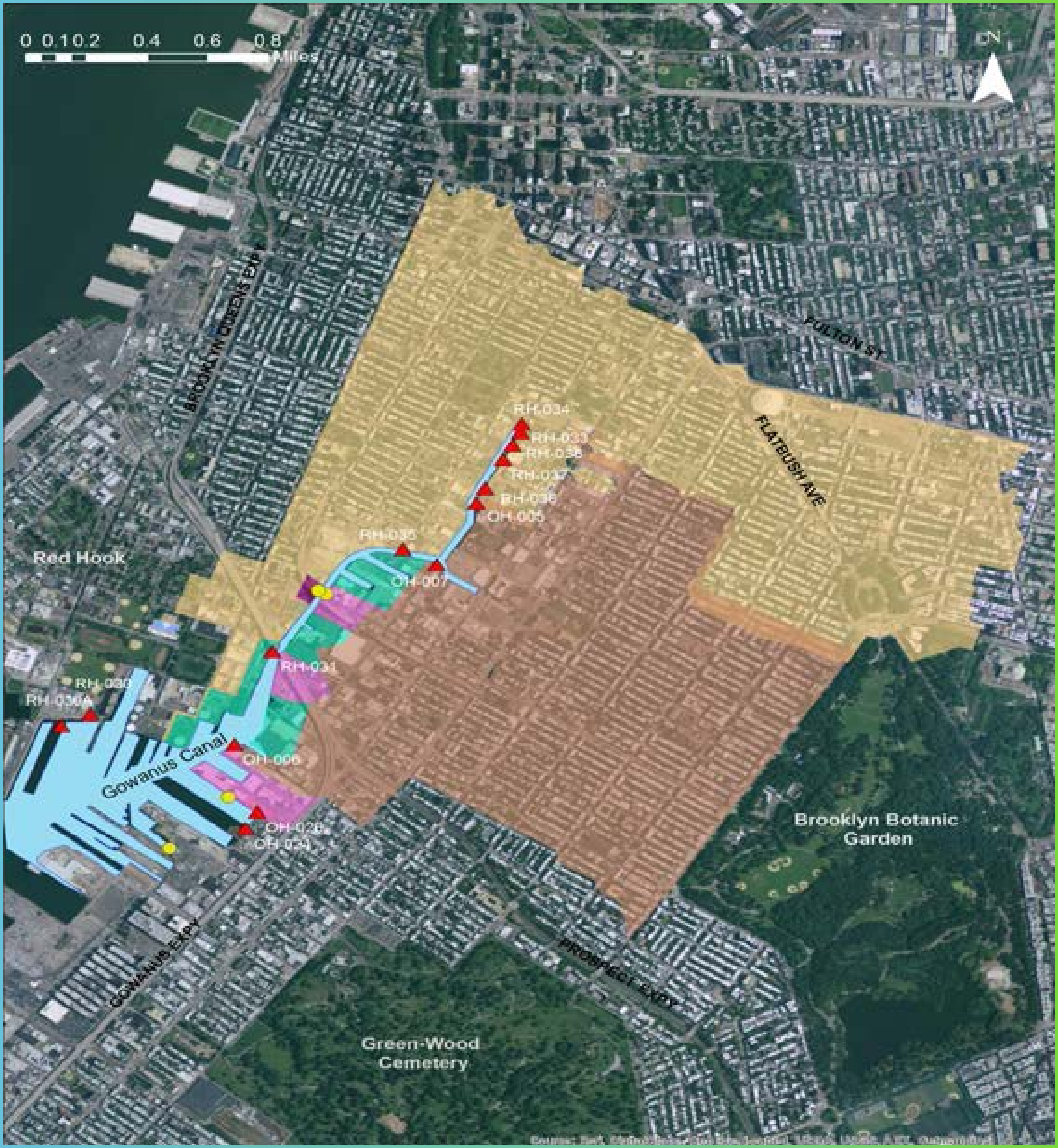
New York City Department of Environmental Protection

Capital Project No. WP-169
Long Term Control Plan II

Combined Sewer Overflow Long Term Control Plan for Gowanus Canal



June 2015

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Combined Sewer Overflow Long Term Control Plan for Gowanus Canal

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The City of New York
Department of Environmental Protection
Bureau of Wastewater Treatment

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EXECUTIVE SUMMARY

This Executive Summary is organized as follows:

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- Findings — A summary of the key findings of the water quality (WQ) data analyses and WQ modeling simulations.
- Evaluations and Conclusion — Evaluations, recommendations and conclusion consistent with the Federal Combined Sewer Overflow (CSO) Control Policy and the Clean Water Act (CWA).

1. BACKGROUND

The New York City (NYC) Department of Environmental Protection (DEP) prepared this Long Term Control Plan (LTCP) for the Gowanus Canal pursuant to a CSO Order on Consent (Department of Environmental Conservation [DEC] Case No. CO2-20110512-25), dated March 8, 2012 (2012 CSO Order on Consent). The 2012 CSO Order on Consent is a modification of a 2005 CSO Order on Consent (DEC Case No. CO2-20000107-8). Under the 2012 CSO Order on Consent, DEP is required to submit to DEC 11 waterbody-specific LTCPs by December 2017. The Gowanus Canal LTCP is the sixth of those LTCPs.

As described in the LTCP Goal Statement in the 2012 CSO Order on Consent, the goal of each LTCP is to identify, with public input, appropriate CSO controls necessary to achieve waterbody-specific water quality standards (WQS), consistent with the Federal CSO Control Policy and related guidance. In addition, the Goal Statement provides: *"Where existing water quality standards do not meet the Section 101(a)(2) goals of the Clean Water Act, or where the proposed alternative set forth in the LTCP will not achieve existing water quality standards or the Section 101(a)(2) goals, the LTCP will include a Use Attainability Analysis examining whether applicable waterbody classifications, criteria, or standards should be adjusted by the State."* DEP conducted water quality assessments where the data is represented by percent attainment with pathogen targets and associated recovery times. Consistent with guidance from DEC, 95 percent attainment of applicable water quality criteria constitutes compliance with the existing WQS or the Section 101(a)(2) goals conditioned on verification through rigorous post-construction compliance monitoring (PCM).

Regulatory Requirements

The waters of NYC are subject to Federal and New York State (NYS or State) laws and regulations. Particularly relevant to this LTCP is the United States Environmental Protection Agency's (EPA) CSO Control Policy, which provides guidance on the development and implementation of LTCPs, and the setting of WQS. In NYS, CWA regulatory and permitting authority has been delegated to DEC.

DEC has designated the Gowanus Canal Class SD above Hamilton Avenue, and Class I below Hamilton Avenue. The best usage of Class SD waters is fishing and of Class I, secondary contact recreation and fishing (6 New York Code of Rules and Regulations [NYCRR] 701.14). Figure ES-1 shows the area of the Gowanus Canal at Hamilton Avenue, below the Gowanus Expressway.

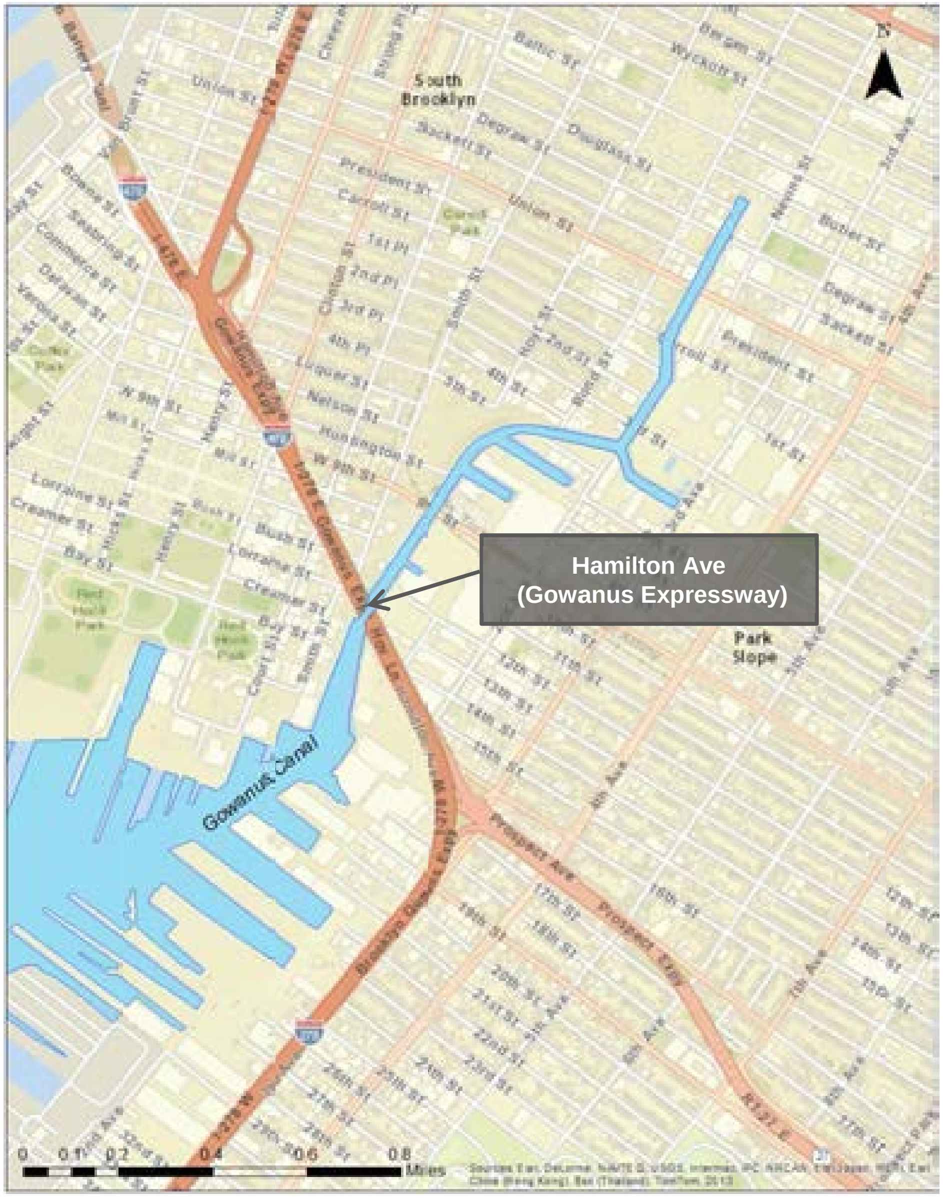

Figure ES-1. Gowanus Canal Area Map

DEC has publicly noticed a proposed rulemaking to amend 6 NYCRR Parts 701 and 703. The proposed total and fecal coliform bacteria criteria of 200 cfu/100mL would be the same for Classes SD, I and SC waters. In addition, DEC has advised DEP that it will soon adopt the 30-day rolling geometric mean (GM) for enterococci of 30 cfu/100mL, with a not-to-exceed the 90th percentile statistical threshold value (STV) of 110 cfu/100mL, which is the EPA Recommended Recreational Water Quality Criteria (2012 EPA RWQC). It is not expected that the recommendations herein will be altered by the new criteria.

The criteria assessed in this LTCP include Existing WQ Criteria (Class SD and I for the Gowanus Canal). Also assessed is the attainment of Primary Contact WQS and Potential Future Primary Contact WQ Criteria. Therefore, water quality assessments associated with current Primary Contact WQ Criteria within the Gowanus Canal considered fecal coliform and dissolved oxygen (DO) criteria exclusively (Table ES-1). As described above, the 2012 EPA RWQC recommended certain changes to the bacteria water quality criteria for primary contact. Although not currently applicable to this waterbody, the Gowanus Canal LTCP includes attainment analyses of the 2012 EPA RWQC (referred to hereinafter as the "Potential Future Primary Contact WQ Criteria")

Table ES-1 summarizes the Existing WQ Criteria, Primary Contact WQ Criteria and Potential Future Primary Contact WQ Criteria applied in this LTCP.

Table ES-1. Classifications and Standards Applied

Analysis	Numerical Criteria Applied	
Existing WQ Criteria Fish Survival (Class SD) and Boating/Fishing (Class I)	Gowanus Canal Above Hamilton Ave (Class SD)	Fecal - None; DO never < 3.0 mg/L
	Gowanus Bay Below Hamilton Ave (Class I)	Fecal Monthly GM ≤ 2,000 DO never <4.0 mg/L
Primary Contact WQ Criteria[(1)]	Saline Water	Fecal Monthly GM≤200 Daily Average DO ≥4.8 mg/L[(3)] DO never < 3.0 mg/L
Potential Future Primary Contact WQ Criteria[(2)]	Entero: rolling 30-d GM – 30 cfu/100mL Entero: STV – 110 cfu/100mL	

Notes:
GM = Geometric Mean; STV = 90 Percent Statistical Threshold Value
(1) This water quality standard is not currently assigned to the Gowanus Canal or Gowanus Bay.
(2) The Potential Future Primary Contact WQ Criteria have not yet been adopted by DEC.
(3) The daily average DO concentration may fall below 4.8 mg/L for a limited number of days.

The Gowanus Canal is also the focus of an EPA Superfund program that has a CSO mitigation component. This CSO program is being conducted under the Comprehensive Environmental Response, Compensation and Liability Act ("CERCLA" or "Superfund") through an EPA Administrative Order for Remedial Design, Index No. CERCLA 02-2014-2019, issued to NYC in advance of, and independent of, this LTCP.

Relevant here, in September 2013, the EPA issued its Record of Decision (ROD) for the Gowanus Canal Superfund Site. The ROD requires the siting, design, construction, and operation of two CSO retention tanks to control discharges of solids to the Gowanus Canal, unless other technically viable alternatives are identified.[1] The ROD preliminarily estimated that an 8 million gallon (MG) tank would be necessary at

[1] *See United States Environmental Protection Agency. Record of Decision, Gowanus Canal Superfund Site: Summary of Remedial Alternatives, page 55.*

Outfall RH-034, and a 4 MG tank at Outfall OH-007. This LTCP evaluated several alternatives including the ROD alternatives for water quality impacts.

Gowanus Canal Watershed

The Gowanus Canal watershed is highly urbanized, comprised primarily of residential areas, with some commercial, industrial, institutional and open space/outdoor recreation areas. The largest outdoor recreation area within this watershed is the Prospect Park in Brooklyn, located next to the area served by the Owls Head Wastewater Treatment Plant (WWTP). Other, smaller parks are located throughout the watershed.

The Gowanus Canal watershed comprises approximately 1,758 acres located on the northwestern shore of the Borough of Brooklyn. The majority of land immediately surrounding the shores of the Gowanus Canal is primarily industrial and commercial. The area is served by a complex collection system comprised of combined and separate storm sewers, interceptor sewers and pump stations, several CSO and stormwater outfalls, and the Flushing Tunnel. The Flushing Tunnel is the major source of flow to the Gowanus Canal, with a rated pumping capacity of 250 million gallons per day (MGD). The watershed is served by both the Red Hook and Owls Head WWTPs.

The Gowanus Canal outfalls and watershed characteristics are shown in Figures ES-2 and ES-3.

DEP activated the upgraded Gowanus Pump Station (PS) in June 20, 2014, and the refurbished Flushing Tunnel in May 3, 2014. The Flushing Tunnel introduces water from the Buttermilk Channel in the East River to the head end of the Gowanus Canal. Water is drawn at an average rate of 215 MGD to the Gowanus Canal PS. The water then flows to the mouth of the Gowanus Canal into Gowanus Bay. The introduction of the East River water has improved the water quality in the Gowanus Canal significantly. The cost of these improvements was $190M.

The Gowanus PS, located on Douglass Street at the head of the Gowanus Canal, is designed to convey sewage flow to the Columbia Street Interceptor via a force main in the Flushing Tunnel. It serves a drainage area of approximately 657 acres. The station was built in 1908 and was last upgraded in 2014. The Gowanus PS has a capacity of 30 MGD with excess flows discharged to the Gowanus Canal via CSO Outfall RH-034. During wet weather, the station receives unregulated combined sewage flow from most of its drainage area, as well as regulated combined sewage flow from the Nevins Street Pump Station.

Green Infrastructure

DEP has determined that the Gowanus Canal watershed is a target area for its Green Infrastructure (GI) Program. The Gowanus Canal has a total tributary combined sewer impervious area of 1,387 acres. DEP projects that GI penetration rates would manage 12 percent of the impervious surfaces within the Gowanus Canal combined sewer service area by 2030. This accounts for right-of-way (ROW) practices, public property retrofits, GI implementation on private properties, and for conservatively estimated new development trends. The model has predicted a reduction in annual overflow volume of 41 MG from this GI implementation based on the 2008 baseline rainfall condition.

2. FINDINGS

Current Water Quality Conditions

Analysis of water quality in the Gowanus Canal was based on data collected from July to September 2014, during the development of the Gowanus Canal LTCP. The sampling stations are shown in Figure ES-4. A second data collection effort that further corroborated the data collected earlier was conducted from November 2014 to June 2015.

Figure ES-5 presents fecal coliform bacteria data collected at Stations GC-1 to GC-11, and Figure ES-6 presents the enterococci data at these same stations for the sampling period of July to September 2014. The plots represent data collected from the LTCP and Harbor Survey Monitoring (HSM) programs.

Overall, the water quality data recently collected within the Gowanus Canal indicates significant improvements over those collected prior to the operation of the flushing tunnel and pump station. The fecal coliform and enterococci dry-weather GMs for the sampling period are below 200 cfu/100mL and 30 cfu/100mL, the bacteria numerical thresholds of the Primary Contact WQ Criteria and GM component of the Potential Future Primary Contact WQ Criteria, respectively.

Figure ES-2. Gowanus Canal Outfalls

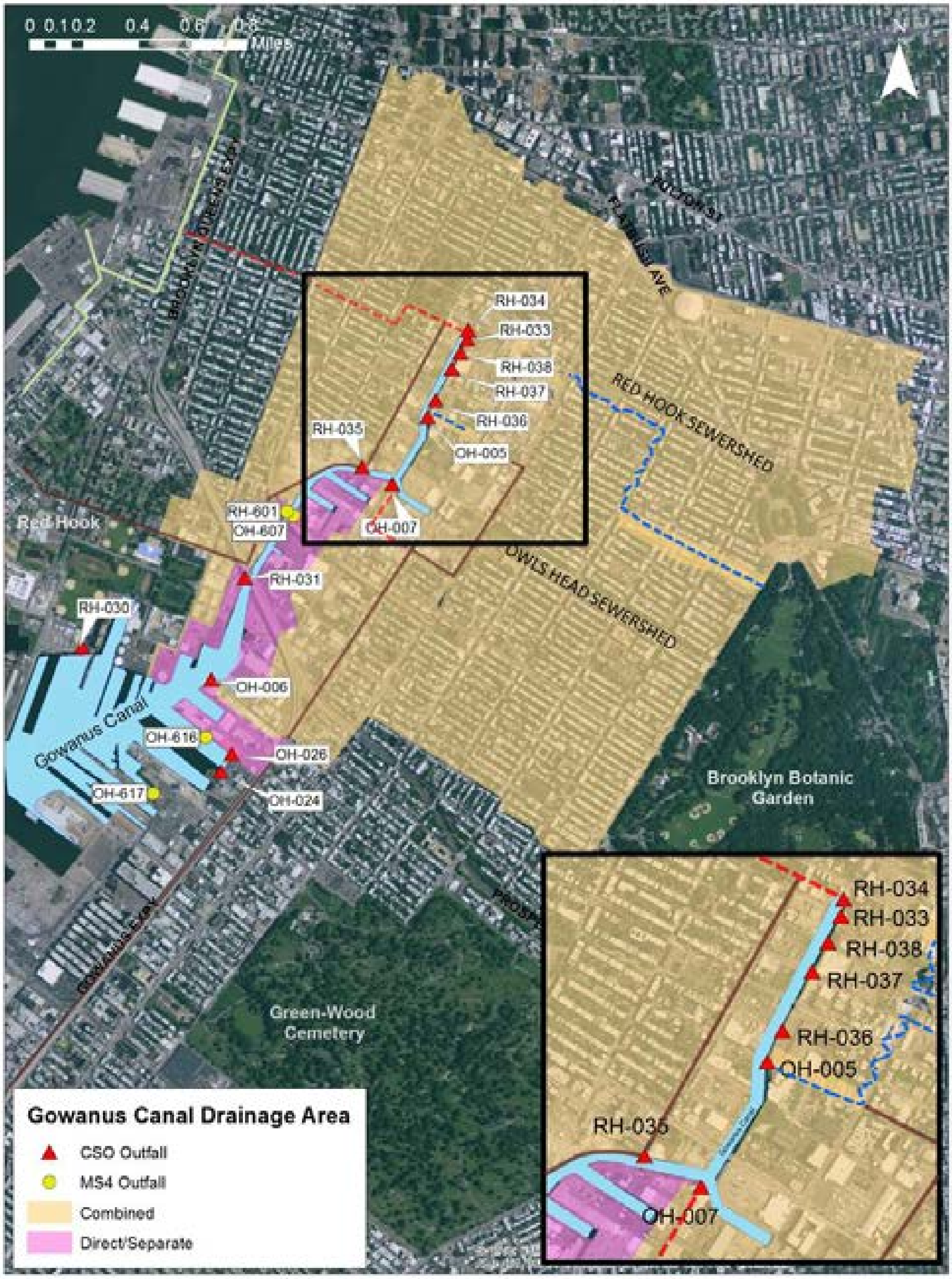

Figure ES-3. Gowanus Canal Watershed and Associated WWTP Service Areas

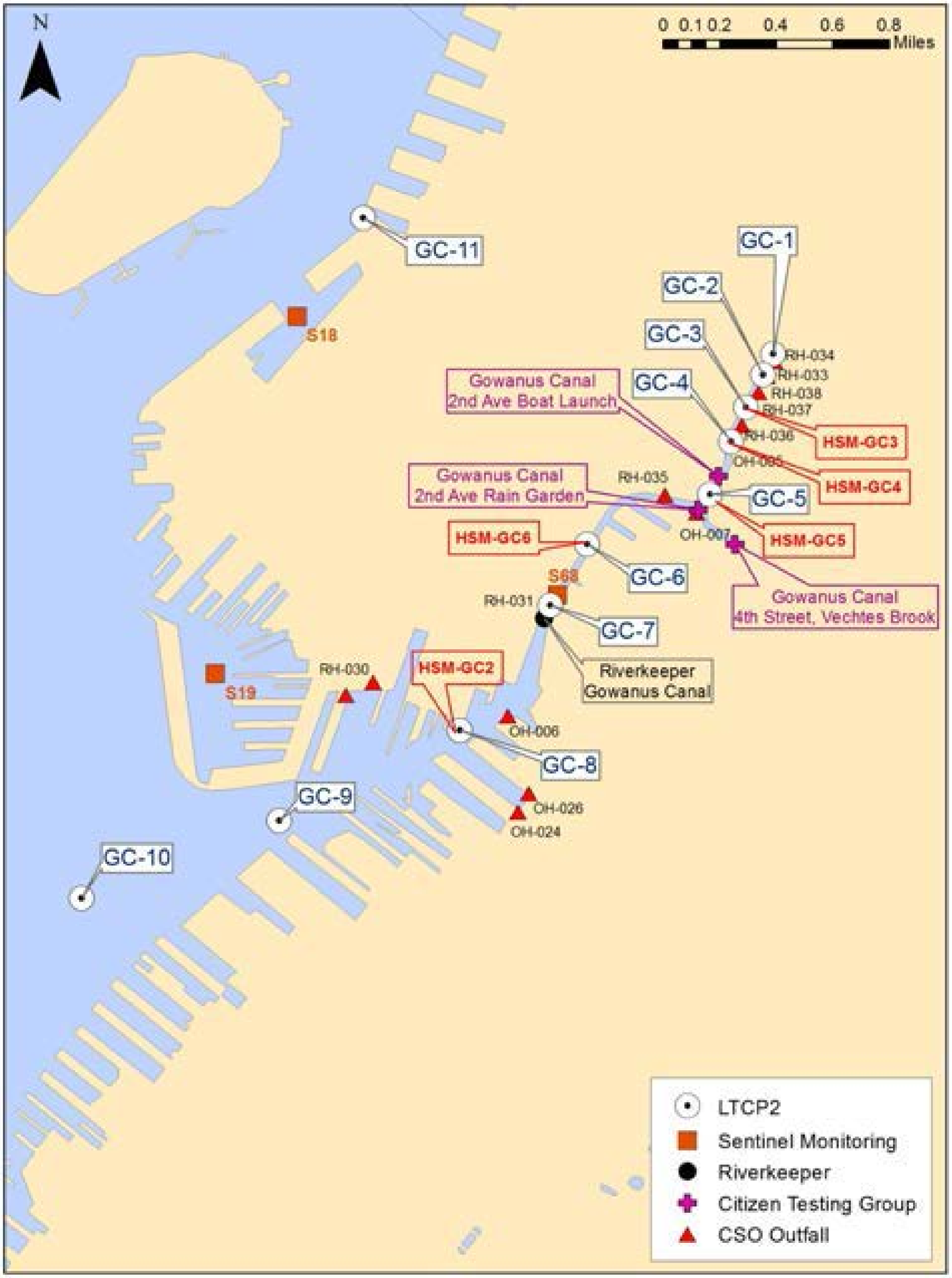

Figure ES-4. Sampling Stations of Various Sampling Programs at Gowanus Canal

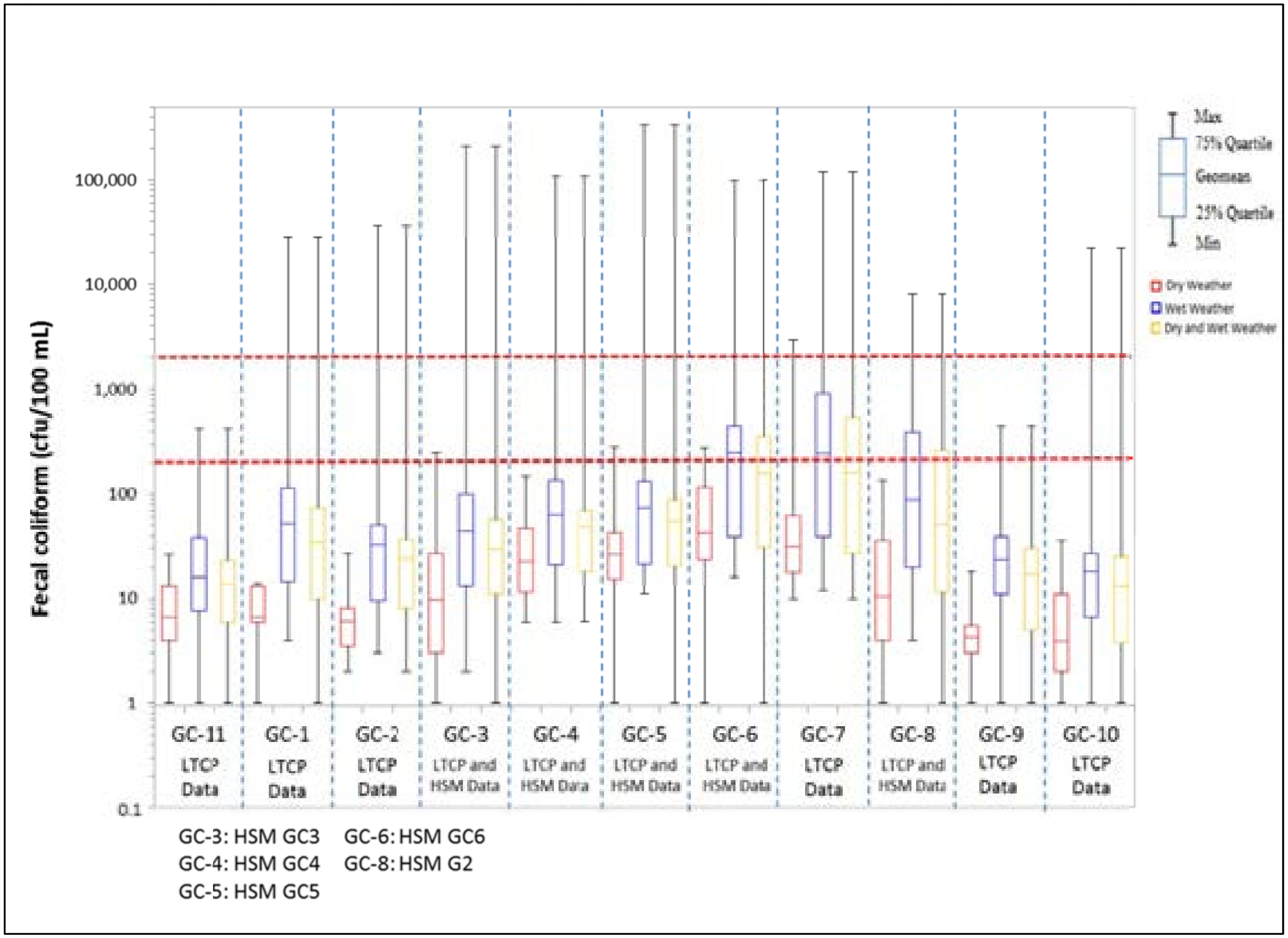

Figure ES-5. Fecal Coliform Data from LTCP and HSM - Gowanus Canal (July – September 2014)

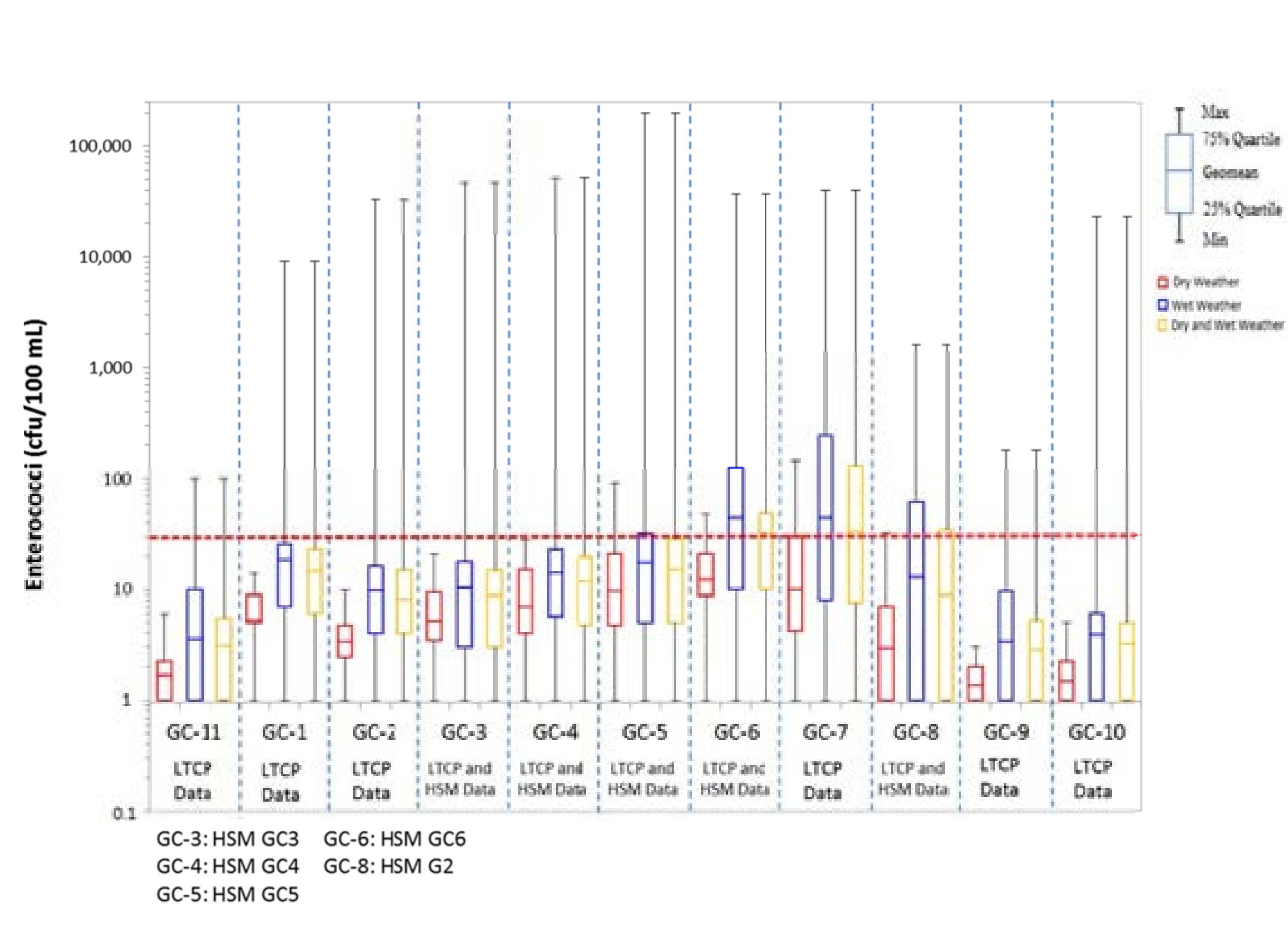

Figure ES-6. Enterococci Data from LTCP and HSM - Gowanus Canal (July – September 2014)

As shown in these graphics, dry weather fecal coliform concentrations are lower than those for wet weather conditions. Overall, the water quality reflects the significant improvements achieved by the 2008 Waterbody/Watershed Facility Plan (WWFP) recommended plan (i.e. operation of the refurbished Flushing Tunnel and upgraded Gowanus PS). As demonstrated by the sampling results and projected LTCP baseline attainment, the water quality in the Gowanus Canal has improved from the concentrations and attainment of WQS documented in prior CSO planning efforts.

Baseline Conditions, 100% CSO Control and Performance Gap

Computer models were used to assess attainment with Existing WQ Criteria (Class SD and I), Primary Contact WQ Criteria (Class SC), including the 200 cfu/100mL fecal coliform criterion and Potential Future Primary Contact WQ Criteria. The analyses focused on two primary objectives:

1. Determine the baseline levels of compliance with water quality criteria with all sources being discharged at existing levels to the waterbody. These sources would primarily be direct drainage runoff, stormwater and CSO. This analysis is presented for Existing WQ Criteria, Primary Contact WQ Criteria and Potential Future Primary Contact WQ Criteria.

2. Determine potential attainment levels with 100% of CSO controlled or no discharge of CSO to the waterbody, keeping the remaining non-CSO sources. This analysis is presented for the classifications and standards criteria shown in Table ES-1.

Given the importance of the water quality modeling, the Gowanus Canal Water Quality Model (GCWQM) was updated and peer-reviewed by independent experts to confirm that the modeling was both up-to-date and accurate. The modeling was conducted using a higher resolution computational grid and hydrodynamic framework than was used in the 2008 Gowanus Canal WWFP modeling simulations. The water quality model was used to calculate ambient bacteria and DO concentrations within the waterbody for a set of baseline conditions, as described in Section 6.0.

Baseline conditions were established in accordance with the guidance provided by DEC to represent future conditions. These included the following assumptions: the design year was established as 2040; Owls Head and Red Hook WWTPs would receive combined peak flows at two times design dry weather flow (2xDDWF) or wet weather capacity of 240 and 120 MGD, respectively; grey infrastructure would include those elements recommended in the 2008 WWFP; and waterbody-specific GI application rates would be based on the best available information. In the case of the Gowanus Canal, the GI application rate was assumed to be 12 percent coverage. The water quality assessments were conducted using continuous water quality simulations – a typical year (2008 rainfall) simulation for bacteria and DO assessment to support the alternatives evaluation. For baseline conditions, Alternatives 1, 2 and 3, the LTCP analysis used the 10-year (2002 to 2011 rainfall) simulation for further analysis of bacteria criteria attainment.

Table ES-2 shows that for the 2008 baseline criteria, the Gowanus Canal meets Existing WQ Criteria for fecal coliform 100 percent of the time.

Table ES-2. Calculated 2008 Baseline Fecal Coliform Maximum Monthly GM and Attainment of Existing Criteria for the Class (I) Boating/Fishing WQ Criteria

Station	Class	Maximum Monthly Geometric Means (cfu/100mL)		% Attainment with Existing Criteria		% Attainment with Class I Criteria	
		Annual	Recreation Period	Annual GM ≤2000 #/100mL	Recreation Period GM ≤2000 #/100mL	Annual GM ≤2000 #/100mL	Recreation Period GM ≤2000 #/100mL
GC-1	SD	213	45	NA	NA	100	100
GC-2	SD	201	43	NA	NA	100	100
GC-3	SD	199	42	NA	NA	100	100
GC-4	SD	197	40	NA	NA	100	100
GC-5	SD	199	39	NA	NA	100	100
GC-6	SD	216	37	NA	NA	100	100
GC-7	SD	215	36	NA	NA	100	100
GC-8	I	181	23	100	100	100	100
GC-9	I	164	24	100	100	100	100
GC-10	I	170	31	100	100	100	100

The Primary Contact WQ Criteria for the 2008 year baseline attainment levels are shown in Table ES-3. The recreational season (May 1st through October 31st) attainment levels are met. The annual attainment levels are met at all locations with the exception of Stations GC-1, GC-2, GC-6 and GC-7 where attainment levels are 92 percent. A 92 percent attainment level means that one month out of 12 was out of attainment. However, when the baseline attainment is evaluated under the more extensive 10-year water quality simulations, as described later in this section, the baseline annual attainment of the primary contact fecal coliform criterion exceeds DEC's prescribed 95 percent attainment target for the corresponding water quality criterion.

Table ES-3. Calculated 2008 Baseline Fecal Coliform Maximum Monthly GM and Attainment of Primary Contact WQ Criteria

Station	Maximum Monthly Geometric Means (cfu/100mL)		% Attainment	
	Annual	Recreation Period	Annual GM ≤ 200 #/100mL	Recreation Period GM ≤ 200 #/100mL
GC-1	213	45	92	100
GC-2	201	43	92	100
GC-3	199	42	100	100
GC-4	197	40	100	100
GC-5	199	39	100	100
GC-6	216	37	92	100
GC-7	215	36	92	100
GC-8	181	23	100	100
GC-9	164	24	100	100
GC-10	170	31	100	100

The attainment levels with Primary Contact WQ Criteria under the 100% CSO control scenario are shown in Table ES-4. The projected level of attainment following 100% control of the CSO discharges is the same as that for existing baseline conditions. This indicates that little improvement in water quality attainment can be achieved with additional CSO controls.

Table ES-4. Calculated 2008 100% CSO Control Fecal Coliform Maximum Monthly GM and Attainment of Primary Contact WQ Criteria

Station	Maximum Monthly Geometric Means (cfu/100mL)	% Attainment
	Annual	Annual GM ≤ 200 #/100mL
GC-1	107	100
GC-2	108	100
GC-3	108	100
GC-4	105	100
GC-5	105	100
GC-6	105	100
GC-7	105	100
GC-8	80	100
GC-9	84	100
GC-10	102	100

The DO attainment levels were met for the Existing WQ Criteria as shown in Table ES-5. As shown in Table ES-6, the Primary Contact WQ Criteria for the 2008 baseline simulation are met at all locations except Stations GC-6 and GC-8 where the attainment levels are 94 percent and 87 percent, respectively.

Table ES-5. Model Calculated DO Attainment – Existing WQ Criteria (2008)

Station	Class	DO Criteria (≥ mg/L)	% Annual Attainment 2008
GC-1	SD	3	100
GC-2	SD	3	100
GC-3	SD	3	100
GC-4	SD	3	100
GC-5	SD	3	100
GC-6	SD	3	98
GC-7	SD	3	99
GC-8	I	4	95
GC-9	I	4	100
GC-10	I	4	100

Table ES-6. Model Calculated DO Attainment for Primary Contact WQ Criteria (2008)

Station	Annual Attainment Percent Attainment			
	Baseline		100% Gowanus CSO Control	
	Chronic[(1)]	Acute[(2)]	Chronic[(1)]	Acute[(2)]
GC-1	100	100	100	100
GC-2	100	100	100	100
GC-3	100	100	100	100
GC-4	100	100	100	100
GC-5	100	100	100	100
GC-6	94	98	95	99
GC-7	95	99	96	100
GC-8	87	100	89	100
GC-9	99	100	100	100
GC-10	100	100	100	100

Notes:

(1) 24-hr average DO ≥ 4.8 mg/L with allowable excursions to ≥ 3.0 mg/L for certain periods of time.
(2) Acute Criteria: DO ≥ 3.0 mg/L.

The Potential Future Primary Contact WQ Criteria attainment is shown below in Table ES-7. The table shows that the 30-day GM of 30 cfu/100mL is met at all stations, and the 110 cfu/100 mL STV criterion is met at six of the 10 stations.

Table ES-7. Calculated 2008 100% CSO Control Enterococci Maximum Monthly GM and Attainment of Potential Future Primary Contact WQ Criteria

Station	Maximum Recreational Period 30-day Enterococci (cfu/100mL)		% Attainment	
	GM	90th Percentile STV	Recreation Period GM ≤ 30 #/100mL	Recreation Period STV ≤ 110 #/100mL
GC-1	17	127	100	91
GC-2	17	132	100	91
GC-3	17	130	100	91
GC-4	17	123	100	93
GC-5	16	116	100	95
GC-6	16	100	100	100
GC-7	16	99	100	100
GC-8	11	46	100	100
GC-9	12	59	100	100
GC-10	15	104	100	100

The baseline conditions modeling shows that the Existing WQ Criteria (Class SD and Class I) are met 100 percent of the time. Similarly, the attainment levels with the Primary Contact WQ Criteria and the

Potential Future Primary Contact WQ Criteria are essentially met both annually and for the recreational season (May 1st through October 31st). WQS attainment does not meet or exceed 95 percent at four stations in which the STV component of the Potential Future WQ Criteria ranges from 91 to 93 percent and two others, at which the chronic standard of the primary contact DO criteria ranges between 84 and 97 percent.

Public Outreach

DEP's comprehensive public participation plan ensured that interested stakeholders were involved in the LTCP process. Stakeholders included both citywide and regional groups, some of whom offered comments at two public meetings. DEP will continue to solicit comments on the public's use of the waterbody, and, at the third public meeting, will present its preferred plan for the Gowanus Canal.

Evaluation of Alternatives

DEP used a multi-step process to evaluate control measures and CSO control alternatives. The evaluation process considered: environmental benefits; community and societal impacts; and implementation and operation and maintenance (O&M). After considering comments generated by detailed technical workshops, the retained alternatives were subjected to cost-performance and cost-attainment evaluations, where economic factors were considered, resulting in the seven retained alternatives presented in Table ES-8.

Table ES-8. Retained Alternatives

Alternative	Description
1	• 8 MG Tank at Outfall RH-034 • 4 MG Tank at Outfall OH-007
2	• 5.7MG Tank at Outfall RH-034 • 2.5 MG Tank at Outfall OH-007
3	• 3.5 MG Tank at Outfall RH-034 • 1.4 MG Tank at Outfall OH-007
4	• 3.5 MG Tank at Outfall RH-034 • Weir Modifications at Outfalls OH-006, OH-007 and OH-024
5	• Bond Lorraine Sewer Reconstruction • Weir Modifications at Outfalls OH-006, OH-007 and OH-024
6	• 8,400 LF-long, 18 ft-diameter tunnel • 15.8 MG storage
7	• 8,400 LF-long, 27 ft-diameter tunnel • 34.6 MG storage

The retained alternatives with CSO volume and bacteria load reductions are presented below in Table ES-9. The reductions range from 36 to 100 percent.

Table ES-9. Gowanus Canal Projected Annual CSO Volume and Bacteria Reductions for the Retained Alternatives (2008 Rainfall)

Basin-Wide Alternative	Annual CSO Volume to Gowanus Canal (MGY)	Increase in Annual CSO Volume Discharged to Other Waterbodies (MGY)	Net Change in Flow to both WWTPs (MGY)	Annual CSO Volume Reduction to Gowanus Canal (%)	Annual Fecal Coliform Reduction to Gowanus Canal (%)	Annual Enterococci Reduction to Gowanus Canal (%)	Frequency of Annual CSO Overflows to Gowanus Canal
Baseline Conditions	263	---	---	---	---	---	44
1. EPA ROD Tanks (8 MG Tank at Outfall RH-034 and 4 MG Tank at Outfall OH-007)	110	0	153	58	53	53	35
2. 5.7 MG Tank at Outfall RH-034 and 2.5 MG Tank at Outfall OH-007	133	0	130	50	45	45	35
3. 3.5 MG Tank at Outfall RH-034 and 1.4 MG Tank at Outfall OH-007	168	0	96	36	33	33	35
4. 3.5 MG Tank at Outfall RH-034 and Weir Modifications at Outfalls OH-006, OH-007 and OH-024	142	59	62	46	45	46	17
5. Bond Lorraine Sewer Reconstruction and Weir Modifications at Outfall OH-006, OH-007 and OH-024	143	117	2	46	48	49	31
6. Tunnel (75% CSO Control)	65	0	198	75	75	75	6
7. Tunnel (100% CSO Control)	0	0	263	100	100	100	0

Costs of LTCP Alternatives

The retained alternative estimated costs for Probable Bid Costs (PBC), O&M and present worth are shown below in Table ES-10. The total present worth ranges from $355M to $873M. The PBCs range from $334M to $846M.

Table ES-10. Cost of Retained Alternatives

Alternative	PBC(2) ($ Million)	Annual O&M Cost(2) ($ Million)	Total Present Worth ($ Million)
1. EPA ROD Tanks (8 MG Tank at Outfall RH-034 and 4 MG Tank at Outfall OH-007)	801(1)	1.9	829
2. 5.7 MG Tank at Outfall RH-034 and 2.5 MG Tank at Outfall OH-007	663	1.4	683
3. 3.5 MG Tank at Outfall RH-034 and 1.4 MG Tank at Outfall OH-007	493	0.9	507
4. 3.5 MG Tank at Outfall RH-034 and Weir Modifications at Outfalls OH-006, OH-007 and OH-024	389	0.8	401
5. Bond Lorraine Sewer Reconstruction and Weir Modifications at Outfalls OH-006, OH-007 and OH-024	334	1.4	355
6. 75% CSO Control Tunnel	680	1.0	695
7. 100% CSO Control Tunnel	846	1.8	873

Notes:
(1) EPA ROD estimate for same tanks is $77M.
(2) PBCs estimated from various methods and sources, including LTCP and Superfund. Annual O&M costs estimated from historical costs of equivalent CSO control projects implemented or previously evaluated within NYC.

3. EVALUATIONS AND CONCLUSION

DEP will implement the plan elements identified in this section upon DEC's approval of this LTCP, which also recommends the continued implementation of WWFP recommendations.

LTCP analyses for the Gowanus Canal are summarized here for the following:

1. Water Quality Modeling Results
2. Use Attainability Analysis (UAA)

3. Recommendations
4. Conclusion

Water Quality Modeling Results

The bacteria simulations used a 10-year period and the typical year (2008) was used for DO. As would be expected, 10-year simulation results vary slightly from the 2008 simulations, which were used for the evaluation of alternatives which provide an effective uniform evaluation platform for multiple CSO control alternatives. The 10-year simulation is processed to confirm the water quality impacts of the LTCP baseline scenario over a longer period. For this particular LTCP, bacteria 10-year simulations were also conducted for retained alternatives that DEP is evaluating separately, consistent with the EPA's ROD for the Gowanus Canal.

The Gowanus Canal 10-year bacteria attainment results for the baseline annual and recreational season (May 1st through October 31st) are shown in Tables ES-11 and ES-12. The tables show that water quality at all sampling stations complies with the bacteria Existing WQ Criteria and Primary Contact WQ Criteria, i.e., attainment above 95 percent. Attainment of the enterococci Potential Future Primary Contact WQ Criteria ranges from 95 to 100 percent for the 30 cfu/100mL criterion and 34 to 86 percent for the 110 cfu/100 mL STV criterion.

Table ES-11. Calculated 10-Year Bacteria Attainment
Baseline Conditions - Annual

Station	Existing WQ Criteria (Class I) [1]		Primary Contact WQ Criteria	
	Criterion (cfu/100mL)	Attainment (%)	Criterion (cfu/100mL)	Attainment (%)
GC-1	Fecal ≤ 2,000	100	Fecal ≤ 200	98
GC-2	Fecal ≤ 2,000	100	Fecal ≤ 200	99
GC-3	Fecal ≤ 2,000	100	Fecal ≤ 200	100
GC-4	Fecal ≤ 2,000	100	Fecal ≤ 200	100
GC-5	Fecal ≤ 2,000	100	Fecal ≤ 200	100
GC-6	Fecal ≤ 2,000	100	Fecal ≤ 200	98
GC-7	Fecal ≤ 2,000	100	Fecal ≤ 200	98
GC-8	Fecal ≤ 2,000	100	Fecal ≤ 200	99
GC-9	Fecal ≤ 2,000	100	Fecal ≤ 200	100
GC-10	Fecal ≤ 2,000	100	Fecal ≤ 200	100

Notes:
(1) Not currently designated to Stations GC-1 through GC-7

Table ES-12. Calculated 10-Year Bacteria Attainment Baseline Conditions - Recreational Season (May 1st through October 31st)

Station	Existing WQ Criteria (Class I)		Primary Contact WQ Criteria		Potential Future Primary Contact WQ Criteria			
	Criterion [1] (cfu/100mL)	Attainment (%)	Criterion (cfu/100mL)	Attainment (%)	Criterion (cfu/100mL)	Attainment (%)	Criterion (cfu/100mL)	Attainment (%)
GC-1	Fecal ≤ 2,000	100	Fecal ≤ 200	100	Enterococci ≤ 30	99	Enterococci STV ≤ 110	70
GC-2	Fecal ≤ 2,000	100	Fecal ≤ 200	100	Enterococci ≤ 30	99	Enterococci STV ≤ 110	73
GC-3	Fecal ≤ 2,000	100	Fecal ≤ 200	100	Enterococci ≤ 30	99	Enterococci STV ≤ 110	73
GC-4	Fecal ≤ 2,000	100	Fecal ≤ 200	100	Enterococci ≤ 30	99	Enterococci STV ≤ 110	74
GC-5	Fecal ≤ 2,000	100	Fecal ≤ 200	100	Enterococci ≤ 30	99	Enterococci STV ≤ 110	66
GC-6	Fecal ≤ 2,000	100	Fecal ≤ 200	100	Enterococci ≤ 30	95	Enterococci STV ≤ 110	34
GC-7	Fecal ≤ 2,000	100	Fecal ≤ 200	100	Enterococci ≤ 30	95	Enterococci STV ≤ 110	35
GC-8	Fecal ≤ 2,000	100	Fecal ≤ 200	100	Enterococci ≤ 30	97	Enterococci STV ≤ 110	36
GC-9	Fecal ≤ 2,000	100	Fecal ≤ 200	100	Enterococci ≤ 30	99	Enterococci STV ≤ 110	59
GC-10	Fecal ≤ 2,000	100	Fecal ≤ 200	100	Enterococci ≤ 30	100	Enterococci STV ≤ 110	86

Notes:

(1) Not currently designated to Stations GC-1 through GC-7

The 10-year simulation bacteria results show that the Gowanus Canal meets bacteria water quality criteria.

The 2008 simulation for DO is presented below in Table ES-13. It shows the DO water quality criteria are met for the Existing WQ Criteria and Primary Contact WQ Criteria, except at two water quality stations in which the chronic standard of the Primary Contact WQ Criteria ranges from 87 to 94 percent.

Table ES-13. Calculated 2008 DO Attainment Baseline Conditions - Annual

Station	Existing WQ Criteria		Primary Contact WQ Criteria			
	Criterion	Attainment (%)	Criterion(1)	Attainment (%)	Criterion(2)	Attainment (%)
GC-1	≥3.0 mg/L	100	≥4.8 mg/L	100	≥3.0 mg/L	100
GC-2	≥3.0 mg/L	100	≥4.8 mg/L	100	≥3.0 mg/L	100
GC-3	≥3.0 mg/L	100	≥4.8 mg/L	100	≥3.0 mg/L	100
GC-4	≥3.0 mg/L	100	≥4.8 mg/L	100	≥3.0 mg/L	100
GC-5	≥3.0 mg/L	100	≥4.8 mg/L	100	≥3.0 mg/L	100
GC-6	≥3.0 mg/L	100	≥4.8 mg/L	94	≥3.0 mg/L	98
GC-7	≥3.0 mg/L	100	≥4.8 mg/L	95	≥3.0 mg/L	99
GC-8	≥4.0 mg/L	100	≥4.8 mg/L	87	≥3.0 mg/L	100
GC-9	≥4.0 mg/L	100	≥4.8 mg/L	99	≥3.0 mg/L	100
GC-10	≥4.0 mg/L	100	≥4.8 mg/L	100	≥3.0 mg/L	100

Notes:
(1) Chronic standard
(2) Acute standard

In sum, the 10 year simulation shows the Gowanus Canal is meeting Existing WQ Criteria and will meet bacteria Primary Contact WQ Criteria. DO water quality criteria are met except at two water quality stations in which the chronic standard of the Primary Contact WQ Criteria ranges from 87 to 94 percent. Additional improvements would have little or no impact on projected attainment of water quality criteria.

Table ES-14 presents an overview of the findings.

Table ES-14. Classifications and Standards Applied - 10 Year Model Simulation Results

Analysis	Numerical Criteria Applied		Compliance
Existing WQ Criteria Fish Survival (Class SD) and Boating/Fishing (Class I)	Gowanus Canal Above Hamilton Ave (Class SD)	Fecal - None	Yes
		DO never < 3.0 mg/L(4)	Yes
	Gowanus Bay Below Hamilton Ave (Class I)	Fecal Monthly GM ≤ 2,000	Yes
		DO never <4.0 mg/L(4)	Yes
Primary Contact WQ Criteria(1)	Saline Water	Fecal Monthly GM ≤ 200	Yes
		Daily Average DO ≥ 4.8 mg/L(3) (4)	No(5)
		DO never < 3.0 mg/L(4)	Yes
Potential Future Primary Contact WQ Criteria(2)	Entero: rolling 30-d GM – 30 cfu/100mL		Yes
	Entero: STV – 110 cfu/100mL		No

Notes:
GM = Geometric Mean; STV = 90 Percent Statistical Threshold Value
(1) This water quality standard is not currently assigned to the Gowanus Canal or Gowanus Bay.
(2) The Potential Future Primary Contact WQ Criteria have not yet been adopted by DEC.
(3) The daily average DO concentration may fall below 4.8 mg/L for a limited number of days. See Section 2 for the equation and calculation description.
(4) DO based on 2008 typical year model simulations.
(5) DO Attainment ranges from 87% to 94% at Stations GC-8 and GC-6.

DEP determined the amount of time following the end of rainfall required for the Gowanus Canal to recover and return to concentrations of less than 1,000 cfu/100mL fecal coliform using analyses from the August 14-15, 2008, 90th percentile storm. Details on the selection of this storm are provided in Section 6.0. The time to return to 1,000 cfu/100mL was then tabulated for each water quality station.

The results of the analysis are summarized in Table ES-15. As noted, the period of time needed for bacteria concentrations to return to levels considered by the NYS Department of Health (DOH) to be safe for primary contact varies with location. Generally, approximately 14 hours is typical for the upper reach of the Gowanus Canal, between Stations GC-1 and GC-7.

Table ES-15. Time to Recovery in Gowanus Canal (August 14-15 2008 Storm)

Class	Stations	Baseline Projected Time to Recovery (hours)
SD	GC-1 to GC-7	8 – 14
I	GC-8 to GC-10	7 – 10

UAA

The analyses contained in this LTCP demonstrate that the Gowanus Canal is projected to fully attain the bacteria Primary Contact WQ Criteria. DO levels largely comply with the primary contact standards except at Stations GC-6 and GC-8 at which attainment with the chronic standard ranges from 87 to 94 percent. As a result, a UAA is not required.

Recommendations

The LTCP presents DEP's recommendations consistent with the CWA, the CSO Control Policy, and the 2012 Order on Consent, with the goal of meeting DEC WQS. However, this LTCP additionally summarizes bacteria and DO attainment achieved by alternatives evaluated pursuant to the ROD.

LTCP Recommendations

Existing WQS are being met as a result of DEP's refurbishment of the Flushing Tunnel and upgrade of the Gowanus PS. Water quality will improve still further with the build-out of planned GI and construction of the planned high level storm sewers (HLSS), as part of the LTCP baseline. The LTCP evaluated alternatives to further reduce CSO loadings to the Gowanus Canal beyond baseline conditions and determined that additional control measures would have little or no impact on projected water quality criteria for primary contact recreation, as the Gowanus Canal meets WQS for the Primary Contact WQ Criteria and the Potential Future Primary Contact WQ Criteria, with the exception of the STV criterion of the Potential Future Primary Contact WQ Criteria (110 cfu/100mL). As discussed herein, implementation of any configuration of the Superfund remedy (two CSO tanks included as Alternatives 1, 2 or 3 referred to below) will serve to further improve water quality.

Water Quality Projections – EPA Superfund Requirements

Roughly concurrent with its analyses supporting the Gowanus Canal LTCP recommendations, DEP undertook additional analyses consistent with the ROD and as directed by the EPA's May 28, 2014 Administrative Order for Remedial Design. The latter analyses resulted in four reports that DEP will submit to the EPA. Those reports consist of the following:

1. Preliminary Remedial Design Report for CSO Facility at Red Hook Outfall RH-034.
2. Preliminary Remedial Design Report for CSO Facility at Owls Head Outfall OH-007.
3. CSO Facility Site Recommendation Report for Red Hook Outfall RH-034.
4. CSO Facility Site Recommendation Report for Owls Head Outfall OH-007.

The facilities evaluated under and described in these reports will further reduce CSO discharges to the Gowanus Canal and will further improve water quality. DEP's analyses of the alternatives proposed pursuant to the ROD are presented in the tables below and discussed fully in Section 8 of this LTCP.

Table ES-16. Performance of Storage Tank Combinations from LTCP Evaluations for Outfall RH-034

Outfall RH-034	Pre-WWFP	LTCP Baseline	ROD Proposed	Volumetric Reduction	
				74%	58%
Tank Size	-	-	8 MG	5.7 MG	3.5 MG
% Reduction	-	25%	82%	74%	58%
Remaining CSO Volume	182 MG	137 MG	33 MG	47 MG	76 MG
Annual Overflow Frequency	45	40	6	7	12

Table ES-17. Performance of Storage Tank Combinations from LTCP Evaluations for Outfall OH-007

Outfall OH-007	Pre-WWFP	LTCP Baseline	ROD Proposed	Volumetric Reduction	
				74%	58%
Tank Size	-	-	4 MG	2.5 MG	1.4 MG
% Reduction	-	16%	87%	74%	58%
Remaining CSO Volume	69 MG	58 MG	9 MG	18 MG	28 MG
Annual Overflow Frequency	48	44	5	6	13

Three alternatives from Section 8, representing alternatives with various tank sizes, are shown below. These are Alternatives 1, 2 and 3 and the corresponding tank sizes are summarized in Table ES-18. The water quality attainment with the 2008 and 10-year model simulation for bacteria and the 2008 model simulation for DO are shown below in Tables ES-19 and ES-20.

Table ES-18. LTCP Evaluated Storage Tank Sizes

Alternative	Tank Size (MG)	
	Outfall RH-034	Outfall OH-007
1. EPA ROD Tanks	8	4
2.	5.7	2.5
3.	3.5	1.4

Table ES-19. Attainment of Primary Contact WQ and Potential Future Primary Contact WQ Criteria with Alternatives 1, 2 and 3 – 2008 Model Simulation for Alternative 1 and 10 Year Model Simulations for Alternatives 2 and 3

Station	Alternatives 1, 2 and 3 Attainment with Primary Contact WQ Criteria (200 cfu/100mL fecal coliform) (%)	Attainment with Potential Future Primary Contact WQ Criteria for Enterococci					
		GM (30 cfu/100mL)			STV (110 cfu/100mL)		
		Alternative 1 (%)	Alternative 2 (%)	Alternative 3 (%)	Alternative 1(1) (%)	Alternative 2 (%)	Alternative 3 (%)
GC-1	100	≥95	≥95	≥95	87	87	86
GC-2	100	≥95	≥95	≥95	87	87	87
GC-3	100	≥95	≥95	≥95	87	87	86
GC-4	100	≥95	≥95	≥95	87	87	87
GC-5	100	≥95	≥95	≥95	90	87	84
GC-6	100	≥95	≥95	≥95	86	71	68
GC-7	100	≥95	≥95	≥95	77	71	69
GC-8	100	≥95	≥95	≥95	74	74	62
GC-9	100	≥95	≥95	≥95	76	75	72
GC-10	100	≥95	≥95	≥95	90	90	87

Notes:

(1) Alternative 1 is based on the 2008 model simulation and Alternatives 2 and 3 are based on the 10 year model simulations

Table ES-20. WQ Criteria Dissolved Oxygen Attainment with LTCP Alternatives 1, 2 and 3 – 2008 Model Simulation

Class	Stations	Criteria		Attainment		
				Alternative 1 (%)	Alternative 2 (%)	Alternative 3 (%)
SD	GC-1 to GC-7	Designated	≥ 3 mg/L	99	99	99
I	GC-8 to GC-10		≥ 4 mg/L	96	96	96
SC/SB	GC-1 to GC-7	Next Higher Classification	≥ 4.8 mg/L(1)	95	95	95
	GC-8 to GC-10			88	88	88
	GC-1 to GC-7		≥ 3 mg/L(2)	99	99	99
	GC-8 to GC-10			100	100	100

Notes:

(1) Chronic Standard.
(2) Acute Standard.

Table ES–21 compares compliance with the water quality classifications for the 2008 and 10 year model simulation for the Existing WQ Criteria, Primary Contact WQ Criteria and the Potential Primary Contact WQ Criteria achieved by Alternatives 1, 2 and 3.

Table ES-21. Alternatives 1, 2 and 3 – Compliance with Classifications and Standards - 2008 Model Simulation for Alternative 1 and 10 Year Model Simulations for Alternatives 2 and 3

Analysis	Numerical Criteria Applied		Compliance
Existing WQ Criteria Fish Survival (Class SD) and Boating/Fishing (Class I)	Gowanus Canal Above Hamilton Ave (Class SD)	Fecal - None;	Yes
		DO never < 3.0 mg/L[4]	Yes
	Gowanus Bay Below Hamilton Ave (Class I)	Fecal Monthly GM ≤ 2,000	Yes
		DO never <4.0 mg/L[4]	Yes
Primary Contact WQ Criteria[1]	Saline Water	Fecal Monthly GM ≤ 200	Yes
		Daily Average DO ≥4.8 mg/L[3] [4]	No[5]
		DO never < 3.0 mg/L[4]	Yes
Potential Future Primary Contact WQ Criteria[2]	Entero: rolling 30-d GM – 30 cfu/100mL		Yes
	Entero: STV – 110 cfu/100mL		No

Notes:
GM = Geometric Mean; STV = 90 Percent Statistical Threshold Value
(1) This water quality standard is not currently assigned to the Gowanus Canal or Gowanus Bay.
(2) The Potential Future Primary Contact WQ Criteria have not yet been adopted by DEC.
(3) The daily average DO concentration may fall below 4.8 mg/L for a limited number of days. See Section 2 for the equation and calculation description.
(4) DO based on 2008 typical year model simulations.
(5) DO Attainment is 88% at Station GC-8.

The water quality benefits achieved with Alternatives 1, 2 and 3 include reductions in CSO discharges to the Gowanus Canal. However, the 10-year water quality model runs do not show an appreciable elevation in WQS attainment. In all instances, the primary benefit will be fewer overflows to the Gowanus Canal and a greater removal of floatables.

The estimated construction and O&M costs for Alternatives 1, 2 and 3, as well as the corresponding Net Present Worth (NPW) are shown in Table ES- 22.

Table ES-22. Cost of Alternatives 1, 2 and 3

Alternative		Capital Cost ($M)	Annual O&M ($M)	NPW ($M)
1	8 MG Tank at Outfall RH-034	490	1.2	508
	4 MG Tank at Outfall OH-007	311	0.7	321
	Total	801	1.9	829
2	5.7 MG Tank at Outfall RH-034	450	0.9	462
	2.5 MG Tank at Outfall OH-007	213	0.5	221
	Total	663	1.4	683
3	3.5 MG Tank at Outfall RH-034	369	0.6	378
	1.4 MG Tank at Outfall OH-007	124	0.3	129
	Total	493	0.9	507

Conclusion

DEC and DEP have achieved dramatic improvements in water quality in the Gowanus Canal through an effective process that resulted in significant infrastructure improvements in the sewershed. These improvements were proposed in the 2008 WWFP submitted by DEP to DEC that was approved by DEC in 2009. That work included:

- Gowanus PS upgrade – increase capacity from 20 to 30 MGD and add screening facility to outfall for floatables control.
- Flushing Tunnel upgrade – three new pumps increasing average design flow to 215 MGD, and making it possible for more continuous flushing even during periods of low tide, with additional screening.
- Total project capital cost – $190M.

These WWFP projects, coupled with the planned GI build-out and the proposed HLSS, are projected to bring the Gowanus Canal into full compliance with designated WQS.

In accordance with EPA Superfund requirements to reduce TSS loadings to the Canal, DEP has evaluated a range of alternatives including various CSO storage tank sizes for Outfalls RH-034 and OH-007. Such tanks, while reducing TSS loadings, also significantly reduce the frequency of overflows from LTCP baseline conditions of over 40 per year to a maximum of approximately 12 to 13 per year. These tanks will, to a certain extent, improve the level of attainment with the potential future enterococci criteria. Schedules for construction of the two tanks would be established pursuant to the Superfund program.

As noted above, the baseline projects have led to projected full compliance with designated WQS. As a result, DEP is proposing upgrading the designated Class SD portion of the Gowanus Canal to a Class I. DEP plans to extend the period of PCM to assess the potential for even further upgrades to the waterbody classification (e.g., Class SC) as it appears, based on the monitoring to date, that water quality might support the uses associated with this classification during the recreational period. The Gowanus Canal should be considered for further upgraded WQS upon completion of the Superfund remediation work and results of water quality conditions after a longer trend of data can be analyzed from further PCM.

1.0 INTRODUCTION

This LTCP for the Gowanus Canal was prepared pursuant to the CSO Order on Consent (DEC Case No. CO2-20110512-25), dated March 8, 2012 (2012 CSO Order on Consent). The 2012 CSO Order on Consent is a modification of the 2005 CSO Order on Consent (DEC Case No. CO2-20000107-8). Under the 2012 CSO Order on Consent, the DEP is required to submit ten waterbody-specific and one Citywide LTCP to the DEC by December 2017. The Gowanus Canal LTCP is the sixth of those 11 LTCPs to be completed.

1.1 Goal Statement

The following is the LTCP Introductory Goal Statement, which appears as Appendix C in the 2012 CSO Order on Consent. It is generic in nature, so that waterbody-specific LTCPs will take into account, as appropriate, the fact that certain waterbodies or waterbody segments may be affected by NYC concentrated urban environment, human intervention, and current waterbody uses, among other factors. DEP will identify appropriate water quality outcomes based on site-specific evaluations in the drainage basin specific LTCP, consistent with the requirements of the CSO Control Policy and CWA.

> *"The New York City Department of Environmental Protection submits this Long Term Control Plan (LTCP) in furtherance of the water quality goals of the Federal Clean Water Act and the State Environmental Conservation Law. We recognize the importance of working with our local, State, and Federal partners to improve water quality within all Citywide drainage basins and remain committed to this goal.*
>
> *After undertaking a robust public process, the enclosed LTCP contains water quality improvement projects, consisting of both grey and green infrastructure, which will build upon the implementation of the U.S. Environmental Protection Agency's (EPA) Nine Minimum Controls and the existing Waterbody/Watershed Facility Plan projects. As per EPA's CSO Control Policy, communities with combined sewer systems are expected to develop and implement LTCPs that provide for attainment of water quality standards and compliance with other Clean Water Act requirements. The goal of this LTCP is to identify appropriate CSO controls necessary to achieve waterbody-specific water quality standards, consistent with EPA's 1994 CSO Policy and subsequent guidance. Where existing water quality standards do not meet the Section 101(a)(2) goals of the Clean Water Act, or where the proposed alternative set forth in the LTCP will not achieve existing water quality standards or the Section 101(a)(2) goals, the LTCP will include a Use Attainability Analysis, examining whether applicable waterbody classifications, criteria, or standards should be adjusted by the State. The Use Attainability Analysis will assess the waterbody's highest attainable use, which the State will consider in adjusting water quality standards, classifications, or criteria and developing waterbody-specific criteria. Any alternative selected by a LTCP will be developed with public input to meet the goals listed above.*
>
> *On January 14, 2005, the NYC Department of Environmental Protection and the NYS Department of Environmental Conservation entered into a Memorandum of Understanding (MOU), which is a companion document to the 2005 CSO Order also executed by the parties and the City of New York. The MOU outlines a framework for coordinating CSO long-term planning with water quality*

standards reviews. We remain committed to this process outlined in the MOU, and understand that approval of this LTCP is contingent upon our State and Federal partners' satisfaction with the progress made in achieving water quality standards, reducing CSO impacts, and meeting our obligations under the CSO Orders on Consent."

This Goal Statement has guided the development of the Gowanus Canal LTCP.

1.2 Regulatory Requirements (Federal, State, Local)

The waters of NYC are subject to Federal and New York State regulations. The following sections provide an overview of the regulatory issues relevant to long term CSO planning.

1.2.a Federal Regulatory Requirements

The CWA established the regulatory framework to control surface water pollution, and gave the EPA the authority to implement pollution control programs. The CWA established the National Pollutant Discharge Elimination System (NPDES) permit program. NPDES regulates point sources discharging pollutants into waters of the United States. CSOs and municipal separate storm sewer systems (MS4) are also subject to regulatory control under the NPDES program. In New York, the NPDES permit program is administered by the DEC, and is thus a State Pollution Discharge Elimination System (SPDES) program. New York State has had an approved SPDES program since 1975. Section 303(d) of the CWA and 40 CFR §130.7 (2001) require States to identify waterbodies that do not meet WQS and are not supporting their designated uses. These waters are placed on the Section 303(d) List of Water Quality Limited Segments (also known as the list of impaired waterbodies or "303(d) List"). The 303(d) List identifies the pollutant or stressor causing impairment, and establishes a schedule for developing a control plan to address the impairment. Placement on the list can lead to the development of a Total Maximum Daily Load (TMDL) for each waterbody and associated pollutant/stressor on the list. Pollution controls based on the TMDL serve as the means to attain and maintain WQS for the impaired waterbody.

As shown in Table 1-1, the Gowanus Canal remains delisted (updated September 2014) as a Category 4b waterbody for which required control measures (i.e. approved LTCP) other than a TMDL are expected to restore uses in a reasonable period of time.

Table 1-1. 2014 DEC 303(d) Impaired Waters Listed and Delisted (with Source of Impairment)

Waterbody	Pathogens	DO/Oxygen Demand	Floatables
Gowanus Canal	Delisted Category 4b Urban/Storm/CSOs	Delisted Category 4b CSOs, Urban/Storm	Not Listed

In September 2013, the EPA issued its ROD for the Gowanus Canal Superfund Site in Brooklyn, New York. The ROD requires the siting, design, construction, and operation of two CSO retention tanks to control discharges of solids to the Gowanus Canal, unless other technically viable alternatives are identified[1]. The ROD estimated that an 8 million gallon tank would be necessary at Outfall RH-034, and a 4 million gallon tank at Outfall OH-007. In addition, in May 2014, EPA issued a Unilateral Order to NYC requiring, among other things, the completion of a siting study to identify recommended locations for the tanks; this study is being submitted at the same time as this LTCP. The final siting, design and schedules for these projects will be determined in accordance with the Superfund process.

1.2.b Federal CSO Policy

The 1994 EPA CSO Control Policy provides guidance to permittees and NPDES permitting authorities on the development and implementation of a LTCP in accordance with the provisions of the CWA. The CSO policy was first established in 1994 and codified as part of the CWA in 2000.

1.2.c New York State Policies and Regulations

NYS has established WQS for all navigable waters within its jurisdiction. The Gowanus Canal is classified as a Class SD waterbody. A Class SD waterbody is defined as “suitable for fish, shellfish, and wildlife survival. This classification may be given to those waters that, because of natural or man-made conditions, cannot meet the requirements for primary and secondary contact recreation and fish propagation.” The best usage of Class SD waters is fishing (6 NYCRR 701.14). On December 3, 2014, DEC publicly noticed a proposed rulemaking which, if promulgated, would in part amend 6 NYCRR Part 701 to require that the quality of Class SD waters be suitable for “primary contact recreation” and to adopt corresponding total and fecal coliform standards in 6 NYCRR Part 703. In developing the Gowanus Canal LTCP, these proposed new regulations are referred to as Potential Future Primary Contact WQ Criteria. At the conclusion of DEC rulemaking, the LTCP will be reviewed for impacts to the findings.

The States of New York, New Jersey and Connecticut are signatories to the Tri-State Compact which designated the Interstate Environmental District and created the Interstate Environmental Commission (IEC). The Interstate Environmental District includes all tidal waters of greater NYC, including the Gowanus Canal. The IEC has recently been incorporated into and is now part of the New England Interstate Water Pollution Control Commission (NEIWPCC), a similar multi-state compact of which NYS is a member. Gowanus Canal is classified as Type B-1 under the IEC system. Details of the IEC Classifications are presented in Section 2.2.

1.2.d Administrative Consent Order

NYC and DEC have entered into Orders on Consent to address CSO issues, including the 2005 CSO Order on Consent, which was issued to bring all DEP CSO-related matters into compliance with the provisions of the CWA and the New York State Environmental Conservation Law (ECL), and requires implementation of the LTCPs. The 2005 CSO Order on Consent requires DEP to evaluate and implement CSO abatement strategies on an enforceable timetable for 18 waterbodies and, ultimately, for citywide long-term CSO control, in accordance with the 1994 EPA CSO Control Policy. The 2005 CSO Order on Consent was modified as of April 14, 2008, to change certain construction milestone dates. In addition, DEP and DEC entered into a separate Memorandum of Understanding (MOU) to facilitate WQS reviews

[1] See United States Environmental Protection Agency. Record of Decision, Gowanus Canal Superfund Site: Summary of Remedial Alternatives, page 55.

in accordance with the EPA CSO Control Policy. A 2009 modification addressed the completion of the Flushing Bay CSO Retention Facility.

In March 2012, DEP and DEC amended the 2005 CSO Order on Consent to provide for incorporation of GI into the LTCP process, as proposed under NYC's Green Infrastructure Plan, and to update certain project plans and milestone dates.

1.3 LTCP Planning Approach

The LTCP planning approach includes several phases. The first is the characterization phase – an assessment of current waterbody and watershed characteristics, system operation and management practices, the status of current green and grey infrastructure projects, and an assessment of current system performance. DEP is gathering the majority of this information from field observations, historical records, analyses of studies and reports, and collection of new data. The next phase involves the identification and analysis of alternatives to reduce the amount and frequency of wet-weather discharges and improve water quality. DEP expects that alternatives will include a combination of green and grey infrastructure elements that are carefully evaluated using both the collection system and receiving water models. Following the analysis of alternatives, DEP will develop a recommended plan, along with an implementation schedule and strategy. If the proposed alternative does not achieve existing WQS or the Section 101(a)(2) goals of CWA, the LTCP will include a UAA examining whether applicable waterbody classifications, criteria, or standards should be adjusted by DEC.

1.3.a Integrate Current CSO Controls from Waterbody/Watershed Facility Plans (Facility Plans)

This LTCP builds upon DEP's prior efforts by capturing the findings and recommendations from the previous facility planning documents for this watershed, including the WWFP. The LTCP integrates and builds on this existing body of work.

In August 2008, DEP issued the Gowanus Canal WWFP, and an addendum in April 2009. The WWFP, which was prepared pursuant to the 2005 CSO Order on Consent, includes an analysis and presentation of operational and structure modifications targeting the reduction of CSOs and improvement of the overall performance of the collection and treatment system within the watershed. The DEC approved the Gowanus Canal WWFP on July 14, 2009.

1.3.b Coordination with DEC

As part of the LTCP process, DEP attempted to work closely with DEC to share ideas, track progress, and work toward developing strategies and solutions to address wet-weather challenges for the Gowanus Canal LTCP.

DEP shared the Gowanus Canal alternatives and held discussions with DEC on the formulation of various control measures, and coordinated public meetings and other stakeholder presentations with DEC. On a quarterly basis, DEC, DEP, and outside technical consultants also convene for larger progress meetings that typically include technical staff and representatives from DEP and DEC's Legal Departments and Department Chiefs who oversee the execution of the CSO program.

1.3.c Watershed Planning

DEP prepared its CSO WWFPs before the emergence of GI as an established method for reducing stormwater runoff. Consequently, the WWFPs did not include a full analysis of GI alternatives for controlling CSOs. In comments on DEP's CSO WWFPs, community and environmental groups voiced widespread support for GI, urging DEP to place greater reliance upon that sustainable strategy. In September 2010, NYC published the *NYC Green Infrastructure Plan*, hereinafter referred to as the GI Plan. Consistent with the GI Plan, the 2012 CSO Order on Consent requires DEP to analyze the use of GI in LTCP development. As discussed in Section 5.0, this sustainable approach includes the management of stormwater at its source through the creation of vegetated areas, bluebelts and greenstreets, green parking lots, green roofs, and other technologies.

1.3.d Public Participation Efforts

DEP made a concerted effort during the Gowanus Canal LTCP planning process to involve relevant and interested stakeholders, and keep interested parties informed about the project. A public outreach participation plan was developed and implemented throughout the process; the plan is posted and regularly updated on DEP's LTCP program website, www.nyc.gov/dep/ltcp. Specific objectives of this initiative included the following:

- Develop and implement an approach that would reach interested stakeholders;
- Integrate the public outreach efforts with other aspects of the planning process; and
- Take advantage of other ongoing public efforts being conducted by DEP and other NYC agencies as part of related programs.

The public participation efforts for this Gowanus Canal LTCP are summarized in Section 7.0 in more detail.

2.0 WATERSHED/WATERBODY CHARACTERISTICS

This section summarizes the major characteristics of the Gowanus Canal watershed and waterbody, building upon earlier documents that present a characterization of the area including, most recently, the WWFP for the Gowanus Canal (DEP, 2008). Section 2.1 addresses watershed characteristics and Section 2.2 addresses waterbody characteristics.

2.1 Watershed Characteristics

The Gowanus Canal watershed is highly urbanized, comprised primarily of residential areas with some commercial, industrial, institutional and open space/outdoor recreation areas. The most notable outdoor recreation area within this watershed is the Prospect Park in Brooklyn, located next to the area served by the Owls Head (OH) WWTP.

This subsection contains a summary of the watershed characteristics as they relate to the land use, zoning, permitted discharges and their characteristics, and sewer system configuration, performance, and impacts to the adjacent waterbodies, as well as the modeled representation of the collection system used for analyzing system performance and CSO control alternatives.

2.1.a Description of Watershed

The Gowanus Canal watershed comprises approximately 1,758 acres located on the northwestern shore of the Brooklyn Borough. The majority of the land immediately surrounding the shores of the Gowanus Canal is primarily industrial and commercial. As described later in this section, the area is served by a complex collection system comprised of combined and separate storm sewers; interceptor sewers and pumping stations; several CSO and stormwater outfalls; and the Flushing Tunnel. The Flushing Tunnel is the major source of flow to the Gowanus Canal, with a rated pumping capacity of 215 MGD.

The watershed has undergone major changes as this part of NYC has been developed. As it developed, the condition of the waterbody and its shoreline was influenced by engineered sewer systems, filled-in wetlands and an overall “hardening” of the shorelines with bulkheads.

The urbanization of the Gowanus Canal has led to the creation of a large combined sewer system (CSS) and smaller pockets served by separate sanitary sewer systems (SSS), including its companion stormwater systems that discharge directly to the Gowanus Canal, or to a nearby CSS. Generally, the combined sewage is conveyed to the WWTPs for treatment. Combined sewage that exceeds the capacity of the CSS during wet-weather overflows through the CSO, outfalls to the Gowanus Canal. As shown in Figure 2-1 the Gowanus Canal watershed is served by both the Owls Head WWTP and Red Hook (RH) WWTP service areas.

As shown in Figure 2-2 and Table 2-1, there are numerous discharges to each section of the river. In total, 228 pipes have been documented to exist along the shoreline of the Gowanus Canal by the Shoreline Survey Unit of DEP’s Compliance Monitoring Section (CMS). Thirteen of those pipes are DEP permitted CSOs; three are DEP MS4 permitted outfalls. The remaining pipes belong to other agencies or are associated with private entities.

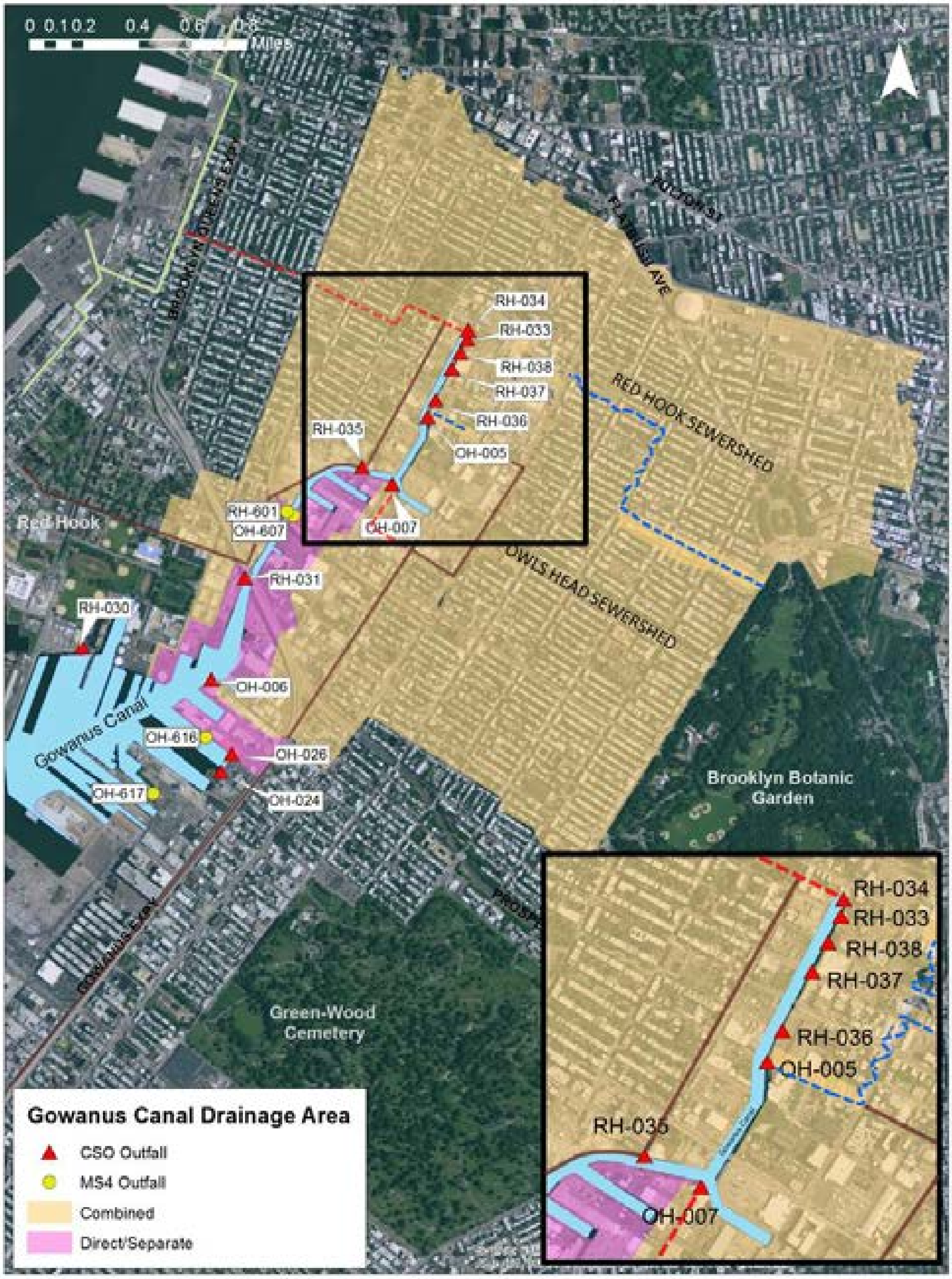

Figure 2-1. Gowanus Canal Watershed and Associated WWTP Service Areas

Figure 2-2. Gowanus Canal Outfalls

Table 2-1. Outfall Pipes to Gowanus Canal

Identified Ownership of Pipes	Number of Pipes
NYC DEP	DEP MS4 Permitted = 3
	DEP CSO Permitted = 13
Non-DEP SPDES	2
NYS Highway	2
NYC Department of Transportation	2
Private	177
Unknown	29
Total	228

As a residential community within NYC, the Gowanus Canal area has several large and notable aboveground transportation corridors that cross the watershed to provide access between industrial, commercial and residential areas. These access routes include the Brooklyn-Queens Expressway and parts of the NYC subway system (Figure 2-3).

2.1.a.1 Existing and Future Land Use and Zoning

Current land use for the watershed is shown in Figure 2-4, and generally aligns with the established zoning. Below is a discussion on current land uses, zoning, neighborhood and community characteristics, as well as NYC's planned future zoning and uses.

In general, the riparian area immediately surrounding the Gowanus Canal (including all blocks which are wholly or partially within a quarter mile of the Gowanus Canal) are dominated by warehouses, commercial and heavy industrial uses, while the rest of the watershed is mostly residential. Table 2-2 summarizes the land-use characteristics of both the Gowanus Canal watershed and riparian area. As a whole, the Gowanus Canal watershed is 50 percent residential, 13 percent industrial, 2 percent parkland and 35 percent a mix of various uses, including public facilities and institutions, commercial, and transportation related uses. Riparian areas are characterized as 20 percent residential, 30 percent industrial, 7 percent parkland, and 43 percent a mix of various uses including public facilities and institutions, commercial, and transportation related uses.

Table 2-2. Existing Land Use within the Gowanus Canal Drainage Area

Land Use Category	Percent of Area	
	Riparian Area (1/4-mile radius) (%)	Drainage Area (%)
Commercial	9	7
Industrial	30	13
Open Space and Outdoor Recreation	7	2
Mixed Use and Other	4	10
Public Facilities	2	7
Residential	20	50
Transportation and Utility	22	5
Parking Facilities	4	4
Vacant Land	2	2

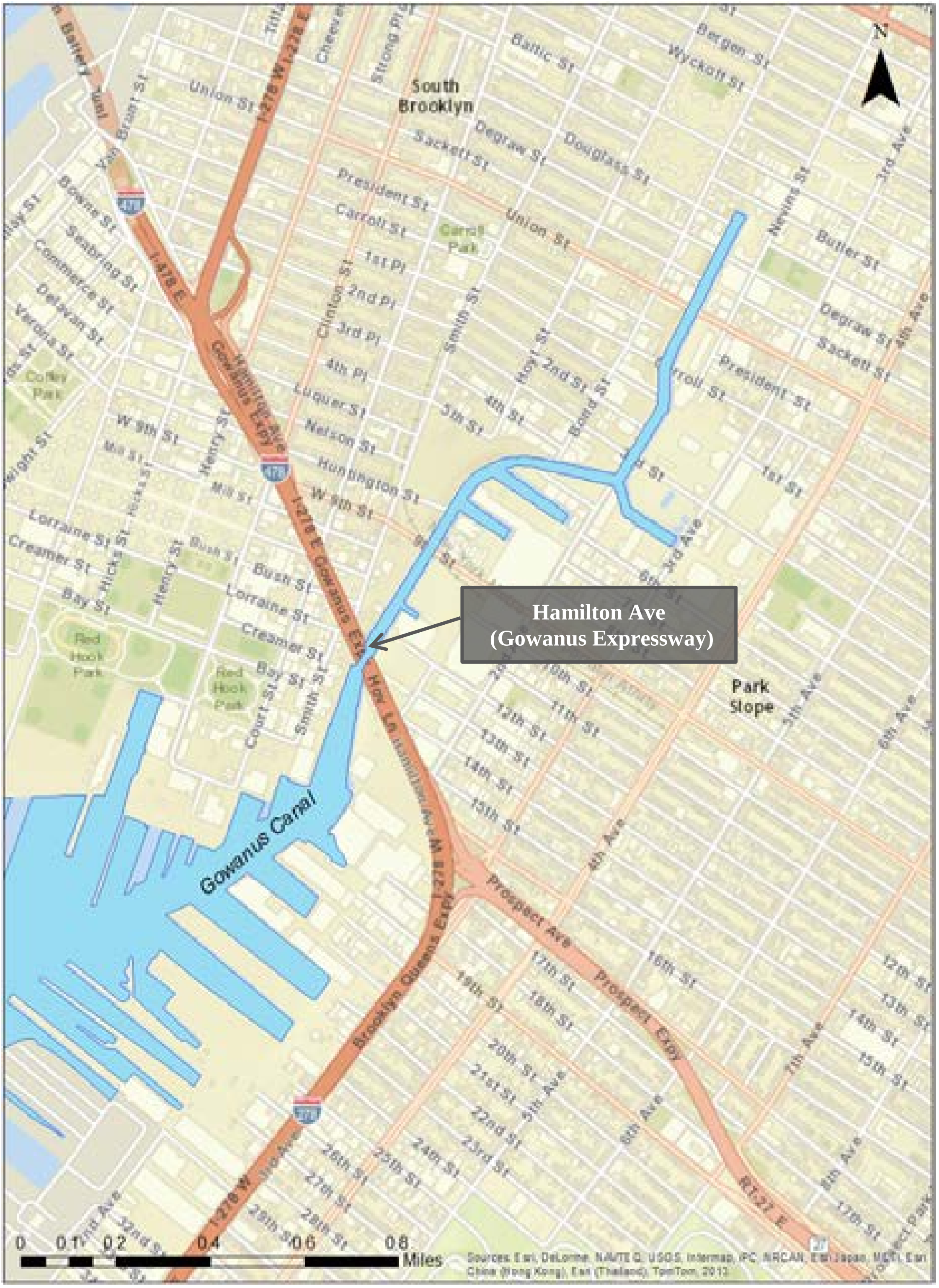

Figure 2-3. Major Transportation Features of Gowanus Canal Watershed

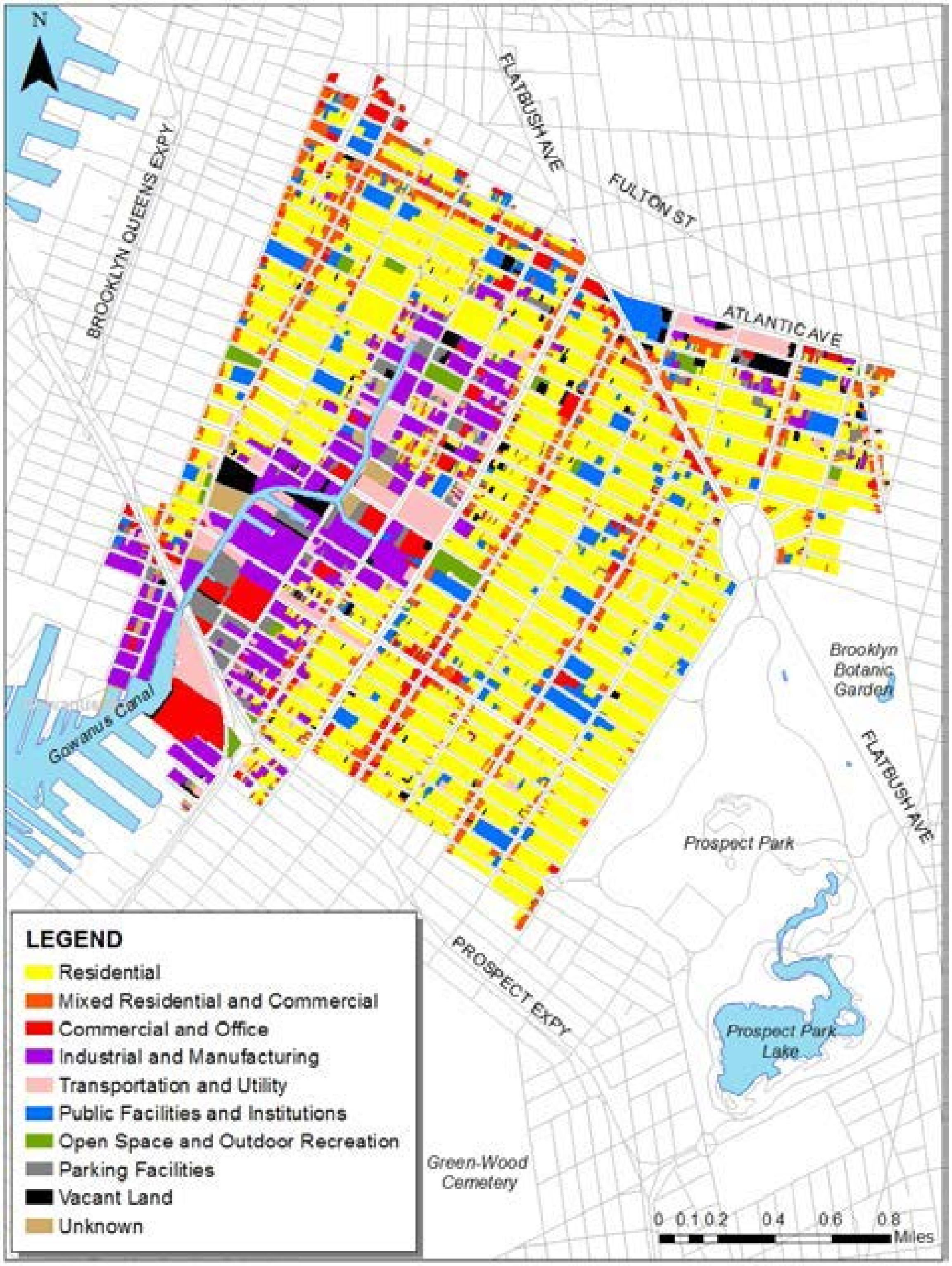

Figure 2-4. Land Use in Gowanus Canal Watershed

The riparian area is generally zoned for industrial uses along the upper reaches, with commercial, institutional and vacant land uses scattered along the waterfront in the vicinity and south of the Gowanus Expressway. Transportation uses are scattered along the watershed (Figure 2-1). Approximately, a quarter of the riparian land area (shown on Figure 2-4) surrounding the Gowanus Canal is classified as having transportation or utility uses. These transportation uses are primarily located near the mouth of the Gowanus Canal. One major transportation use is the South Brooklyn Marine Terminal, currently undergoing planning reviews, is located along the southern shoreline beyond the Gowanus Canal. Another is the Erie Basin Barge Port, which has barge slips and distribution centers located along the interior of Erie Basin. Erie Basin also features a New York City Police Department vehicle impound lot at the western end of the seawall arm, a large one-story warehouse building and associated parking area, and additional storage and commercial uses. In addition, the newly refurbished Columbia Street Esplanade, which includes a pedestrian walkway, bikeway and fishing pier, is located along the south side of the seawall. The former New York Shipyard is located to the north of Erie Basin, approximately one-quarter mile west of the lower reaches of the Gowanus Canal. Industrial, semi-industrial and warehousing uses are found along the Gowanus Canal waterfront, and generally extend from the waterfront to the first upland block from the Gowanus Canal. These uses exist on approximately 23 percent of the land within the assessment area. Common industrial uses throughout the reach include various manufacturing operations, distribution/ trucking centers, warehouses and bulk fuel/petroleum storage facilities. A cement plant is located at the intersection of Hoyt and 5th Street. Further south, along the western bank of the Gowanus Canal, fuel tanks, a scrap metal yard and a parking lot are located between 9th Street and the Gowanus Expressway. Further south and west of the Gowanus Expressway, a fuel-storage facility is located in the vicinity of Bryant and Court Streets: this facility extends from Clinton Street east to Smith Street and the Gowanus Canal. North of the fuel-storage facility, several automotive and truck repair facilities exist along the Gowanus Canal waterfront.

Situated at the intersection of Smith and 5th Streets is a six-acre parcel of NYC-owned property that was designated a “Public Place” by the NYC Board of Estimate in 1974. This parcel, which was previously occupied by a coal gasification plant, was declared an Inactive Hazardous Waste Site by the DEC due to the presence of solvents, coal tar residues, and phthalate wastes left from former industrial tenants (reference: Community Board 6 website). This parcel remains vacant pending decisions regarding remediation and lack of consensus over its future use. In general, residential uses are located upland within close proximity to the Gowanus Canal waterfront.

The Red Hook Houses, a New York City Housing Authority (NYCHA) development, is located at the westernmost extent of the assessment area, approximately three blocks north of the Gowanus Canal waterfront. Northeast of the Red Hook Houses, residential uses predominate, with scattered institutional uses and small-scale commercial uses that serve the residential populations of the area. Public and community facilities in the vicinity include the NYC Fire Department Engine Company 279, Ladder 131 facility (at the corner of Smith and Lorraine Streets), Saint Mary’s Roman Catholic Church and Convent (along Nelson Street), and the Brooklyn Psychiatric Center (at the intersection of Union and Hoyt Streets).

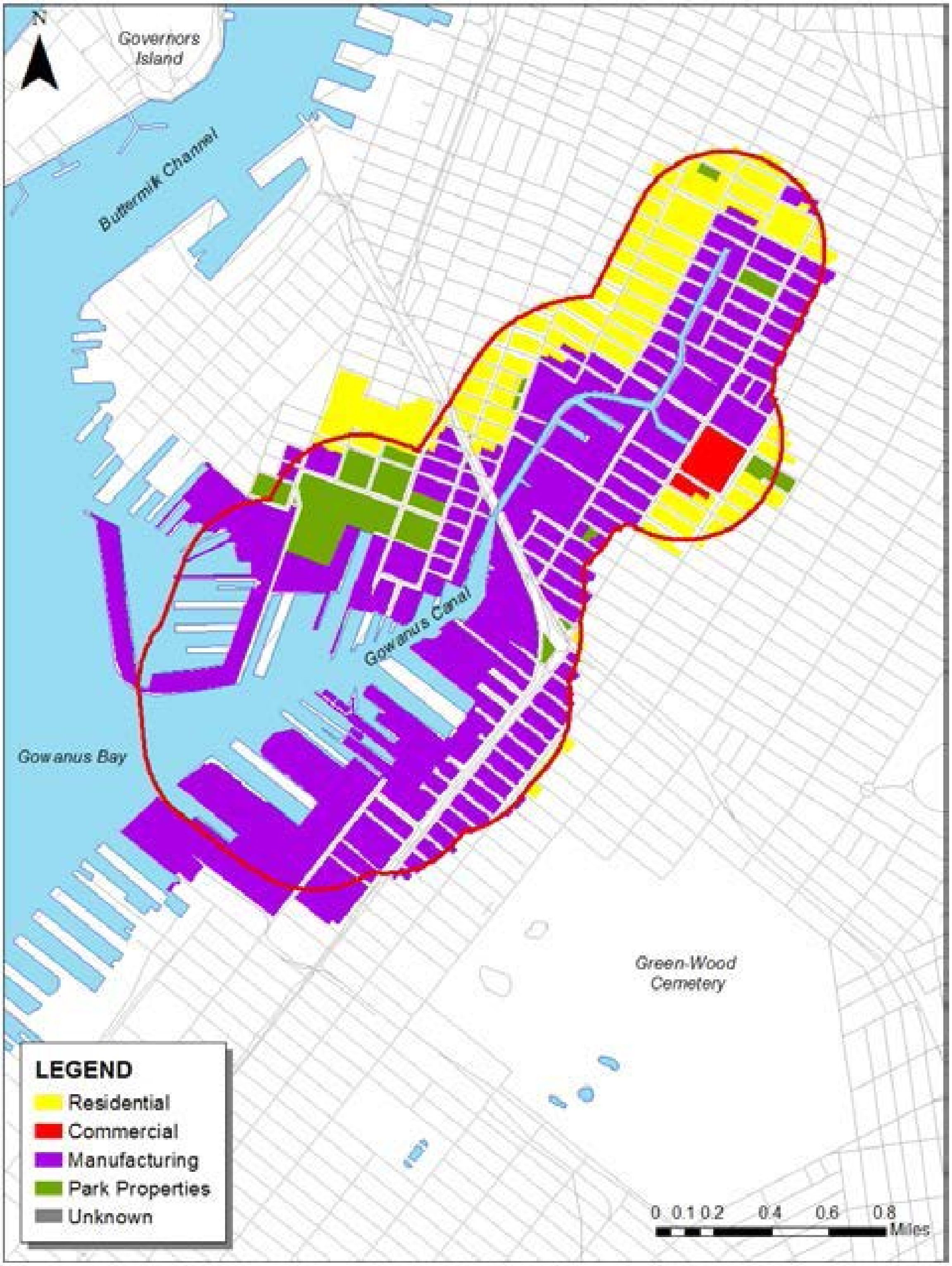

Figure 2-5. Quarter Mile Riparian Zoning in the Gowanus Canal Vicinity

Near the head of the Gowanus Canal, are the Gowanus Houses, a large NYCHA housing development that is located on Douglass Street, between Hoyt and Bond Streets. North of 1st Street, the ends of streets in the vicinity of the Gowanus Canal have undergone various improvements. These include community gardens and Green Streets, intended to convert paved, vacant areas, medians, and unused traffic islands into green spaces filled with trees, shrubs and other types of ground cover. These improvements have created small areas of open space within the assessment area. In addition, street-end improvements are currently in place along DeGraw Street, east of the Gowanus Canal. Beginning at the north end of the Gowanus Canal and proceeding southward, the eastern side of the Gowanus Canal is dominated by industrial uses, with other land uses interspersed. The Wyckoff Houses, a NYCHA housing development, is located in the vicinity of Baltic and Nevins Streets, north and east of the Gowanus Canal. The Thomas Greene Playground is located between Nevins and 3rd Avenue, east of the Gowanus Canal. Consolidated Edison of New York maintains a vehicle parking and maintenance facility between 3rd and 4th Avenues at 3rd Street, adjacent to and south of P.S. 372 - The Children's School at 219 1st Street. Further south, J.J. Byrne Park is located in the vicinity of the 4th Street Basin.

East of the Pathmark shopping center is the New York City Department of Sanitation (DSNY) Brooklyn District 6 Garage, which is located at the intersection of 2nd Avenue and 14th Street. Several large industrial and institutional operations are located south of the Gowanus Expressway and Hamilton Avenue along the Gowanus Canal waterfront.

The New York City Department of Transportation (DOT) operates an asphalt plant on the south side of the Gowanus Canal immediately west of Hamilton Avenue. Adjacent to the DOT facility is the DSNY Hamilton Avenue Marine Transfer Station, also on the south side of the Gowanus Canal. South of the DSNY facility, along Hamilton Avenue, are two large commercial uses, specifically a home-improvement retailer and a retail supermarket. To the east of 3rd Avenue, land uses are mixed residential and industrial.

Waterfront uses to the south are dominated by large-scale industrial and transportation uses.

Figure 2-5 presents a map of the established zoning within the riparian areas surrounding the Gowanus Canal. Zoning in the areas immediately surrounding the waterbody is important, not only to characterize the waterbody and the uses associated with it, but also as a consideration when developing engineering solutions as part of this LTCP, particularly siting considerations and impacts of CSO control facilities in the surrounding neighborhoods.

As shown on Figure 2-5, the riparian area, comprised of blocks wholly or partially within a quarter mile of the Gowanus Canal waterfront, is dominated by industrial zoning classifications. South of the Gowanus Expressway/Hamilton Avenue, the waterfront area (the block extending inland from the Gowanus Canal) is zoned for the heaviest industrial and manufacturing uses. This area features marine terminals, power-generating facilities, transfer stations, and an asphalt plant. North of the Gowanus Expressway, the waterfront area along the western side is mostly heavy industrial to 4th Street, while the waterfront area north of 4th Street and along the eastern side of the Gowanus Canal is virtually all zoned for moderate manufacturing uses. On the eastern side of the Gowanus Canal, just to the north of the Gowanus Expressway, there is a lighter industrial classification. On the western side, beyond the first upland block surrounding the Gowanus Canal, the zoning changes from industrial to residential. South of the Gowanus Expressway/Hamilton Avenue and east of the Gowanus Canal, the area to the east of 3rd Avenue is zoned for light industrial use that allow for limited residential development by Special Permit. On the west side of the Gowanus Canal, the heavy industrial zones adjacent to the Gowanus Canal give way to park designations, which include the Red Hook Recreational Area. Extending north from this park area to about 3rd Street are several small areas of light industrial classification that allows for certain community uses. To the west is a residential area that extends north around the head of the Gowanus Canal, just beyond the waterfront block. This residential area allows for medium-density housing—typically buildings between 3 and 12 stories. North of 3rd Street, this residential area is adjacent to the industrial-zoned waterfront block that surrounds the Gowanus Canal. Near the head of the Gowanus Canal, but just east of the waterfront block, there is a light industrial classification that generally serves as a buffer between heavier industrial uses and residential uses. South of this area, on the east side of the Gowanus Canal between 7th and 3rd Streets, there is a commercial area that serves as a transition between manufacturing and residential uses. To the south and east of these zones are residential areas that define medium-density housing districts of slightly different lot coverage and set-back requirements. The 4th Avenue corridor in the assessment area features a higher-density residential classification.

An assessment of currently proposed land uses, or significant new facilities, was conducted for the Gowanus Canal watershed area. Several significant proposed or recently completed developments were identified within the assessment area. As part of widespread revitalization and expansion efforts within the Port of New York, the NYC Economic Development Corporation (EDC) has commenced improvements within the existing South Brooklyn Marine Terminal (SBMT), located at the southernmost extent of the assessment area along the Upper New York Bay waterfront.

The Atlantic Yards project will involve the development of landscaped open space, a boutique hotel, ground-floor retail space for local businesses, office space, and over 6,400 units of affordable, middle-income and market-rate housing. The proposed project will be located at the intersection of Atlantic and Flatbush Avenues, bounded by Pacific and Dean Streets and Vanderbilt Avenue, and primarily situated over the existing Metropolitan Transit Authority (MTA)/Long Island Rail Road (LIRR) Vanderbilt rail yards. Atlantic Yards will span 22 acres and transform the current rail yards and predominantly underutilized and industrial area into 17 buildings. The $4B development will encompass 336,000 square feet of office space, up to 6.4 million square feet of residential space, an 850,000-square-foot sports and entertainment arena, 247,000 square feet of retail space, a 165,000-square-foot hotel (180 rooms) and over eight acres of publicly accessible open space. Initial construction began in 2007, and the project will be developed in phases over an estimated 10-year period. North of 3rd Street, on the eastern side of the Gowanus Canal, is a Whole Foods supermarket that was built in 2013. This approximately 1.5-acre site is located at the northwestern corner of 3rd Street at 3rd Avenue. This is an approximately 75,421-square-foot store with a 430-car parking lot. Residential developments by Lighthouse have also been proposed for areas immediately adjacent to the Gowanus Canal. Lighthouse has begun construction of an approximately 700-unit residential development along the western shore of the Gowanus Canal. In addition, other residential developments have been proposed or are in the active planning stages.

2.1.a.2 Permitted Discharges

There are several permitted stormwater and CSO discharge points along the Gowanus Canal. These are discussed in more detail in Section 2.1.c. There are no dry-weather permitted discharges associated with this waterbody. Based on data available on-line at the date of submittal of this LTCP, it was determined that a total of four state-significant industrial SPDES permit holders operate facilities located in the watershed. Table 2-3 lists these permits, their owners and location.

Table 2-3. Industrial SPDES Permits within the Gowanus Canal Watershed

Permit Number	Owner	Location
NY0201049	NYC Department of Transportation	9th Street Bridge and Gowanus Canal
NY0028606	Bayside Fuel Oil Depot Corporation	537 Smith Street
NY0110001	Hess Corporation	722 Court Street and Gowanus Canal
NY0201006	Astoria Generating Company LP	29th Street and 2nd Avenue

2.1.a.3 Impervious Cover Analysis

Impervious surfaces within a watershed are those characterized by an artificial surface, such as concrete, asphalt, rock, or rooftop. Rainfall occurring on an impervious surface will experience a small initial loss through ponding and seasonal evaporation on that surface, with the remaining rainfall volume becoming overland runoff that flows directly into the CSS and/or a separate stormwater system. The impervious surface is important when characterizing a watershed and CSS performance, as well as when constructing hydraulic models used to simulate CSS performance.

A representation of the impervious cover was made in the 13 NYC WWTPs combined area drainage models developed in 2007 to support the several WWFPs that were submitted to DEC in 2009. As described below, efforts to update the model and the impervious surface representation were recently completed.

As NYC began to focus attention on the use of GI to manage street runoff of stormwater by either slowing it down prior to entering the combined sewer network, or preventing it from entering the network entirely, it became clear that a more detailed evaluation of the impervious cover would be beneficial. In addition, NYC realized that it would be important to distinguish between impervious surfaces that directly introduce storm runoff to the sewer system (Directly Connected Impervious Areas [DCIA]) from those impervious surfaces that may not contribute runoff directly to the sewers. For example, a rooftop with roof drains directly connected to the combined sewers (as required by the NYC Plumbing Code) would be an impervious surface that is directly connected. However, a sidewalk or impervious surface adjacent to parkland may not contribute storm runoff to the CSS and, as such, would not be considered directly connected.

In 2009 and 2010, DEP invested in the development of high-quality satellite measurements of impervious surfaces required to conduct the analyses that improved the differentiation between pervious and impervious surfaces, as well as the different types of impervious surfaces. The data and the approach used are described in detail in the InfoWorks CS™ (IW) Citywide Model Recalibration Report (DEP, 2012a). The result of this effort yielded an updated model representation of the areas that contribute runoff to the CSS. This improved set of data aided in model recalibration, and provided DEP with a better idea of where GI can be deployed to reduce the runoff contributions from impervious surfaces that contribute flow to the collection system.

2.1.a.4 Population Growth and Projected Flows

DEP routinely develops water consumption and dry-weather wastewater flow projections for DEP planning purposes. In 2012, DEP projected an average per capita water demand of 75 gallons per day that was representative of future uses. The year 2040 was established as the planning horizon, and populations for that time were developed by the New York City Department of City Planning (DCP) and the New York Transportation Metropolitan Council.

The 2040 population projection figures were then used with the dry-weather per capita sewage flows to establish the dry-weather sewage flows contained in the IW models for the Owls Head and Red Hook WWTP sewersheds. This was accomplished by using Geographical Information System (GIS) tools to proportion the 2040 populations locally from the 2010 census information for each landside subcatchment tributary to each CSO outfall. Per capita dry-weather sanitary sewage flows for these landside model subcatchments were established as the ratio of two factors: the per capita dry-weather sanitary sewage flow for each year; and 2040 estimated population for the landside model subcatchment within the WWTPs service areas.

2.1.a.5 Update Landside Modeling

The Gowanus Canal watershed is represented within the overall Owls Head and Red Hook WWTPs system IW models. Several modifications to both collection systems have occurred since the models were calibrated in 2009, supporting the Gowanus Canal WWFP. Given that both models have been used for analyses associated with the annual reporting requirements of the SPDES permit, Best Management Practices (BMPs) and PCM, many of these changes have already been incorporated into the models. Other updates to the modeled representation of the collection systems that have been made since the 2009 update include:

- Outfall OH-007 tributary area pipe connectivity updated and runoff parameters validated with recent flow monitoring data.
- Outfall OH-007 diversion structures updated with recent field survey data.

In addition to changes made to the modeled representations of the collection system configuration, other changes include:

- ***2013/2014 Additional Validation.*** Additional meters were installed to further characterize CSO discharges at Outfalls OH-007 and RH-034 for the LTCP. The meters at Outfall OH-007 were installed for 12 months as part of DEP's CSO Flow Monitoring Pilot Study, wherein both the influent sewer and overflow were monitored. For each validation event, modeled versus measured hydrographs were generated to evaluate the model's performance relative to the measured data. In addition, the overall goodness-of-fit was examined by comparing the modeled event volume, peak flow and maximum water depth of the events to the measured data in goodness-of-fit scatter plots. The validation indicates that the model closely matches measured overflow predictions at Outfall OH-007. Figure 2-6 summarizes the measured versus model-predicted overflow statistics for the monitoring period. Meters were placed at Outfall RH-034 in both the influent and overflow lines to evaluate overflows from this CSO. Due to meter data issues, only one event was available for comparison. During the April 20, 2015 storm, the meter data recorded approximately 3.7 MG of overflow. The model predicted 4.2 MG for the same storm. Although there was only one storm event to compare, a previous analysis suggests that Outfall RH-034 is reasonably calibrated. The hydrologic characteristics of the area tributary to Outfall RH-034 were calibrated during the 2012 Citywide InfoWorks Model Recalibration utilizing a meter within the Outfall RH-034 tributary area. The dry-weather flow conveyed to the Red Hook WWTP is governed by a pump station whose maximum capacity is 30 MGD. With the inflow calibrated and the flow going to the treatment plant defined, the remainder can be calculated as overflow.

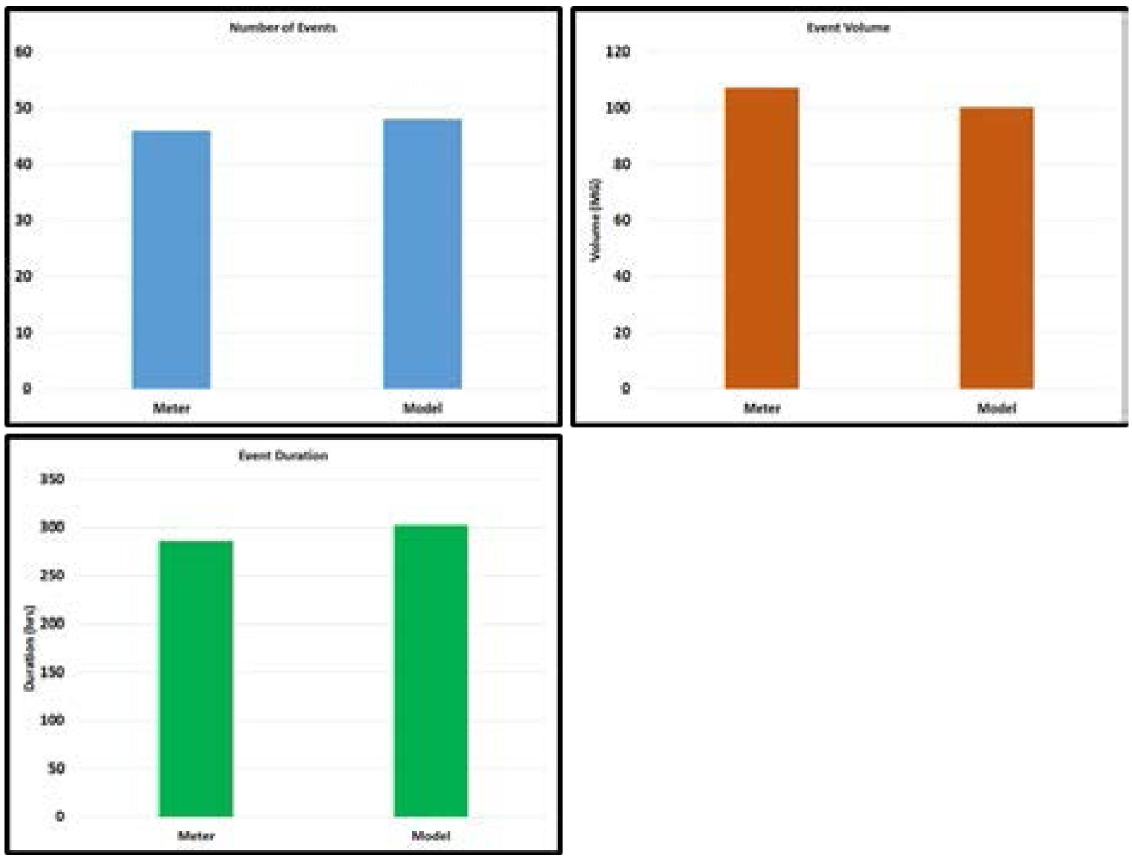

Figure 2-6. Comparison of Measured Versus Modeled Overflows at Outfall OH-007

- ***Runoff generation methodology***, including the identification of pervious and impervious surfaces. As described in Section 2.1.a.3 above, the impervious surfaces were also categorized into DCIAs and impervious runoff surfaces that do not contribute runoff to the collection system.

- ***GIS Aligned Model Networks.*** Historical IW models were constructed using record drawings, maps, plans, and studies. Over the last decade, DEP has been developing a GIS system that will provide the most up-to-date information available on the existing sewers, regulators, outfalls, and pump stations. Part of the update and model recalibration utilized data from the GIS repository for interceptor sewers.

- ***Interceptor Sediment Cleaning Data.*** Between April 2009 and May 2011, DEP undertook a citywide interceptor sediment inspection and cleaning program over approximately 136 miles of NYC's interceptor sewers. Data on the average and maximum sediment in the inspected interceptors were available for use in the model as part of the update and recalibration process. Multiple sediment depths available from sonar inspections were spatially averaged to represent depths for individual interceptor segments included in the model but not yet cleaned.

- ***Evapotranspiration Data.*** Evapotranspiration (ET) is a meteorological input to the hydrology module of the IW model that represents the rate at which depression storage (surface ponding) is depleted and available for use for additional surface ponding during subsequent rainfall events. In previous versions of the model, an average rate of 0.1 inches/hour (in/hr) was used for the model calibration, while no evaporation rate was used as a conservative measure during alternatives analyses. During the update of the model, hourly ET estimates obtained from four National Oceanic and Atmospheric Administration (NOAA) climate stations (John F. Kennedy [JFK], Newark [EWR], Central Park [CPK], and LaGuardia [LGA]) for an 11-year period were reviewed. These data were used to calculate monthly average ETs, which were then used in the updated model. The monthly variations enabled the model simulation to account for seasonal variations in ET rates, which are typically higher in the summer months.

- ***Tidal Boundary Conditions at CSO Outfalls.*** Tidal stage can affect CSO discharges when tidal backwater in a CSO outfall reduces the ability of that outfall to relieve excess flow. Model updates took into account this variable boundary condition at CSO outfalls that were influenced by tides. Water elevation based on the tides was developed using a customized interpolation tool that assisted in the computation of meteorologically-adjusted astronomical tides at each CSO outfall in the New York Harbor complex.

- ***Dry-Weather Sanitary Sewage Flows.*** Dry-weather sewage flows were developed as discussed in Section 2.1.a.4 above. Hourly dry-weather flow (DWF) data for 2011 were used to develop the hourly diurnal variation patterns at each plant. Based on the calibration period, the appropriate DWFs for 2005 or 2006, or another calendar year, were used.

- ***Precipitation.*** A review of the rainfall records for model simulations was undertaken as part of this exercise, as discussed in Section 2.1.b below.

In 2012, 13 of NYC's IW landside models underwent recalibration in addition to the updates and enhancements listed above. This effort is summarized with the calibration results in the IW Citywide Recalibration Report (DEP, 2012a) required by the 2012 CSO Order on Consent. Following this report, DEP submitted to DEC a Hydraulic Analysis Report in December 2012. The general approach followed was to recalibrate the model in a stepwise fashion beginning with the hydrology module (runoff). The following summarizes the overall approach to model update and recalibration:

- ***Site scale calibration (Hydrology).*** The first step was to focus on the hydrologic component of the model, which had been modified since 2007. Using updated satellite data flow monitoring data were collected in upland areas of the collection systems, remote from (and thus largely unaffected by) tidal influences and in-system flow regulation, for use in understanding the runoff characteristics of the impervious surfaces. Data were collected in two phases – Phase 1 in the Fall of 2009, and Phase 2 in the Fall of 2010. These areas ranged from 15 to 400 acres. A range of areas with different land-use mixes was selected to support the development of standardized sets of coefficients that can be applied to other unmonitored areas of NYC. The primary purpose of this element of the recalibration was to adjust pervious and impervious area runoff coefficients to provide the best fit of the runoff observed at the upland flow monitors.

- ***Area-wide recalibration (Hydrology and Hydraulics).*** The next step in the process was to focus on larger areas of the modeled systems where historical flow metering data were available, and which were neither impacted by tidal backwater conditions nor subjected to flow regulation. Where necessary, runoff coefficients were further adjusted to provide reasonable simulation of flow measurements made at the downstream end of these larger areas. The calibration process then moved downstream further into the collection system, where flow data were available in portions of the conveyance system where tidal backwater conditions could exist, as well as potential backwater conditions from throttling at the WWTPs. The flow measured in these downstream locations would further be impacted by regulation at in-system control points (regulator, internal reliefs, etc.). During this step in the recalibration, minimal changes were made to runoff coefficients.

The results of this effort are models with better representation of the collection systems and their tributary areas. These updated models are used for the alternatives analysis as part of the Gowanus Canal LTCP. A comprehensive discussion of the recalibration efforts can be found in the IW Citywide Recalibration Report (DEP, 2012a) and Hydraulic Analysis Report (DEP, December 2012).

2.1.b Review and Confirm Adequacy of Design Rainfall Year

DEP has been consistently applying the 1988 annual precipitation characteristics to the landside IW models to develop loads from combined and separately sewered drainage areas. To-date, 1988 has been considered to be representative of long term average conditions. Therefore, that year has been used to analyze facilities where "typical" rather than extreme conditions serve as the basis of design, in accordance with the EPA CSO Control Policy of using an "average annual basis" for analyses. However, in light of increasing concerns over climate change, with the potential for more extreme and possibly more frequent storm events, the selection of 1988 as the average condition was re-considered. Recent landside modeling analyses in NYC have used the 2008 precipitation pattern to drive the runoff-conveyance processes, together with the 2008 tide observations. Because it also included some extreme storms, DEP now believes 2008 to be more representative than 1988 conditions.

While the WWFPs for the NYC waterbodies were based on 1988 rainfall conditions, future baseline conditions runs are now being performed using 2008 as the typical precipitation year. A comparison of these rainfall years, which led to the selection of 2008 as the typical year for this LTCP, is provided in Table 2-4. For 10-year simulations, the period of 2002-2011 is used (see Section 6).

Table 2-4. Comparison of Rainfall Years to Support Evaluation of Alternatives

Parameter	WWFP JFK 1988	Present-Day Average 1969-2010	Present Best Fit JFK 2008
Annual Rainfall (in)	40.7	45.5	46.3
July Rainfall (in)	6.7	4.3	3.3
November Rainfall (in)	6.3	3.7	3.3
Number of Very Wet Days (>2.0 in)	3	2.4	3
Average Peak Storm Intensity (in/hr)	0.15	0.15	0.15

2.1.c Description of Sewer System

The Gowanus Canal watershed/sewershed is located within the Borough of Brooklyn (Brooklyn County, within NYC) political jurisdiction. The watershed is served by the Owls Head and Red Hook WWTPs and associated collection systems. The Gowanus Canal watershed and associated WWTP service areas are shown in Figure 2-1. The following sections describe the major features of the Owls Head and Red Hook WWTP tributary areas. Table 2-5 shows the areas served by the various drainage system categories.

Table 2-5. Gowanus Canal Sewershed: Acreage Per Sewer System Category

Sewer Area Description	Area (acres)
Combined	**1,612**
Separate	**42**
Direct Drainage	**146**
Total	**1,758**

It should be noted that the combined sewer drainage areas have been delineated over many years and during numerous planning studies. As such, they fairly accurately represent the area draining to the Gowanus Canal serviced by combined sewers. This is not the case for the Separate and Direct Drainage categories listed in Table 2-5. Generally the area between the CSO drainage boundary and the shoreline of the waterbody have been delineated and loosely assigned as separate if they appeared to be serviced by municipal storm sewer and as direct drainage if they drained directly in to the Gowanus Canal or were from commercial/industrial/manufacturing sites or parkland/open space located immediately adjacent to the shoreline. The allocation of areas to these categories should be considered a rough estimate at best and should be further developed through a refined analysis.

2.1.c.1 Overview of Drainage Area and Sewer System

Owls Head WWTP Drainage Area and Sewer System

The southeastern portion of the Gowanus Canal watershed is served by the Owls Head WWTP as shown in Figure 2-1. The Owls Head sewershed includes sanitary and combined sewers. The Owls Head collection system associated with the Gowanus Canal includes:

- Two pumping stations;
- Six active combined sewer flow regulator structures; and
- Six active CSO discharge outfalls.

Table 2-6 shows the acreage by outfall/regulator/relief structure for the Owls Head WWTP Service Area within the Gowanus Canal watershed.

Table 2-6. Owls Head WWTP Service Area Within Gowanus Canal Watershed: Acreage by Outfall/Regulator/Relief Structure

Outfall	Outfall Drainage Area (acres)	Regulator/Relief Structure	Regulator Drainage Area	Regulated Drainage Area Type
OH-005	34	3rd Ave. Sewer Relief	34	Combined
OH-006	306	3rd Ave. Sewer Relief	306	Combined
OH-007	339	2nd Ave. Pump Station	339	Combined
OH-009	0	3rd Ave. Sewer Relief	0	Combined
OH-024	7	3rd Ave. Sewer Relief	7	Combined
OH-026	(1)	3rd Ave. Sewer Relief	(1)	Combined

Notes:
(1) Outfall recently reclassified to CSO in draft 2013 SPDES permit.

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 373 acres. The pump station has a 1.0 MGD capacity. During dry-weather, its service area contributes an average of 0.6 MGD of sanitary flow. During wet-weather, the flow generated by the drainage area is tributary to the pump station, which conveys up to 1.0 MGD to the 3rd Avenue Sewer. Excess flow discharges to the 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 19th Street Pump Station conveys flow to the 3rd Avenue Interceptor Sewer.

The Owls Head WWTP is located in the Bay Ridge section of the Borough of Brooklyn, City of New York, on the southwestern tip of the Owls Head Park. The Owls Head WWTP treats wastewater from a combined sewage collection system, which serves a population of approximately 780,000 and drains stormwater flow from an area of almost 13,664 acres. The Owls Head WWTP 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. The Owls Head WWTP has a design dry-weather flow (DDWF) capacity of 120 MGD, and is designed to receive a maximum wet-weather flow of 240 MGD (2xDDWF), with 180 MGD (one and one-half times design dry-weather flow [1.5xDDWF]) receiving secondary treatment. Flows over 180 MGD receive primary treatment and disinfection.

Owls Head Non-Sewered Areas

There are no known unsewered areas in the Gowanus Canal sewershed served by the Owls Head WWTP.

Owls Head Permitted Stormwater Outfalls

There are three DEP MS4 permitted stormwater outfalls discharging to the Gowanus Canal, as shown on Figure 2-2: OH-607, OH-616 and OH-617. These outfalls are currently included in the MS4 permit. These outfalls drain stormwater runoff from small separate sewer areas around the Gowanus Canal. While runoff from these areas does not enter the combined system, the stormwater drains from the separate sewer areas to the Gowanus Canal.

There are planned ongoing HLSS works in the Gowanus Canal sewershed. These will create a separate stormwater system discharging through a stormwater outfall at Carroll Street. The planned works will be constructed in phases. Phase I is scheduled to be constructed throughout 2015 and Phase 2 is scheduled to be implemented in 2019. A portion of the new separate drainage areas to be created will also reduce CSO discharges in the Red Hook collection system.

In addition, as identified by the DEP Shoreline Survey, there are 101 other pipes that are located on the bank of the Gowanus Canal within the Owl's Head WWTP drainage area. Some of these pipes likely direct stormwater from highways and commercial/industrial sites in to the creek. For the purposes of this LTCP, these areas are considered part of the Direct Point Discharge category.

Owls Head/Gowanus Canal CSOs

Wet-weather flows in the CSS, with incidental sanitary and stormwater contributions result in overflows to the nearby waterbodies when the flows exceed the hydraulic capacity of the sewer system, or the specific capacity of the local regulator structure. The Owls Head SPDES permitted CSO outfalls to the Gowanus Canal are OH-005, OH-006, OH-007, OH-024 and OH-026. Outfall OH-007 contributes the most annual CSO volume to the Gowanus Canal from the Owls Head CSS. The locations of the Owls Head SPDES CSO outfalls tributary to the Gowanus Canal are shown in Figure 2-2.

Red Hook WWTP Drainage Area and Sewer System

The portion of the Gowanus Canal sewershed draining to the Red Hook WWTP surrounds the upper reaches of the Gowanus Canal and includes the area west of the Gowanus Canal. This drainage area is approximately 933 acres, includes two pump stations, and nine active CSOs. Table 2-7 shows the acreage by outfall/regulator/relief structure for the Red Hook WWTP Service Area within the Gowanus Canal watershed.

Table 2-7. Red Hook WWTP Service Area Within Gowanus Canal Watershed: Acreage by Outfall/Regulator/Relief Structure

Outfall	Outfall Drainage Area (acres)	Regulator/ Relief Structure	Regulator Drainage Area	Regulated Drainage Area Type
RH-030	86	CSO-2	86	Combined
RH-030A	(1)	CSO-2	(1)	Combined
RH-031	69.5	Bond Lorraine Sewer Relief	69.5	Combined
RH-033	5.1	Reg # R-25	5.1	Combined
RH-034	657	Gowanus PS	657	Combined

Table 2-7. Red Hook WWTP Service Area Within Gowanus Canal Watershed: Acreage by Outfall/Regulator/Relief Structure

Outfall	Outfall Drainage Area (acres)	Regulator/ Relief Structure	Regulator Drainage Area	Regulated Drainage Area Type
RH-035	88	CSO-3; Bond Lorraine Sewer Relief	88	Combined
RH-036	9.8	Reg # R-22	9.8	Combined
RH-037	7.4	Reg # R-23	7.4	Combined
RH-038	10	Reg # R-24	10	Combined
Notes: (1) Outfall recently reclassified to CSO in draft 2013 SPDES permit.				

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. 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 the Gowanus Canal via Outfall RH-038. The Gowanus Pump Station, located on Douglass Street at the head of the Gowanus Canal, is designed to convey flow to the Columbia Street Interceptor via a force main in the Flushing Tunnel. It serves a drainage area of about 657 acres. It was built in 1908 and was last upgraded in 2014. This pump station has a capacity of 30 MGD with excess flows discharged to the Gowanus Canal via CSO Outfall RH-034. During wet-weather, the pump station receives unregulated combined sewage flow from most of its drainage area, as well as regulated combined sewage flow from the Nevins Street Pump Station.

Red Hook Non-Sewered Areas

There are no known unsewered areas in the Gowanus Canal sewershed served by the Red Hook WWTP.

Red Hook Permitted Stormwater Outfalls

According to the MS4 permit, there is a separate storm sewer drainage area along the western shore of the Gowanus Canal contributing to stormwater Outfall RH-601. There is also an open area; a direct drainage area on the western shore near the mouth of the Gowanus Canal. In addition, as identified by the DEP Shoreline Survey, there are 111 other pipes that are located on the bank of the Gowanus Canal within the Red Hook WWTP drainage area. Some of these pipes likely direct stormwater from highways and commercial/industrial sites in to the creek. For purposes of this LTCP, these areas are considered part of the Direct Point Discharge category.

Red Hook CSOs

The Red Hook SPDES permitted CSO outfalls to the Gowanus Canal are RH-030, RH-030A, RH-031, RH-033, RH-034, RH-035, RH-036, RH-037 and RH-038. Outfall RH-034 contributes the most annual

CSO volume to the Gowanus Canal from the Red Hook CSS. The locations of the Red Hook SPDES CSO outfalls tributary to the Gowanus Canal are shown in Figure 2-2.

2.1.c.2 Stormwater and Wastewater Characteristics

The concentrations found in wastewater, combined sewage, and stormwater can vary based on a number of factors, including flow rate, runoff contribution, and the mix of the waste discharged to the system from domestic and non-domestic customers. Because the mix of these waste streams can vary, it can be challenging to identify a single concentration to use for analyzing the impact of discharges from these systems to receiving waters.

Data collected from sampling events were used to estimate concentrations for biochemical oxygen demand (BOD), total suspended solids (TSS), total coliform bacteria, fecal coliform bacteria, and enterococci bacteria to use in calculating loadings from various sources.

Previously collected citywide sampling data from the Inner Harbor Facility Planning Study (DEP, 1994), data for the EPA Harbor Estuary Program (HydroQual, 2005a), and data collected for other high density urban areas (DEP, 2014), was used to estimate the stormwater concentrations. The stormwater concentrations cited in Table 2-8 are based on the most recent data available.

A flow monitoring and sampling program targeting CSO contributing to the Gowanus Canal was implemented as part of this LTCP. Data were collected to supplement existing information on the flows/volumes and concentrations of various sources to the waterbody.

Table 2-8. Stormwater Discharge Concentrations
Owls Head and Red Hook WWTP Service Areas

Constituent	Stormwater Concentration
$CBOD_5$ (mg/L) (1)	15
TSS (mg/L) (1)	20
Fecal Coliform Bacteria (cfu/100mL) (2,3)	120,000
Enterococci (cfu/100mL) (2,3)	50,000

Notes:
(1) HydroQual, 2005b.
(2) HydroQual Memo to DEP, 2005a.
(3) Bacterial concentrations expressed as “colony forming units” per 100mL.

CSO concentrations can be extremely variable and are a function of many factors. Generally, CSO concentrations are a function of local sanitary sewage and runoff entering the combined sewers.

CSO concentrations were measured in 2014 to provide site-specific information for Outfalls RH-034, OH-007 and OH-026. The CSO overflow bacteria concentrations were characterized by direct measurements of Outfalls RH-034 (3 CSO events), OH-007 (4 CSO events) and OH-026 (4 CSO events) during various storms throughout August/September 2014. These concentrations are shown in Figures 2-7, 2-8 and 2-9, showing cumulative frequency distribution graphics. Individual sample points are shown, as well as the trend line that best fits the data distribution. For the Outfall RH-034 CSO discharges, measured fecal coliform concentrations are log-normally distributed, as is typical for this type of data, and values range from 54,600 to 2,500,000 cfu/100mL (Figure 2-7). Similarly, enterococci concentrations are also log-normally distributed and range from 40,000 to 1,700,000 cfu/100mL. For the Outfall OH-007 overflows, measured fecal coliform concentrations are log-normally distributed as well and values range from 72,700 to 6,000,000 cfu/100mL (Figure 2-8). Similarly, enterococci concentrations are also log-normally distributed and range from 70,000 to 8,000,000 cfu/100mL. In median terms, the CSO bacteria concentrations of both outfalls do not differ significantly. Lastly, for the Outfall OH-026 overflows, measured fecal coliform concentrations are again log-normally distributed, and values range from 36,300 to 3,900,000 cfu/100mL (Figure 2-9). Similarly, enterococci concentrations are also log-normally distributed and range from 32,000 to 500,000 cfu/100mL. In median terms, the CSO bacteria concentrations of Outfall OH-026 are lower than those of CSO Outfalls RH-034 and OH-007.

Flow monitoring data were collected for three CSO outfalls supporting the development of the Gowanus Canal LTCP. The Owls Head WWTP IW model calibration was supported by the peer-reviewed data gathered under the NYC CSO Pilot Monitoring Program encompassing the period of July 1, 2014 to October 15, 2014 for Outfall OH-007. Data for one wet-weather event at Outfall RH-034 that occurred on April 20, 2015 was used for verification of the prior calibration of the IW model representing the Red Hook WWTP collection system. The reason for a verification based on a single event is related to the date upon which this latter data became available. Additionally, flow monitoring data was collected at Outfall OH-026. However, such data was not included in the IW model calibration because this outfall recently had been reclassified as a CSO outfall. Corresponding updates to the IW model of the Owls Head collection system will be conducted within the scope of future CSO planning efforts.

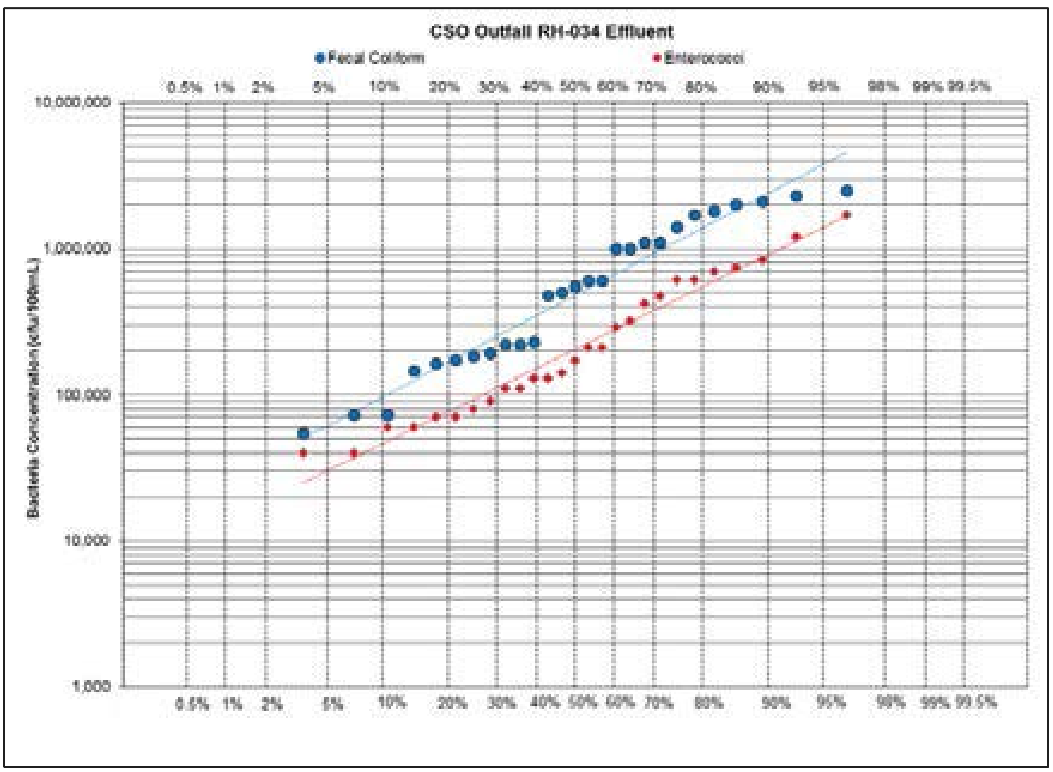

Figure 2-7. Outfall RH-034 Effluent Bacteria Concentrations

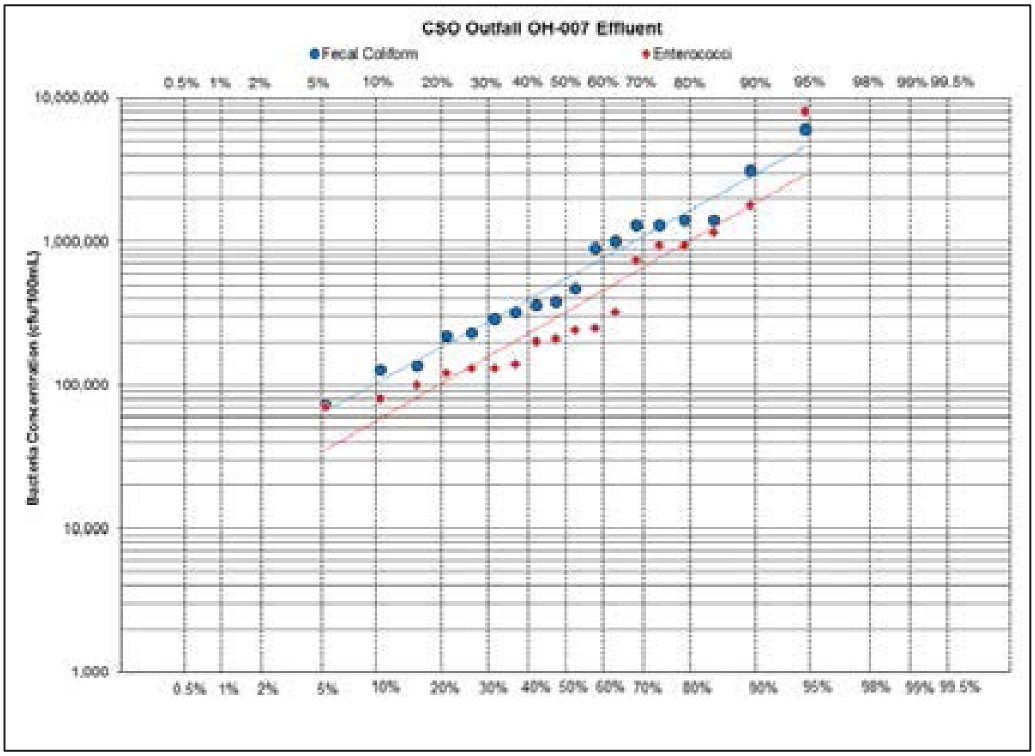

Figure 2-8. Outfall OH-007 Effluent Bacteria Concentrations

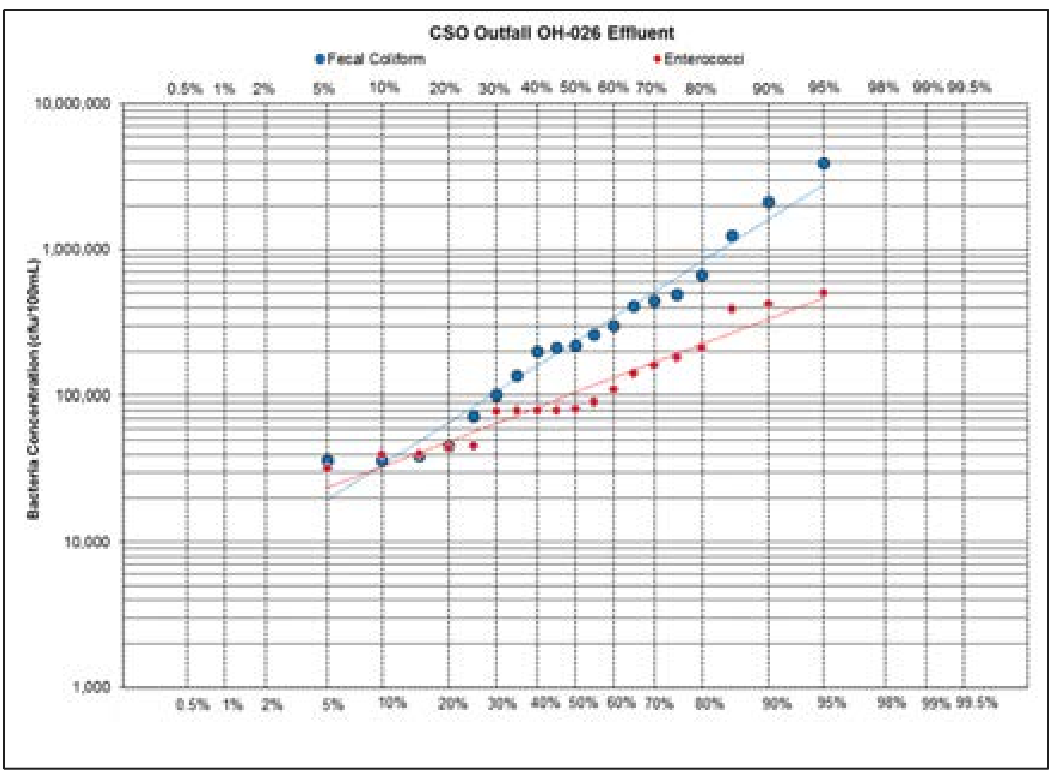

Figure 2-9. Outfall OH-026 Effluent Bacteria Concentrations

Stormwater discharge concentrations are assigned an event mean concentration (EMC) for inclusion in the water quality model calibration and LTCP baseline analyses. Historical information and data collected from sampling events were used to guide the selection of concentrations of BOD, TSS, total coliform, fecal coliform, and enterococci to use in calculating loadings from the various sources. Table 2-9 shows EMC stormwater concentrations for NYC stormwater discharges to the Gowanus Canal from the separate stormwater collection systems. Previously collected citywide sampling data from the Inner Harbor CSO Facility Planning Study (DEP, 1994), data for the EPA Harbor Estuary Program (HydroQual, 2005a), and data collected recently for other high density urban areas, was combined to develop these stormwater concentrations (DEP, 2014). The IW sewer system model (Section 2.1.a.5) is used to generate the flows from NYC storm sewer outfalls and concentrations noted in Table 2-8 are associated with the flows used to develop loadings.

Sampling, data analyses, and water quality modeling calibration resulted in the assignment of flows and loadings to these sources for inclusion in the calibration/validation of the water quality model for the November 2013 to October 2014 period.

The recently upgraded Flushing Tunnel significantly affects the water quality in the Gowanus Canal. The tunnel draws from the Buttermilk Channel and releases the water at the head of the Gowanus Canal. The water quality of the flow released at the head of the Gowanus Canal is provided by the Regional Model which is used extensively to simulate water-quality conditions in the New York Bay, checked against measurements.

Table 2-9. Gowanus Canal Source Loadings Characteristics

Source	Flow	Enterococci (cfu/100mL)	Fecal Coliform (cfu/100mL)	BOD-5 (mg/L)
Stormwater	IW	50,000	120,000	15
CSOs (based on Outfalls RH-034,OH-007 and OH-026)	IW	Monte Carlo	Monte Carlo	78
Direct Drainage	IW	6,000	4,000	15
Flushing Tunnel	Variable(1)	Regional Model	Regional Model	Variable(2)

Notes:

(1) Flows for the November 2014 through October 2014 model calibration/validation period represent the turn-on and ramp-up operations of the Flushing Tunnel based on operations and measurements, varying as a function of tidal conditions. Flushing Tunnel flows for projection purposes represent full design and current operations. Concentrations for the Flushing Tunnel are based on calculations developed using a Regional Water Quality Model of the entire NY Harbor complex.

(2) Harbor survey measurements were used to define monthly varying concentrations which constrain modeled particulate organic carbon (POC) and dissolved organic carbon (DOC) concentrations.

2.1.c.3 Hydraulic Analysis of Sewer System

A citywide hydraulic analysis was completed in December 2012 (an excerpt of which is included in this subsection), to provide further insight into the hydraulic capacities of key system components and system responses to various wet-weather conditions. The hydraulic analyses can be divided into the following major components:

- Annual simulations to estimate the number of annual hours that the WWTP is predicted to receive and treat up to 2xDDWF for rainfall years 2008, and with projected 2040 DWFs; and
- Estimation of peak conduit/pipe flow rates that would result from a significant single event with projected 2040 DWFs.

Detailed presentations of the data were contained in the December 2012 Hydraulic Analysis Report submitted to DEC. The objective of each evaluation and the specific approach undertaken are briefly described in the following paragraphs.

Annual Hours at 2xDDWF for 2008 with Projected 2040 DWFs

Model simulations were conducted to estimate the annual number of hours that the Owls Head and Red Hook WWTPs would be expected to treat 2xDDWF for the 2008 precipitation year, which contained a total precipitation of 46.26 inches, as measured at JFK Airport. These simulations were conducted using projected 2040 DWFs for two model input conditions – the recalibrated model conditions as described in the December 2012 IW Citywide Recalibration Report, and the Cost-Effective Grey (CEG) alternative defined for the service area. The CEG elements represent the CSO controls that became part of the 2012 CSO Order on Consent. For these simulations, the primary input conditions applied were as follows:

- Projected 2040 DWF conditions.
- 2008 tides and precipitation data.
- Owls Head WWTP at 2xDDWF capacity of 240 MGD and Red Hook WWTP at 2xDDWF capacity of 120 MGD.
- No sediment in the combined sewers (i.e., clean conditions).
- Sediment in interceptors representing the sediment conditions after the inspection and cleaning program undertaken in 2011 and 2012.
- No green infrastructure.

The CEG conditions applicable to both service areas included the Avenue V Pump Station upgrade in the Owls Head service area and those applicable to the Red Hook service area included inflatable dams in the Regulator R-20 drainage area, upgrading of Gowanus Pump Station to 30 MGD capacity, and associated construction of a new force main to send flows directly to the interceptor.

Key observations/findings are summarized below:

- Simulation of the 2008 annual rainfall year resulted in a prediction that the Owls Head WWTP would operate at its 2xDDWF capacity for 105 hours under the no-CEG condition. When the CEG conditions were applied in the model, the annual number of hours at 2xDDWF remained about the same - at 98 hours.
- Simulation of the 2008 annual rainfall year resulted in a prediction that the Red Hook WWTP would operate at its 2xDDWF capacity for 136 hours under the no-CEG condition. When the CEG conditions were applied in the model, the annual number of hours at 2xDDWF increased to 152 hours.

- The total volume (dry- and wet-weather combined) treated annually at the Owls Head plant for the 2008 non-CEG condition was predicted to be about 38,064 MG, while the 2008 with CEG condition resulted in a prediction that 38,074 MG would be treated at the plant – an increase of 10MG.

- The total volume (dry- and wet-weather combined) treated annually at the Red Hook plant for the 2008 non-CEG condition was predicted to be about 12,976MG, while the 2008 with CEG condition resulted in a prediction that 13,096 MG would be treated at the plant – an increase of 120 MG.

- The total annual CSO volume predicted for the outfalls in the Owls Head service area were as follows:
  - 2008 non-CEG: 2,198 MG
  - 2008 with CEG: 2,196MG

- The total annual CSO volume predicted for the outfalls in the Red Hook service area were as follows:
  - 2008 non-CEG: 813 MG
  - 2008 with CEG: 758 MG

The above results indicate a slight decrease in the number of hours at the 2xDDWF operating capacity for Owls Head WWTP, while for Red Hook WWTP the above results indicate an increase in the number of hours at the 2xDDWF operating capacity.

Estimation of Peak Conduit/Pipe Flow Rates

Model output tables containing information on several pipe characteristics were prepared, coupled with calculation of the theoretical, non-surcharged, full-pipe flow capacity of each sewer included in the models. To test the conveyance system response under what would be considered a large storm event condition, a single-event storm that was estimated to approximate a five-year return period (in terms of peak hourly intensity as well as total depth), was selected from the historical record.

The selected single event was simulated in the models WWFP conditions, and the second with the CEG conditions implemented. The maximum flow rates and maximum depths predicted by the models for each modeled sewer segment were retrieved and aligned with the other pipe characteristics. Columns in the tabulations were added to indicate whether the maximum flow predicted for each conduit exceeded the non-surcharged, full-pipe flow, along with a calculation of the maximum depth in the sewer as a percentage of the pipe full height. It was suspected that potentially, several of the sewer segments could be flowing full, even though the maximum flow may not have reached the theoretical maximum full-pipe flow rate for reasons such as: downstream tidal backwater; interceptor surcharge; or other capacity-limiting reasons. The resulting data were then scanned to identify the likelihood of such capacity-limiting conditions, and also to provide insight into potential areas of available capacity, even under large storm event conditions. Key observations/findings of this analysis are described below.

- Capacity exceedances for each sewer segment were evaluated in two ways for both interceptors and combined sewers:

- Full flow exceedances, where the maximum predicted flow rate exceeded the full-pipe non-surcharged flow rate. This could be indicative of a conveyance limitation.
- Full depth exceedances, where the maximum depth was greater than the height of the sewer segment. This could be indicative of either a conveyance limitation or a backwater condition.

- For the single storm event simulated, the model predicted that 55.8 percent (by length) of the interceptor sewer segments in the Owls Head service area would exceed full-pipe capacity flow, while about 42.8 to 44.3 percent (by length) of the upstream combined sewers would exceed their full-pipe flow.
- For the single storm event simulated, the model predicted that about 33 percent (by length) of the interceptor sewer segments in the Red Hook service area would exceed full-pipe capacity flow, while about 45 percent (by length) of the upstream combined sewers would exceed their full-pipe flow.
- 100 percent (by length) of the interceptors in the Owls Head service area were predicted to flow at full depth or higher. Between 76.1 and 78.9 percent (by length) of the combined sewers were also predicted to flow at full depth, indicating that many of these sewers experienced backwater conditions from the downstream sewer (and interceptor) system as a result of either pipe or plant capacity limitations.
- 100 percent (by length) of the interceptors in the Red Hook service area were predicted to flow at full depth or higher under both the CEG and non-CEG scenarios and about 55 and 70 percent (by length) of the combined sewers were also predicted to flow at full depth, for the non-CEG and CEG scenarios, respectively. Many of these sewers experience some backwater conditions from the downstream sewer (and interceptor) system as a result of either pipe or plant capacity limitations.
- The length of sewers that did not reach full depth under the CEG simulations (about 21 to 24 percent) in the Owls Head service area.
- The length of sewers that did not reach full depth under the CEG simulations (about 30 percent) indicates there is some potential for in-line storage capability in the Red Hook service area.
- The results for the system condition without CEG improvements were nearly the same as the system condition that included CEG improvements in the Owls Head service area.
- The results for the system conditions without CEG improvements showed that the CEG elements will improve the system conditions to convey flows to 2xDDWF in the Red Hook service area; the number of hours at which the 2xDDWF rate was achieved increased as a result of the CEG improvements.

2.1.c.4 Identification of Sewer System Bottlenecks, Areas Prone to Flooding and History of Sewer Back-ups

There are no known system bottlenecks and areas prone to flooding in the Gowanus Canal watershed. DEP conducts regular sewer inspections and cleaning as reported in the SPDES BMP Annual reports. Figure 2-10 shows the sewers inspected and cleaned throughout 2014 in the Borough of the Brooklyn.

DEP recently conducted a sediment accumulation analysis to quantify levels of sediments in the CSSs. For this analysis, the normal approximation to the hypergeometric distribution was used to randomly select a sample subset of sewers representative of the modeled systems as a whole, with a confidence level commensurate to that of the IW watershed models. Field crews investigated each location, and estimated sediment depth using a rod and tape. Field crews also verified sewer pipe sizes shown on maps, and noted physical conditions of the sewers. The data were then used to estimate the sediment levels as a percentage of overall sewer area. The aggregate mean for the entire NYC was approximately 1.25 percent, with a standard deviation of 2.02 percent.

2.1.c.5 Findings from Interceptor Inspections

In the last decade, DEP has implemented technologies and procedures to enhance its use of proactive sewer maintenance practices. DEP has many programs and staff devoted to sewer maintenance, inspection and analysis. GIS and Computerized Maintenance and Management Systems (CMMS) provide DEP with expanded data tracking and mapping capabilities, and can facilitate identification of trends to allow provision of better service to its customers. As referenced above, reactive and proactive system inspections result in maintenance, including cleaning and repair as necessary. Figure 2-10 illustrates the intercepting sewers that were inspected in the Borough of Brooklyn, encompassing the entire Gowanus Canal watershed. Throughout 2014, 5,156 feet of Owls Head WWTP intercepting sewers were inspected leading to a removal of 115 cubic yards of sediment and 5,732 feet of Red Hook WWTP intercepting sewers were inspected leading to a removal of 21 cubic yards of sediment. Citywide, 145,668 feet of intercepting sewers were inspected leading to a removal of 11,038 cubic yards of sediment.

2.1.c.6 Status of Receiving Wastewater Treatment Plants (WWTPs)

The Gowanus Canal watershed is served by the Owls Head WWTP and Red Hook WWTP service areas.

The Red Hook WWTP was constructed in 1987 to provide secondary treatment for a design flow of 60 MGD. Current treatment includes preliminary treatment, primary settling, secondary treatment (activated sludge, step-feed aeration), and disinfection (sodium hypochlorite). Sludge is treated by gravity thickening, anaerobic digestion and dewatering by centrifuge prior to transport to a landfill for disposal. It serves an area of 3,200 acres, throughout the northwest section of Brooklyn, as well as Governor's Island.

The Owls Head WWTP was constructed in 1952. The treatment system was upgraded in 1995 and provides secondary treatment for a design flow of 120 MGD. Current treatment includes preliminary treatment, primary settling, secondary treatment (activated sludge, step-feed aeration), and disinfection (sodium hypochlorite). Sludge is treated by gravity thickening and anaerobic digestion prior to off-site transportation to a landfill for disposal. It serves an area of 13,664 acres and a population of 780,000 throughout the Borough of Brooklyn.

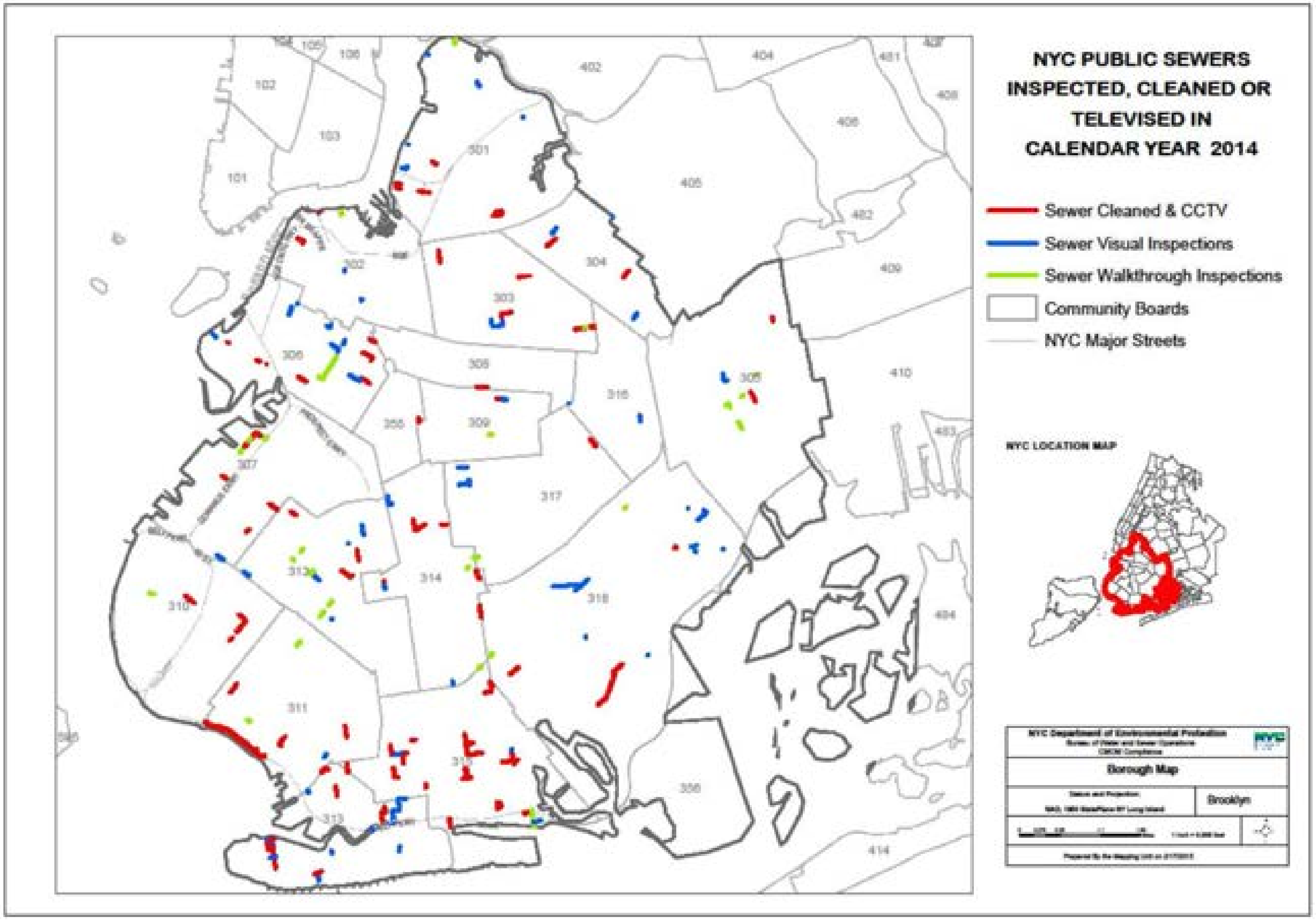

Figure 2-10. Sewers Inspected and Cleaned in Brooklyn Throughout 2014

2.2 Waterbody Characteristics

This section of the report describes the features and attributes of the Gowanus Canal. Characterizing the features of this waterbody is important for assessing the impact of wet-weather inputs and creating approaches and solutions that mitigate the impact from wet-weather discharges.

2.2.a Description of Waterbody

Gowanus is a saline waterbody located in Brooklyn, New York. The Gowanus Canal is tributary to Gowanus Bay, and the Bay is tributary to the Upper New York Bay. Water quality in the Gowanus Canal is influenced by the Flushing Tunnel continuous release of 215 MGD of East River water, as well as CSO and stormwater discharges. (See Section 4 for further description of the Flushing Tunnel.) The following section describes the present-day physical and water-quality characteristics of the Gowanus Canal, along with its existing uses.

2.2.a.1 Current Waterbody Classification(s) and Water Quality Standards

New York State Policies and Regulations

In accordance with the provisions of the CWA, the State of New York has established WQS for all navigable waters within its jurisdiction. The State has developed a system of waterbody classifications based on designated uses that include five classifications for saline waters. DEC considers the Class SA and Class SB classifications to fulfill the CWA goals. Class SC supports aquatic life and recreation, but the primary and secondary recreational uses of the waterbody are limited due to other factors. Class I supports the CWA goal of aquatic life protection, as well as secondary contact recreation. SD waters shall be suitable only for fish, shellfish and wildlife survival because natural or man-made conditions limit the attainment of higher standards. DEC has classified the Gowanus Canal as a Class SD waterbody. Numerical bacteria criteria do not apply to Class SD waters.

Numerical standards corresponding to these waterbody classifications are shown in Table 2-10. DO is the numerical criteria that DEC uses to establish whether a waterbody supports aquatic life uses. Total and fecal coliform bacteria concentrations are the numerical criteria that DEC uses to establish whether a waterbody supports recreational uses. In addition to numerical criteria, NYS has narrative criteria to protect aesthetics in all waters within its jurisdiction, regardless of classification (see Section 1.2.c.). As indicated in Table 2-11, these narrative criteria apply to all five classes of saline waters.

Note that the enterococci criterion of 35 cfu/100mL listed in Table 2-10, although not promulgated by DEC, is now an enforceable standard in NYS, as EPA established January 1, 2005 as the date upon which the criteria must be adopted for all coastal recreational waters. According to DEC's interpretation of the Beaches Environmental Assessment and Coastal Health (BEACH) Act, the criterion applies on a 30-day moving GM basis during recreational season (May 1st through October 31st). Furthermore, the Gowanus Canal waters are not considered coastal recreational waters; therefore, this criterion would not apply under current water quality classifications.

Currently, DEC is conducting its federally-mandated "triennial review" of the NYS WQS. DEC has publicly noticed a proposed rulemaking to amend 6 NYCRR Parts 701 and 703. The proposed total and fecal coliform standards for Class I are the same as the existing standards for Class SC waters.

Table 2-10. New York State Numerical Surface WQS (Saline)

Class	Usage	Dissolved Oxygen (mg/L)	Total Coliform (cfu/100mL)	Fecal Coliform (cfu/100mL)	Enterococci (cfu/100mL)(7)
SA	Shellfishing for market purposes, primary and secondary contact recreation, fishing. Suitable for fish, shellfish and wildlife propagation and survival.	≥ 4.8(1) ≥ 3.0(2)	≤ 70(3)	N/A	
SB	Primary and secondary contact recreation and fishing. Suitable for fish, shellfish and wildlife propagation and survival.	≥4.8(1) ≥ 3.0(2)	≤ 2,400(4) ≤ 5,000(5)	≤ 200(6)	≤ 35(8)
SC	Limited primary and secondary contact recreation, fishing. Suitable for fish, shellfish and wildlife propagation and survival.	≥ 4.8(1) ≥ 3.0(2)	≤ 2,400(4) ≤ 5,000(5)	≤ 200(6)	N/A
I(9)	Secondary contact recreation and fishing. Suitable for fish, shellfish and wildlife propagation and survival.	≥ 4.0	≤ 10,000(6)	≤ 2,000(6)	N/A
SD(9)	Fishing. Suitable for fish, shellfish and wildlife survival. Waters with natural or man-made conditions limiting attainment of higher standards.	≥ 3.0	N/A	N/A	N/A

Notes:

(1) Chronic standard based on daily average. The DO concentration may fall below 4.8 mg/L for a limited number of days, as defined by the formula:

$$DO_i = \frac{13.0}{2.80 + 1.84e^{-0.1t_i}}$$

where DO_i = DO concentration in mg/L between 3.0 – 4.8 mg/L and t_i = time in days. This equation is applied by dividing the DO range of 3.0 – 4.8 mg/L into a number of equal intervals. DO_i is the lower bound of each interval (i) and t_i is the allowable number of days that the DO concentration can be within that interval. The actual number of days that the measured DO concentration falls within each interval (i) is divided by the allowable number of days that the DO can fall within interval (t_i). The sum of the quotients of all intervals (i …n) cannot exceed 1.0: i.e.,

$$\sum_{i=1}^{n} \frac{t_i(actual)}{t_i(allowed)} < 1.$$

(2) Acute standard (never less than 3.0 mg/L).
(3) Colony forming unit per 100mL value in any series of representative samples.
(4) Monthly median value of five or more samples.
(5) Monthly 80th percentile of five or more samples.
(6) Monthly geometric mean of five or more samples.
(7) This standard, although not promulgated by DEC, is now an enforceable standard in NYS since the EPA established January 1, 2005 as the date upon which the criteria must be adopted for all coastal recreational waters.
(8) 30-day moving geometric mean.
(9) DEC has publicly noticed a proposed rulemaking which, if promulgated, would amend 6 NYCRR Part 701 to require that the quality of Class I and Class SD waters be suitable for “primary contact recreation” and to adopt corresponding total and fecal coliform standards in 6 NYCRR Part 703.

The Gowanus Canal LTCP evaluates compliance with various primary contact water quality numerical limits including the Primary Contact WQ Criteria for fecal coliform. With DEC's December 3, 2014 proposed rulemaking to change Class SD fecal coliform bacteria criteria to 200 cfu/100mL, the term Class SD criteria used in this LTCP is interchangeable with the proposed Class I and Class SC numerical criteria when used in the context of bacteria water quality limits.

Interstate Environmental Commission

The States of New York, New Jersey, and Connecticut are signatory to the Tri-State Compact that designated the Interstate Environmental District and created the IEC. The IEC includes all saline waters of greater NYC. The Gowanus Canal is an interstate water and is regulated by IEC as Class B-1 waters. Numerical standards for IEC-regulated waterbodies are shown in Table 2-12, while narrative standards are shown in Table 2-13.

The IEC also restricts CSO discharges to within 24 hours of a precipitation event, consistent with the DEC definition of a prohibited dry-weather discharge. IEC effluent quality regulations do not apply to CSOs if the CSS is being operated with reasonable care, maintenance, and efficiency. Although IEC regulations are intended to be consistent with State WQS, the three-tiered IEC system and the five NYS saline classifications in New York Harbor do not spatially overlap exactly.

Table 2-11. New York State Narrative WQS

Parameters	Classes	Standard
Taste-, color-, and odor-producing toxic and other deleterious substances	SA, SB, SC, I, SD A, B, C, D	None in amounts that will adversely affect the taste, color or odor thereof, or impair the waters for their best usages.
Turbidity	SA, SB, SC, I, SD A, B, C, D	No increase that will cause a substantial visible contrast to natural conditions.
Suspended, colloidal and settleable solids	SA, SB, SC, I, SD A, B, C, D	None from sewage, industrial wastes or other wastes that will cause deposition or impair the waters for their best usages.
Oil and floating substances	SA, SB, SC, I, SD A, B, C, D	No residue attributable to sewage, industrial wastes or other wastes, nor visible oil film nor globules of grease.
Garbage, cinders, ashes, oils, sludge and other refuse	SA, SB, SC, I, SD A, B, C, D	None in any amounts.
Phosphorus and nitrogen	SA, SB, SC, I, SD A, B, C, D	None in any amounts that will result in growth of algae, weeds and slimes that will impair the waters for their best usages.

Table 2-12. IEC Numeric WQS

Class	Usage	DO (mg/L)	Waterbodies
A	All forms of primary and secondary contact recreation, fish propagation, and shellfish harvesting in designated areas	≥ 5.0	East River, east of the Whitestone Bridge; Hudson River north of confluence with the Harlem River; Raritan River east of the Victory Bridge into Raritan Bay; Sandy Hook Bay; lower New York Bay; Atlantic Ocean
B-1	Fishing and secondary contact recreation, growth and maintenance of fish and other forms of marine life naturally occurring therein, but may not be suitable for fish propagation.	≥ 4.0	Hudson River, south of confluence with Harlem River; upper New York Harbor; East River from the Battery to the Whitestone Bridge; Harlem River; Arthur Kill between Raritan Bay and Outerbridge Crossing
B-2	Passage of anadromous fish, maintenance of fish life	≥ 3.0	Arthur Kill north of Outerbridge Crossing; Newark Bay; Kill Van Kull

Table 2-13. IEC Narrative Regulations

Classes	Regulation
A, B-1, B-2	All waters of the Interstate Environmental District (whether of Class A, Class B, or any subclass thereof) shall be of such quality and condition that they will be free from floating solids, settleable solids, oil, grease, sludge deposits, color or turbidity to the extent that none of the foregoing shall be noticeable in the water or deposited along the shore or on aquatic substrata in quantities detrimental to the natural biota; nor shall any of the foregoing be present in quantities that would render the waters in question unsuitable for use in accordance with their respective classifications.
A, B-1, B-2	No toxic or deleterious substances shall be present, either alone or in combination with other substances, in such concentrations as to be detrimental to fish or inhibit their natural migration or that will be offensive to humans or which would produce offensive tastes or odors or be unhealthful in biota used for human consumption.
A, B-1, B-2	No sewage or other polluting matters shall be discharged or permitted to flow into, or be placed in, or permitted to fall or move into the waters of the District, except in conformity with these regulations.

EPA Policies and Regulations

For designated bathing beach areas, the EPA has established an enterococci reference level of 104 cfu/100mL to be used by agencies for announcing bathing advisories or beach closings in response to pollution events. The New York City Department of Health and Mental Hygiene (DOHMH) uses a 30-day moving GM of 35 cfu/100mL to trigger such closures. If the GM exceeds that value, the beach is closed pending additional analysis. Enterococci of 104 cfu/100mL is an advisory upper limit used by DOHMH. If beach enterococci data are greater than 104 cfu/100mL, a pollution advisory is posted on the DOHMH website, additional sampling is initiated, and the advisory is removed when water quality is acceptable for primary contact recreation. Advisories are posted at the beach and on the agency website.

For non-designated beach areas of primary contact recreation, which are used infrequently for primary contact, the EPA has established an enterococci reference level of 501 cfu/100mL be considered indicative of a pollution event.

According to EPA documents these reference levels are not regulatory criteria but, rather, are to be used as determined by the State agencies to make decisions related to recreational uses and pollution control needs. For bathing beaches, these reference levels are to be used for announcing beach advisories or beach closings in response to pollution events. There are no areas of the Gowanus Canal shoreline authorized by the DOHMH for operation of a bathing beach.

In December 2012, the EPA released RWQC recommendations that are designed to protect human health in coastal and non-coastal waters designed for primary recreational use. These recommendations were based on a comprehensive review of research and science that evaluated the link between illness and fecal contamination in recreational waters. The recommendations are intended as guidance to States, territories, and authorized tribes in developing or updating WQS to protect swimmers from exposure to pathogens found in water with fecal contamination.

The 2012 RWQC recommends two sets of numeric concentration thresholds, as listed in Table 2-14, and includes limits for both the GM (30-day) and a STV based on exceeding a 90^{th} percentile value associated with the geometric mean. The STV is a new limit, and is intended to be a value that should not be exceeded by more than 10 percent of the samples taken.

Table 2-14. 2012 RWQC Recommendations

Criteria Elements	**Recommendation 1 (estimated illness Rate 36/1,000)**		**Recommendation 2 (estimated illness Rate 32/1,000)**	
Indicator	**GM (cfu/100mL)**	**STV (cfu/100mL)**	**GM (cfu/100mL)**	**STV (cfu/100mL)**
Enterococci (saline and fresh)	35	130	30	110
E. coli (fresh)	126	410	100	320

It is not known at this time how DEC will implement the 2012 EPA RWQC. It is DEP's understanding that DEC intends to follow Recommendation 2 to update Primary Contact WQ Criteria. The LTCP analyses for the Gowanus Canal were therefore based on the enterococci numerical criteria associated with EPA's RWQC Recommendation 2.

2.2.a.2 Physical Waterbody Characteristics

The Gowanus Canal is located in Brooklyn, NY. The Gowanus Canal opens into the southeast end of Gowanus Bay. Gowanus Bay opens to the Upper New York Bay, between the Erin Basin and the SBMT. The Bay and the Gowanus Canal have a navigational channel maintained by the U.S. Army Corps of Engineers (USACE) extending from the Gowanus Bay to Hamilton Avenue Bridge.

The Gowanus Canal is located at the northeastern end of Gowanus Bay. The saline tributary runs southward and its mouth opens to Gowanus Bay. The shoreline is bulkheaded or rip-rap protected throughout most of its extension and the land use immediately surrounding the Gowanus Canal is primarily industrial.

The Gowanus Canal is within the Coastal Zone Boundary as designated by the DCP.

Shoreline Physical Characterization

The shorelines of the Gowanus Canal are bulkheaded or rip-rap protected throughout most of the extension of the Gowanus Canal as shown in Figures 2-11 and 2-12.

Shoreline Slope

The Gowanus Canal shoreline is bulkheaded or rip-rap protected throughout most of its extension. There are no significant natural slopes along the shoreline.

Figure 2-11. Shoreline View of Gowanus Canal (Looking North Near the Head)

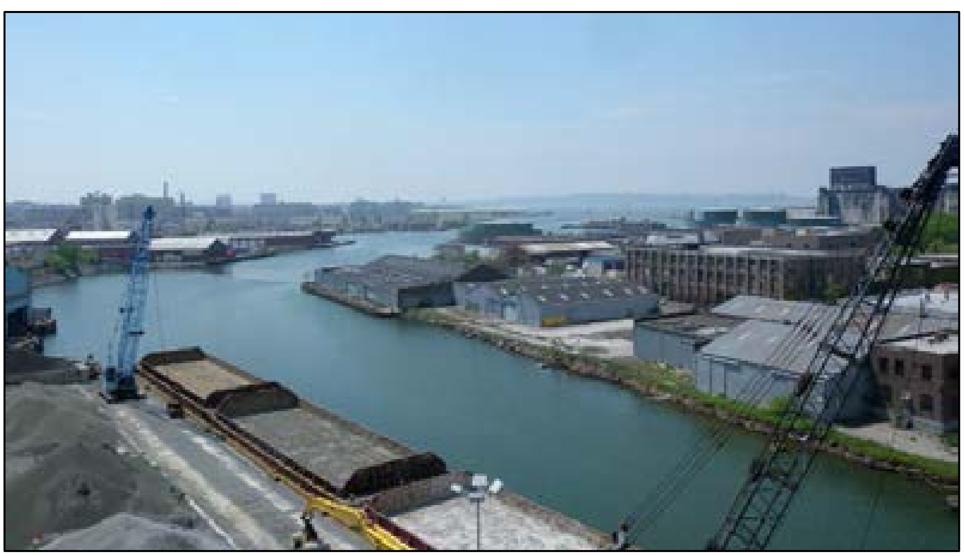

Figure 2-12. Shoreline View of Gowanus Canal (Looking South Near the Mouth)

Waterbody Sediment Surficial Geology/Substrata

According to the Feasibility Study Report Addendum prepared for EPA (CH2MHILL, 2012), the physical and chemical characteristics of the shallow sediments in the upper reach of the Gowanus Canal more closely resemble CSO solids than reference sediments from Gowanus Bay and Upper New York Bay. Shallow sediments (i.e., 0-2 foot depth interval) in the upper reach of the Gowanus Canal were deposited after the period of greatest industrial activity in the Gowanus Canal. Industrial use of the Gowanus Canal peaked in the 1930s, declined until the 1940s, stabilized at a lower level until the mid-1960s, and then declined from the mid-1960s to the present (Hunter Research, 2004). The upper reach of the Gowanus Canal was last dredged to a depth of 7 feet in 1975 (except for a small area near the Flushing Tunnel outlet that was dredged in 1999). Overall, the percentage of sand found in the surface and shallow sediments decreased in the downstream direction within the upper reach, from the head of the Gowanus Canal to 3rd Street.

USACE records indicate that the navigation channel, generally extending from Gowanus Bay to the Hamilton Avenue Bridge, was last dredged by the USACE in 1971.

Waterbody Type

The Gowanus Canal is a saline tributary. It receives flow from the Flushing Tunnel and freshwater contributions from stormwater and CSOs.

Freshwater Systems Biological Systems

No NYS regulated freshwater wetlands are located in the watershed of the Gowanus Canal (i.e., freshwater wetlands greater than 12.4 contiguous acres).

Tidal/Estuarine Wetlands

There are no tidal/estuarine wetlands reported by the U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI) maps throughout the Gowanus Canal study area.

2.2.a.3 Current Public Access and Uses

In the Gowanus Canal, swimming (primary contact recreation use) is not an existing sanctioned use. Furthermore, secondary contact recreation opportunities are limited mainly due to the access restrictions imposed by the physical characteristics of the shoreline and surrounding land uses. However, there are three identified access points along the Gowanus Canal as shown in Figure 2-13.

The boat/kayak launch at the 2^{nd} Street is highly used for recreational activities by different public groups (Figure 2-14).

Lowe's walkway with seating (Figure 2-15) along the Gowanus Canal between 9th and 11th Streets was built voluntarily by Lowe's in conjunction with construction of the store.

Shore public walkway along the Gowanus Canal and the 4th Street Basin between 3rd Street Bridge and 3rd Avenue Bridge, with lighting, seating and other amenities was built in conjunction with the development of Whole Foods Store 9 (Figure 2-16). The resulting total waterfront public access area is 36,080 square feet.

Figure 2-13. Access Points to the Gowanus Canal

Figure 2-14. 2nd Street Boat Launch at Gowanus Canal

Figure 2-15. Lowe's Walkway with Sitting at the Gowanus Canal

Figure 2-16. Whole Foods Walkway with Seating at the Gowanus Canal

2.2.a.4 Identification of Sensitive Areas

Federal CSO Policy requires that the LTCP give the highest priority to controlling overflows to sensitive areas. The policy defines sensitive areas as:

- Waters designated as Outstanding National Resource Waters (ONRW);
- National Marine Sanctuaries;
- Public drinking water intakes;
- Waters designated as protected areas for public water supply intakes;
- Shellfish beds;
- Water with primary contact recreation;
- Waters with threatened or endangered species and their habitat; and
- Additional areas determined by the Permitting Authority (i.e., DEC).

General Assessment of Sensitive Areas

An analysis of the waters of the Gowanus Canal with respect to the CSO Policy was conducted and is summarized in Table 2-15.

Table 2-15. Sensitive Areas Assessment

CSO Discharge Receiving Water Segments	Current Uses Classification of Waters Receiving CSO Discharges Compared to Sensitive Areas Classifications or Designations(1)							
	Outstanding National Resource Water (ONRW)	National Marine Sanctuaries(2)	Threatened or Endangered Species and their Habitat (3)	Primary Contact Recreation	Public Water Supply Intake	Public Water Supply Protected Area	Shellfish Bed	Additional Area Determined by Permitting Authority
Gowanus Canal	None	None	No	No(4)	None(5)	None(5)	None	Yes(6)

Notes:
(1) Classifications or Designations per CSO Policy.
(2) NOAA.
(3) Department of State - Significant Coastal Fish and Wildlife Habitats.
(4) Existing uses include fish and wildlife survival, Class SD.
(5) These waterbodies contain salt water.
(6) Targeted for regional watershed management plan by DEC (2005).

The Gowanus Canal was targeted for a regional watershed management plan by DEC in 2005. This last item in the list was derived from the policy statement that the final determination should be the prerogative of the NPDES Permitting Authority. The Natural Resources Division of DEC was consulted during development of the assessment approach, and provided additional sensitive areas for CSO abatement prioritization based on local environmental issues (Vogel, 2005). Their response listed the following: Jamaica Bay; Bird Conservation Areas; Hudson River Park; “important tributaries” such as the Bronx River in the Bronx, and Mill, Richmond, Old Place, and Main Creeks in Staten Island; the Raritan Bay shellfish harvest area; and waterbodies targeted for regional watershed management plans (the Newtown Creek and the Gowanus Canal). Designation of the Gowanus Canal as a whole does not assist in prioritizing outfalls or evaluating alternatives to address CSO discharges within the waterbody itself. Therefore, prioritization of outfalls within the waterbody and the selection and implementation of CSO control alternatives can be driven by those alternatives that most reasonably attain maximum benefit to water quality.

2.2.a.5 Tidal Flow and Background Harbor Conditions and Water Quality

DEP has been collecting New York Harbor water quality data since 1909. These data are utilized by regulators, scientists, educators, and citizens to assess impacts, trends, and improvements in the water quality of New York Harbor. The HSM program has been the responsibility of DEP’s Marine Sciences Section (MSS) for the past 27 years. These initial surveys were performed in response to public complaints about quality-of-life near polluted waterways. The initial effort has grown into a survey that consists of 72 stations distributed throughout the open waters of the Harbor and smaller tributaries within NYC. The number of water quality parameters measured has also increased from five in 1909, to over 20 at present.

Harbor water quality has improved dramatically since the initial surveys. Infrastructure improvements and the capture and treatment of virtually all dry-weather sewage are the primary reasons for this improvement. During the last decade, water quality in New York Harbor has improved to the point that the waters are now utilized for recreation and commerce throughout the year. Still, impacted areas remain within the Harbor, and the LTCP process has begun to focus on those areas. The LTCP program will look at ten waterbodies and their drainage basins and will develop a comprehensive plan for each waterbody.

The HSM program focuses on fecal coliform bacteria, DO and Secchi disk transparency as the water quality parameters of concern. Data are presented in four sections, each delineating a geographic region within the Harbor. The Gowanus Canal is located within the Upper New York Bay (HR-Upper New York Bay) section. This area contains 12 open-water monitoring stations and eight tributary sites. Figure 2-17 shows the location of Stations GC3, GC4, GC5, GC6 and G2 of the HSM tributaries program.

Fecal coliform and enterococci are indicators of human waste and pathogenic bacteria. According to data (collected between January 2013 and June 2014), fecal coliform annual geometric means representative of all-weather conditions are above the existing, non-designated primary contact bacteria criteria at Stations GC3, GC4, GC5 and GC6, with values of 888 cfu/100mL, 1054 cfu/100mL, 714 cfu/100mL and 473 cfu/100mL, respectively. The fecal coliform annual all weather geometric mean for the same time frame is below the existing non-designated primary contact bacteria at Station G2 with a value of 75 cfu/100mL. The computed enterococci GMs are 325 cfu/100mL, 319 cfu/100mL, 192 cfu/100mL, 97 cfu/100mL and 12 cfu/100mL for Stations GC3, GC4, GC5, GC6 and G2, respectively.

DO is the oxygen in a waterbody available for aquatic life forms. Hypoxia is a water quality condition associated with low DO, and occurs when DO levels fall below 3.0 mg/L. DO measurements below 3.0 mg/L were recorded at Stations GC3, GC4 and GC5 in the Gowanus Canal during the summer period, also consistent with observations from prior summers.

Secchi disk transparency is a measure of the clarity of surface waters. Clarity is measured as a depth when the Secchi disk blends in with the water and is no longer visible. Clarity is most affected by the concentrations of suspended solids and plankton. Lack of clarity limits sunlight, which inhibits the nutrient cycle. The average summer Secchi depth for Station G2 was 4.2-ft. Secchi readings were not collected for Stations GC3, GC4, GC5 and GC6.

For the period post-Flushing Tunnel reactivation, from July 2014 to February 2015, the Harbor Survey data shows significant improvements in water quality along the Gowanus Canal. The fecal coliform annual geometric means representative of all-weather conditions are below the existing non-designated primary contact criterion with values of 148 cfu/100mL and 43 cfu/100mL at Stations GC3 and G2, respectively. The geometric means were above the criteria with values of 200 cfu/100mL, 211 cfu/100mL and 337 cfu/100mL at Stations GC4, GC5 and GC6, respectively. The computed enterococci GMs are 42 cfu/100mL, 52 cfu/100mL, 65 cfu/100mL, 62 cfu/100mL and 5 cfu/100mL for Stations GC3, GC4, GC5, GC6 and G2, respectively.

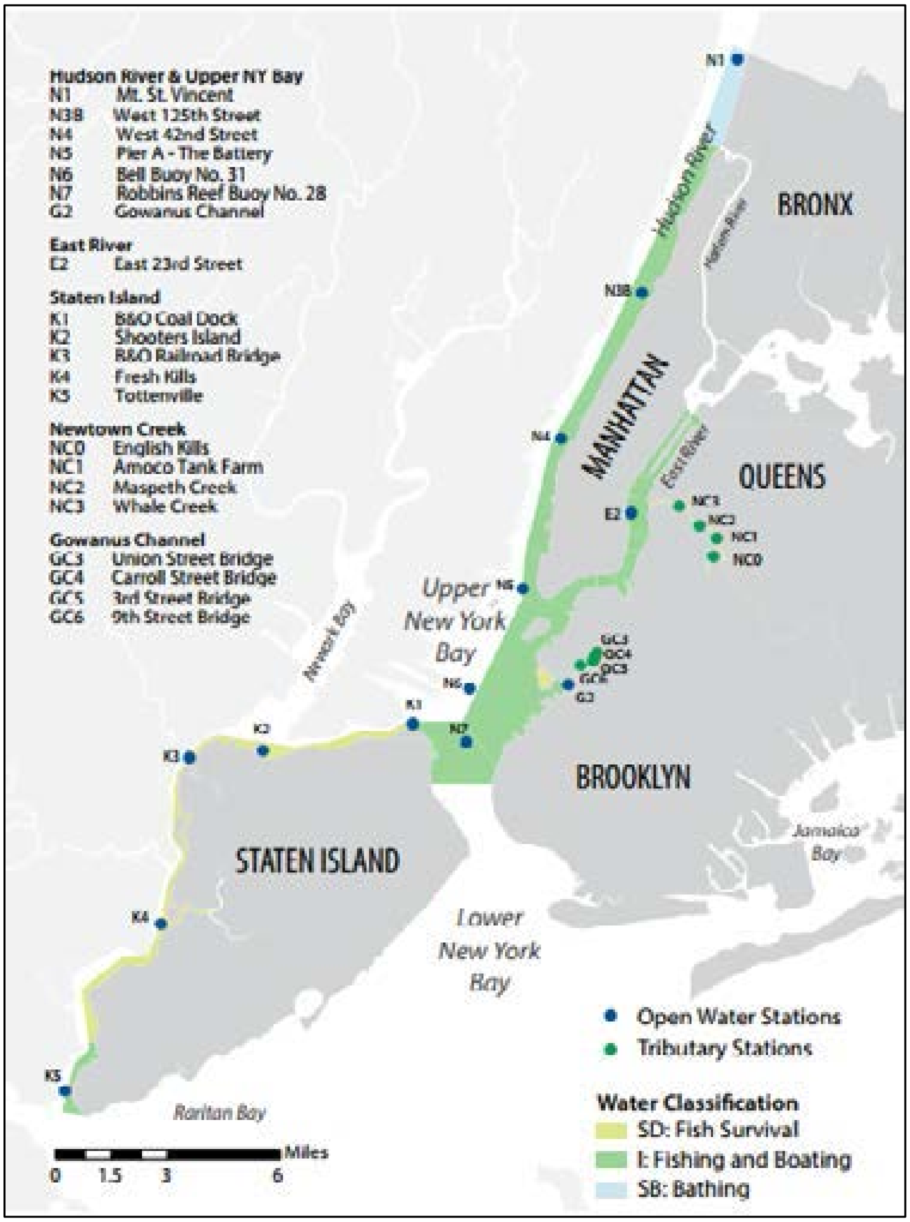

Figure 2-17. Harbor Survey HR-Upper New York Bay Region

For the period from July 2014 to February 2015, post-Flushing Tunnel reactivation, the average surface DO at Station GC3 was measured at 8.42 mg/L, while the average bottom DO was measured at 8.18 mg/L. For Station GC4, surface average DO was measured at 8.03 mg/L, while the average bottom DO was measured at 7.74 mg/L. For Station GC5, surface average DO was measured at 7.79 mg/L, while the average bottom DO was measured at 7.60 mg/L. For Station GC6, surface average DO was measured at 7.01 mg/L, while average bottom DO was measured at 6.25 mg/L. For Station G2, surface average DO was measured at 6.46 mg/L, while average bottom DO was measured at 6.00 mg/L.

During summer months, the Gowanus Canal waters met their classification requirement. No DO measurements below 3.0 mg/L were taken at Stations GC3, GC4, GC5, GC6 and G2 in the Gowanus Canal during the summer period of 2014. The average summer Secchi depth for Station G2 was 4.4-ft. Secchi disk readings were not collected for Stations GC3, GC4, GC5 and GC6.

2.2.a.6 Compilation and Analysis of Existing Water Quality Data

Data collected within the Gowanus Canal are available from sampling conducted by DEP's HSM program from 2006 to 2015, and from intensive sampling conducted from July to September 2014 (Table 2-16), supporting the development of the LTCP. The sampling locations of both sampling programs are depicted in Figure 2-18. Figures 2-19 and 2-20 show the GM of both datasets over the concurrent sampling period (July to September 2014) along with data ranges (minimum to maximum and 25th percentile to 75th percentile) for fecal coliform and enterococci, respectively. For reference purposes, the figures also show the monthly, non-designated Primary Contact WQ Criteria GM for fecal coliform and enterococci, respectively.

Table 2-16. Number of Bacteria Samples Collected for the Period of July – September 2014

Sampling Program	Fecal Coliform No. of samples	Enterococci No. of samples
LTCP2	598	598
Harbor Survey Monitoring	71	71
Sentinel Monitoring	1	0
Third Party Data	0	30

Samples were collected at Station GC-11 to capture the water quality parameters of the flow conveyed through the Flushing Tunnel and discharged at the head of the Gowanus Canal. The bacteria concentrations measured at Station GC-11 are shown in Figures 2-19 and 2-20.

Overall, the fecal coliform levels measured throughout the LTCP sampling program period resulted in geometric means generally uniform and below that of the non-applicable primary contact monthly GM criterion for fecal coliform (200 cfu/100mL), except at Stations GC-6 and GC-7, for wet-weather, as shown in Figure 2-19. These wet-weather excursions above the numerical criterion are explained by the CSO and stormwater impacts typical of wet-weather conditions. Similarly, wet-weather upper excursions at these locations are seen for the enterococci levels measured as well, as seen in Figure 2-20.

Available third party data collected (July through September, 2014) by Riverkeeper and Citizen Testing Group has been analyzed. The data include enterococci results for four sampling locations in the Gowanus Canal. Overall, the third party data collected from July to September was comparable to concurrent LTCP and HSM data for both wet- and dry-weather conditions. These data were included in the calibration processes described in later sections.

The LTCP and HSM sampling results also show that DO concentration in the Gowanus Canal improved significantly with the reactivation of the Flushing Tunnel. Figure 2-21 depicts the average DO measured at the LTCP and HSM sampling stations throughout the sampling period (July through September 2014). The data shows average DO above 6.0 mg/L at all stations and no single measurements below 4.0 mg/L.

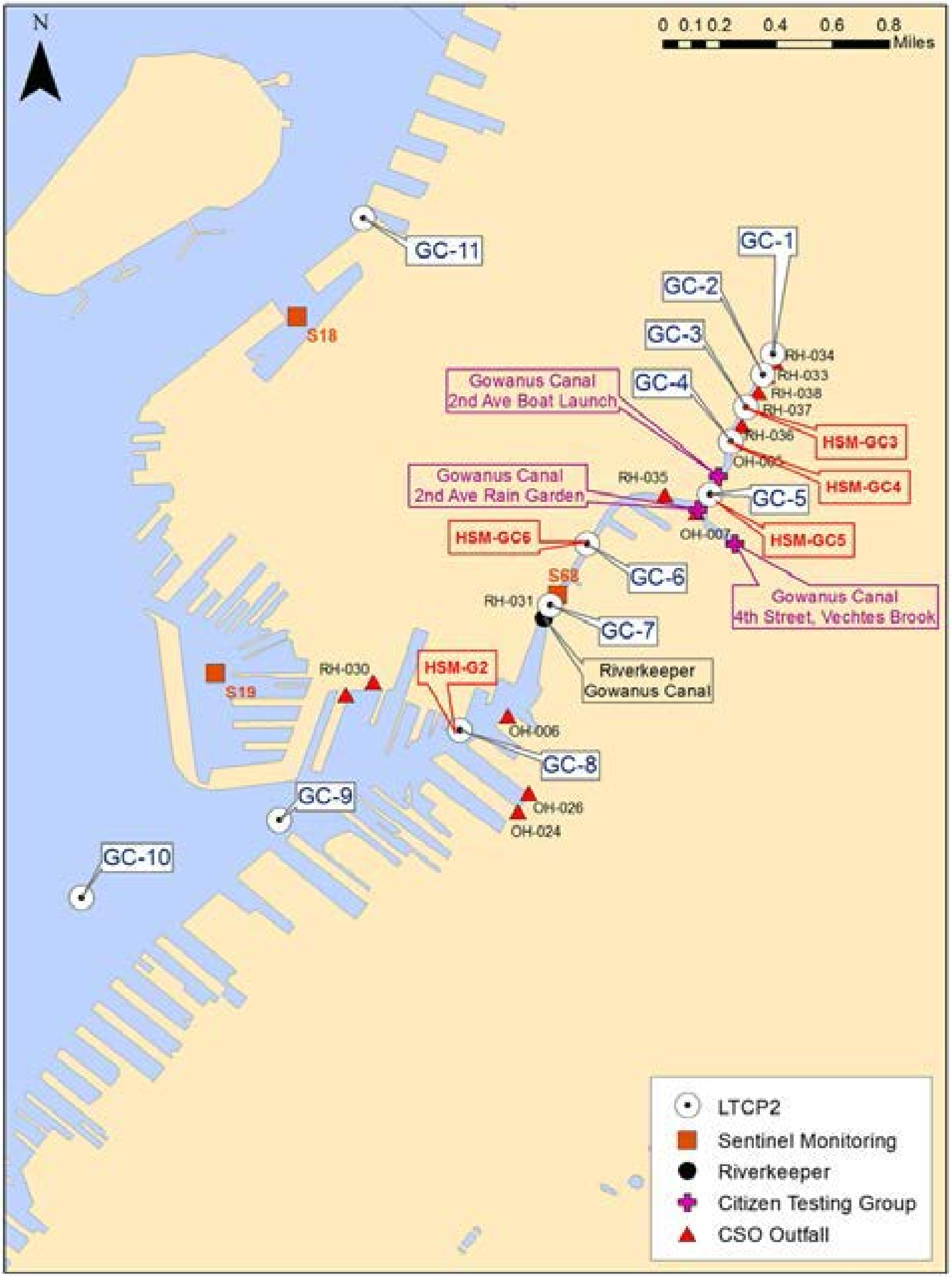

Figure 2-18. Sampling Stations of Various Sampling Programs at Gowanus Canal

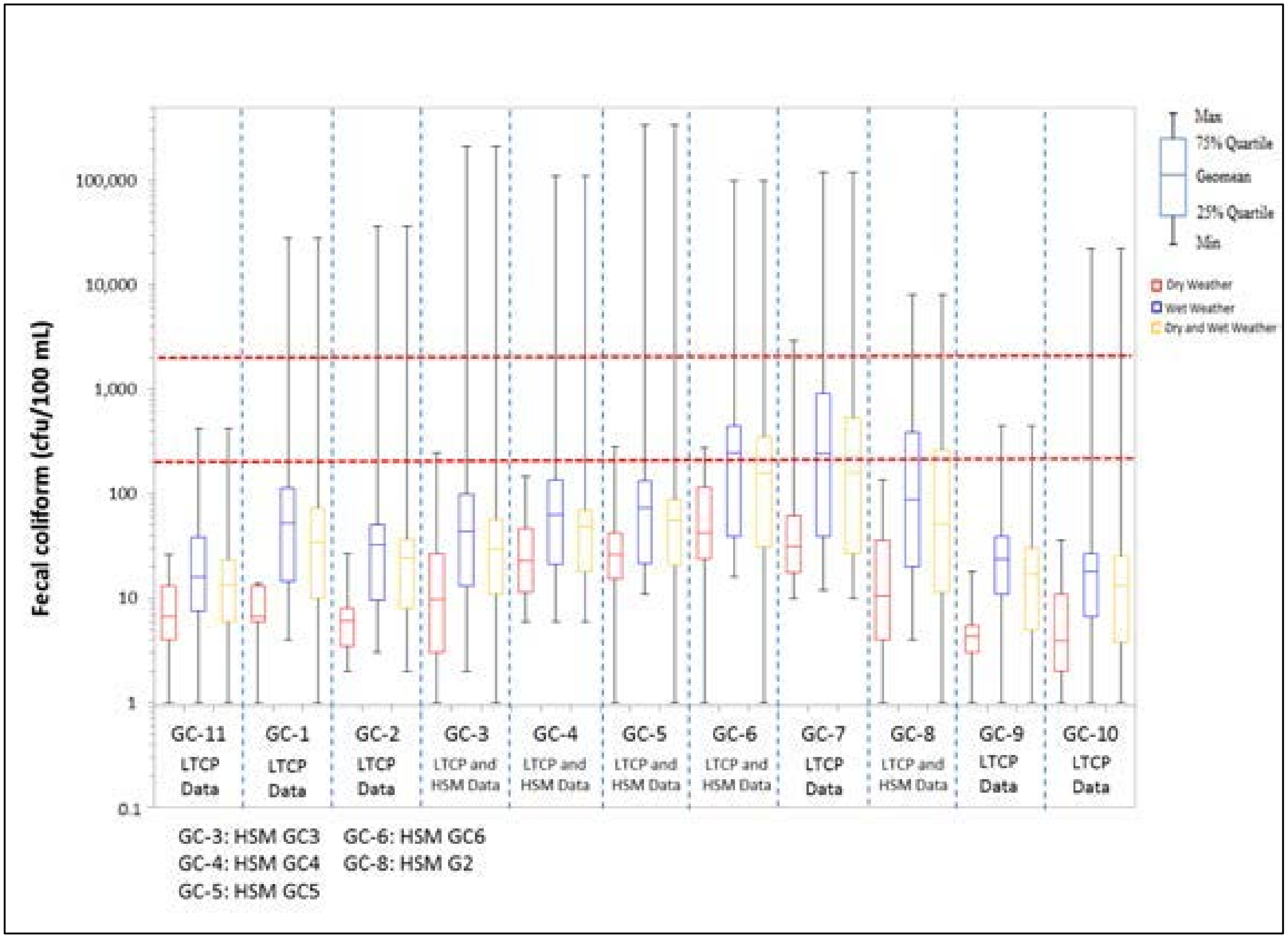

Figure 2-19. Fecal Coliform Data from LTCP and HSM - Gowanus Canal (July – September 2014)

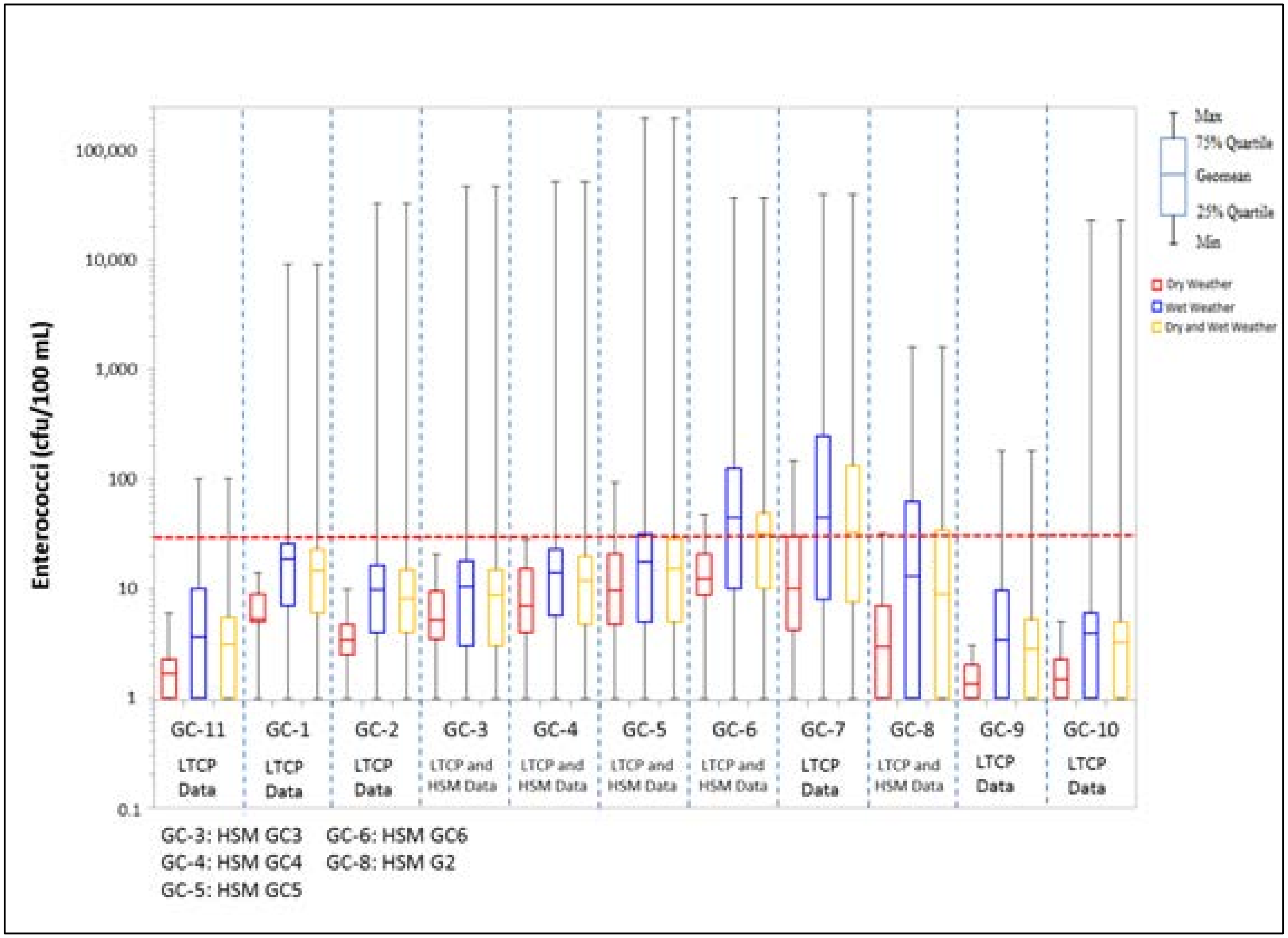

Figure 2-20. Enterococci Data from LTCP and HSM - Gowanus Canal (July – September 2014)

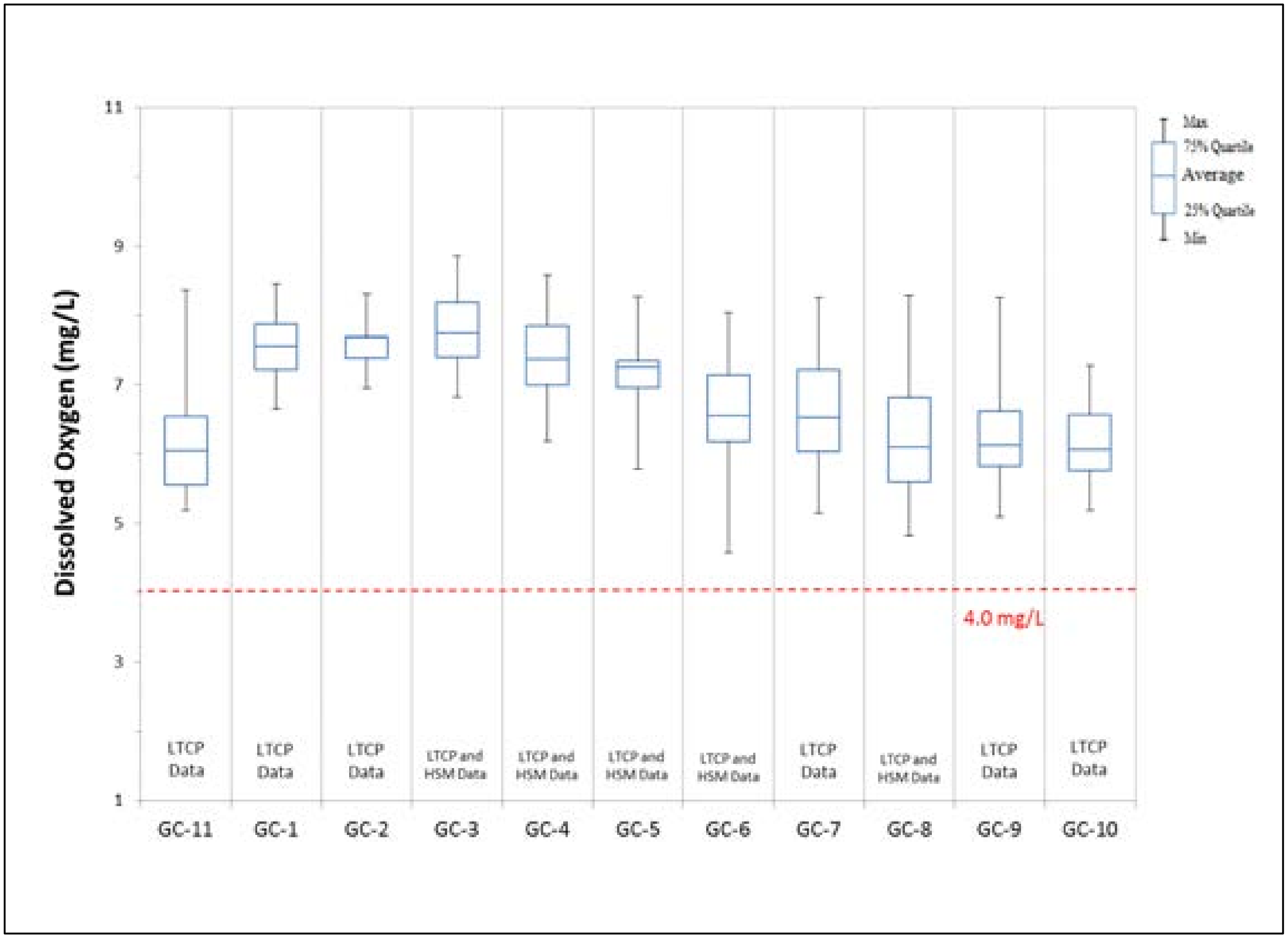

Figure 2-21. DO Data from LTCP and HSM - Gowanus Canal (July-September 2014)

2.2.a.7 Water Quality Modeling

In addition to the collection, compilation, and analysis of measurements described in Section 2.2.a.6, water quality modeling was also used to characterize and assess the Gowanus Canal water quality. A model computational grid was developed for the LTCP to represent the Gowanus Canal at a higher resolution than had been used for modeling supporting previous waterway planning. The model computational grid, shown in Figures 2-22 and 2-23, was used for LTCP hydrodynamic, pathogens, and dissolved oxygen modeling. The calibration and validation of these water quality models using measurements collected and compiled from November 1, 2013 to October 31, 2014 is described in the Gowanus Canal LTCP Sewer System and Water Quality Modeling Report (DEP, 2015). The measurements used for model calibration and validation include LTCP, DEP Harbor Survey, Citizen Testing Group and Riverkeeper data, with wet-weather volumetric loading information from validated InfoWorks models. Once calibrated and validated, the water quality models were used to aid in the assessment of water quality benefits associated with LTCP CSO control alternatives as will be presented in Sections 6 and 8.

The Gowanus Canal water quality models were peer reviewed by a panel of internationally renowned modeling experts convened by NYC. The peer review panel met seven times over the course of model development, calibration/validation, and application, providing continual feedback and guidance. A written report being prepared by the peer review panel, expected to be available in July 2015, will document the modeling peer review process and conclusions. The peer review experts are listed below:

- Alan Blumberg -Stevens Institute of Technology; Hydrodynamics
- Steven Chapra - Tufts University; Water Quality and Contaminant Fate and Transport
- Joseph Gailani - USACE Engineer Research and Development Center; Sediment Transport

Figure 2-22. Computational Grid for Gowanus Canal Water Quality Modeling, Full View

Figure 2-23. Computational Grid for Gowanus Canal Water Quality Modeling, Zoomed-In View

3.0 CSO BEST MANAGEMENT PRACTICES

The SPDES permits for all 14 WWTPs in NYC require DEP to report annually on the progress of the following 13 CSO BMPs:

1. CSO Maintenance and Inspection Program
2. Maximum Use of Collection Systems for Storage
3. Maximize Flow to Publicly Owned Treatment Plant (POTW)
4. Wet Weather Operating Plan (WWOP)
5. Prohibition of Dry Weather Flow (DWF)
6. Industrial Pretreatment
7. Control of Floatable and Settleable Solids
8. Combined Sewer Replacement
9. Combined Sewer Extension
10. Sewer Connection and Extension Prohibitions
11. Septage and Hauled Waste
12. Control of Runoff
13. Public Notification

These BMPs are equivalent to the Nine Minimum Controls (NMCs) required under the EPA CSO Policy, and were developed by EPA to represent BMPs that would serve as technology-based CSO controls. The BMP's were intended to be "determined on a best professional judgment basis by the NPDES permitting authority" and to be the best available technology-based controls that could be implemented within two years by permittees. EPA developed two guidance manuals that embodied the underlying intent of the NMCs for permit writers and municipalities, offering suggested language for SPDES permits and programmatic controls that may accomplish the goals of the NMCs (EPA, 1995a, 1995b). A comparison of the EPA's NMCs to the 13 SPDES BMPs is shown in Table 3-1.

On May 8, 2014, DEP and the DEC entered into an administrative Consent Order[1], referred to as the 2014 CSO BMP Order on Consent, which extends and replaces the 2010 CSO BMP Order. The 2014 CSO BMP Order on Consent addresses remaining milestones from the 2010 CSO BMP Order by including an updated Schedule of Compliance identifying both new milestones and milestones that already have been met.

[1] 2014 CSO BMP Order on Consent. DEC File No. R2-20140203-112.

Upcoming 2014 CSO BMP Order on Consent tasks include, but are not limited to:

- Issuing Notice to Proceed to Construction for repair, rehab or replacement of interceptors;
- Post-construction compliance monitoring;
- Maximizing flow at WWTPs;
- CSO monitoring and equipment at key regulators;
- Updating WWOPs with throttling protocols and updating critical equipment lists;
- Bypass reporting;
- Key regulator monitoring reporting;
- Regulators with CSO monitoring equipment identification program reporting; and
- Hydraulic modeling verification.

This section is based on the practices summarized in the 2014 Best Management Practices Annual Report (2014 BMP Annual Report) and the 2014 CSO BMP Order on Consent.

Table 3-1. Comparison of EPA NMCs with SPDES Permit BMPs

EPA Nine Minimum Controls	SPDES Permit Best Management Practices
NMC 1: Proper Operations and Regular Maintenance Programs for the Sewer System and the CSOs	BMP 1: CSO Maintenance and Inspection Program BMP 4: Wet Weather Operating Plan BMP 8: Combined Sewer Replacement BMP 9: Combined Sewer Extension BMP 10: Sewer Connection and Extension Prohibitions BMP 11: Septage and Hauled Waste
NMC 2: Maximum Use of the Collection System for Storage	BMP 2: Maximum Use of Collection Systems for Storage
NMC 3: Review and Modification of Pretreatment Requirements to Assure CSO Impacts are Minimized	BMP 6: Industrial Pretreatment
NMC 4: Maximization of Flow to the Publicly Owned Treatment Works for Treatment	BMP 3: Maximize Wet Flow to POTW BMP 4: Wet Weather Operating Plan
NMC 5: Prohibition of CSOs During Dry Weather	BMP 5: Prohibition of Dry Weather Overflow
NMC 6: Control of Solid and Floatable Material in CSOs	BMP 7: Control of Floatables and Settleable Solids
NMC 7: Pollution Prevention	BMP 6: Industrial Pretreatment BMP 7: Control of Floatables and Settleable Solids BMP 12: Control of Runoff
NMC 8: Public Notification to Ensure that the Public Receives Adequate Notification of CSO Occurrences and CSO Impacts	BMP 13: Public Notification
NMC 9: Monitoring to Effectively Characterize CSO Impacts and the Efficacy of CSO Controls	BMP 1: CSO Maintenance and Inspection Program BMP 5: Prohibition of Dry Weather Overflow BMP 6: Industrial Pretreatment BMP 7: Control of Floatables and Settleable Solids

This section presents a brief summary of each BMP and its respective relationship to the Federal NMCs. In general, the BMPs address operation and maintenance procedures, maximum use of existing systems and facilities, and related planning efforts to maximize capture of CSO and reduce contaminants in the CSS, thereby reducing water quality impacts.

3.1 Collection System Maintenance and Inspection Program

This BMP addresses NMC 1 (Proper Operations and Regular Maintenance Programs for the Sewer System and the CSOs) and NMC 9 (Monitoring to Effectively Characterize CSO Impacts and the Efficacy of CSO Controls). Through regularly scheduled inspections of the CSO regulator structures and the performance of required repair, cleaning, and maintenance work, dry-weather overflows and leakage can be prevented and flow to the WWTP can be maximized. Specific components of this BMP include:

- Inspection and maintenance of CSO tide gates;
- Telemetering of regulators;
- Reporting of regulator telemetry results;
- Recording and reporting of events that cause discharge at outfalls during dry-weather; and,
- DEC review of inspection program reports.

Details of recent preventative and corrective maintenance reports can be found in the appendices of the BMP Annual Reports.

3.2 Maximizing Use of Collection System for Storage

This BMP addresses NMC 2 (Maximum Use of the Collection System for Storage) and requires cleaning and flushing to remove and prevent solids deposition within the collection system, and an evaluation of hydraulic capacity. These practices enable regulators and weirs to be adjusted to maximize the use of system capacity for CSO storage, which reduces the amount of overflow. DEP provides general information in the 2014 BMP Annual Report, describing the status of citywide Supervisory Control and Data Acquisition (SCADA), regulators, tide gates, interceptors, in-line storage projects, and collection-system inspections and cleaning.

Additional data gathered in accordance with the requirements of the 2014 CSO BMP Order on Consent, such as CSO monitoring, will be used to verify and/or further calibrate the hydraulic model developed for the CSO LTCPs.

3.3 Maximizing Wet Weather Flow to WWTPs

This BMP addresses NMC 4 (Maximization of Flow to the Publicly Owned Treatment Works for Treatment), and reiterates the WWTP operating targets established by the SPDES permits regarding the ability of the WWTP to receive and treat minimum flows during wet-weather. The WWTP must be physically capable of receiving a minimum of 2xDDWF through the plant headworks; a minimum of 2xDDWF through the primary treatment works (and disinfection works, if applicable); and a minimum of 1.5xDDWF through the secondary treatment works during wet-weather. The actual process control set points may be established by the WWOP required in BMP 4.

NYC's WWTPs are physically capable of receiving a minimum of twice their permit-rated design flow through primary treatment and disinfection in accordance with their DEC-approved WWOPs. However, the maximum flow that can reach a particular WWTP is controlled by a number of factors, including: hydraulic capacities of the upstream flow regulators; storm intensities within different areas of the collection system; and plant operators, who can restrict flow using "throttling" gates located at the WWTP entrance to protect the WWTP from flooding and process upsets. DEP's operations staff is trained in how to maximize pumped flows without impacting the treatment process, critical infrastructure, or public safety. For guidance, DEP's operations staff follow their plant's DEC-approved WWOP, which specifies the "actual Process Control Set Points," including average flow, in accordance with Sections VIII (3) and (4) of the SPDES permits. Analyses presented in the 2014 BMP Annual Report indicate that DEP's WWTPs generally complied with this BMP during 2014.

The 2014 CSO BMP Order on Consent has a number of requirements related to maximizing wet-weather flows to WWTPs including, but not limited to:

- An enforceable compliance schedule to ensure that DEP maximizes flow to and through the WWTP during wet-weather events;
- Incorporating throttling protocol and guidance at the WWTPs;
- Updating the critical equipment lists for WWTPs, which includes screening facilities at pump stations that deliver flow directly to the WWTP and at WWTP headworks; and,
- Reporting bypasses to the DEC per the 2014 CSO BMP Order on Consent.

3.4 Wet Weather Operating Plan

This BMP addresses NMC 1 (Proper Operations and Regular Maintenance Programs for the Sewer System and the CSOs) and NMC 4 (Maximization of Flow to the Publicly Owned Treatment Works for Treatment). To maximize treatment during wet-weather events, WWOPs were developed for each WWTP drainage area in accordance with the DEC publication entitled *Wet Weather Operating Practices for POTWs with Combined Sewers*. Components of the WWOPs include:

- Unit process operating procedures;
- CSO retention/treatment facility operating procedures, if relevant for that drainage area; and,
- Process control procedures and set points to maintain the stability and efficiency of Biological Nutrient Removal (BNR) processes, if required.

As required by the 2014 CSO BMP Order on Consent, DEP resubmitted all WWOPs, including the Owls Head WWTP WWOP and Red Hook WWTP WWOP, to DEC in December 2014. DEC has not yet responded to those submittals.

3.5 Prohibition of Dry Weather Overflows

This BMP addresses NMC 5 (Prohibition of CSOs during Dry Weather) and NMC 9 (Monitoring to Effectively Characterize CSO Impacts and the Efficacy of CSO Controls), and requires that any dry-weather overflow event be promptly abated and reported to DEC within 24 hours. A written report must follow within 14 days and contain the information required by the corresponding SPDES permit. The status of the shoreline survey, the Dry Weather Discharge Investigation report, and a summary of the total bypasses from the treatment and collection system are provided in the BMP Annual Reports.

Dry-weather overflows from the CSS are prohibited and DEP's goal is to reduce and/or eliminate dry-weather bypasses. The data for regulators and pump stations reveal that there were dry-weather flows to the Gowanus Canal due to a pump station bypass in 2014. The event took place at the Red Hook-Gowanus PS bypass on February 9, 2013, due to failure of a generator that overheated.

3.6 Industrial Pretreatment Program

This BMP addresses three NMCs: NMC 3 (Review and Modification of Pretreatment Requirements to Assure CSO Impacts are Minimized); NMC 7 (Pollution Prevention); and NMC 9 (Monitoring to Effectively Characterize CSO Impacts and the Efficacy of CSO Controls). By regulating the discharges of toxic pollutants from unregulated, relocated, or new Significant Industrial Users (SIUs) tributary to CSOs, this BMP addresses the maximization of persistent toxics treatment from industrial sources upstream of CSOs. Specific components of this BMP include:

- Consideration of CSOs in the calculation of local limits for indirect discharges of toxic pollutants;
- Scheduled discharge during conditions of non-CSO, if appropriate for batch discharges of industrial wastewater;
- Analysis of system capacity to maximize delivery of industrial wastewater to the WWTP, especially for continuous discharges;
- Exclusion of non-contact cooling water from the CSS and permitting of direct discharges of cooling water; and
- Prioritization of industrial waste containing toxic pollutants for capture and treatment by the WWTP over residential/commercial service areas.

Since 2000, the average total industrial metals loading to NYC WWTPs has been declining. As described in the 2014 BMP Annual Report, the average total metals discharged by all regulated industries to the WWTPs was 12.2 lbs/day, and the total amount of metals discharged by regulated industrial users remained very low. Applying the same percentage of CSO bypass (1.5 percent) from the CSO report to the current data, it appears that, on average, less than 0.181 lbs/day of total metals from regulated industries bypassed to CSOs in 2014 (DEP, 2015).

3.7 Control of Floatables and Settleable Solids

This BMP addresses NMC 6 (Control of Solid and Floatable Material in CSOs), NMC 7 (Pollution Prevention), and NMC 9 (Monitoring to Effectively Characterize CSO Impacts and the Efficacy of CSO Controls), by requiring the implementation of the following four practices to eliminate or minimize the discharge of floating solids, oil and grease, or solids of sewage origin that cause deposition in receiving waters.

- Catch Basin Repair and Maintenance: This practice includes inspection and maintenance scheduled to ensure proper operations of basins.
- Catch Basin Retrofitting: By upgrading basins with obsolete designs to contemporary designs with appropriate street litter capture capability; this program is intended to increase the control of floatable and settleable solids citywide.

- Booming, Skimming and Netting: This practice implements floatables containment systems within the receiving waterbody associated with applicable CSO outfalls. Requirements for system inspection, service and maintenance are also established.
- Institutional, Regulatory, and Public Education: The report must also include recommendations for alternative NYC programs and an implementation schedule to reduce the water quality impacts of street and toilet litter.

3.8 Combined Sewer Replacement

This BMP addresses NMC 1 (Proper Operations and Regular Maintenance Programs for the Sewer Systems and the CSO's), requiring all combined sewer replacements to be approved by the NYSDOH and to be specified within the DEP's Master Plan for Sewage and Drainage. Whenever possible, separate sanitary and storm sewers should be used to replace combined sewers. Each BMP Annual Report describes the citywide plan, and addresses specific projects occurring in the reporting year. According to the 2014 BMP Annual Report, DEP has proposed HLSS in the Gowanus area of Brooklyn. The project is proposed in two (2) phases. The area covered by this project currently consists of combined storm and sanitary sewers that are directed to the Red Hook and Owl‘s Head WWTP areas, and drain to the Gowanus Canal during periods of overflow. Phase I of the HLSS Corridor consists of: the entire length of Denton Place between 1st Street and Carroll Street; Carroll Street from the Gowanus Canal to 4th Avenue; 3rd Avenue between Carroll Street and Douglass Street; and President, Union, Sackett and Degraw Streets between 3rd Avenue and 4th Avenue in Brooklyn.,. Phase II of the HLSS Corridor continues northward including Douglas Street, Butler Street, Baltic Street, St. Mark‘s Place, Bergen Street, Dean Street, Pacific Avenue, Atlantic Avenue and State Street, generally between 3rd Avenue and 4th Avenue in Brooklyn. The new storm sewer will discharge to the Gowanus Canal at Carroll Street. Phase I is currently in final design.

3.9 Combined Sewer Extension

This BMP addresses NMC 1 (Proper Operations and Regular Maintenance Programs for the Sewer System and the CSOs). A brief status report is provided in the 2014 BMP Annual Report. According to the report, DEP completed five private sewer extensions in 2014. To minimize stormwater entering the CSS, this BMP requires combined sewer extensions to be accomplished using separate sewers whenever possible. If separate sewers must be extended from combined sewers, analyses must be performed to demonstrate that the sewage system and treatment plant are able to convey and treat the increased dry-weather flows with minimal impact on receiving water quality.

3.10 Sewer Connection & Extension Prohibitions

This BMP addresses NMC 1 (Proper Operations and Regular Maintenance Programs for the Sewer System and the CSOs), and prohibits sewer connections and extensions that would exacerbate recurrent instances of either sewer back-up or manhole overflows upon letter notification from DEC. Wastewater connections to the CSS downstream of the last regulator or diversion chamber are also prohibited. Each BMP Annual Report contains a brief status report for this BMP and provides details pertaining to chronic sewer back-up and manhole overflow notifications submitted to DEC when necessary. For the calendar year 2014, conditions did not require DEP to prohibit additional sewer connections or sewer extensions.

3.11 Septage and Hauled Waste

This BMP addresses NMC 1 (Proper Operations and Regular Maintenance Programs for the Sewer System and the CSOs). The discharge or release of septage or hauled waste upstream of a CSO (e.g., scavenger waste) is prohibited under this BMP. Scavenger wastes may only be discharged at designated manholes that never drain into a CSO, and only with a valid permit. The 2008 BMP Annual Report summarizes the three scavenger waste acceptance facilities controlled by DEP and the regulations governing discharge of such material at the facilities. The facilities are located in the Hunts Point, Oakwood Beach, and 26th Ward WWTP service areas. The program remained unchanged through the 2014 BMP Annual Report.

3.12 Control of Runoff

This BMP addresses NMC 7 (Pollution Prevention) by requiring all sewer certifications for new development to follow DEP rules and regulations, to be consistent with the DEP Master Plan for Sewers and Drainage, and to be permitted by the DEP. This BMP ensures that only allowable flow is discharged into the combined or storm sewer system.

A rule to "reduce the release rate of storm flow from new developments to 10 percent of the drainage plan allowable or 0.25 cfs per impervious acre, whichever is higher (for cases when the allowable storm flow is more than 0.25 cfs per impervious acre)," was promulgated on January 4, 2012, and became effective on July 4, 2012.

3.13 Public Notification

BMP 13 addresses NMC 8 (Public Notification to Ensure that the Public Receives Adequate Notification of CSO Occurrences and CSO Impacts) as well as NMC 1 (Proper Operations and Regular Maintenance Programs for the Sewer System and the CSOs) and NMC 9 (Monitoring to Effectively Characterize CSO Impacts and the Efficacy of CSO Controls).

This BMP requires easy-to-read identification signage to be placed at or near CSO outfalls, with contact information for DEP, to allow the public to report observed dry-weather overflows. All signage information and appearance must comply with the Discharge Notification Requirements listed in the SPDES permit. This BMP also requires that a system be in place to determine the nature and duration of an overflow event, and that potential users of the receiving waters are notified of any resulting, potentially harmful conditions. The BMP allows the DOHMH to implement and manage the notification program. Accordingly, the Wet Weather Advisories, Pollution Advisories and Closures are tabulated for all NYC public and private beaches. There are no bathing beaches in or near the Gowanus Canal.

3.14 Characterization and Monitoring

Previous studies have characterized and described the Red Hook WWTP collection system, Owls Head WWTP collection system, and the water quality for the Gowanus Canal (see Chapters 3 and 4 of the Gowanus Canal WWFP, 2008). Additional data were collected and is analyzed in this LTCP (see Section 2.2). Continuing monitoring occurs under a variety of DEP initiatives, such as floatables monitoring programs and DEP Harbor Monitoring Survey, and is reported in the BMP Annual Reports under SPDES BMPs 1, 5, 6 and 7, as described above.

Future monitoring includes the installation of CSO monitoring equipment (Doppler sensors in the telemetry system and inclinometers where feasible) at key regulators for the purpose of detecting CSO discharges (2014 CSO BMP Order on Consent). Following installation of the CSO monitoring equipment, a monthly report of all known or suspected CSO discharges from key regulators, outside the period of a critical wet-weather event, will be submitted to DEC. Additional quarterly reports and one comprehensive report summarizing one year of known or suspected CSO discharges will be submitted to DEC describing the cause of each discharge and providing options to reduce or eliminate similar future events with an implementation schedule.

3.15 CSO BMP Report Summaries

In accordance with the SPDES permit requirements, annual reports summarizing the citywide implementation of the 13 BMPs described above are submitted to DEC. DEP has submitted 12 annual reports to date, covering calendar years 2003 through 2014. Typical reports are divided into 13 sections, one for each of the BMPs in the SPDES permits. Each section of the annual report describes ongoing DEP programs, provides statistics for initiatives occurring during the preceding calendar year, and discusses overall environmental improvements.

4.0 GREY INFRASTRUCTURE

4.1 Status of Grey Infrastructure Projects Recommended in Facility Plans

Water quality issues in the Gowanus Canal were identified as early as the late 19th Century, when construction of a flushing tunnel and pumping station were first conceived to improve circulation through the waterbody. CSO facility planning became a priority around 1978, when New York City's City-Wide 208 Water Quality Study identified it as requiring additional study. Subsequently, the NYC was awarded a revised 201 Facilities Plan grant for the Gowanus Pump Station that included a water quality study of the Gowanus Canal and Bay, a pump station and force main study, and public participation. Among other recommendations, the 1983 Facilities Plan report identified upgrading the Gowanus Pump Station, rehabilitating the Bond Lorraine Sewer, rehabilitating and reactivating the Gowanus Canal Flushing Tunnel, and installing a force main to convey sewage to the Columbia Street Interceptor. These recommendations remained through the 1993 Inner Harbor CSO Facility Plan, which focused on quantifying and assessing the impacts of CSO discharges to the Gowanus Canal, among other waterbodies, as well as the 2008 WWFP. The recommendations are thus considered part of the WWFP improvements included in the baseline described in this section.

4.1.a Completed Projects

The 2012 CSO Order on Consent capital projects to improve water quality in the Gowanus Canal was constructed under contract CSO-GCER:

1. Rehabilitation of the Gowanus Canal Flushing Tunnel System to eliminate shutdowns during low tide and improve maintenance operations with the installation of a new pumping system with redundant, interchangeable pumps.

2. Gowanus Pumping Station reconstruction to improve operational reliability and to redirect flow directly to the Columbia Street Interceptor via a new force main to be constructed within the Flushing Tunnel.

Each of these is discussed in detail below. Both projects were certified as completed by the DEP on February 27, 2015 at a total cost of $160.3M.

The Gowanus Canal Flushing Tunnel Modernization

The Gowanus Canal Flushing Tunnel was originally constructed in 1911 to convey water in either direction between the Gowanus Canal and Buttermilk Channel. The original flushing system consisted of a 400 horsepower (hp) motor and a 7-foot-diameter propeller that could pump 325 MGD through the approximately 6,070-foot-long, 12-foot-diameter brick tunnel. The system failed in the 1960s and remained out-of-service until 1999, when it was rehabilitated and returned to service as recommended in the Inner Harbor CSO Facility Plan. However, once reactivated, this system was determined to be deficient. The actual capacity of the system, as installed, averaged only about half the design flow, and was inoperable at low tide. Further, the physical assets were problematic for numerous operations and maintenance considerations, including accelerated corrosion, custom-made equipment, inadequate redundancy, and the need to deploy SCUBA crews or dewatering for basic maintenance.

To address these issues, the Gowanus Canal Flushing Tunnel pumping system was modernized to reduce downtime and to improve overall operation (see Figure 4-1). The system features three submersible, vertical, axial-flow pumps installed in parallel within the existing motor pit (which became the wet well), with two additional pumps stored on-site as spares that can be changed in without dewatering or system shutdowns. The design capacity of each pump is 69,500 gym (100 MGD) at a head of 20 feet when operated at full speed (500 rpm), discharging through a 54-inch-diameter concrete tube opening to a common discharge chamber. The Flushing Tunnel itself was also rehabilitated by minimizing the occlusion in its cross-section cause by the Columbia Street Interceptor, and the tie-in of the existing 36-inch Gowanus Pump Station force main that lies within the tunnel.

Gowanus Pump Station Reconstruction

Combined sanitary and wastewater flow from a 650-acre tributary area enters the Gowanus Pump Station via three large sewers from Butler Street. Hydraulic analyses of these influent conduits show that the maximum wet-weather flow rate that can be delivered to the pump station is about 650 MGD. During wet-weather, flows exceeding the pumping capacity of the station bypass via Outfall RH-034 to the head end of the Gowanus Canal. The Gowanus Pump Station previously discharged to the nearby Bond Lorraine Sewer via the Butler Street force main, but the force main was redirected to the Columbia Street Interceptor to bypass the hydraulically limited sewer that discharges CSO to the Gowanus Canal. The new force main runs approximately one mile within the 12-foot diameter Gowanus Canal Flushing Tunnel. The new force main was sized to provide an optimum balance between combined sewer conveyance needs and Flushing Tunnel capacity.

The increased sewer system capacity that this new force main provides allows for the expansion of the firm capacity of the Gowanus Pump Station from 20.2 MGD to 30 MGD. The gain in capacity was accomplished through the installation of four 140-hp submersible wastewater pumps, each with a rating point of 6,950 gym at 55 feet total dynamic head, providing 30 MGD combined flow capacity at this rating point. Up to three pumps are in service at any given time, with a fourth providing redundancy and allowing for pump servicing without reducing operating capacity.

In addition, CSO screening facilities were upgraded to provide floatables control of overflows to the Gowanus Canal, including a horizontally raked bar screen above the existing dry-weather influent channel to the pumping station, capable of screening a CSO flow rate of up to 200 MGD (more than the 5-minute peak CSO flow of 172 MGD calculated during the design rainfall year). Only the portion of the flow in excess of 200 MGD is unscreened for larger events. Floatables already captured in such storms are retained rather than discharged.

Figure 4-2 shows a rendering of the Rehabilitated Gowanus Pump Station located at the head end of the Gowanus Canal.

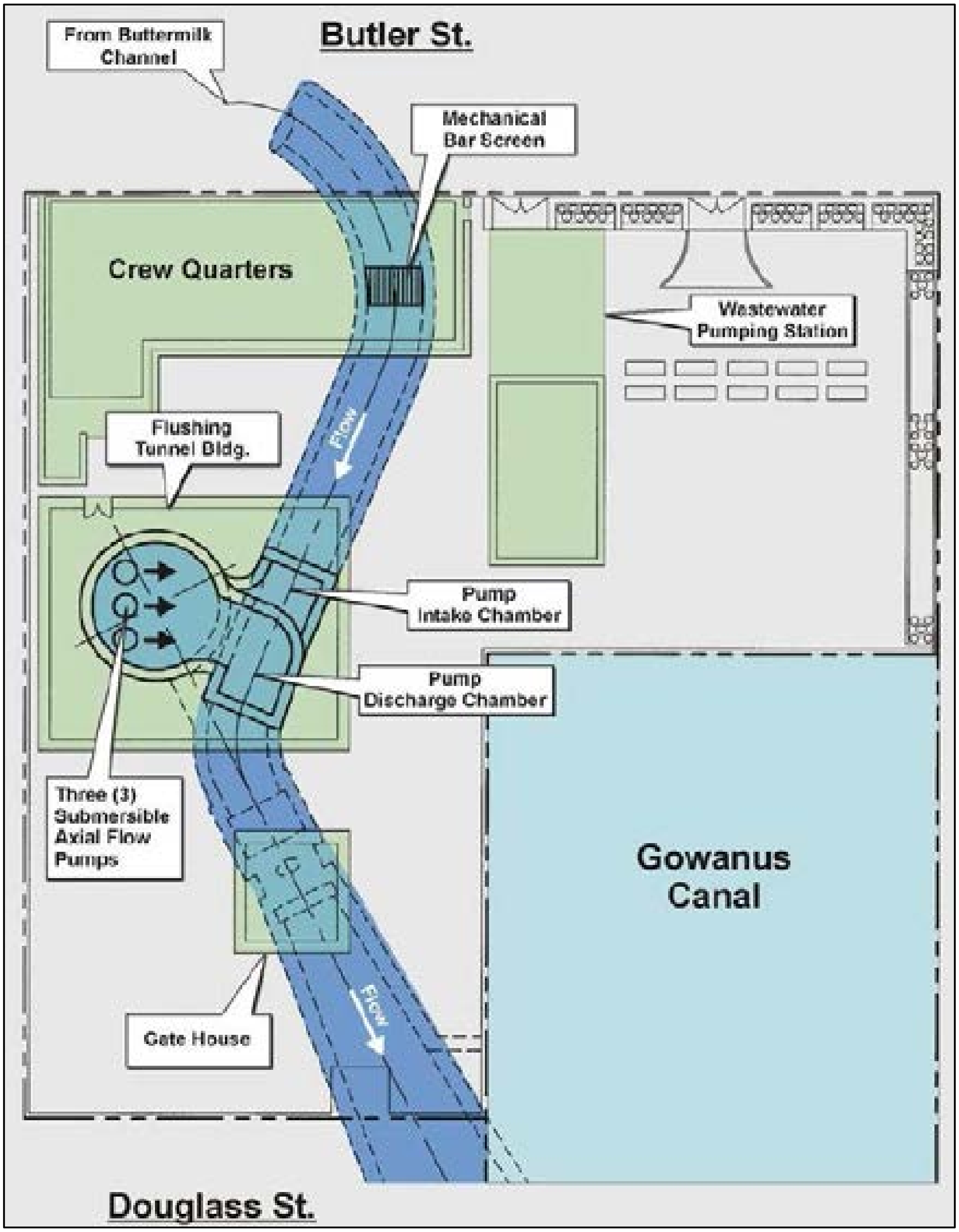

Figure 4-1. Flushing Tunnel Rehabilitation

Figure 4-2. Rehabilitated Gowanus Pump Station at the Head End of Gowanus Canal

4.1.b Ongoing Projects

There are no ongoing grey infrastructure projects in the Gowanus Canal planning area.

4.1.c Planned Projects

In September 2013, the EPA issued its ROD for the Gowanus Canal Superfund Site in Brooklyn, New York. The ROD requires the siting, design, construction, and operation of two CSO retention tanks to control discharges of solids to the Gowanus Canal, unless other technically viable alternatives are identified[1]. The ROD estimated that an 8 million gallon tank would be necessary at Outfall RH-034, and a 4 million gallon tank at Outfall OH-007. In addition, in May 2014, EPA issued a Unilateral Order to NYC requiring, among other things, the completion of a siting study to identify recommended locations for the tanks; this study is being submitted at the same time as this LTCP. The final siting, design and schedules for these projects will be determined in accordance with the Superfund process.

[1] *See United States Environmental Protection Agency. Record of Decision, Gowanus Canal Superfund Site: Summary of Remedial Alternatives, page 55.*

4.2 Other Water Quality Improvement Measures Recommended in Facility Plans (Dredging, Floatables, Aeration)

The CSO Consent Order included a dredging project to be executed under Contract CSO-DRDG/DRG. Environmental dredging was to be performed in approximately 825 feet of the head end of the Gowanus Canal to a final water depth of 3.0 feet below mean lower low water (MLLW). The estimated cost of this project is $13.1M. DEP has placed the design under CSO-DRDG/DRG on hold pending reconciliation of that project with the sediment-related requirements of the USEPA's ROD.

4.3 Post-Construction Monitoring

The PCM Program is integral to optimization of the Gowanus Canal LTCP, providing data for model validation and feedback on system performance. Each year's data set will be compiled and evaluated to refine the understanding of the interaction between the Gowanus Canal and the actions identified in this LTCP with the ultimate goal of fully attaining compliance with current WQS. The data collection monitoring consists of three basic components:

1. Evaluation of the inflows and loads entering the Gowanus Canal;
2. Receiving-water data collection in the Gowanus Canal using DEP HSM locations; and
3. Modeling of the collection system and receiving waters to characterize water quality using the existing IW model and the Gowanus Water Pathogen Model (GC-PATH), respectively.

The details provided herein are limited to the Gowanus Canal PCM and may be modified as the DEP's CSO program advances through the completion of other LTCPs, including the citywide LTCP in 2017.

PCM in the Gowanus Canal commenced before the WWFP elements became operational, and will precede any additional CSO control measures proposed under this LTCP becoming operational. Build-out of any GI would be factored into the final scheduling. Monitoring will continue for several years after the controls are in place in order to quantify the difference between the expected and actual performance. Any gap identified by the monitoring program can then be addressed through operations adjustments, retrofitting additional controls, or through the implementation of additional technically feasible and cost-effective alternatives. If it becomes clear that CSO control will not result in full attainment of applicable WQS, DEP will pursue the necessary regulatory mechanism for a UAA.

4.3.a Collection and Monitoring of Water Quality in the Receiving Waters

PCM sampling program in the Gowanus Canal commenced in 2013, with all stations being sampled a minimum of twice per month from May through September, and then monthly during the remainder of the year.

Measured parameters relating to water quality include: DO, fecal coliform, enterococci, chlorophyll 'a', and Secchi depth. With the exception of enterococci, the NYC has used these parameters for decades to identify historical and spatial trends in water quality throughout New York Harbor. DO and chlorophyll 'a' are collected and analyzed at surface and bottom locations; the remaining parameters are measured at the surface only.

Results from the PCM for this waterbody have not been reported formally as part of the citywide PCM Annual Report because these data are being collected as part of the pre-control baseline. Monitoring will continue for several years after the actions identified in this LTCP are in place, as part of the adaptive management approach, to assess the extent of water quality improvements and their similarity to those predicted by the models (i.e. difference between the projected and actual performance). Build-out of GI will factor into this schedule as well.

4.3.b CSO Facilities Operations – Flow Monitoring and Effluent Quality

Any flow and effluent quality monitoring program would be dependent on the types and sizes of proposed CSO controls implemented under this LTCP. Effluent quality data is not expected to be collected routinely at an unmanned facility, nor is routine CSO flow and effluent quality data anticipated to be collected on outfalls for which no controls have been provided. If the implemented control is permitted under the SPDES, the conditions of that permit regarding effluent monitoring would be followed.

4.3.c Assessment of Performance Criteria

CSO controls implemented under this LTCP will be designed to achieve a specific set of water quality and/or CSO reduction goals as established in this LTCP, and as directed in the subsequent Basis of Design Report (BODR) that informs the design process. If no additional CSO controls are proposed, then affirmation of water quality projections would be necessary. In both cases, the PCM data, coupled with the modeling framework used for annual reporting, will be used to assess the performance of the CSO controls implemented in comparison to the water quality goals.

Differences between actual overflows and model-predicted overflows are often attributable to the fact that the model results are based on the rainfall measured at a single NOAA rain gauge being taken to represent the rainfall over the entire drainage area. In reality, storms move through the area and are variable, so that the rainfall actually varies over time and space. Because rainfall patterns tend to even out over the area over time, the practice of using the rainfall measured at one nearby location typically provides good agreement with long-term performance for the collection system as a whole; however, model results for any particular storm may vary somewhat from observations.

Given the uncertainty associated with potentially widely varying precipitation conditions, rainfall analyses is an essential component of the PCM. For the Gowanus Canal, the most representative long-term rainfall data record is available from the National Weather Service's JFK gauges (Owls Head and Red Hook). Rain data for each calendar year of the PCM program will be compared to the 10-year model period (2002-2011), and to the JFK 2008 rain data used for alternative evaluations. Statistics, including number of storms, duration, total annual and monthly depths, and relative and peak intensities, will be used to classify the particular reporting year as wet or dry relative to the time series on which the concept was based. Uncertainty in the analyses may be supplemented with radar rainfall data where there is evidence of large spatial variations.

The reporting year will be modeled utilizing the existing IW/GC-PATH framework using the reporting year tides and precipitation. The resulting CSO discharges and water quality attainment will then be compared with available PCM data for the year as a means of validating model output. The level of attainment will be calculated from the modeling results and coupled with the precipitation analyses to determine relative improvement and the existence of any gap. Three successive years of evaluation will be necessary before capital improvements are considered, but operational adjustments will be considered throughout operation and reporting.

5.0 GREEN INFRASTRUCTURE

By capturing stormwater runoff and managing it through the processes of volume retention, infiltration, evapotranspiration, and re-use, GI can reduce stormwater discharge to the CSS.[1] In 2010, the New York City Department of Environmental Protection (DEP) wrote and adopted the *NYC Green Infrastructure Plan: A Sustainable Strategy for Clean Waterways* ("GI Plan"), which was subsequently incorporated into the 2012 CSO Order on Consent.

The 2012 CSO Order on Consent requires DEP to control the equivalent of stormwater generated by one inch of precipitation on 1.5 percent of impervious surfaces in combined areas citywide by December 31, 2015. If this 1.5 percent goal is not met, DEP must certify that $187M has been encumbered for the purpose of GI and submit a contingency plan to the DEC by June 20, 2016. By 2030, DEP is required to control the equivalent of stormwater generated by one inch of precipitation on 10 percent of impervious surfaces citywide in combined sewer areas. Over the next 20 years, DEP is planning for $2.4B in public and private funding for targeted GI installations, and $2.9B in cost-effective grey infrastructure upgrades to reduce CSOs. The Green Infrastructure Program, including citywide and CSO tributary area specific implementation, is described below. Pursuant to the 2012 CSO Order on Consent, DEP publishes the *Green Infrastructure Annual Report* every April 30th to provide details on GI implementation and related efforts. These reports can be found at http://www.nyc.gov/html/dep/ html/ stormwater/ nyc_green_ infrastructure_plan.shtml.

5.1 NYC Green Infrastructure Plan (GI Plan)

The GI Plan presents an alternative approach to improving water quality through additional CSO volume reductions by outlining strategies to implement decentralized stormwater source controls. An initial estimate, produced in 2010, used a hybrid green/grey infrastructure approach that indicated DEP could reduce CSO volume by an additional 3.8 billion gallons per year (BGY), or approximately 2 BGY more than by implementing an all-grey strategy. In addition to its primary objective, enhancing water quality in NYC, the GI Plan will yield co-benefits which include, but are not limited to, improved air quality, urban heat island mitigation, carbon sequestration, increased shade, and increased urban habitat for pollinators and wildlife.

In January 2011, DEP created the Office of Green Infrastructure (OGI) to implement the goals of the GI Plan, and committed $1.5B through 2030, including $5M in Environmental Benefit Project (EBP) funds.[2] OGI, in conjunction with other DEP Bureaus and partner NYC agencies, is tasked with designing and constructing GI practices that capture and manage, by infiltration and evapotranspiration, stormwater runoff before it reaches the CSS. The OGI has developed design standards for Right-of-Way GI Practices, such as Bioswales (ROWBs), Stormwater Greenstreets (SGSs), and Rain Gardens (ROWRGs), and has designed other projects on NYC-owned properties that include pervious pavement, rain gardens, retention/detention systems and green and blue roofs. The Area-wide implementation strategy and other implementation details initiated by OGI to achieve the milestones in the 2012 CSO

[1] U.S. EPA, March 2014. *Greening CSO Plans: Planning and Modeling Green Infrastructure for Combined Sewer Overflow (CSO) Control.*

[2] EBP projects are undertaken in connection with the settlement of an enforcement action taken by New York State and DEC for violations of New York State law and DEC regulations.

Order on Consent are described in more detail below, and in the 2012 and 2013 *Green Infrastructure Annual Report,* available on DEP's website.

5.2 Citywide Coordination and Implementation

To meet the GI goals of the 2012 CSO Order on Consent, DEP has identified several target CSO tributary areas ("target areas") for GI implementation based on the following criteria: annual CSO volume; frequency of CSO events; other CSO control projects undertaken through the WWFPs; and other grey system improvements planned in the future. DEP also notes outfalls in close proximity to existing and future public access locations. Over the course of the 20-year Green Infrastructure Program, DEP will continue to review and expand the number of targeted areas to comply with the 2012 CSO Order on Consent milestones (also see Section 5.4c). The current target areas are shown in Figure 5-1. DEP employs adaptive management principles in the implementation of the Green Infrastructure Program, which allows for factoring in field conditions, costs, and other challenges, as it proceeds toward each milestone.

The identification of target areas enables DEP to focus resources on specific outfall CSO Tributary Drainage Areas (TDAs) in order to analyze all potential GI opportunities, saturate these areas with GI practices to the extent possible, and achieve efficiencies in design and construction. This Area-wide strategy is made possible by DEP's standardized GI designs and procedures that enable systematic implementation of GI. This strategy also provides an opportunity to measure and evaluate the CSO benefits of Area-wide GI implementation at the outfall level.

DEP utilizes the Area-wide strategy for all public property retrofits, as described in more detail in the *2013 Green Infrastructure Annual Report*. DEP works directly with its partner agencies on retrofit projects at public schools, public housing, parkland, and other NYC-owned property within the target areas. DEP coordinates on a regular basis with partner agencies to review designs for new projects and to gather current capital plan information to identify opportunities to integrate GI into planned public projects.

DEP manages several of its own design and construction contracts for right-of-way and on-site GI practices. Additionally, the EDC, Department of Parks and Recreation (DPR), and Department of Design and Construction (DDC) manage the design and construction of several of these Area-wide contracts on behalf of DEP.

5.2.a Community Engagement

Stakeholder participation is a critical success factor for the effective implementation of decentralized GI projects. To this end, DEP engages and educates local neighborhoods, community groups, and other environmental and urban planning stakeholders about their role in the management of stormwater. DEP's outreach efforts involve presentations and coordination with elected officials, community boards, stormwater advocacy organizations, green job non-profits, environmental justice organizations, schools and universities, Citizens Advisory Committees (CACs), civic organizations, and other NYC agencies.

DEP launched its new website at www.nyc.gov/dep in 2013. As part of this update, DEP reorganized and added new content to the GI pages at www.nyc.gov/dep/greeninfrastructure. Users can now easily access more information on the Green Infrastructure Program, including Standard Designs for Right-of-Way (ROW) GI practices. Users can also view a map of the target areas to learn whether GI is coming to their neighborhood.

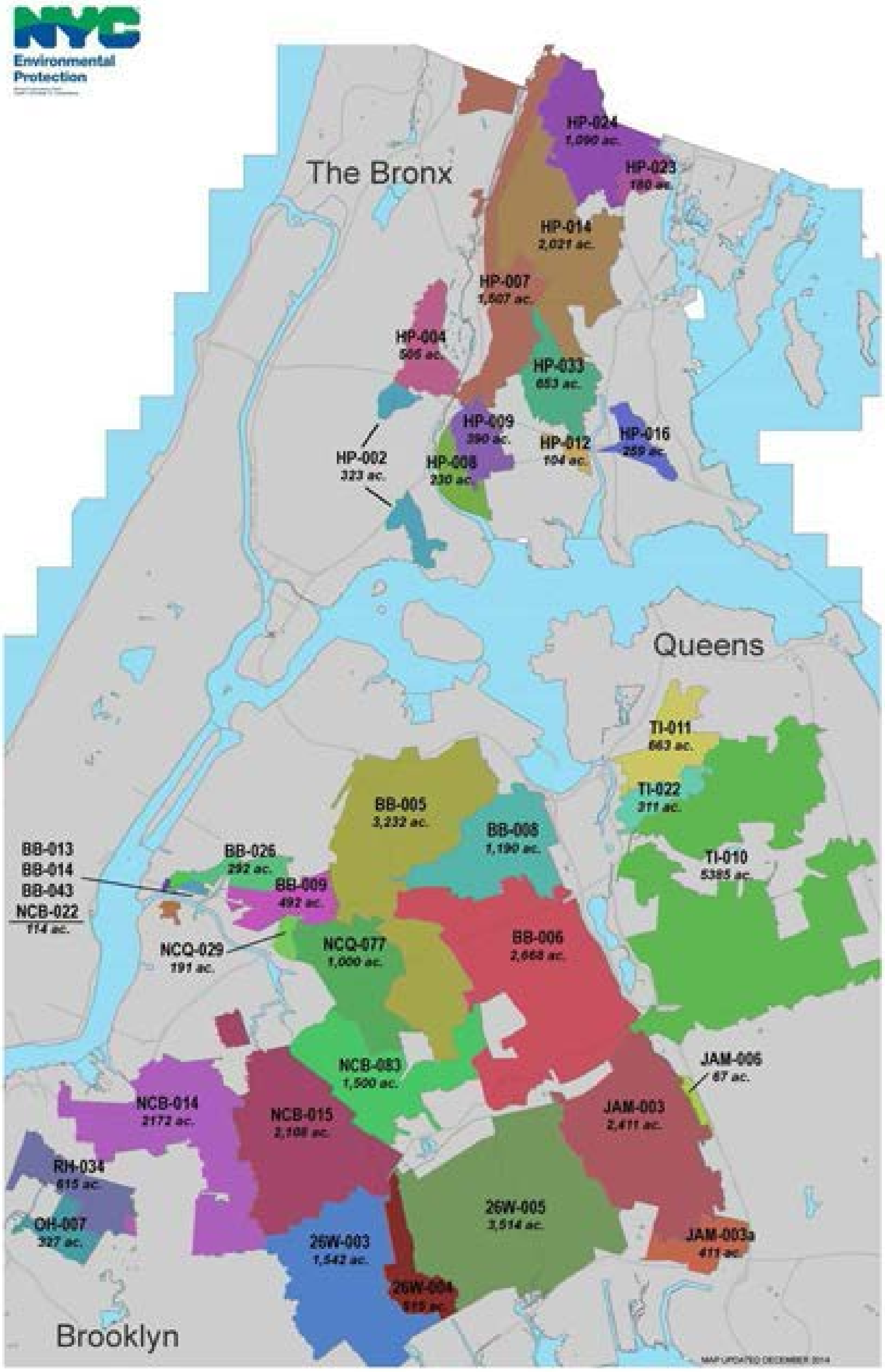

Figure 5-1. Target CSO Tributary Areas for Green Infrastructure Implementation

DEP also created an educational video on the Green Infrastructure Program. This video gives a brief explanation of the environmental challenges posed by CSOs, while featuring GI technologies such as retention/detention systems, green/blue roofs, rain gardens, porous paving and permeable pavers. The video is available at DEP's YouTube page.

To provide more information about the Green Infrastructure Program, DEP developed an informational brochure that describes the site selection and construction process for projects in the ROW. The brochure also includes frequently asked questions and answers, and explains the co-benefits of GI.

DEP notifies abutting property owners in advance of ROW GI construction projects. In each contract area, DEP and its partner agencies provide construction liaison staff to be present during construction. The contact information for the construction liaison is affixed to the door hangers, for use if the need to alert NYC to a problem which arises during construction.

As part of its ongoing outreach efforts, DEP continues to make presentations to elected officials and their staffs, community boards, and other civic and environmental organizations about the Green Infrastructure Program, upcoming construction schedules, and final GI locations.

5.3 Completed Green Infrastructure to Reduce CSOs (Citywide and Watershed)

The *Green Infrastructure Annual Reports* contain the most up-to-date information on completed projects and can be found on the DEP website. Reporting on completed projects on a citywide and watershed basis by April 30th is a requirement of the 2012 CSO Order on Consent. In addition, Quarterly Progress Reports are posted on the DEP Long Term Control Plan (LTCP) webpage: http://www.nyc.gov/html/dep/html/cso_long_term_control_plan/ index.shtml.

5.3.a Green Infrastructure Demonstration and Pilot Projects

The Green Infrastructure Program applies an adaptive management approach, based on information collected and evaluated from Demonstration Projects and on pilot monitoring results. In particular, accumulated information will be used to develop a GI performance metrics report by 2016 relating the benefits of CSO reduction with the number of GI practices constructed.

Pilot Site Monitoring Program

DEP initiated site selection and design of its Pilot Monitoring Program in 2009. This program has provided DEP opportunities to test different designs and monitoring techniques, and to determine the most cost-effective, adaptable, and efficient GI strategies that can be implemented citywide. Specifically, the pilot monitoring aimed to assess the effectiveness of each of the evaluated source controls at reducing the volume and/or rate of stormwater runoff from the drainage area by measuring quantitative aspects (e.g., source control inflow and outflow rates), as well as qualitative issues (e.g., maintenance requirements, appearance and community perception). Since 2010, more than 30 individual pilot GI practices have been constructed and monitored as part of the citywide pilot program for GI. These practices include: ROW GI such as bioswale rain gardens; rooftop practices such as blue roofs and green roofs; subsurface detention/retention systems with open bottoms for infiltration; porous pavement; and bioretention facilities. Data collection began in 2010 as construction for each of the monitoring sites was completed. Pilot Monitoring Program results will assist in validating modeling methods and parameters. Results are discussed further in Section 5.3.e.

Neighborhood Demonstration Area Projects

The 2012 CSO Order on Consent includes design, construction, and monitoring milestones for three Neighborhood Demonstration Area Projects ("Demonstration Projects"), which DEP met in 2012 and 2013. DEP has completed construction of GI practices within a total of 66 acres of tributary area in Hutchinson River, the Newtown Creek and Jamaica Bay CSO TDAs. DEP has monitored these GI practices to study the benefits of GI application on a neighborhood scale and from a variety of techniques. A PCM Report was submitted to DEC in August 2014. DEP received requests for clarification from DEC regarding the PCM Report and resubmitted an updated PCM Report in January 2015. The results obtained from the Demonstration Projects, including monitoring, will be incorporated into the 2016 Performance Metrics Report, which will model the CSO reductions from GI projects. The approximately one-year pre-construction monitoring for all three Demonstration Projects started in fall 2011, and the approximately one-year PCM continued throughout 2013.

Construction of ROWBs as part of the Hutchinson River Green Infrastructure Demonstration Project was completed in April 2013 by DPR. There were 22 ROWBs installed within the 24-acre tributary area, and the design and construction costs were approximately $625,000. In the 23-acre Jamaica Bay Green Infrastructure Demonstration Project, DEP completed 31 ROW GI installations in 2012 and the permeable pavement retrofit projects at NYCHA Seth Low Houses in 2013. The total design and construction costs were approximately $1.5M. In the 19-acre Newtown Creek Green Infrastructure Demonstration Project, DEP constructed 19 ROWBs, two rain gardens, and a subsurface storm chamber system on the site of NYCHA's Hope Gardens Houses. The projects were completed in 2013, and costs totaled approximately $1.6M for design and construction. For more detailed information on the Demonstration Projects, see the *2012 Green Infrastructure Annual Report.*

While DEP's Pilot Monitoring Program provides performance data for individual GI installations, the Demonstration Projects provided standardized methods and information for calculating, tracking, and reporting derived stormwater volume reductions, impervious area managed, and other benefits associated with both multiple installations within identified sub-TDAs. The data collected from each of the three demonstration areas will enhance DEP's understanding of the benefits of GI relative to runoff control and resulting CSO reduction. The results will then be extrapolated for calculating and modeling water quality and cost-benefit information on a citywide and waterbody basis in the 2016 Performance Metrics Report.

5.3.b Public Projects

Green Infrastructure Schoolyards

The "Schoolyards to Playgrounds" program, one of PlaNYC 2030's initiatives aimed at ensuring that all New Yorkers live within a ten-minute walk from a park, is a collaboration between the non-profit Trust for Public Land (TPL), DPR, New York City Department of Education (DOE), and New York City School Construction Authority (SCA) to renovate public school playgrounds and extend playground access to surrounding neighborhoods. In 2011, DEP joined TPL, SCA, and DOE funding up to $5M for construction of up to ten GI schoolyards each year for the next four years. The partnership is a successful component of DEP's strategy to leverage public-private partnerships to improve public property using GI retrofits.

See the Green Infrastructure Annual Reports, "Citywide Coordination and Implementation," for up-to-date information on completed public property retrofit projects.

5.3.c Performance Standard for New Development

DEP's stormwater performance standard ("stormwater rule") enables NYC to manage discharges to the CSS from new developments or major site alterations. Promulgated in July 2012,[3] the stormwater rule requires any new premises or any requests for sewer site connections to NYC's CSS to comply with stricter stormwater release rates, effectively requiring greater on-site detention. DEP's companion document, *Guidelines for the Design and Construction of Stormwater Management Systems,*[4] assists the development community and licensed professionals in the selection, planning, design, and construction of on-site source controls that comply with the stormwater rule.

The stormwater rule applies to new development or the alteration of an existing development in combined sewer areas of NYC. For a new development, the stormwater release rate[5] is required to be 0.25 cubic feet per second (cfs) or 10 percent of the drainage plan allowable flow, whichever is greater.[6] If the allowable flow is less than 0.25 cfs, then the stormwater release rate shall be equal to the allowable flow. For alterations, the stormwater release rate for the altered area will be directly proportional to the ratio of the altered area to the total site area, and no new points of discharge are permitted.[7] As discussed in Section 5.4.c. below, DEP anticipates that the stormwater rule will contribute to CSO reduction in each priority watershed.

5.3.d Other Private Projects (Grant Program)

Green Infrastructure Grant Program

Since its introduction in 2011, the Grant Program has sought to strengthen public-private partnerships and public engagement in regard to the design, construction and maintenance of GI.

The 2012 CSO Order on Consent requires the Green Infrastructure Grant Program to commit $3M of EBP funds[8] to projects by 2015. DEP met this commitment in 2014.

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[3] See Chapter 31 of Title 15 of the *Rules of the City of New York Governing House/Site Connections to the Sewer System*. (New York City, N.Y., Rules, Tit. 15, § 31).

[4] The *Guidelines* are available at DEP's website, at http://www.nyc.gov/html/dep/pdf/green_infrastructure/ stormwater_guidelines_ 2012_final.pdf.

[5] New York City, N.Y., Rules, Tit. 15, § 31-01(b)

[6] Allowable flow is defined as the storm flow from developments based on existing sewer design criteria that can be released into an existing storm or combined sewer.

[7] New York City, N.Y., Rules, Tit. 15, § 31-03(a)(2)

[8] EBP Projects are undertaken by DEP in connection with the settlement of an enforcement action taken by New York State and the New York State Department of Environmental Conservation for violations of New York State law and DEC regulations.

Green Roof Property Tax Abatement

The NYC Green Roof Tax Abatement (GRTA) has provided a fiscal incentive to install green roofs on private property since 2008. DEP has worked with the Mayor's Office of Long Term Planning and Sustainability (OLTPS), the Department of Buildings (DOB), the Department of Finance (DOF) and the Office of Management and Budget (OMB), as well as environmental advocates and green roof designers, to modify and extend the GRTA through 2018. DEP has met with stakeholders and incorporated much of their feedback to improve the next version to help increase the number of green roofs in NYC. Additionally, DEP funded an outreach position to educate applicants and assist them through the abatement process, to help facilitate application approval and respond to issues that may arise.

The tax abatement includes an increase to the value of the abatement from $4.50 to $5.23 per square foot, to continue offsetting construction costs by roughly the same value as the original tax abatement. Also, given that rooftop farms tend to be larger than typical green roofs (approximately one acre in size), the abatement value cap was also increased from $100,000 to $200,000 to allow such applicants to receive the full value of the abatement. Finally, based on the amount allocated for this abatement, the total annual amount available for applicants (i.e., in the aggregate) is $750,000 in the first year, and $1,000,000 in each subsequent year through March 15, 2018. The aggregate amount of abatements will be allocated by the DOF on a pro rata basis. See the *2013 Green Infrastructure Annual Report* for up-to-date information on the Green Roof Property Tax Abatement.

5.3.e Projected vs. Monitoring Results

Pilot Site Monitoring Program

As mentioned above, more than 30 pilot GI practices have been constructed and monitored as part of the pilot program for GI. Quantitative monitoring parameters included:

- Water quantity: inflow, outflow, infiltration, soil moisture and stage.
- Weather: evaporation, rainfall, wind, relative humidity and solar radiation.
- Water/soil quality: diesel/gas, nutrients, TSS, total organic carbon (TOC), salts, metals, soil sampling and infiltrated water sampling.

Quantitative monitoring was conducted primarily through remote monitoring equipment, such as pressure transducer water level loggers in conjunction with weirs or flumes to measure flows, monitoring aspects of source control performance at five-minute intervals. On-site testing and calibration efforts included infiltration tests and metered discharges to calibrate flow monitoring equipment and assess the validity of assumptions used in pilot performance analysis.

Monitoring efforts focused on the functionality of the GI practices and their impact on runoff rates and volumes, along with water and soil quality and typical maintenance requirements. Monitoring activities largely involved remote monitoring equipment that measured water level or flows at a regular interval, supporting analysis of numerous storms throughout at each site.

Monitoring analyses through 2013 demonstrated that all pilot GI practices are providing effective stormwater management, particularly for storms with depths of one inch or less. All GI practices have provided benefits for storms greater than one inch, with specific impacts varying based upon location and type. In many cases, bioretention practices have fully retained the volume of one inch storms they received.

Monitoring activities will be discontinued at several sites that have multiple years of performance data and have exhibited relatively consistent performance throughout that period. Further monitoring at these locations may be resumed in the future to further examine long term performance. Monitoring data for these locations is included in the *2012 Pilot Monitoring Report*. In addition, up-to-date information on the Pilot Monitoring Program can be found in the *2013 Green Infrastructure Annual Report*.

Neighborhood Demonstration Area Projects

As previously discussed, the objective of DEP's Demonstration Projects is to maximize the management and control of stormwater runoff near where it is generated, and then monitor the reduction of combined sewage originating from identified sub-TDAs. DEP's PCM Report documented the performance of installed GI practices in the demonstration areas and was submitted to DEC in August 2014. After receiving comments from DEC, the report was resubmitted in January 2015. The 2016 Performance Metrics Report will relate the benefits of CSO reduction associated with the type and number of GI constructed, and detail methods by which DEP will calculate the CSO reduction benefits in the future.

The three Demonstration Projects were selected because the existing sewers flow in a single combined sewer pipe of a certain size to a receiving manhole where monitoring could take place. In each of the Demonstration Projects, DEP identified GI opportunities in the ROW as well as on-site at NYC-owned property.

The combined sewer flow reductions achieved by built GI practices were monitored through the collection of high quality flow monitoring data at the point at which the combined sewer system exits the Demonstration Project area's delineated sub-drainage tributary area. Monitoring activities consisted of recording combined flow and depth and using meters placed within a key outlet sewer at a manhole. Data acquisition was continuous, with measurements recorded at 15-minute intervals.

Data collection continued for approximately one-year each for pre- and post-construction. Subsequent analysis involved a review of changes in pervious and impervious surface coverage between pre- and post-construction conditions, consisting of several elements, including statistical analyses. This statistical analysis will enable DEP to determine the overall amount of combined flow reduction within the Demonstration Project's tributary area and the impervious area managed associated with GI practices implemented at scale.

Project data collected will be used to calibrate the IW computer model to the monitored flows for pre- and post-construction conditions. Post-construction performance data will be used to ensure that retention modeling techniques adequately account for the degree of flow reduction within TDAs with planned GI and equivalent CSO volume reductions.

5.4 Future Green Infrastructure in the Watershed

5.4.a Relationship Between Stormwater Capture and CSO Reduction

The modeling approach described here outlines how CSO reductions are projected for waterbody-specific projected GI penetration rates (see Section 6). Potential CSO reduction and load reduction through stormwater capture in the Gowanus Canal was evaluated using the landside model, developed in IW modeling software, based on the extent of GI (retention and detention) practices in combined sewer areas. The extent of stormwater capture from GI projects is configured in terms of a percent of impervious cover where one inch of stormwater is managed through different types of GI practices. Due to their distributed locations within a TDA, retention for different GI practices is lumped on a sub-TDA level in the landside model. This is also due to the fact that the landside model does not include small combined sewers and cannot model them in a distributed manner. Retention is modeled with the applicable storage and/or infiltration elements. Similarly, the distributed detention locations within a TDA are represented as a lumped detention tank, with the applicable storage volume and constricted outlet configured based on allowable peak flows from their respective TDA. Modeling methods designed during the development of DEP's GI Plan have been refined over time to better characterize the retention and detention functions.

5.4.b Opportunities for Cost-Effective CSO Reduction Analysis

For each LTCP, the citywide target for managing one inch of rain on 10 percent impervious area in combined sewered areas has been broken out into estimated targets for each waterbody and used to calculate the baseline CSO reductions from GI projects. The estimated targets for each waterbody are the best information available because the GI implementation is being carried out simultaneously as the LTCPs are developed. At this time, there are no additional GI projects identified in the watershed that would exceed the baseline target rate (as described above and below). The Green Infrastructure Program will be implemented through 2030 and the final penetration rate will be reassessed as part of the adaptive management approach.

5.4.c Watershed Planning to Determine 20 Year Penetration Rate for Inclusion in Baseline Performance

To meet the 1.5-, 4-, 7-, and 10-percent citywide GI penetration rates by 2015, 2020, 2025 and 2030, respectively, DEP has developed a waterbody prioritization system described above in Section 5.2. This approach has provided an opportunity to build upon existing data and make informed estimates available.

Waterbody-specific penetration rates for GI are estimated based on the best available information from modeling efforts. Specific WWFPs, the Green Infrastructure Plan, CSO outfall tiers data, and historic building permit information were reviewed to better assess waterbody-specific GI penetration rates.

The following criteria were applied to compare and prioritize watersheds in order to determine waterbody-specific GI penetration rates:

- WQS
  - Fecal Coliform
  - Total Coliform
  - Dissolved Oxygen

- Cost-effective grey investments
  - Planned/constructed grey investments
  - Projected CSO volume reductions
  - Remaining CSO volumes
  - Total capital costs

- Additional considerations:
  - Background water quality conditions
  - Public concerns and demand for recreational uses
  - Site-specific limitations (i.e., groundwater, bedrock, soil types, etc.)
  - Presence of high frequency outfalls
  - Eliminated or deferred CSO storage facilities
  - Additional planned CSO controls not captured in WWFPs or 2012 CSO Order on Consent (i.e., HLSS)

The overall goal for this prioritization is to saturate GI implementation rates within the priority watersheds, such that the total managed impervious acres will be maximized based on the specific opportunities and field conditions in the Gowanus Canal as well as costs.

Green Infrastructure Baseline Penetration Rate – The Gowanus Canal

Based on the above criteria, the Gowanus Canal's characterization ultimately determined that the waterbody is a target area for the Green Infrastructure Program. This particular waterbody has a total tributary combined sewer impervious area of 1,387 acres. DEP projects that GI penetration rates would manage 12 percent of the impervious surfaces within the Gowanus Canal combined sewer service area by 2030. This accounts for ROW practices, public property retrofits, GI implementation on private properties, and includes conservatively estimated new development trends based on DOB building permit data to account for compliance with the stormwater performance standard during the years 2012-2030. The model has predicted a reduction in annual overflow volume of 41 MG from this GI implementation based on the 2008 baseline rainfall condition.

Furthermore, as LTCPs are developed, baseline GI penetration rates for specific watersheds may be adjusted based on the adaptive management approach as described above in Section 5.2. DEP anticipates that the Green Infrastructure Program will meet the citywide requirements to manage the equivalent of one inch of rain on 10 percent of impervious surfaces in the combined sewer area as set forth in the 2012 CSO Order on Consent. Figure 5-2 below shows the current contracts in progress in Gowanus Canal that will be accounted for as the Green Infrastructure Program progresses toward the 2030 goal. The current Area-wide contracts in the Gowanus Canal CSO TDA are in RH-034 and OH-007. As more information on field conditions, feasibility, and costs becomes known, and GI projects progress, DEP will continue to model the GI penetration rates and make the necessary adjustments at that time.

Figure 5-2. Green Infrastructure Projects in Gowanus Canal

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6.0 BASELINE CONDITIONS AND PERFORMANCE GAP

This Section compares the existing baseline water quality to the 100% of CSO control condition. Modeling simulations are used to predict water quality for the baseline and 100% CSO control conditions. A comparison of the two simulations is then done to determine the gap between the baseline and 100% CSO Control. A Key to development of the Gowanus Canal LTCP is the assessment of water quality using applicable WQSs within the waterbody. Water quality was assessed using the GC-PATH and the Gowanus Canal Sediment Transport and Eutrophication Model (GC-STEM), verified with both Harbor Survey and the synoptic water quality data collected in 2014. The models simulated ambient bacteria concentrations within the Gowanus Canal and Gowanus Bay for a set of baseline conditions, as described in this section, to assess future conditions. The IW sewer system model was used to provide flows and loads from intermittent wet-weather sources as input to the GC-PATH and GC-STEM models.

The assessment of water quality described herein starts with a baseline condition simulation to determine the future bacterial levels without CSO controls. Next, a simulation was performed to determine bacteria levels under the assumption of 100% CSO control. The baseline condition was then compared to a 100% CSO control simulation. The gap between the two scenarios was then compared to assess whether bacteria criteria can be attained through application of CSO controls. Continuous water quality simulations were performed to evaluate the gap between calculated baseline bacteria and DO levels and both the Existing WQ Criteria and Potential Future Primary Contact WQ Criteria. As detailed below, a one-year (using average 2008 rainfall) simulation was performed for bacteria and DO. This simulation served as a basis for evaluating the control alternatives presented in Section 8.

This section of the LTCP describes the baseline conditions, loading volumes calculated with the IW model, bacteria and DO loadings, and the resulting bacteria and DO concentrations calculated by the GC-PATH and GC-STEM water quality models. It further describes the gap between calculated baseline DO and bacteria concentrations and both the existing and potential future WQSs. The section assesses whether the gap can be closed through CSO reductions alone (100% CSO control).

6.1 Define Baseline Conditions

Establishing baseline conditions is an important step in the LTCP process. Baseline conditions are used to compare and contrast the effectiveness of CSO controls and to predict whether water quality goals would be attained if implemented. Baseline conditions for this LTCP were established in accordance with guidance set forth by the DEC to represent future conditions. Specifically, these conditions included the following assumptions:

- The design dry-weather sanitary flow and load was based on CY 2040 projections.
- The Red Hook and Owls Head WWTPs can accept and treat peak flows at 2xDDWF during wet-weather events.
- Cost-effective Grey Infrastructure CSO controls included in the 2012 CSO Order on Consent for the Red Hook and Owls Head sewersheds are operating. For Red Hook this includes: the Gowanus Canal Pump Station upgrade; the Gowanus Canal Flushing Tunnel improvements and

demonstration bending weir at RH-2 (Outfall RH-028). For Owls Head, this includes the Avenue V Pump Station upgrade.

- HLSS for flood mitigation.
- GI application rate of 10 percent ROW and 2 percent GI through on-site detention in the Red Hook and Owls Head-Gowanus Canal drainage areas implemented.
- Completion of Superfund dredging within the Gowanus Canal to the depths noted in the EPA Region 2 Feasibility Study (FS) and Proposed Remedial Action Plan (PRAP) documents for the Gowanus Canal: *Feasibility Study Report for the Gowanus Canal Site Brooklyn, NY, December 2011 Appendix A, Non-Aqueous-Phase Liquid (NAPL) Technical Evaluation* and *Superfund Proposed Plan Gowanus Canal Superfund Site Kings County, NY December 2012*.

Mathematical modeling tools were used to calculate the CSO volume and loadings of pathogen indicator organisms and nutrients and their impacts on water quality. The performance gap is assessed by comparing the baseline pathogen and DO concentrations, within the Gowanus Canal, as calculated by the water quality model to the WQS. In addition, complete removal of CSO was evaluated. Further analyses were conducted for CSO control alternatives as presented in Section 8. The mathematical modeling tools include the IW model and several models for water quality. The current IW model and the water quality models are described in the *Gowanus Canal LTCP Sewer System and Water Quality Modeling Report (DEP, 2015).*

The IW model was used to develop stormwater flows, conveyance system flows, and CSO volumes within the Gowanus Canal for a defined set of future or baseline conditions. For the Gowanus Canal LTCP, the baseline conditions were developed in a manner consistent with the earlier WWFP. However, based on more recent data, as well as the public comments received on various WWFPs, it was recognized that some of the baseline condition model input data needed to be updated to reflect more recent meteorological conditions, as well as the current operating characteristics of various collection and conveyance system components. Furthermore, the mathematical models were updated from their configurations and levels of calibration developed and documented prior to this LTCP. IW model modifications reflected a better understanding of loadings, catchment areas and new or upgraded physical components of the system. In addition, an IW model recalibration report was issued in 2012 (*InfoWorks Citywide Recalibration Report, June 2012a*) that used improved impervious surface satellite data. Specific to the Gowanus Canal, the IW model was calibrated to represent 2013/2014 conditions as described in the *Gowanus Canal LTCP Sewer System and Water Quality Modeling Report (DEP, 2015).* The new IW model network was then used to estimate CSO volumes and loads for the baseline conditions. It also was used as a tool to estimate CSO volumes and loads resulting from CSO control alternatives evaluated in Section 8. The baseline modeling conditions primarily related to dry-weather flow (DWF) rates, wet-weather capacity for the Red Hook and Owls Head WWTPs, sewer conditions, precipitation conditions and tidal boundary conditions are as follows:

- **Rainfall/Tides:** The 2008 year rainfall and tides were used in the model, in addition to evaluating a 10-year period (2002-2011).
- **Dry-Weather Flows**: The 2040 projected dry-weather flow rates at the Red Hook and Owls Head WWTPs are 28 and 85 MGD, respectively.

- **Wet-Weather Capacity**: The rated wet-weather capacity at the Red Hook and Owls Head WWTPs (2xDDWF) are 120 and 240 MGD, respectively.

- **Sewer Conditions**: The IW model was developed to represent the sewer system on a macro scale, generally including all conveyance elements with equivalent diameters of 48 inches or larger, along with all regulating structures and CSO outfall pipes. Post-Interceptor cleaning levels of sediments were also included for the interceptors in the collection system to better reflect actual conveyance capacities to the WWTPs.

- **Upstream Source Loadings:** The Gowanus Canal receives continuous flows from Buttermilk Channel via the Gowanus Canal Flushing Tunnel. During 2014, Flushing Tunnel flows for modeling were estimated based on start-up and other preliminary operational conditions and 2014 tidal conditions. For the baseline, Flushing Tunnel flows were modeled based on design operations and performance and baseline tidal conditions. In 2014, the intake of the Flushing Tunnel in Buttermilk Channel was sampled for bacteria and organic carbon. Year 2014 concentration measurements were used for developing 2014 loadings, as well as validating baseline loadings to the Gowanus Canal from the Flushing Tunnel.

To properly represent future baseline water quality conditions in the Gowanus Canal, it was first necessary to update the NYC Gowanus Canal water quality models. Water quality modeling was conducted using a higher resolution computational grid and hydrodynamic model than was used for the Gowanus Canal WWFP modeling. Further, the water quality models were upgraded to include the same modern eutrophication and DO kinetics now used in the models for other NYC LTCP waterways. In addition, the Gowanus Canal water quality models include sediment transport calculations for particulate organic carbon and suspended sediment within the eutrophication framework. LTCP water quality modeling work for the Gowanus Canal was in progress for more than one year, allowing for twelve month calibrations/validations of the hydrodynamic, pathogens, and dissolved oxygen models for contemporary conditions, including the Flushing Tunnel activation and various levels of Flushing Tunnel operation. The calibrations/validations were based on model and data comparisons using continuous measurements from moored instruments and discrete measurements conducted during wet- and dry-conditions, including the days immediately following wet-weather. Further, all of the Gowanus Canal water quality modeling was peer reviewed by an internationally renowned panel that met on seven occasions during the course of model selection, development, calibration/validation and application. The updates to the IW model and the water quality models are described in the Gowanus Canal LTCP Sewer System and Water Quality Modeling Report (DEP, 2015). The peer review panel is preparing a report summarizing their review findings, which is expected to be ready in July 2015. The future baseline conditions simulated with the updated models are discussed in the remainder of this document section.

6.1.a Hydrological Conditions

For this LTCP, the precipitation characteristics from JFK 2008 NOAA gauges were used for the baseline condition, as well as for alternatives evaluations, and were considered to be representative of a typical rainfall year. In addition to the 2008 precipitation pattern, the observed tide conditions that existed in 2008 were also applied in the models as the tidal boundary conditions at the CSO outfalls that discharge to the tidally influenced the Gowanus Canal and Gowanus Bay.

6.1.b Flow Conservation

Consistent with previous studies, the dry-weather sanitary sewage flows used in the baseline modeling were escalated to reflect anticipated population growth in NYC. In 2014, DEP completed detailed analyses of water demand and wastewater flow projections. A detailed GIS analysis was performed to apportion total population among the 14 WWTP drainage areas. For this analysis, Transportation Analysis Zones (TAZs) were overlaid with WWTP drainage areas. Population projections for 2010-2040 were derived from population projections developed by the DCP and New York Metropolitan Transportation Council (NYMTC). These analyses used the 2010 census data to reassign population values to the watersheds in the model and project sanitary flows to 2040. These projections also reflect water conservation measures that already have significantly reduced flows to the WWTPs and freed capacity in the conveyance system.

6.1.c BMP Findings and Optimization

A list of BMPs, along with a brief summary of each and its respective relationship to the EPA NMCs, were reported in Section 3.0, as they pertain to the Gowanus Canal CSOs. In general, the BMPs address operation and maintenance procedures, maximum use of existing systems and facilities and related planning efforts to maximize capture of CSO and reduce contaminants in the CSS, thereby improving water quality conditions.

The following provides an overview of the specific elements of various DEP, SPDES and BMP activities as they relate to development of the baseline conditions, specifically in setting up and using the IW models to simulate CSO discharges and in establishing non-CSO discharges that impact water quality in the Gowanus Canal:

- Sentinel Monitoring: In accordance with BMPs #1 and #5, DEP collects quarterly samples of bacteria water quality at three locations in the Gowanus Canal vicinity (near LTCP2 Stations GC-7, GC-9 and GC-11; Figure 2-18) in dry-weather to assess whether dry-weather sewage overflows occur, or whether illicit connections to storm sewers exist. While no evidence of large illicit sanitary sewer connections was observed based on these data, these measurements show non-zero bacteria concentrations during dry-weather, likely due to sources outside of the Gowanus Canal and, potentially, small distributed sources within the Gowanus Canal. It is not known whether the sources are human or non-human. Dry-weather measurements collected for the LTCP and by NYC HSM Program are in agreement with the sentinel monitoring results. Although a small number of dry-weather sources of bacterial internal to the Gowanus Canal were included in the water quality model calibration exercises to accurately simulate the observed ambient bacteria concentrations, these sources were excluded from the baseline conditions to reflect future corrected conditions within the Gowanus Canal. Background dry-weather sources outside the Gowanus Canal model boundaries were maintained in the baseline conditions.

- Interceptor Sediments: Sewer sediment levels determined through the post-cleaning inspections are included in the IW model.

- Combined Sewer Sediments: The IW models assume no sediment in upstream combined trunk sewers in accordance with BMP #2.

- WWTP Flow Maximization: In accordance with the 2014 CSO BMP Order on Consent, the Red Hook and Owls Head WWTPs treat wet-weather flows that are conveyed to the plants, up to 2xDDW. DEP follows the wet-weather operating plan and receives and regularly treats 2xDDWF. Cleaning of the interceptor sediments has increased the ability of the system to convey 2xDDWF to the WWTP.

- WWOPs: The Red Hook and Owls Head WWOP (BMP #4) establishes procedures for pumping at the plant headworks to assure treatment of 2xDDWF.

6.1.d Elements of Facility Plan and GI Plan

Cost-effective grey infrastructure for the Gowanus Canal watershed included in the 2012 CSO Order on Consent has been represented in the IW and water quality models. For the Red Hook sewershed, the grey infrastructure includes the Gowanus Canal Pump Station upgrade, the Gowanus Canal Flushing Tunnel improvements, the demonstration bending weir at RH-2 (Outfall RH-028), and HLSS. Flushing Tunnel improvements were in progress for the period of model calibration so that variable performance flows were used for model calibration analyses. Modeled baseline conditions include Flushing Tunnel design performance flows.

The cost-effective grey infrastructure for the Owls Head sewershed includes the completed Avenue V Pump Station upgrade and both in progress and near future HLSS projects. The HLSS projects planned for construction within the next 10 years were included in the model baseline. These projects are known as the SEK20065 and SEK20067 projects.

The GI plan for the Gowanus Canal is also included in baseline modeling. The citywide total application rate of 10 percent of combined sewer impervious drainage areas was applied to the baseline model on a citywide basis. The Red Hook-Gowanus Canal area individual baseline watershed GI application rate for baseline modeling was defined as 10 percent ROW and 2 percent GI through on-site detention. The Owls Head-Gowanus Canal area individual baseline watershed GI application rate for baseline modeling was defined as 10 percent ROW and 2 percent GI through on-site detention.

6.1.e Non-CSO Discharges

Non-CSO discharges to the Gowanus Canal for modeling are considered in terms of both the Red Hook and Owls Head WWTP drainage areas as shown on Figure 2-1. The Red Hook WWTP drainage area for the Gowanus Canal includes both stormwater and direct drainage. According to the latest SPDES permit (Red Hook WWTP SPDES permit issued November 1, 2010), there is a small separately sewered drainage area along the western shore of the Gowanus Canal contributing to stormwater Outfall RH-601. There is also a 13.7-acre direct drainage area on the western shore near the mouth of the Gowanus Canal which drains to the Gowanus Canal. The Owls Head WWTP drainage area for the Gowanus Canal includes three MS4-permitted stormwater outfalls: OH-607, OH-616 and OH-617. These MS4 outfalls are currently included in the WWTP's SPDES permit. These outfalls drain stormwater runoff from small, separate sewer areas around the Gowanus Canal. While runoff from these areas does not enter the CSS, the stormwater drains from the separate sewer areas to the Gowanus Canal and the stormwater is included in modeling. It is further noted that the direct drainage areas for the Gowanus Canal are inclusive of highway drains and other local pipes not associated with the NYC's MS4 system.

There is planned and ongoing HLSS work in the Gowanus Canal sewershed that is relevant to baseline modeling. Once completed, the HLSS projects will create a separate stormwater discharge to the Gowanus Canal through a stormwater outfall at Carroll Street. The planned work will be constructed in phases. Phase I is scheduled to be constructed throughout 2015, and Phase 2 is scheduled to be implemented in 2019. A portion of the new, separate drainage areas to be created will also reduce CSO discharges in the Red Hook collection system.

Discharge volumes from stormwater and direct drainage for the baseline conditions were estimated in concert with CSO discharge volumes using the IW model. It is noted that the IW model represents CSO structures in combined sewered areas with greater detail than it represents separately sewered, direct drainage and highway drainage areas. Accordingly, the volumes provided for separately sewered, direct drainage and highway drainage areas should be considered rough estimates. Stormwater, direct drainage and highway areas roughly included in the IW models are combined to represent the area between the boundary of the CSO drainage system and the waterfront. Like volumes, the loadings from these areas could not be estimated with the same level of accuracy as CSO loads. Calculated volume and loading contributions from individual fractions of the non-CSO areas will require future refinement.

6.2 Baseline Conditions – Projected CSO Volumes and Loadings after the Facility Plan and GI Plan

As discussed in Section 2, the Red Hook and Owls Head WWTP drainage areas to the Gowanus Canal include multiple CSO outfalls. The IW model was used to develop CSO discharge volumes for the baseline conditions. The IW model incorporates the implementation of the grey infrastructure and GI improvements described in Section 6.1.d. Using these overflow volumes, loadings from the CSOs were generated using measured enterococci, fecal coliform and BOD concentrations and provided input to the receiving water quality models, GC-PATH and GC-STEM. GC-PATH and GC-STEM were calibrated using 2013/2014 monitoring data collected during preparation of this LTCP, as well as HSM measurements for the same period. The calibration assessment consisted of comparing the time series and cumulative frequency distributions of 2013/2014 collected concentration data against the time series and cumulative frequency distribution output from the model for coincident dry- and wet-weather periods.

In addition to CSO loadings, loadings from other sources, such as storm sewer discharges, highway drains, and direct drainage may impact water quality in the Gowanus Canal, but to a lesser degree, based on the rough modeling estimates. These are summarized in Table 6-2. The concentrations assigned to various sources to the Gowanus Canal are summarized in Table 6-1. Concentrations in Table 6-1 represent typical stormwater, direct drainage and sanitary sewage for the Gowanus Canal drainage area and are based on data collected from the Gowanus Canal area.

For the modeling baseline simulations, concentrations presented in Table 6-1 were used to develop mass loadings based on the volumes presented in Table 6-2. For the CSOs, bacteria loading concentrations were developed based on a Monte Carlo analysis of LTCP measurements collected at four locations within the Gowanus Canal sewer system (Section 2.0). Time-varying concentrations associated with the Flushing Tunnel were determined using results of the regional Harbor models, as well as measurements collected for the LTCP and by HSM in Buttermilk Channel and the Lower East River. The concentrations in Table 6-1 used for baseline modeling were verified during the calibrations of the GC-PATH and GC-STEM models.

Table 6-1. Source Concentrations from Sources to Gowanus Canal

Source	Enterococci (cfu/100mL)	Fecal Coliform (cfu/100mL)	BOD_5 (mg/L)
Flushing Tunnel (1)	Regional Model	Regional Model	Variable(4)
CSOs (1)	Monte Carlo	Monte Carlo	78
Urban Stormwater (2,1)	50,000	120,000	15
Highway Runoff (3,1)	8,000	20,000	15
Direct Drainage (3,1)	6,000	4,000	15

Notes:

(1) Gowanus Canal LTCP Sewer System and Water Quality Modeling, 2015
(2) HydroQual Memo to DEP, 2005a.
(3) Basis – NYS Stormwater Manual, Charles River LTCP, National Stormwater Data Base.
(4) Harbor Survey measurements were used to define monthly varying BOD concentrations which constrain modeled Particulate Organic Carbon (POC) and Dissolved Organic Carbon (DOC) concentrations.

Typical baseline volumes of CSO, stormwater and direct drainage to the Gowanus Canal are summarized in Table 6-2 for the 2008 year, along with mass loadings. Table 6-2 also shows the loading delivered to the Gowanus Canal from Buttermilk Channel in the East River through the Flushing Tunnel under baseline modeling conditions. Table 6-3 includes outfall-specific information for baseline volumes of CSO.

Table 6-2. 2008 Baseline Loading Summary

Totals by Source by Waterbody		Volume	Enterococci	Fecal Coliform	BOD
Waterbody	**Source**	**Total Discharge (MG/yr)**	**Total Org (10^12/yr)**	**Total Org (10^12/yr)**	**Total (lbs/yr)**
Gowanus Canal and Bay	Flushing Tunnel	80,448	85	308	863,376
	CSO	659	7106	13,605	402,807
	Stormwater	26	49	118	3274
	Direct Drainage	220	50	33	27746
	Highway Runoff	16	5	12	2016
Total		**81,369**	**7,295**	**14,077**	**1,299,219**

Notes:

The above summary does not consider bacteria and nutrients entering the Gowanus Canal through tidal exchange between Gowanus Bay and Upper New York Bay.

Table 6-3. 2008 Baseline Loading CSO Volume and Overflows per Year

CSO Outfall	Waterbody	Volume	Annual Overflow Events
		Total Discharge (MG/yr)	Total (No./yr)
OH-003	Upper New York Bay	370.6	47
OH-004	Upper New York Bay	5.9	15
OH-005	Gowanus Canal	0.5	1
OH-006	Gowanus Canal	15.6	32
OH-007	Gowanus Canal	57.6	44
OH-023	Gowanus Bay	0.9	12
OH-024	Gowanus Canal	26.4	35
RH-030	Gowanus Bay	16.2	15
RH-031	Gowanus Canal	16.7	15
RH-033	Gowanus Canal	0.3	7
RH-034	Gowanus Canal	136.8	40
RH-035	Gowanus Canal	5.4	14
RH-036	Gowanus Canal	1.8	17
RH-037	Gowanus Canal	0.4	9
RH-038	Gowanus Canal	0.6	7

6.3 Performance Gap

Concentrations of bacteria and DO in the Gowanus Canal are controlled by a number of factors, including the volumes of all sources of bacteria and nutrients into the Gowanus Canal, and the concentrations of those bacteria and nutrients, by the Flushing Tunnel entering near the head of the Gowanus Canal, and by exchange with Gowanus Bay and Upper New York Bay. Because portions of the flow and loads discharged into this waterbody are the result of runoff from rainfall events, the frequency, duration and amounts of rainfall influence the Gowanus Canal's water quality. In addition, the Flushing Tunnel produces a reduced residence time in the Gowanus Canal, especially near the head of the Gowanus Canal, which improves water quality.

The GC-PATH and GC-STEM models were used to simulate bacteria and DO concentrations for the baseline conditions using 2008 rainfall and tidal data. Hourly model calculations were saved for post-processing and comparison with the Existing WQ Criteria, Primary Contact Criteria, and Potential Future Primary Contact WQ Criteria, discussed in Section 6.3.c. The performance gap was then developed as the difference between the model-calculated baseline waterbody DO and bacteria concentrations, and the applicable numerical WQS. The analysis is developed to address the following three sets of criteria:

- Existing WQ Criteria (Upstream of Hamilton Ave – Class SD, Downstream of Hamilton Ave – Class I);
- Primary Contact WQ Criteria; and

- Potential Future Primary Contact Recreational WQ Criteria (EPA RWQC, 2012).

Analyses are developed to reflect the differences in attainment both spatially and temporally. Because the gap analysis is meant to assess the impact of CSOs on water quality, the spatial assessment focuses on ten locations spaced somewhat evenly across the entire length of the Gowanus Canal and Gowanus Bay. The temporal assessment focuses on compliance with the applicable fecal coliform water quality criteria over the entire year and, in the case of enterococci, during the recreational season of May 1st through October 31st. A summary of the criteria that were applied is shown in Table 6-4. Analyses in this LTCP were performed using the 30-day rolling geometric mean (GM) of 30 cfu/100mL, and the STV of 110 cfu/100mL for enterococci.

Table 6-4. Classifications and Standards Applied

Analysis	Numerical Criteria Applied	
Existing WQ Criteria Fish Survival (Class SD) and Boating/Fishing (Class I)	Gowanus Canal Above Hamilton Ave (Class SD)	Fecal - None; DO never < 3.0 mg/L
	Gowanus Bay Below Hamilton Ave (Class I)	Fecal Monthly GM ≤ 2,000 DO never < 4.0 mg/L
Primary Contact WQ Criteria(1)	Saline Water	Fecal Monthly GM ≤ 200 Daily Average DO ≥ 4.8 mg/L(3) DO never < 3.0 mg/L
Potential Future Primary Contact WQ Criteria(2)	Entero: rolling 30-d GM – 30 cfu/100mL Entero: STV – 110 cfu/100mL	

Notes:
GM = Geometric Mean; STV = 90 Percent Statistical Threshold Value
(1) This water quality standard is not currently assigned to the Gowanus Canal or Gowanus Bay.
(2) The Potential Future Primary Contact WQ Criteria have not yet been adopted by DEC.
(3) The daily average DO concentration may fall below 4.8 mg/L for a limited number of days. See Section 2 for the equation and calculation description.

6.3.a CSO Volumes and Loadings Needed to Attain Current Water Quality Standards

Assessing the performance gap required calculating the Gowanus Canal fecal coliform concentrations under baseline conditions, comparing them to the current (existing) water quality criteria, determining if they exceed the criteria, and then establishing whether the gap could be closed through reductions to CSO overflows. The assessment was extended to determine whether water quality met the standards for Class I Boating/Fishing WQ Criteria throughout the Gowanus Canal. Upstream of Hamilton Avenue, the Gowanus Canal is not assigned Class I. The portion of the Gowanus Canal that is downstream of

Hamilton Avenue is assigned that Class. A one-year simulation of bacteria water quality was performed for the 2008 baseline loading conditions. The results of the 2008 baseline simulation are summarized in Table 6-5. The results shown in this table summarize the highest calculated monthly GM on an annual basis and during the recreation period. The results are presented for each sampling location in the Gowanus Canal.

Table 6-5. Calculated 2008 Baseline Fecal Coliform Maximum Monthly GM and Attainment of Existing Criteria and the Class (I) Boating/Fishing WQ Criteria

Station	Class	Maximum Monthly Geometric Means (cfu/100mL)		% Attainment with Existing Criteria		% Attainment with Class I Criteria	
		Annual	Recreation Period	Annual GM ≤2,000 #/100mL	Recreation Period GM ≤2,000 #/100mL	Annual GM ≤2,000 #/100mL	Recreation Period GM ≤2,000 #/100mL
GC-1	SD	213	45	NA	NA	100	100
GC-2	SD	201	43	NA	NA	100	100
GC-3	SD	199	42	NA	NA	100	100
GC-4	SD	197	40	NA	NA	100	100
GC-5	SD	199	39	NA	NA	100	100
GC-6	SD	216	37	NA	NA	100	100
GC-7	SD	215	36	NA	NA	100	100
GC-8	I	181	23	100	100	100	100
GC-9	I	164	24	100	100	100	100
GC-10	I	170	31	100	100	100	100

This table presents the maximum monthly geometric means (units of cfu/100mL) for the 2008 baseline simulation at each location. The table also presents the annual attainment (percent) of the fecal coliform GM criterion of 2,000 cfu/100mL. Table 6-5 shows that the Existing Criteria and the Class I Criteria (monthly GM of 2,000 cfu/100mL) for boating/fishing are met at all sampling locations in the Gowanus Canal and Bay and, as such, there is no gap between the baseline conditions and the calculated bacteria concentrations for the Class I Criteria.

Water quality model simulation DO attainment results are presented in Table 6-6 for year 2008 conditions. Water quality model calculations indicate DO standard attainment equal to or greater than the DEC desired attainment of 95 percent for 2008 baseline conditions.

Table 6-6. Model Calculated DO Attainment – Existing WQ Criteria (2008)

Station	Class	DO Criteria (≥ mg/L)	% Annual Attainment 2008
GC-1	SD	3	100
GC-2	SD	3	100
GC-3	SD	3	100
GC-4	SD	3	100

Table 6-6. Model Calculated DO Attainment – Existing WQ Criteria (2008)

Station	Class	DO Criteria (≥ mg/L)	% Annual Attainment 2008
GC-5	SD	3	100
GC-6	SD	3	98
GC-7	SD	3	99
GC-8	I	4	95
GC-9	I	4	100
GC-10	I	4	100

6.3.b CSO Volumes and Loadings that Would Be Needed to Support Primary Contact Uses

DEC has introduced a proposed rule to require Class SD and I waterways to meet the Primary Contact WQ Criteria for bacteria. The Primary Contact WQ Criteria for fecal coliform is a monthly GM less than or equal to 200 cfu/100mL. Table 6-7 presents the maximum monthly geometric means for fecal coliform during annual and recreation periods at each sampling station location. The table also contains the percent attainment of the Primary Contact WQ Criteria for the same periods.

Table 6-7. Calculated 2008 Baseline Fecal Coliform Maximum Monthly GM and Attainment of Primary Contact WQ Criteria

Station	Maximum Monthly Geometric Means (cfu/100mL)			% Attainment		
	Annual	11 Months	Recreation Period	Annual GM ≤200 #/100mL	11 Month GM ≤200 #/100mL	Recreation Period GM ≤200 #/100mL
GC-1	213	171	45	92	100	100
GC-2	201	163	43	92	100	100
GC-3	199	162	42	100	100	100
GC-4	197	159	40	100	100	100
GC-5	199	162	39	100	100	100
GC-6	216	184	37	92	100	100
GC-7	215	182	36	92	100	100
GC-8	181	159	23	100	100	100
GC-9	164	139	24	100	100	100
GC-10	170	133	31	100	100	100

Table 6-7 shows that full annual attainment of the Primary Contact WQ Criteria was not calculated for baseline conditions; however, modeling results presented in Table 6-7 show full attainment of Primary Contact WQ Criteria has been calculated for 2008 baseline conditions for eleven months of the year, including the recreation season. The cause of the calculated annual non-attainment is the model calculated maximum monthly geometric means as shown in Table 6-7 right at or slightly above the standard for several stations for one month, the month of February. The calculated maximum monthly geometric means for the eleven remaining months also shown in Table 6-7 attain the standard. To address the calculated annual non-attainment, a gap analysis was performed to determine the effect of 100% CSO controls during all months of the 2008 baseline conditions. Gap analysis results shown in Table 6-8 demonstrate that 100% CSO controls would fully attain the Primary Contact WQ Criteria, achieving geometric means well below the Primary Contact WQ Criteria for all months.

Table 6-8. Calculated 2008 100% CSO Controls Fecal Coliform Maximum Monthly GM and Attainment of Primary Contact WQ Criteria

Station	Maximum Monthly Geometric Means (cfu/100mL)	% Attainment
	Annual	Annual GM ≤200 #/100mL
GC-1	107	100
GC-2	108	100
GC-3	108	100
GC-4	105	100
GC-5	105	100
GC-6	105	100
GC-7	105	100
GC-8	80	100
GC-9	84	100
GC-10	102	100

The calculated attainment results for the Primary Contact WQ DO Criteria are presented in Table 6-9 for the 2008 baseline conditions. Greater than 98 percent attainment is calculated for the acute portion of the Primary Contact WQ DO Criteria. For the chronic portion of the Primary Contact WQ DO Criteria, the calculated attainment is greater than 95 percent for eight out of ten stations, with two stations having calculated attainment of 94 percent and 87 percent, respectively. A gap analysis was performed to determine the effect of 100% CSO controls on attainment of the chronic portion of the Primary Contact WQ DO Criteria. Gap analysis results are presented in Table 6-9. Calculations indicate that 100% CSO controls would result in greater than 99 percent attainment for the acute portion of the Primary Contact WQ DO Criteria as compared to 98 percent attainment for baseline conditions. This gap analysis shows a small improvement in DO concentrations with 100% removal of the Gowanus Canal CSOs. Calculations indicate that 100% CSO controls would result in greater than 95 percent attainment for the chronic portion of the Primary Contact WQ DO Criteria at nine stations as compared to eight stations for baseline conditions. Calculations indicate that attainment for the chronic portion of the Primary Contact WQ DO Criteria at the worst station with 100% CSO controls would be 89 percent as compared to 87 percent for baseline conditions. This would still be lower than the DEC desired goal of 95 percent attainment, even though all the CSOs are removed. The station, GC-8, located at the interface of the Gowanus Canal and the Bay is subject to changing geometry and complex circulation patterns which may explain the relatively lower attainment results.

Table 6-9. Model Calculated DO Attainment for Primary Contact WQ Criteria (2008)

Station	Annual Attainment Percent Attainment			
	Baseline		100% Gowanus CSO Control	
	Chronic(1)	Acute(2)	Chronic(1)	Acute(2)
GC-1	100	100	100	100
GC-2	100	100	100	100
GC-3	100	100	100	100
GC-4	100	100	100	100
GC-5	100	100	100	100
GC-6	94	98	95	99
GC-7	95	99	96	100
GC-8	87	100	89	100
GC-9	99	100	100	100
GC-10	100	100	100	100

Notes:
(1) 24-hr average DO ≥ 4.8 mg/L with allowable excursions to ≥ 3.0 mg/L for certain periods of time.
(2) Acute Criteria: DO ≥ 3.0 mg/L.

6.3.c Potential Future Primary Contact WQ Criteria

As noted in Section 2.0, EPA released its RWQC recommendations in December 2012. These included recommendations for RWQC for protecting human health in all coastal and non-coastal waters designated for primary contact recreational use. The standards would include a rolling 30-day GM of either 30 cfu/100mL or 35 cfu/100mL and a 90^{th} percentile STV during the rolling 30-day period of either 110 cfu/100mL or 130 cfu/100mL. An analysis using the 2008 baseline and 100% CSO control condition model simulation results was conducted using both the 30 cfu/100mL GM and 110 cfu/100mL 90^{th} percentile STV criteria, to assess attainment with these potential future RWQC.

6.3.d Load Reductions Needed to Attain the Potential Future Primary Contact Water Quality Criteria

Additional water quality modeling analyses were performed to assess the extent to which CSO and non-CSO sources impact enterococci concentrations at key locations in the Gowanus Canal and Bay. That analysis consisted of first assessing the baseline conditions for enterococci. The results of the analyses for baseline conditions are presented in Table 6-10 for the maximum 30-day GM and attainment of the rolling 30-day GM criterion and maximum 30-day 90^{th} percentile concentrations and attainment of the STV. All results are for the attainment of the potential future recreational water quality criterion during the May 1^{st} through October 31^{st} recreational period defined by the DEC.

Table 6-10. Calculated 2008 Baseline Enterococci Maximum Monthly GM and Attainment of Potential Future Recreational WQ Criteria

Station	Maximum Recreational Period 30-day Enterococci (cfu/100mL)		% Attainment	
	GM	90th Percentile STV	Recreation Period GM ≤ 30 #/100mL	Recreation Period STV ≤ 110 #/100mL
GC-1	24	690	100	59
GC-2	23	460	100	65
GC-3	22	496	100	65
GC-4	22	454	100	65
GC-5	23	635	100	61
GC-6	30	1,358	100	22
GC-7	29	1,562	100	30
GC-8	25	653	100	27
GC-9	20	250	100	63
GC-10	17	150	100	90

Calculated attainment of the 30-day rolling GM enterococci concentration of 30 cfu/100mL standard is 100 percent at all stations for baseline conditions. It is noted that, for several stations, the calculations are at compliance. Calculated attainment of the 90th percentile STV at 10 stations, for 2008 baseline conditions, ranges from 90 percent attainment at the Bay boundary (GC-10), to 22 percent at the lowest attainment station (GC-6). Water quality modeling analyses were conducted to assess attainment of the 30-day rolling GM and 90th percentile STV with 100% removal of the CSO enterococci loadings.

Water quality modeling analyses conducted to assess attainment of the enterococci criteria with complete removal of the CSO enterococci loadings, as provided in Table 6-11, show that 100% CSO controls would result in full attainment of the 30-day rolling GM enterococci criterion and greater than 91 percent attainment of the 90th percentile STV enterococci criterion. This high level of improved STV attainment with 100% CSO controls calculated for the Gowanus Canal, as compared to other waterways. Other waterways being addressed by NYC LTCP's do not show this high degree of improvement in calculated STV attainment with 100% CSO controls. Since STV attainment is driven by 90th percentile concentrations in the Gowanus Canal, the calculated improvements in STV attainment suggest that in the Gowanus Canal, the 90th percentile enterococci concentrations are produced by CSOs and therefore can be altered with CSO controls. The reasons specific to the Gowanus Canal why CSO's produce the 90th percentile in the Gowanus Canal enterococci concentrations can be explained by the small magnitude of stormwater entering the Gowanus Canal and the large volume of water with low enterococci concentrations introduced to the Gowanus Canal by the Flushing Tunnel.

Table 6-11. Calculated 2008 100% CSO Control Enterococci Maximum Monthly GM and Attainment of Potential Future Recreational WQ Criteria

Station	Maximum Recreational Period 30-day Enterococci (cfu/100mL)		% Attainment	
	GM	90th Percentile STV	Recreation Period GM ≤ 30 #/100mL	Recreation Period STV ≤ 110 #/100mL
GC-1	17	127	100	91
GC-2	17	132	100	91
GC-3	17	130	100	91
GC-4	17	123	100	93
GC-5	16	116	100	95
GC-6	16	100	100	100
GC-7	16	99	100	100
GC-8	11	46	100	100
GC-9	12	59	100	100
GC-10	15	104	100	100

6.3.g Component Analysis

A loading source component analysis was conducted for the 2008 baseline condition using JFK Airport rainfall data to better understand how each source type contributes to bacteria concentrations in the Gowanus Canal. The source types include: the Buttermilk Channel, entering via the Flushing Tunnel; stormwater and direct drainage; CSOs; and Gowanus Bay. The analysis was completed using the GC-PATH model, and included the calculation of fecal coliform and enterococci bacteria GMs, both in total and from each component. For fecal coliform, a maximum winter month (February) was analyzed because the decay rate is lower in winter, resulting in generally higher fecal coliform concentrations. Enterococci concentrations were evaluated on a recreational season (May 1st through October 31st) basis.

Table 6-12 summarizes the fecal coliform component analysis for the maximum winter month. While the Gowanus Canal is a Class SD waterbody (which has no fecal coliform criterion), modeling calculations indicate that the waters of the Gowanus Canal fully meet the Class I Existing WQ fecal coliform Criteria, and are slightly above and below the Primary Contact WQ fecal coliform Criteria during the month with the highest fecal coliform monthly GM. From Stations GC-1 through GC-7, the Buttermilk Channel dominates the monthly fecal coliform GM. This switches to Gowanus Bay having the largest contribution to the monthly GM at Stations GC-8 through GC-10. The highest contribution to the monthly GM made by CSOs is 54 cfu/100mL at Stations GC-6 and GC-7. The highest monthly fecal coliform GM is also calculated at GC-6 at 216 cfu/100mL, which is just above the Primary Contact WQ Criteria of 200 cfu/100mL.

Table 6-12 also summarizes the enterococci component analysis. The rolling 30-day enterococci GM 30 cfu/100mL is not exceeded during baseline conditions. The maximum rolling 30-day enterococci GM calculated by the model is 30 cfu/100mL at Station GC-6. The maximum calculated GM contribution at any location from CSOs is 14 cfu/100mL. This is because CSOs discharge infrequently relative to other bacteria sources.

Table 6-12. Fecal and Enterococci GM Source Components

Source	Station	Fecal Coliform Contribution (cfu/100mL)	Enterococcus Contribution (cfu/100mL)
		Annual Worst Month February Monthly GM	Max 30-Day Rolling GM during the Recreational Period
Buttermilk Channel	GC-1	171	17
Stormwater and Direct Drainage	GC-1	0	0
CSO	GC-1	42	7
Gowanus Bay	GC-1	1	0
Total	GC-1	213	24
Buttermilk Channel	GC-2	171	17
Stormwater and Direct Drainage	GC-2	0	0
CSO	GC-2	28	7
Gowanus Bay	GC-2	1	0
Total	GC-2	201	23
Buttermilk Channel	GC-3	171	17
Stormwater and Direct Drainage	GC-3	0	0
CSO	GC-3	28	5
Gowanus Bay	GC-3	1	0
Total	GC-3	199	22
Buttermilk Channel	GC-4	168	17
Stormwater and Direct Drainage	GC-4	0	0
CSO	GC-4	28	5
Gowanus Bay	GC-4	1	0
Total	GC-4	197	22
Buttermilk Channel	GC-5	165	16
Stormwater and Direct Drainage	GC-5	0	0
CSO	GC-5	32	7
Gowanus Bay	GC-5	1	0
Total	GC-5	199	23
Buttermilk Channel	GC-6	139	12
Stormwater and Direct Drainage	GC-6	9	3
CSO	GC-6	54	14
Gowanus Bay	GC-6	13	0
Total	GC-6	216	30
Buttermilk Channel	GC-7	134	12
Stormwater and Direct Drainage	GC-7	9	3
CSO	GC-7	54	14
Gowanus Bay	GC-7	17	1
Total	GC-7	215	29

Table 6-12. Fecal and Enterococci GM Source Components

Source	Station	Fecal Coliform Contribution (cfu/100mL)	Enterococcus Contribution (cfu/100mL)
		Annual Worst Month February Monthly GM	Max 30-Day Rolling GM during the Recreational Period
Buttermilk Channel	GC-8	46	4
Stormwater and Direct Drainage	GC-8	5	2
CSO	GC-8	46	14
Gowanus Bay	GC-8	84	6
Total	GC-8	**181**	**25**
Buttermilk Channel	GC-9	15	1
Stormwater and Direct Drainage	GC-9	3	1
CSO	GC-9	20	8
Gowanus Bay	GC-9	126	11
Total	GC-9	**164**	**20**
Buttermilk Channel	GC-10	1	0
Stormwater and Direct Drainage	GC-10	0	0
CSO	GC-10	8	2
Gowanus Bay	GC-10	160	15
Total	GC-10	**170**	**17**

Table 6-12 indicates that CSO discharges influence the 30-day GM bacteria concentrations throughout the Gowanus Canal, but not at a level that exceeds even the Primary Contact WQ Criteria during baseline conditions.

6.3.e Time to Recovery

The analyses provided above examines the long-term impacts of wet-weather sources, as is required by existing and future primary contact bacteria criteria (monthly GM and 30-day GM). Shorter-term impacts are not evaluated using these regulatory criteria. Therefore, to gain insight to the shorter-term impacts of wet-weather sources of bacteria, DEP has reviewed the New York State Department of Health (DOH) guidelines relative to single sample maximum bacteria concentrations that DOH believes "constitute a potential hazard to health if used for bathing". The presumption is that if the bacteria concentrations are lower than these levels, then the waterways do not pose potential hazards if primary contact is practiced.

DOH considers fecal coliform concentrations that exceed 1,000 cfu/100mL to be potential hazards to bathing. Water quality modeling analyses were conducted to assess the amount of time following the end of rainfall required for the Gowanus Canal to recover and return to concentrations of less than 1,000 cfu/100mL.

The LGA rainfall data were first analyzed for the period of 2002-2011. The SYNOP model was used to identify each individual storm and calculate the storm volume, duration and start and end times. Rainfall periods separated by four hours or more were considered separate storms. Statistical analysis of the individual rainfall events for the recreational seasons (May 1st through October 31st) of the 10-year period resulted in a 90th percentile rainfall event of 1.09 inches. Based on this information, a storm approximating the 90th percentile storm was chosen from the 2008 recreational season (May 1st through October 31st) as a design storm.

This design storm was the August 15, 2008 JFK rainfall event, which resulted in 1.02 inches of precipitation. A principal feature of this storm, aside from its volume, was that there was sufficient time before the next rainfall event started to allow fecal coliform concentrations in the Gowanus Canal associated with the August 15, 2008 JFK rainfall event adequate time to reach and remain at or below the fecal coliform target concentration. It would not be possible to calculate time of recovery for a given storm if a second storm started before the impact of the first storm attenuated.

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>
> 6-2.15 Water quality monitoring
> (a) No bathing beach shall be maintained … to constitute a potential hazard to health if used for bathing. To determine if the water quality constitutes a potential hazard … shall consider one or a combination of any of the following items: results of a sanitary survey; historical water quality model for rainfall and other factors; verified spill or discharge of contaminants affecting the bathing area; and water quality indicator levels specified in this section.
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> (1) Based on a single sample, the upper value for the density of bacteria shall be: (i) 1,000 fecal coliform bacteria per 100 ml; or …(iii) 104 enterococci per 100 ml for marine water; ….

Table 6-13 presents the time to recovery for the baseline condition and the Gowanus Canal 100% CSO control scenario. Under the baseline conditions, Stations GC-6 and GC-7 have the longest time to recovery of 14 hours. The longest time to recovery occurs in the middle of the Gowanus Canal because the upper end of the Gowanus Canal is flushed out by the Flushing Tunnel and the lower end of the Gowanus Canal is flushed out due to tidal exchange more rapidly than in the middle of the Gowanus Canal. DEC has indicated that it is desirable to have a time to recovery of less than 24 hours. Times to recovery in the Gowanus Canal are below 14 hours.

When the Gowanus Canal CSO loading is removed, the time to recovery for all stations is below 10 hours. Time to recovery is 0 hours at GC-6, GC-8 and GC-9 because, during the design storm at those locations, the fecal coliform concentrations do not exceed 1,000 cfu/100mL after precipitation ends. It is noted that while the time to recovery is reported as 10 hours at GC-7 with 100% CSO control, calculated fecal coliform concentrations are at or above 1,000 cfu/100mL only for hours 9 and 10 after the storm. Decreases in the time to recovery within the Gowanus Canal due to the removal of CSO loadings are from 0 to 14 hours, depending on location. The time to recovery is significantly less than the DEC's 24-hour target, irrespective of CSO discharges.

Table 6-13. Time to Recovery

Station	Time to Recovery (hours)	
	Fecal Threshold (1,000 cfu/100mL)	
	Baseline	100% CSO Control
GC-1	9	9
GC-2	8	8
GC-3	9	9
GC-4	9	9
GC-5	10	10
GC-6	14	0
GC-7	14	10
GC-8	10	0
GC-9	7	0
GC-10	9	9