Environmental Protection

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

Combined Sewer Overflow Long Term Control Plan for Flushing Bay

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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, the WQ modeling simulations and the alternatives analysis.
- Evaluations and Conclusions — A list of assessments that are consistent with the Federal Combined Sewer Overflow (CSO) Control Policy and the Clean Water Act (CWA).

1. BACKGROUND

The New York City Department of Environmental Protection (DEP) prepared this Long Term Control Plan (LTCP) for Flushing Bay pursuant to an Order on Consent for CSOs, Case No. CO2-20000107-8 (2005 CSO Order), modified by a 2012 CSO Order on Consent (Case No CO2-20110512-25) (2012 CSO Order) and subsequent modifications (collectively referred to herein as the "CSO Order") overseen by the New York State Department of Environmental Conservation (DEC). Pursuant to the CSO Order, DEP is required to submit 11 waterbody-specific LTCPs to DEC for review and approval. The Flushing Bay LTCP is the eighth of these LTCPs.

As described in the LTCP Goal Statement in the 2012 CSO Order, 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 advises: *"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 post-construction compliance monitoring (PCM).

Regulatory Requirements

The waters of NYC are subject to Federal and New York State (NYS) laws and regulations. Particularly relevant to this LTCP is the U.S. 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 Flushing Bay as a Class I waterbody. The best usages of Class I waters are secondary contact recreation and fishing. These waters "shall be suitable for fish, shellfish, and wildlife propagation and survival. In addition, the water quality shall be suitable for primary contact recreation, although other factors may limit the use for this purpose" (6 NYCRR 701.13). Figure ES-1 shows the Flushing Bay watershed.

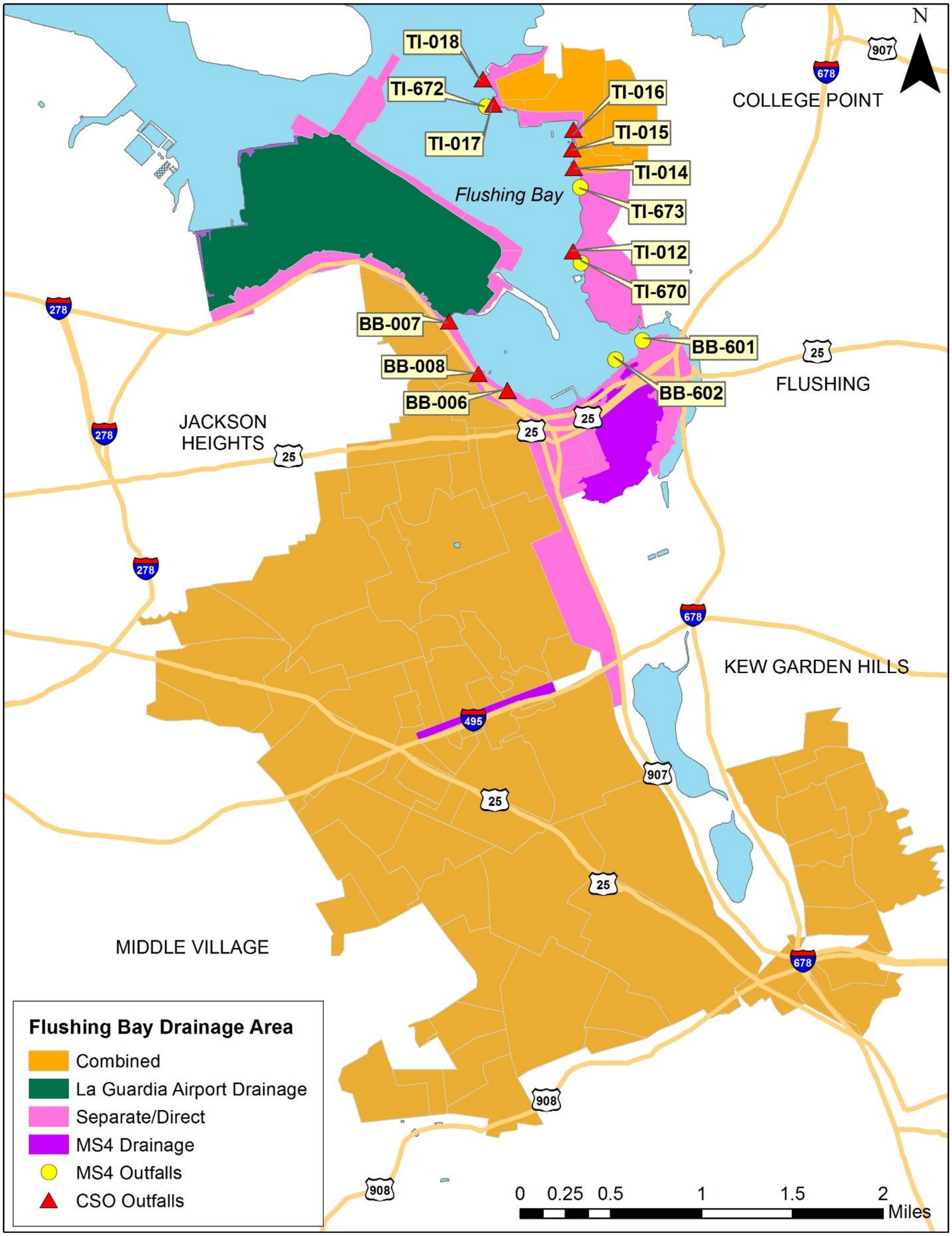

Figure ES-1. Flushing Bay Watershed Characteristics and Associated WWTP Sewershed

The criteria assessed in this Flushing Bay LTCP include the Existing WQ Criteria (Class I) and Dissolved Oxygen (DO) Class SC criteria. Enterococci criteria do not apply to tributaries such as Flushing Bay under the Beaches Environmental Assessment and Coastal Health (BEACH) Act of 2000. However, because the 2012 EPA Recreational Water Quality Criteria (RWQC) recommended certain changes to the bacterial water quality criteria for primary contact, this LTCP includes attainment analyses for both current WQ Criteria and for the proposed 2012 EPA RWQC (referred to hereinafter as the "Potential Future Primary Contact WQ Criteria"). These criteria include a 30-day rolling geometric mean (GM) for enterococci of 30 cfu/100mL with a not-to-exceed 90th percentile statistical threshold value (STV) of 110 cfu/100mL.

Table ES-1 summarizes the Existing WQ Criteria, Bacteria Primary Contact WQ Criteria/DO Class SC 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	Class I	Fecal Monthly GM ≤ 200; DO never <4.0 mg/L
Bacteria Primary Contact WQ Criteria / DO Class SC(1)	Class SC	Fecal Monthly GM ≤ 200 DO between > 3.0 & ≤4.8 mg/L(1, 3); DO never < 3.0 mg/L(1)
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 Flushing Bay.
(2) DEC has not yet adopted the Potential Future Primary Contact WQ Criteria.
(3) This is an excursion based limit that allows for the average daily DO concentrations to fall between 3.0 and 4.8 mg/L for a limited number of days as described in more detail on Table 2-7 in Section 2.

Flushing Bay Watershed

Flushing Bay watershed characteristics, including the Bay's CSO and stormwater outfalls, are shown in Figure ES-1. Flushing Bay is a saline waterbody located to the east of LaGuardia Airport and north of Willets Point in the Borough of Queens. Flushing Bay is tributary to the East River. Water quality in Flushing Bay is influenced by multiple sources including stormwater discharges, dry-weather sources and CSOs. The Flushing Bay watershed comprises approximately 6,877 acres and the majority of the land immediately surrounding the shoreline is utilized for recreational, transportation and commercial purposes. The urbanization of NYC and the Flushing Bay watershed has led to the creation of a large combined sewer system and smaller pockets served by separate sanitary and storm sewer systems, including its companion stormwater outfalls that discharge directly to the Bay. The Flushing Bay watershed is served by both the Bowery Bay Wastewater Treatment Plant (WWTP) and Tallman Island

WWTP. Dry-weather flow is conveyed to the WWTPs for treatment. During wet-weather, the combined sewage flow that exceeds the capacity of the WWTP may discharge through any one or more of the nine State Pollution Discharge Elimination System (SPDES)-permitted CSO Outfalls to Flushing Bay. Table ES-2 summarizes the model projected annual volume and frequency of overflow for each SPDES-permitted CSO Outfall under the CSO LTCP selected baseline conditions as described on page ES-13. A total of five DEP owned Municipal Separate Storm Sewer System (MS4) outfalls also discharge to Flushing Bay. Figure ES-2 illustrates the location of the MS4 outfalls as well as Department of Transportation (DOT) outfalls and other stormwater discharge points to Flushing Bay.

Table ES-2. CSO Discharges Tributary to Flushing Bay (2008 Typical Year)

Combined Sewer Outfalls	Location	Discharge Volume (MGY)	No. of Discharges	Percentage of Total CSO Discharge to Flushing Bay
BB-006 UL(2)	Inner Flushing Bay	631	45	43.4%
BB-006 LL(2)	Inner Flushing Bay	258	29	17.8%
BB-007	Inner Flushing Bay	38	40	2.6%
BB-008	Inner Flushing Bay	478	47	32.9%
TI-012	Outer Flushing Bay	0	0	0.0%
TI-014(1)	Outer Flushing Bay	10	37	0.7%
TI-015(1)	Outer Flushing Bay	3	20	0.2%
TI-016(1)	Outer Flushing Bay	29	45	2.0%
TI-017(1)	Outer Flushing Bay	2	21	0.1%
TI-018(1)	Outer Flushing Bay	4	34	0.3%
Total CSO	Flushing Bay	1,453		

Notes:

(1) To be separated as part of the College Point Sewer Separation Project as referenced in the WWFP.

(2) Outfall BB-006 is a single permitted outfall and statistics have been provided for each level of the two tiered outfall.

LL=lower level; UL=upper level; MGY=million gallons year

Green Infrastructure

Flushing Bay is a priority watershed for DEP's Green Infrastructure (GI) Program. The overall goal of the program is to saturate priority watersheds with GI to maximize benefits and cost effectiveness, based on the specific opportunities in each watershed. DEP has installed or plans to install over 1,000 GI assets, including right-of-way (ROW) practices, public property retrofits, and GI implementation on private properties, to manage approximately (2.8 percent impervious acres) in the Flushing Bay watershed. From these installations, modeling predicts a 52 MG reduction in annual CSO volume, based on the 2008 baseline rainfall condition.

As LTCPs are developed, model-based baseline GI penetration rates for each watershed may be adjusted based on the adaptive management approach described in Section 5.2, and as additional information on field conditions, feasibility, and costs becomes available. Figure ES-3 shows the current contracts in progress near CSO Outfalls BB-006 and BB-008 in Flushing Bay. DEP will continue to pursue additional GI opportunities beyond the baseline assumptions and will make necessary adjustments as needed.

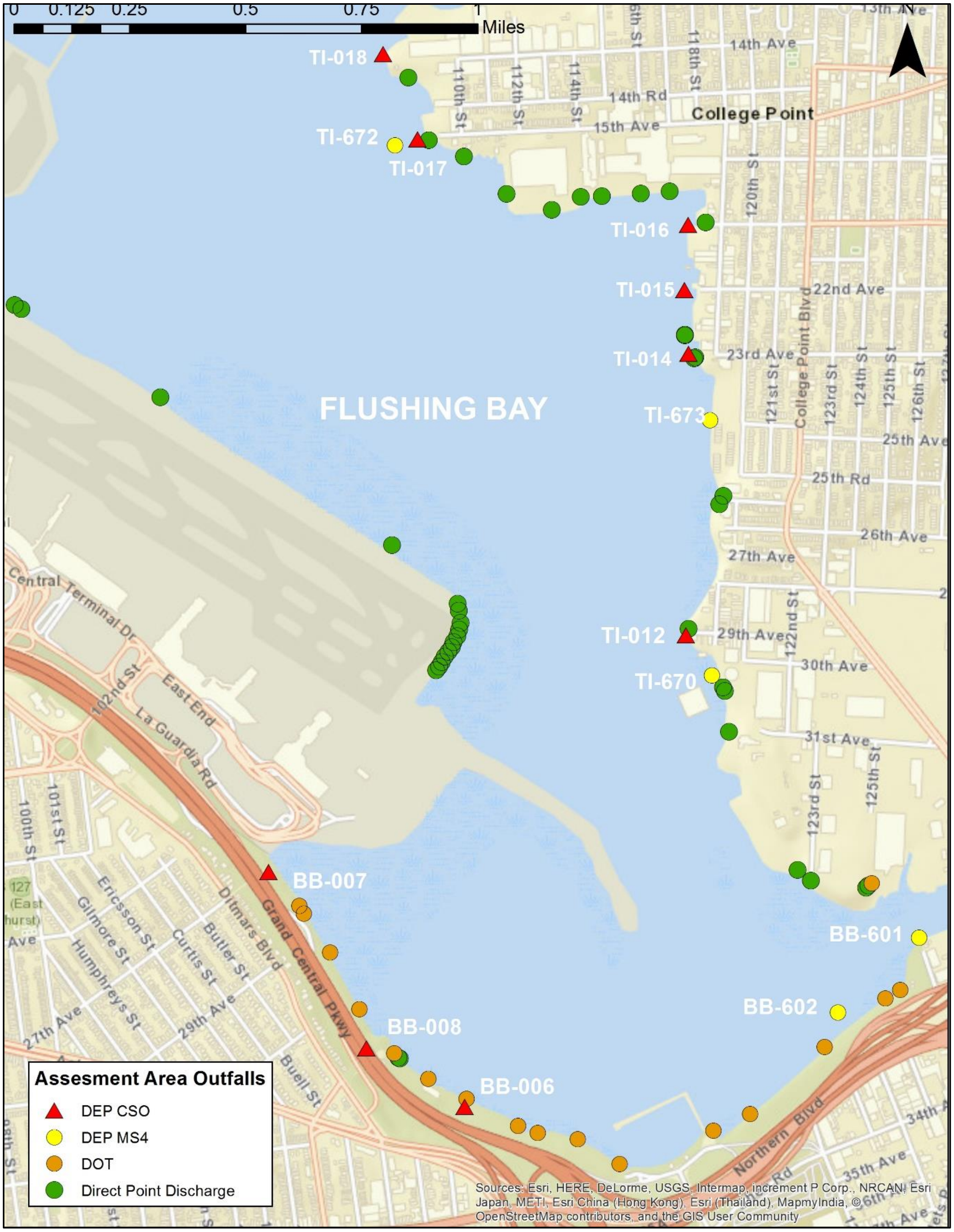

Figure ES-2. Flushing Bay Outfalls

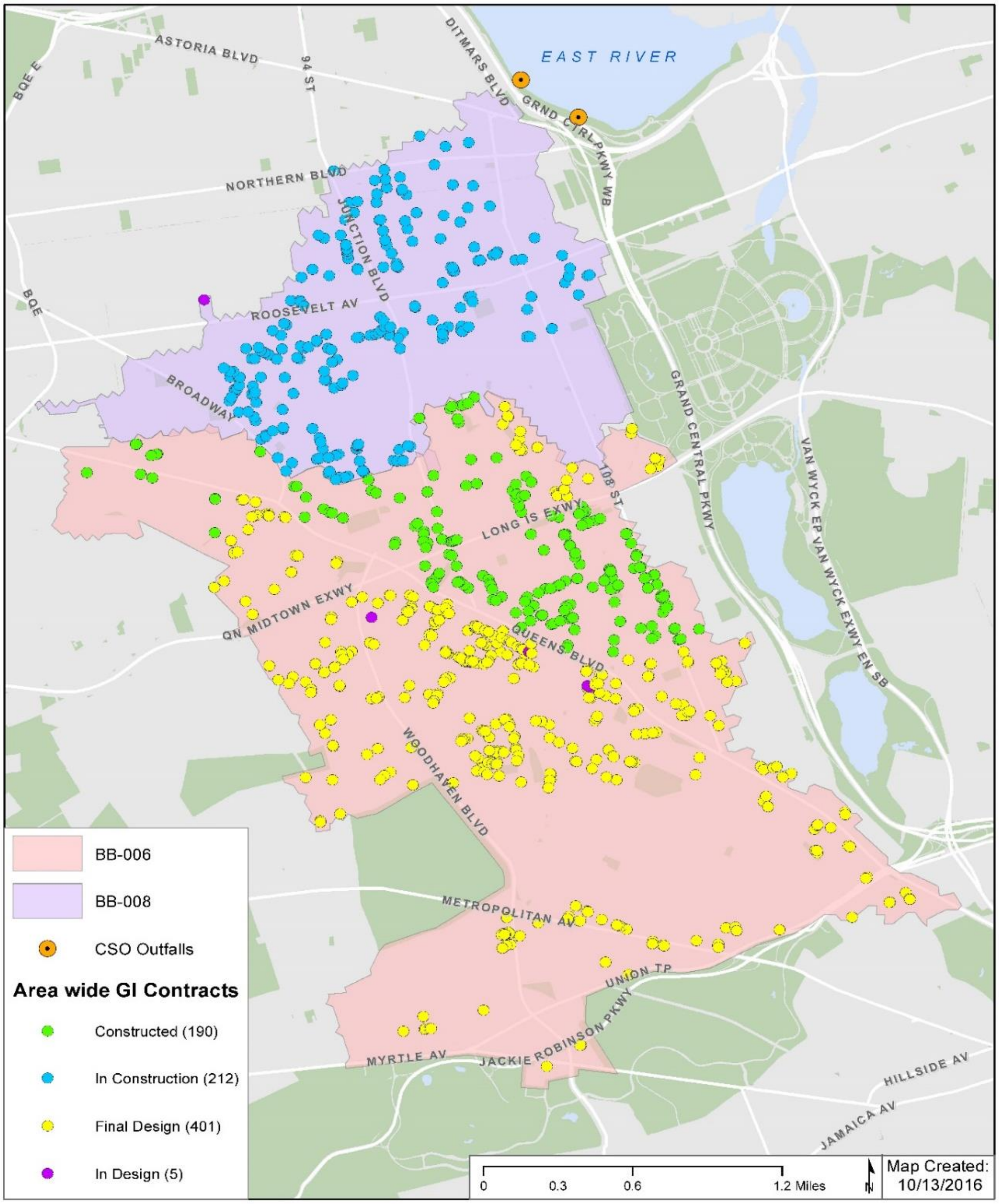

Figure ES-3. Green Infrastructure Projects in Flushing Bay

2. FINDINGS

Current Water Quality Conditions

Data collected within Flushing Bay are available from sampling conducted by DEP's Harbor Survey Monitoring Program (HSM) program between 2007 and 2015, and from sampling conducted from November 2013 through May 2014 during the implementation of the LTCP sampling program. The sampling locations of both programs are depicted in Figure ES-4. Figures ES-5 and ES-6 show the GM along with data ranges (minimum to maximum and 25th percentile to 75th percentile) for fecal coliform and enterococci, respectively, for the LTCP sampling program. Figures ES-7 and ES-8 show similar data for the HSM sampling program over the concurrent sampling period. For reference purposes, Figures ES-5 and ES-7 also show the monthly GM water quality numerical criterion for fecal coliform (200 cfu/100 ml).

Overall, the fecal coliform levels measured throughout the LTCP sampling program result in GMs indicative of the impacts of wet-weather pollution sources in Inner Flushing Bay. As shown in Figure ES-5, the wet-weather GM at the Inner Flushing Bay Stations OW-7 to OW-9 are all above 200 cfu/100mL, while the dry-weather GM are all below 200 cfu/100mL. For the Outer Flushing Bay Stations OW-10 to OW-15, wet-weather impacts are also apparent, as the wet-weather GMs are all above the dry-weather GM. However, the wet-weather GM are all below 200 cfu/100mL, except at Station OW-10, where the GM is 201. The LTCP enterococci data generally follow a similar trend as the fecal coliform data, with wet-weather GM higher than dry-weather GM, and the Inner Flushing Bay GM generally higher than the Outer Flushing Bay GM (Figure ES-6).

The HSM fecal coliform data presented in Figure ES-7 are also consistent with the LTCP sampling program data. The wet-weather geometric means at Inner Flushing Bay Station E15 are above 200 cfu/100mL for 2013 through 2015, while the dry-weather GM are below 200 cfu/100mL. The Outer Flushing Bay Station E6 showed wet-weather geometric means above the dry-weather GM, but the wet-weather GM were all below 200 cfu/100mL. The data at Station FB1, located between Stations E15 and E6, showed GM generally between the means for Stations E15 and E6 for dry- and wet-weather, respectively. In general, HSM enterococci data showed a pattern (Figure ES-8) that was reflective of the LTCP sampling program data.

Data collected by the Citizens Testing Group was also made available to the public by Riverkeeper. This dataset is limited to enterococci bacteria concentrations for three sampling stations along the southwestern shore of Flushing Bay, as shown in Figure ES-4. These data are available on Riverkeeper's website http://www.riverkeeper.org/. Consistent with the LTCP and HSM data, Riverkeeper's data showed a relationship between wet-weather conditions and higher enterococci concentrations throughout 2013, 2014 and 2015.

Figure ES-9 depicts the DO averages derived from the LTCP dataset measured during late 2013/early 2014. The measured DO concentrations portray winter conditions and hence do not capture the lower DO values expected to occur during the summer periods. However, based on the HSM program DO dataset, extremely few DO values were observed below 4.0 mg/L, except in three instances in which the DO concentration was measured slightly below the Class I criterion, throughout 2013, 2014 and 2015.

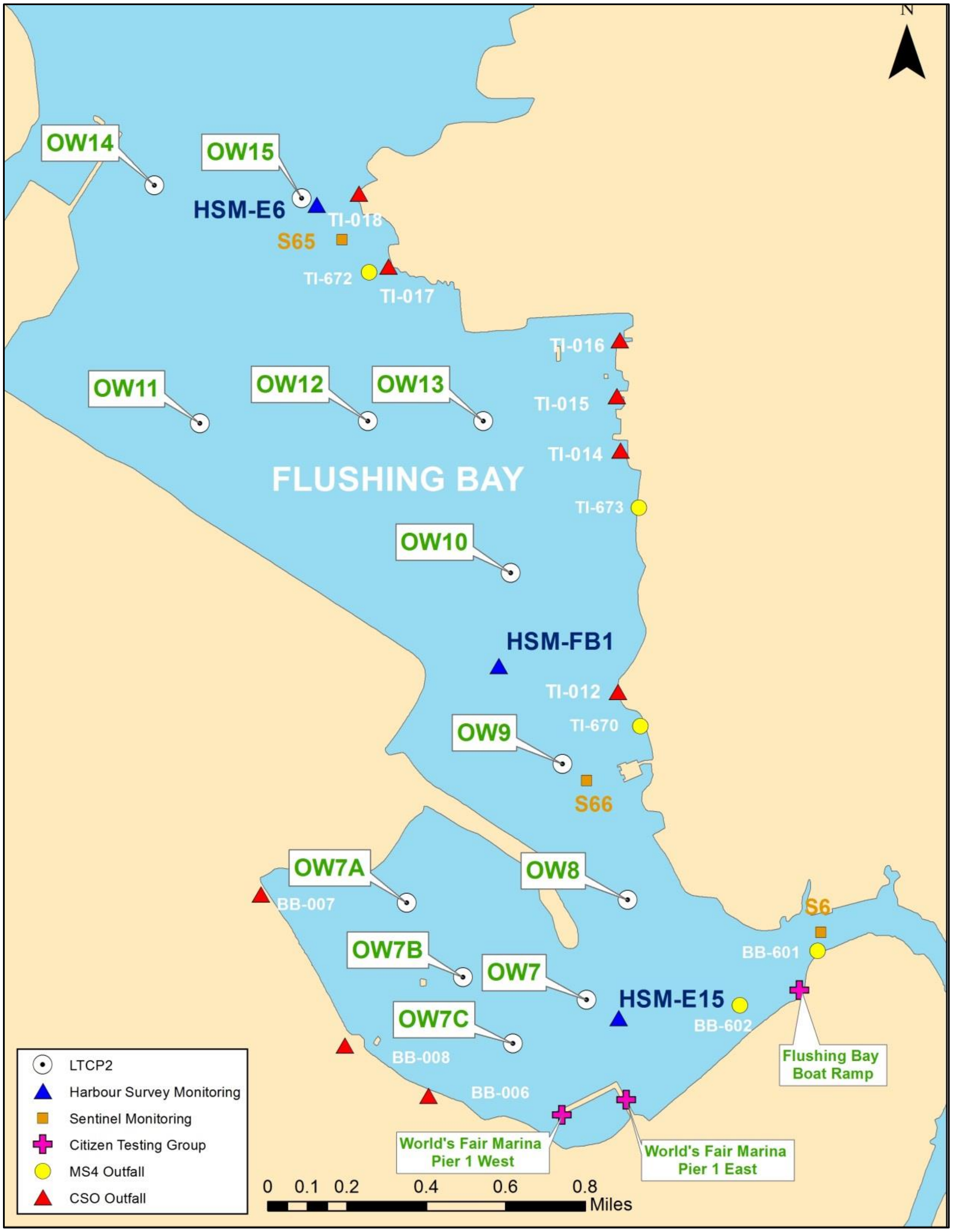

Figure ES-4. Flushing Bay LTCP Field Sampling Analysis Program and Harbor Survey Monitoring Program Sampling Locations

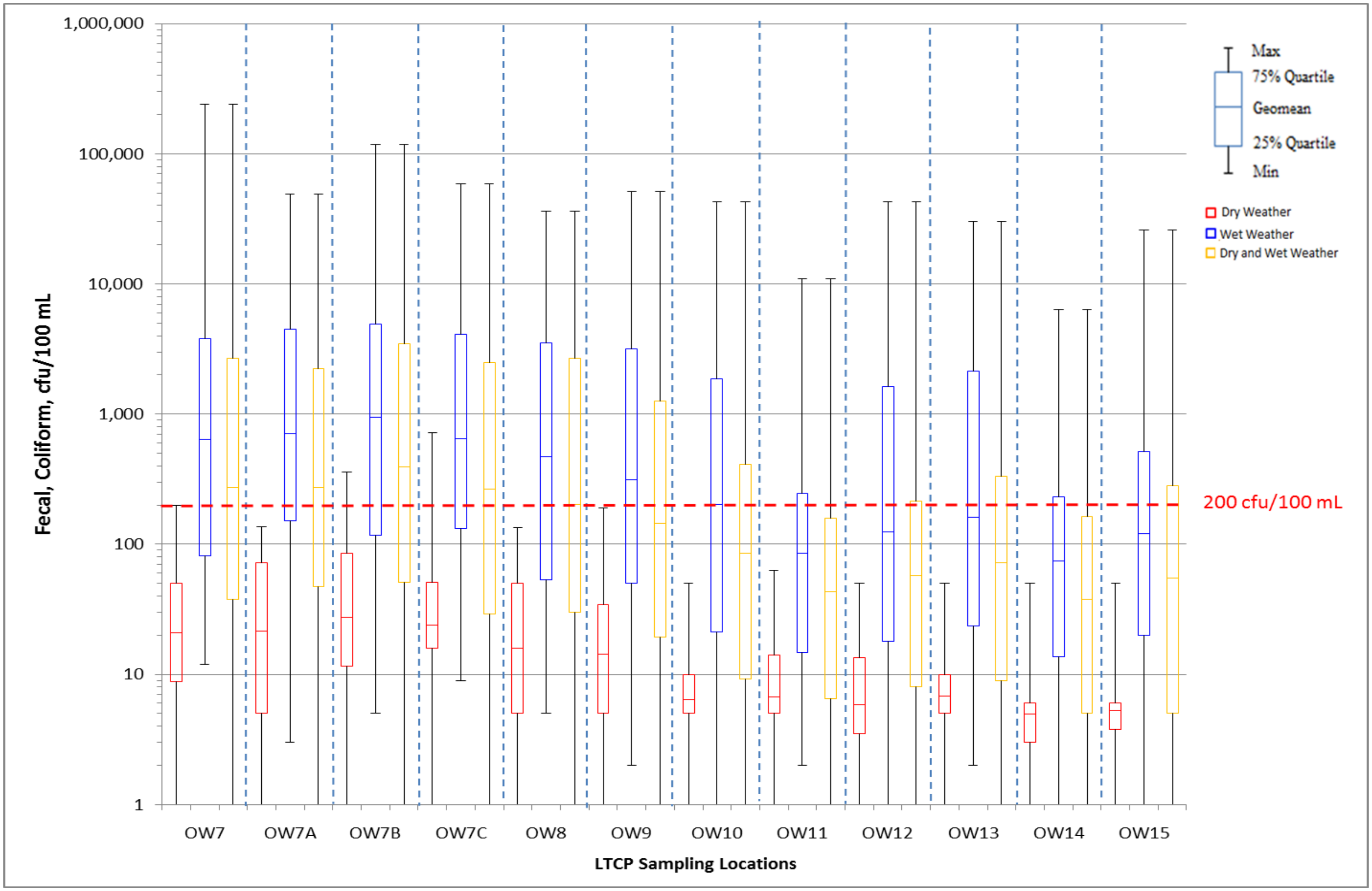

Figure ES-5. Fecal Coliform Concentrations at Flushing Bay LTCP Monitoring Stations

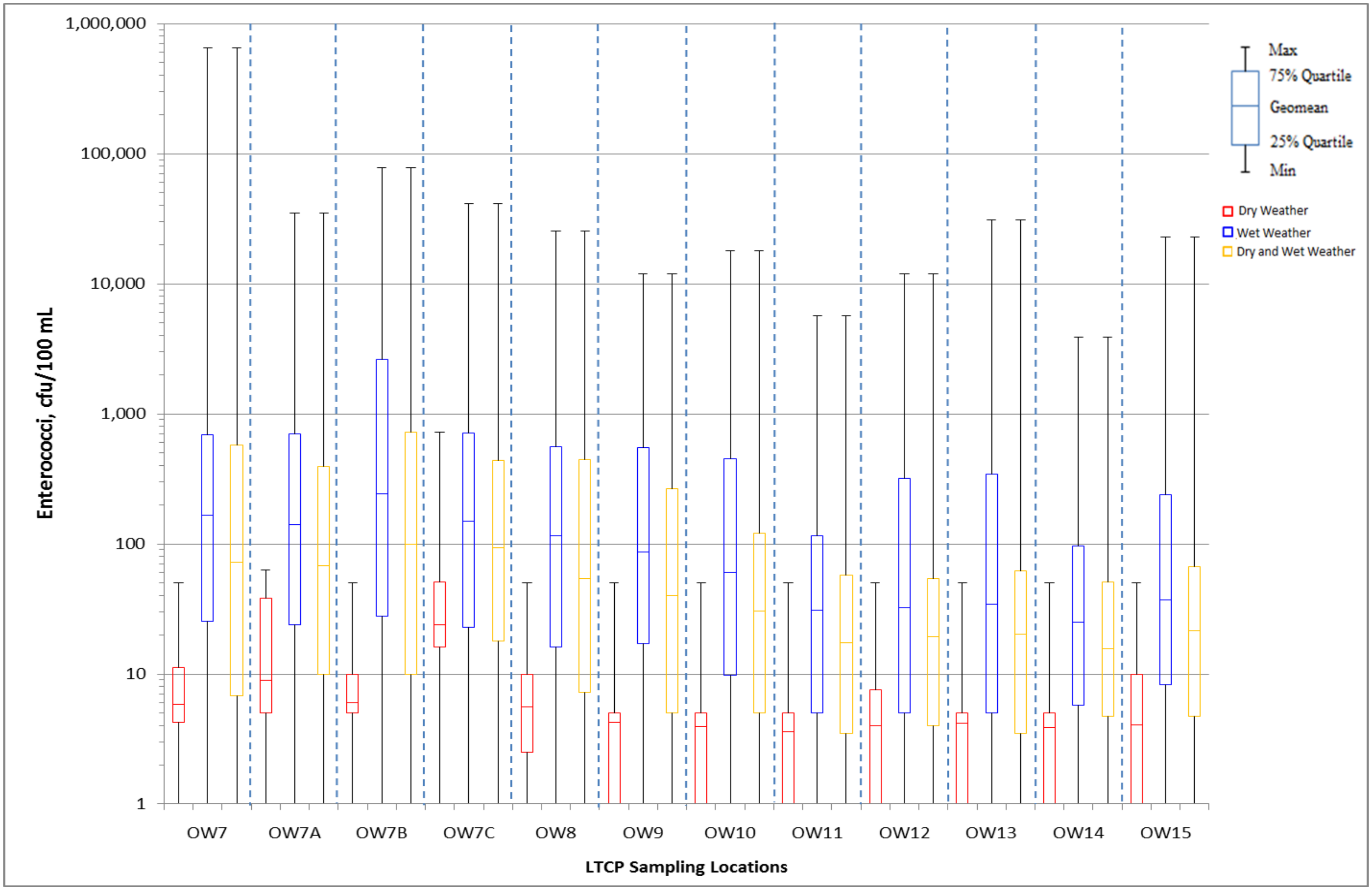

Figure ES-6. Enterococci Concentrations at Flushing Bay LTCP Monitoring Stations

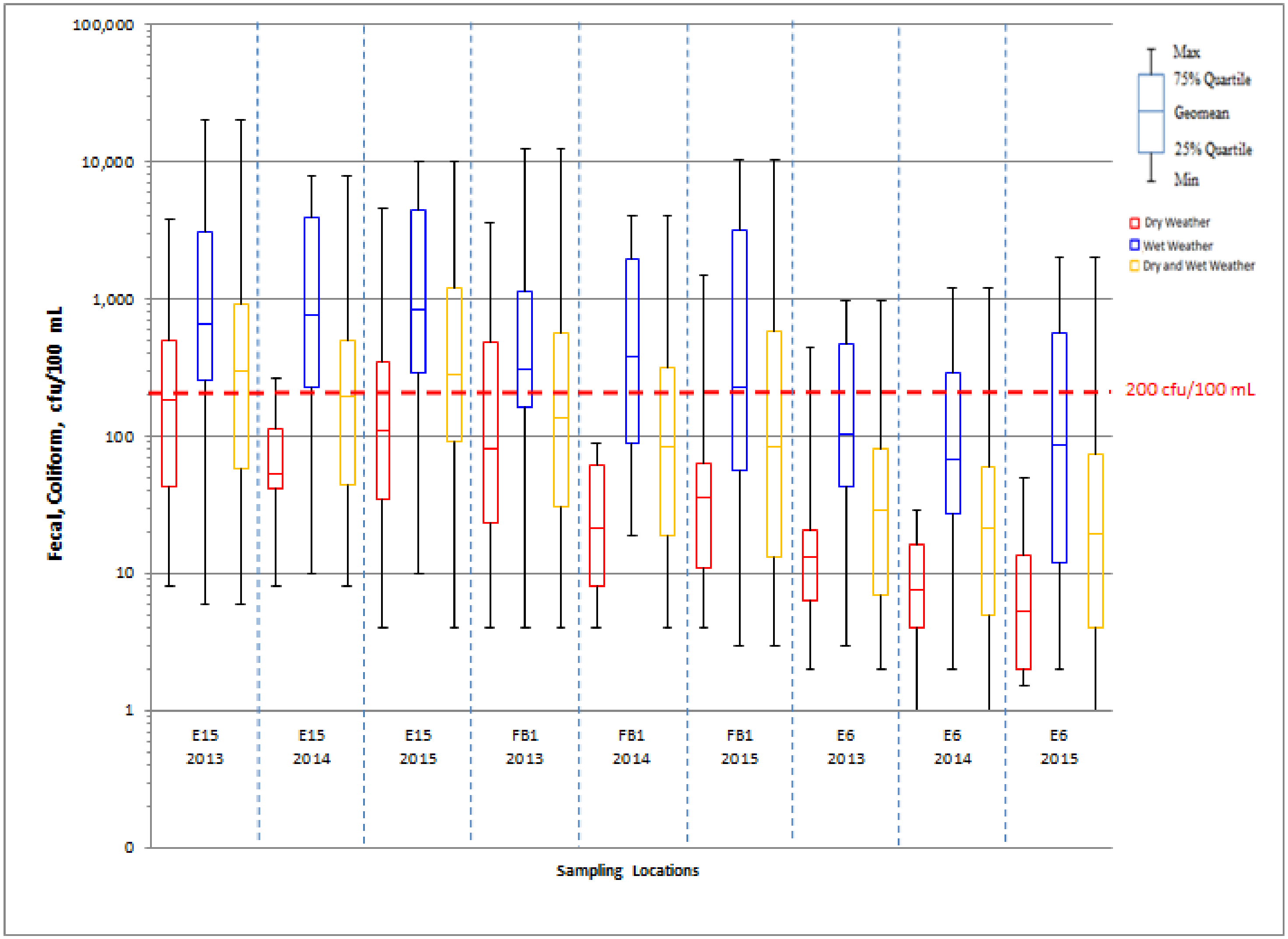

Figure ES-7. Fecal Coliform Concentrations at Flushing Bay Harbor Survey Monitoring Stations

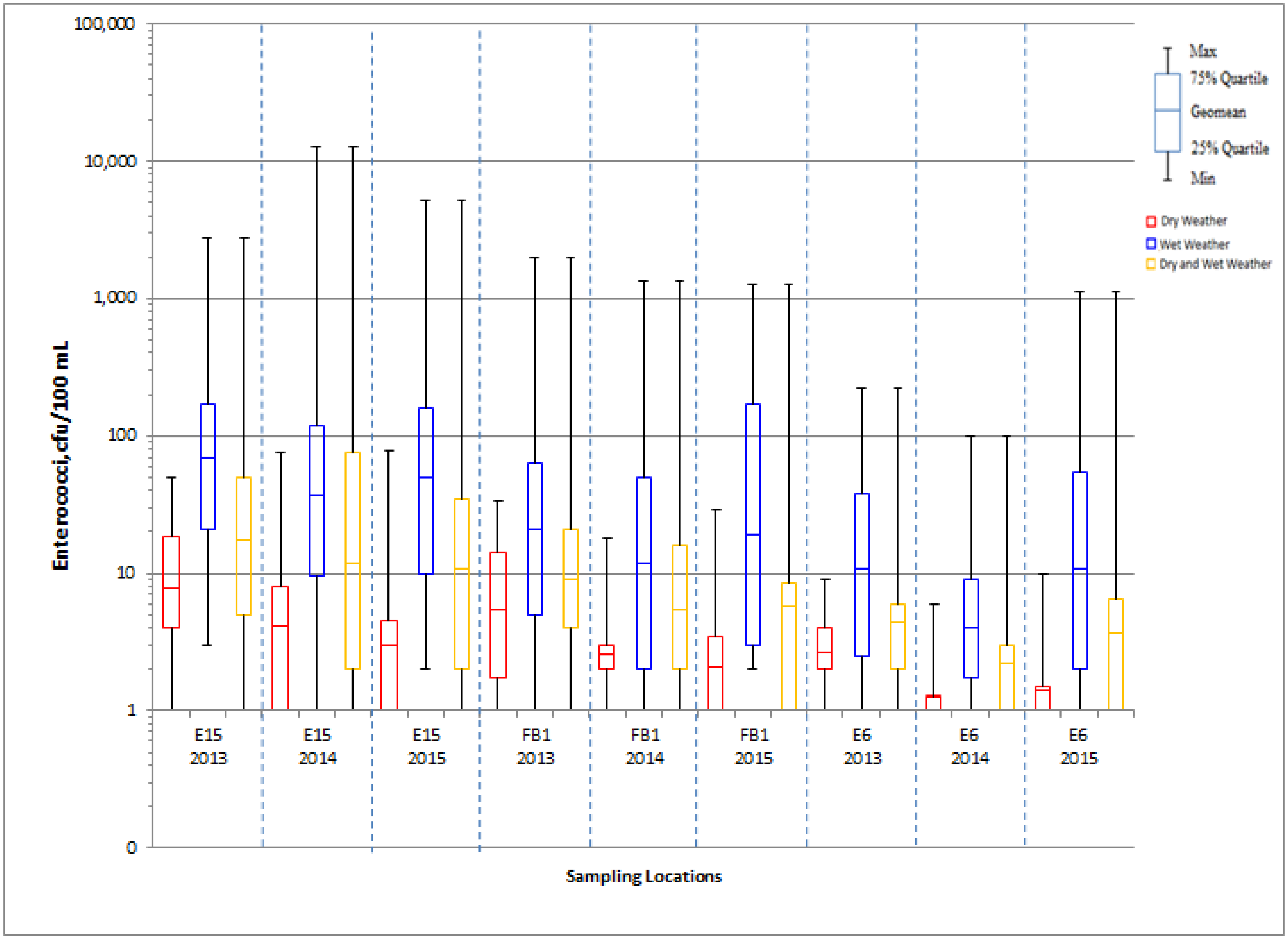

Figure ES-8. Enterococci Concentrations at Flushing Bay Harbor Survey Monitoring Stations

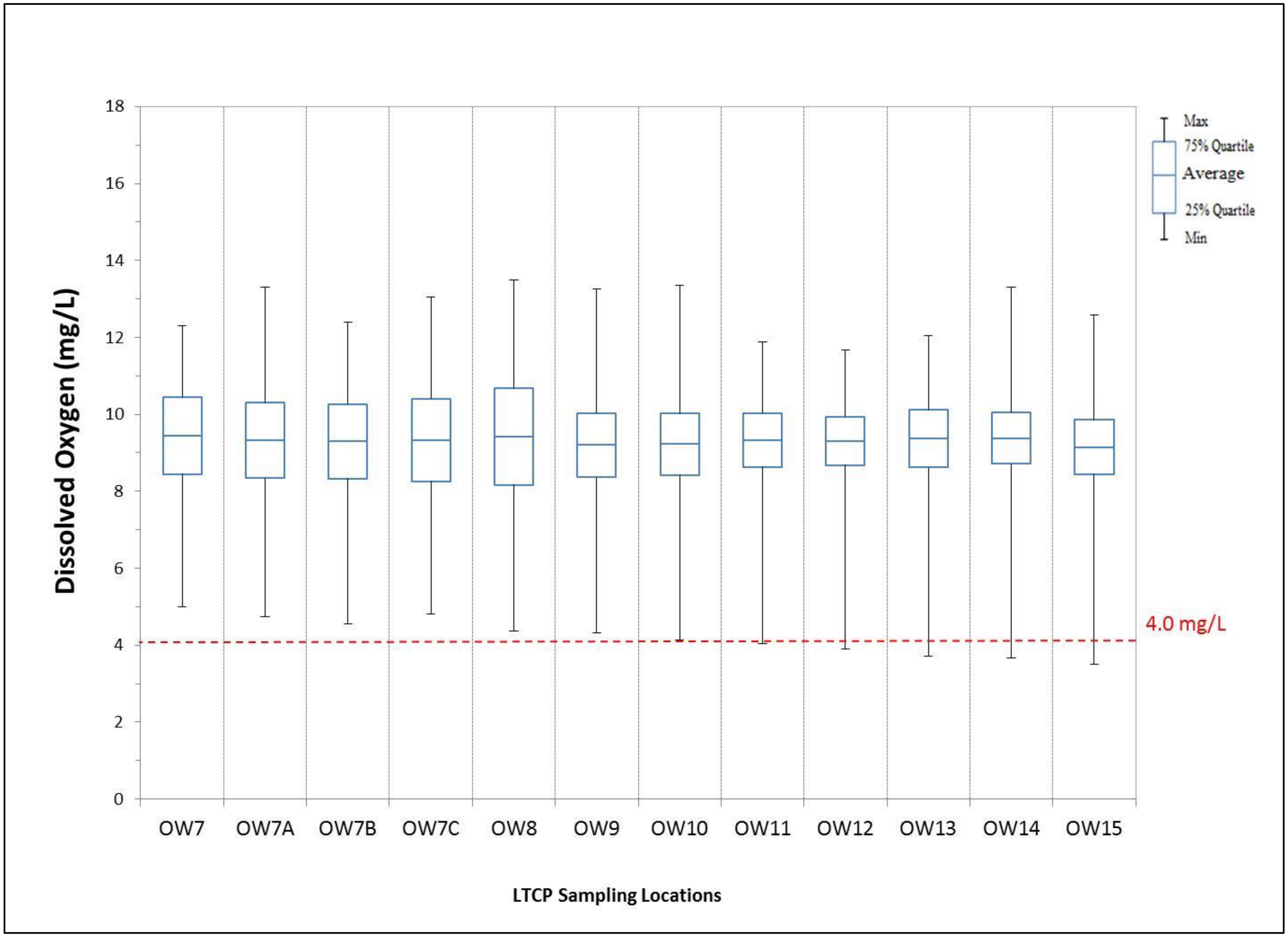

Figure ES-9. DO Concentration at Flushing Bay LTCP WQ Stations (November 2013 – May 2014)

Baseline Conditions, 100 Percent CSO Control and Performance Gap

Computer models were used to assess attainment with Existing WQ Criteria (Class I), Class SC DO Criteria and Potential Future Primary Contact WQ Criteria. The analyses focused on two primary objectives:

1. Determine the levels of compliance with water quality criteria under future baseline conditions, defined as conditions with sanitary flows based on 2040 population projections, with all other sources being discharged at existing levels to the waterbody. The primary sources would be dominated by CSO but also include stormwater, direct drainage, Flushing Creek, and the East River. This analysis is presented for Existing WQ Criteria (Class I), Class SC DO Criteria and Potential Future Primary Contact WQ Criteria.
2. Determine potential attainment levels without discharge of CSO to the waterbody (100 percent control), keeping the remaining non-CSO sources. This analysis is based on the criteria shown in Table ES-1.

DEP assessed water quality using the Flushing Bay Model (FBM). This was an existing model that was updated and validated using receiving water data collected throughout 2014. Model outputs for fecal coliform and enterococci bacteria, as well as for DO, were compared with various monitored data sets during validation. This improved the accuracy and robustness of the models for LTCP evaluations. The InfoWorks CS™ (IW) sewer system model was used to provide flows and loads from intermittent wet-weather sources as input to the FBM. The water quality model was then used to calculate ambient pathogen concentrations within the waterbody for a set of baseline conditions.

Baseline conditions were established in accordance with the guidance provided by DEC to represent future conditions. Baseline conditions included the following assumptions: the design year for projected future dry-weather flows was established as 2040; Bowery Bay WWTP and Tallman Island WWTP would receive peak flows at two times design dry-weather flow (2xDDWF); Flushing Creek CSO LTCP recommended plan in operation, grey infrastructure would include those elements recommended in the 2011 Waterbody/Watershed Facility Plan (WWFP); and waterbody-specific GI application rates would be based on the best available information. In the case of the Flushing Bay project area, DEP has plans to manage approximately 2.8 percent of impervious acres within the total tributary combined sewer impervious area.

The water quality assessments were conducted using continuous water quality simulations. A one-year (2008 rainfall) simulation for bacteria and DO assessment was used to support an alternatives evaluation. A 10-year rainfall bacteria simulation (2002 to 2011) for attainment analysis was used for the preferred alternative. The gaps between calculated baseline concentrations of bacteria, as well as DO, were then compared to the applicable pathogen and DO criteria to quantify the level of attainment.

Table ES-3 presents a summary of the baseline annual and recreational season (May 1st through October 31st) of Bacteria Existing WQ Criteria for the 2008 rainfall year, along with the maximum monthly fecal coliform GM. As shown, all stations within Flushing Bay meet Bacteria Existing WQ Criteria (200 cfu/100mL) in the recreational season and on an annual basis. As shown in Table ES-4, DO is projected to be attained for the Existing WQ Criteria with all stations exceeding the DEC attainment goal of 95 percent.

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

Station		Maximum Monthly Geometric Means (cfu/100mL)		% Attainment (GM <200 cfu/100mL)	
		Annual	Recreational Season	Annual	Recreational Season
OW7	Inner Bay	129	15	100	100
OW7A		84	13	100	100
OW7B		148	16	100	100
OW7C		156	17	100	100
OW8		179	16	100	100
OW9		105	14	100	100
OW10	Outer Bay	77	13	100	100
OW11		47	16	100	100
OW12		65	14	100	100
OW13		62	13	100	100
OW14		49	21	100	100
OW15		59	19	100	100

Table ES-4. Model Calculated Baseline DO Attainment – Existing WQ Criteria (2008)

Station		Annual Attainment (%)
		Entire Water Column
		>=4.0 mg/L
OW7	Inner Bay	100
OW7A		100
OW7B		100
OW7C		100
OW8		100
OW9		100
OW10	Outer Bay	99
OW11		99
OW12		99
OW13		99
OW14		97
OW15		98

Levels of attainment for the Bacteria Primary Contact WQ Criteria on an annual or recreational season basis are the same as those shown for the Bacteria Existing WQ Criteria in Table ES-3, given that both standards share the same fecal coliform numerical threshold which is 200 cfu/100mL. All stations in Flushing Bay are in attainment during the recreational season and on an annual basis.

Table ES-5 presents a comparison of the maximum monthly GM and the annual percent attainment for baseline conditions and 100% CSO control. The data in Table ES-5 show the CSO contribution to the maximum monthly fecal coliform GM. The largest impact of the 100% CSO control scenario is calculated at Station OW7B within Inner Flushing Bay where there is a 57% decrease from the baseline GM of 148 cfu/100mL. However, both the baseline and 100% CSO control fully attain the existing fecal coliform criteria.

Table ES-5. Comparison of the Model Calculated 2008 Baseline and 100% Flushing Bay CSO Control Fecal Coliform Maximum Monthly GM and Attainment of Primary Contact WQ Criteria

Station		Maximum Monthly Geometric Means (Annual)		% Attainment (Annual)	
		Baseline	100% CSO Control	Baseline	100% CSO Control
OW7	Inner Bay	129	77	100	100
OW7A		84	32	100	100
OW7B		148	63	100	100
OW7C		156	73	100	100
OW8		179	133	100	100
OW9		105	69	100	100
OW10	Outer Bay	77	55	100	100
OW11		47	38	100	100
OW12		65	48	100	100
OW13		62	45	100	100
OW14		49	44	100	100
OW15		59	47	100	100

The attainment of the DO Class SC criteria for the entire water column is presented in Table ES-6 for baseline and 100% CSO control conditions. Determination of attainment with Class SC DO criteria can be very complex as the standard allows for excursions from the daily average limit of 4.8 mg/L for a limited number of consecutive calendar days. To simplify the analysis, attainment was based solely upon attainment of the daily average without the allowed excursions. While the analysis performed was conservative, the results project full attainment at fourteen (14) of the fifteen (15) stations with the exception of Station OW-14 that is more impacted by the East River. In addition, the gap analysis indicates that the 100% CSO control alternative provides no benefits in DO attainment at this station. Attainment of the Acute DO Criterion (never less than 3.0 mg/L) is satisfied at all locations throughout the Bay on an annual basis for the 2008 baseline conditions.

Table ES-6. Model Calculated 2008 Baseline and 100% CSO Control DO Attainment of Class SC WQ Criteria

Station		Annual Attainment Percent Attainment (Water Column)			
		Baseline		100% Flushing Bay CSO Control	
		Chronic[1]	Acute [2]	Chronic[1]	Acute [2]
OW7	Inner Bay	100	100	100	100
OW7A	Inner Bay	100	100	100	100
OW7B	Inner Bay	100	100	100	100
OW7C	Inner Bay	100	100	100	100
OW8	Inner Bay	100	100	100	100
OW9	Inner Bay	100	100	100	100
OW10	Outer Bay	100	100	100	100
OW11	Outer Bay	97	100	97	100
OW12	Outer Bay	100	100	100	100
OW13	Outer Bay	100	100	100	100
OW14	Outer Bay	83	100	83	100
OW15	Outer Bay	96	100	97	100

Notes:

(1) Chronic Criteria: 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 for baseline conditions, 2008 recreational season, is shown below in Table ES-7. Attainment of the potential future primary contact GM criterion is achieved at all stations within Flushing Bay for the recreation season. However, attainment of the 90th percentile STV criterion is not achieved at any of the stations. The percent attainment is very low in Inner Flushing Bay, ranging from 9 to 13 percent. Attainment in Upper Flushing Bay ranges from 29 to 78 percent under baseline conditions. As shown in Table ES-8, 100% CSO control would significantly improve attainment with the Potential Future Primary Contact STV Criteria but still would not enable the waterbody to fully attain this potential future STV criteria.

Baseline modeling showed that Flushing Bay exhibits a high level of attainment of the Class I fecal coliform Primary Contact WQ criterion and DO criterion on an annual basis. Attainment of the Class SC fecal coliform Primary Contact WQ criterion is also fully achieved on an annual basis. While the Class SC Acute DO Criterion is fully attained during baseline conditions, the chronic DO criteria is not fully attained under baseline conditions or 100% CSO control on an annual daily basis but the actual chronic DO WQS is a complex duration based criteria and basing the analysis on a daily average is very conservative. The projected improvement in the chronic DO WQS attainment is less than 1 percent between the baseline scenario and 100% CSO reduction indicating that there is minimal performance benefit for DO through control of CSO alone. Attainment of the GM for enterococci is fully achieved under the Potential Future

Primary Contact WQ Criteria. However, attainment of the 90th Percentile STV falls well short of criteria, particularly within Inner Flushing Bay. While significant improvement and attainment of this criterion is observed at 9 of the 12 monitoring stations, the results indicate that these proposed STV criteria may be extremely difficult to attain in these confined CSO waterbodies and the STV may not be statistically relevant in these confined CSO waterbodies as the statistical analysis used to develop this STV (90th percentile value) was based entirely on data collected at beaches in which there are no direct CSO discharges and where there is significantly more mixing occurring than in these confined CSO waterbodies.

Table ES-7. Model Calculated 2008 Baseline Enterococci Maximum 30-day GM and Attainment of Potential Future Primary Contact Water Quality Criteria

Station		Maximum Recreational Season 30-day Enterococci (cfu/100mL)		% Attainment	
		GM	90th Percentile STV	GM (<30 cfu/100mL)	90th Percentile STV (<110 cfu/100mL)
OW7	Inner Bay	18	2,890	100	9
OW7A	Inner Bay	18	4,417	100	9
OW7B	Inner Bay	22	5,696	100	9
OW7C	Inner Bay	22	6,166	100	9
OW8	Inner Bay	17	1,274	100	12
OW9	Inner Bay	14	1,565	100	13
OW10	Outer Bay	12	930	100	29
OW11	Outer Bay	11	288	100	78
OW12	Outer Bay	12	475	100	57
OW13	Outer Bay	13	648	100	60
OW14	Outer Bay	13	243	100	77
OW15	Outer Bay	13	327	100	72

Table ES-8. Model Calculated 2008 100% CSO Control Enterococci Maximum 30-day GM and Attainment of Potential Future Primary Contact WQ Criteria

Station		Maximum Recreational Season 30-day Enterococci (cfu/100mL)		% Attainment	
		GM	90th Percentile STV	GM	90th Percentile STV
OW7	Inner Bay	5	120	100	93
OW7A	Inner Bay	4	43	100	100
OW7B	Inner Bay	5	74	100	100
OW7C	Inner Bay	5	92	100	100
OW8	Inner Bay	7	180	100	81
OW9	Inner Bay	6	94	100	100
OW10	Outer Bay	6	117	100	99
OW11	Outer Bay	8	118	100	99
OW12	Outer Bay	8	123	100	97
OW13	Outer Bay	7	114	100	97
OW14	Outer Bay	11	151	100	87
OW15	Outer Bay	10	140	100	95

Public Outreach

DEP's comprehensive public participation plan provides the opportunity for interested stakeholders to be involved in the LTCP process. Stakeholders include local residents and citywide and regional groups, a number of whom offered comments at two public meetings held for this LTCP.

On September 30, 2015, DEP hosted a Public Kickoff Meeting to initiate the water quality planning process for the Flushing Bay LTCP. Approximately 80 stakeholders from 25 different non-profit, community, planning, environmental, economic development, governmental organizations, and the broader public attended the event, as did three media representatives. The two-and-half-hour event, held at Al Oerter Recreation Center, Queens, provided stakeholders with information about DEP's LTCP Program, Flushing Bay watershed characteristics, and the status of waterbody improvement projects. DEP also solicited information from the public about their recreational use of Flushing Bay, and described additional opportunities for public input and outreach. The presentation is available on DEP's LTCP Program Website: http://www.nyc.gov/dep/ltcp/.

DEP hosted a second Public Meeting on October 26, 2016 to continue the public planning process. Approximately 50 stakeholders from several different non-profit, community planning, environmental, economic development, and governmental organizations, as well as the general public, attended the event. The purpose of the almost three-hour event, held at the United States Tennis Association Billie Jean King Tennis Center, was to describe the alternatives identification and selection processes, and solicit public comment and feedback. This presentation is also available on DEP's LTCP Program Website: http://www.nyc.gov/dep/ltcp/.

DEP has received several stakeholder emails and comment letters. These documents and additional information on the public outreach activities are available on DEP's website and are also included in Appendix B, Public Participation Materials.

Evaluation of Alternatives

DEP used a multi-step process to evaluate CSO control measures and CSO control alternatives. Figures and descriptions of the conceptual layouts were evaluated for the tunnel alternatives with siting of the dewatering pump stations at potential sites including but not limited to Ingraham's Mountain and Luyster Creek. These conceptual layouts and sites were developed for the purposes of developing costs and evaluating the feasibility of the various CSO storage tunnel alternatives. The final siting of the dewatering pumping station, the tunnel alignment and other associated details of the tunnel alternatives presented herein will be further evaluated and finalized during subsequent planning and design stages. The evaluation process considered: environmental benefits; community and societal impacts; and issues related to implementation and operation and maintenance (O&M). Following the comments generated by detailed technical workshops, the retained alternatives were subjected to a functional review and cost-performance and cost-attainment evaluations, where economic factors were introduced. Table ES-9 presents the retained alternatives that resulted from the evaluation process.

Table ES-9. Retained Alternatives

Alternative	Description
1. Disinfection of Outfalls BB-006 and BB-008	Outfall BB-006: Install disinfection facilities at the CAVF Outfall BB-008: Install disinfection facilities at Regulator BB-09
2. Re-purpose the CAVF as a RTB	Outfall BB-006 (Lower Level only): Convert the CAVF to a RTB with disinfection facilities
3. In-line Storage Outfalls BB-006 & BB-008	Outfalls BB-006 and BB-008 • Install bending weirs for control and capture of CSO • Install dewatering pumping station to convey captured flow back to the interceptor following a storm event
4. Combination of Alternatives 2 and 3	Disinfection of Outfall BB-006 • Install disinfection facilities at the CAVF Outfalls BB-006 and BB-008 • Install bending weirs for control and capture of CSO • Install dewatering pumping station to convey captured flow back to the interceptor following a wet-weather event
5. In-Water RTB	• 72 MGD In-Water RTB with disinfection facilities
6. 25% CSO Control Tunnel	• Ingraham's: 13,300-LF, 10-ft diameter tunnel (8 MG storage), and 15 MGD dewatering pumping station • Luyster Creek: 16,600-LF, 9-ft diameter tunnel (9 MG storage) and 15 MGD dewatering pumping station

Table ES-9. Retained Alternatives

Alternative	Description
7. ***50% CSO Control Tunnel***	• Ingraham's: 13,300-LF long, 18-ft diameter tunnel (25 MG storage), and 25 MGD dewatering pumping station • Luyster Creek: 16,600-LF, 16-ft diameter tunnel (25 MG storage), and 25 MGD dewatering pumping station
8. **75% CSO Control Tunnel**	• Ingraham's: 13,300-LF long, 29-ft diameter tunnel (66 MG storage), and 70 MGD dewatering pumping station • Luyster Creek: 16,600-LF, 16-ft diameter tunnel (25 MG storage) and 60 MGD RTB
9. **100% CSO Control Tunnel**	• Ingraham's:13,300-LF long, 29-ft diameter tunnel (66 MG storage) and 400 MGD RTB • Luyster Creek: 16,600 LF, 16-ft diameter tunnel (25 MG storage) and 400 MGD RTB

Notes:
CAVF = Corona Avenue Vortex Facility
RTB = Retention Treatment Basin
Multiple sites were evaluated for the tunneling alternatives. The final site and details of the preferred alternative will be further developed during subsequent planning and design phases.

Table ES-10 summarizes the projected Flushing Bay CSO volumes, and percent reductions in CSO volume and bacteria loads for the retained alternatives. The bacteria loading reductions shown in Table ES-10 were computed on an annual basis. As indicated in Table ES-2, the combined sewers tributary to the Outer Bay CSOs (TI-013, 014, 015, 016, 017, and 018) are planned for separation, thereby reducing CSO discharges to Flushing Bay by 48 MG from 1453 MG to 1405 MG annually. As a result, evaluation of the retained alternatives focused on addressing the 1405 MG of CSO contributed to the Inner Bay from Outfalls BB-006, BB-007 and BB-008. For those alternatives with levels of control less than 100% (Alternatives 1 through 8), CSO capture focused on the largest CSOs, BB-006 and BB-008. For 100% control (Alternative 9), all of the CSO from Outfalls BB-006, BB-007 and BB-008 was captured and treated.

Table ES-10. Flushing Bay Retained Alternatives Summary (2008 Rainfall)

Alternative(1)	Untreated CSO Volume (MGY) (3)	Frequency of Overflow(5)	Untreated CSO Volume Reduction (%)	Fecal Coliform Reduction(2) (%)	Enterococci Reduction (%)(2)
Baseline Conditions(3)	1405	47	-	-	-
1. Disinfection of Outfalls BB-006 and BB-008	1405	47	0	27	27
2. Re-purpose CAVF as a RTB	1189	26/47(4)	15	17	17

Table ES-10. Flushing Bay Retained Alternatives Summary (2008 Rainfall)

Alternative[(1)]	Untreated CSO Volume (MGY) [(3)]	Frequency of Overflow[(5)]	Untreated CSO Volume Reduction (%)	Fecal Coliform Reduction[(2)] (%)	Enterococci Reduction (%)[(2)]
3. In-line Storage Outfalls BB-006 and BB-008	1208	40	14	14	14
4. Combination Alternatives 2 and 3	1189	40	15	17	17
5. In-Water RTB	1020	29	27	27	27
6. 25% CSO Control Tunnel	1056	35	25	25	25
7. 50% CSO Control Tunnel	659	14	53	53	53
8. 75% CSO Control Tunnel	346	8	75	75	75
9. 100% CSO Control Tunnel	0	0	100	100	100

Notes:
CAVF = Corona Avenue Vortex Facility
RTB = Retention Treatment Basin

(1) Alternatives 2 through 9 include floatables control using an underflow baffle & static or bending weirs. The existing containment booms would be retained under Alternative 1.
(2) Bacteria reduction is computed on an annual basis.
(3) Based upon 2008 Typical Year. As the TI Outfalls are planned for separation, Untreated CSO Volumes are based upon CSO discharges from Outfalls BB-006, BB-007 and BB-008. May differ from results reported in Section 6.0, which were based on 10 year simulations and included discharge from the TI Outfalls.
(4) Seasonal disinfection of CSOs for Outfall BB-006. No disinfection of Outfall BB-008.
(5) Frequency of overflow includes remaining CSO discharges to the Inner Flushing Bay from CSOs BB-006 and BB-008 that are not captured or receive primary treatment.

Estimated Costs of Retained Alternatives and Selection of the Preferred Alternative

The alternatives were reviewed for cost effectiveness, ability to meet WQ Criteria, public comments and operations. The construction costs were developed as Probable Bid Costs (PBC) and the total Net Present Worth (NPW) costs were determined by adding the estimated PBC to the NPW of the projected annual O&M costs at an assumed interest rate of 3 percent over a 20-year life cycle. Design, construction management and land acquisition costs are not included in the cost estimates. All costs are in February 2016 dollars and are considered Level 5 cost estimates by AACE International with an accuracy of -50% to +100%. The retained alternative estimated PBC, annual O&M costs, and total present worth are shown below in Table ES-11. The total Net Present Worth ranges from $49M to $3,493M.

Table ES-11. Cost of Retained Alternatives

Alternative	PBC(1) ($ Million)	Annual O&M Cost ($/Yr Million)	Total Net Present Worth ($ Million) (2)
1. Disinfection of Outfalls BB-006 and BB-008	32	1.1	49
2. Re-purpose CAVF as a RTB	52	0.7	61
3. Outfall Storage (BB-006 and BB-008)	114	0.2	118
4. Combination of Alts. 2 and 3	166	0.9	179
5. In-Water RTB	533	1.3	552
6a. 25% CSO Control Tunnel at Ingraham's Mountain	434	0.6	443
6b. 25% CSO Control Tunnel at Luyster Creek	448	0.6	457
7a. 50% CSO Control Tunnel at Ingraham's Mountain	670	0.9	683
7b. 50% CSO Control Tunnel at Luyster Creek	829	0.9	842
8a. 75% CSO Control Tunnel at Ingraham's Mountain	1,114	1.4	1,136
8b. 75% CSO Control Tunnel at Luyster Creek	1,286	1.4	1,306
9a. 100% CSO Control Tunnel at Ingraham's Mountain	3,420	4.9	3,494
9b. 100% CSO Control Tunnel at Luyster Creek	2,850	4.9	2,923

Notes:
PBC = Probable Bid Cost
(1) The PBC for the construction contract based on CY2016 dollars.
(2) The Net Present Worth is calculated by taking the annual O&M cost multiplying it by a present worth factor of 14.877 and adding this value to the PBC.

After reviewing the costs and potential benefits, it is noted that the retained alternatives represent a wide range of expenditures for a relatively small improvement of attainment of bacterial and DO WQS for Primary Contact WQ Criteria. However, recreational use of Flushing Bay is heavily influenced by solids and floatables discharged by CSOs which account for over 70 percent of the wet-weather discharge by volume to Flushing Bay. The World's Fair Marina, Flushing Bay Promenade, boat launches and other recreational uses are impacted by odors associated with the deposition of organic solids and aesthetic impacts from floatables.

The selection of the preferred alternative is based on multiple considerations including public input, environmental and water quality benefits, and costs. A traditional knee-of-the-curve (KOTC) analysis is presented in Section 8.5 of the LTCP. Based on that analysis a 25 MG CSO Storage Tunnel was identified as the most cost-effective alternative for reducing the frequency and volume of CSOs to Flushing Bay. Conceptual layouts for this tunnel are provided in Section 8 and the specific dimensions and routes will be finalized during the design phase.

This preferred 25 MG CSO Storage Tunnel alternative is projected to result in full attainment of the existing pathogen criteria and will provide significant reduction in CSO volume and frequency of overflow. The preferred alternative for the Flushing LTCP is projected to reduce CSO discharges from Outfalls

BB-006 and BB-008 to Flushing Bay by 53 percent from 1,405 MG/year to 659 MG/year. CSO events are projected to be reduced by 70 percent from 47 to 14 events annually. The implementation of these elements has an estimated Net Present Worth ranging from $683M to $842M, reflecting $0.9M of annual O&M over the course of 20 years and a PBC ranging from $670M to $829M.

Affordability and Financial Capability

DEP is in the midst of an unprecedented period of investment to improve water quality in New York Harbor. Since 2002, projects worth almost $10.0B have been completed or are under way, including projects for nutrient removal, CSO abatement, marshland restoration, and hundreds of other projects. DEP has committed a total of nearly $4.2B from the WWFP ($2.7B) and the GI Program ($1.5B), slightly more than half of which has been incurred to-date. Table ES-12 provides a summary of CSO improvement projects that have been completed or are underway.

Table ES-12. Completed and Underway CSO Improvement Projects

1995 – 2015 (Completed): • NC WWTP MSP (620 MGD to 700 MGD) • Four CSO Storage Tanks (118 MG) • Pumping Station Expansions (GC & Ave V PS) • Floatables Control (Bronx & Gowanus) • NYC Green Infrastructure Program Initiated • Wet Weather Maximization (Tallman Island) • Dredging (Paerdegat Basin & Hendrix Creek) • Gowanus Canal Flushing Tunnel Expansion
2016 – 2030 (Underway): • Dredging (Flushing Bay) • Aeration (Newtown Creek) • Regulator Modifications Flushing Bay High Level Interceptor • Regulator Modifications and Floatables Control (Westchester Creek, Newtown Creek, Jamaica Tributaries) • Sewer Work (Pugsley Creek, Fresh Creek High Level Storm Sewers (HLSS), Belt Pkwy Crossing, and Flushing Bay Low Lying Sewers) • 26th Ward Plant Wet Weather Stabilization • NYC Green Infrastructure Program
Total Costs (Completed and Ongoing): • Grey Infrastructure: $2.7 Billion • Green Infrastructure: $1.5 Billion

A preliminary Financial Capability Assessment has been conducted to assess the impact of current and future expenditures, including costs associated with the LTCP, on the financial capability of NYC and on the financial burden to the rate payers. This assessment is included in Section 9.6 of this LTCP. According to EPA 1997 Guidance, a high economic impact occurs when expenditures per household exceed two percent of the Median Household Income (MHI) of the ratepayer base. The current figure for NYC is 0.92 percent for the average household, which translates to a low financial impact. When combined with the score based on six additional criteria for NYC's financial capacity, the EPA method indicates that the overall impact of the current wastewater expenditures fall into the "low burden" category. However, the standard MHI metric used by EPA to define a high economic impact to ratepayers (i.e., affordability) is poorly applicable to NYC because of NYC's skewed distribution of household income and other factors, including the very high cost of living for housing, food, transportation, and utilities relative to the nation as a whole.

EPA issued new guidance in 2014 that clarifies that permittees are encouraged to supplement the standard metrics with information that provides a more detailed and localized characterization of that permittee's financial capability and the economic status of the residential ratepayer base. The type of information that could be presented includes, but is not limited to:

- presentation of household income by quintiles;
- poverty rates and trends;
- cost of living;
- total utility expenditures including expenditures to meet Safe Drinking Water Act (SDWA) mandates;
- historical increases in rates or other dedicated revenue streams; and
- information on the percent of households who own versus rent.

The supplemental information considered for this assessment indicates that when taking into account estimates for future spending, 50 percent of households are estimated to pay more than 2.0 percent of MHI by 2042 on wastewater bills alone, suggesting a "high" financial impact on residential users based on EPA guidance. When accounting for both water and wastewater bills, the percentage of households spending at least 4.5 percent of their income could reach 42 percent by 2042. Applying cost of living adjustment factors to discount the value of household incomes and make them comparable to the U.S. average, would increase this percentage dramatically.

NYC has a poverty rate of approximately 20 percent, far higher than the national average of 15 percent. Thus, a large percentage of households would be adversely impacted by sustained rate increases. Additionally, recent data show stagnant to decreasing household incomes in the lower economic brackets. Accordingly, the snapshot picture of household income may underestimate the impacts of future rate increases.

Ultimately, the environmental, social, and financial benefits of all water-related obligations should be considered when priorities for spending are developed and implementation of mandates is scheduled, so that resources can be focused where the community will receive the greatest possible environmental benefit.

3. EVALUATIONS AND CONCLUSIONS

DEP will implement the elements of the preferred alternative after approval of the LTCP by DEC. This LTCP also recommends the continued implementation of WWFP recommendations.

The analyses for the Flushing Bay LTCP recommended plan are summarized below for the following three areas:

1. Summary of Recommended Plan.
2. Water Quality Modeling Results.
3. Use Attainability Analysis (UAA), Water Quality Compliance and Time to Recovery.

Summary of Recommend Plan

Water quality in Flushing Bay will be improved through the implementation of the following: (1) currently planned improvements including those recommended in the 2011 WWFP; (2) planned GI projects: (3) completed and planned CSO mitigation projections in Flushing Creek; and (4) the implementation of this recommended Flushing Bay LTCP alternative which calls for the design, construction, and operation of a 25 MG CSO Storage Tunnel. A preliminary constructability analysis has been conducted and DEP has deemed these improvements to be implementable based on information currently available. These identified actions have been balanced with input from the public and awareness of the cost to the citizens of NYC.

Water Quality Modeling Results

The water quality modeling results associated with the recommended plan for Flushing Bay are shown in Tables ES-13 through ES-16. These results provide the calculated annual and recreational attainment of the fecal coliform bacteria concentrations and the recreational season attainment for enterococci. The results show, for the different calculated levels of attainment, when concentrations would be at or lower than the Existing WQ Criteria and Potential Future Primary Contact WQ Criteria under the 10-year simulation. Class SC DO criteria are also shown based on the 2008 WQ simulation.

The Existing WQ Criteria for fecal coliform attainment levels (monthly GM<200 cfu/100mL) as determined using the 10-year simulation are shown below in Table ES-13. This table indicates that the recommended plan will achieve attainment of the existing fecal coliform criteria annually and during the recreational season.

The Potential Future Primary Contact WQ Criteria attainment levels for enterococci are shown in Table ES-14 for the 10-year simulation. As indicated in this table, Potential Future Primary Contact WQ Criteria for enterococci (rolling 30-day geometric mean <30 cfu/100mL) are met 100 percent of the time. However, the 90th percentile STV of <110 cfu/100mL is attained between 48 and 81 percent of the time.

The DO attainment for Existing WQ Criteria for Class I as well as Class SC is the same as that reported for baseline conditions in Tables ES-4 and ES-6. The LTCP framework does not evaluate DO attainment under a 10-year simulation.

Table ES-13. Model Calculated 10-year Preferred Alternative Attainment of Existing WQ Criteria and Primary Contact WQ Criteria

Station		Fecal Coliform % Attainment	
		Annual Monthly GM < 200 cfu/100mL	**Recreational Season**(1) Monthly GM < 200 cfu/100mL
OW-7	Inner Bay	100	100
OW-7A	Inner Bay	100	100
OW-7B	Inner Bay	100	100
OW-7C	Inner Bay	100	100
OW-8	Inner Bay	100	100
OW-9	Inner Bay	100	100
OW-10	Outer Bay	100	100
OW-11	Outer Bay	100	100
OW-12	Outer Bay	100	100
OW-13	Outer Bay	100	100
OW-14	Outer Bay	100	100
OW-15	Outer Bay	100	100

Notes:

(1) The Recreational Season is from May 1st through October 31st.

Table ES-14. Model Calculated 10-year Preferred Alternative Attainment of Potential Future Primary Contact WQ Criteria

Station		Enterococci Attainment During Recreational Season (%)	
		30-day rolling GM <30 cfu/100mL	**90th Percentile STV <110 cfu/100mL**
OW-7	Inner Bay	98	57
OW-7A	Inner Bay	99	48
OW-7B	Inner Bay	98	55
OW-7C	Inner Bay	98	57
OW-8	Inner Bay	98	52
OW-9	Inner Bay	98	62
OW-10	Outer Bay	99	66
OW-11	Outer Bay	99	81
OW-12	Outer Bay	99	71
OW-13	Outer Bay	99	69
OW-14	Outer Bay	99	73
OW-15	Outer Bay	99	72

Notes:

(1) The Recreational Season is from May 1st through October 31st.

The LTCP assessment shows that Flushing Bay meets the Existing GM WQ Criteria for fecal coliform bacteria during the recreational season. The same is true for the Primary Contact WQ Criteria for fecal coliform bacteria. Table ES-15 presents an overview of the attainment status.

Table ES-15. Recommended Plan Compliance with Bacteria WQ Criteria Attainment

Location	Meets Existing WQ Criteria (Class I)	Meets Primary Contact WQ Criteria (Class SC)	Meets Potential Future Primary Contact WQ Criteria
Flushing Bay	YES[(1)]	YES[(1)]	NO[(2)]

Notes:
YES indicates attainment is calculated to occur ≥ 95 percent of time.
NO indicates attainment is calculated to be ≤ 95 percent of time.
(1) Annual attainment achieved.
(2) STV Criteria not met annually or during the recreational season (May 1st through October 31st). GM Criteria attained annually at all monitoring stations.

UAA, WQ Compliance and Time to Recovery

The 2012 CSO Order Goal Statement stipulates that, in situations where the proposed alternatives presented in the LTCP will not achieve existing WQS or the CWA Section 101(a)(2) goals, the LTCP will include a UAA. Because the analyses developed indicate that Flushing Bay is projected to fully attain primary contact water quality criteria, fully attain the Existing DO Criteria, and largely attain the Primary Contact DO Criteria, a UAA is not included in this LTCP.

DEP has performed an analysis to determine the amount of time following the end of rainfall periods required for Flushing Bay to recover and return to fecal coliform concentrations of less than 1,000 cfu/100mL. The analyses consisted of examining water quality model bacteria concentrations for the August 15, 2008 storm event. The basis for selection of the August 15, 2008 event for this analysis is described in Section 6. The time to recovery, defined as return to fecal coliform concentrations below 1,000 cfu/100mL, was then tabulated for each water quality station within the waterbody. The results of these analyses are summarized in Table ES-16 for Flushing Bay.

As noted in the table, the duration of time for the bacteria concentrations to return to levels that the NYS Department of Health (DOH) considers safe for primary contact varies according to location. Generally, a value of approximately 24 hours would be reasonable to cover the extent of Flushing Bay. All stations recovered within 21 hours or less.

Table ES-16. Time to Recovery within the Flushing Bay (August 14-15 2008)

Sampling Location and Waterbody Conditions		Preferred Alternative Time to Recovery (hrs) Fecal Coliform Target (1,000 cfu/100mL)
OW-7	Inner Bay	21
OW-7A		21
OW-7B		22
OW-7C		21
OW-8		17
OW-9		19
OW-10	Outer Bay	19
OW-11		8
OW-12		11
OW-13		11
OW-14		9
OW-15		10

1.0 INTRODUCTION

This LTCP for Flushing Bay was prepared pursuant to the Combined Sewer Overflow Consent Order (DEC Case No. CO2-20110512-25), dated March 8, 2012 (2012 CSO Order), which modified a 2005 CSO Consent Order (DEC Case No. CO2-20000107-8) (2005 CSO Order). Under the 2012 CSO Order, DEP is required to submit ten waterbody-specific and one citywide LTCP to DEC by December 2017. The Flushing Bay LTCP is the eighth of those 11 LTCPs.

1.1 Goal Statement

The following is the LTCP Introductory Goal Statement, which appears as Appendix C in the 2012 CSO Order. 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's 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 Flushing Bay LTCP.

1.2 Regulatory Requirements (Federal, State, Local)

The waters of NYC are subject to Federal and NYS 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. The NPDES permit program regulates point sources discharging pollutants into waters of the United States. CSOs and MS4 are also subject to regulatory control under the NPDES permit program. In New York, the NPDES permit program is administered by DEC, and is thus a SPDES program. NYS 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 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 to maintain WQS for the impaired waterbody.

Table 1-1 shows, as of September 2014, Flushing Bay remains delisted as a Category 4b waterbody for which required control measures (i.e., an 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	DO/Oxygen Demand	Floatables
Flushing Bay	Delisted Category 4b CSOs, Urban/Storm	Delisted Category 4b CSOs, Urban/Storm

1.2.b Federal CSO Policy

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

1.2.c New York State Policies and Regulations

New York State has established WQS for all navigable waters within its jurisdiction. Flushing Bay is classified as a Class I waterbody. Based on recent revisions to the NYS regulations, Class I waterbodies are defined as follows: The best usages of Class I waters are secondary contact recreation and fishing. These waters "shall be suitable for fish, shellfish, and wildlife propagation and survival" and the water quality "shall be suitable for primary contact recreation, although other factors may limit the use for this purpose." The corresponding total and fecal coliform standards for primary contact recreation are set forth in 6 NYCRR Part 703. This LTCP reflects these new regulatory standards, i.e., Primary Contact Water Quality Criteria.

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 saline waters of greater NYC, including Flushing Bay. The IEC was recently 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. Flushing Bay 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 entered into a 2005 CSO Order to address CSOs in NYC. Among other requirements, the 2005 CSO Order, as successively modified in 2012, requires DEP to evaluate and to implement CSO abatement strategies on an enforceable timetable for 18 waterbodies and, ultimately, for citywide long-term CSO control. The CSO Order also requires that DEP, in accordance with the 1994 EPA CSO Control Policy, meet construction milestones, complete the Flushing Bay CSO Retention Facility, and incorporate GI into the LTCP process, as proposed under NYC's Green Infrastructure Plan. In a separate MOU, DEP and DEC provided for WQS reviews in accordance with the EPA CSO Control Policy.

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, green and grey infrastructure projects, and 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 to improve water quality. Alternatives may 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 develops 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, an LTCP also includes 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 integrates and builds upon DEP's prior efforts by capturing the findings and recommendations from the previous facility planning documents for this watershed, including the WWFP.

In August 2011, DEP issued the Flushing Bay WWFP. The WWFP, which was prepared pursuant to the 2005 CSO Order, includes an analysis and presentation of operational and structural modifications targeting the reduction of CSOs and improvement of the overall performance of the collection and treatment system within the watershed. DEC approved the Flushing Bay WWFP on May 4, 2012.

1.3.b Coordination with DEC

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

DEP shared the Flushing Bay 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, DEP published the *NYC Green Infrastructure Plan* (GI Plan). Consistent with the GI Plan, the 2012 CSO Order 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 Flushing Bay LTCP planning process to involve relevant and interested stakeholders, and to 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 include 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 the Flushing Bay LTCP are summarized in Section 7.0.

2.0 WATERSHED/WATERBODY CHARACTERISTICS

This section summarizes the major characteristics of the Flushing Bay watershed and waterbody, building upon earlier documents that characterize the area including, most recently, the WWFP for Flushing Bay (DEP, 2011). Section 2.1 addresses watershed characteristics and Section 2.2 addresses waterbody characteristics.

2.1 Watershed Characteristics

The Flushing Bay watershed is highly urbanized, comprised primarily of residential areas with some commercial, industrial, institutional and open space/outdoor recreation areas within the Borough of Queens, NY. The most notable outdoor recreation area within this watershed is the Flushing Bay Promenade along the southwestern shoreline of Flushing Bay.

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

2.1.a Description of Watershed

The Flushing Bay watershed is comprised of approximately 6,877 acres on the north shore of Queens County. The Flushing Bay watershed is highly urbanized. With the exception of NYC park areas, cemeteries and the World's Fair Marina, the watershed is a dense mixture of residential, transportation, commercial, industrial and institutional development. Flushing Bay shares waters with the East River through tidal exchange processes. Flushing Creek discharges into the Bay at its southeastern corner and is the Bay's sole tributary. The neighborhoods of East Elmhurst, North Corona, College Point and Flushing surround the Bay. The predominant uses of the eastern shore include industrial, residential, and maritime-related uses. The southern shore is mostly outdoor recreational area, while the west mostly supports LaGuardia Airport. As described later in this section, the area is served by a complex collection system of: combined sewers, separate sanitary and storm sewers; interceptor sewers and pumping stations; nine CSO and five stormwater outfalls under the jurisdiction of DEP. The majority of the watershed (6,012 acres) is served by the Bowery Bay WWTP. A smaller drainage area (438 acres) on the northeastern shore of the Bay is served by the Tallman Island WWTP. LaGuardia Airport adds 427 acres of drainage area to the watershed.

As the watershed was developed, the condition of the waterbody and its shoreline was influenced by engineered sewer systems, filled-in wetlands and waterways, and an overall "hardening" of the shorelines with bulkheads. The urbanization of NYC and the Flushing Bay watershed has led to the creation of a large combined sewer system, as well as areas served by a municipal separate storm sewer system (MS4). A total of five SPDES-permitted MS4 outfalls also discharge to Flushing Bay. Generally, the combined sewage is conveyed to the WWTPs for treatment. Combined sewage flow that exceeds the capacity of the WWTP and combined sewer system (2xDDWF) during wet-weather, may discharge through any one or more of the nine SPDES-permitted CSO Outfalls to Flushing Bay. The predominant source of CSO to Flushing Bay is associated with three CSO outfalls which provide wet-weather relief to the combined sewer system tributary to the Bowery Bay WWTP. A smaller drainage area served by the Tallman Island WWTP, on the northeastern end of the watershed, has multiple CSO outfalls that discharge low volumes of CSO infrequently. As shown in Figure 2-1, the Flushing Bay watershed is located between the western end of the Tallman Island WWTP tributary area and the eastern end of the Bowery Bay WWTP tributary area.

Further inland lie the neighborhoods of Elmhurst, Corona, Corona Heights, Rego Park, Lefrak City, Forest Hills, Forest Hills Gardens, Briarwood, and Kew Gardens Hills.

As a residential community within NYC, Flushing Bay has several large and notable transportation corridors that cross the watershed to provide access between industrial, commercial and residential areas, such as the Van Wyck Expressway, the Whitestone Expressway, the Long Island Expressway, the Grand Central Parkway, and the Long Island Rail Road (Figure 2-2). These transportation corridors limit access to some portions of the waterbody and are taken into consideration when developing CSO control solutions.

The watershed includes approximately 5,203 acres (81 percent) of low- medium- and high-density residential, commercial, industrial and institutional lands, as well as streets, highways, railroads, and 454 acres of transportation related areas, including LaGuardia Airport. Approximately 1,220 acres (19 percent) of the watershed consists of parks, open water, and cemeteries. The portion of the Flushing Bay watershed that is occupied by Flushing Meadows-Corona Park complex in the Flushing Bay watershed includes a mixture of pervious and impervious areas, such as parking lots, roads, Citi Field, and open space. Other relatively open space developments representing previously developed lands include: 1,093 acres of major parks (Cunningham, Forest, and College Point Shorefront Parks); 126 acres of major cemeteries; and several large school campuses.

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

The existing land uses within the Flushing Bay watershed are shown in Figure 2-3. The existing land uses along Flushing Bay follow a four-part division: a mix of industrial, commercial, and residential use in the College Point area on the northeast side of the Bay; predominant parkland on the southern side of the Bay; mixed residential and shoreline parkland on the southwestern side of the Bay; and LaGuardia Airport on the northwest side of the Bay.

Table 2-1 summarizes the land use characteristics of the Flushing Bay watershed area.

Table 2-1. Existing Land Use within the Flushing Bay Drainage Area

Land Use Category	Percent of Area	
	Riparian Area (1/4-mile radius) (%)	Drainage Area (%)
Commercial	3	6
Industrial	8	5
Open Space and Outdoor Recreation	13	5
Mixed Use and Other	1	4
Public Facilities	3	6
Residential	15	52
Transportation and Utility	49	15
Parking Facilities	2	2
Vacant Land	6	5

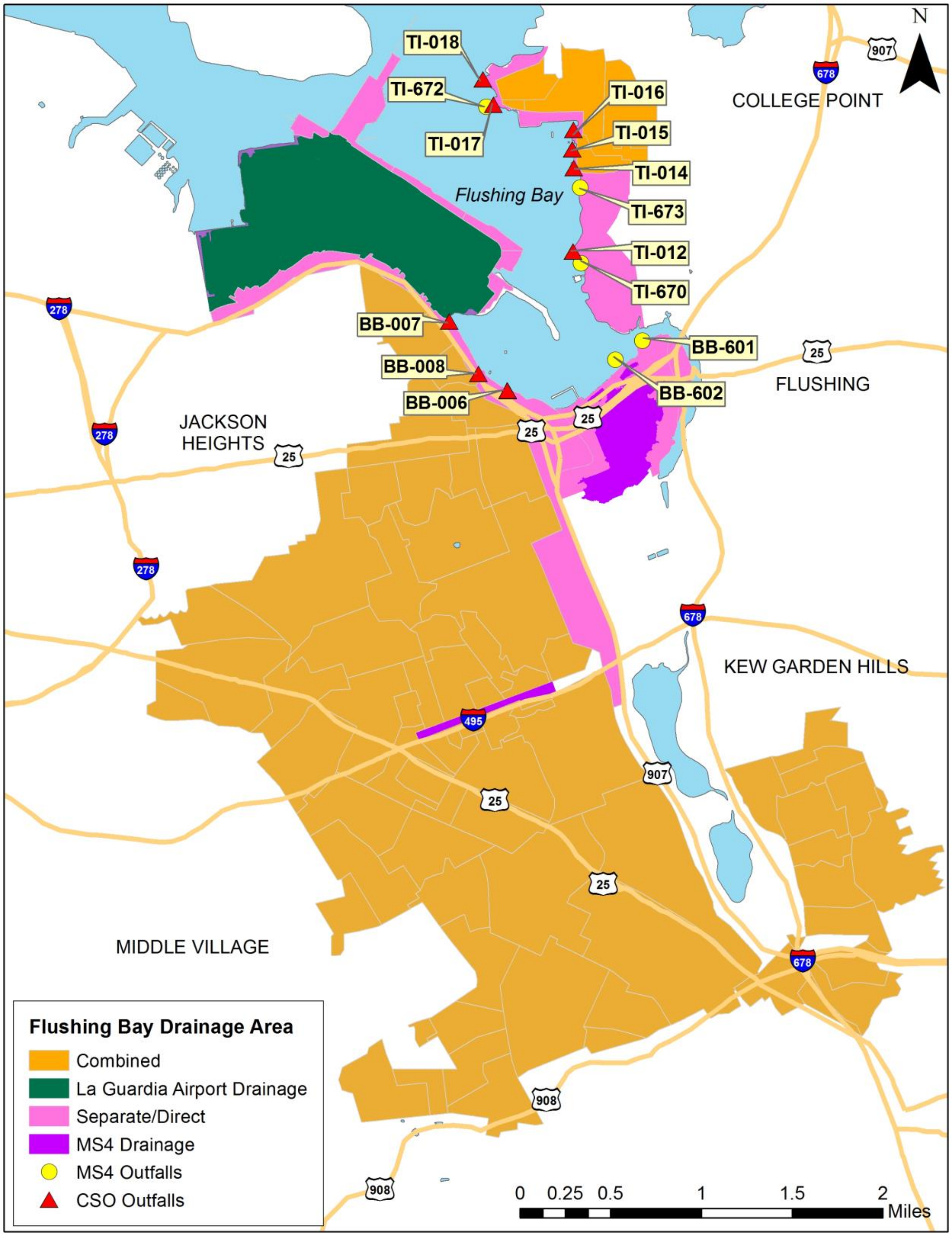

Figure 2-1. Flushing Bay Watershed and Associated WWTP Sewershed

Figure 2-2. Major Transportation Features of Flushing Bay Watershed

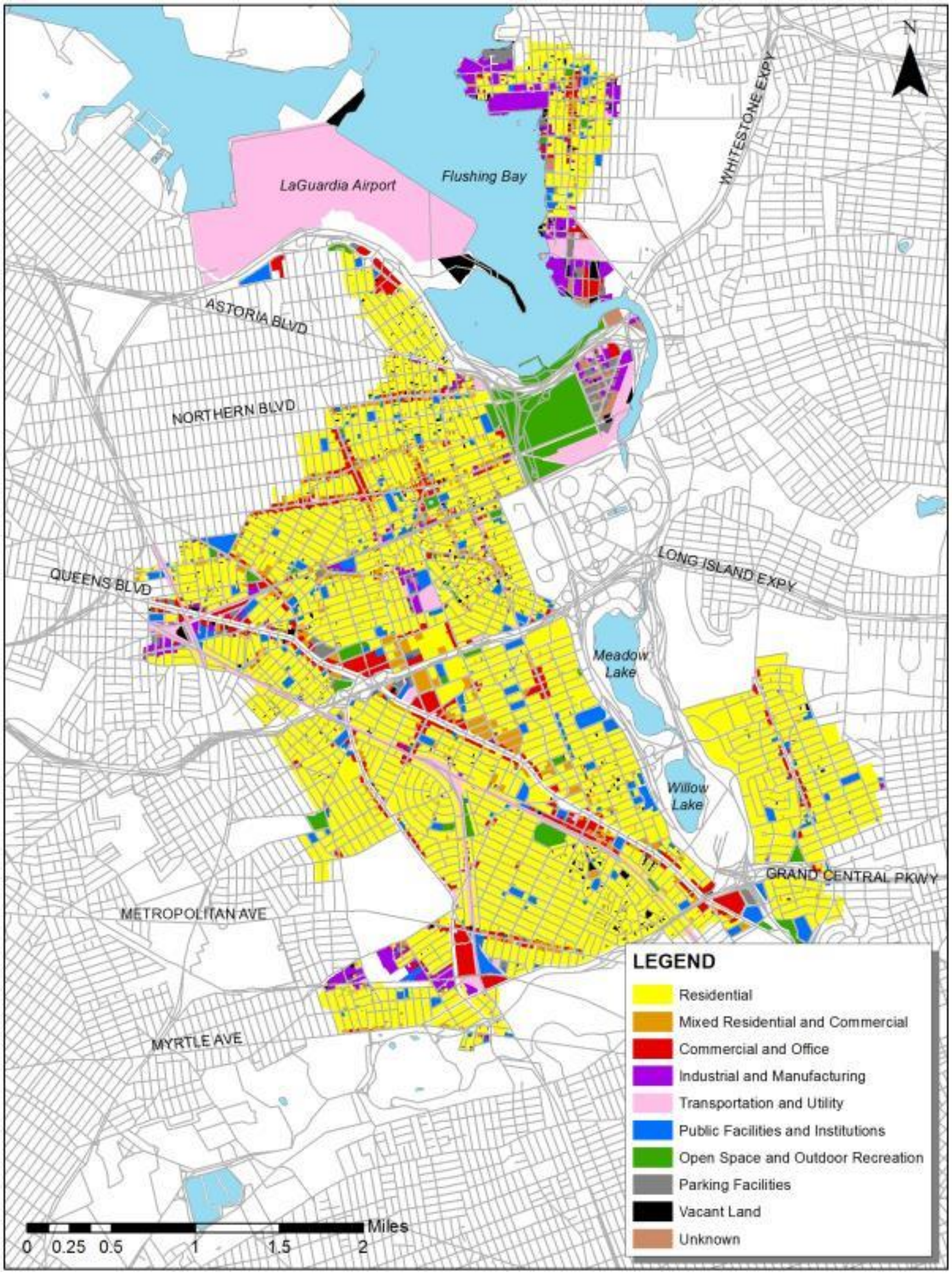

Figure 2-3. Land Use in Flushing Bay Watershed

The College Point area on the northeast side of the Bay is mostly residential and industrial, with several commercial and institutional uses mixed in. The industrial areas of College Point are mostly located along the waterfront and adjacent to residential areas. A large mass of industry is located in the area due to historic land use and development patterns. College Point experienced significant industrial development in its early years. It is now comprised mostly of manufacturing and construction uses. Several marinas and yacht clubs are located along the eastern shore of College Point. Recent redevelopment on portions of the inland section of the College Point area includes the first phase of NYC's new Police Academy located west of the former Flushing Airport, which has been closed since 1984 and has returned to largely a wetland state. The former airport, and much of the surrounding area, lies within the Special College Point District which was established in 2009 to maintain an attractive, well-functioning business park setting for business uses and ensure that there are minimal effects on adjacent residential blocks. Specific regulations pertaining to yards, signage, parking and bulk storage are based in large measure on the former Urban Renewal Plan that successfully guided the transformation of the area beginning in 1971. The corporate park environment is sustained by requiring front and side yards, restricting signage and loading locations, and setting higher parking requirements for certain commercial uses. Street tree planting and landscaping for front yards and parking lots are required for manufacturing and industrial uses.

The Flushing Bay Promenade runs for 1.4 miles along the southern shore of the Bay, from approximately 126th Street to 27th Avenue. Inland of the promenade, on the western shore of the Bay, is a large residential area made up of small apartment buildings, three-story rowhouses and garden apartments. A commercial node at the northern terminus of the promenade is primarily comprised of hotels serving LaGuardia Airport. Citi Field (home of the New York Mets professional baseball team) is located directly south of Flushing Bay on the eastern side of Grand Central Parkway, within Flushing Meadows-Corona Park. LaGuardia Airport lies on the northwest edge of Flushing Bay. The airport has a water shuttle that operates between its Marine Terminal and locations in Downtown and Midtown Manhattan. A portion of the Rikers Island correctional facility lies within the quarter-mile cut-off of Flushing Bay, but is in the East River watershed.

The Willets Point peninsula spans the western shore of Flushing Creek and the southern shore of Flushing Bay. Known as the Iron Triangle, current land uses in this unsewered, locked-in area primarily include automotive-related businesses and junkyards. A 61-acre portion of the peninsula generally bounded by the Van Wyck Expressway, Northern Boulevard, 126th Street, and Willets Point Boulevard, was the subject of a comprehensive planning, rezoning, and redevelopment strategy adopted in 2008. The 2008 Willets Point Development Plan is further discussed below.

The zoning classifications within the riparian area comprised of blocks wholly or partially within a quarter-mile of Flushing Bay are shown in Figure 2-4. The zoning in the inland College Point area is low-density residential, R2A, R4, R4A and R4-1 with a small C3 commercial zone located immediately south of Herman MacNeil Park to reflect the boating-related uses in the area. This area was rezoned in 2005 as a part of the Department of City Planning's Whitestone rezoning. The remainder of the College Point shoreline is predominantly industrial and zoned M1-1, M2-1 and M3-1. A segment of the shoreline between 23rd and 25th Street, extending to 120th Street, was rezoned to C3, to promote marina, restaurant and residential development. A portion of College Point Boulevard was also rezoned to R5B/C1-3 and R5B/C2-3 to encourage mixed use and infill development on College Point Boulevard to reinforce its traditional character. Citi Field and the Flushing Bay Promenade are designated parkland. The railroad corridor is zoned M1-1, while the industrial area to the northeast of it is zoned M3-1. The residential area south of LaGuardia Airport is R3-2 and R5, while the airport is zoned M1-1. Further inland, and to the west of the Flushing Bay Promenade is the East Elmhurst neighborhood. East Elmhurst was rezoned in 2013 to R3A, R3X, and R3-1 to reflect the neighborhood's one- and two-family residential character.

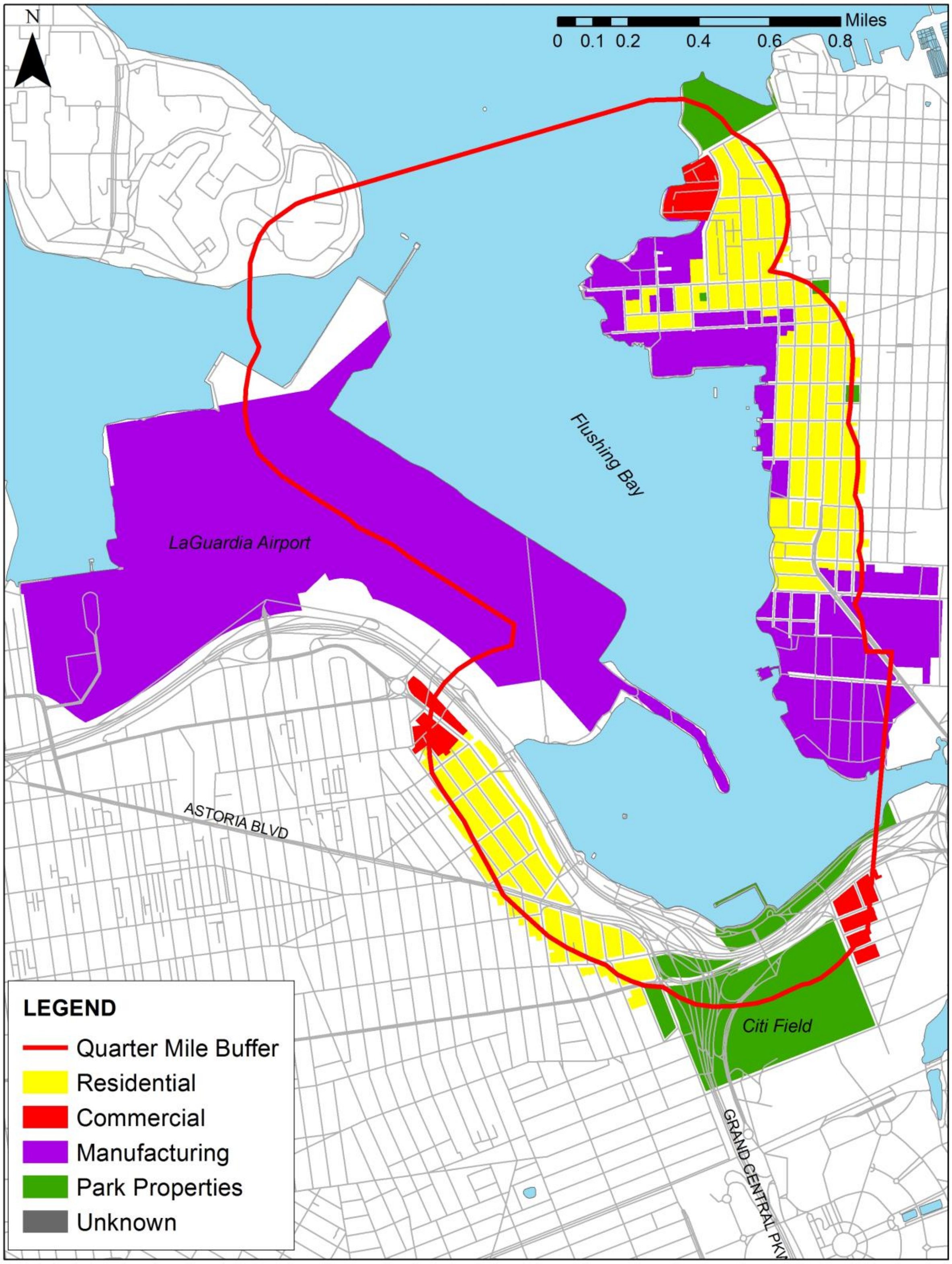

Figure 2-4. Quarter-Mile Riparian Zoning in the Flushing Creek Vicinity

Plans for significant development and redevelopment within the Flushing Bay watershed are noted below.

The 2008 Willets Point Development Plan aims at transforming a 61-acre largely under-utilized site with substandard conditions and substantial environmental degradation into a lively, sustainable mixed use community. The Plan calls for up to 5,850 residential units, 1.7 million square feet of retail space, a 400,000 square foot convention center, a 700-room hotel, 500,000 square feet of office space, and 6,700parking spaces. To provide quality-of-life amenities for residents and visitors, the program would also include an 850-seat school, 150,000 square feet of community facility space and a minimum of eight acres of public open space. In 2013, the NYC Council adopted a series of actions to facilitate an initial phase of development on a 23-acre portion of the 61-acre Special Willets Point District along 126th Street that would set the stage for a long term redevelopment of the entire Special District.

The Willets Point redevelopment will require a comprehensive remediation of the site and, according to the Environmental Impact Statement, will create separate sanitary sewered areas which will direct sanitary sewage to the Bowery Bay WWTP and send stormwater to Flushing Bay. The Willets Point/Downtown Flushing redevelopments are located within Recommendation Area 4 of the NYC Vision 2020 Comprehensive Waterfront Plan, shown in Figure 2-5. Vision 2020 also includes Recommendation Area 3 that encompasses the shore of inner Flushing Bay. The Plan proposes the study of the hydrology and means of improving water circulation and siltation, exploration of options for expanding mooring fields for recreational boats, improving maintenance of the Flushing Bay Promenade, and improving pedestrian and bicycle connections to upland areas to the west and south of the Flushing Bay Promenade including Flushing Meadows-Corona Park.

The proposed LaGuardia Airport redevelopment depicted in Figure 2-6 includes the construction of a new terminal south of the existing Central Building, four new concourses, roadways and parking with direct access to the new terminal, releasing space for aircraft maneuvering.

Another significant redevelopment is the conversion of the LaGuardia Convention Center into the Eastern Emerald Hotel. The proposed plans include a 12 story, 106,000 square foot mixed use building comprised of 197 hotel guestrooms, 206 residential apartments, a community facility and a parking garage.

2.1.a.2 Permitted Discharges

Five permitted MS4 stormwater outfalls and nine permitted CSO outfalls are located along Flushing Bay. These discharge locations, as well as other entities that hold industrial SPDES permits in the Flushing Bay watershed, are discussed in more detail in Section 2.1.c. No permitted dry-weather discharges are 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 three State-significant industrial SPDES permit holders are operating facilities located in the watershed.

Figure 2-5. NYC Vision 2020 – Reach 11 Comprehensive Waterfront Plan

Figure 2-6. Proposed LaGuardia Airport Redevelopment

Table 2-2 lists these permits, their owners and location.

Table 2-2. Industrial SPDES Permits within the Flushing Bay Watershed

Permit Number	Owner	Location
NY0008133	Port Authority of NY and NJ	Grand Central Pkwy and 94th Street
NY0032816	Lefferts Oil Terminal INC	31-70 College Point Blvd
NY0201278	Tully Environmental INC	127-20 34th Avenue

2.1.a.3 Impervious Cover Analysis

Impervious surfaces within a watershed are those characterized by an artificial surface that prevents infiltration, such as concrete, asphalt, rock, or rooftop. Some of the rainfall that lands on an impervious surface will remain on the surface via ponding, and will evaporate. The remaining rainfall volume becomes overland runoff that may flow directly into the combined sewer system or into a separate stormwater system, may flow to a pervious area and soak into the ground, or may flow directly to a waterbody. Impervious surface that is directly connected to the combined sewer system, is an important parameter in the characterization of a watershed and in the development of hydraulic models used to simulate combined sewer system performance.

A representation of the impervious cover was made in the models for the 13 NYC WWTPs that serve combined drainage areas which were developed in 2007 to support the several WWFPs that were submitted to DEC in 2009. Efforts to update the models and the impervious surface representation concluded in 2012.

As DEP began to focus 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, DEP determined that the distinction between impervious surfaces that introduce storm runoff directly to the sewer system (Directly Connected Impervious Areas [DCIA]) and impervious surfaces that may not contribute runoff directly to the sewers was important. For example, a rooftop with 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 might not contribute runoff to the combined sewer system 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. Flow meter data were then used to estimate the DCIA. 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 combined sewer system. This improved set of data aided in model recalibration, and better informed the deployment of GI projects to reduce runoff from impervious surfaces that contribute flow to the combined sewer system. As a result of the recalibration efforts, it was determined that the volume of runoff that enters the Bowery Bay High Level Interceptor system decreased significantly, particularly upstream of Outfall BB-006, from prior WWFP results. The reduction in runoff in turn resulted in a reduction in the predicted annual baseline CSO volumes to Flushing Bay. Additional information on model changes between the WWFP and LTCP2 versions of the InfoWorks model, and calibration of the LTCP2 InfoWorks model is presented in the sections below.

2.1.a.4 Population Growth and Projected Flows

DEP routinely develops water consumption and dry-weather wastewater flow projections for 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 in the IW models for the Bowery Bay WWTP and Tallman Island 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. 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 Tallman Island and Bowery Bay WWTP sewershed.

2.1.a.5 Updated Landside Modeling

The majority of the Flushing Bay watershed is included within the overall Bowery Bay WWTP system IW model. A smaller portion of the watershed, at the northeastern end, is served by the Tallman Island WWTP and is represented within the Tallman Island IW model. Several modifications to both collection systems have occurred since the models were calibrated in 2007. Given that both models have been used for analyses associated with the annual reporting requirements of the SPDES permit, Best Management Practices (BMPs) and Post-Construction Compliance Monitoring (PCM) program for the Flushing Creek CSO Retention Facility, also known as Flushing Bay CSO Retention Facility, many of these changes already have been incorporated into the models. Other updates to the modeled representation of the collection systems that have been made since the 2007 update include:

<u>Tallman Island IW Model</u>

- The Flushing Creek and Alley Creek CSO Retention Tanks were added to the model, including the dewatering operations for each facility.
- The Bowery Bay drainage areas that contribute CSOs to the Flushing Creek CSO Retention Facility were added to the Tallman Island model. Because the overflows from three of the Bowery Bay high level sewershed regulators are conveyed to this facility through the Park Avenue outfall, this model update was performed to avoid the need to run the Bowery Bay model as a precursor to every Tallman Island model run.
- Weirs at Regulators 10, 10A and 13 were modified, per final design.
- The weir in Regulator TI-09 was raised.
- Stormwater areas were modified based on information provided by DEP. Boundaries for stormwater Outfalls TI-71, TI-608, TI-639, TI-641, and MS4 Outfalls TI-670 and TI-673 were modified.

<u>Bowery Bay IW Model</u>

- A new subcatchment representing the Lutheran Cemetery was added.
- The Corona Avenue Vortex Facility was removed from the model because it was out-of-service since 2011.
- The BB-006 outfall pipe dimensions were revised.
- The 24th Street weir model setup was revised.
- The representation of several weirs was updated based on new information.
- Stormwater areas tributary to stormwater Outfalls BB-54, BB-55, and MS4 Outfalls BB-601 and BB-602 were modified based on information provided by DEP .
- Stormwater areas for LaGuardia Airport and Citi Field were added.
- The Bowery Bay High-level (BBH) and Bower Bay Low-level (BBL) models were combined to better simulate the effects of linking the high- and low-level wet wells.

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

- ***Runoff Generation Methodology***. The identification of pervious and impervious surfaces. As described in Section 2.1.a.3 above, the impervious surfaces were also categorized into DCIA 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 were inspected. 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 that had not yet been 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. For the calibration period, the DWF generation rates were developed by dividing 2011 plant flows by the population from the 2010 census. The DWF generation rate was then applied to each catchment in the model based on population. The resulting DWF was then adjusted if necessary to match the calibration meters. The projected 2040 DWF were used in the LTCP Baseline Conditions model that was the basis for evaluating alternatives.

- ***Precipitation.*** The annual rainfall series that was to be used to represent a typical year of rainfall for annual model simulations was re-evaluated as part of this exercise. This re-evaluation is discussed in Section 2.1.b below.

In addition to the updates and enhancements listed above, 13 of DEP's IW landside models underwent recalibration in 2012. The recalibration process and results are included in the IW Citywide Recalibration Report (DEP, 2012a) required by the 2012 CSO Order. Following this report, DEP submitted to DEC a Hydraulic Analysis report in December 2012 (DEP, 2012b). 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 components of the model, which had been modified since 2007. 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. The upland areas ranged from 15 to 400 acres in size. A range of areas with different land use mixes was selected to support the development of standardized sets of coefficients which could 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 were 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 Flushing Bay LTCP. A comprehensive discussion of the recalibration efforts can be found in the previously noted IW Citywide Recalibration Report (DEP, 2012a) and the Hydraulic Analysis Report (DEP, December 2012). Additional model updates were made in support of this LTCP and were described above.

2.1.b Review and Confirm Adequacy of Design Rainfall Year

In previous planning work for the WWFPs, DEP applied the 1988 annual precipitation characteristics to the landside IW models to develop loads from combined and separately sewered drainage areas. The year 1988 was considered representative of long term average conditions. Therefore, that year was used to analyze facilities where "typical" rather than extreme conditions served as the basis of design, in accordance with 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. A comprehensive range of historical rainfall data were evaluated from 1969 to 2010 at four rainfall gauges (CPK, LGA, JFK, EWR). The 2008 JFK rainfall was determined to be the most representative of average annual rainfall across all four gauges. Figure 2-7 shows the annual rainfall at JFK for 1969 through 2014. As indicated in Figure 2-7, the JFK 2008 rainfall currently used for the LTCP typical year includes almost six inches more rainfall than JFK 1988 rainfall that was used for the WWFP evaluations, and is more consistent with recent rainfall trends. As a result, recent landside modeling analyses as part of the LTCP process have used the 2008 precipitation as the typical rainfall year in NYC, together with the 2008 tide observations. Based on an analysis of 30 years of rainfall data at four rain gauges (JFK, LGA, EWR, CPK), the rainfall recorded at the JFK gauge in 2008 was also determined to be closest in characteristics to the 30-year average of all four gauges together. The 2008 JFK data had a higher total rainfall volume than the JFK 1988 data, and was considered to be more reflective of current climate conditions. The 10-year period of 2002 to 2011 is also used to assess long term performance of the LTCP recommended plans (see Section 6).

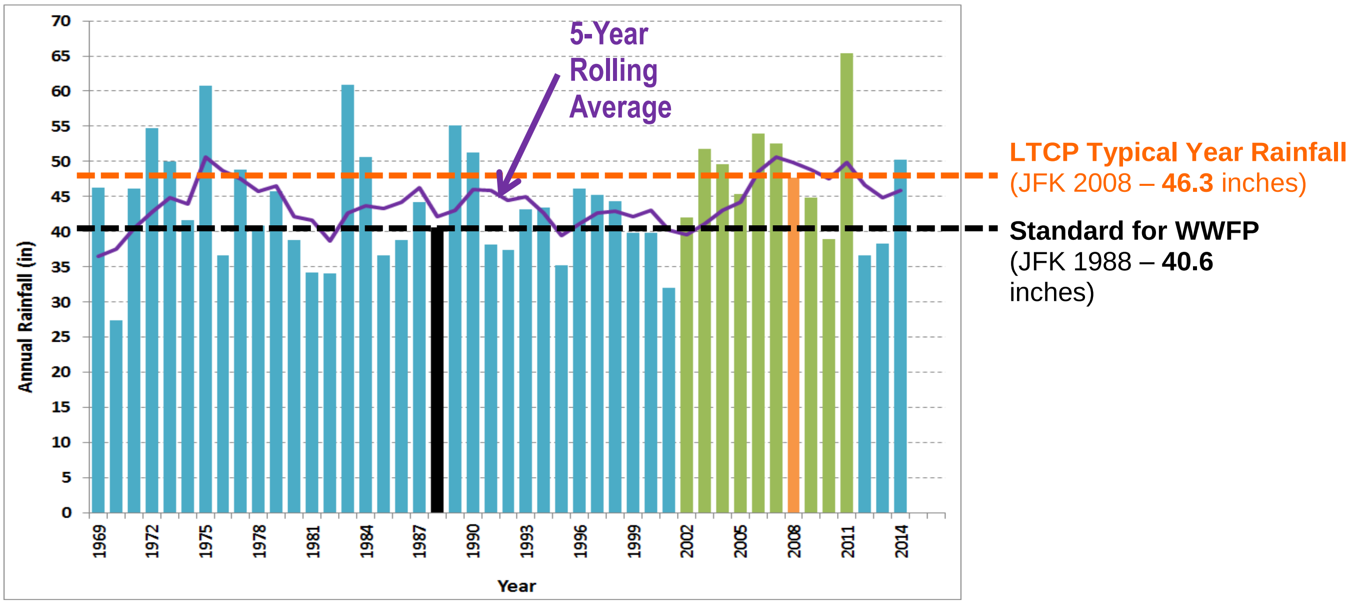

Figure 2-7. Annual Rainfall Data and Selection of the Typical Year

2.1.c Description of Sewer System

The Flushing Bay watershed/sewershed is located within the Borough of Queens (Queens County, within NYC). The western shore of the watershed is served by the Bowery Bay WWTP and its collection system, which is the major contributor of CSO to the waterbody. Table 2-1 shows the different land uses within the drainage areas served by the Bowery Bay WWTP and tributary to the Flushing Bay watershed. The Tallman Island WWTP collection system contributes small volumes of CSO to Flushing Bay at the northeastern end of the watershed. The locations of these wastewater treatment facilities and the respective sewershed boundaries are as shown in Figures 2-9 and 2-12. The CSO and stormwater outfalls associated with Flushing Bay are shown in Figure 2-8. As the figure shows, numerous discharge points are located around the perimeter of Flushing Bay. In total, 72 discharge points have been documented to exist along the shoreline of Flushing Bay by the Shoreline Survey Unit of the DEP, as shown in Table 2-3.

Table 2-3. Outfalls Discharging to Flushing Bay

Identified Ownership of Outfalls	Number of Outfalls
NYCDEP	DEP MS4 Permitted = 5
	DEP CSO Permitted = 9
NYS Department of Transportation	18
Private	34
Unknown	7
Total	72

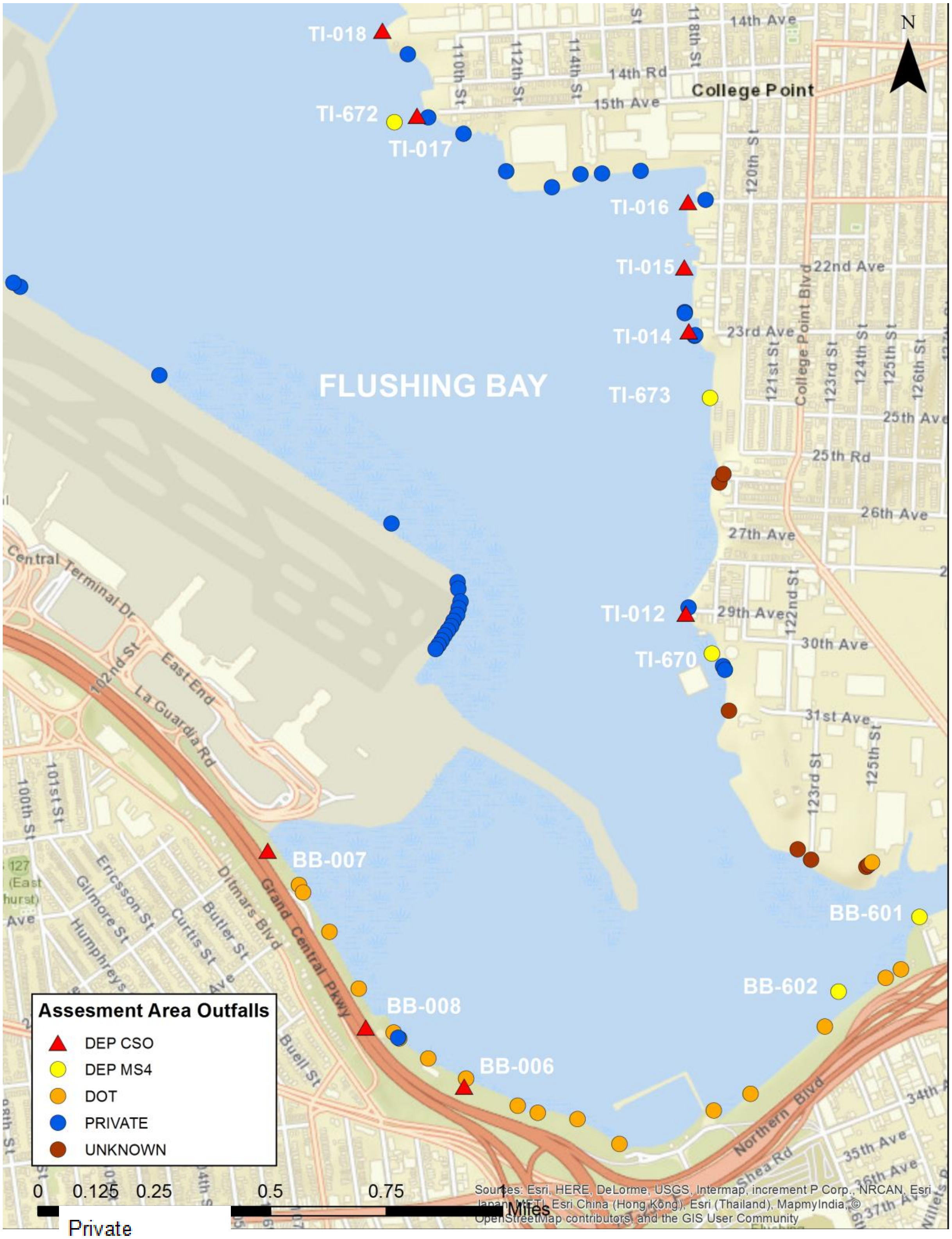

Figure 2-8. Flushing Bay Outfalls

The following sections describe the major features of the Bowery Bay and Tallman Island WWTP sewersheds within the Flushing Bay watershed. Table 2-4 shows the areas served by the various drainage system categories.

Table 2-4. Bowery Bay WWTP and Tallman Island WWTP Sewersheds Tributary to Flushing Bay: Acreage Per Sewer Category

Sewer Area Description	Area (acres)
Combined	**5,291**
Separate MS4	**122**
Direct Overland and Other	**1,037**
LaGuardia Airport	**427**
Total	**6,877**

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

Bowery Bay WWTP Drainage Area and Sewer System

The Bowery Bay WWTP is located at 43-01 Berrian Blvd. in the Astoria section of Queens, on a 34.6 acre site adjacent to the Rikers Island Channel. The Bowery Bay WWTP serves an area in the northwest section of Queens, including the communities of Kew Garden Hills, Rego Park, Forest Hills, Forest Hills Gardens, North Corona, South Corona, Lefrak City, Elmhurst, Jackson Heights, Maspeth, Woodside, Sunnyside Gardens, Sunnyside, Hunters Point, Long Island City, Astoria, Astoria Heights, Steinway, Ravenswood, and Roosevelt Island. Wastewater flows to the Bowery Bay WWTP through two interceptors. The Low Level Interceptor flows east toward the plant and the High Level Interceptor flows west toward the plant. The elevation differential between the High Level and Low Level Interceptors at the Bowery Bay WWTP is 29 feet. The Low Level Interceptor serves approximately 3,502 acres in the western side of the Bowery Bay sewershed, carrying flow from individual drainage basins along the East River extending to Newtown Creek. The High Level Interceptor serves approximately 8,392 acres in the central and eastern part of the Bowery Bay sewershed, carrying flows from individual drainage basins extending from Steinway Creek, Bowery Bay itself, and Flushing Bay. Figure 2-9 shows the Bowery Bay Collection System. The drainage areas of the Bowery Bay WWTP sewershed are depicted in Figure 2-10.

The major conveyance and regulation components of the High Level Interceptor include seven combined sewer pump stations and 19 diversion regulator structures.

Table 2-5 shows the drainage areas that contribute CSO to Flushing Bay. Regulators 06, 07, 08 and 09 are located in series from downstream to upstream, so for example, the tributary area to Regulator 06 includes all of the Regulator 07 tributary area, plus some additional area downstream of Regulator 07.

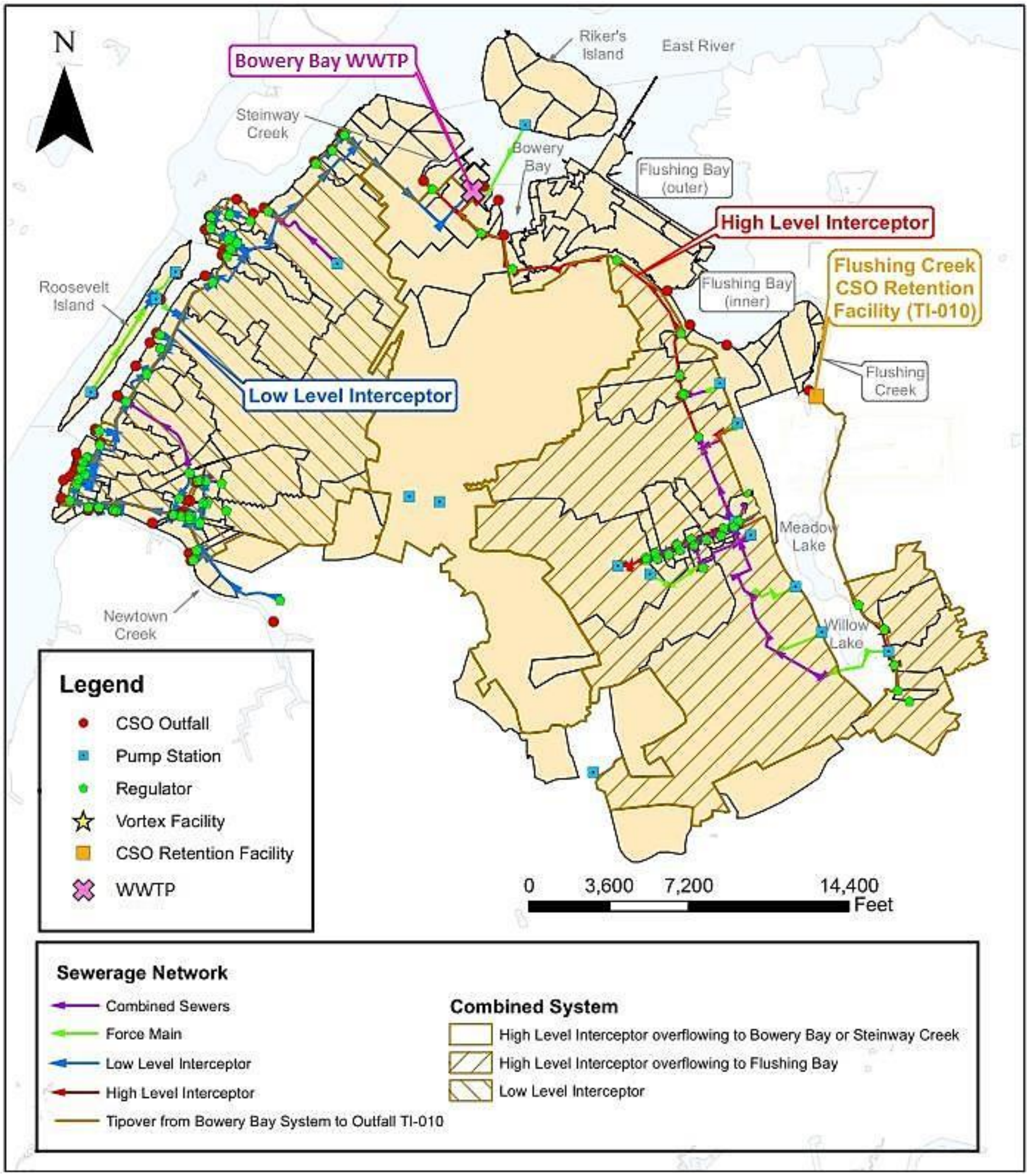

Figure 2-9. Bowery Bay WWTP Collection System

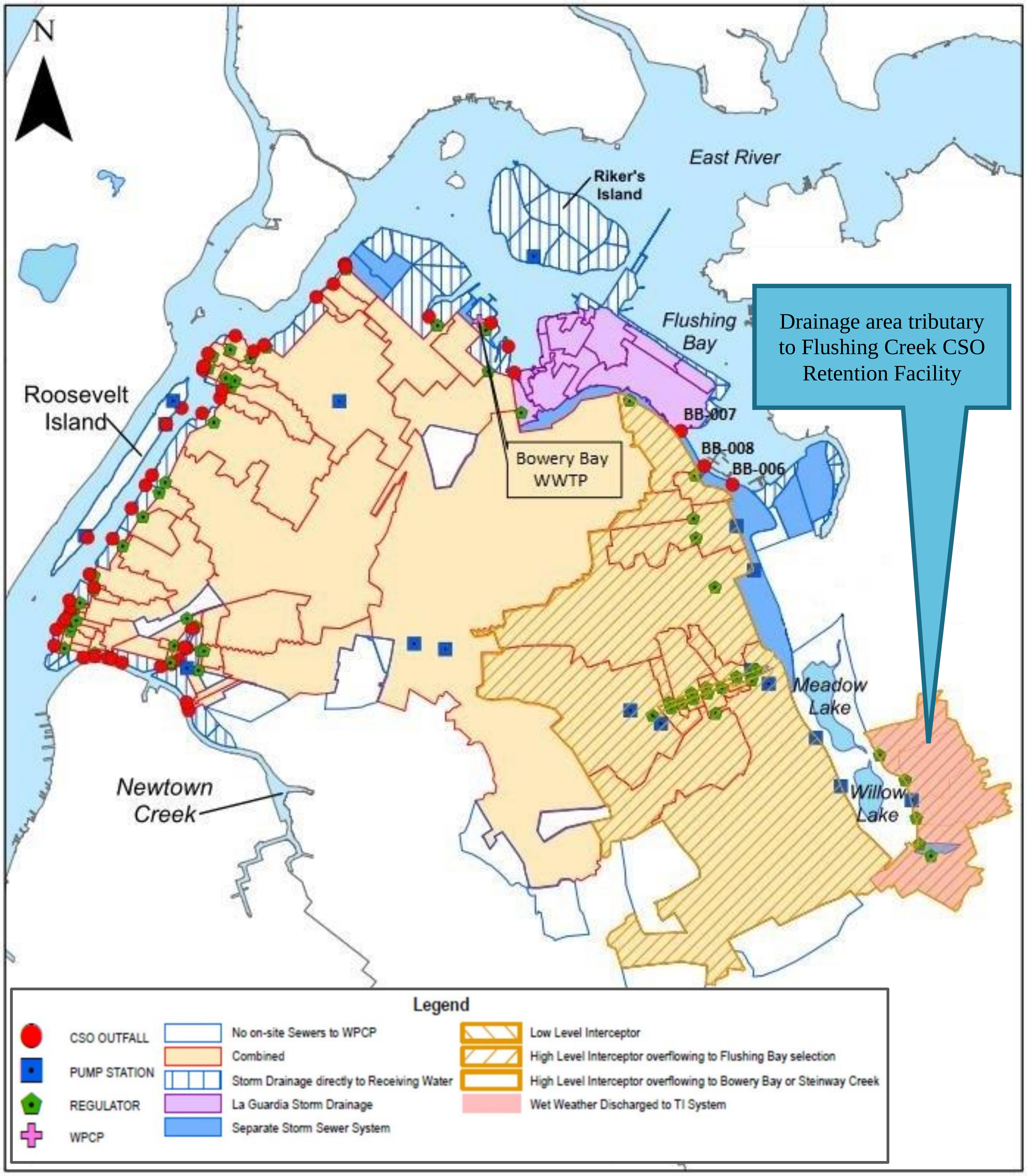

Figure 2-10. Bowery Bay WWTP Drainage Areas

Table 2-5. Bowery Bay WWTP Drainage Area Contributing to Flushing Bay: Acreage by Outfall/Regulator

Outfall	Outfall Drainage Area	Regulator	Regulator Drainage Area (acres)	Regulated Drainage Area Type	Receiving Water
BB-006	**3,775**	10 (Upper Deck)	2,707	**Combined**	Flushing Bay
		13 (Lower Deck)	1,068		
		Total	**3,775**		
BB-008	**1,151**	06	1,151(1)	**Combined**	
		07	1,107(2)		
		08	1,026(3)		
		09	811		
		Total	**1,151**		
BB-007	**146**	**Total**	**146**	**Combined**	

Notes:
(1) Area tributary to BB-008 Regulator 09, Regulator 08, Regulator 07, and Regulator 06.
(2) Area tributary to BB-008 Regulator 09, Regulator 08, and Regulator 07.
(3) Area tributary to BB-008 Regulator 09 and Regulator 08.

Bowery Bay Non-Sewered Areas

Some areas within the Bowery Bay sewershed are considered direct drainage areas, where stormwater drains directly to receiving waters without entering the combined sewer system or a separate drainage pipe network. As shown in Figure 2-10, these areas are generally located along the shoreline. Some areas, also shown in Figure 2-10, are not served by sanitary sewers, relying on on-site septic systems for sanitary sewage disposal. In one of these areas, the Willets Point redevelopment will include build-out of sanitary sewers tributary to the Bowery Bay WWTP combined sewer system and storm sewers discharging through outfalls along Flushing Bay. This redevelopment is part of Reach 11 - Queens Upper East River of the Vision 2020 New York City Comprehensive Waterfront Plan. The Willets Point/Downtown Flushing redevelopments are located within Recommendation Area 4 shown in Figure 2-11. As shown, the Vision 2020 Plan also includes Recommendation Area 3 that encompasses the shore of inner Flushing Bay. The Plan proposes the study of the hydrology and means of improving water circulation and siltation, exploration of options for expanding mooring fields for recreational boats, improving maintenance of the Flushing Bay Promenade, and improving pedestrian and bicycle connections to upland areas to the west and south of the Flushing Bay Promenade including Flushing Meadows-Corona Park.

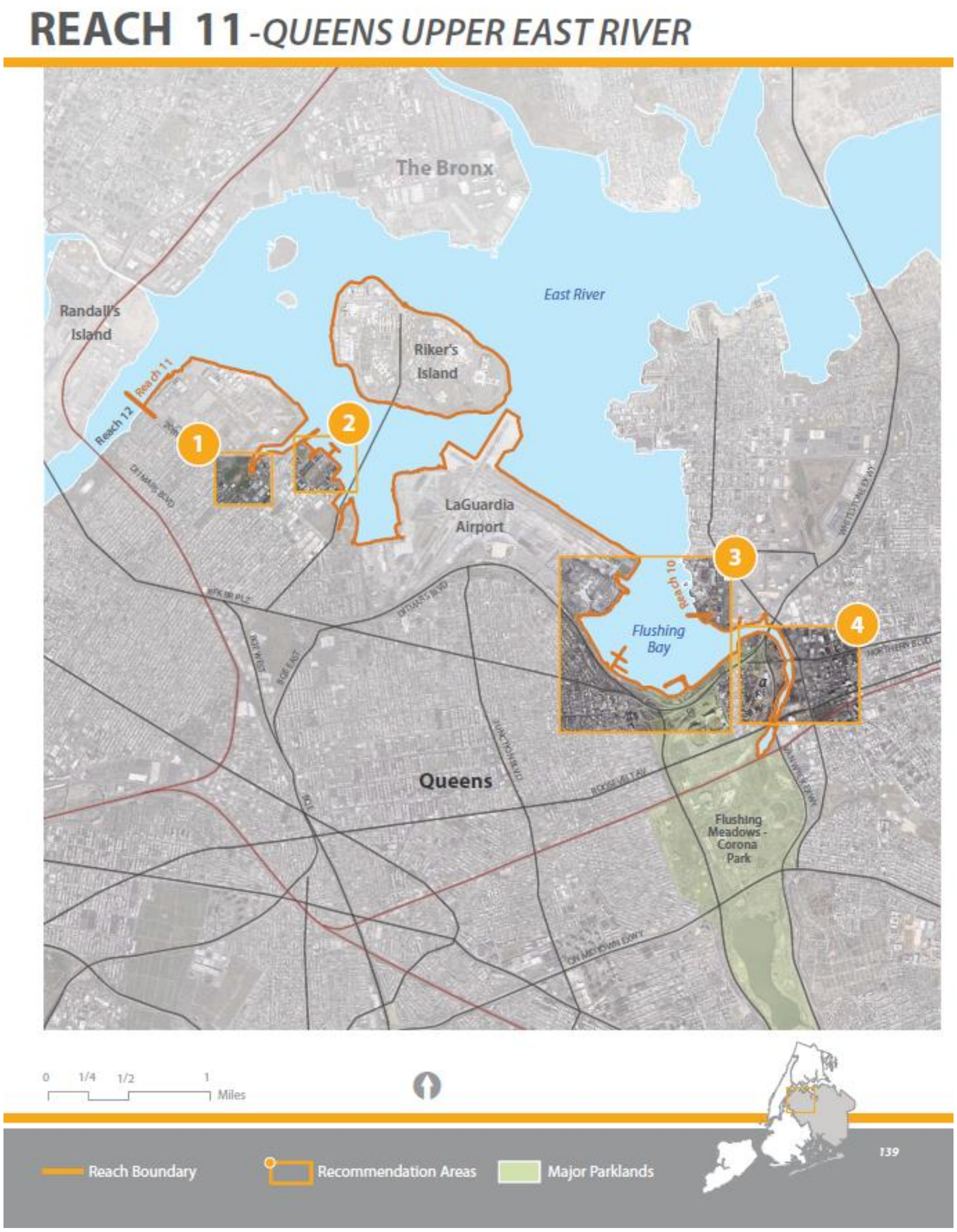

Figure 2-11. NYC Vision 2020 – Reach 11 Comprehensive Waterfront Plan

Bowery Bay MS4 Outfalls

Two SPDES-permitted MS4 outfalls (BB-601 and BB-602) are associated with the Bowery Bay WWTP sewershed served by the High Level Interceptor. These MS4 outfalls, shown in Figure 2-7, both discharge to Flushing Bay near the mouth of Flushing Creek. These outfalls drain stormwater runoff from the separate sanitary sewer areas around the Willets Point area. While runoff from these areas does not enter the combined system, the stormwater discharging to Flushing Bay can impact water quality in the Bay and Creek.

Bowery Bay CSOs

Three SPDES-permitted Bowery Bay CSO outfalls associated with the High Level Interceptor discharge to Flushing Bay. These three outfalls, BB-006, BB-007 and BB-008, are shown in Figure 2-7. It should be noted that BB-006 discharges the largest annual CSO volume of all the CSO outfalls citywide.

Tallman Island WWTP Drainage Area and Sewer System

The northeastern portion of the Flushing Bay watershed is served by the Tallman Island WWTP. The Tallman Island sewershed includes sanitary and combined sewers. The Tallman Island service area includes:

- 16 pumping stations, with five serving combined system areas;
- 49 combined sewer flow regulator structures; and
- 24 CSO outfalls, two of which are permanently bulkheaded.

The Tallman Island WWTP is located at 127-01 134th Street, in the College Point section of Queens, on a 31-acre site adjacent to Powells Cove. The Tallman Island WWTP serves the sewered area in the northeast section of Queens, including the communities of Little Neck, Douglaston, Oakland Gardens, Bayside, Auburndale, Bay Terrace, Murray Hill, Fresh Meadows, Hillcrest, Utopia, Pomonok, Downtown Flushing, Malba, Beechhurst, Whitestone, College Point, and Queensboro Hill. A total of 490 miles of sanitary, combined, and interceptor sewers feed into the Tallman Island WWTP, as shown on Figure 2-12. The corresponding Tallman Island WWTP sewershed are shown in Figure 2-13. A total of 438 acres of the Flushing Bay watershed area are served by the Tallman Island WWTP.

The Tallman Island WWTP has provided full secondary treatment since 1978. 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 Tallman Island WWTP has a design dry-weather flow (DDWF) capacity of 80 million gallons per day (MGD), and is designed to receive a maximum flow of 160 MGD (two times design dry-weather flow) with 120 MGD (one and one-half times design dry-weather flow) receiving secondary treatment. Flows over 120 MGD receive primary treatment and disinfection.

The Tallman Island WWTP includes four principal interceptors: the Main Interceptor, the College Point Interceptor, the Flushing Interceptor, and the Whitestone Interceptor.

- The Main Interceptor is a direct tributary to the Tallman Island WWTP, and picks up flow from the College Point and Flushing interceptors.

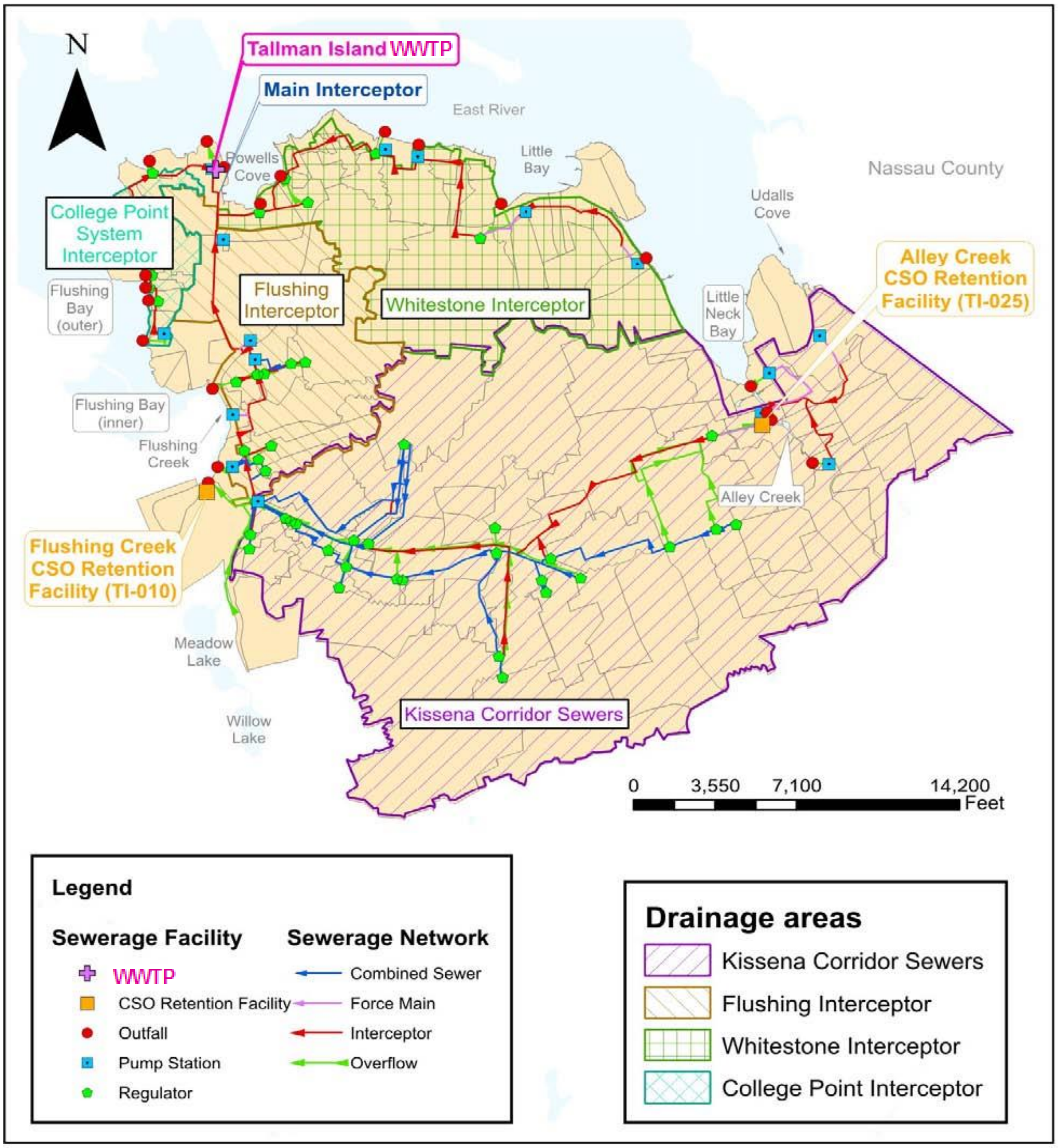

Figure 2-12. Tallman Island WWTP Sewershed Collection System

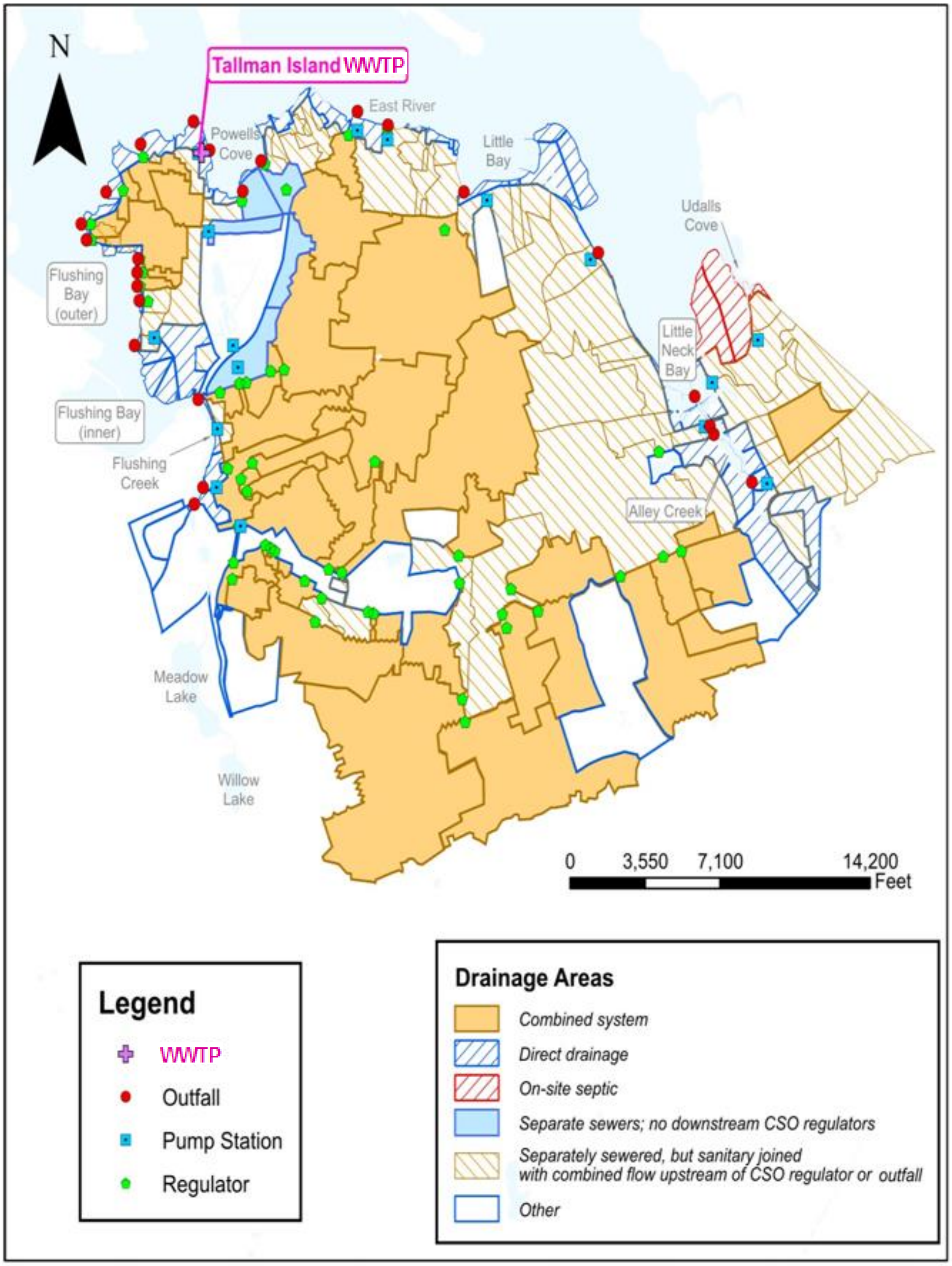

Figure 2-13. Tallman Island WWTP Drainage Areas

- The College Point Interceptor carries flow from sewersheds to the west of the treatment plant, and discharges into the Powell's Cove Pumping Station, which discharges into the Main Interceptor within the WWTP premises.
- The Flushing Interceptor is an extension of the Main Interceptor south of the Whitestone connection, and serves most of the areas to the south in the system. The Flushing Interceptor also receives flow from the southeast areas of the system, along the Kissena Corridor Interceptor (via trunk sewers upstream of the TI-R31 regulator), and from the Douglaston area. The Alley Creek sewershed drains to the Tallman Island WWTP via the Kissena Corridor Interceptor.
- The Whitestone Interceptor conveys flow from the area east of the treatment plant along the East River. Until recently, the Whitestone Interceptor used to discharge to the Main Interceptor from the west side, just upstream of the College Point Interceptor connection, via gravity discharge. As proposed in the Flushing Creek WWFP, the Whitestone Interceptor was extended and disconnected from the Flushing Interceptor. The new extension came on-line in mid-2014.

This service area also includes two CSO retention facilities that were developed from the East River Facility Planning and WWFP processes. The first facility is the Flushing Creek CSO Retention Facility, also referred to as Flushing Bay CSO Retention Facility, with a total capacity of 43.4 million gallons (MG) (28.4 MG of off-line storage and 15 MG of in-line storage in large outfall pipes). This facility has been operational since May 2007. Post-event, retained flow is pumped to the upper end of the Flushing Interceptor, upstream of Regulator TI-009. This regulator was reconstructed in 2005 to provide adequate capacity to convey both sanitary flows and dewatered flow from the retention tank following wet-weather events.

The second facility is the Alley Creek Retention Tank, which was put into operation in March 2011. This retention tank has an off-line storage capacity of 5 MG. During wet-weather, flows are directed to the off-line storage tank by the diversion weir in Chamber 6 of the Alley Creek CSO Retention Tank. When the retention tank reaches capacity, excess water overflows the storage basin and is discharged to Alley Creek through Outfall TI-025, after receiving floatables control. Post-event dewatering of this tank is accomplished through the upgraded Old Douglaston Pumping Station, which has a peak capacity of 8.5 MGD.

Tallman Island Non-Sewered Areas

Some areas within the Tallman Island WWTP sewershed are considered direct drainage areas, where stormwater drains directly to receiving waters without entering the combined sewer system. These areas are generally located along the shoreline, and were delineated based on topography. Some areas are not served by sanitary sewers, relying on on-site septic systems for wastewater disposal. The direct drainage and septic system areas are shown in Figure 2-13.

Tallman Island MS4 Outfalls

The Tallman Island WWTP SPDES permit currently includes three permitted MS4 outfalls tributary to Flushing Bay, as shown in Figure 2-7. Outfalls TI-670, TI-672 and TI-673 drain stormwater runoff from the separate sanitary sewer areas around Flushing Bay. Runoff from these areas contributes stormwater discharges to Flushing Bay.

Tallman Island/Flushing Creek CSOs

Six SPDES-permitted CSO outfalls discharge to Flushing Bay from the Tallman Island system. The six CSO outfalls, identified as TI-012, TI-014, TI-015, TI-016, TI-017 and TI-018, are shown in Figure 2-7.

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 carbonaceous biochemical oxygen demand ($CBOD_5$), total suspended solids, fecal coliform bacteria and enterococci bacteria to use in calculating loadings from various sources.

Table 2-6 shows both the sanitary and stormwater concentrations assigned to the service areas of the collection systems that discharge to Flushing Bay. Influent dry-weather samples at the WWTPs were used to model sanitary concentrations (HydroQual, 2005b). Previously-collected citywide sampling data from Inner Harbor Facility Planning Study (DEP, 1994) was combined with data from the EPA Harbor Estuary Program (HydroQual, 2005a) to develop the stormwater concentrations. The stormwater concentrations shown below are based on the most recent data available. The IW sewer system model (Section 2.1.a.5) is used to generate the flows from NYC CSO and storm sewer outfalls.

Table 2-6. Flushing Bay Source Loadings Characteristics

Source	Enterococci (cfu/100mL)	Fecal Coliform (cfu/100mL)	BOD_5 (mg/L)
Urban Stormwater(2)	15,000	35,000	15
CSOs (BB-006 and BB-008)(1)	Monte Carlo	Monte Carlo	Mass Balance (Sanitary =140)
Sanitary for Mass Balance CSOs(1)	600,000	4,000,000	Mass Balance (Sanitary=140)
Highway/Airport Runoff (3)	8,000	20,000	15
Direct Drainage(3)	6,000	4,000	15

Notes:
(1) Flushing Bay LTCP Sewer System and Water Quality Modeling, 2016.
(2) HydroQual Memo to DEP, 2005a.
(3) Basis – NYS Stormwater Manual, Charles River LTCP, National Stormwater Data Base.

A flow monitoring and sampling program targeting CSO tributary to Flushing Bay 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.

CSO concentrations can vary widely 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 2015 to provide site-specific information for Outfalls BB-006 and BB-008. The CSO bacteria concentrations were characterized by direct measurements of four CSO events during various storms occurring during the months of July 2015 through October 2015. These concentrations are shown in the form of a cumulative frequency distribution in Figures 2-14 and 2-15. Individual sample points are shown, as well as the trend line that best fits the data distribution. For Outfall BB-006, CSO discharges measured fecal coliform concentrations are log-normally distributed and values range from 78,000 to 4,400,000 cfu/100mL (Figure 2-14). As shown in the figure, one analytical fecal coliform result of 2,000 cfu/100mL does not follow the same distribution as the remainder data points and is therefore not used within the LTCP processes. Similarly, enterococci concentrations are also log-normally distributed and range from 63,000 to 12,700,000 cfu/100mL. For Outfall BB-008, measured CSO fecal coliform concentrations are log-normally distributed, and values range from 90,000 to 4,600,000 cfu/100mL (Figure 2-15). Similarly, enterococci concentrations are also log-normally distributed and range from 90,000 to 2,700,000 cfu/100mL.

Flow monitoring data were collected for CSO Outfalls BB-006 and BB-008 to support the development of the Flushing Bay LTCP. A description of the Bowery Bay WWTP IW model update and calibration processes based on the flow monitoring data gathered for Outfalls BB-006 and BB-008 was provided earlier in Section 2.1.a.5.

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.

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 WWTPs are predicted to receive and treat up to 2xDDWF for the rainfall year 2008 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 (DEP, 2012b) submitted to DEC. The objective of each evaluation and the specific approach undertaken are briefly described in the following paragraphs. Because the CSO contribution from the Tallman Island WWTP collection system to Flushing Bay is minimal in comparison to the CSO contribution from the Bowery Bay system, the following summary of the 2012 recalibration effort is presented for the Bowery Bay WWTP exclusively.

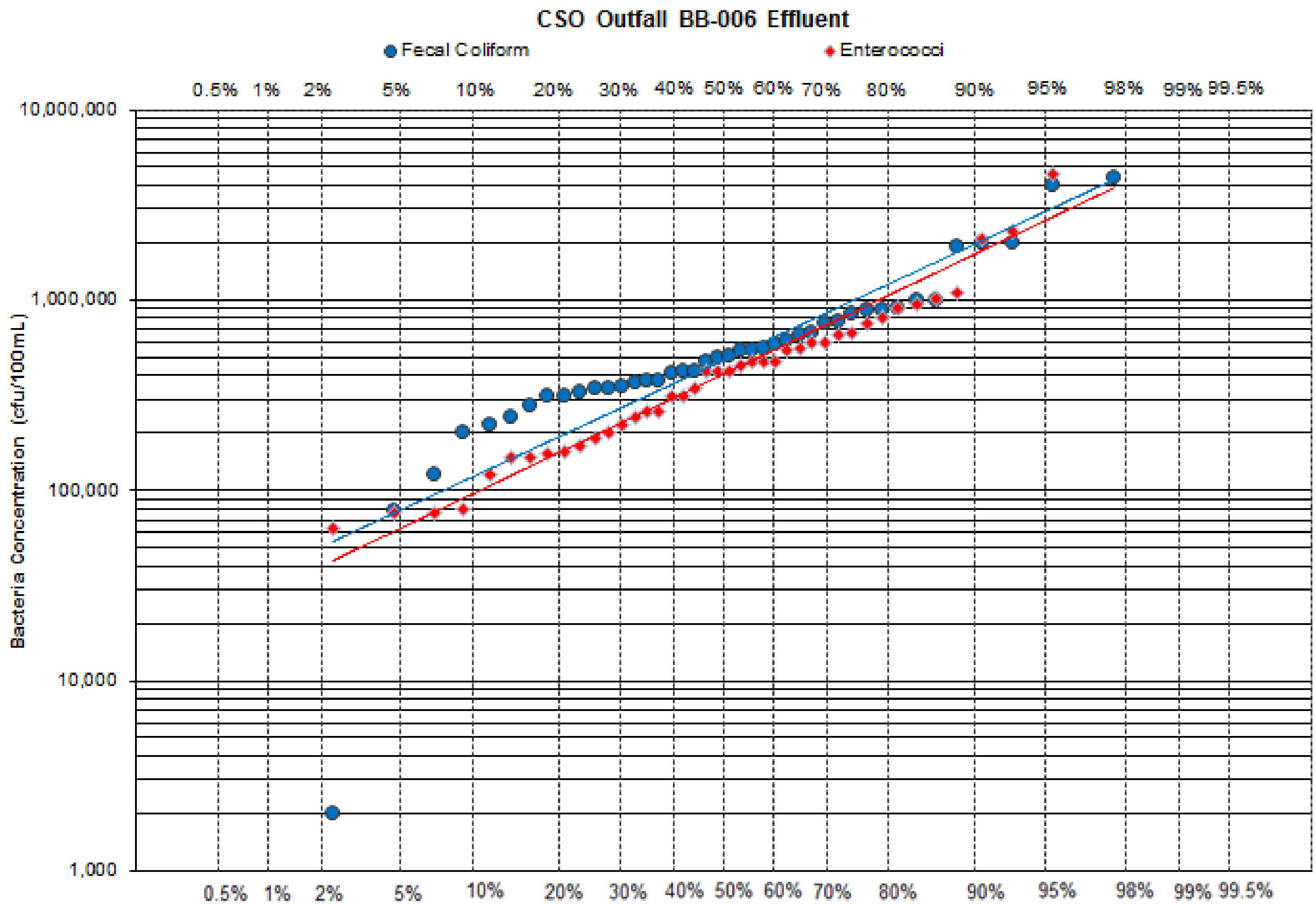

Figure 2-14. Outfall BB-006 Measured CSO Bacteria Concentrations

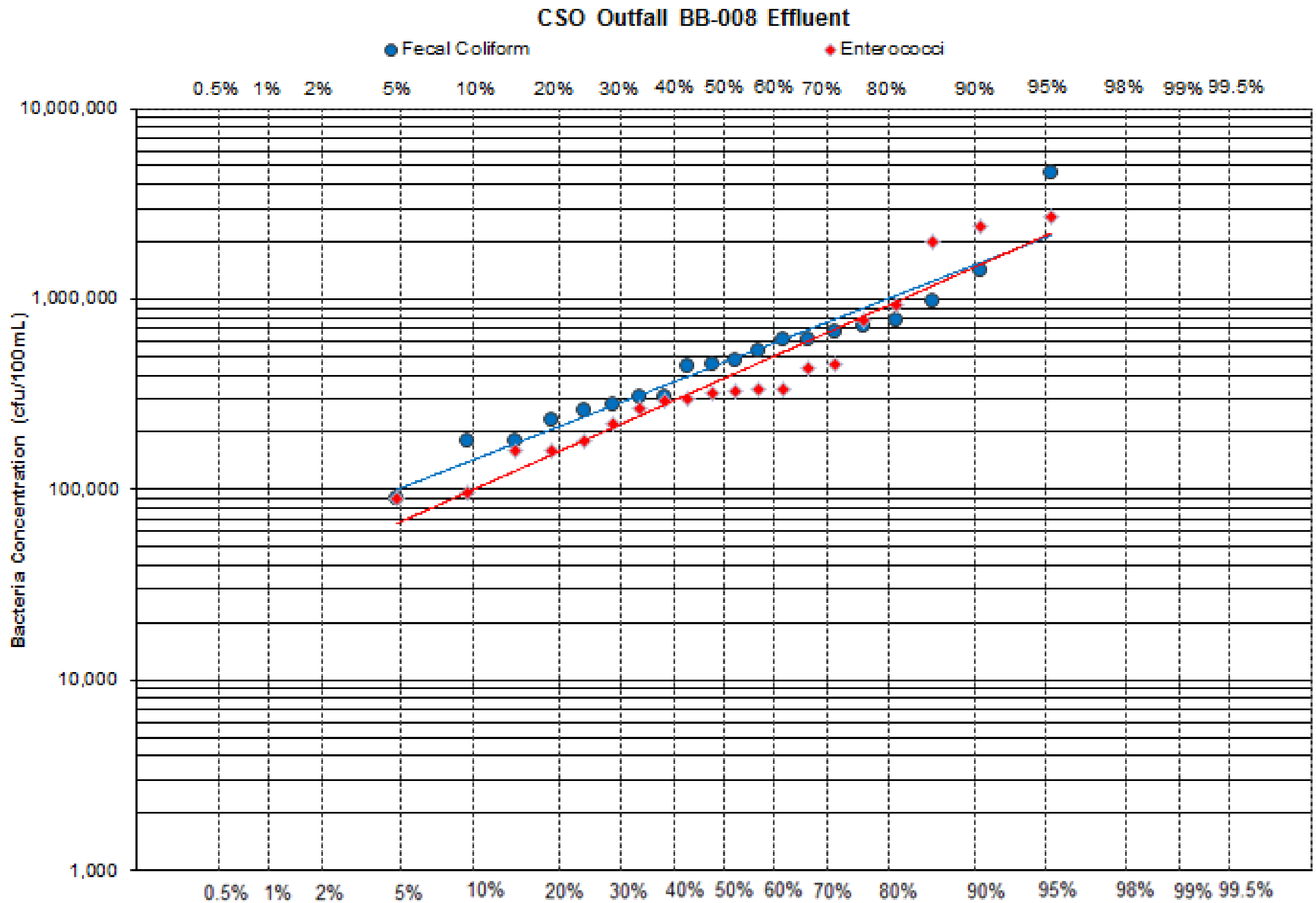

Figure 2-15. Outfall BB-008 Measured CSO Bacteria Concentrations

Annual Hours at 2xDDWF for 2008 with Projected 2040 DWF

Model simulations were conducted to estimate the annual number of hours that the Bowery Bay WWTP would be expected to treat 2xDDWF for the 2008 precipitation year. These simulations were conducted using projected 2040 DWF for two model input conditions – the recalibrated model conditions as described in the December 2012 IW Citywide Recalibration Report (DEP, 2012a), 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. For these simulations, the primary input conditions applied were as follows:

- Projected 2040 DWF conditions.
- 2008 tides and precipitation data.
- Bowery Bay WWTP at 2xDDWF capacity of 300 MGD.
- No sediment in the combined sewers (i.e., clean conditions).
- Sediment in interceptors representing the sediment conditions after the inspection and cleaning program completed in 2011 and 2012.
- No green infrastructure.

Key observations/findings are summarized below:

- Simulation of the 2008 annual rainfall year resulted in a prediction that the Bowery Bay WWTP would operate at its 2xDDWF capacity for 58 hours under the no-CEG condition. When the CEG conditions were applied in the model, the annual number of hours at 2xDDWF was slightly higher - at 74 hours.
- The total volume (dry- and wet-weather combined) treated annually at the Bowery Bay plant for the 2008 non-CEG condition was predicted to be about 47,289 MG, while the 2008 with CEG condition resulted in a prediction that 47,471 MG would be treated at the plant – an increase of 182 MG.
- The total annual CSO volume predicted for the outfalls in the Bowery Bay sewershed were as follows:
  - 2008 non-CEG: 4,720 MG
  - 2008 with CEG: 4,333 MG

The above results indicate an increase in the number of hours at the 2xDDWF operating capacity for Bowery Bay WWTP, an increased annual volume being delivered to the WWTP, and a decrease in CSO volume from the outfalls in the service area.

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 modeled WWFP for two conditions, the first being prior to implementation of CEG conditions, and the second with the CEG conditions implemented. The maximum flow rates and maximum depths predicted by the model 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 between 70 and 84 percent (by length) of the High Level Interceptor sewer segments would exceed full-pipe capacity flow for the non-CEG and CEG scenarios, respectively. About 38 percent (by length) of the upstream combined sewers would exceed their full-pipe flow under both scenarios. For the same event, the model predicted that between 91 and 96 percent (by length) of the Low Level Interceptor sewer segments would exceed full-pipe capacity flow for the non-CEG and CEG scenarios, respectively. About 32 to 34 percent (by length) of the upstream combined sewers would exceed their full-pipe flow under the same scenarios.
- For both the non-CEG and CEG scenarios, the full lengths of all of the interceptors (High Level Interceptor [HLI] and Low Level Interceptor [LLI]) were predicted to flow at full depth or higher.
- The results for the system condition with CEG improvements showed that the overall peak plant inflow near the plant improved, in comparison to the non-CEG conditions in the Bowery Bay sewershed.
- About 70 percent of the combined sewers (by length) reached a depth of at least 75 percent under the CEG simulations.

Based on the review of various metrics, the Bowery Bay system generally exhibits full or near full-pipe flows during wet-weather, allowing little potential for in-line storage capability.

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

DEP maintains and operates the collection systems throughout the five boroughs. To do so, DEP employs a combination of reactive and proactive maintenance techniques. NYC's "Call 311" system routes complaints of sewer issues to DEP for response and resolution. Though not every call reporting flooding or sewer back-ups corresponds to an actual issue with the municipal sewer system, each call to 311 is responded to. Sewer functionality impediments identified during a DEP response effort are corrected as necessary.

2.1.c.5 Findings from Interceptor Inspections

DEP has several programs with staff devoted to sewer maintenance, inspection and analysis, and regularly inspects and cleans its sewers, as reported in the SPDES BMP Annual reports. In the last decade, DEP has implemented advanced technologies and procedures to enhance its proactive sewer maintenance practices. GIS and Computerized Maintenance and Management Systems provide DEP with expanded data tracking and mapping capabilities, through which it can identify and respond to trends to better serve its customers. Both reactive and proactive system inspections result in maintenance, including cleaning and repair as necessary. Figure 2-16 illustrates the intercepting sewers that were inspected in the Borough of Queens, encompassing the entire Flushing Bay watershed. Throughout 2015, 22 cubic yards of sediment was removed from Tallman Island WWTP intercepting sewers and 37 cubic yards of sediment was removed from Bowery Bay WWTP intercepting sewers. Citywide, the inspection of 66,262 feet of intercepting sewers resulted in the removal of 3,306 cubic yards of sediment.

DEP recently conducted a sediment accumulation analysis to quantify levels of sediments in the combined sewer system. For this analysis, a statistical approach was used to randomly select a sample subset of collection 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 measuring 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 cross-sectional area. The aggregate mean sediment level for the entire NYC was approximately 1.25 percent, with a standard deviation of 2.02 percent.

2.1.c.6 Status of Receiving Wastewater Treatment Plants

The majority of the Flushing Bay basin is served by the Bowery Bay WWTP sewershed and the CSO outfalls associated with its collection system are the major contributors of CSO to Flushing Bay. The Bowery Bay WWTP underwent upgrades for Biological Nutrient Removal (BNR) and improvements that enable the collection system and treatment facility to deliver, accept, and treat influent at twice the plant's DDWF of 150 mgd during storm events.

2.2 Waterbody Characteristics

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

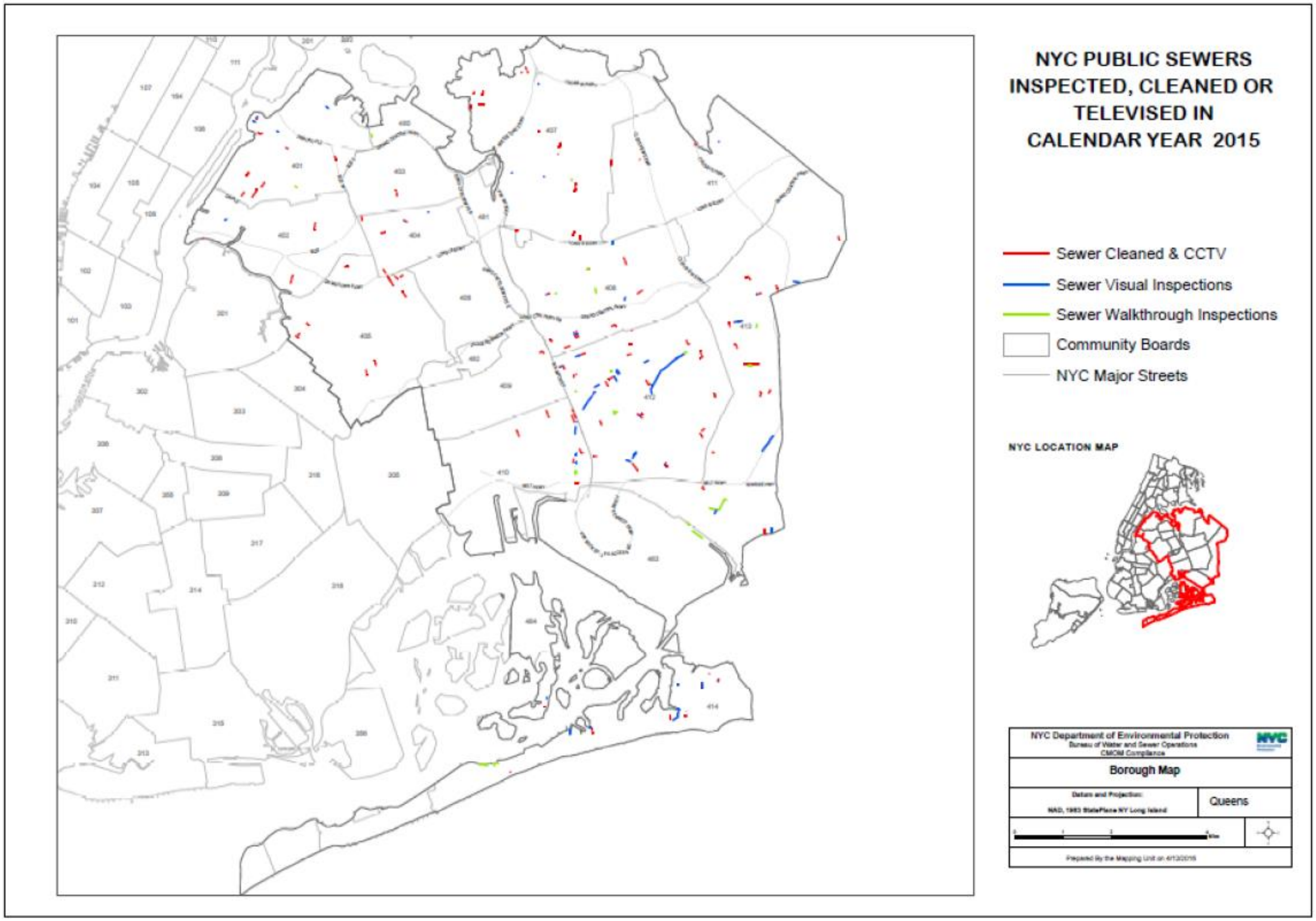

Figure 2-16. Sewers Inspected and Cleaned in Queens Throughout 2015

2.2.a Description of Waterbody

Flushing Bay is a tidal waterbody located in Queens, New York. Flushing Creek is the sole tributary to the Bay and the Bay is tributary to the Upper East River. Water quality in Flushing Bay is influenced by CSO, stormwater discharges and the tidal exchange with the Upper East River. The following section describes the present-day physical and water quality characteristics of Flushing Bay, 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. Classes SC, I and SD support aquatic life and recreation, but the primary and secondary recreational uses of the waterbody are limited due to other factors. Class I best uses are aquatic life protection, as well as secondary contact recreation. SD waters best uses are fish, shellfish and wildlife survival. DEC has classified Flushing Bay as a Class I waterbody.

Numerical standards corresponding to these waterbody classifications are shown in Table 2-7. Dissolved oxygen (DO) is the numerical standard 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 standards, 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 2-7, these narrative criteria apply to all five classes of saline waters. Narrative WQS criteria are presented in Table 2-8.

Note that the enterococci criterion of 35 cfu/100mL listed in Table 2-7, although not promulgated by DEC, is now an enforceable standard in NYS, because 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 of 2000, the criterion applies on a 30-day moving geometric mean (GM) basis during the recreational season (May 1st through October 31st). Furthermore, this criterion is not applicable to the tributaries of the Long Island Sound and the East River tributaries and therefore would not apply to Flushing Bay under current water quality classifications.

Currently, DEC is conducting its Federally-mandated "triennial review" of the NYS WQS, in which States are required to review their WQS every three years. DEC is in the pre-public proposal phase of this rule, and staff is considering a wide range of revisions/additions to WQS regulations. DEC has indicated that in accordance with the 2012 EPA Recreational Water Quality Criteria (RWQC), DEC intends to establish the enterococci criterion as a promulgated standard through a formal rulemaking within NYS sometime in the future.

Table 2-7. 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	Secondary contact recreation and fishing. Suitable for fish, shellfish and wildlife propagation and survival.	≥ 4.0	≤ 2,400$^{(4)}$ ≤ 5,000$^{(5)}$	≤ 200$^{(6)}$	N/A
SD	Fishing. Suitable for fish, shellfish and wildlife survival. Waters with natural or man-made conditions limiting attainment of higher standards.	≥ 3.0	≤ 2,400$^{(4)}$ ≤ 5,000$^{(5)}$	≤ 200$^{(6)}$	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 100mLvalue 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 New York State 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 promulgated by the EPA BEACH Act of 2000 that is only applicable to coastal waters.

Table 2-8. 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.

Interstate Environmental Commission

The States of New York, New Jersey, and Connecticut are signatories to the Tri-State Compact that designated the Interstate Environmental District and created the IEC). The IEC includes all saline waters of greater NYC. Flushing Bay is an interstate water and is regulated by IEC as Class B-1 waters. Numerical standards for IEC-regulated waterbodies are shown in Table 2-9, while narrative standards are shown in Table 2-10.

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 combined sewer system 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.

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. For example, Douglas Manor Association is a private club located in Little Neck Bay with a permit to operate a beach by New York City Department of Health and Mental Hygiene (DOHMH). 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. An enterococci level 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 and additional sampling is initiated. The advisory is removed when water quality is acceptable for primary contact recreation. Advisories are posted at the beach and on the agency website.

Table 2-9. 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 2-10. 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.

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

Flushing Bay is classified as a Class I waterbody (secondary contact recreation best use). According to EPA documents, these reference levels are not binding regulatory criteria; rather, they are to be used by the State agencies in making 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. No areas of the Flushing Bay shoreline are authorized by the DOHMH for bathing.

In December 2012, the EPA released RWQC recommendations that are designed to protect human health in coastal and non-coastal waters designated to protect human health in coastal and non-coastal waters designated 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 2-11, and includes limits for both the GM (30-day) and a statistical threshold value (STV) based on exceeding a 90th 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 2-11. 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 (Marine and Fresh)	35	130	30	110
E. coli (Fresh)	126	410	100	320

Based upon its understanding that DEC will implement EPA's RWQC Recommendation 2, DEP has based its LTCP analysis for Flushing Bay on the enterococci numerical criteria associated with that Recommendation.

2.2.a.2 Physical Waterbody Characteristics

Flushing Bay is located in northern Queens, NY. Its sole tributary, Flushing Creek, opens into the southeast end of Flushing Bay. Flushing Bay opens to the Upper East River, between College Point and Rikers Island, north of LaGuardia Airport. At the northern end of the airport, a short, narrow strait connects Flushing Bay and Bowery Bay. The Bay has a navigational channel formally known as Flushing Bay Navigational Channel that extends into the Creek up to the Whitestone Expressway overpass.

Flushing Bay starts at the northwestern end of Flushing Creek and extends to the Upper East River. The World's Fair Marina and promenade are located along the southwestern shoreline. LaGuardia Airport filled-in perimeter defines most of the northwestern shore of the Bay. The eastern shore accommodates primarily industrial and residential uses.

Inner Flushing Bay is located within the Coastal Zone Boundary as designated by DCP. DCP has also designated inner Flushing Bay as a Significant Natural Waterfront Area (SNWA). As defined by DCP, SNWA is a large area of concentrated natural resources, such as wetlands and natural habitats, which possesses a combination of important coastal ecosystem features.

Proposed redevelopment and re-zoning of the Iron Triangle area of Willets Point may include revitalization of the waterfront and habitats of the southern shore of Flushing Bay and western shore of Flushing Creek.

Shoreline Physical Characterization

The shorelines of Flushing Bay are composed of a mix of natural areas, rip-rap, marina and bulkhead, as shown in Figure 2-17. The shoreline of the inner bay from the mouth of the Creek to LaGuardia Airport is composed mainly of rip-rap and a marina with a small extent of natural shoreline. The shoreline defined by the LaGuardia Airport perimeter is mainly composed of rip-rap within the inner bay and natural slopes along the outer bay. The eastern shoreline is composed of a mix of natural, rip-rap and marina, with small pockets of bulkhead and a few piers. Figures 2-18, 2-19 and 2-20 show the predominant shoreline characteristics along the Bay. Figure 2-18 shows the typical rip-rap protection found throughout the Bay, Figure 2-19 shows a typical natural shoreline and Figure 2-20 depicts the World's Fair Marina.

Shoreline Slope

Shoreline slope has been qualitatively characterized along shoreline banks where applicable, and where the banks are not channelized or otherwise developed with regard to physical condition. Steep is defined as greater than 20 degrees, or 80-foot vertical rise for each 200-foot horizontal distance perpendicular to the shoreline. Intermediate is defined as 5 to 20 degrees. Gentle is defined as less than 5 degrees, or 18-foot vertical rise for each 200-foot horizontal distance. In general, the three classification parameters describe the shoreline slope well for LTCP purposes. Gentle and intermediate slopes characterize the natural or vegetated shorelines of Flushing Bay.

Waterbody Sediment Surficial Geology/Substrata

The bottom of Flushing Bay is predominantly composed of mud/silt/clay with a small proportion of sand, according to data from previous studies. Sampling conducted by HydroQual in 2003 indicated a predominantly mud/silt/clay bottom with some areas of sand bottom. The composition of the mud/silt/clay designated areas ranged from 66 percent to 99 percent mud/silt/clay and zero to seven percent gravel.

Waterbody Type

Flushing Bay is a tidal tributary of the Upper East River that receives freshwater from stormwater and CSOs, as well as groundwater inflows from the man-made freshwater lakes located upstream of the tidal portion of Flushing Creek, the Bay's sole tributary.

Tidal/Estuarine Systems Biological Systems

Tidal/Estuarine Wetlands

Tidal/estuarine wetlands reported by the U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI) maps show limited tidal/estuarine wetlands throughout the Flushing Bay study area, as shown in Figure 2-21. The three identified classes of estuarine wetlands shown in Figure 2-21 are described in Table 2-12.

Table 2-12. NWI Classification Codes

NWI Classification	Description
E2EM1P	Estuarine, inter-tidal, emergent-persistent, irregular
E2EM1N	Estuarine, inter-tidal, persistent, regularly flooded
E2US2N	Estuarine, inter-tidal, unconsolidated shore, regularly flooded

Aquatic and Terrestrial Communities

The DCP Plan for the Queens Waterfront (DCP, 1993) reports a diverse range of species supported by the habitat in the Flushing Creek area. A more detailed summary of the aquatic and terrestrial communities can be found in the 2011 Flushing Bay WWFP.

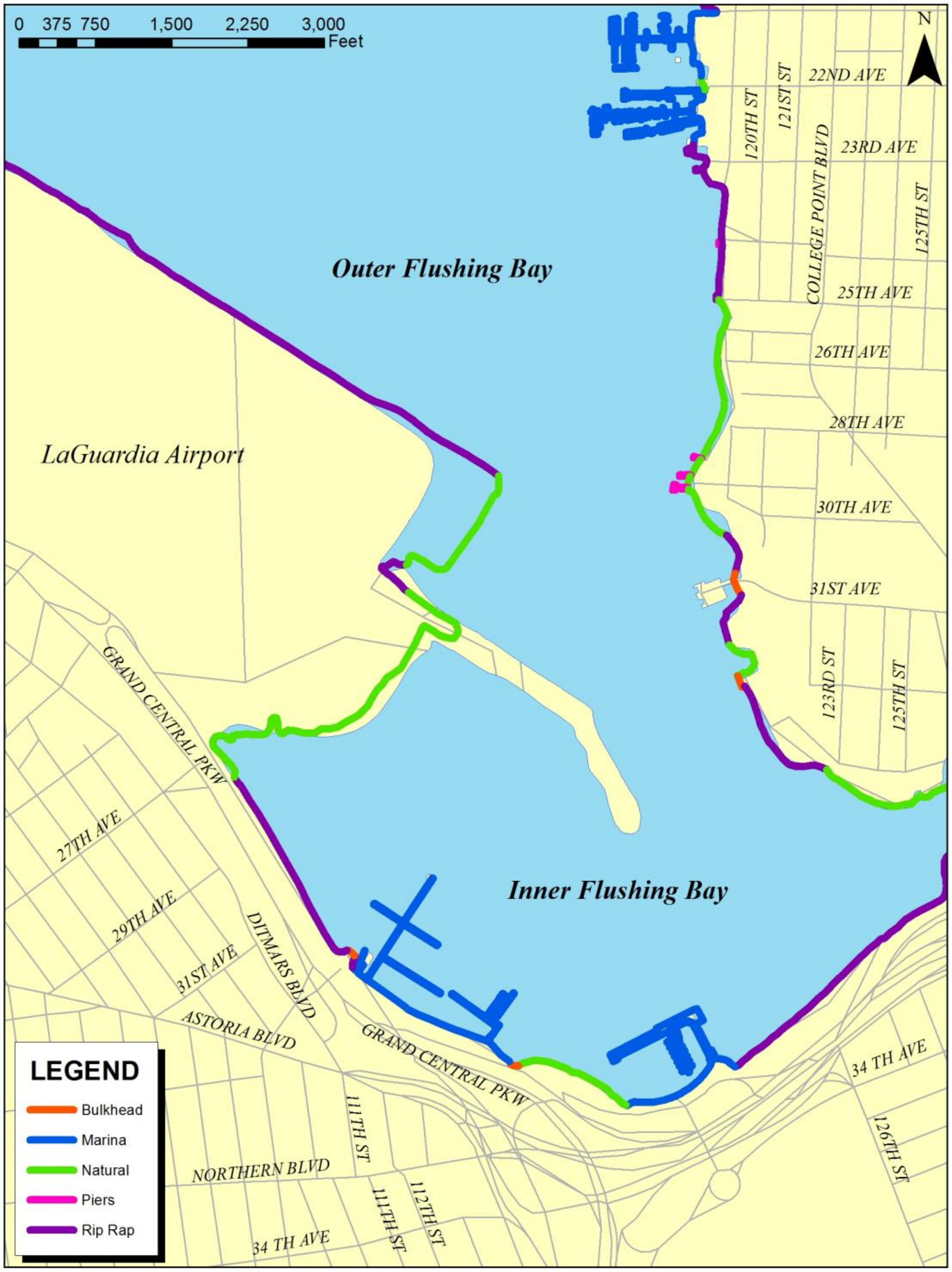

Figure 2-17. Flushing Bay Shoreline Characteristics

AECOM with Hazen

Figure 2-18. Rip-rap Shoreline View of Flushing Bay from Whitestone Expressway (Looking West)

Figure 2-19. Natural Shoreline of Flushing Bay (Looking West)

Figure 2-20. World's Fair Marina

Figure 2-21. National Wetlands Inventory Source: NYS GIS Clearinghouse-2014

Freshwater Systems Biological Systems

Three generalized freshwater wetlands areas are shown in DEC's Freshwater Wetlands Maps. Within the Flushing Bay watershed, these areas are mapped solely in the former Flushing Airport property.

2.2.a.3 Current Public Access and Uses

In Flushing Bay, swimming (primary contact recreation use) is not the best use, as defined by New York State Codes, Rules and Regulations for Class I waterbodies. Secondary contact recreation opportunities are facilitated exclusively by access points along Flushing Bay as shown in Figure 2-22. Figure 2-23 identifies a public boat/kayak launch located at the east end of the Flushing Bay Promenade. Two other locations along Flushing Bay depicted in Figures 2-24 and 2-25 have been identified to promote waterfront observation and do not promote primary or secondary contact recreational activities.

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

Flushing Bay was analyzed under the federal CSO Policy as set forth in Table 2-13.

Table 2-13. 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)	Best Use - Primary Contact Recreation	Public Water Supply Intake	Public Water Supply Protected Area	Shellfish Bed
Flushing Bay	None	None	No	No(4)	None(5)	None(5)	None

Notes:
(1) Classifications or Designations per CSO Policy.
(2) NOAA.
(3) Department of State - Significant Coastal Fish and Wildlife Habitats.
(4) Existing uses include secondary contact recreation and fishing, Class I.
(5) These waterbodies contain salt water.

Figure 2-22. Access Points to Flushing Bay

AECOM *with* Hazen

Figure 2-23. Boat/Kayak Launch at the East End of Flushing Bay Promenade

Figure 2-24. Flushing Bay Promenade and Marina

Figure 2-25. Professional Service Center for the Handicapped

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 Harbor Survey Monitoring (HSM) Program has been the responsibility of DEP's Marine Sciences Section 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 5 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. The LTCP process has begun to focus on those areas that could be improved still further. The LTCP program evaluates 11 waterbodies and their drainage basins and develops a comprehensive improvement plan for each.

The HSM program focuses on the water quality parameters of fecal coliform and enterococci bacteria, DO, chlorophyll 'a', and Secchi disk transparency. HSM data are presented in four sections, each delineating a geographic region within the Harbor. Flushing Bay is located within the Upper East River – Western Long Island Sound (UER-WLIS) section. This area contains nine open-water monitoring stations and five tributary sites. Figure 2-26 shows the location of three HSM tributary Stations: E6, FB1 and E15.

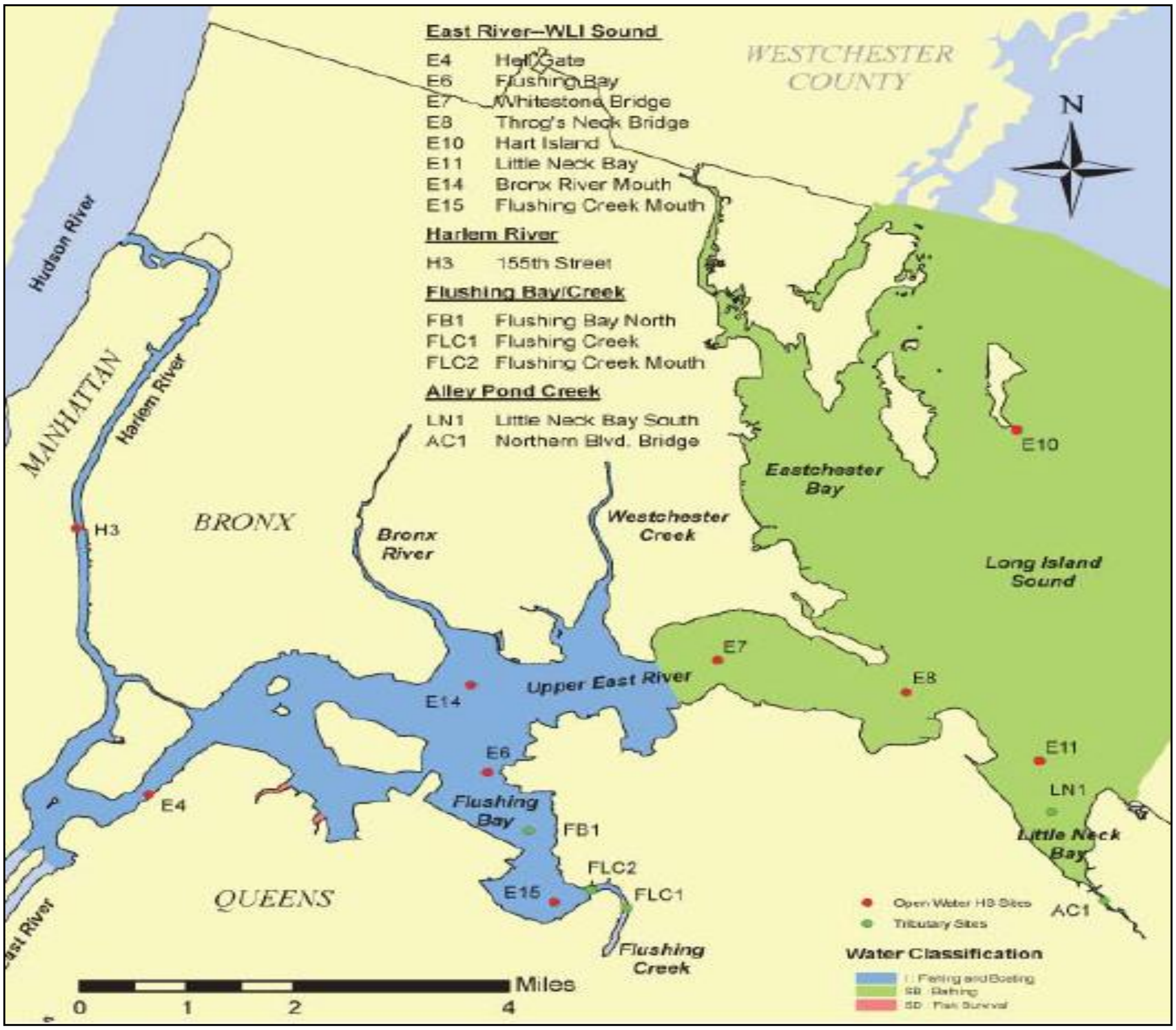

Figure 2-26. Harbor Survey UER-WLIS Region

Fecal coliform and enterococci are indicators of human waste and pathogenic bacteria. According to 2013 through 2015 HSM program data, fecal coliform geometric means representative of wet- and dry-weather conditions for the period range from 23 cfu/100mL at Station E6 to 255 cfu/100mL at Station E15. The computed enterococci GMs range from 3 cfu/100mL at Station E6 to 13 cfu/100mL at Station E15.

DO is the oxygen in a waterbody available for aquatic life forms. Throughout recent years, average DO levels have been measured consistently above the compliance requirement of 4.0 mg/L most of the time. Throughout 2013, 2014 and 2015, DO was measured slightly below 4.0 mg/L on three days. These low DO measurements are listed in Table 2-14. The average at Station E6 was measured at 6.8 mg/L. For FB1, average DO was measured at 7.1 mg/L, while the average DO at Station E15 was measured at 7.2 mg/L. During summer months, the Flushing Bay waters essentially met their DO classification requirement. Hypoxia is another water quality condition associated with DO, and occurs when DO levels fall below 3.0 mg/L. DO measurements below 3.0 mg/L were never taken at Stations E16, FB1 and E16 in Flushing Bay throughout 2013, 2014 and 2015.

AECOM with Hazen

Table 2-14. Measured Low DO Levels (2013 throughout 2015)

Station	8/12/2013	9/2/2014	8/31/2015
E15			3.9
FB1		3.8	3.8
E6	3.9	3.8	3.7

Chlorophyll 'a' is the green pigment in algae and plankton. The amount of chlorophyll 'a' is a gage of primary productivity, which is used to measure ecosystem quality. A concentration of 20 µg/L or above is considered eutrophic. In a state of eutrophication, phytoplankton reproduction rates greatly increase, causing a depletion of DO. Based on the HSM program data, the average chlorophyll 'a' concentration in the Bay from 2013 throughout 2015 was 8.3 µg/L.

Secchi 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. 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 from 2013 throughout 2015 was 2.8 feet for E15, 2.9 for FB1 and 3.7 for E6. All stations in Flushing Bay reported a significant number of low transparency values (under 3.0 feet).

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

Data collected within Flushing Bay are available from sampling conducted by DEP's HSM program from 2007 to 2015, and from intensive sampling conducted from November 2013 through May 2014 to support the Flushing Bay LTCP. The sampling locations of both programs are shown in Figure 2-27. Figures 2-29 through 2-32 show the GM of both datasets over the concurrent sampling period along with data ranges (minimum to maximum and 25th percentile to 75th percentile) for fecal coliform and enterococci, respectively. For reference purposes, each figure also shows the monthly GM water quality numerical criterion for the respective pathogen.

Overall, the fecal coliform levels measured throughout the LTCP sampling program result in geometric means indicative of the impacts of wet-weather pollution sources on inner Flushing Bay. As shown in Figure 2-29, the wet-weather geometric means at the inner Flushing Bay Stations OW-7 to OW-9 are all above 200 cfu/100mL, while the dry-weather geometric means at those stations are all below 200 cfu/100mL. For the outer-Flushing Bay Stations OW-10 to OW-15, wet-weather impacts are also apparent, as the wet-weather geometric means are all above the dry-weather geometric means. However, the wet-weather geometric means are all below 200 cfu/100mL except at Station OW-10, where the geometric mean is 201. The LTCP enterococci data generally follow a similar trend as the fecal coliform data, with wet-weather geometric means higher than dry-weather geometric means, and the inner bay geometric means generally higher than the outer bay geometric means (Figure 2-30), consistent with the more favorable tidal exchange conditions near the East River.

The HSM fecal coliform data presented in Figure 2-31 are also consistent with the LTCP2 data. The wet-weather geometric means at inner bay Station E-15 are above 200 cfu/100mL for 2013 through 2015, while the dry-weather geometric means at Station E-15 are below 200 cfu/100mL. The outer bay Station E6 showed wet-weather geometric means above the dry-weather geometric means, but the wet-weather geometric means were all below 200 cfu/100mL. The data at Station FB1, located between Stations E-15 and E-6, showed geometric means generally between the means for Stations E-15 and E-6 for dry- and wet-weather, respectively. HSM enterococci data showed generally a similar pattern (Figure 2-32).

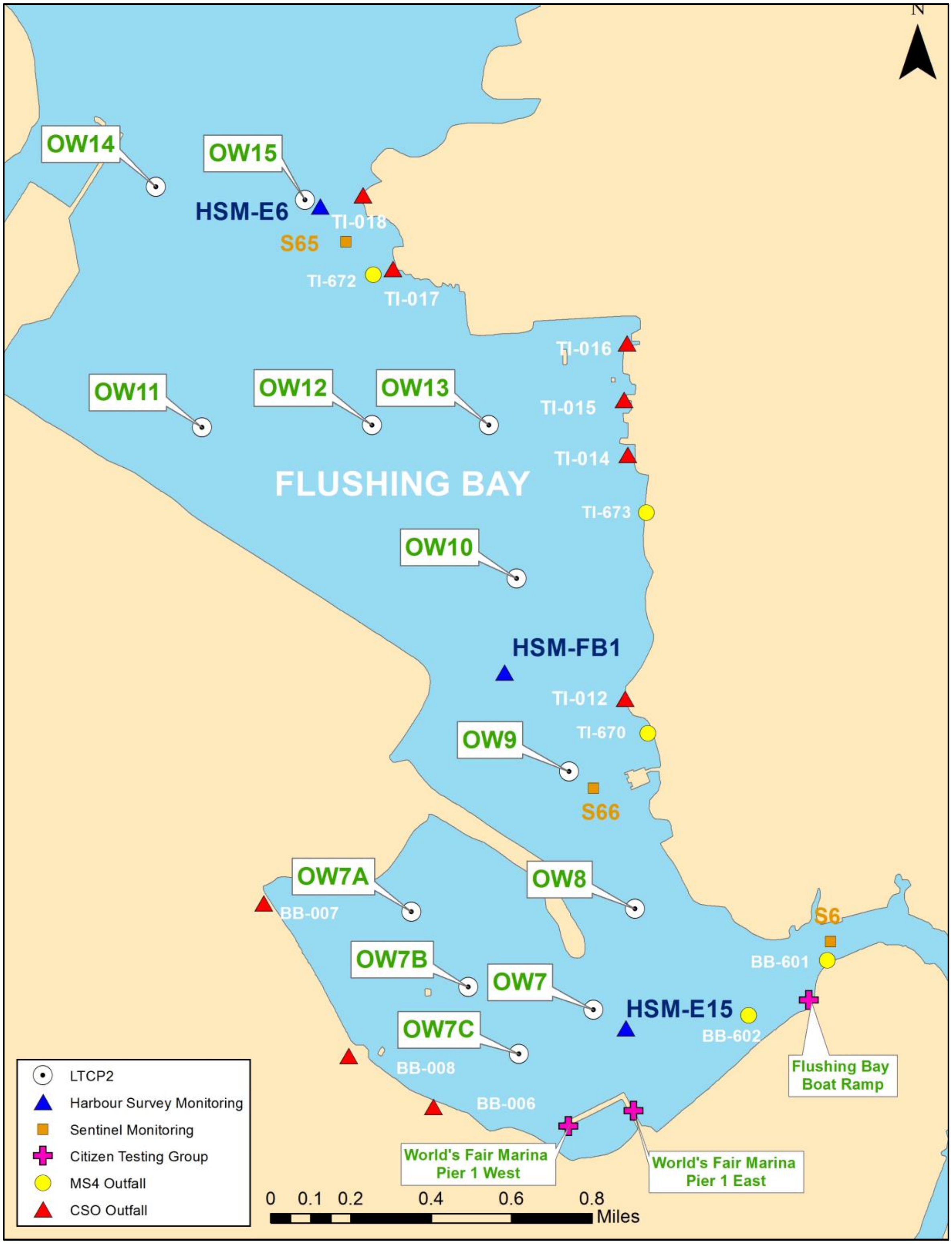

Figure 2-27. LTCP Field Sampling Analysis Program and Harbor Survey Monitoring Program Sampling Locations

Data collected by the Citizens Testing Group is also made available to the public by the Riverkeeper Group. This dataset is limited to enterococci bacteria concentrations for a sampling station along the southwestern shore of Flushing Bay, in close proximity with the mouth of Flushing Creek, as shown in Figure 2-27. These data are available at the Riverkeeper Group's website http://www.riverkeeper.org/ and, consistent with the LTCP and HSM data, showed a relationship between wet-weather conditions and higher enterococci concentrations throughout the years 2013, 2014 and 2015.

Figure 2-32 depicts the DO averages derived from the LTCP dataset measured during late 2013/early 2014. The measured DO concentrations portray winter conditions and hence do not capture the lower DO values expected to occur during the summer periods. However, throughout 2013, 2014 and 2015, based on the HSM program DO dataset, no DO values were observed below 4.0 mg/L, except in three instances in which the DO concentration was measured slightly below the Class I criterion, as previously noted.

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 Flushing Bay water quality. A model computational grid as part of the East River Tributaries Model (ERTM) was used in the LTCP analysis to represent Flushing Bay. The model computational grid, shown in Figure 2-28, was used for LTCP hydrodynamic, pathogens, and dissolved oxygen modeling. The validation of these water quality models using measurements collected during 2013 and 2014 is described in the Flushing Bay LTCP Sewer System and Water Quality Modeling Report (DEP, 2016). The measurements used for model calibration and validation include LTCP, DEP Harbor Survey and Sentinel Monitoring, with wet-weather volumetric loading information from validated IW 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.

Figure 2-28. Computational Grid for Flushing Bay Water Quality Modeling

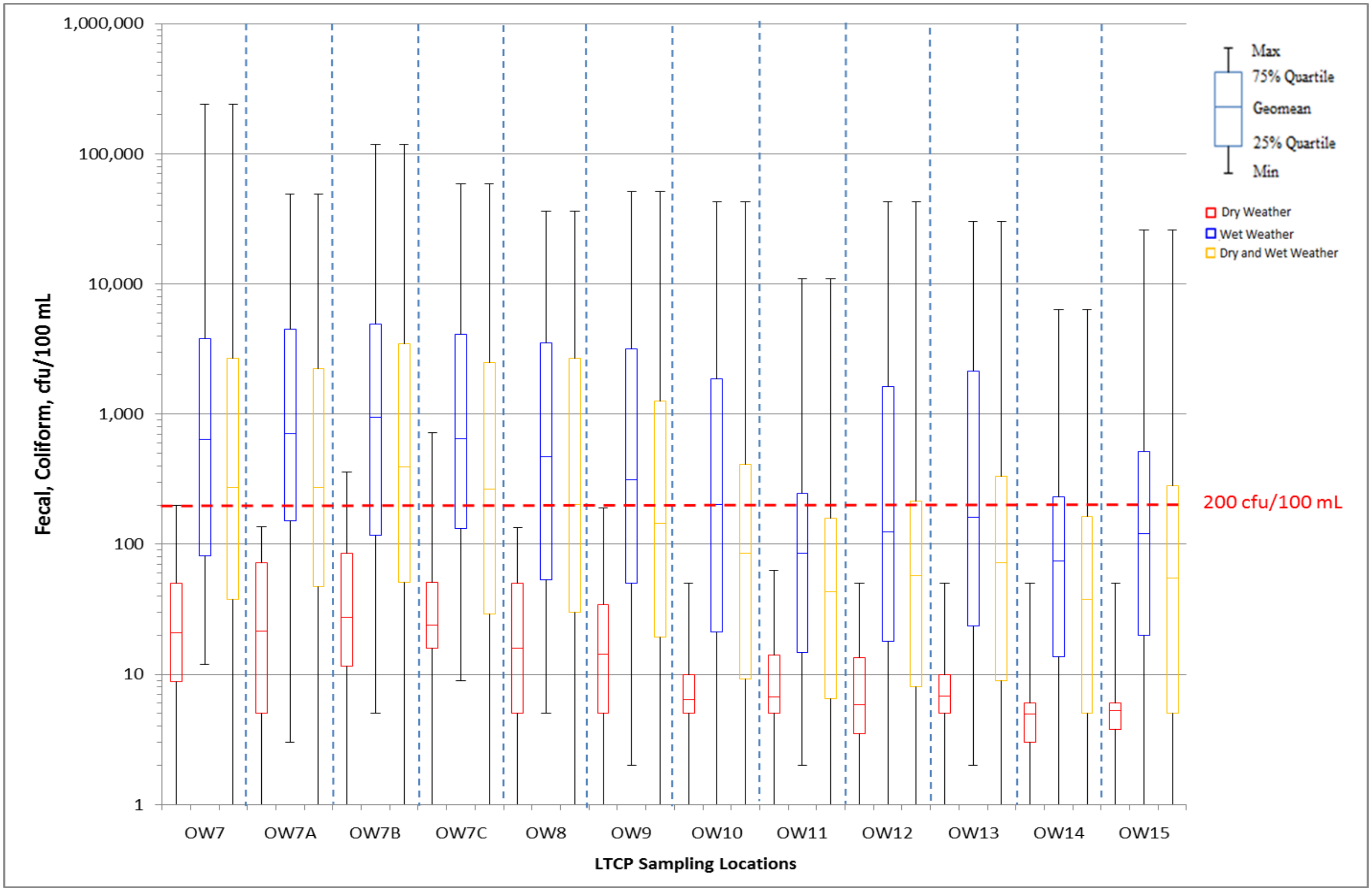

Figure 2-29. Fecal Coliform Concentrations at Flushing Bay LTCP Monitoring Station

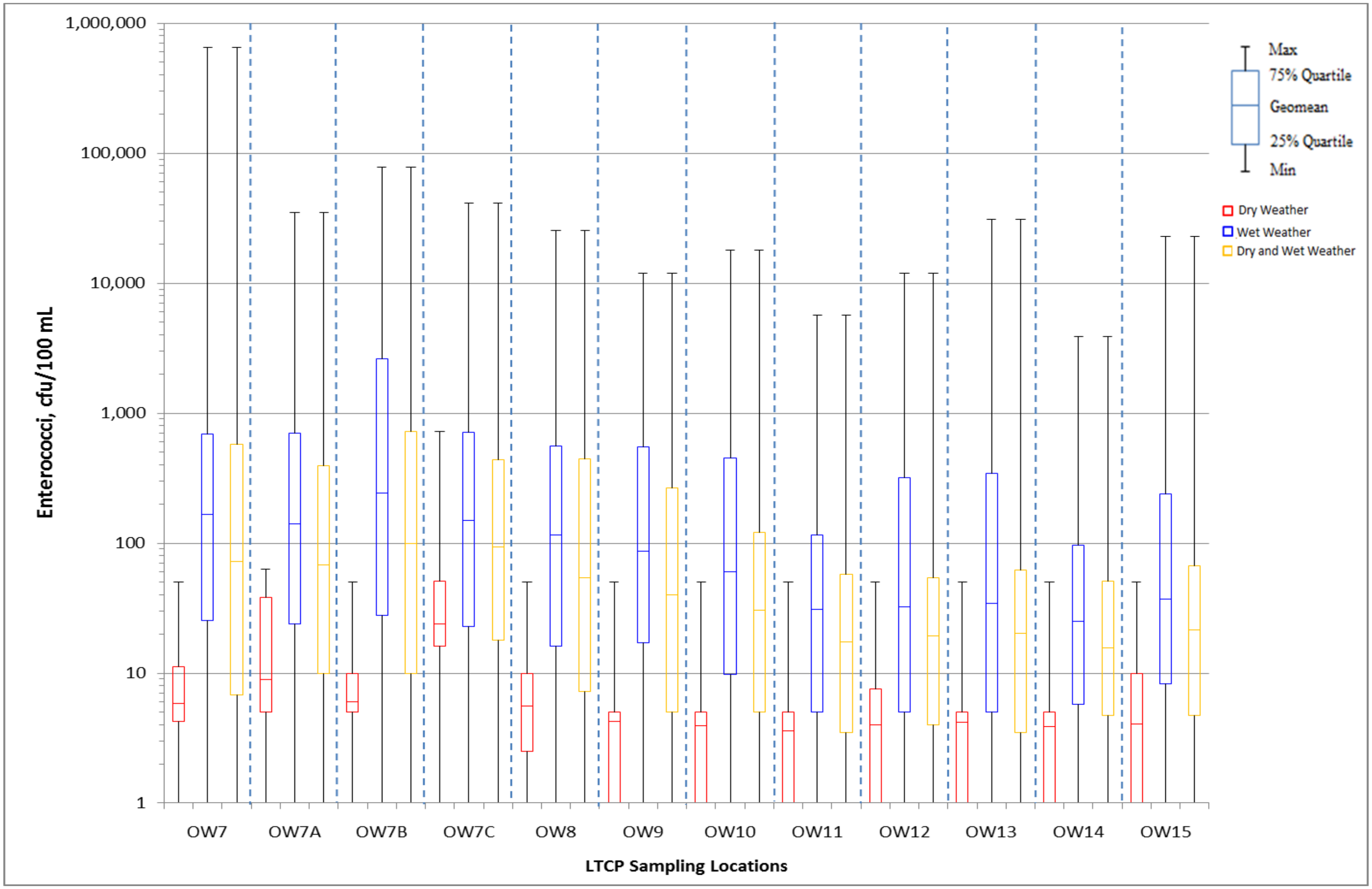

Figure 2-30. Enterococci Concentrations at Flushing Bay LTCP Monitoring Stations

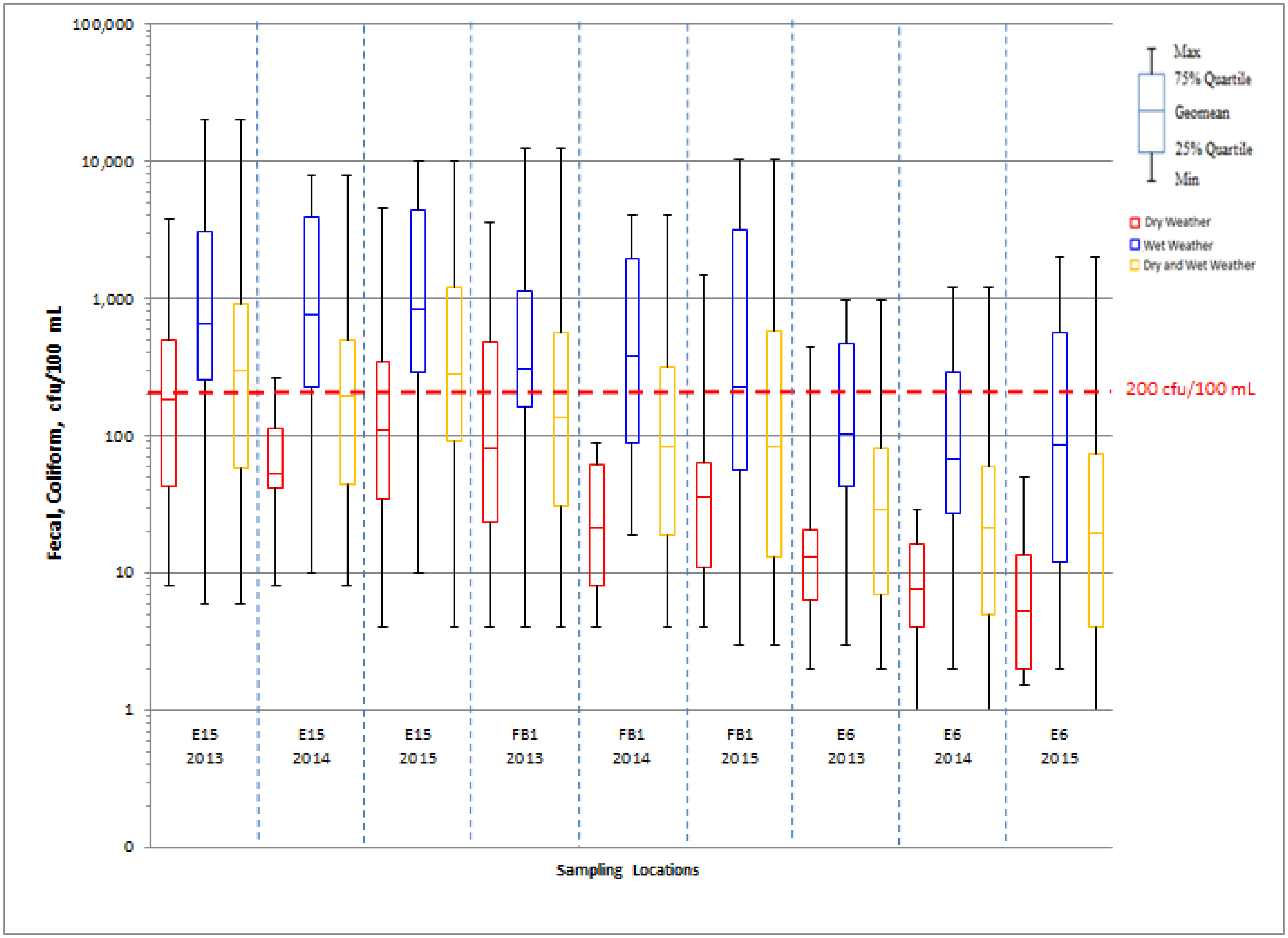

Figure 2-31. Fecal Coliform Concentrations at Flushing Bay Harbor Survey Monitoring Stations

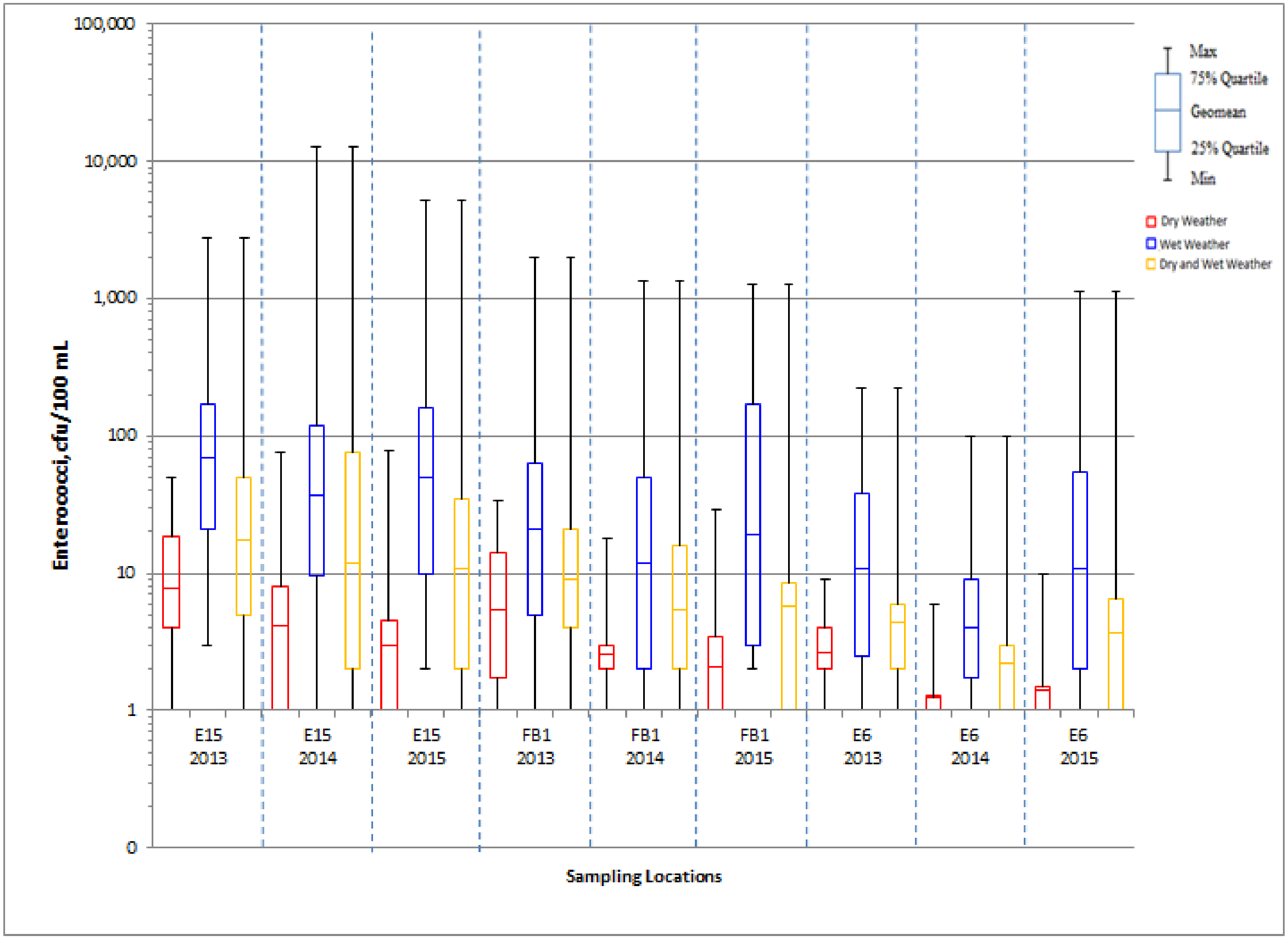

Figure 2-32. Enterococci Concentrations at Flushing Bay Harbor Survey Monitoring Stations

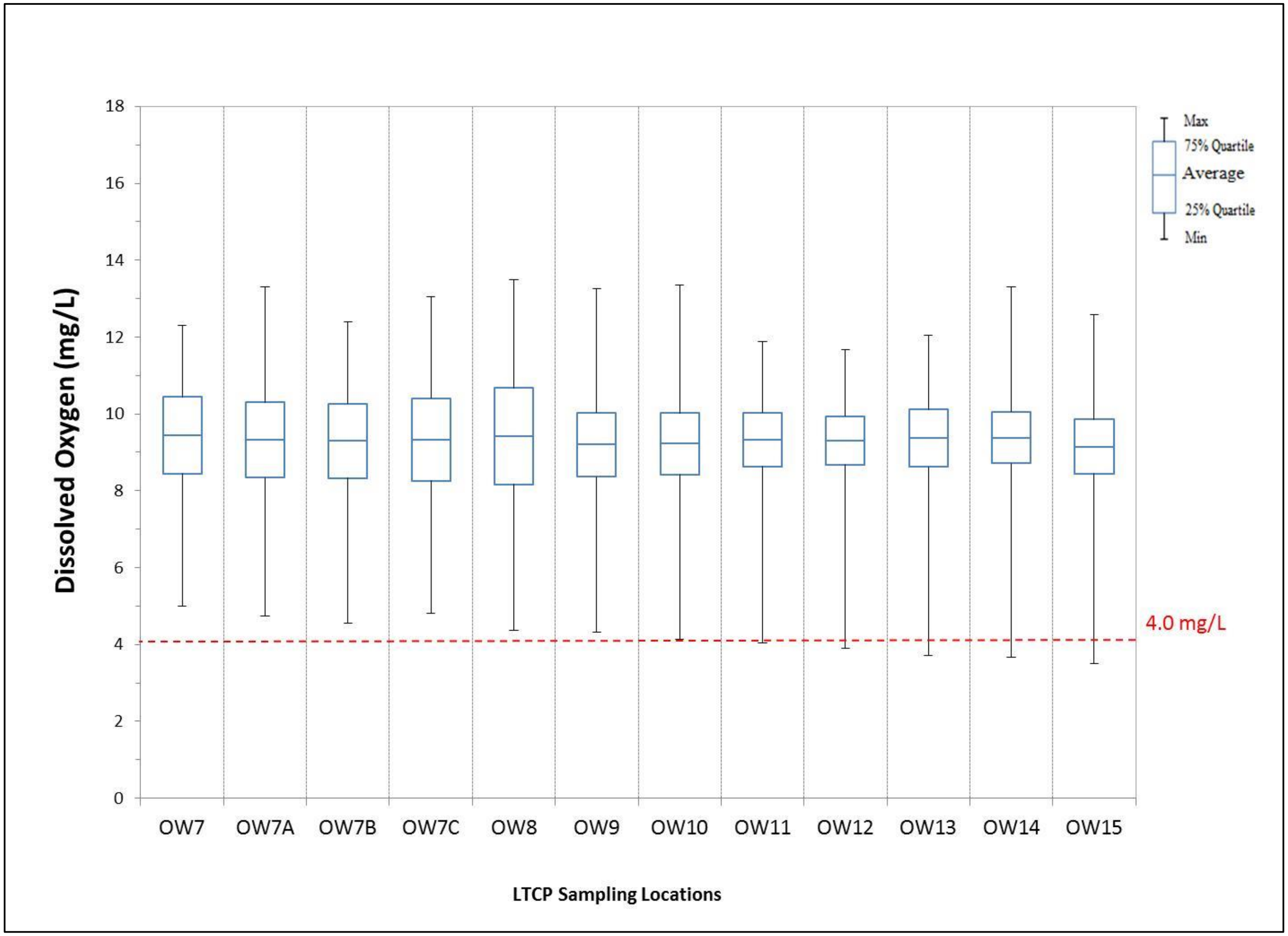

Figure 2-33. DO Concentration at Flushing Bay LTCP WQ Stations (November 2013 – May 2014)

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 Best Management Practices (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

The 2015 BMP Annual Report included a section on Additional CSO BMP Special Conditions. This section was submitted pursuant to Item 5.c. in Appendix B of Additional CSO BMP Special Conditions in the SPDES Permits. Item 5.b requires DEP to submit monthly reports of all known or suspected CSO discharges from key regulators outside the period of a critical wet-weather event. For the first year after the effective date of the 2014 CSO BMP Order, Item 5.b also required DEP to quarterly "submit for New York State Department of Environmental Conservation approval an engineering analysis of the cause(s) for each discharge and an analysis of options to reduce or eliminate similar future events." Subsequent updates of the engineering analyses are to be provided in the CSO BMP Annual Reports. On February 1, 2016, DEP submitted the Regulator(s) with CSO Monitoring Equipment Identification Program Report which identified BBH-06 as a key regulator with known or suspected discharges outside the period of a critical wet-weather event. The evaluation of CSO control alternatives and selection of the LTCP Recommendation will consider and seek to address these "early tipping" discharges from this key regulator.

The BMPs listed above are equivalent to the Nine Minimum Controls (NMCs) required under the EPA CSO Control Policy and were developed by the EPA to represent BMPs that would serve as technology-based CSO controls. The BMPs 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 permittees could implement within two years. 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 could 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.

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

On May 8, 2014 DEP and DEC entered into an administrative Consent Order[1] that superseded the parties' 2010 CSO BMP Consent Order. The 2014 CSO BMP Order on Consent (2014 CSO BMP Order) identified certain new milestones and procedures in Appendices A and B that were added to DEP's SPDES permit in October 2015 as "Additional CSO BMP Special Conditions." The SPDES Additional CSO BMP Special Conditions are in addition to the SPDES Best Management Practices for Combined Sewer Overflows and consist of the following:

Additional CSO BMP Special Conditions – Appendix A

- Interceptor Cleaning
- Management of Interceptor Sewer Physical Assets
- Interceptor Re-inspection and Cleaning
- Data Submission

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

Additional CSO BMP Special Conditions – Appendix B

- Maximizing Flow to WWTP;
- Maximizing Flow at WWTP;
- CSO Monitoring and Equipment;
- Wet Weather Operating Plan;
- Event Reporting and Corrective Actions;
- Hydraulic Modeling Verification.

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 to reduce contaminants in the combined sewer system, 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 2015 BMP Annual Report, describing the status of citywide Supervisory Control and Data Acquisition, 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 Consent Order, 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 two times design dry-weather flow (2xDDWF) through the plant headworks; a minimum of 2xDDWF through the primary treatment works (and disinfection works, if applicable); and a minimum of one and one-half times design dry-weather flow (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 2015 BMP Annual Report indicate that DEP's WWTPs generally complied with this BMP during 2014.

The 2014 CSO BMP Consent Order 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 Consent Order.

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 sewershed 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 BNR processes, if required.

As required by the 2014 CSO BMP Consent Order, DEP resubmitted all WWOPs to DEC, including the Bowery Bay WWTP WWOP in March 2014 and the Tallman Island WWTP WWOP in December 2014.

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 combined sewer system are prohibited and DEP's goal is to reduce and/or eliminate dry- weather bypasses.

The 2015 data for regulators and pump stations reveal that there were two (2) dry-weather overflows to Flushing Bay due to a regulator blockage. The event took place at the TI-06 and TI-07 regulators and resulted in a 4,535-gallon overflow.

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 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 combined sewer system 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 sewersheds .

Since 2000, the average total industrial metals loading to NYC WWTPs has been declining. As described in the 2015 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 is estimated that, on average, less than 0.18 lbs/day of total metals from regulated industries bypassed to CSOs in 2015 (DEP, 2016).

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 CSOs), requiring all combined sewer replacements to be approved by the DOH 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.

No projects are reported for the Bowery Bay WWTP and Tallman Island WWTP sewersheds in the 2015 BMP Annual Report.

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 2015 BMP Annual Report. According to the report, DEP completed four private sewer extensions in 2015. To minimize stormwater entering the combined sewer system, 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 combined sewer system 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 2015, 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 sewersheds. The program remained unchanged through the 2015 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 Flushing Bay; Local Law explicitly prohibits bathing beaches in the upper East River and its tributaries.

3.14 Characterization and Monitoring

Previous studies have characterized and described the Bowery Bay WWTP collection system, Tallman Island WWTP collection system, and the water quality for Flushing Bay (see Chapters 3 and 4 of the Flushing Bay WWFP, 2009). Additional data were collected and are analyzed in this LTCP (see Section 2.2). Continued monitoring occurs under a variety of DEP initiatives, such as floatables monitoring programs and the 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 Consent Order). 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 13 annual reports to-date, covering calendar years 2003 through 2015. The 2015 BMP Annual Report is divided into 14 sections, one for each of the BMPs in the SPDES permits and one section for the SPDES Permit CSO BMP Special Conditions. 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

CSO planning for Flushing Bay began via the East River CSO Facility Planning Project. This planning focused on quantifying and assessing the impacts of CSO discharges to the Upper East River, Western Long Island Sound, and their tributaries. For this planning project, which was published in 1989, Flushing Creek and Flushing Bay were studied as a single waterbody. The report recommended a storage facility with 43 MG of capacity (28 MG in tank, 15 MG in upstream sewers). During the development of the Flushing Bay Waterbody/Watershed Facility Plan Report, DEC required that Flushing Creek and Flushing Bay be separated into two distinct CSO planning areas – with the Flushing Bay CSO Retention Facility falling under the Flushing Creek Waterbody/Watershed Facility Plan Report (DEP, 2011). A Flushing Bay Waterbody/Watershed Facility Plan Report was subsequently submitted to DEC August 2011 with the following recommended CSO construction projects:

1. Construction of a Low Level Diversion Sewer to redirect a portion of the flow from the high level interceptor into the low level interceptor;
2. Raising the Regulator BB-R02 weir height from -1.75 to +2.5;
3. Environmental dredging of selected areas of Flushing Bay; and
4. Bending weirs at Regulators BB-R03 through BB-R10, BB-R26 and 24th Avenue Weir that was later modified to regulator modifications at BB-R04 through BB-R06, BB-R09, and BB-R10.

4.1.a Completed Projects

With the exception of the 43 MG Flushing Bay CSO Retention Facility, which falls under the Flushing Creek LTCP, there are no completed projects within the Flushing Bay planning area.

4.1.b Ongoing Projects

All three projects recommended in the Flushing Bay WWFP Report have moved forward and are ongoing. Below is a brief summary of each project:

1. Raising Regulator BB-R02
   - *Project Summary*: Divert low-lying sewers in the vicinity of Bowery Bay WWTP into the Bowery Bay High Level Interceptor and raise the weir at Regulator BB-R02 from -1.75 to +2.5 to capture more wet-weather flow. See Figure 4-1 for further information.
   - *Status*: Project is scheduled to be completed by December 2017.
2. Regulator Modifications at BB-R04 through BB-R06, BB-R09, and BB-R10
   - *Project Summary*: The regulator improvements include raising the existing weir crest elevation and lengthening the weirs to allow greater storage within the interceptor

system. The regulator sites are all within the existing Bowery Bay WWTP High Level Interceptor collection system. See Figure 4-2 for further information.

- *Status*: The Construction Notice to Proceed was granted to the contractor December 2015 with construction scheduled to continue through June 2018.

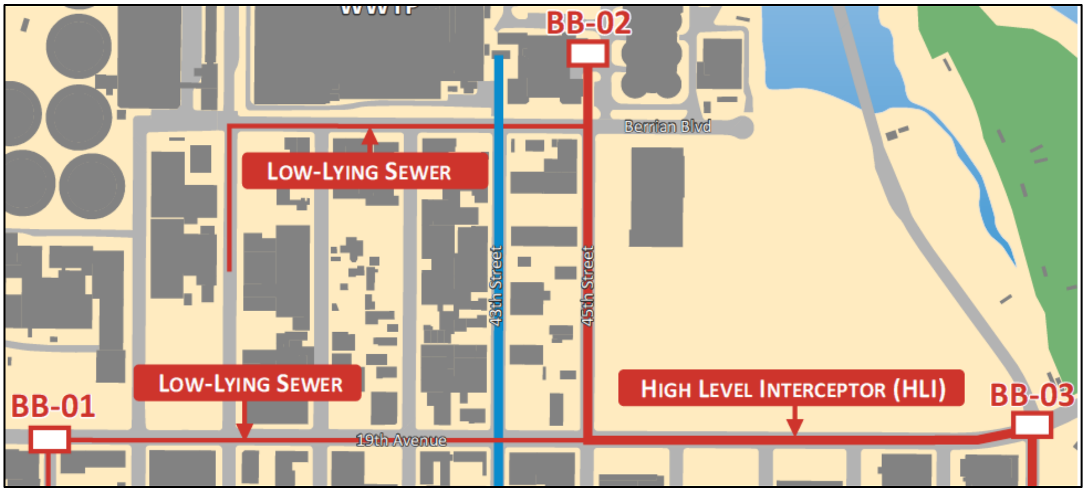

Figure 4-1. Diversion of Low-Lying Sewers near Bowery Bay WWTP into the High Level Interceptor

Figure 4-2. Flushing Bay High Level Interceptor Regulator Improvements

3. Environmental Dredging of Flushing Bay

- *Project Summary*: Under the proposed project, approximately 17.5 acres of Flushing Bay will be dredged to about five feet below mean lower low water. The proposed dredging will remove accumulated sediment mounds exposed at low tide in the area of CSO Outfalls BB-006 and BB-008 to reduce associated nuisance odors in locations adjacent to Flushing Bay. In addition, the bottom two feet will then be capped to cover any exposed sediments that might be classified as Class C (per DEC guidance). The dredging area is depicted in Figure 4–3.

  Status: An Order to Commence Work became effective on July 5, 2016 before the Consent Order Milestone Date of September 2016 and dredging is to be completed by March 2019.

Figure 4-3. Dredging Location in Flushing Bay

4.1.c Planned Projects

DEP proposes a variety of resiliency improvements for the Bowery Bay WWTP and pumping stations within the Flushing Bay sewershed, consistent with the October 2013 NYC Wastewater Resiliency Plan. However, no other CSO-related grey infrastructure projects are planned. Impacts on the frequency and/or amount of CSO overflows from the proposed WWTP and pumping station improvements will be determined when the specific projects are identified.

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

With the exception of the environmental dredging project discussed in Section 4.2, no additional water quality improvement measures were recommended for Flushing Bay.

4.3 Post-Construction Monitoring

The PCM program is integral to the optimization of the Flushing Bay 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 impacts of the interaction between Flushing Bay and the actions identified in this LTCP, with the ultimate goal of fully attaining compliance with current WQS or supporting a UAA to revise such standards, if appropriate. The PCM program contains two basic components:

1. Receiving water data collection in Flushing Bay at the stations of DEP's HSM and Sentinel Monitoring (SM) programs; and

2. Modeling the collection system and receiving waters to characterize water quality using the existing InfoWorks CS™ (IW) and East River Tributaries Model (ERTM), respectively.

The details provided herein are limited to the Flushing Bay PCM and may be modified as DEP's CSO planning advances through the completion of other LTCPs, including the Citywide LTCP.

In a letter dated March 13, 2008, DEC approved the plan dated January 25, 2008 which superseded a series of earlier submissions and incorporated revisions per DEC comments. PCM sampling commenced in the summer of 2007 and monitoring will continue for a ten-year duration after the grey infrastructure 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 operational adjustments, retrofitting additional controls or through the implementation of additional technically feasible and cost-effective alternatives. If it becomes clear that CSO control alone will not result in full attainment of applicable WQS, DEP will pursue the necessary regulatory mechanism for a UAA.

The first PCM report was submitted April 1, 2008 and was limited to the presentation of the results of the monitoring performed in 2007 for the Flushing Bay CSO Retention Facility and each of the other retention facilities. Subsequent annual PCM reports, starting with the April 1, 2009 report, addressed the monitoring data and included the presentation of hydraulic and water quality modeling analyses performed for each of the CSO retention treatment facilities.

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

PCM sampling in the Flushing Bay Stations HSM-E6, HSM-FB-1 and HSM-E15 commenced in the summer of 2007 when the Flushing Bay CSO Retention Facility became fully operational. Figure 4-4 shows the locations of LTCP2 PCM Stations FB1, E6 and E15, as well as FLC1 and FLC2 in Flushing Creek. Sampling at all stations related to the Flushing Bay PCM program is typically scheduled monthly in the non-recreational season (November 1st through April 31st) and weekly in the recreational season (May 1st through October 31st). Additional ambient water quality data was also collected in Flushing Bay and Creek by the LTCP2 team to calibrate and validate the landside and water quality models. It is anticipated that the PCM associated with any additional CSO controls identified for implementation as part of this LTCP would require a subsequent PCM program in Flushing Bay (and Flushing Creek).

Measured parameters relating to receiving water quality include: dissolved oxygen (DO), fecal coliform, enterococci, chlorophyll 'a', and Secchi depth. With the exception of enterococci, NYC has used these parameters for decades to identify historical and spatial trends in water quality throughout New York Harbor.

The PCM program measures dissolved oxygen and chlorophyll 'a' at surface and bottom depths; the remaining parameters are measured at the surface only.

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

DEP performed monitoring and evaluation of the Corona Avenue Vortex Facility. The following reports were prepared and submitted to DEC on the facility performance:

1. "Evaluation of Corona Avenue Vortex Facility," City of New York Department of Environmental Protection September 29, 2003 2-volumes; and

2. "Corona Avenue Vortex Facility Underflow Evaluation," City of New York Department of Environmental Protection, October 2005.

Based upon the findings of these reports, the Corona Avenue Vortex Facility was decommissioned. As a result, performance monitoring identified in the permit is no longer performed.

Any flow and effluent quality monitoring program would be dependent on the types and sizes of proposed CSO controls recommended under this LTCP. If the implemented control is permitted under 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 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 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.

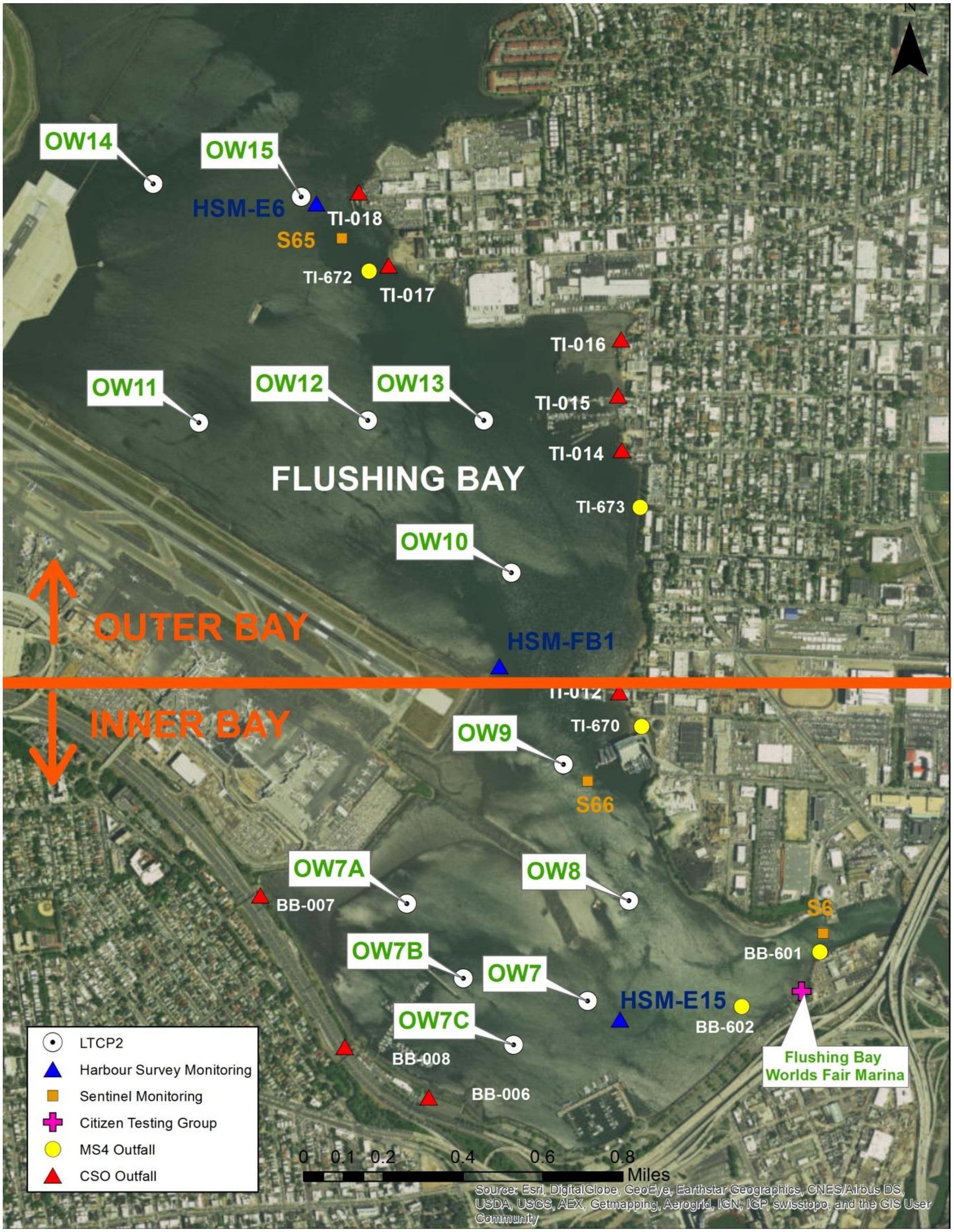

Figure 4-4. LTCP2 and PCM Sampling Locations in Flushing Bay

Because precipitation patterns are primary drivers of wet-weather overflows, accurate representation of precipitation is important to enable models to accurately calculate CSO discharges. For that reason, modeling analyses of actual conditions now rely on precipitation estimates developed using a combination of rainfall radar and local rain gauge measurements. These so-called “gauge-adjusted radar rainfall” estimates provide high-resolution (1-km^2) geographically distributed rainfall estimates on a 5-minute interval. Other DEP studies have shown that model calculations of CSO volumes can be more reliable than in-situ sensor results, and so assessments of hydraulic performance will use results of both methods where applicable.

The PCM report will show the results of the hydraulic performance assessment through comparison of observed and modeled overflow results on an annual, monthly, and storm-by-storm basis, and in the context of the design performance metrics established for the Flushing Bay Retention Facility. In this way, the PCM report will provide a determination of whether or not the Flushing Bay Retention Facility achieved its hydraulic performance metrics during the subject period.

Assessments of water quality conditions during the monitoring period will be based upon the ambient water quality measurements during the subject period compared to the modeled range for the LTCP long term analysis period (2002-2011). The PCM report will present the monitoring results graphically along with the long term expected range and commentary about how the subject year’s rainfall statistics compared to those for the long term period. In this way, the PCM report will provide a determination of whether or not the water quality improvements were achieved during the subject period as expected with the operation of the Flushing Bay Retention Facility and the Tallman Island collection system as a whole. The subsequent PCM program will be conducted for five years to capture a wide range of events and compare monitored results versus the modeling projections.

5.0 GREEN INFRASTRUCTURE

The New York City Green Infrastructure (GI) Program was initiated to manage stormwater to reduce combined sewer overflow in NYC and also provide resiliency and other co-benefits to local communities. More details on the overall program elements are described below. 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 www.nyc.gov/dep/greeninfrastructure.

5.1 NYC Green Infrastructure Plan (GI Plan)

In January 2011, DEP launched the GI Program and committed $1.5B in funding through 2030 to implement green infrastructure on public property, including $5M in Environmental Benefit Project (EBP) funds.[1] DEP's green infrastructure staff focuses on a wide variety tasks to accomplish GI Program goals ranging from planning, design, construction, maintenance of the assets to improving knowledge on how they function and perform through extensive peer-reviewed scientific research, assessments and modeling. In addition to its primary objective of improving water quality, the Program will yield climate change resiliency resulting in co-benefits including: improved air quality; urban heat island mitigation; and carbon sequestration and biodiversity co-benefits, including increased urban habitat for pollinators and wildlife.

5.2 Citywide Coordination and Implementation

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 rights-of-way and on-site GI practices. The New York City Economic Development Corporation, the NYC Department of Parks and Recreation (DPR), and the Department of Design and Construction manage the design and construction of several of these Area-wide contracts in conjunction with DEP. For GI Program status, please refer to the *2015 Green Infrastructure Annual Report* on DEP's website. DEP has developed design standards for Right-of-Way (ROW) GI Practices and is developing additional GI standards to address various certain field conditions and restrictions. New standards include the ROW Infiltration Basins, Green Strips, and porous pavement. The Office of Green Infrastructure is also developing on-site GI standards to retrofit city-owned properties. These standards include porous pavement, rain gardens, retention systems, and synthetic turf.

DEP's GI database contained information for approximately 4,500 assets that have already been constructed, are in construction, or are designed and awaiting construction bid.

[1] 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.

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, civic organizations, and other NYC agencies.

DEP recently launched its new searchable on-line map to view the status of green infrastructure assets (Final Design, In Construction, or Constructed) in the context of Area-wide contracts. This addition expands the way users can now easily access information on the GI Program, including Reports and Standard Designs for ROW GI practices at www.nyc.gov/dep/greeninfrastructure.

DEP also created an educational video on the GI 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 (https://www.youtube.com/user/nycwater).

To provide more information about the GI 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 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 GI Program, upcoming construction schedules, and final GI locations.

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

DEP's Green Infrastructure Annual Reports contain the most up-to-date information on completed projects and can be found on the DEP website. In addition, Quarterly Progress Reports are posted on the DEP 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 GI Program applies an adaptive management approach, based on information collected and evaluated from lessons learned in the field and performance monitoring results.

Pilot Site Monitoring Program

DEP initiated site selection and design of its Pilot Monitoring Program in 2009. This Program provided DEP opportunities to test different designs and monitoring techniques, and to determine the most cost-effective, adaptable, and efficient GI strategies. 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). Starting in 2010, more than 30 individual pilot GI practices were constructed and monitored as part of the citywide Pilot Program. 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 has been completed. Pilot Monitoring Program results assisted greatly in validating modeling methods and parameters.

Additional performance monitoring work is planned over the next five years as a part of the GI-RD project and will provide field-collected data for further documenting GI performance and improving modeling representation. This significant undertaking will create inputs for evaluating GI life cycle costs, volumetric stormwater runoff and CSO reduction performance and co-benefits. This work will be used to compare GI to traditional grey infrastructure options, incorporating the real cost of maintenance into financial consideration.

Neighborhood Demonstration Area Projects

The 2012 CSO Order included design, construction, and monitoring milestones for three Neighborhood Demonstration Area Projects (Demonstration Projects). DEP completed construction of GI practices within a total of 66 acres of tributary area in Hutchinson River, Newtown Creek and Jamaica Bay CSO watersheds. DEP 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, and resubmitted an updated PCM Report in January 2015.

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 enhanced DEP's understanding of the benefits of GI relative to runoff control and resulting CSO reduction and were used in the development of the 2016 Performance Metrics Report.

5.3.b Public Projects

In coordination with NYC agency and non-profit partners, DEP continues to identify, design and construct public property GI retrofit projects. In 2015, DEP initiated design on over 100 publicly owned properties, and has identified approximately 150 more. These projects will advance design through 2016 and construction is expected to start in 2017 and continue as more projects are added to the pipeline. Detailed information on project status, the site selection and design processes for public property retrofit projects can be found in the Green Infrastructure Annual Reports.

5.3.c 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 the design, construction and maintenance of GI.

The 2012 CSO Order requires the Grant Program to commit $3M of EBP funds[2] to projects by 2015. DEP met this commitment in 2014. To date, the Grant Program has committed more than $14M to 32 private property owners to build green infrastructure projects. In 2015, two projects started construction and six others were completed. Also in 2015, DEP transitioned the Grant Program application process from a single annual submission date to a year-round, open application process.

In September 2016, DEP released a Request for Information (RFI) for Management of a green infrastructure private property incentive program. The goal of the RFI, and potential subsequent program development, is to build on DEP's experience administering the Grant Program and scale it up considerably. Ultimately, DEP would like to offer an easier application process and engage additional property owners to participate in retrofitting their property with green infrastructure.

Green Roof Property Tax Abatement

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

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. More information on the Green Roof Property Tax Abatement can be found in the Green Infrastructure Annual Reports.

5.3.d Projected vs. Monitoring Results

See the 2016 Green Infrastructure Performance Metrics Report and Appendices which are available at http://www.nyc.gov/html/dep/html/ stormwater/nyc_green_infrastructure_plan.shtml.

5.4 Future Green Infrastructure in the Watershed

5.4.a Relationship Between Stormwater Capture and CSO Reduction

The 2016 Performance Metrics report describes CSO reductions based on the 1.5 percent GI implementation rate and a modeled CSO volume reduction based on the 10 percent implementation rate.

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[2] EBP Projects are undertaken by DEP in connection with the settlement of an enforcement action taken by NYS and DEC for violations of NYS law and DEC regulations.

The 1.5 percent equivalency rate incorporates data on the existing and planned GI implemented through the Program to-date, which has primarily included retention-based ROW bioswales using site-specific information to model individual, distributed assets. By contrast, the 10 percent equivalency rate incorporates a lumped approach to estimate future projects where GI asset specifics such as location, technology type and design details are currently unknown.

In order to summarize the relationship between stormwater capture and CSO reduction, DEP has included two equivalency rates based on the 1.5 percent GI implementation rate that are defined as: (a) "Stormwater capture to CSO reduction ratio;" and (b) "Million Gallons (MG) of CSO eliminated on an annual basis per acre (Ac) of impervious area managed by GI."

For the Flushing Bay LTCP, the baseline model incorporated the 1.5 percent GI scenario described in the report that represents a 2.8 percent GI application rate.

5.4.b Opportunities for Cost-Effective CSO Reduction Analysis

As described above, the 2.8 percent application rate represents built or planned GI assets in the Flushing Bay watershed. At this time in the Flushing Bay area, the vast majority of ROW GI projects have been implemented or are in progress and have been incorporated into the baseline conditions. Additional GI projects planned for the watershed will include public property retrofits (such as schools and parks) and private property projects implemented through DEP's Grant Program. Benefits from these projects would exceed the baseline target rate (as described above and below). The GI 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

Waterbody-specific penetration rates for GI are estimated based on the best available information from known subsurface conditions, zoning and land use data, availability of publicly owned properties as well as modeling efforts, WWFPs, and CSO outfall tiers data.

The following criteria were applied to prioritize CSO tributary areas in order to determine waterbody-specific GI penetration rates:

- WQS;
- Cost-effective grey investments; and
- Additional considerations:
  - Background water quality conditions
  - Public concerns and demand for recreational uses
  - Site-specific limitations (i.e., groundwater, bedrock, soil types, etc.)
  - Additional planned CSO controls not captured in WWFPs or 2012 CSO Order (i.e., high level storm sewers [HLSS]).

The overall goal for this prioritization is to saturate GI implementation rates within the priority watersheds, to maximize benefits based on the specific opportunities and field conditions in the Flushing Bay watershed, as well as costs.

Green Infrastructure Baseline Penetration Rate – Flushing Bay

Flushing Bay is a priority watershed for DEP's Green Infrastructure (GI) Program. The overall goal of the program is to saturate priority watersheds with GI to maximize benefits and cost effectiveness, based on the specific opportunities in each watershed. DEP has installed or plans to install over 1,000 GI assets, including right-of-way (ROW) practices, public property retrofits, and GI implementation on private properties, to manage approximately (2.8 percent impervious acres) in the Flushing Bay watershed. From these installations, modeling predicts a 52 MG reduction in annual CSO volume, based on the 2008 baseline rainfall condition.

Figure 5-1 below shows the current contracts in progress in the Flushing Bay CSO tributary areas of BB-006 and BB-008. As more information on field conditions, feasibility, and costs becomes known, and as GI projects progress, DEP will continue to model the GI penetration rates.

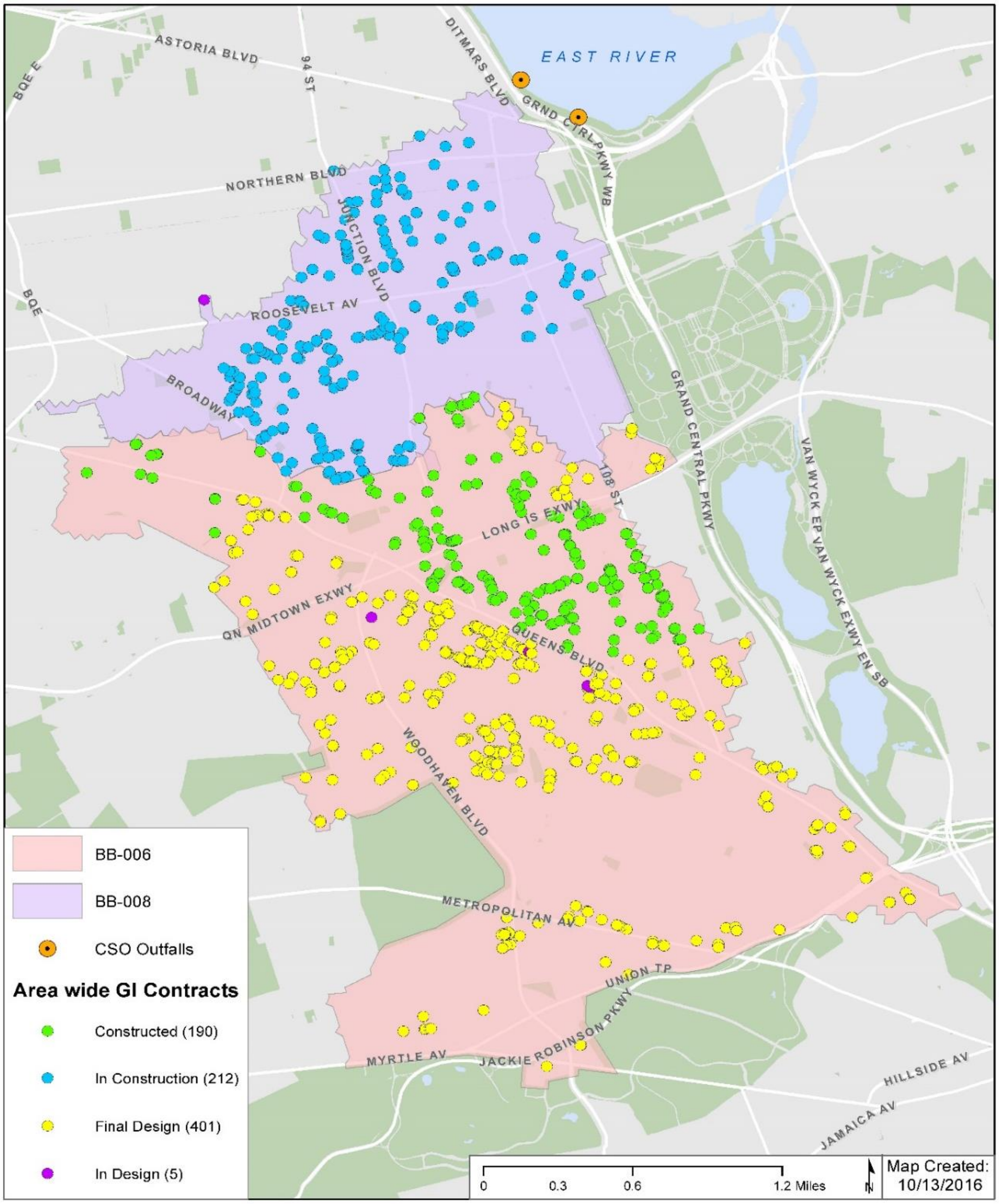

Figure 5-1. Green Infrastructure Projects in Flushing Bay

6.0 BASELINE CONDITIONS AND PERFORMANCE GAP

Key to development of the Flushing Bay LTCP was the assessment of water quality using applicable WQS within the waterbody. Water quality was assessed using the ERTM water quality model, verified with both Harbor Survey and the synoptic water quality data collected in 2013/2014 as part of the LTCP development. The ERTM water quality model was used to simulate ambient bacteria concentrations within Flushing Bay for a set of baseline conditions as described in this section. The IW sewer system model was used to provide flows and loads from intermittent wet-weather sources as input to the ERTM water quality model.

The assessment of water quality described herein started with a baseline condition simulation to determine the future bacterial levels without additional CSO controls beyond those already required under the CSO Order. 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 the calculated baseline bacteria and DO levels and both the Existing WQ Criteria and the Potential Future Primary Contact WQ Criteria. As detailed below, a one-year simulation using 2008 JFK Airport rainfall was performed for bacteria and DO. This simulation served as a basis for the evaluation of the control alternatives presented in Section 8.0.

This section of the LTCP describes the baseline conditions, the bacteria concentrations and loads calculated by the IW model, and the resulting bacteria concentrations calculated by the ERTM water quality model. It further describes the gap between calculated baseline bacteria concentrations and both the existing and potential future WQS. This section also assesses whether the gap can be closed through CSO reductions alone (100% CSO control).

It should be noted that enterococci criteria do not apply to the East River Tributaries, such as Flushing Bay, under the BEACH Act of 2000 for Existing WQS. Therefore, Flushing Bay water quality assessments for existing Class SB and proposed Class I criteria considered the fecal coliform criterion only. However, Potential Future Primary Contact WQ Criteria assessments took into account both enterococci and fecal coliform criteria for primary contact recreation.

6.1 Define Baseline Conditions

Establishing baseline conditions was an important step in the LTCP process, because the baseline conditions were used to compare and contrast the effectiveness of CSO controls identified pursuant to the LTCP process and to predict whether water quality goals would be attained after the identified preferred alternative LTCP is 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:

- Dry-weather flow and loads to the Bowery Bay WWTP were based on CY2040 projections.
- The Bowery Bay and Tallman Island WWTPs can accept and treat peak flows at two times design dry-weather flow (2xDDWF).

- Green Infrastructure (GI) projects to control the first inch of runoff on selected impervious surfaces within the Bowery Bay and Tallman Island WWTP combined sewer service area.

- Cost-effective Grey Infrastructure CSO controls included in the 2012 CSO Order. For Flushing Bay, this includes Environmental Dredging, diversion of low-lying sewers and modifications to regulators along the HLI.

- The precipitation characteristics from 2008 at the JFK rainfall gauge which has been selected as the typical year rainfall.

- Flushing Creek disinfection facilities at Outfalls TI-010 and TI-011. Sensitivity analysis of the Flushing Bay and Creek loadings in terms of the selected CSO controls in Flushing Bay was also evaluated (Section 8.3c).

Mathematical modeling tools were used to calculate the CSO volume and loads and their impacts on water quality. The performance gap was assessed by comparing the baseline conditions with the WQS. In addition, complete removal or control of CSO loadings was evaluated. Further analyses were conducted for CSO control alternatives as presented in Section 8.0.

The IW model was used to develop stormwater flows, conveyance system flows and CSO volumes for the Flushing Bay sewershed for a defined set of future or baseline conditions. For the Flushing Bay LTCP, the baseline conditions were developed in a manner consistent with the earlier WWFPs for other waterbodies. However, based on more recent data, WWFPs as well as the public comments received on the preceding 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 for this LTCP reflected a better understanding of dry- and wet-weather pollutant sources, catchment areas and new or upgraded physical components of the system. In addition, a model recalibration report was issued in 2012 (*InfoWorks Citywide Recalibration Report, June 2012*) that used improved impervious surface satellite data.

Minor improvements, including an updated and more refined model segmentation, were also made as part of this LTCP to the water quality model. Changes to, and recalibration of, the IW and water quality models are discussed in *Flushing Bay LTCP – Sewer System and Water Quality Modeling – April 2016, Revised December 2016.* The new IW model network was then used to calculate CSOs and loads for the baseline conditions and was used as a tool to evaluate the impact on CSOs of potential alternative operating strategies and other possible physical changes to the collection system.

The baseline modeling conditions primarily related to DWF rates, wet-weather capacity for the Bowery Bay WWTP, sewer conditions, loadings and boundary conditions, precipitation conditions, and tidal boundary conditions are briefly discussed in the following:

- **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 used for the Bowery Bay WWTP was 113.5 MGD and Tallman Island WWTP was 57.1 MGD.

- **Wet-Weather Capacity**: The rated wet-weather capacity at the Bowery Bay WWTP is 300 MGD (2xDDWF) and Tallman Island WWTP is 160 MGD.

- **Sewer Conditions**: The IW model was developed to represent the sewer system on a macro scale, including all conveyance elements greater than 48-inches in equivalent diameter, along with all regulator 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.

6.1.a Hydrological Conditions

For this LTCP, the precipitation characteristics for 2008, based on JFK Airport precipitation data, 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 model.

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 analysis of water demand and wastewater flow projections. A detailed GIS analysis was also performed to apportion total population among the 14 WWTP sewersheds throughout NYC. For this analysis, Transportation Analysis Zones were overlaid with WWTP sewersheds. Population projections for 2010-2040 were derived from population projections developed by DCP and the New York Metropolitan Transportation Council. 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 Best Management Practices Findings and Optimization

A list of BMPs pertaining to Flushing Bay CSOs, along with a brief summary of each and their respective relationship to the EPA NMCs appear in Section 3.0. 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 combined sewer system, 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 the development of the baseline conditions, specifically in developing and using the IW models to simulate CSO discharges and in establishing non-CSO discharges that impact water quality in Flushing Bay:

- Sentinel Monitoring: In accordance with BMPs #1 and #5, DEP collects quarterly samples of bacteria water quality at two locations in Flushing Bay (Stations S-65 and S-66 as shown in Figure 2-27) in dry-weather to assess whether dry-weather sewage overflows occur, or whether illicit connections to storm sewers exist. No evidence of illicit sanitary sewer connections was observed based on these data and no illicit sources were included in the baseline conditions.

AECOM with Hazen

- 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 BMP #3 and the 2014 CSO BMP Order on Consent, the Bowery Bay and Tallman Island WWTPs treat wet-weather flows that are conveyed to the plant, up to 2xDDWF. DEP follows the WWOP to receive and regularly treat 2xDDWF. Cleaning of the interceptor sediments has increased the ability of the system to convey 2xDDWF to the WWTP.

- Wet Weather Operating Plan: The Bowery Bay and Tallman Island WWOPs (BMP #4) establish procedures for pumping at the plant headworks to facilitate treatment of 2xDDWF.

6.1.d Elements of Facility Plan and GI Plan

DEP maintains containment booms to control floatables at CSO Outfalls BB-005, BB-006 and BB-008. The captured floatables are removed using skimmer vessels. Results of this program are provided in the Annual CSO BMP Report. The Flushing Bay LTCP also includes the following grey projects that are currently under construction as recommended in the Flushing Bay 2011 WWFP:

- Modification to regulator structure BB-02 that discharges to Outfall BB-002 and construction of a new sanitary sewer to reroute this direct connection from the HLI to the LLI to avoid potential flooding from the increased hydraulic grade line due to the regulator modifications. These improvements allow the regulator weir at BB-02 to be raised to convey more wet-weather flow to the Bowery Bay WWTP.

- Modifications to regulator structures BB-04, BB-05, BB-06, BB-09, BB-010 that discharge to Outfalls BB-005, BB-006, BB-007, BB-008 to reduce CSO discharges to Flushing Bay and allow more wet-weather flow to be delivered to the Bowery Bay WWTP.

- Flushing Creek LTCP recommended alternative consisting of seasonal disinfection of the TI-010 Outfall Disinfection at the Flushing Bay CSO Retention Tank, Diversion Chamber 5 and Outfall TI-011 Outfall Disinfection.

These capital projects were included in the 2012 CSO Order with milestones for the modifications associated with BB-02 to be completed by December 2017 and the other Bowery Bay regulator modifications to be completed by June 2018.

As discussed in Section 5.0, the Flushing Bay watershed has been targeted for GI projects by DEP. The list of GI projects presented in Section 5 has been assumed to be fully implemented in the baseline model.

6.1.e Non-CSO Discharges

Over the past approximately 30 years, DEP has invested heavily in mapping and delineating combined sewer drainage areas and piping systems as part of CSO facility planning and waterbody watershed facility planning efforts. However, non-CSO drainage areas have not received the same level of effort.

Non-CSO drainage areas were first identified during WWFP activities as land areas that were not contained within the CSO drainage areas. They were labeled as direct drainage and stormwater drainage areas, but that distinction had no real meaning since both areas were assigned the same runoff characteristics. As part of DEP's LTCP work, a distinction was made to further refine these areas. Direct drainage areas (parks, cemeteries, large un-occupied open areas, etc.) are now assigned lower pathogen runoff concentrations than are assigned to more urbanized non-CSO drainage areas (residential, commercial areas with a separate storm sewer system). In addition, highway runoff has been established as a category, but in many cases highway runoff is lumped together with other stormwater discharges.

In several sections of the Bowery Bay and Tallman Island WWTP sewersheds, runoff drains directly to receiving waters via overland flow, open channels, or privately owned pipes, without entering the combined sewer system or separate storm sewer system. These areas were depicted as "Direct Drainage" in Figure 6-1 and were estimated based on topography and the direction of stormwater runoff flow in those areas. In general, shoreline areas adjacent to waterbodies comprise the direct drainage category, as they consist of parks, marinas, sporting venues and trailways. These areas, however, also contain industrial properties, LaGuardia Airport, and sections of highways adjacent to Flushing Bay (Grand Central Parkway, Whitestone Expressway, etc.). In total, these areas comprise approximately 1,105 acres of the 6,603 acres of drainage area tributary to Flushing Bay.

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

As previously noted, the IW model was used to develop CSO volumes for baseline conditions. The model incorporated the implementation of planned GI and grey infrastructure associated with the regulator modifications for the Tallman Island and Bowery Bay sewersheds, respectively. Using these overflow volumes, CSO loadings were generated using the enterococci, fecal coliform and BOD concentrations and provided input to the receiving water quality model, ERTM. ERTM was assessed using 2013 and 2014 monitoring data collected during the Flushing Creek LTCP, as well as 2014 Sentinel Monitoring data. The assessment employed an hourly Monte Carlo randomization of the measured range of CSO concentrations assigned to the hourly overflows simulated by IW for the two outfalls contributing the most annual volume of CSO to Flushing Bay (BB-006 and BB-008). Other smaller CSO outfalls were assigned loadings based on a mass balance procedure, described below. The model validation consisted of comparing the time series and cumulative frequency distributions of 2013 and 2014 concentration data against the time series and cumulative frequency distribution output from the model for storms of similar sizes. Further details on the modeling validation analyses are provided in the technical memorandum *"Flushing Bay LTCP Sewer System and Water Quality Modeling, April 2016, Revised December 2016."*

In addition to CSO loadings, storm sewer discharges and direct drainage impact the water quality in Flushing Bay. The concentrations assigned to the various discharge sources to Flushing Bay are summarized in Table 6-1. Concentrations in Table 6-1 represent typical stormwater, direct drainage and sanitary sewage concentrations for the Flushing Bay watershed are based on water quality data collected in the Flushing Bay watershed.

For the outfalls where a mass balance approach was used, CSO concentrations were calculated using the stormwater and sanitary concentrations assigned in Table 6-1, multiplied by the flow calculated by the IW model.

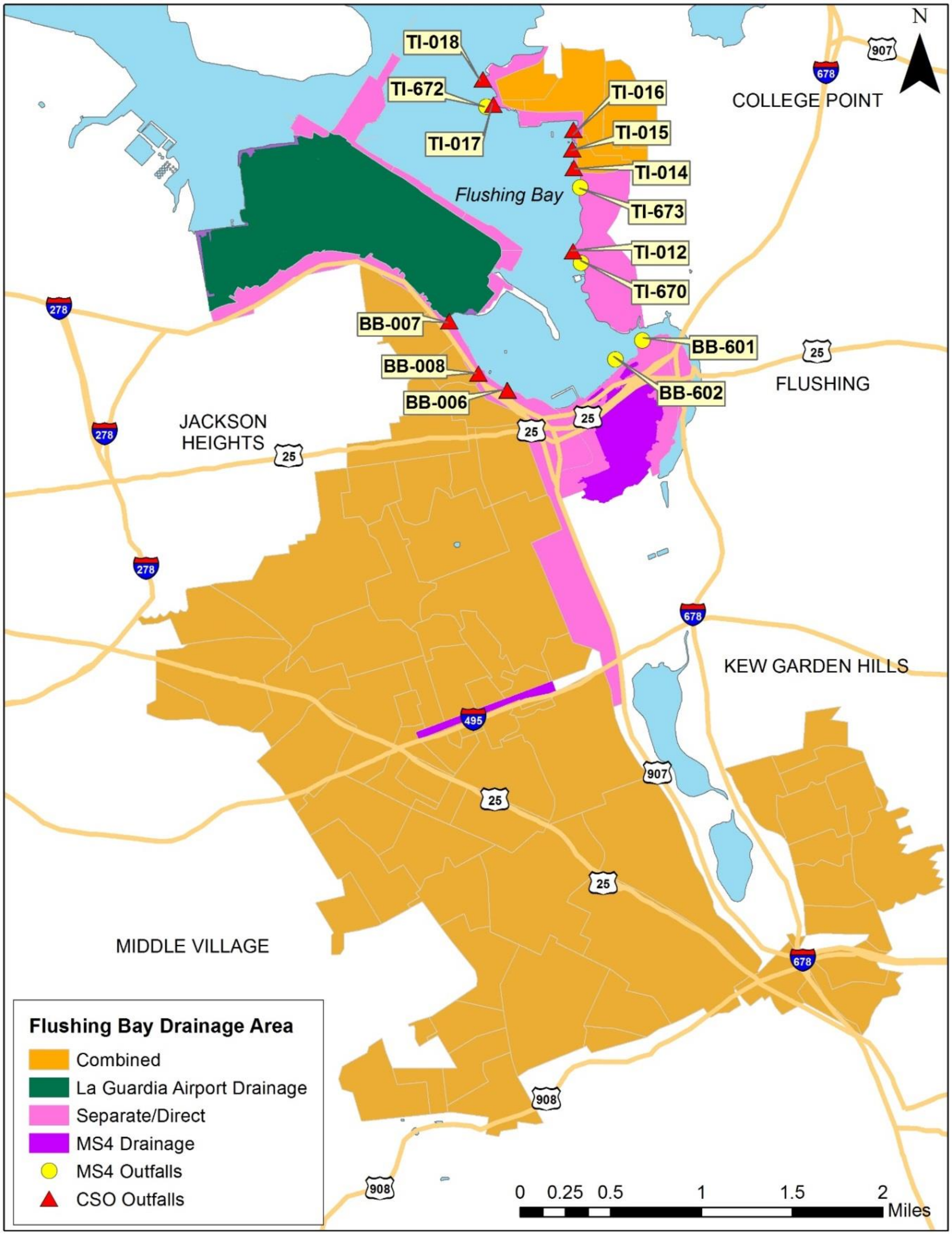

Figure 6-1. InfoWorks CSO and MS4 Subcatchments within the Flushing Bay

The model provides a calculated fraction of flow from stormwater and flow from sanitary sources, as follows:

$C_{cso} = fr_{san}*C_{san} + fr_{sw}*C_{sw}$

where: C_{cso} = CSO concentration

C_{san} = sanitary concentration

C_{sw} = stormwater concentration

fr_{san} = fraction of flow that is sanitary

fr_{sw} = fraction of flow that is stormwater

Table 6-1. Source Concentrations from NYC Sources

Source	Enterococci (cfu/100mL)	Fecal Coliform (cfu/100mL)	BOD_5 (mg/L)
Urban Stormwater(2)	15,000	35,000	15
CSOs (BB-006 and BB-008)(1)	Monte Carlo	Monte Carlo	Mass Balance (Sanitary =140)
Sanitary for Mass Balance CSOs(1)	600,000	4,000,000	Mass Balance (Sanitary=140)
Highway/Airport Runoff (3)	8,000	20,000	15
Direct Drainage(3)	6,000	4,000	15

Notes:
(1) Flushing Bay LTCP Sewer System and Water Quality Modeling, 2016.
(2) HydroQual Memo to DEP, 2005a.
(3) Basis – NYS Stormwater Manual, Charles River LTCP, National Stormwater Data Base.

MS4 areas in the IW model were updated based on desk-top analysis conducted by DEP. Non-MS4 stormwater areas and direct drainage areas are meant to represent the remaining areas of the drainage areas, and do not always consider the drainage area of each individual outfall. Figure 6-1 presents the IW subcatchments within the drainage area of Flushing Bay.

Baseline volumes of CSO to Flushing Bay for the 2008 typical year by outfall are summarized in Table 6-2, and the total baseline volumes of CSO, stormwater and direct drainage to Flushing Bay along with the associated fecal coliform, enterococci, and BOD annual loadings are summarized in Table 6-3 for the 2008 typical year. The specific SPDES permitted outfalls associated with these sources are shown in Figure 6-1. Additional tables that summarize annual volumes and loadings can be found in Appendix A. The information in these tables is provided for the 2008 rainfall condition.

Table 6-2. 2008 CSO Volume and Overflows per Year

CSO	Volume(1)	Annual Overflow Events
	Total Discharge (MG/yr)	Total (No./yr)
BB-006U	631	45
BB-006L	258	29
BB-007	38	40
BB-008	478	47
TI-012	0	0
TI-014	10	37
TI-015	3	20
TI-016	29	45
TI-017	2	21
TI-018	4	34
Total	1,453	-

Note:
(1) Volumes are rounded to the nearest MG.

Table 6-3. 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)
Flushing Bay	CSO	1,453	32,804	42,781	515,687
	MS4 SW	110	62	144	13,582
	Non-MS4 SW	119	68	158	14,876
	LGA & Highway	220	66	166	27,430
	Direct Drainage	163	37	25	20,359
Total		**2,065**	**33,037**	**43,274**	**591,934**

As indicated in Table 6-2, the majority of the total CSO discharge volume originates from Outfalls BB-006 and BB-008 with 888 MG and 478 MG of CSO volume, respectively, under 2008 conditions. The CSO outfalls from the Bowery Bay sewershed discharge relatively frequently on the order of two to four times per month on average and account for over 95 percent of the CSO volume discharge to the Bay annually. CSO discharges from the Tallman Island sewershed that discharge directly to the Bay are much smaller by volume and less frequent. These outfalls account for less than 5 percent of the CSO discharged to the Bay annually.

The loadings for the two largest CSOs presented in Table 6-3 was developed using the Monte Carlo approach based on sampling data. For the remaining CSOs, the mass balance approach was used. An example of the IW CSO mass balance concentration calculation for CSO enterococci concentration is presented below using sanitary and storm runoff concentrations from Table 6-1:

$$73{,}500 \text{ cfu/100mL} = 0.10 \times 600{,}000 \text{ cfu/100mL} + 0.90 \times 15{,}000 \text{ cfu/100mL}$$

6.3 Performance Gap

Bacteria and DO concentrations in Flushing Bay are controlled by a number of factors, including the volumes of all sources, the concentrations of the respective loadings, flow entering from Flushing Creek, and the exchange of tidal flow with the East River. Because much of the flow and loads discharged into this waterbody are the result of runoff from rainfall events, the frequency, duration, and amounts of rainfall strongly influence Flushing Bay's water quality.

The Flushing Bay portion of the ERTM model was 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 the Potential Future Primary Contact WQ Criteria for bacteria, as well as designated and next higher use classifications for DO, as 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 (Class I);
- Bacteria Primary Contact WQ Criteria and DO next higher use classification (Class SC); and
- Bacteria Potential Future Primary Contact Recreational WQ Criteria (2012 EPA RWQC).

Within the following sections, analyses are described that reflect the differences in attainment both spatially and temporally. 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 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	(Class I)	Fecal Monthly GM ≤ 200; DO never < 4.0 mg/L
Bacteria Primary Contact WQ Criteria / DO Class SC(1)	(Class SC)	Fecal Monthly GM ≤ 200 DO between > 3.0 & ≤4.8 mg/L(1, 3); DO never < 3.0 mg/L(1)
Potential Future Primary Contact WQ Criteria(2)	Entero: rolling 30-day 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 Flushing Bay.
(2) DEC has not yet adopted the Potential Future Primary Contact WQ Criteria.
(3) This is an excursion based limit that allows for the average daily DO concentrations to fall between 3.0 and 4.8 mg/L for a limited number of days as described in more detail on Table 2-7 in Section 2.

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

Assessing the performance gap required calculating Flushing Bay fecal coliform concentrations under baseline conditions and then establishing whether the gap could be closed through reductions to, or control of, CSOs. The assessment was to determine if Flushing Bay water quality would comply with Existing WQ Criteria. The water quality monitoring stations are shown in Figure 6-2.

2008 Annual Rainfall Simulation – Bacteria

A one-year simulation of bacteria water quality was performed for the 2008 baseline loading conditions, assuming all known dry-weather illicit discharges have been eliminated. The results of these simulations 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 recreational season (May 1st through October 31st). The maximum monthly GM is presented for each sampling location in Flushing Bay.

Table 6-5. Model Calculated 2008 Baseline Fecal Coliform Maximum Monthly GM and Attainment of Existing WQ Criteria

Station	Maximum Monthly Geometric Means		% Attainment	
	Annual	Recreational Season	Annual	Recreational Season
OW7	129	15	100	100
OW7A	84	13	100	100
OW7B	148	16	100	100
OW7C	156	17	100	100
OW8	179	16	100	100
OW9	105	14	100	100
OW10	77	13	100	100
OW11	47	16	100	100
OW12	65	14	100	100
OW13	62	13	100	100
OW14	49	21	100	100
OW15	59	19	100	100

Table 6-5 also presents the annual attainment (percent) of the fecal coliform GM criterion of 200 cfu/100mL. Although the highest GMs were found to occur in the Inner Flushing Bay near the CSOs, 100 percent attainment is achieved at all of the stations within the Bay during the recreational season (May 1st through October 31st) and on an annual basis. As a result, there is no gap in attainment of the fecal coliform standard.

2008 Annual Rainfall Simulation – Dissolved Oxygen

Water quality model simulation DO attainment results are presented in Table 6-6 for year 2008 conditions as calculated for the entire water column. When assessing the water column in its entirety, attainment of the DO criterion is very high. All of the station locations that were assessed have a water column annual attainment of 97 percent or greater for year 2008 conditions, which is greater than the 95 percent target DEC uses to assess compliance.

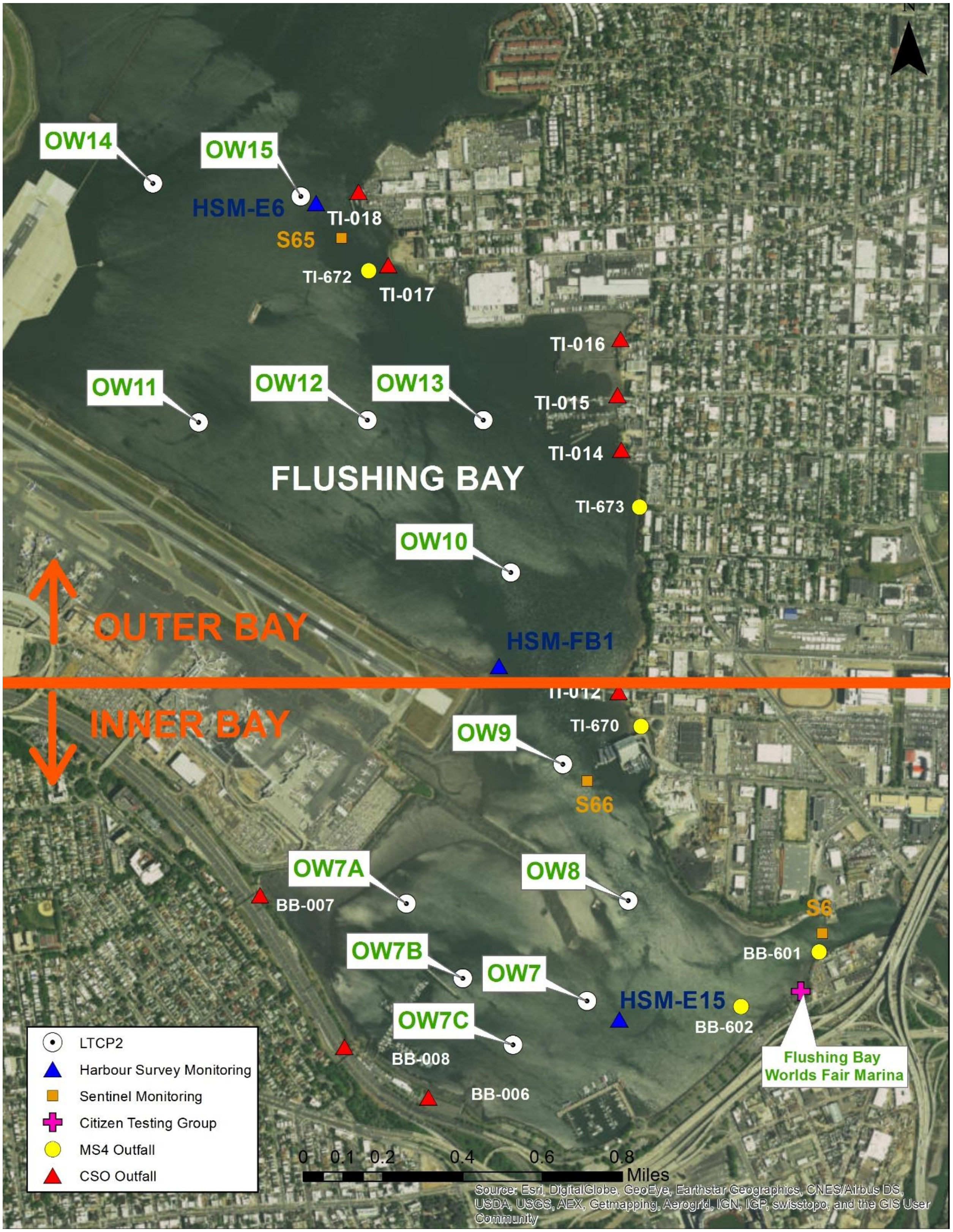

Figure 6-2. LTCP2 Water Quality Monitoring Stations in Flushing Bay

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

Station	Annual Attainment (%) Entire Water Column >=4.0 mg/L
OW7	100
OW7A	100
OW7B	100
OW7C	100
OW8	100
OW9	100
OW10	99
OW11	99
OW12	99
OW13	99
OW14	97
OW15	98

Table 6-7 presents a comparison of the Class I DO criterion attainment under baseline and 100% CSO control. The model generally calculates changes of only a few tenths of one percent improvement in attainment with the DO criterion. Thus, CSO loads are not the controlling factor for DO concentrations and CSO controls will not improve DO concentrations substantially. This is not unexpected as the DO in Flushing Bay is influenced by many factors including stormwater loads, tidal flushing and the nitrogen discharged from WWTPs.

Table 6-7. Model Calculated Baseline and 100% CSO Control DO Attainment – Existing WQ Criteria (2008)

Station	Annual Attainment Percent Attainment (Entire Water Column)	
	Baseline	100% Flushing Bay CSO Control
OW7	100	100
OW7A	100	100
OW7B	100	100
OW7C	100	100
OW8	100	100
OW9	100	100
OW10	99	99
OW11	99	99
OW12	99	99
OW13	99	99
OW14	97	97
OW15	98	98

6.3.b CSO Volumes and Loadings That Would be Needed to Support the Next Highest Use or Swimmable/Fishable Uses

Bacteria

The next highest use for Flushing Bay is Class SC with fishing being the best usage. DEC has promulgated new regulations that require Class SD and I waterbodies to meet the primary contact (Class SC) bacteria criteria. The primary contact fecal coliform criterion is a monthly GM less than or equal to 200 cfu/100mL.

The 2008 baseline condition scenario was rerun with the Flushing Bay CSO loadings removed. This projection represents the maximum possible reduction of Flushing Bay CSO loads and is referred to as the 100% CSO control scenario. It should, however, be noted that there are numerous other CSO outfalls that discharge to the East River/Upper East River which remain at baseline conditions for this CSO control scenario. All other conditions from the baseline projection remain unchanged in the 100% CSO control scenario. Table 6-8 presents the maximum monthly coliform GM concentration and the annual attainment of the Class SC criterion for fecal coliform.

Table 6-8. Comparison of the Model Calculated 2008 Baseline and 100% Flushing Bay CSO Control Fecal Coliform Maximum Monthly GM and Attainment of Primary Contact WQ Criteria

Station	Maximum Monthly Geometric Means (Annual)		% Attainment (Annual)	
	Baseline	100% CSO Control	Baseline	100% CSO Control
OW7	129	77	100	100
OW7A	84	32	100	100
OW7B	148	63	100	100
OW7C	156	73	100	100
OW8	179	133	100	100
OW9	105	69	100	100
OW10	77	55	100	100
OW11	47	38	100	100
OW12	65	48	100	100
OW13	62	45	100	100
OW14	49	44	100	100
OW15	59	47	100	100

Table 6-8 shows that the CSOs have the largest impact in the vicinity of Stations OW7B and OW7C, where the removal of the CSO loadings results in a reduction of the maximum monthly fecal coliform GM concentration by 85 and 83 cfu/100mL, respectively. Improvements in the monthly fecal coliform GM (due to 100% CSO control) are less significant in the outer portions of Flushing Bay. Attainment with the fecal coliform monthly geomean criteria remains at 100 percent with the removal of the CSOs resulting in lower geomean concentrations at each of the monitoring locations.

Dissolved Oxygen

The attainment of the DO Class SC criteria for the entire water column is presented in Table 6-9, for the baseline and 100% Flushing Bay CSO control conditions. Determination of attainment with Class SC DO criteria can be very complex as the standard allows for excursions from the daily average limit of 4.8 mg/l for a limited number of consecutive calendar days. To simplify the analysis, attainment was based solely upon attainment of the daily average without the allowed excursions. While the analysis performed was conservative, the results indicate full attainment at all stations, except for Station OW-14. Under baseline conditions, stations in the Inner Flushing Bay have a greater than 95 percent attainment of the chronic DO criterion (greater than or equal to 4.8 mg/L), while Station OW14 in the Outer Flushing Bay has attainment less than 95 percent on an annual basis. 100% CSO control results in no improvement of percent annual attainment of the chronic DO criterion. All of the stations have 100 percent attainment of the acute criterion (never less than 3.0 mg/L) under baseline conditions based on the entire water column. Since 100% CSO control does not result in improvements in attainment of the Class SC criterion, there is no gap between attainment and non-attainment at all monitoring locations within Flushing Bay, regardless of the level of control implemented.

Table 6-9. Model Calculated 2008 Baseline and 100% CSO Control DO Attainment of Class SC WQ Criteria

Station	Annual Attainment Percent Attainment (Water Column)			
	Baseline		100% Flushing Bay CSO Control	
	Chronic(1)	Acute(2)	Chronic(1)	Acute(2)
OW7	100	100	100	100
OW7A	100	100	100	100
OW7B	100	100	100	100
OW7C	100	100	100	100
OW8	100	100	100	100
OW9	100	100	100	100
OW10	100	100	100	100
OW11	97	100	97	100
OW12	100	100	100	100
OW13	100	100	100	100
OW14	83	100	83	100
OW15	96	100	97	100

Notes:
(1) Chronic Criteria: 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 recreational water quality criteria for protecting human health in all coastal and non-coastal waters designated for primary contact recreation use. The standards would include a rolling 30-day GM of either 30 cfu/100mL or 35 cfu/100mL and a 90th 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 90th percentile STV criteria, to assess attainment with these potential future RWQC.

6.3.d Load Reductions Needed to Attain the Potential Future Primary Contact WQ 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 Flushing Bay. That analysis consisted of first assessing the baseline conditions for enterococci and then determining whether complete Flushing Bay CSO reduction (100% CSO control) could close the gap between the baseline conditions and the potential future recreational water quality criterion of a 30-day rolling GM enterococci concentration of 30 cfu/100mL. The results of the analyses are presented in Table 6-10 for the maximum 30-day GM and attainment of the rolling 30-day GM criterion. All results are for the attainment of the Potential Future Primary Contact WQ Criteria during the May 1st through October 31st recreational season defined by the DEC.

Table 6-10. Model Calculated 2008 Baseline Enterococci Maximum 30-day GM and Attainment of Potential Future Primary Contact WQ Criteria

Station	Maximum Recreational Season 30-day Enterococci (cfu/100mL)		% Attainment	
	GM	90th Percentile STV	GM	90th Percentile STV
OW7	18	2,890	100	9
OW7A	18	4,417	100	9
OW7B	22	5,696	100	9
OW7C	22	6,166	100	9
OW8	17	1,274	100	12
OW9	14	1,565	100	13
OW10	12	930	100	29
OW11	11	288	100	78
OW12	12	475	100	57
OW13	13	648	100	60
OW14	13	243	100	77
OW15	13	327	100	72

Under 2008 baseline conditions, 100 percent attainment of the rolling 30-day GM enterococci criteria of 30 cfu/100mL is achieved during the recreational season (May 1st through October 31st). Attainment of the 90th percentile STV criterion of 110 cfu/100mL within Outer Flushing Bay (Stations OW10 through OW15), ranges from 29 to 78 percent, while Inner Flushing Bay (Stations OW7 through OW9), ranges from 9 to 13 percent. These results indicate that while rainfall events have significant short term impacts, particularly within the Inner Flushing Bay, bacteria impacts dissipate before the 30-day GM criterion is violated.

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 control would result in full attainment of the 30-day rolling GM enterococci criterion. Attainment of the 90th percentile STV enterococci criterion ranges from 81 to 100 percent. The improvement in STV attainment with 100% CSO controls, as calculated for Flushing Bay, is high in comparison to other waterways. The high degree of attainment with 100% CSO control indicates that the 90th percentile enterococci concentrations are predominantly generated by CSOs and therefore can be altered with CSO controls. This is further supported by Table 6-3 above, which shows that CSOs are the source of an overwhelming majority of the bacteria loading to Flushing Bay. With 100% control of CSOs, the model calculates comparatively high attainment of the 90th percentile STV criterion. However, other non-CSO sources of bacteria, such as storm sewers, direct runoff, Flushing Creek and the East River also contribute to the non-attainment of the criterion.

Table 6-11. Model Calculated 2008 100% CSO Control Enterococci Maximum 30-day GM and Attainment of Potential Contact WQ Criteria

Station	Maximum Recreational Season 30-day Enterococci (cfu/100mL)		% Attainment	
	GM	90th Percentile STV	GM	90th Percentile STV
OW7	5	120	100	93
OW7A	4	43	100	100
OW7B	5	74	100	100
OW7C	5	92	100	100
OW8	7	180	100	81
OW9	6	94	100	100
OW10	6	117	100	99
OW11	8	118	100	99
OW12	8	123	100	97
OW13	7	114	100	97
OW14	11	151	100	87
OW15	10	140	100	95

A load source component analysis was conducted for the 2008 baseline condition using JFK Airport rainfall data, to provide a better understanding of how each source type contributes to bacteria concentrations in Flushing Bay. The source types include CSOs, stormwater, direct drainage, Flushing Creek, and the East River. Since the stormwater contribution to bacteria loads is relatively small when compared to CSOs, the MS4 and non-MS4 loads were lumped together as one source, and the direct drainage and LaGuardia Airport runoff was analyzed as one source. The analysis included the calculation of fecal coliform and enterococci bacteria GMs in total and from each component. For fecal coliform, a maximum winter month (December) was analyzed because the decay rate is lower in winter, resulting in generally higher fecal coliform concentrations. Enterococci was evaluated on a maximum recreational season (May 1st through October 31st) 30-day GM basis. The 30-day period chosen for the enterococci component analysis included both the maximum 30-day period and the 30-day period where the maximum contribution of CSOs to the geometric mean was observed.

Table 6-12 summarizes the fecal coliform component analysis for the maximum winter month during 2008. The fecal coliform criterion (monthly GM less than or equal to 200 cfu/100mL) is not exceeded during this maximum winter month (December) at all locations. The maximum monthly CSO contribution is 85 cfu/100mL at Station OW7C. CSOs are the largest contributor to the monthly GM fecal coliform concentration in the Inner Flushing Bay at Stations OW7A, OW7B, and OW7C. Monthly GM fecal coliform concentrations at Stations OW7, OW8, OW9, OW10, OW12, and OW13 are more heavily influenced by Flushing Creek, while Stations OW11, OW14, and OW15 are most heavily influenced by the East River. A review of Figure 6-2 indicates that in each case the source of fecal coliform in closest proximity to a particular monitoring station has the greatest influence on the monthly GM fecal coliform concentration at that station. Regardless of the source of fecal coliform, all stations achieved attainment with a maximum monthly fecal coliform GM less than the criterion of 200 cfu/100mL.

Table 6-12 also summarizes the enterococci component analysis. CSO is the largest contributor to the 30-day GM at Stations OW7 and OW10 with a maximum contribution at Inner Flushing Bay Stations OW7B and OW7C of 17 cfu/100mL. The East River is the largest influence on Outer Flushing Bay at Stations OW11 through OW15 with a maximum contribution of 11 cfu/100mL at Station OW14. None of the stations had a 30-day enterococci GM greater than the potential future criterion of 30 cfu/100mL.

Table 6-12 indicates that CSO impacts to attainment are most evident within Inner Flushing Bay, although the extent of CSO contribution varies both spatially and temporally. As such, the alternatives analysis described in Section 8.0 focuses on reduction of the CSO discharges to Flushing Bay.

Table 6-12. Fecal and Enterococci GM Source Components

Source	Station	Fecal Coliform Contribution (cfu/100mL)	Enterococcus Contribution (cfu/100mL)
		Annual Worst Month December Monthly GM	Max 30-Day Rolling GM during the Recreational Season (May 1st through October 31st)
Flushing Creek	OW7	68	3
Direct Drainage	OW7	2	0
Stormwater	OW7	3	0
CSO	OW7	52	13
East River	OW7	4	2
Total	OW7	**129**	**18**
Flushing Creek	OW7A	26	2
Direct Drainage	OW7A	3	1
Stormwater	OW7A	1	0
CSO	OW7A	52	15
East River	OW7A	2	1
Total	OW7A	**84**	**18**
Flushing Creek	OW7B	55	3
Direct Drainage	OW7B	3	1
Stormwater	OW7B	2	0

Table 6-12. Fecal and Enterococci GM Source Components

Source	Station	Fecal Coliform Contribution (cfu/100mL)	Enterococcus Contribution (cfu/100mL)
		Annual Worst Month December Monthly GM	Max 30-Day Rolling GM during the Recreational Season (May 1st through October 31st)
CSO	OW7B	85	17
East River	OW7B	3	1
Total	OW7B	**148**	**22**
Flushing Creek	OW7C	63	3
Direct Drainage	OW7C	4	1
Stormwater	OW7C	3	0
CSO	OW7C	83	17
East River	OW7C	3	1
Total	OW7C	**156**	**22**
Flushing Creek	OW8	121	5
Direct Drainage	OW8	0	1
Stormwater	OW8	6	0
CSO	OW8	46	10
East River	OW8	6	2
Total	OW8	**179**	**17**
Flushing Creek	OW9	55	2
Direct Drainage	OW9	3	0
Stormwater	OW9	2	0
CSO	OW9	36	8
East River	OW9	9	3
Total	OW9	**105**	**13**
Flushing Creek	OW10	40	2
Direct Drainage	OW10	1	0
Stormwater	OW10	1	0
CSO	OW10	22	6
East River	OW10	13	4
Total	OW10	**77**	**12**
Flushing Creek	OW11	6	0
Direct Drainage	OW11	2	0
Stormwater	OW11	2	0
CSO	OW11	9	3
East River	OW11	28	8
Total	OW11	**47**	**11**
Flushing Creek	OW12	25	1
Direct Drainage	OW12	1	0

Table 6-12. Fecal and Enterococci GM Source Components

Source	Station	Fecal Coliform Contribution (cfu/100mL)	Enterococcus Contribution (cfu/100mL)
		Annual Worst Month December Monthly GM	Max 30-Day Rolling GM during the Recreational Season (May 1st through October 31st)
Stormwater	OW12	1	0
CSO	OW12	17	5
East River	OW12	21	6
Total	OW12	**65**	**12**
Flushing Creek	OW13	23	1
Direct Drainage	OW13	0	0
Stormwater	OW13	2	0
CSO	OW13	17	6
East River	OW13	20	6
Total	OW13	**62**	**13**
Flushing Creek	OW14	2	0
Direct Drainage	OW14	1	0
Stormwater	OW14	0	0
CSO	OW14	5	2
East River	OW14	41	11
Total	OW14	**49**	**13**
Flushing Creek	OW15	11	0
Direct Drainage	OW15	0	0
Stormwater	OW15	1	0
CSO	OW15	12	3
East River	OW15	35	9
Total	OW15	**59**	**12**

6.3.d Time to Recovery

The analyses provided above examine the long term impacts of wet-weather sources, as is required by Existing and Potential Future Primary Contact WQ 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 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 waterbodies do not pose potential hazards if used for primary contact activities.

> **From NYS DOH**
>
> **https://www.health.ny.gov/regulations/nycrr/title_10/part_6/subpart_6-2.htm**
>
> **Operation and Supervision**
>
> 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.
>
> (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; ….

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 Flushing Bay to recover and return to concentrations of less than 1,000 cfu/100mL.

LGA rainfall data were first analyzed for the period of 2002-2011. The Synoptic Surface Plotting Models (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 the time until the next rainfall event, which allows concentrations to reach the fecal coliform target concentration. The period of dry-weather following this event allows for sufficient time to assess a wide range of recovery times that may occur depending on the characteristics of the CSO discharges and the receiving waterbodies.

Table 6-13 presents the time to recovery for the baseline condition and the 100% Flushing Bay CSO control scenario. Under the baseline conditions, Stations OW7, OW7B, OW7C, and OW9 have the longest time to recovery of 23 hours. DEC has indicated that it is desirable to have a time to recovery of less than 24 hours. The other Flushing Bay stations have time to recovery ranging between 9 and 21 hours.

Once CSOs are removed in Flushing Bay (100% CSO control), there is a fairly significant reduction in the time to recovery compared to baseline conditions. In most areas within Flushing Bay, the time to recovery will be decreased by 10 hours or more. In areas influenced by other sources such as OW14, there would be little change in the time to recovery.

Table 6-13. Time to Recovery

Station	Time to Recovery (hours) Fecal Threshold (1,000 cfu/100mL)	
	Baseline	100% CSO Control
OW7	23	10
OW7A	21	0
OW7B	23	0
OW7C	23	0
OW8	22	10
OW9	23	10
OW10	21	9
OW11	11	0
OW12	21	0
OW13	20	5
OW14	9	9
OW15	20	10

In summary, the time to recovery for baseline conditions appears to be on the order of DEC's desired target of 24 hours. However, there is a significant decrease in the time to recovery if CSO loadings are removed.

7.0 PUBLIC PARTICIPATION AND AGENCY COORDINATION

DEP is committed to implementing a proactive and robust public participation program to inform the public about the development of watershed-specific and citywide LTCPs. Public outreach and public participation are important aspects of the plans, which are designed to reduce CSO-related impacts to achieve waterbody-specific WQS, consistent with the Federal CSO Policy and the CWA, and in accordance with EPA and DEC mandates.

DEP's Public Participation Plan was released to the public on June 26, 2012, and describes the tools and activities DEP uses to inform, involve and engage a diverse group of stakeholders and the broader public throughout the LTCP process. The purpose of the Plan is to create a framework for communicating with and soliciting input from interested stakeholders and the broader public concerning water quality and the challenges and opportunities for CSO controls. As described in the Public Participation Plan, DEP will strategically and systematically implement activities that meet the information needs of a variety of stakeholders in an effort to meet critical milestones in the overall LTCP schedule outlined in the 2012 CSO Order.

As part of the CSO Quarterly Reports, DEP reports to DEC on public participation activities outlined in the Public Participation Plan, along with the quarterly summary of public participation activities.

7.1 Local Stakeholder Team

DEP began the public participation process for the Flushing Bay LTCP by reaching out to the Flushing Bay Community Boards to identify the stakeholders who would be instrumental to the development of this LTCP. Identified stakeholders included both citywide and regional groups such as: environmental organizations (S.W.I.M. Coalition, Riverkeeper, Guardians of Flushing Bay, Friends of Flushing Creek, Save the Sound, New York-New Jersey Harbor and Estuary Program, Empire Dragon Boat, Women in Canoe, DCH Racing, Coastal Preservation Network); community planning organizations (Kissena Park Civic Association); academic and research organizations (Queens College, Queens Historical Society); City governmental agencies (NYC Department of Parks and Recreation, NYC Department of City Planning, New England Interstate Water Pollution Control Commission).

7.2 Summaries of Stakeholder Meetings

DEP held two public meetings and several stakeholder meetings to aid in the development and execution of the LTCP. The objective of the public meetings and a summary of the discussions are presented below:

Public Meetings

- Public Meeting #1: Flushing Bay LTCP Kickoff Meeting (September 30, 2015)

  Objectives: Provide overview of LTCP process, public participation schedule, watershed characteristics and sampling program.

  DEP hosted a Public Kickoff Meeting to initiate the water quality planning process for the Flushing Bay LTCP. Approximately 80 stakeholders from 25 different non-profit, community, planning, environmental, economic development, governmental organizations, and the broader public, attended the event, as did three media representatives. The two-and-half-hour event, held at Al Oerter Recreation Center, Queens, provided stakeholders with information about DEP's LTCP Program, Flushing Bay watershed characteristics, and the status of waterbody improvement projects. DEP also solicited information from the public about their recreational use of Flushing Bay, and described additional opportunities for public input and outreach. The presentation is available on DEP's LTCP Program website: http://www.nyc.gov/dep/ltcp.

  The Flushing Bay LTCP Kickoff Public Meeting was the first opportunity for public participation in the development of this LTCP. As part of the development of the LTCP, and in response to stakeholder comments, DEP provided detailed information about each of the following:

  - Flushing Bay water quality standard classification;
  - Flushing Bay ongoing and new developments;
  - Flushing Bay current uses;
  - Flushing Bay watershed and land uses;
  - Flushing Bay sampling program;
  - Flushing Bay water quality improvement projects;
  - Flushing Bay Pre-WWFP and LTCP Baseline modeled CSO volumes; and
  - Flushing Bay CSO mitigation options.

  Stakeholder comments and DEP's responses are posted to DEP's LTCP Program website and are included in Appendix B, Public Participation Materials.

- Public Meeting #2: Flushing Bay LTCP Alternatives Review Meeting (October 26, 2016)

  Objectives: Review proposed alternatives, related waterbody uses and water quality conditions.

  DEP hosted a second Public Meeting to continue discussion of the water quality planning process. Approximately 50 stakeholders from several different non-profit, community planning, environmental, economic development, and governmental organizations, as well as the general public, attended the event. The purpose of the almost three-hour event, held at the United States Tennis Association Billie Jean King Tennis Center, was to describe the alternatives identification and selection processes, and solicit public comment and feedback. The presentation is available on DEP's LTCP Program website: http://www.nyc.gov/dep/ltcp.

As part of the development of the LTCP, and in response to stakeholder comments, DEP provided detailed information about each of the following:

- Review of Flushing Bay public comments received;
- Review of water quality standards and goals for Flushing Bay;
- Flushing Bay field sampling program results;
- Grey and green infrastructure investments to-date in Flushing Bay;
- Modeling results and performance gap analysis for Flushing Bay;
- Fecal, entero and dissolved oxygen projected attainment for Flushing Bay;
- CSO reduction alternatives evaluation for Flushing Bay;
- Potential sites and alternatives under further review for Flushing Bay;
- Percent CSO Volume and Bacteria Reduction versus Cost for Flushing Bay; and
- Frequency of Overflow versus Cost for Flushing Bay.

Stakeholder comments and DEP's responses are posted on DEP's website, and are included in Appendix B, Public Participation Materials.

- Public Meeting #3: Draft LTCP Review Meeting (not yet scheduled)

  Objectives: Present LTCP after review by DEC.

  This meeting will present the final Recommended Plan to the public after DEC review. Outcomes of the discussion and a copy of presentation materials will be posted to DEP's website.

Stakeholder Meetings

- Flushing Bay and Flushing Creek Community Workshop (March 5, 2016)

  Environmental stakeholders including Riverkeeper, the Guardians of Flushing Bay and the S.W.I.M. Coalition held a community meeting on water quality programs in Flushing Bay and Flushing Creek. DEP attended and gave a brief update on the Flushing Creek and Flushing Bay Long Term Control Plans as well as an update on DEP's Green Infrastructure Program. The meeting was held at the World's Fair Marina and was well attended by local organizations.

- Elected Official and Community Board Meetings:

  DEP maintains positive working relationships with elected officials, community boards, and neighborhood associations. The meetings and briefings listed below allowed DEP to provide information about the Flushing Creek and Flushing Bay Long Term Control Plans, updates on projects under the Flushing Bay Waterbody Watershed Facility Plans, and the green infrastructure implementation in the Flushing Bay watershed.

  - Meeting with Community Board 3 (September 17, 2015)

- Meeting with DCP Community on Flushing West Neighborhood Study (July 29, 2015)
- Briefing for Queens Borough President and Borough Service Cabinet (January 12, 2016)
- Flushing West Neighborhood Study Community Workshop with DCP (February 11, 2016)
- Briefing for Queens Community Board 7 – Environmental Protection Committee (February 25, 2016)
- Briefing for Council Member Koo. (March 15, 2016)
- Briefing for Queens Community Board 7 – Land Use Committee (May 3, 2016)

On July 27, 2016 DEP staff joined The Guardians of Flushing Bay and the Empire Dragon Boating team on a dragon boating excursion in Flushing Bay. This event allowed DEP staff to see and hear first-hand from environmental activists and recreational boaters about the water quality impacts they experience after rain events. A video of the excursion is available on the DEP website.

Public Comments Received

DEP received the following comments:

- Email from Mariana. Flushing Bay, October 30, 2015.
- Email from Marne Asia. How much Flushing can the Flushing Bay take? October 30, 2015.
- Email from Cody Ann Hermann. Flushing Creek LTCP. October 30, 2015.
- Email from Korin Tangtrakul. CSO Discharge in Flushing Bay – discrepancy in the data. December 13, 2015.
- Greater Flushing Chamber of Commerce. DEP's Long Term Control Plan for Flushing Creek. October 30, 2015.
- Empire Dragon Boat Team NYC. Comments on Proposed Final Recommendations – Flushing Creek CSO Long Term Control Plan, October 27, 2015.
- Guardians of Flushing Bay. Comments on Proposed Final Recommendations – Flushing Creek CSO Long Term Control Plan, October 29, 2015.
- Friends of Flushing Creek. Comments on Flushing Creek LTCP Final Recommendations. October 20, 2015.
- School of Earth and Environmental Sciences. Comments on Flushing Creek LTCP. October 30, 2015.
- Queensboro Hill Flushing Civic Association. Flushing Bay CSO Long Term Control Plan. November 23, 2016.
- Guardians of Flushing Bay. Flushing Bay CSO Long Term Control Plan. November 28, 2016.
- Member/Empire Dragon Boat Team. Flushing Bay CSO Long Term Control Plan. November 28, 2016.

- Councilmember Peter Koo. Flushing Bay CSO Long Term Control Plan. November 30, 2016.
- Timothy Eaton and Gregory O'Mullen. Flushing Bay CSO Long Term Control Plan Initial Public Presentation. November 28, 2016.
- Stormwater Infrastructure Matters (S.W.I.M.) Coalition Steering Committee. Flushing Bay CSO LTCP. November 30, 2016.
- Save The Sound. Flushing Bay CSO LTCP. November 30, 2016.
- Friends of Flushing Creek. Comments on Flushing Bay CSO LTCP. December 2, 2016.

These comments are posted to DEP's website and are included in Appendix B, Public Participation Materials.

7.3 Coordination with Highest Attainable Use

Flushing Bay is a Class I water, with the best usages defined by DEC as "secondary contact recreation and fishing. These waters shall be suitable for fish, shellfish, and wildlife propagation and survival. In addition, the water quality shall be suitable for primary contact recreation, although other factors may limit the use for this purpose". Flushing Bay can fully support existing uses, kayaking and wildlife propagation, and the waterbody is in full attainment with its current primary contact classification for bacteria and Class I criteria for DO. This LTCP also incorporates assessments for attainment with the next highest use classification (Class SC). For bacteria, the criteria for the SC classification is the same as for Class I, so the level of attainment is the same. DO levels largely comply with the Class SC standards except at Station OW-14 at which attainment with the chronic standard is 83 percent.

This LTCP further investigated the spatial and temporal attainment with Potential Future Primary Contact WQ Criteria consistent with the 2012 EPA RWQC. Based on 10-year model simulations with the Recommended Plan conducted as part of this LTCP, Flushing Bay is currently predicted to be in full attainment with the potential 30-day geometric mean enterococcus criterion of 30 cfu/100mL during the recreational season (May 1st through October 31st), but the STV value of 110 cfu/100mL could not be attained. Analyses presented herein clearly show that attainment of the STV value of 110 cfu/100mL is not possible through CSO control alone. If the Potential Future Primary Contact WQ Criteria is adopted, DEP would need to confirm whether these projectcions for compliance remain accurate.

DEP is committed to improving water quality in Flushing Bay, and the Recommended Plan for Flushing Bay presented herein will significantly reduce the wet-weather pollutant loads to the Bay. However, while water quality standards are currently attained in Flushing Bay, water quality evaluations conducted as part of the LTCP have demonstrated that short-term impacts to water quality will continue to occur during wet-weather events. As a result, wet-weather advisories based on time to recovery analysis are recommended for consideration for this waterbody.

7.4 Internet Accessible Information Outreach and Inquiries

Both traditional and electronic outreach tools are important elements of DEP's overall communication effort. DEP will ensure that outreach tools are accurate, informative, up-to-date and consistent, and are widely distributed and easily accessible. Table 7-1 presents a summary of Flushing Bay LTCP public participation activities.

Table 7-1. Summary of Flushing Bay LTCP Public Participation Activities Performed

Category	Mechanisms Utilized	Dates (if applicable) and Comments
Regional LTCP Participation	Citywide LTCP Kickoff Meeting and Open House	• June 26, 2012
	Annual Citywide LTCP Meeting – Modeling Meeting	• February 28, 2013
	Annual Citywide LTCP Meeting #3	• December 11, 2014
	Annual Citywide LTCP Meeting #4	• January 12, 2016
Waterbody-specific Community Outreach	Public meetings and open houses	• Kickoff Meeting: September 30, 2015 • Meeting #2: October 26, 2016 • Meeting #3: TBD
	Stakeholder meetings and forums	• DCP Community Meeting on July 29, 2015 and February 11, 2016 • Community Board 3 Meeting on September 17, 2015 • Community Board 7 meetings on February 25, 2016 and May 3, 2016
	Elected officials briefings	• November 18, 2014 • January 12, 2016 • March 15, 2016
Data Collection and Planning	Establish online comment area and process for responding to comments	• Comment area added to website on October 1, 2012 • Online comments receive response within two weeks of receipt
	Update mailing list database	• DEP updates master stakeholder database (1100+ stakeholders) before each meeting
Communication Tools	Program Website or Dedicated Page	• LTCP Program website launched June 26, 2012 and frequently updated • Flushing Bay LTCP web page launched October 1, 2015
	Social Media	• Facebook and Twitter Announcements of Meetings
	FAQs	• LTCP FAQs developed and disseminated beginning June 2014 via website, meetings and email

Table 7-1. Summary of Flushing Bay LTCP Public Participation Activities Performed

Category	Mechanisms Utilized	Dates (if applicable) and Comments
Communication Tools	Print Materials	• LTCP FAQs: June 11, 2014 • LTCP Goal Statement: June 26, 2012 • LTCP Public Participation Plan: June 26, 2012 • LTCP Program Brochure: February 12, 2015 • Glossary of Modeling Terms: February 28, 2013 • Meeting advertisements, agendas and presentations • PDFs of poster board displays from meetings • Meeting summaries and responses to comments • Quarterly Reports • WWFPs
	Translated Materials	• Advertisements for the Alternatives Meeting were distributed in English, Korean, and Spanish • Translators were available for the Alternatives Meeting
	Portable Informational Displays	• Poster board displays at meetings
Student Education	Participate in ongoing education events	• DEP has robust and ongoing education programs in local schools.
	Provide specific green and grey infrastructure educational modules	• DEP has robust and ongoing education programs in local schools.

DEP launched its LTCP Program website on June 26, 2012. The website provides links to documents related to the LTCP Program, including CSO Orders on Consent, approved WWFPs, CSO Quarterly Reports, links to related programs, such as the Green Infrastructure Plan, and handouts and poster boards distributed and displayed at public meetings and open houses. An LTCP feedback email account was also created to receive LTCP-related feedback, and stakeholders can sign up to receive LTCP Program announcements via email. In general, DEP's LTCP Program Website:

- Describes the LTCP process, CSO-related information and citywide water quality improvement programs to-date;
- Describes waterbody-specific information including historical and existing conditions;
- Provides the public and stakeholders with timely updates and relevant information during the LTCP process, including meeting announcements;
- Broadens DEP's outreach campaign to further engage and educate the public on the LTCP process and related issues; and
- Provides an online portal for submission of comments, letters, suggestions, and other feedback.

A dedicated Flushing Bay LTCP webpage was created on October 1, 2015 and includes the following information:

- Flushing Bay public participation and education materials
  - Flushing Bay Summary Paper
  - LTCP Public Participation Plan
- Flushing Bay LTCP Meeting Announcements
- Flushing Bay Kickoff Meeting Documents – September 30, 2015
  - Advertisement
  - Meeting Presentation
  - Meeting Summary
- Flushing Bay Meeting #2 Meeting Documents – October 26, 2016
  - Meeting Advertisement
  - Meeting Presentation
  - Meeting Summary

8.0 EVALUATION OF ALTERNATIVES

This section describes the development and evaluation of CSO control measures and watershed-wide alternatives. A CSO control measure is defined as a technology (e.g., treatment or storage), practice (e.g., NMC or BMP), or other method (e.g., source control or GI) of abating CSO discharges or the effects of such discharges on the environment. Alternatives evaluated are comprised of a single CSO control measure or a group of control measures that will collectively address the water quality objectives for Flushing Bay.

This section contains the following information:

- Process for developing and evaluating CSO control alternatives that reduce CSO discharges and improves water quality (Section 8.1).
- CSO control alternatives and their evaluation (Section 8.2).
- CSO reductions and water quality benefits achieved by the higher-ranked alternatives, as well as their estimated costs (Sections 8.3 and 8.4).
- Cost-performance and water quality attainment assessment for the higher-ranked alternatives for the selection process of the preferred alternative (Section 8.5).

Water quality (WQ) attainment in Flushing Bay for the CSO control alternatives evaluated in this section considered three sets of WQ criteria for bacteria and two for dissolved oxygen (DO) as presented in Section 6.2, Table 6-4.

In consideration of the recreational amenities associated with local marinas and the Flushing Bay Promenade as well as potential future economic development plans for Willets Point, DEP also considered CSO controls which could address aesthetic issues which could impact such uses. Specifically, DEP evaluated CSO control alternatives capable of providing higher levels of treatment and/or reduction of CSO discharges, including disinfection.

8.1 Considerations for LTCP Alternatives Under the Federal CSO Policy

This LTCP addresses the water quality objectives of the CWA and the New York State Environmental Conservation Law. This LTCP also builds upon the conclusions presented in DEP's August 2011 Flushing Bay WWFP. As required by the 2012 CSO Order, when the proposed alternative set forth in the LTCP will not achieve Existing WQ Criteria or the Section 101(a)(2) goals, a Use Attainability Analysis (UAA) must be prepared. A UAA is the mechanism to examine whether applicable waterbody classifications, criteria, or standards should be adjusted by the State. If deemed necessary, the UAA would assess the compliance of the next higher classification that the State would consider in adjusting WQS and developing waterbody-specific criteria. In addition, when existing water quality criteria cannot be achieved (even with 100 percent capture of CSO discharges), a Water Quality Based Effluent Limitation (WQBEL) variance to the SPDES permit of the Flushing Bay CSO Retention Facility may be required.

The remainder of Section 8.1 discusses the development and evaluation of CSO control measures and watershed-wide alternatives to comply with the CWA in general, and with the CSO Control Policy in particular. The evaluation factors considered for each alternative are described, followed by the process for evaluating the alternatives.

8.1.a Performance

A summary of the IW model output data for volume and frequency of discharge is provided in Table 8-1 for each CSO Outfall tributary to Flushing Bay. Table 8-1 also identifies whether the CSO outfalls discharge to Inner or Outer Flushing Bay and the percentage of the total volume discharged to Flushing Bay. Figure 8-1 identifies the location of each CSO discharge to Flushing Bay.

Table 8-1. CSO Discharges Tributary to Flushing Bay (2008 Typical Year)

Combined Sewer Outfalls	Location	Discharge Volume (MGY)	No. of Discharges	Percentage of Total CSO Discharge to Flushing Bay
BB-006 UL	**Inner Flushing Bay**	**631**	**45**	**43.4%**
BB-006 LL	**Inner Flushing Bay**	**258**	**29**	**17.8%**
BB-007	Inner Flushing Bay	38	40	2.6%
BB-008	**Inner Flushing Bay**	**478**	**47**	**32.9%**
TI-012	Outer Flushing Bay	0	0	0.0%
TI-014(1)	Outer Flushing Bay	10	37	0.7%
TI-015(1)	Outer Flushing Bay	3	20	0.2%
TI-016(1)	Outer Flushing Bay	29	45	2.0%
TI-017(1)	Outer Flushing Bay	2	21	0.1%
TI-018(1)	Outer Flushing Bay	4	34	0.3%
Total CSO	Flushing Bay	1,453		

Note:
(1) To be separated as part of the College Point Sewer Separation Project as referenced in the WWFP.

Since Outfall BB-006 consists of a dual level arch culvert with varying configurations as shown in Figure 8-2, CSO discharge statistics have been provided for each level of the culvert. The upper and lower levels of Outfall BB-006 are noted as UL and LL, respectively. This data will be used in assessing the performance of CSO control alternatives that may be applied separately to the upper or lower levels of this outfall due to hydraulic grade line impacts between the UL and LL that would result from consolidating facilities at points along this outfall where the sewers are stacked. Outfall BB-006 transitions between Cross Section No. 1 and Cross Section No. 2 near the Corona Avenue Vortex Facility (CAVF). The portion of the outfall upstream of the CAVF was constructed using Cross Section No. 1, while the portion downstream of the CAVF was constructed using Cross Section No. 2. Outfall BB-006 transitions to a four barrel box culvert as it crosses under the Grand Central Parkway just prior to its point of discharge to Flushing Bay. A review of the table indicates that the upper level of Outfall BB-006 conveys about 43 percent of the annual CSO discharge. Outfalls BB-006 and BB-008 account for over 94 percent of the CSO discharged to Flushing Bay and over 97 percent of the CSO discharges to Inner Flushing Bay.

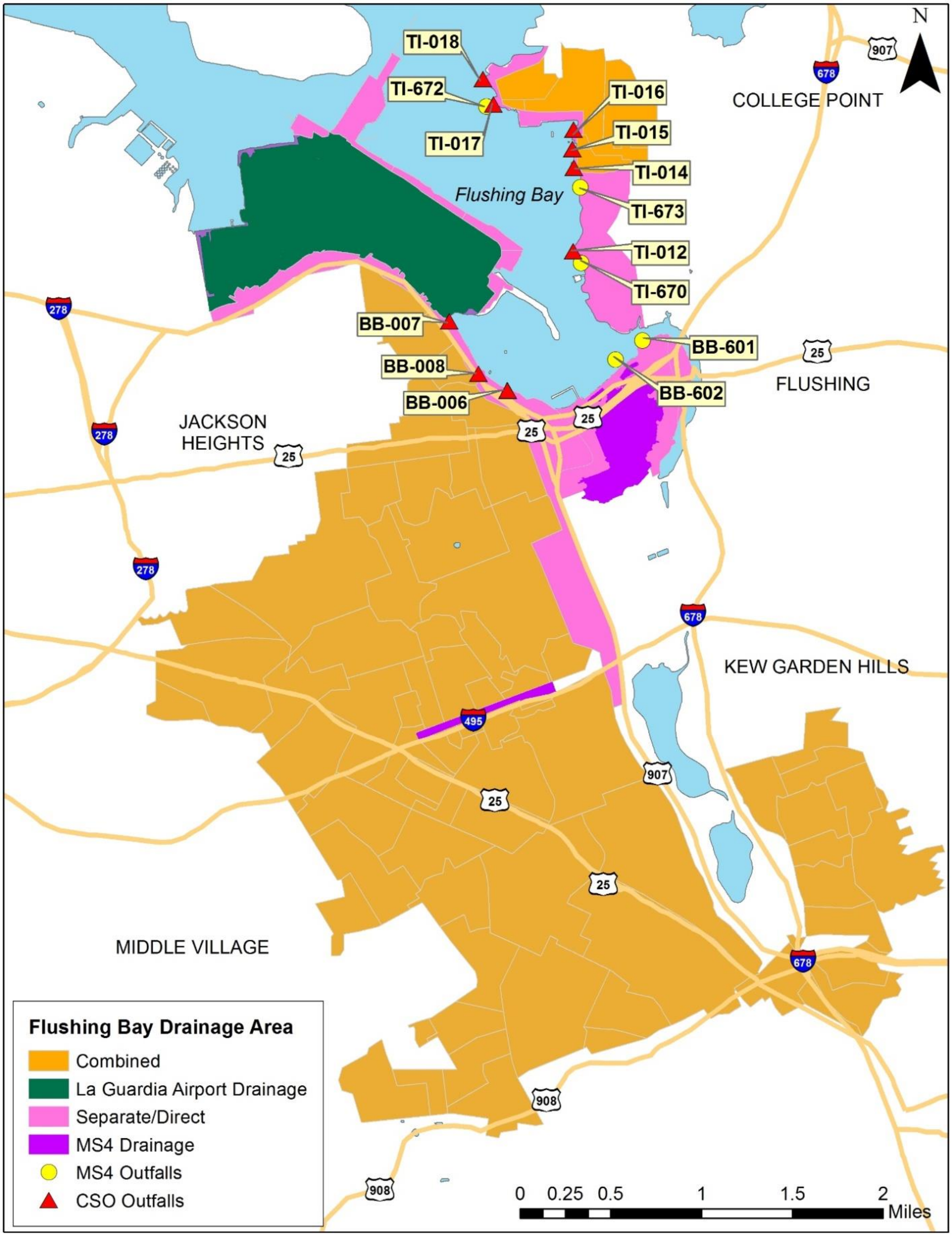

Figure 8-1. CSO Discharges to Flushing Bay

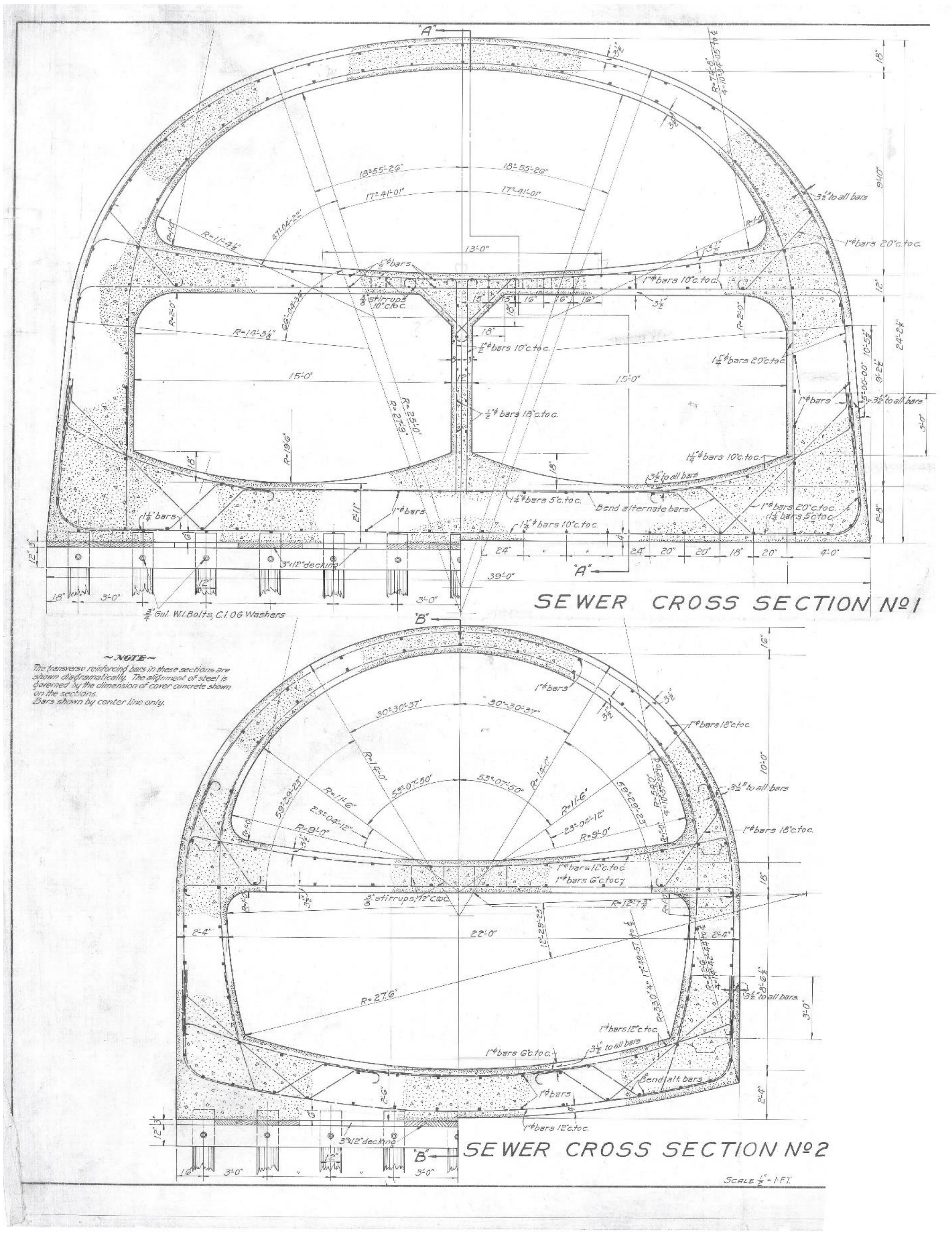

Figure 8-2. CSO Outfall BB-006 Cross Sectional Views

The location of the CSO discharges is important when considering the results of the load source component analysis summarized in Section 6.3.d. The findings of this analysis indicate that the bacteria contributions to Inner Flushing Bay are primarily associated with CSOs and Flushing Creek, whereas bacterial impacts to Outer Flushing Bay are primarily influenced by the East River. Considering results of the source analysis in conjunction with the volume and frequency of CSO discharge identified in Table 6-2, the alternatives evaluations will focus on the reduction of bacterial loads to Flushing Bay from the two predominant sources of CSO discharge, Outfalls BB-006 and BB-008. The size and close proximity of these outfalls provides for efficiencies through economies of scale.

To determine the influence of CSO control on the attainment of existing and future WQ criterion, a Performance Gap Analysis was performed. The results of the analysis are summarized in Section 6.3. The evaluations concluded that no performance gaps exist because Primary Contact WQ Criteria, for fecal coliform bacteria, will be attained under baseline conditions. However, the analyses presented in Section 6 show that while Flushing Bay achieves attainment of the maximum 30-day geomean criteria under the Potential Future Primary Contact WQ Criteria for Baseline Conditions and 100% CSO control, the 90^{th} Percentile Standard Threshold Value (STV) for enterococci cannot be attained for both conditions. Based upon the load source component analysis, the cause of non-attainment appears to be due to several other non-CSO factors, including limited tidal exchange and flushing, input from Flushing Creek and the East River, and the presence of non-CSO sources being discharged to the Bay (i.e., lake outflows to Flushing Creek and direct runoff from LaGuardia Airport and highways). As a result, discussion of performance for the Flushing Bay alternatives, related to bacteria, will focus on improving the frequency of attaining the 90^{th} Percentile STV under the Potential Future Primary Contact WQ Criteria (2012 EPA RWQC). The alternatives evaluations will also consider the level of control necessary to achieve the DEC goal for the Time to Recovery of less than 24 hours after a wet-weather event.

The analyses in Section 6 indicated that all of the monitoring stations within Flushing Bay achieved 97 percent or greater attainment of the Existing WQ Criteria for DO for Year 2008 conditions. This level of attainment is greater than the 95 percent target DEC generally uses to assess compliance. The review of attainment of Class SC WQ Criteria for DO indicated that the Acute Criteria (never less than 3.0 mg/L) is met for the entire water column at all monitoring stations for both baseline conditions and 100% CSO control. While the Acute Criteria is achieved greater than 95 percent for all of the monitoring stations for both baseline conditions and 100% CSO control, there is a station in Outer Flushing Bay where the Chronic Criteria (greater than or equal to 4.8 mg/L) achieves attainment less than the 95 percent target. Under baseline conditions, Station OW-14 within Outer Flushing Bay was found to achieve attainment 83 percent of the time during the typical 2008 year. With 100% CSO control, the attainment for Station OW-14 remains at 83 percent of the time during 2008 typical year, which implies that the DO conditions at Station OW-14 are caused by other factors unrelated to CSO, such as nitrogen loading in the East River. The gap analysis for DO indicates that application of 100% CSO control of CSO discharges to Flushing Bay will not result in significant improvement in the attainment of Class SC DO WQ Criteria. Improvements in attainment results increase one percent at Station OW-15 with 100% CSO control. Based upon the results of the analyses, the performance gap for DO is negligible.

Traditionally, the major focus of the development and evaluation of control alternatives is the ability to achieve bacteria load reduction and to attain applicable water quality criteria. A two-step process is typically used. First, based upon watershed model runs (InfoWorks CS™ [IW]) for typical year rainfall (2008), the level of CSO control of each alternative is established, including the reduction of CSO volume, fecal coliform and enterococci loading. The second step uses the estimated levels of CSO control to project levels of attainment in the receiving waters. This step uses the ERTM water quality model. LTCPs are typically developed with alternatives that span a range of CSO volumetric (and loadings) reductions. Accordingly, this LTCP includes alternatives that consider a wide range of reductions in CSO loadings - up to 100% CSO control - including investments made by DEP through green and grey infrastructure. Intermediate levels of CSO volume control, approximately 25 percent, 50 percent and 75 percent, are also evaluated. Table 8-2 provides a summary of the required storage volume and associated dewatering rates for each level of CSO control.

Table 8-2. Summary of Storage and Dewatering Rates Required for Each Level of CSO Control

Required Capacity	25% CSO Control	50% CSO Control	75% CSO Control	100% CSO Control
Storage Capacity (MG)	12	25	67	161
Dewatering Rate (MGD) (1)	15	25	70	160

Note:
(1) Based upon a maximum 24 hour dewatering period following a wet-weather event.

Considering the current recreational uses of Flushing Bay (promenade and marinas), redevelopment plans for Willets Point, and the current aesthetic issues (sediment deposition, floatables and odor), it is prudent to consider control alternatives that achieve CSO solids load reduction in addition to bacteria reduction and DO improvements. Such alternatives would require capture or treatment of CSO to remove settleable solids and floatables that currently impact the recreational uses of these waters. A cursory review of Table 8-2 indicates that the dewatering rates for storage facilities sized for 25% and 50% CSO control appear to be within ranges that could be reasonably accommodated upon pump down of a storage facility to the High Level Interceptor (HLI) with minimal risk of overflowing at downstream outfalls. The Bowery Bay Wastewater Treatment Plant (BB WWTP) can accommodate the dewatering rates for 25%, 50% and 75% CSO control. For higher levels of control, separate treatment of the dewatered flow would need to be considered.

To better understand the wet-weather capacity constraints at the BB WWTP, a desktop review was performed utilizing historical operating data during wet-weather conditions. A year was selected where rainfall was comparable in volume to the typical rainfall year of 2008 and where the WWTP operated throughout the year without any capacity limitations due to planned construction or mechanical failures. Influent flow data was analyzed for 65 wet-weather events during 2012 that produced peak influent flow exceeding 225 MGD through the secondary treatment process.

Figure 8-3 shows the hourly variation of daily influent flow at the Bowery Bay WWTP without CSO pump-back in dark blue. The other graphs in Figure 8-3 superimpose 25, 50, 75 and 100 MG CSO storage volume pumped back to the plant in 24 hours. As the graph indicates, the hydraulic capacity of the secondary treatment process is reached with a 75 MG storage volume and if exceeded would activate the secondary bypass. This volume is the upper limit of the additional CSO volume that can be safely treated at the existing Bowery Bay WWTP. Section 8.5.d provides additional process analyses with respect to total nitrogen loadings at the WWTP. This 1.5 x DDWF is the rated wet-weather capacity of the secondary treatment system but targeting treating these high flows for any extended amount of time may detrimentally impact secondary treatment and biological nutrient removal.

The dewatering rate for 100% CSO control (160 MGD) would require either a satellite treatment facility or increased capacity at the BB WWTP. Depending on location of the CSO storage facility, upgrades to the interceptor capacity may also be necessary.to convey this pump-back flow. As a result, the alternatives evaluations for retention/storage technologies will generally focus on a 25 percent, 50 percent and 75 percent level of CSO control. For higher levels of control, treatment alternatives will be incorporated as a component of storage facilities or as a separate alternative (i.e., storage with satellite treatment facilities).

For some alternative control measures, however, such as disinfection, there would be no reduction in CSO volume, but significant reductions in bacteria loading. Performance of each control alternative is measured against its ability to meet the CWA and water quality requirements for the 2040 planning horizon as described in Section 6.

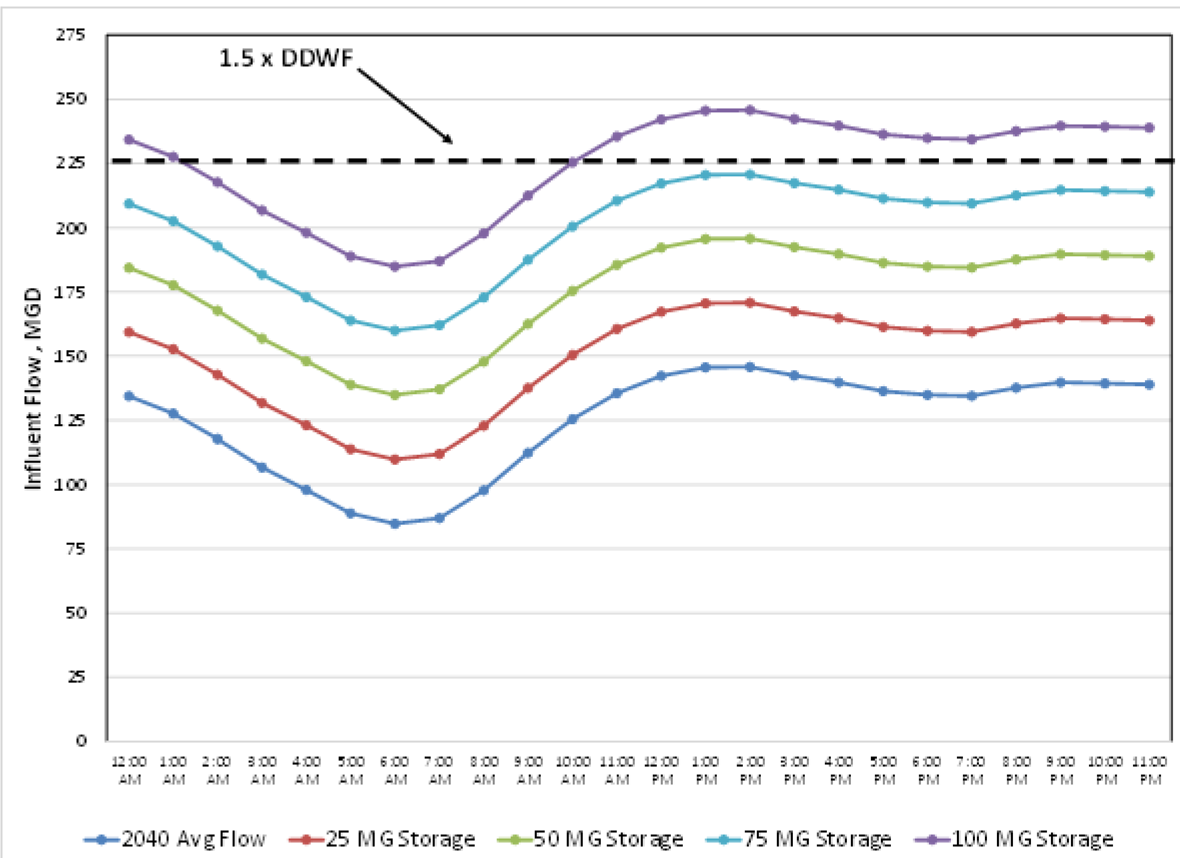

Figure 8-3. Impact of CSO Pump-Back on Diurnal Influent Flow to Bowery Bay WWTP

8.1.b Impact on Sensitive Areas

In developing LTCP alternatives, special effort is made to minimize the impact of construction, to protect existing sensitive areas, and to enhance water quality in sensitive areas. As described in Section 2.0, no sensitive areas exist within Flushing Bay, so only construction impacts were considered, as appropriate.

8.1.c Cost

Cost estimates for the alternatives were computed using a costing tool based on parametric costing data. This approach provides an Association for the Advancement of Cost Engineering (AACE) Class 5 estimate (accuracy range of minus 20 to 50 percent to plus 30 to 100 percent), which is typical and appropriate for this type of planning evaluation. For the purpose of this LTCP, all costs are in February 2016 dollars.

For the LTCP alternatives, Probable Bid Cost (PBC) was used as the estimate of the construction cost. Annual operation and maintenance costs are then used to calculate the total or net present worth (NPW) over the projected useful life of the project. A lifecycle of 20 years and an interest rate of three (3.0) percent were assumed resulting in a Present Worth Factor of 14.877.

To quantify costs and benefits, alternatives are compared based on reductions of both CSO discharge volume and bacteria loading against the total cost of the alternative. These costs are then used to plot the performance and attainment curves. A pronounced inflection point appearing in the resulting graphs, the so-called Knee-of-the-Curve (KOTC) point, suggests a potential cost-effective alternative for further consideration. In essence, this would reflect the alternative that achieves the greatest appreciable water quality improvements per unit of cost. However, this may not necessarily be the preferred alternative. The final, or preferred alternative, must be capable of improving water quality in a fiscally responsible and affordable manner to ensure that resources are properly allocated across the overall citywide LTCP program. These monetary considerations also must be balanced with non-monetary factors, such as construction impacts, environmental benefits, technical feasibility, and operability, which are discussed below.

8.1.d Technical Feasibility

Several factors were considered when evaluating technical feasibility, including:

- Effectiveness for controlling CSO
- Reliability
- Implementability

The effectiveness of CSO control measures was assessed based on their ability to reduce CSO frequency, volume and load. Reliability is an important operational consideration, and can have an impact on overall effectiveness of a control measure. Therefore, reliability and proven history were used to assess the technical feasibility of a CSO control measure.

Several site-specific factors were considered to evaluate an alternative’s implementability, including available space, neighborhood assimilation, impact on parks and green space and overall practicability of installing - and later maintaining - CSO controls. In addition, the method of construction was factored into the final selection. Some technologies require specialized construction methods that typically incur additional impacts as well as costs.

CSO storage is further constrained by the size of the tunnel that can be physically constructed in soft ground conditions within the drainage area. Although soft ground tunnels have been successfully constructed worldwide, the construction along the available tunnel routes to Bowery Bay WWTP limit the maximum tunnel diameter to approximately 30 feet. The tunneling risks (i.e., ground settlement, potential impacts to existing utilities and highways, right-of-way constraints, etc.) and costs increase disproportionally as the tunnel diameter increases. As four 20-foot diameter tunnels have been recently constructed for the East Side Access Project located just west of the Bowery Bay drainage area, we have focused on tunnel sizes consistent with this successful soft ground tunneling project.

8.1.e Cost-Effective Expansion

All alternatives evaluated were sized to handle the CSO volumes based on the 2008 typical year rainfall and 2040 design year dry-weather flows, with the understanding that the predicted and actual flows may differ. To help mitigate the difference between predicted and actual flows, adaptive management was considered for those CSO technologies that can be expanded in the future to capture or treat additional CSO flows or volumes, should it be needed. In some cases, this may have affected where the facility would be constructed, or gave preference to a facility that could be expanded at a later date with minimal cost and disruption of operation.

Breaking construction into segments allowed adjustment of the design of future phases based on the performance of already-constructed phases. Lessons learned during operation of the current facilities can be incorporated into the design of the future facilities. However, phased construction also exposes the local community to a longer construction period. Where applicable, for those alternatives that can be expanded, the LTCP discusses the ease of expansion, what additional infrastructure may be required, and if additional land acquisition would be needed.

As regulatory requirements change, other water quality improvements may be required. The ability of a CSO control technology to be retrofitted to address additional pollutant parameters or more stringent discharge limits strengthens the case for application of that technology.

8.1.f Long Term Phased Implementation

The recommended implementation steps associated with the preferred alternative are structured in a way that makes them adaptable to change by expansion and modification, in response to new regulatory and/or local drivers. If applicable, the project(s) would be implemented over a multi-year schedule. Because of this, permitting and approval requirements must be identified prior to selection of the alternative. These were identified along with permit schedules where appropriate. With the exception of GI, which is assumed to occur on both private and public property, most of the CSO grey technologies are limited to NYC-owned property and right-of-way-acquisitions. DEP will work closely with other NYC agencies, and NYS as necessary, to ensure proper coordination with other government entities.

8.1.g Other Environmental Considerations

Consideration will be given to minimizing impacts on the environment and surrounding neighborhood during construction. These impacts could potentially include traffic, site access issues, park and wetland disruption, noise pollution, air quality, and odor emissions. To minimize environmental impacts, they will be identified with the selection of the preferred plan and communicated to the public. The specific details on the mitigation of the identified concerns and/or impacts, such as erosion control measures and the rerouting of traffic, will be addressed in a pre-construction environmental assessment.

8.1.h Community Acceptance

As described in Section 7, DEP is committed to involving the public, regulators, and other stakeholders throughout the planning process. The scope of the LTCP, background, and newly collected data, WQS and the development and evaluation of alternatives, were presented. Community acceptance of the recommended plan is essential to its success. As such, DEP has used the LTCP public participation process to solicit public support and feedback. The Flushing Bay LTCP is intended to improve water quality, and public health and safety are a priority of the LTCP. The goal of raising awareness of, and access to waterbodies was considered throughout the alternative analysis. Several CSO control measures, such as GI, have been shown to enhance communities while increasing local property values. As such, the benefits of GI were considered in the formation of the baseline and the final recommended plan.

8.1.i Methodology for Ranking Alternatives

The multi-step evaluation process DEP utilized in developing the Flushing Bay LTCP accomplished the following:

1. Evaluated benchmarking scenarios, including baseline and 100% CSO control, to establish the full range of controls within the Flushing Bay watershed. The results of this step were described in Section 6.
2. Used baseline conditions to prioritize the CSO outfalls for possible controls.
3. Developed a list of promising control measures for further evaluation based in part on the prioritized CSO list.
4. Established levels of intermediate CSO control that provide a range between baseline and 100% CSO control for the receiving water quality simulations that were conducted.
5. Conducted an initial “brainstorming” meeting with DEP staff on December 21, 2015 and DEC on January 15, 2016, to review the most promising control measures and to solicit additional options to explore.
6. Held a second “brainstorming” meeting with DEP on March 24, 2016, to further review additional detail on the most promising control measures and to solicit additional options to further explore.
7. Conducted a broader LTCP workshop on April 2, 2016, where the water quality benefits, costs and fatal flaws of the alternatives under consideration were evaluated.
8. Held a workshop with DEP operations staff on April 12, 2016 to discuss the operations and maintenance requirements of a CSO tunnel.
9. Conducted a second workshop with operations staff on October 7, 2016 to review and address comments and concerns identified during the April 12 meeting.
10. Toured the Narragansett Bay Commission’s CSO tunnel on October 19, 2016 to solicit feedback and lessons learned.

11. Conducted a workshop with DEP staff on November 4, 2016 to present the findings of a "fatal flaw" analysis performed to assess the constructability of an 18 foot diameter CSO tunnel along Astoria Boulevard to the Bowery Bay WWTP.

The focal points of this process were the meetings and workshops listed above. Prior to the first meeting, the universe of control measures that were evaluated in the 2011 WWFP were revisited from the perspective of the LTCP goal statement and in light of the implemented WWFP. Additional control measures were also identified and assessed. The resultant control measures were introduced at the first meeting. Based on discussions at the first meeting, further additional control measures were identified. A preliminary evaluation of these control measures was then conducted including an initial estimation of costs and water quality impacts. During the second meeting, promising alternatives were reviewed in more detail. The LTCP workshops, attended by a broader array of DEP operational and engineering staff, included updated alternative assessments and a final fatal flaw analysis.

The range of control measures included the categories of Source Control, System Optimization, CSO Relocation, Water Quality/Ecological Enhancement, Treatment and Storage. Specific control measures considered under those categories are listed below:

Source Control

- Additional Green Infrastructure
- Sewer Separation

System Optimization

- Fixed Weirs
- Inflatable Dams, Bending Weirs or Control Gates
- Pumping Station (PS) Expansion

CSO Relocation

- Interceptor Flow Regulation
- Flow Tipping to Other Watersheds
- Re-purpose Corona Avenue Vortex
- Parallel Interceptor/Sewer

Water Quality/Ecological Enhancement

- Floatables Control
- Maintenance Dredging
- Aeration

Treatment

- Outfall Disinfection
- Retention Treatment Basin (RTB)
- High Rate Clarification (HRC)
- WWTP Expansion

Storage

- In-System/Outfall
- Shaft

- Off-line Tank
- Tunnel

Figure 8-4 presents these control measures according to their relative cost and level of complexity. The control measures in the upper left hand corner are generally the least costly and least complex to construct and/or operate while those towards the lower right are the most costly and most complex to construct and/or operate. The level of loading removal performance of each measure typically corresponds with the level of cost and complexity.

Following the initial screening meeting, control measures were advanced to a second level of evaluation with the exception of the following (either marked with an "X" or highlighted as an on-going project in Figure 8-4):

- *Additional Green Infrastructure:* Flushing Bay is a priority target area for DEP's Green Infrastructure Program. DEP has installed or plans to install over 1,000 green infrastructure assets consisting of ROW practices, public property retrofits, and GI implementation on private properties. Figure 8-5 illustrates the location of the built or planned GI projects. While GI will be encouraged in areas proposed for redevelopment, site characteristics in publicly owned rights-of-way throughout the sewershed limit the ability to implement GI and has resulted in a reduction of the GI goal from 8 percent to 2.8 percent. Since the application of additional GI would rely on commitments from private property owners, it is not feasible to definitively identify and commit to such private GI projects within the timeframe for development of this LTCP. As a result, application of additional GI will not be evaluated as part of this LTCP. DEP will continue to develop programs to incentivize the application of GI by private property owners for the purposes of managing stormwater runoff.
- *Sewer Separation:* Outfalls TI-014, TI-015, TI-016, TI-017 and TI-018 will be separated using high level storm sewer strategies under the College Point Sewer Separation Project. Since final schedules for construction have not been developed, these outfalls were included as active CSOs in the Baseline Conditions. The drainage areas tributary to CSOs BB-006 and BB-008 are expansive and generate large volumes of CSO. The cost and disruption to the neighborhoods to separate sewers would be very significant while only providing limited water quality benefit due to the remaining stormwater discharges. As a result, sewer separation will not be evaluated further as part of this LTCP.
- *Fixed Weirs:* Regulator improvements were recommended under the WWFP. The Regulator Improvement Project evaluated opportunities to improve wet-weather capture and conveyance for treatment at the Bowery Bay WWTP. Fixed weirs were designed and the modifications are currently under construction.
- *Inflatable Dam, Bending Weirs, Control Gates:* Mechanical methods of regulating CSO were evaluated along the HLI sewer under the Regulator Improvements Project. The evaluation of technologies performed during the Basis of Design Phase of the project recommended the use of fixed weirs, primarily due to access limitations for performance of long term maintenance of these technologies.
- *Pumping Station Expansion/Modification*: The 108^{th} Street, Corona, and Pell Avenue Pumping Stations each discharge to the upstream reaches of the Bowery Bay HLI. Since flow is regulated at several locations downstream of the respective force main connections to the interceptor, any CSO captured as a result of the pumping station capacity improvements could overflow at

downstream regulators. To effectively capture the increased pumping station discharges, a parallel interceptor would also be required to convey the increased wet-weather flow to the Bowery Bay WWTP. Construction of a parallel interceptor or tunnel to convey wet-weather flows to the WWTP from Outfalls BB-006, BB-007 and BB-008 could provide the same benefit without the need to upgrade pumping station capacity. Thus, this CSO control alternative was not considered further.

- *Interceptor Flow Regulation*: This CSO control strategy was eliminated from further consideration, due to the absence of adjacent sewers for management and diversion of wet-weather flows.
- *Flow Tipping to Other Watersheds*: This CSO control strategy was eliminated from further consideration due to the size of the outfalls and the distance to the Tallman Island combined sewer system and other branches of the Bowery Bay combined sewer system.
- *Parallel Interceptor/Sewer*: Tunneling was considered in lieu of this CSO control strategy since trenchless measures would be necessary to construct parallel sewers and minimize impacts to neighborhoods and transportation corridors. Tunneling facilitates the construction of larger sewers that can provide storage capacity to attenuate peak flows, in addition to delivering supplemental conveyance capacity.
- *Floatables Control*: While floatables collection booms are currently implemented at the major Flushing Bay outfalls, additional control measures will be considered only as part of the control alternatives to be evaluated and discussed below.
- *Maintenance Dredging*: Dredging of Flushing Bay was recommended in the August 2011 WWFP and is a project identified in Appendix A of the Order on Consent. The Notice to Proceed for this project was issued in July 2016 and construction has advanced. No further evaluation of dredging as a CSO control alternative will be considered under this LTCP.
- *In-stream Aeration*: The gap analysis for DO in Section 6, indicated that 95 percent or greater attainment of the Class SC water quality standards is achieved at all stations within Flushing Bay except for Station OW-14 located in the Outer Flushing Bay. As a result, this alternative was eliminated from further consideration.
- *High Rate Clarification*: Suspended solids and BOD from CSO discharges were not identified as loadings contributing to non-attainment of WQS, thus the higher cost of high rate clarification compared to other treatment technologies would not be justified for providing remote treatment or supplemental wet-weather treatment capacity at the Bowery Bay WWTP.
- *WWTP Expansion*: While there appears to be available wet-weather capacity at the Bowery Bay WWTP, the limiting factor is the capacity of the collection system to convey wet-weather flow to the plant. This LTCP will focus on maximizing wet-weather flow to the WWTP to utilize available capacity. As land constraints limit the ability to expand existing plant processes, storage or remote treatment will be considered in lieu of WWTP expansion.
- *Storage Shafts*: Shaft storage involves constructing a deep circular shaft to provide storage, with pump-out facilities to dewater the shaft after the storm event. Shaft storage construction techniques would be similar to those used to construct deep tunnel drop or access shafts. The benefit of shaft storage is that it allows for relatively large storage volumes with relatively small facility footprints. The disadvantages of shaft storage include the depth of the shafts (often >200 feet), complex pumping operations, high level of maintenance,, and the relatively small number of successfully completed and operating shaft storage facilities nationwide. In addition,

the storage volume required would necessitate the installation of multiple shafts in locations with limited access, such as highway medians. Since the range of levels of CSO control could be provided by more conventional storage tanks or tunnels, storage shafts did not appear to offer significant advantages that would outweigh their disadvantages. For these reasons, shaft storage was eliminated from further evaluation.

The evaluation of the retained control measures is described in Section 8.2.

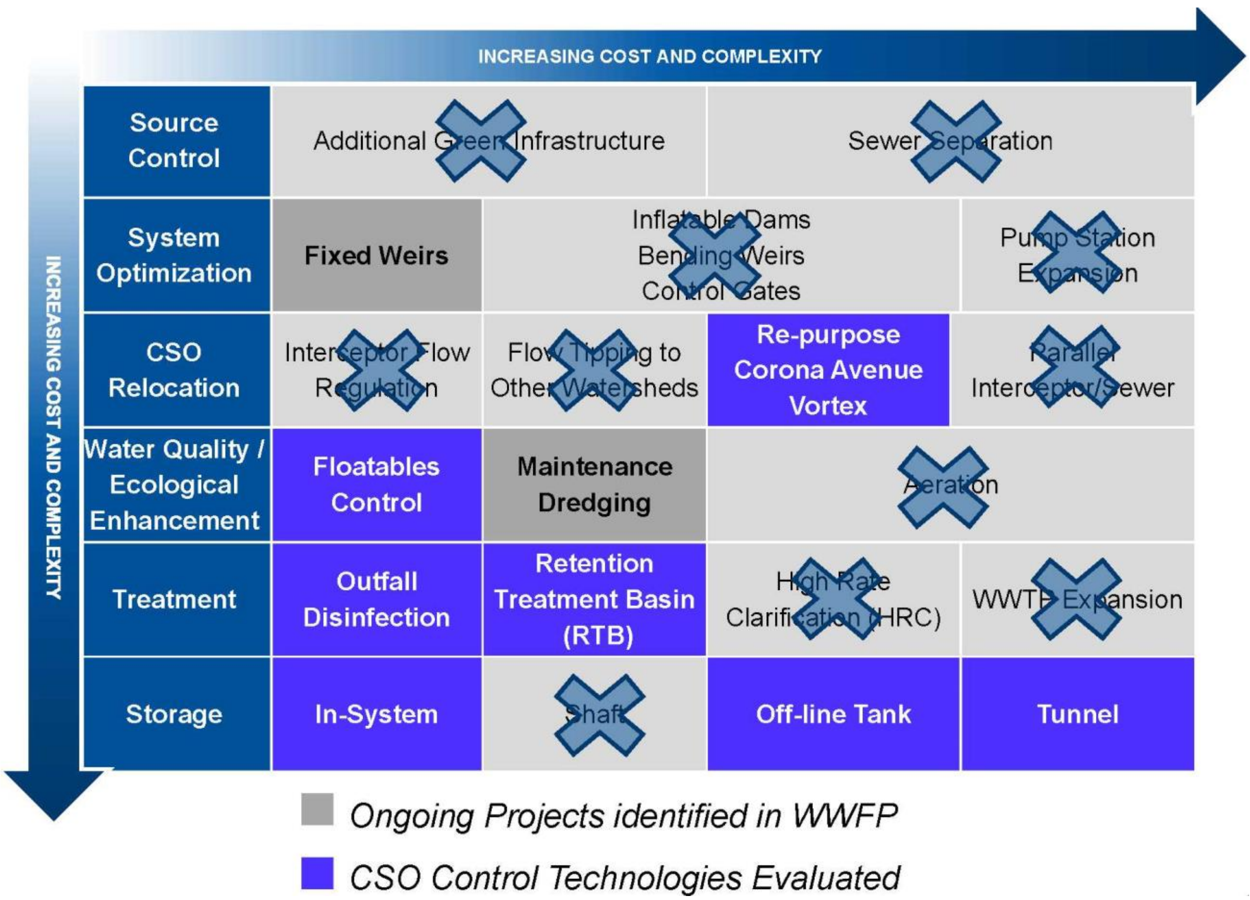

Figure 8-4. Matrix of CSO Control Measures for the Flushing Bay

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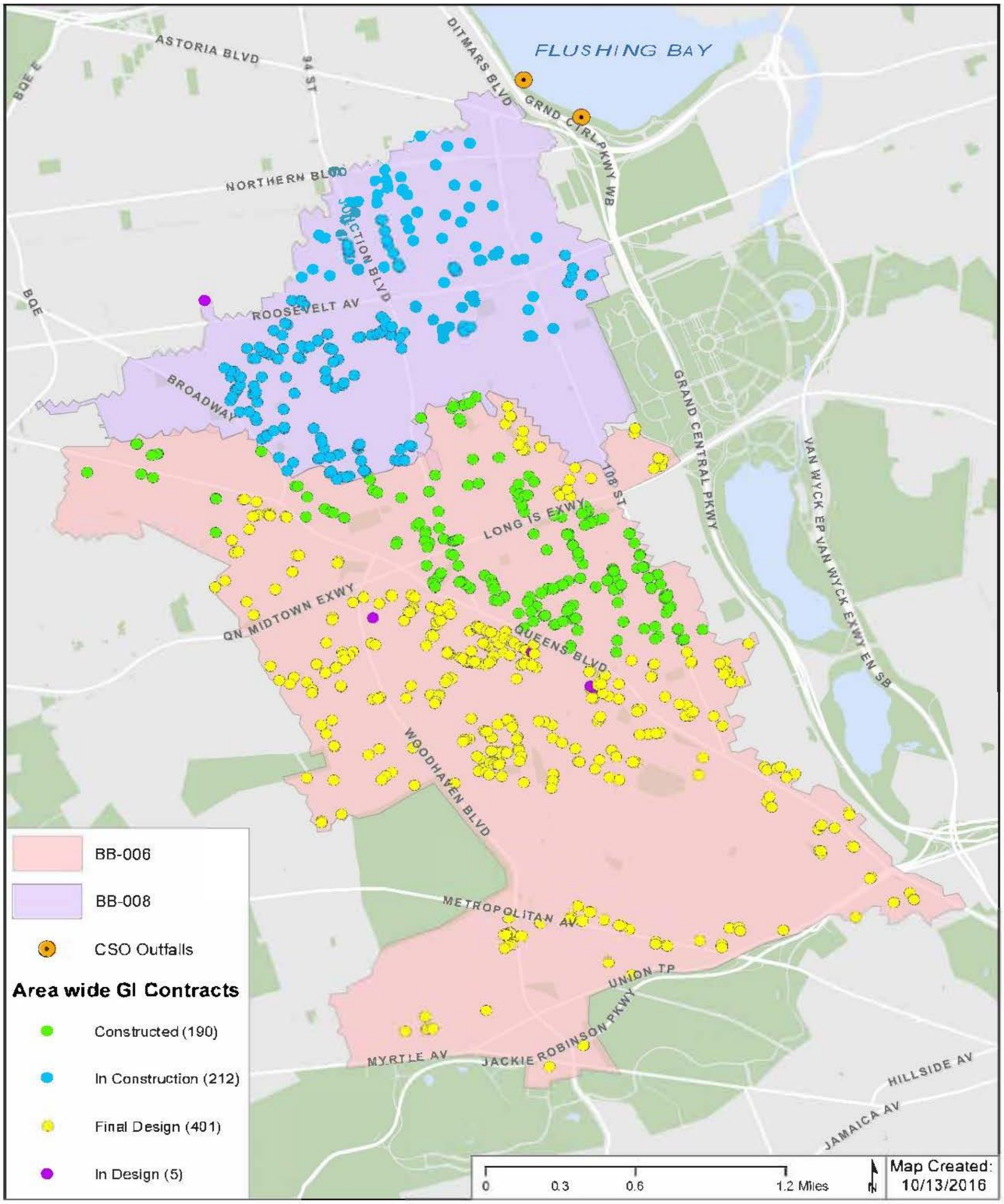

Figure 8-5. Built and Planned Green Infrastructure Projects

8.2 Matrix of Potential CSO Reduction Alternatives to Close Performance Gap from Baseline

Each control measure was initially evaluated on three of the key considerations described in Section 8.1: (1) benefits, as expressed by level of CSO control and attainment; (2) costs; and (3) challenges, such as siting and operations. Using this methodology, the retained control measures listed in Section 8.1 were evaluated on a cost-performance basis and used to develop the basin-wide alternatives.

Following the LTCP outline, these control measures are described under the following categories: Other Future Grey Infrastructure, Other Future Green Infrastructure and Hybrid Green/Grey Alternatives, and subsets thereof.

8.2.a Other Future Grey Infrastructure

For the purpose of this LTCP, “Other Future Grey Infrastructure” refers to potential grey infrastructure beyond existing control measures implemented based on previous planning documents. “Grey infrastructure” refers to systems used to control, reduce, or eliminate discharges from CSOs. These are the technologies that have been traditionally employed by DEP and other wastewater utilities in their CSO planning and implementation programs. They include retention tanks, tunnels and treatment facilities, including satellite facilities, and other similar capital-intensive facilities.

Grey infrastructure projects implemented under previous CSO control programs and facility plans, such as the 2011 WWFP, are described in Section 4. These projects include:

1. A project to install a Low Level Diversion Sewer to redirect a portion of the flow from the HLI into the Low Level Interceptor (shown in blue in Figure 8-6) and raise the Regulator BB-R02 weir height from -1.75 to +2.5 is under construction and scheduled for completion in December 2017 ($5.6M);

2. Fixed weir modifications at Regulators BB-R04, BB-R05, BB-R06, BB-R09 and BB-R10, as identified in Figure 8-7, are under construction and scheduled to be completed in June 2018 ($41.4M); and

3. Environmental dredging of selected areas of Flushing Bay is underway, as illustrated in Figure 8-8, and is scheduled for completion in March of 2021 ($38.8M).

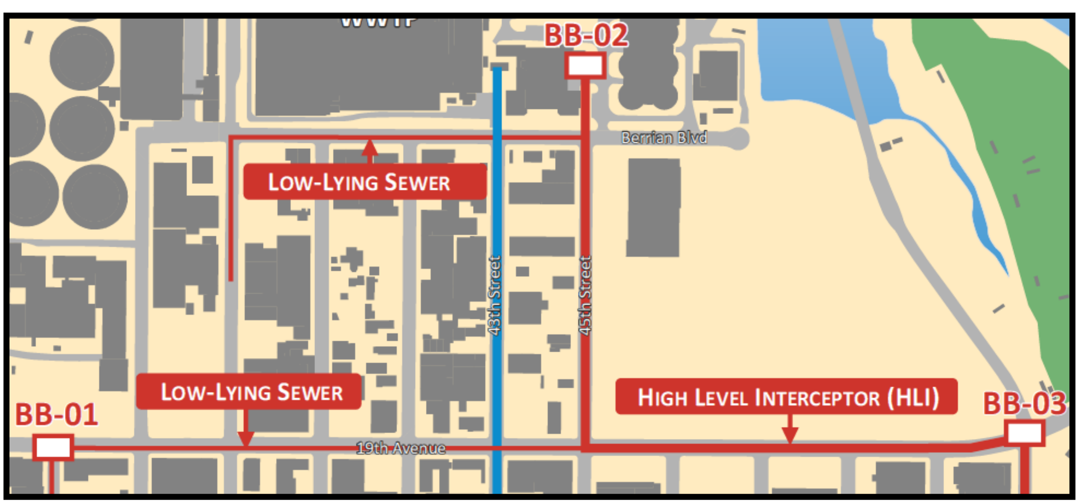

Figure 8-6. Diversion of Low Lying Sewers

Figure 8-7. Regulator Weir Modifications

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Figure 8-8. Environmental Dredging Within Flushing Bay

8.2.a.1 High Level Sewer Separation

High Level Storm Sewers (HLSS) is a form of partial separation that separates the combined sewers only in the streets or the public right-of way, while leaving roof leaders or other building connections unaltered. In NYC, this is typically accomplished by constructing a new stormwater collection system in NYC streets and directing flow from street inlets and catch basins to the new storm sewers. Challenges associated with HLSS include constructing new sewers with minimal disruption to the neighborhoods along the proposed alignment and finding a viable location for necessary new stormwater outfalls. Separation of sewers minimizes the amount of CSO being discharged to receiving waters, but can also result in increased separate stormwater discharges, which may also carry loadings to receiving waters.

Alternative 7-1 evaluated HLSS for diversion of stormwater from areas susceptible to flooding and conveyance of storm flow to Meadow and Willow Lakes. Figure 8-9 provides a historical record of flooding complaints in the BB-006 drainage area to the west of the lakes. An example of one of several alternatives considered is shown in Figure 8-10. Flood and CSO reduction benefits were found to be small in comparison to the length and cost of the required diversion conduits. In addition, the stormwater loadings associated with the diversions will negatively impact the lakes and Flushing Creek. As a result, this alternative was eliminated from further consideration.

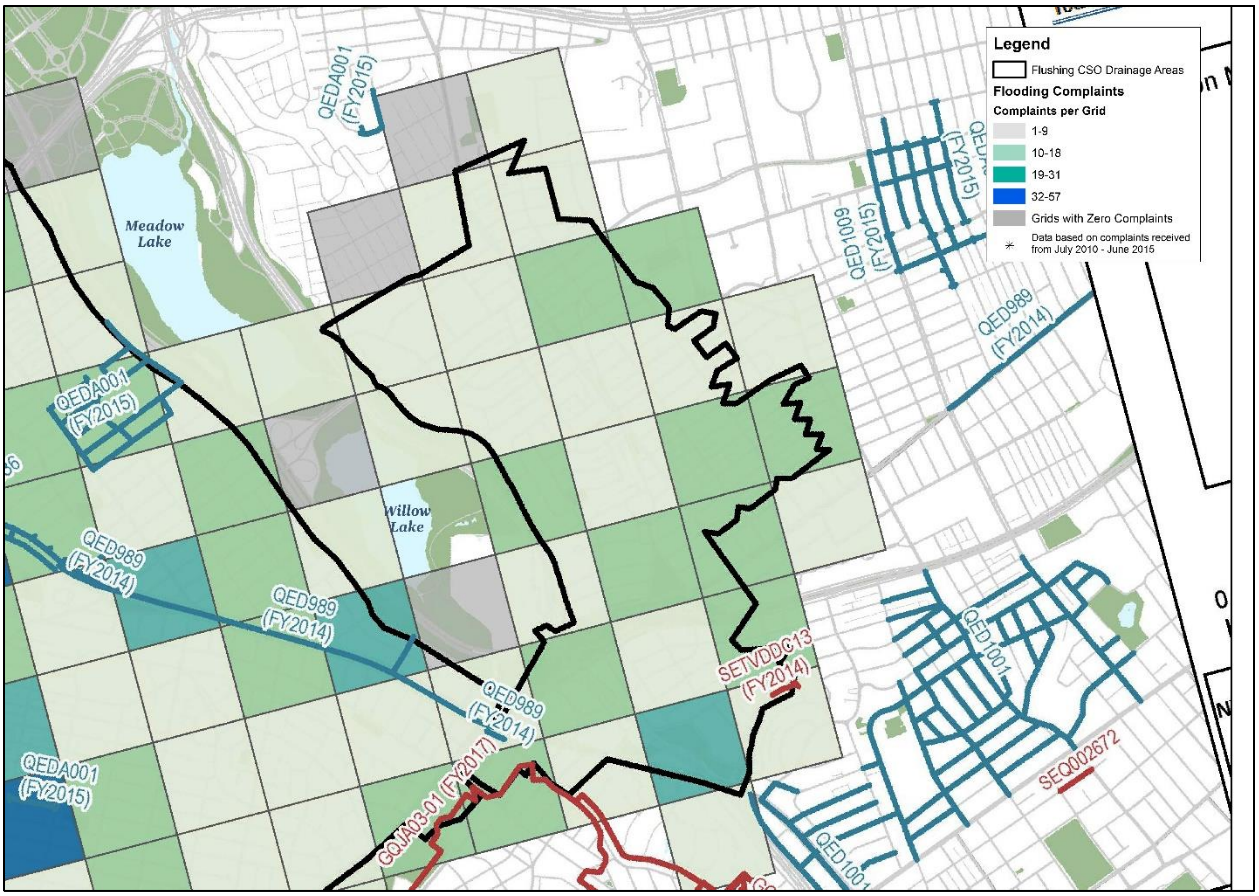


Figure 8-9. Flushing Bay CSO Drainage Area Flooding Complaints

Figure 8-10. Alternative 7-1 HLSS Diversion to Willow Lake

8.2.a.2 Sewer Enhancements

Sewer enhancements typically include measures to optimize the performance of the sewer system that often take advantage of in-system storage capacity to reduce CSO through automated controls or modifications to the existing collection system infrastructure. Examples include: regulator or weir modifications including fixed and bending weirs; control gate modifications; real time control; and increasing the capacity of select conveyance system components, such as gravity lines, pumping stations and/or force mains. Force main relocation or interceptor flow regulation would also fall under this category. These control measures generally retain more of the combined sewage within the collection system during storm events. The benefits of retaining this additional volume must be balanced against the potential for sewer back-ups and flooding, or the relocation of the CSO discharge elsewhere in the watershed or an adjacent watershed. Viability of these control measures is system-specific, depending on existing physical parameters such as pipeline diameter, length, slope and elevation. The modifications to five regulators, as recommended under the WWFP, were the result of an extensive evaluation of multiple alternatives culminating with the recommendations for raising and/or lengthening the fixed weirs at five regulator sites within the HLI. However, in-system storage uses the sewers upland of the interceptor and there is limited available volume for additional storage along with risks of potential upland flooding and increased sediment deposits in the sewer system.

As part of the control measure review process described in Section 8.1, two system optimization measures passed the initial screening process and were subsequently developed and evaluated for Flushing Bay:

- A 96-inch diameter Consolidation Conduit for the Bowery Bay HLI
- Extension of the 96-inch diameter BB HLI Consolidation Conduit to Address Outfall TI-011 from Flushing Creek

Each are described as follows:

Alternative 7-2a: Consolidation Conduit for the Bowery Bay High Level Interceptor (BB HLI)

Initial hydraulic analyses of the BB HLI indicate that a section of the interceptor sewer downstream of Regulator BB-R05 has limited capacity due to its mild slope and reductions in cross sectional area at two sewer crossings along 19th Avenue at Hazen and 49th Streets. This causes the hydraulic grade line to back-up considerably during wet-weather events, thereby limiting the conveyance of more than two times design dry-weather flow (2xDDWF) to the Bowery Bay WWTP for treatment. Improving the capacity of the BB HLI would increase the CSO flow to the Bowery Bay WWTP, and potentially reduce the frequency and volume of overflow discharged from the Flushing Bay CSO outfalls.

In order to improve the BB HLI conveyance capacity downstream of Regulator BB-R05, the additional wet-weather conveyance capacity resulting from the construction of a 96-inch diameter relief pipe (approximately 15,000 linear feet) between Regulators BB-R06 and BB-R02 was evaluated. The consolidation conduit diameter was determined based upon a sewer size (96-inch diameter) that is technically feasible using microtunneling construction methods (the largest known microtunnel is approximately 144” in diameter). The routing of the proposed 96-inch diameter relief pipe is shown in Figure 8-11. As indicated in the figure, microtunneling would be used during construction due to the highly congested nature of the route and the crossings of the Grand Central Parkway and other high volume roadways along the sewer alignment. IW modeling predicted a 31 percent net basin-wide reduction in annual CSO volume with this alternative.

The benefits, costs and challenges associated with the BB HLI relief sewer are as follows:

<u>Benefits</u>

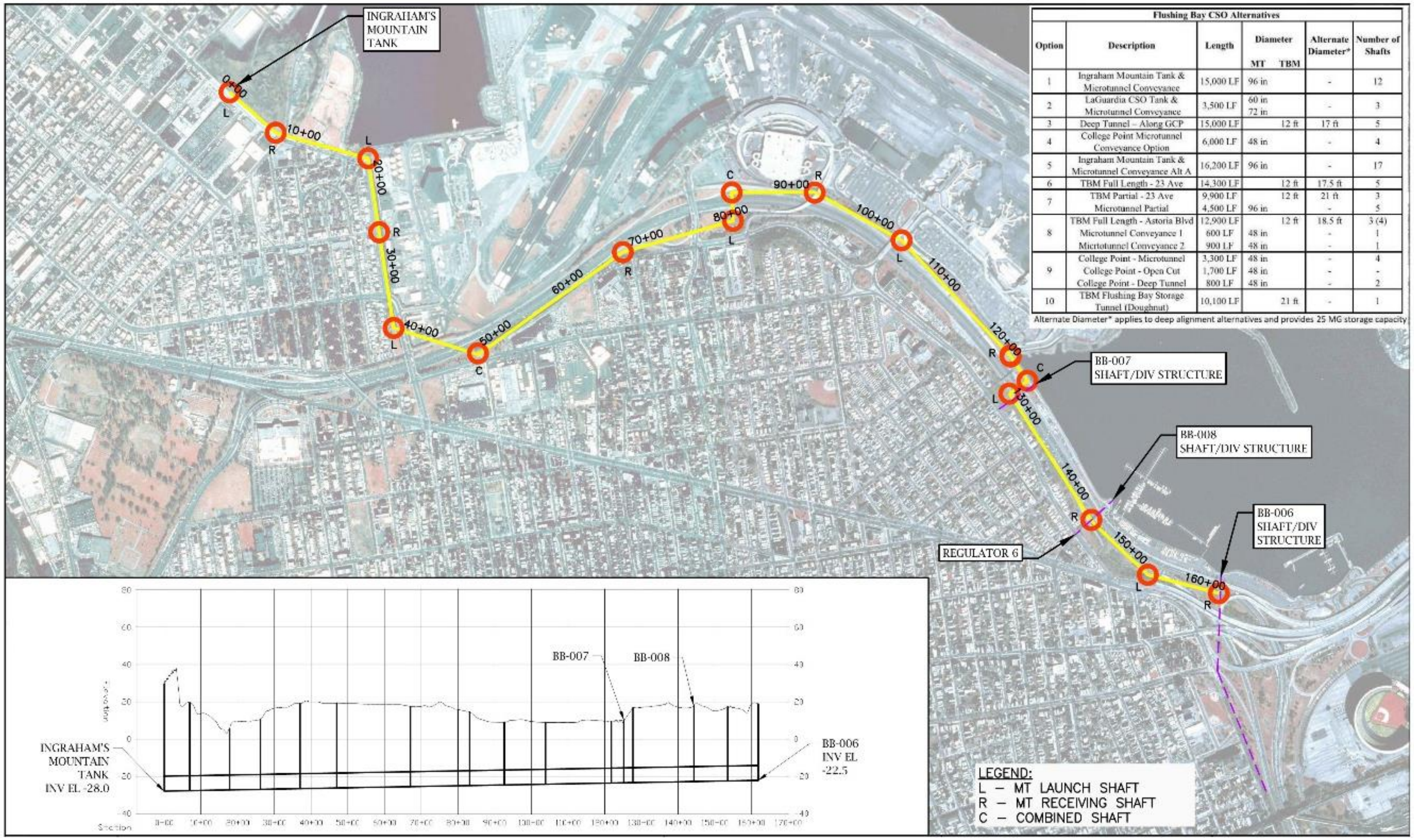
There are three primary benefits associated with this control measure. The first is that the 96-inch consolidation conduit would reduce a large volume of annual CSO discharge to Flushing Bay. Second, the relief sewer would not present the permanent siting issues associated with remote treatment or storage facilities, both above and below ground. Finally, as disinfection would not be involved, long term remote operation of chemical storage and feed equipment would not be required.

<u>Cost</u>

The estimated NPW for this control measure is $368M. Details of the estimate are presented in Section 8.4.

<u>Challenges</u>

There are numerous challenges associated with this consolidation conduit alternative, primarily the capacity limitations at the Bowery Bay WWTP and the hydraulic grade line impacts to the Low Level Interceptor (LLI). Construction of a gravity relief sewer would require connection to the Bowery Bay Lower Level of the WWTP influent pumping station, which would result in an increase in the hydraulic grade line and a subsequent increase in CSO discharge to the East River and Luyster Creek.



Flushing Bay CSO Alternatives

Option	Description	Length	Diameter MT	Diameter TBM	Alternate Diameter*	Number of Shafts
1	Ingraham Mountain Tank & Microtunnel Conveyance	15,000 LF	96 in		-	12
2	LaGuardia CSO Tank & Microtunnel Conveyance	3,500 LF	60 in 72 in		-	3
3	Deep Tunnel – Along GCP	15,000 LF		12 ft	17 ft	5
4	College Point Microtunnel Conveyance Option	6,000 LF	48 in		-	4
5	Ingraham Mountain Tank & Microtunnel Conveyance Alt A	16,200 LF	96 in		-	17
6	TBM Full Length - 23 Ave	14,300 LF		12 ft	17.5 ft	5
7	TBM Partial - 23 Ave Microtunnel Partial	9,900 LF 4,500 LF	 96 in	12 ft	21 ft -	3 5
8	TBM Full Length - Astoria Blvd Microtunnel Conveyance 1 Micrtotunnel Conveyance 2	12,900 LF 600 LF 900 LF	 48 in 48 in	12 ft	18.5 ft - -	3 (4) 1 1
9	College Point - Microtunnel College Point - Open Cut College Point - Deep Tunnel	3,300 LF 1,700 LF 800 LF	48 in 48 in 48 in		- - -	4 - 2
10	TBM Flushing Bay Storage Tunnel (Doughnut)	10,100 LF		21 ft	-	1

Alternate Diameter* applies to deep alignment alternatives and provides 25 MG storage capacity

Figure 8-11. Routing of Alternative 7-2a - Hydraulic Relief Sewer for the BB HLI from Regulator BB-R06 to Bowery Bay WWTP

Construction of a relatively shallow parallel gravity sewer would result in a high risk of conflicts with existing utilities, highways and local streets. While microtunneling would minimize some of these conflicts, siting the shafts would still be challenging. Limited space is available in the existing medians and traffic islands along the route. Reaches of the relief sewer paralleling and crossing the Grand Central Parkway interchange would require close coordination with New York City Department of Transportation (DOT) and the Port Authority of New York and New Jersey (PANYNJ). This coordination would need to confirm requirements for microtunneling and open cut construction of shafts adjacent to and under the highways, and to avoid the bridge supports and other below grade infrastructure. In addition to siting the microtunneling shafts, staging areas would also be required for the general construction activities. Traffic impacts to the Grand Central Parkway interchange would be anticipated as a result of the need for truck access to the microtunneling shaft sites.

Alternative 7-2b: Extension of the BB HLI Consolidation Conduit to Address from Flushing Creek Outfall TI-011

Outfall CSO TI-011 discharges 377 MG of CSO annually to Flushing Creek, a tributary to Flushing Bay. Although a $10M remote disinfection alternative has been proposed for this outfall under the Flushing Creek CSO LTCP, extension of the BB HLI Consolidation Conduit to capture CSO from Flushing Creek CSO TI-011 was evaluated. In consideration of this outfall’s relative close proximity to Outfall BB-006 and the influence of the remaining Flushing Creek CSOs on the water quality in Flushing Bay, this alternative provides an opportunity to eliminate a remote disinfection facility and the issues associated with chemical handling storage, facility maintenance and control of chlorine byproducts.

Under Alternative 7-2b, the BB HLI Consolidation Conduit would be extended from Outfall BB-006 to Outfall TI-011. A pumping station would be required at Outfall TI-011 to convey CSOs across Flushing Creek to a 48-inch diameter sewer that would convey the captured overflows to the upstream end of the BB HLI Consolidation Conduit at BB-006. The force main crossing of Flushing Creek would be about 1,000 feet in length, while the gravity sewer would be approximately 5,000 feet long. The sewer alignment is shown in Figure 8-12, running in a northeasterly alignment from Outfall BB-006 along Marina Road, under the Whitestone Expressway and Flushing Creek. Trenchless technologies would be utilized for crossing Flushing Creek and the expressway. The extension of the consolidation conduit would be capable of capturing about 50 percent of the CSO from Outfall TI-011, resulting in a 36 percent net basin-wide reduction in annual CSO volume with this alternative.

The benefits, costs and challenges associated with extending the BB HLI relief sewer to capture CSO from Outfall TI-011 are as follows:

<u>Benefits</u>

The three primary benefits associated with Alternative 7-2a are still applicable. In addition, the extension of the relief sewer allows for elimination of remote disinfection facilities currently proposed for treatment of CSOs at TI-011.

<u>Cost</u>

The estimated NPW for this control measure is $100M. Details of the estimate are presented in Section 8.4.

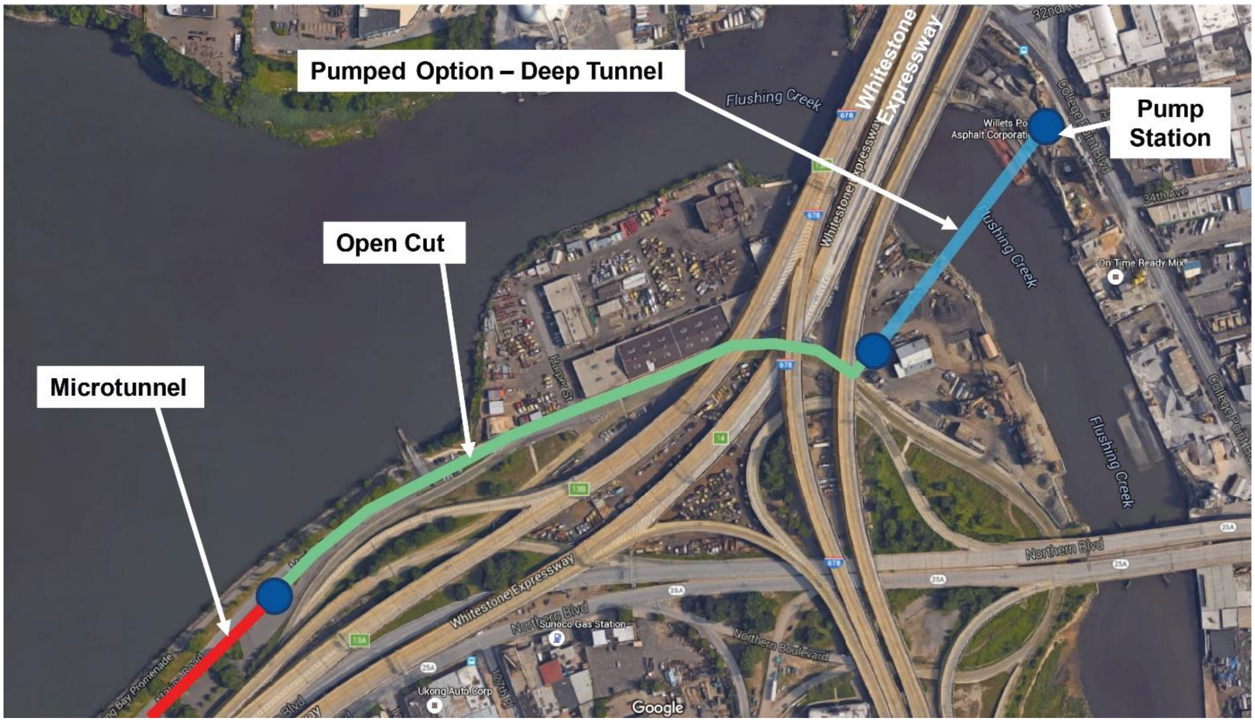


Figure 8-12. Layout of Alternative 7-2b – Extension of the BB HLI Consolidation Conduit to Address from Flushing Creek Outfall TI-011

<u>Challenges</u>

Numerous challenges are associated with extending the consolidation conduit to capture CSO from TI-011, first and foremost being the potential conflict with existing utilities, highways and the Flushing Bay Promenade. While trenchless technologies could be utilized to minimize some of these conflicts, siting the shafts and developing an alignment that minimizes the construction risks would still be challenging. Limited space is available in the existing medians and traffic islands along the route and the alignment would need to work around the existing bridge foundations and other below grade infrastructure. Reaches of the relief sewer extension paralleling and crossing the Whitestone Expressway will require close coordination with DOT and New York State Department of Transportation (NYSDOT) to confirm construction requirements for locations adjacent to and under the highway, and to avoid the bridge supports and other below grade infrastructure. In addition to siting the microtunneling shafts, staging areas would also be required for the general construction activities. Traffic impacts to the Whitestone Expressway are not anticipated since the sewer alignment will pass under the bridge. Finally, while a 188 MG reduction in CSO volume would result at Outfall TI-011, an increase in CSO volume of 245 MG would occur at multiple outfalls along the Bowery Bay LLI.

As the sewer optimization Alternatives 7-2a and 7-2b described above result in increases to CSO discharges to the other tributaries, they will not be carried forward to the next level of evaluation for possible inclusion in basin-wide alternatives.

In addition to the three alternatives described above, one other sewer enhancement alternative was identified but was not determined to be appropriate for inclusion in basin-wide alternatives. This alternative is summarized briefly in the paragraph below, along with the reasons for not evaluating it further.

Other Sewer Enhancement Alternatives Not Carried Forward

Alternative 7-3: Connection of the Bowery Bay HLI and LLI Pumping Station Wet Wells. The influent pumping station for the Bowery Bay WWTP currently isolates the flow entering from the High Level and Low Level Interceptors. The HLI was originally constructed to intercept wastewater from sewers discharging directly to Flushing and Bowery Bays while the LLI was constructed to intercept wastewater from sewers discharging to the East River, Steinway Creek and Newtown Creek. Connecting the wet wells was evaluated to determine if there were any CSO capture benefits that would result from connecting the wet wells and presumably maximizing the capacity of the existing pumping station. IW modeling indicated that although the annual CSO volume discharged from those outfalls associated with regulators along the HLI would decrease by 272 MG, the CSO discharges from regulators located along the LLI would increase by 452 MG. This would result in a net increase in annual CSO discharge volume of 180 MG, essentially shifting CSO from Flushing Bay to Bowery Bay and the East River. As a result, this alternative was not evaluated further.

8.2.a.3 Retention/Treatment Alternatives

A number of the control measures considered for Flushing Bay fall under the dual category of treatment and retention. For the purposes of this LTCP, the term "storage" is used in lieu of "retention." These control measures include in-line or in-system storage, an off-line tank and deep tunnel storage. Treatment refers to disinfection, in either CSO outfalls or at RTBs, and other, more advanced, treatment processes such as high rate clarification.

Evaluation of Retrofitting and Re-purposing of Existing Infrastructure for Retention/Treatment

Initial evaluations focused on maximizing the performance of existing infrastructure to capture and/or treat CSO discharges. Alternatives 9-1 through 9-4 evaluate opportunities to modify Outfalls BB-006 and BB-008 and retrofit or re-purpose the CAVF.

Alternative 9-1: Disinfection of Outfalls BB-006 and BB-008

The CAVF was constructed in the late 1990s to evaluate the performance of three swirl/vortex technologies at a full-scale test facility (133 MGD each). The purpose of the test was to demonstrate the effectiveness of the vortex technology for control of CSO pollutants, primarily floatables, oil and grease, settleable solids and total suspended solids. The two-year testing program, completed in late 1999, evaluated the floatables-removal performance of the facility for a total of 22 wet-weather events. Overall, the results indicated that the vortex units provided virtually no reductions in total suspended solids and an average floatables removal of approximately 60 percent during the tested events. Based on the results of the testing, DEP concluded that widespread application of the vortex technology is not effective for control of CSOs and was not a cost-effective way to control floatables. As a result of these findings, it would be desirable to develop an alternative use for the CAVF.

Designated as Alternative 9-1 and illustrated as Figure 8-13, retrofitting the CAVF with facilities for disinfection of CSOs conveyed by Outfall BB-006 was evaluated. Since the CAVF was originally designed to only receive wet-weather flow from the lower level of Outfall BB-006, options were considered for maximizing the volume of flow to be disinfected by the retrofitted facilities. Evaluation of options to divert flow from the upper level of BB-006 or from Outfall BB-008 to the CAVF were found to be infeasible due to limitations in outfall conveyance capacity and the difference in hydraulic grade lines. In consideration of these constraints, de-commissioning the vortex facilities was proposed to allow the available space to be utilized for below grade installation of the disinfection equipment with feed lines provided to the upper and lower levels of Outfall BB-006.

As part of this alternative, a separate remote disinfection facility would be provided for Outfall BB-008. As shown in Figure 8-14, this facility was sited near Regulator BB-R09 due to site constraints and the need to provide sufficient contact time in the outfall. At this site, an above-grade facility would be provided for housing the disinfection storage tanks, feed equipment, electrical, heating, ventilation and air conditioning (HVAC) and other ancillary equipment. Additional floor space would be provided should dechlorination equipment be required in the future.

DEP would seek to optimize the sodium hypochlorite dose to achieve a two-log kill (99 percent bacteria reduction) in order to minimize residuals to near non-detect and avoid the need for dechlorination. Towards this end, DEP is conducting CSO chlorination studies at the Spring Creek Auxiliary Water Pollution Control Plant (AWPCP). The information collected in that study would be used to support the final design of the Flushing Bay (BB-008) and Corona Avenue CAVF (BB-006) disinfection facilities if this alternative were part of the recommended plan.

Alternative 9-1 is projected to provide 27 percent control of the annual bacteria load to Flushing Bay. The percent control represents the predicted percent reduction in bacteria load throughout the entire year with disinfection only applied during the recreational season (May 1st through October 31st). The level of control estimates are based on the assumption of a two-log (99 percent) bacteria kill for flow rates up to a design flow rate of 75 MGD for the retrofitted CAVF and 20 MGD for the remote disinfection facilities for Outfall BB-008. At the design flow, greater than 15 minutes of contact time would be provided. Modifications to both the upper and lower levels of Outfall BB-006 would be necessary to accommodate injection of hypochlorite and generate turbulence to provide mixing. Static devices such as vanes, baffles or other devices would be provided in both Outfalls BB-006 and BB-008 as opposed to high speed mixers that would require frequent maintenance and could be damaged by solids in the flow. Ancillary electrical, controls and HVAC systems would also be included. The layout of the facilities and key components are provided in Figures 8-13 and 8-14.

The benefits, costs and challenges associated with retrofitting the CAVF with disinfection facilities are as follows:

Benefits

The primary benefit is the reuse of existing infrastructure to provide CSO control and a reduction in bacterial loads to Flushing Bay. Seasonal disinfection of the CSO discharged from Outfall BB-006 and Outfall BB-008 is projected to result in an annual reduction in bacterial load of approximately 27 percent to Flushing Bay.

Cost

The estimated NPW for this control measure is $49M. Details of the estimates are presented in Section 8.4.

Figure 8-13. Alternative 9-1 – Retrofit of CAVF for Disinfection of Outfall BB-006

Figure 8-14. Alternative 9-1 – Remote Disinfection Facility for Outfall BB-008

Challenges

The specific challenges include the need to construct devices within the existing outfall to create proper mixing of the disinfectant with the CSO, without impacting the system hydraulics or creating impediments to cleaning of sediment deposition from the outfall. The installation of chemical storage tanks and associated facilities within the existing CAVF will require removal of a portion of the tank ceiling, alteration of interior walls and de-commissioning of the remainder of the CAVF facilities. In addition, a remote disinfection facility would need to be sited in a dense residential area along Outfall BB-008 near Regulator BB-R09. Intermittent operation of two remote chemical feed systems presents O&M challenges. Finally, Regulator BB-06 has been identified as a Key Regulator and overflows to Outfall BB-008. Outfall disinfection will not address early tipping and will require additional improvements outside of this LTCP.

Alternative 9-1 has been carried forward to the next level of evaluation for inclusion in the basin-wide alternatives.

Alternative 9-2: Re-purpose the Corona Avenue Vortex Facility as a Retention Treatment Basin

The CAVF provided control of CSO discharges from the lower level of Outfall BB-006. An influent channel conveyed flow to the vortex units from the lower level of BB-006 to the facility. An overflow pipe returned effluent to the lower level of Outfall BB-006, while captured solids and floatables were conveyed back to the interceptor via a 48-inch sewer that flows by gravity to the 108th Street Pumping Station.

In consideration of DEP’s familiarity with the performance, operation and maintenance of RTBs and storage tanks, the CAVF could be modified to re-purpose the facility. The vortex facilities would be demolished and alterations would be made to the partition/support walls and tank bottom to reconfigure the facility as a RTB. Mechanical screens would be installed to provide for capture of solids and floatables. The captured floatables and solids would be conveyed by conveyor to storage bins that would need to be periodically emptied. Mechanical flushing would also be provided to facilitate post-storm event cleaning.

A pretreatment building would be constructed in the roadway median to house the mechanical screening facilities, the disinfection equipment and piping for chemical delivery, storage and feed. Ancillary electrical, controls and HVAC systems would also be included. With this concept, the facility would be made integral to the RTB tank. The disinfection facilities are projected to provide 17 percent control of the annual bacteria load to Flushing Bay. The percent control represents the predicted percent reduction in bacteria load throughout the entire year with disinfection only applied during the recreational season (May 1st through October 31st), based on the assumption of a two-log (99 percent) bacteria kill for flow rates up to the existing CAVF influent design flow rate of 75 MGD. At the design flow, greater than 15 minutes of contact time would be provided. Static devices such as vanes, baffles or other devices would be provided to create turbulence and mixing at the point of chemical injection. Ancillary electrical, instrumentation controls and HVAC systems would also be included. The layout of the facilities is provided in Figure 8-15. A cross sectional view is provided in Figure 8-16.

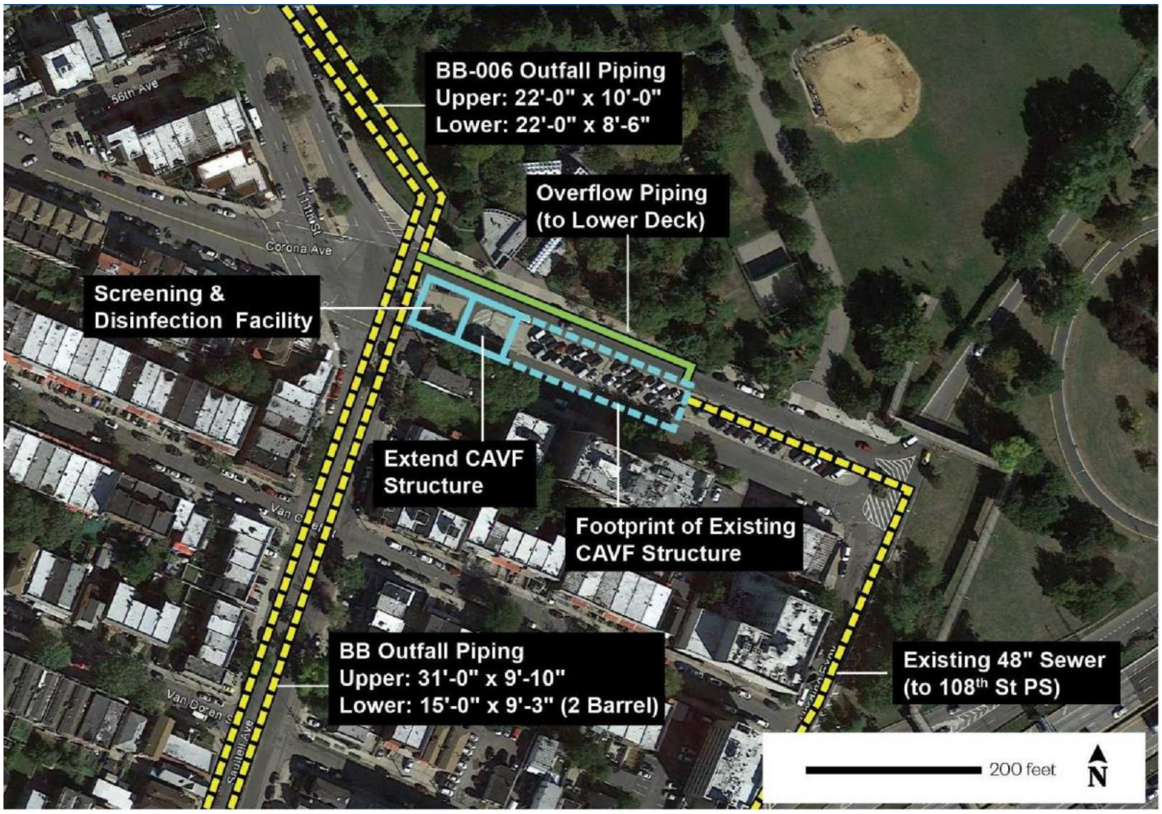


Figure 8-15. Layout of Alternative 9-2 – Re-purpose the CAVF as a Retention Treatment Basin

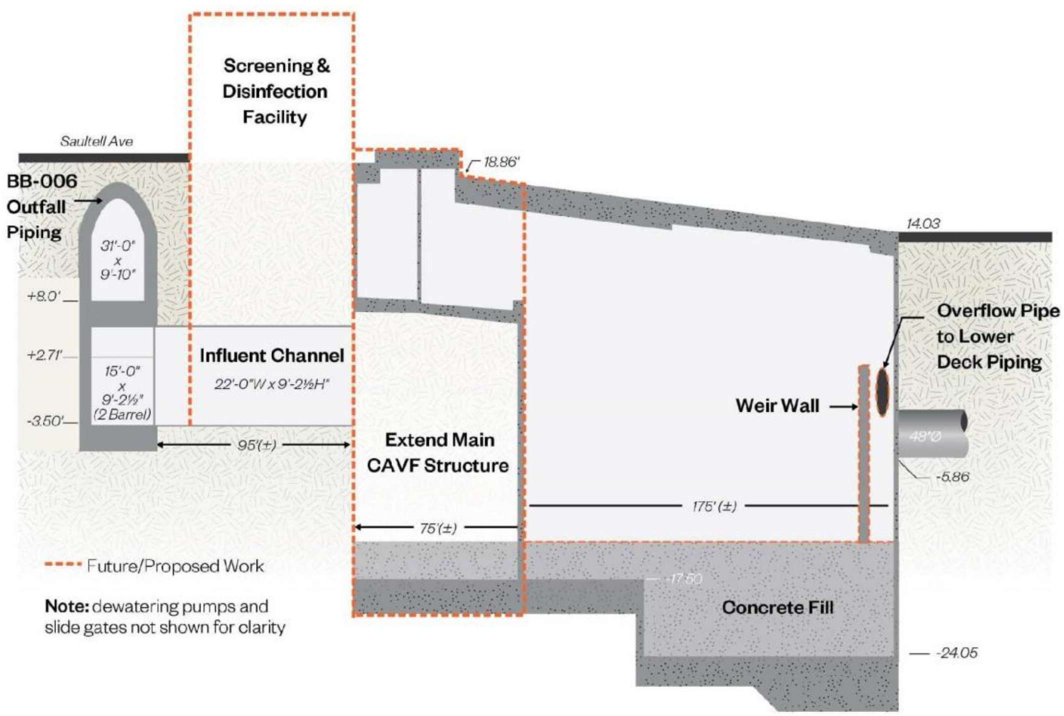


Figure 8-16. Section View of Alternative 9-2 – Re-purpose the CAVF as a Retention Treatment Basin

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The benefits, costs and challenges associated with re-purposing the CAVF as a RTB are as follows:

Benefits

The primary benefit is the reuse of existing infrastructure to provide CSO control and a reduction in bacterial loads to Flushing Bay associated with discharges from the lower level of Outfall BB-006. Property acquisition would be limited to the green space required to construct the disinfection facilities. In addition to bacterial load reductions, the RTB would also provide solids and floatables control. The annual CSO volume reduction is estimated to be approximately 15 percent. As this is a flow-through facility, disinfection of the effluent would provide a reduction in bacterial load of approximately 17 percent.

Cost

The estimated NPW for this control measure is $61M. Details of the estimates are presented in Section 8.4.

Challenges

The primary challenge associated with this alternative will be the modification of the existing structural components of the CAVF. Temporary structural support will be needed throughout the existing structure during modification of existing roof beams, bearing walls and other structural support members. Geotechnical conditions and existing foundations will need to be evaluated to verify that any additional load associated with the mechanical and structural modifications can be supported by the existing foundation. Permanent relocation of parking spaces or the median will be necessary to provide a surface structure to house the screening facilities and disinfection equipment. Temporary relocation of on-street parking and maintenance and protection of traffic will be challenging due to the location of the CAVF in relation to access driveways for Flushing Meadow Park West, the entrance to the Playground for All Children and Rego Park Health Care. Seasonal operation of the disinfection system also presents O&M challenges.

Alternative 9-2 for re-purposing the CAVF has been carried forward to the next level of evaluation for inclusion in the basin-wide alternatives.

Alternative 9-3: In-line Storage Along Outfalls BB-006 and BB-008

The large cross sectional area and significant length of the outfall sewers for Outfalls BB-006 and BB-008 provide an opportunity for storage within the outfall barrels. This would be achieved by installing bending weirs at the downstream end of the barrels and using small pumping stations constructed adjacent to the bending weirs for dewatering at the end of each rainfall event. This alternative includes the following:

- The lower level of the Outfall BB-006 consists of 7,000-feet of 22-foot x 8.5-foot and is estimated to provide 3.8 MG of storage up to the CAVF.
- The upper level of Outfall BB-006 consists of 8,400-feet of 22-foot x 10-foot barrel arched sewer and is estimated to provide 1.5 MG of storage up to Regulator BB-R10.
- Outfall BB-008 is a 5,400 feet long, 12.5 foot diameter sewer. The estimated storage volume within this conduit is 1.2 MG up to Regulator BB-R09.

The stored volume (a maximum of 6.5 MG) behind the bending weirs would be pumped into the Bowery Bay HLI after the storm event. Small dewatering facilities with chopper pumps for handling large solids and floatables would be installed adjacent to the bending weirs to dewater the outfall barrels and remove retained floatables. The locations of the bending weirs and pumping stations along Outfalls BB-006 and BB-008 are shown in Figures 8-17 and 8-19, respectively. Conceptual plan views of the installations are shown in Figures 8-18 and 8-20 respectively.

The benefits, costs and challenges associated with outfall storage are as follows:

Benefits

The primary benefit of outfall storage is the use of available capacity within the existing system. It also provides approximately 14 percent CSO volume reduction with minimal permanent above-ground land requirements. Also, because disinfection would not be involved, siting and maintenance of chemical storage and feed equipment would not be required.

Cost

The estimated NPW for this control measure is $118M. Details of the estimates are presented in Section 8.4.

Challenges

One of the major challenges with outfall storage is the required O&M in deep, confined spaces. Bending weirs, screens and pumps will require periodic maintenance. In addition, the management of grit and large solids deposited along the outfall bottom when velocities drop during storage mode will be a long term maintenance issue. In addition, design of the bending weir and provisions for emergency bypass in case of a mechanical failure will need to be carefully considered to minimize the risk of upstream flooding.

The siting of the pumping stations within green space adjacent to the Grand Central Parkway presents construction challenges. Excavation support will need to protect the roadway ramp, support columns and other below grade infrastructure of the Grand Central Parkway at the pumping station site for Outfall BB-006 and the Flushing Bay Promenade footbridge at Outfall BB-008. Also, dewatering pumps will be required and electric power will need to be secured, which would require construction of duct banks under the Grand Central Parkway to the pumping station site for Outfall BB-006. The construction would also result in the removal of trees within the green space requiring mitigation efforts at both sites coordinated with the Department of Parks and Recreation. Permitting of access driveways for pumping station maintenance and approval of construction to be performed within road rights-of-way will also need to be coordinated with NYSDOT and DOT.

Outfall storage, Alternative 9-3, has been carried forward to the next level of evaluation for inclusion in the basin-wide alternatives.

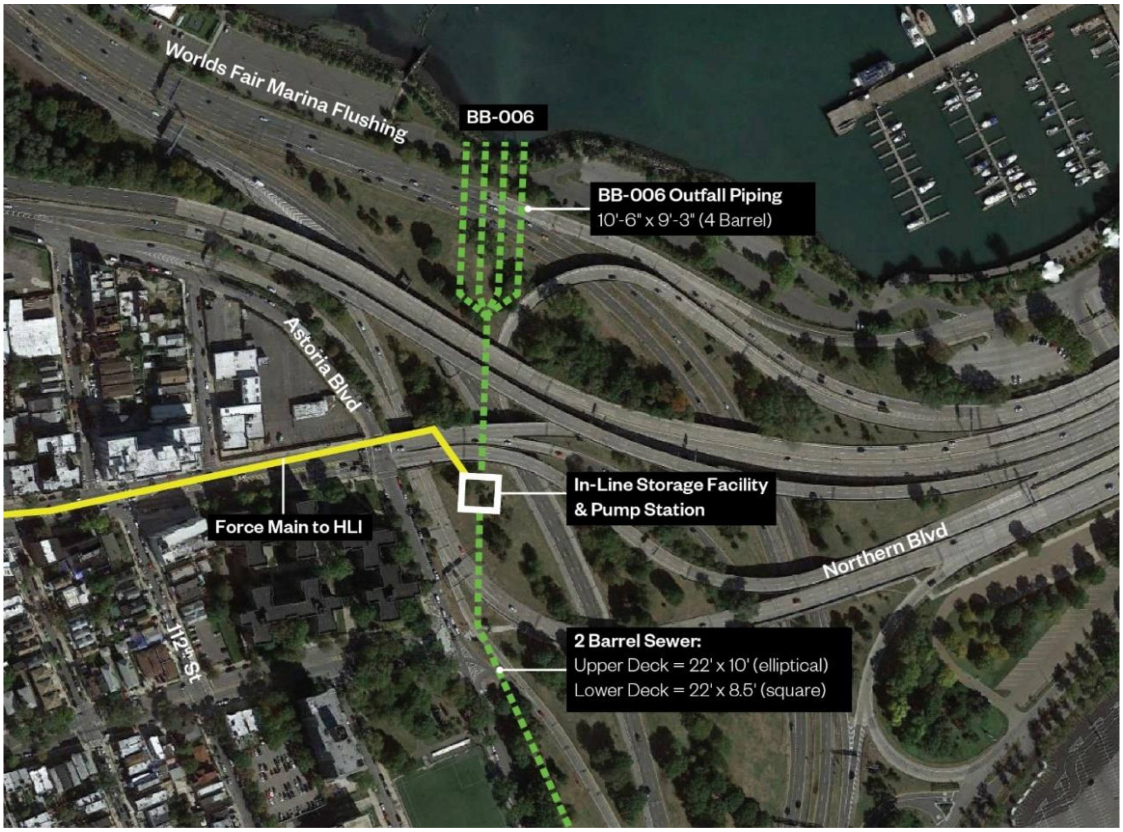

Figure 8-17. Layout of Alternative 9-3 – Outfall Storage for BB-006

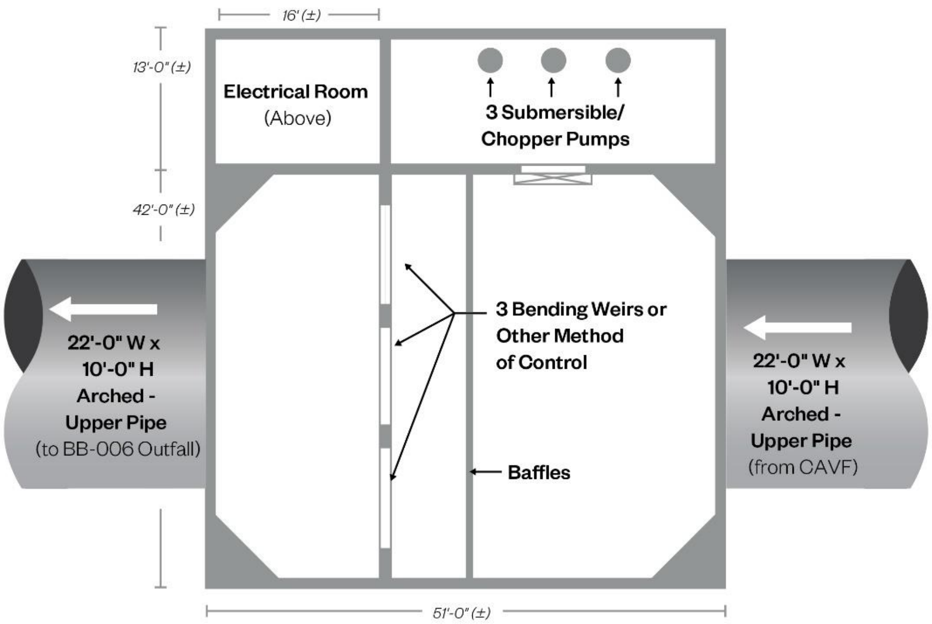

Figure 8-18. Layout of Alternative 9-3 – Outfall Storage Pumping Station for BB-006

Figure 8-19. Layout of Alternative 9-3 – Outfall Storage for BB-008

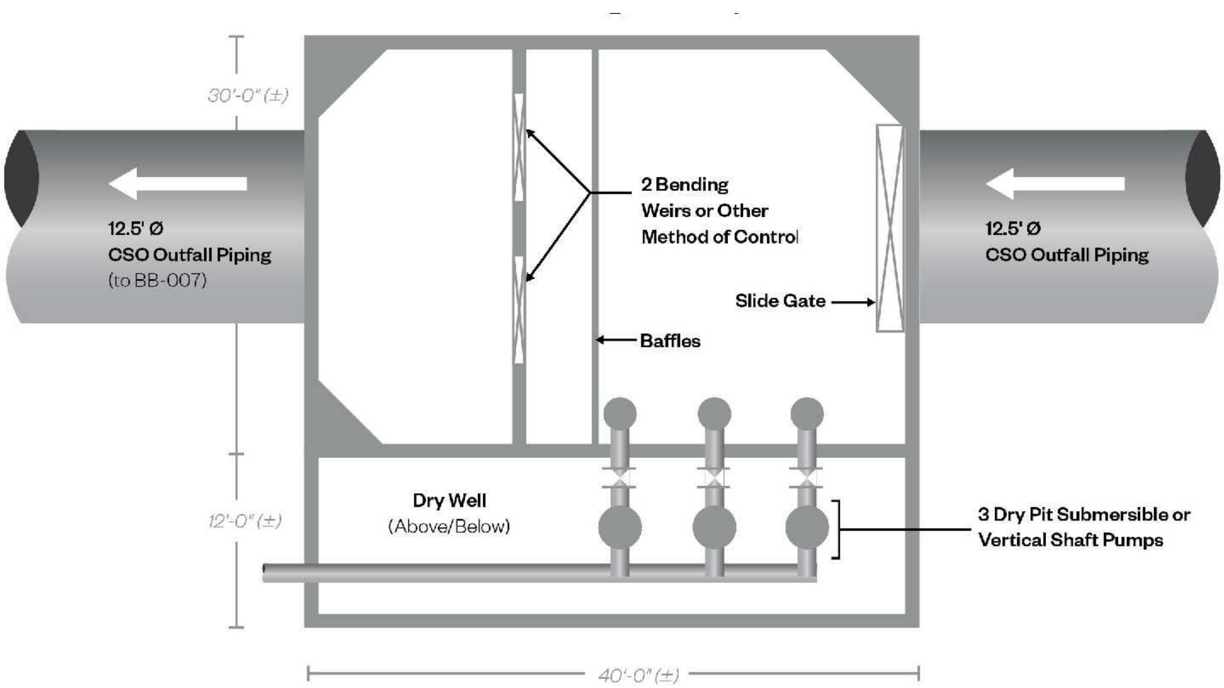

Figure 8-20. Layout of Alternative 9-3 – Outfall Storage Pumping Station for BB-008

Alternative 9-4: Combination of Disinfection of Outfall BB-006 and In-line Storage at Outfalls BB-006 and BB-008

Alternative 9-4 consists of a combination of the retrofit of the Corona Avenue Vortex Facility for disinfection of Outfall BB-006 and Alternative 9-3 In-line Storage at Outfalls BB-006 and BB-008. This combined alternative utilizes and modifies existing infrastructure to reduce discharges from the two largest CSOs, Outfalls BB-006 and BB-008.

The benefits, costs and challenges associated with the combination of these alternatives are as follows:

<u>Benefits</u>

The primary benefit of this combined alternative is the reuse of existing infrastructure to provide CSO control. Retrofitting the CAVF with disinfection equipment provides for bacterial reductions for those storms generating CSO in excess of the available in-line storage capacity. CSO volume reduction is estimated to be approximately 15 percent. However, disinfection of CSO within Outfall BB-006 would provide a reduction in bacterial load (two-log kill) of approximately 17 percent.

<u>Cost</u>

The estimated NPW for this control measure is $179M. Details of the estimates are presented in Section 8.4.

<u>Challenges</u>

The specific challenges associated with this alternative include the need to construct devices within the existing outfalls to provide for proper mixing of the disinfectant with the CSO without impacting the system hydraulics or creating impediments to cleaning of sediment deposition from the outfall. The installation of chemical storage tanks and associated facilities within the existing CAVF will require removal of a portion of the tank ceiling of the structure, alteration of interior walls and de-commissioning of the remainder of the CAVF facilities. Finally, intermittent operation of remote chemical feed systems presents O&M challenges.

One of the major challenges with outfall storage is the required O&M in deep, confined spaces. In addition, the management of grit and large solids deposited along the outfall bottom when velocities drop during storage mode will be a long term maintenance issue. In addition, design of the bending weir and provisions for emergency bypass in case of a mechanical failure will need to be carefully considered to minimize the risk of upstream flooding.

The siting of the pumping stations within green space adjacent to the Grand Central Parkway presents construction challenges. Excavation support will need to protect the roadway ramp, support columns and other below grade infrastructure. Electric power will need to be secured, which would require construction of duct banks under the Grand Central Parkway to the pumping station site for Outfall BB-006. The construction would also result in the removal of trees within the green space at both sites requiring mitigation efforts coordinated with the Department of Parks and Recreation. Permitting of access driveways for pumping station maintenance and approval of construction to be performed within road rights-of-way will also need to be coordinated with NYSDOT and DOT.

Combined Outfall BB-006 Disinfection and In-line Storage (Alternative 9-4) has been carried forward to the next level of evaluation for inclusion in the basin-wide alternatives.

Evaluation of New Retention/Treatment Facilities

A review of existing land uses near the discharge of Outfalls BB-006 and BB-008 was performed for the purposes of identifying potential sites for new retention/treatment facilities. Although sizable properties were identified within Flushing Meadows Corona Park, concerns relating to alienation of parklands eliminated these sites from consideration. Economic development projects planned for the surface parking lots surrounding Citi Field eliminated these properties as potential sites. The remaining vacant properties are limited to the green space within the highway right-of-way. While these areas are suitable for conveyance alternatives, they are not large enough to site a storage tank or treatment facility. In consideration of the siting constraints, a review was conducted of developed properties that could be acquired through the eminent domain process. Although this process of land acquisition is highly undesirable, it was felt that it was necessary to consider this option for the purposes of developing a traditional off-line storage tank option for comparison to other CSO control alternatives. For similar reasons, an alternative was developed for construction of a RTB within the Flushing Bay waterbody, despite the unlikelihood of acquiring the necessary environmental permits and approvals.

As a result of the limited availability of suitable sites for traditional storage and treatment technologies within the Flushing Bay watershed, tunnel storage was retained after the initial screening process described in Section 8.1. Unlike traditional tank storage, tunnel storage:

1) Provides for both conveyance and storage of CSO;
2) Requires less permanent above-ground property per equivalent unit of storage volume;
3) Minimizes surface construction impacts;
4) Reduces construction related groundwater pumping and treatment costs; and
5) Reduces the volume of spoil material to be treated, handled and transported for disposal during construction.

These benefits make tunnel storage more practical, in many cases, for highly-developed watersheds such as Flushing Bay.

A RTB and a traditional off-line storage tank were evaluated for control of CSO from both Outfalls BB-006 and BB-008. CSO Storage/Conveyance Tunnels were also considered and evaluated. Discussion relating to these alternatives follows.

Each of the Retention/Treatment Alternatives described below requires dewatering or treatment of the retained CSO volumes after wet-weather events occur. Table 8-3 provides a summary of the storage, dewatering and treatment capacity that would be required for sizing facilities for 25 percent, 50 percent, 75 percent and 100 percent levels of CSO control. Dewatering pumping station rates are based on a 24 hour dewatering period.

Table 8-3. Storage, Dewatering Pumping Station and Treatment System Capacity for Retention and Treatment Alternatives

Level of Control	Storage Volume (MG)	Dewatering PS Capacity[(1)] (MGD)	RTB Capacity (MGD)
25% CSO Control	12	15	32
50% CSO Control	25	25	72
75% CSO Control	66	70	197
100% CSO Control	161	160	1,381

Note:
(1) Assumes pump-back of stored CSO within a 24 hour period.

A review of Table 8-3 indicates that the dewatering pumping station capacity for 100% CSO control exceeds the Bowery Bay WWTP DDWF capacity of 150 MGD. For 100% CSO control, there is not available capacity at the Bowery Bay WWTP to treat the stored flow through all plant processes (225 MGD or 1.5xDDWF) at the proposed dewatering rates. As a result, provision of a parallel treatment train (Retention Treatment Basin) will be necessary to supplement the Bowery Bay WWTP capacity to accommodate the tunnel dewatering rates for 100% CSO control.

Alternative 9-5: In-Water Retention Treatment Basin

Designated as Alternative 9-5, this concept would entail the construction of an In-Water RTB to provide for treatment and disinfection of CSO discharges to Flushing Bay from Outfalls BB-006 and BB-008. The facility would be located to the northwest of Outfall BB-006 and would be sized to provide 50 percent seasonal control of bacteria. At the design flow (72 MGD), 15 minutes of contact time would be provided. The 72 MGD in-water retention treatment facility is projected to provide 27 percent control of the annual bacteria load to Flushing Bay. The percent control represents the predicted percent reduction in bacteria load throughout the entire year with disinfection only applied during the recreational season (May 1st through October 31st), based on the assumption of a two-log (99 percent) bacteria kill for flow rates up to a design flow rate of 72 MGD. The layout of Alternative 9-5 is shown in Figure 8-21.

Flows entering the facility would be screened of large solids and floatable material. Following the event, the tank would be dewatered and cleaned and made ready for the next event. Flushing gates or tipping buckets would be provided to facilitate cleaning of the tank bottom. Flushed grit and solids would be conveyed in a channel to a wet well containing dewatering pumps for pump down of the facilities to the HLI in Ditmars Boulevard for conveyance to the Bowery Bay WWTP. Due to its proximity to the promenade and marinas, odor control facilities using activated carbon would be provided.

Disinfection would be accomplished by dosing sodium hypochlorite just upstream of the tank. DEP will seek to optimize the sodium hypochlorite dose to achieve a two-log kill (99 percent bacteria reduction) in order to minimize residuals to near non-detect, and avoid the need for dechlorination. Towards this end, DEP is conducting CSO chlorination studies at the Spring Creek AWPCP. The information collected in that study would be used to inform the final design of the Flushing Bay disinfection facilities. Sodium hypochlorite would be dosed at the disinfection facility during the recreational season (May 1st through October 31st).

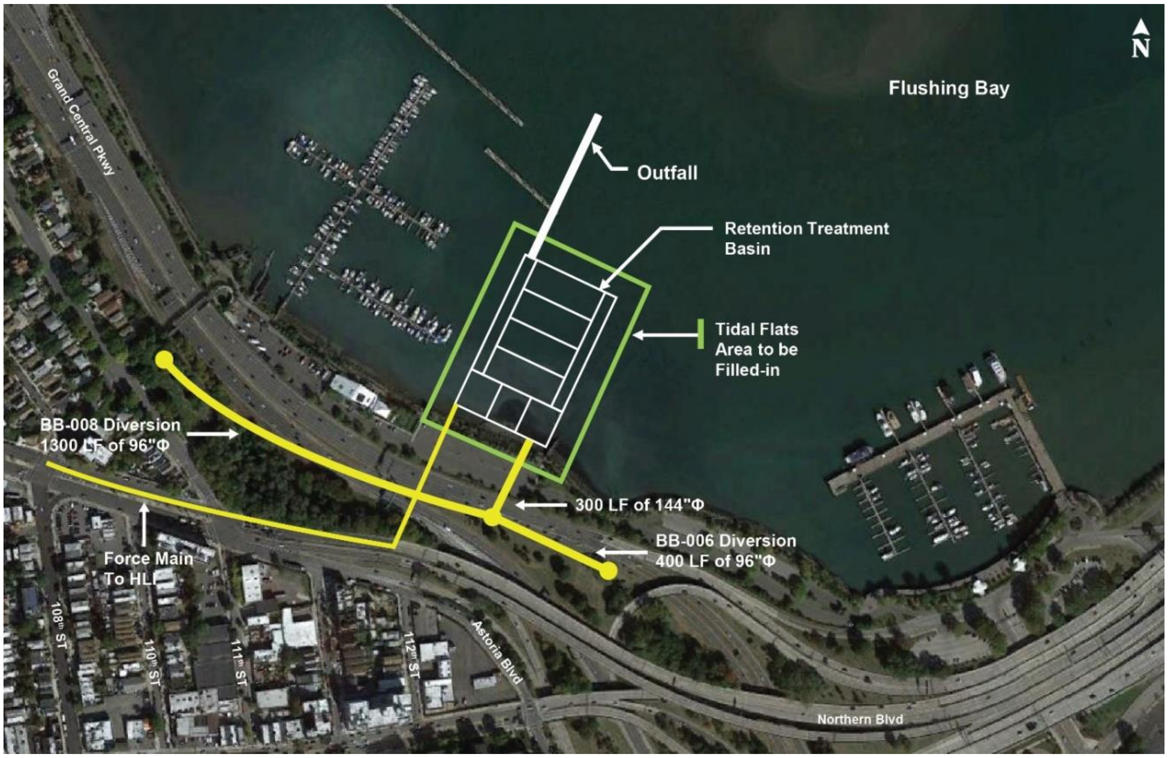

Figure 8-21. Layout of Alternative 9-5 – In-water Retention Treatment Basin

A headworks building would be constructed to house screening facilities, pumps, odor control and equipment and piping for chemical delivery, storage, and feed. Ancillary electrical, instrumentation, controls and HVAC systems would also be included. With this concept, the facility would be made integral to the RTB tank. Should dechlorination be required in the future, such addition has been considered in the conceptual layouts.

The benefits, costs and challenges associated with construction and operation of the In-Water RTB are as follows:

Benefits

The primary benefit of an RTB is its predicted high degree of seasonal bacterial control. An additional benefit would be a reduction in solids and floatables captured by the screens and settled solids pumped back upon dewatering the tank after each storm event. The capture and treatment of the CSO discharges would help to reduce odors and provide aesthetic benefits to the marinas and along the promenade by capture of floatables contained in the CSO discharges. In addition, the surface of the RTB could be designed to provide an observation deck, gathering area or other park amenity.

Cost

The estimated NPW for this control measure is $552M. Details of the estimate are presented in Section 8.4.

Challenges

One of the major challenges with this alternative is the siting of the facilities within Flushing Bay. Construction within Flushing Bay would require environmental approvals and permits from DEC and the U.S. Army Corps of Engineers. Permitting and approvals would also be necessary for construction of a new outfall to Flushing Bay. The construction of the outfall diversions and dewatering force main would also result in the removal of trees within the green space requiring mitigation efforts coordinated with the Department of Parks and Recreation. Approval of construction to be performed within road rights-of-way would also need to be coordinated with NYSDOT and DOT.

During construction, access and use of the marinas and the promenade would be affected, particularly during construction of the diversion sewers from Outfalls BB-006 and BB-008 to the RTB site. In addition, parking would be lost to provide area for construction staging. Although construction methods may be implemented to minimize the volume of groundwater and bay water entering the excavation, discharges of pumped groundwater would need to be treated prior to reintroducing the flow to Flushing Bay. In addition to construction issues, future operation of the facilities could temporarily interfere with the use of the promenade during removal of screenings, tank wash down and maintenance after CSO events. Finally, the seasonal operation of the chemical system would present O&M challenges.

Despite the environmental permitting challenges, construction of an In-Water RTB would provide a sizable reduction of CSO and bacterial loads to Flushing Bay, while providing opportunities for further enhancement of the promenade and marina facilities. As a result, Alternative 9-5 has been carried forward to the next level of evaluation for inclusion in the basin-wide alternatives.

Alternative 9-6: Off-line Storage Tank

A 25 MG off-line storage tank would be provided to capture CSO discharges to Flushing Bay from Outfalls BB-006 and BB-008. Due to the footprint size of the tank (425 feet long by 225 feet wide) necessary for 50 percent capture and the limited availability of large vacant properties, it would be necessary to condemn property through the eminent domain process to construct this facility. Siting the tank near Outfalls BB-006 and BB-008 could potentially impact one or more city blocks. Properties at lower elevations would be more desirable to reduce the excavation and disposal of spoil material required to construct the facility.

A diversion chamber would need to be constructed along each outfall to divert overflows from the upper and lower levels of Outfall BB-006 and from Outfall BB-008 to the storage tank. A 48-inch diameter sewer would be constructed to convey the overflows from BB-008 to the facility. Sewers conveying CSO from Outfalls BB-006 and BB-008 would come together in a junction chamber immediately upstream of the CSO storage tank.

Flows entering the facility would be screened of large solids and floatable material. Following the event, the tank would be dewatered and cleaned and made ready for the next event. Flushing gates or tipping buckets would be provided to facilitate cleaning of the tank bottom. Flushed grit and solids would be conveyed in a channel to a wet well containing dewatering pumps for pump down of the facilities to the HLI in 118th Street for conveyance to the Bowery Bay WWTP. Due to its proximity to residential and commercial properties, odor control facilities using activated carbon would be provided. Figure 8-22 indicates the general area that would need to be considered for siting an off-line storage tank. The siting is driven by the proximity to the HLI and Outfalls BB-006 and BB-008.

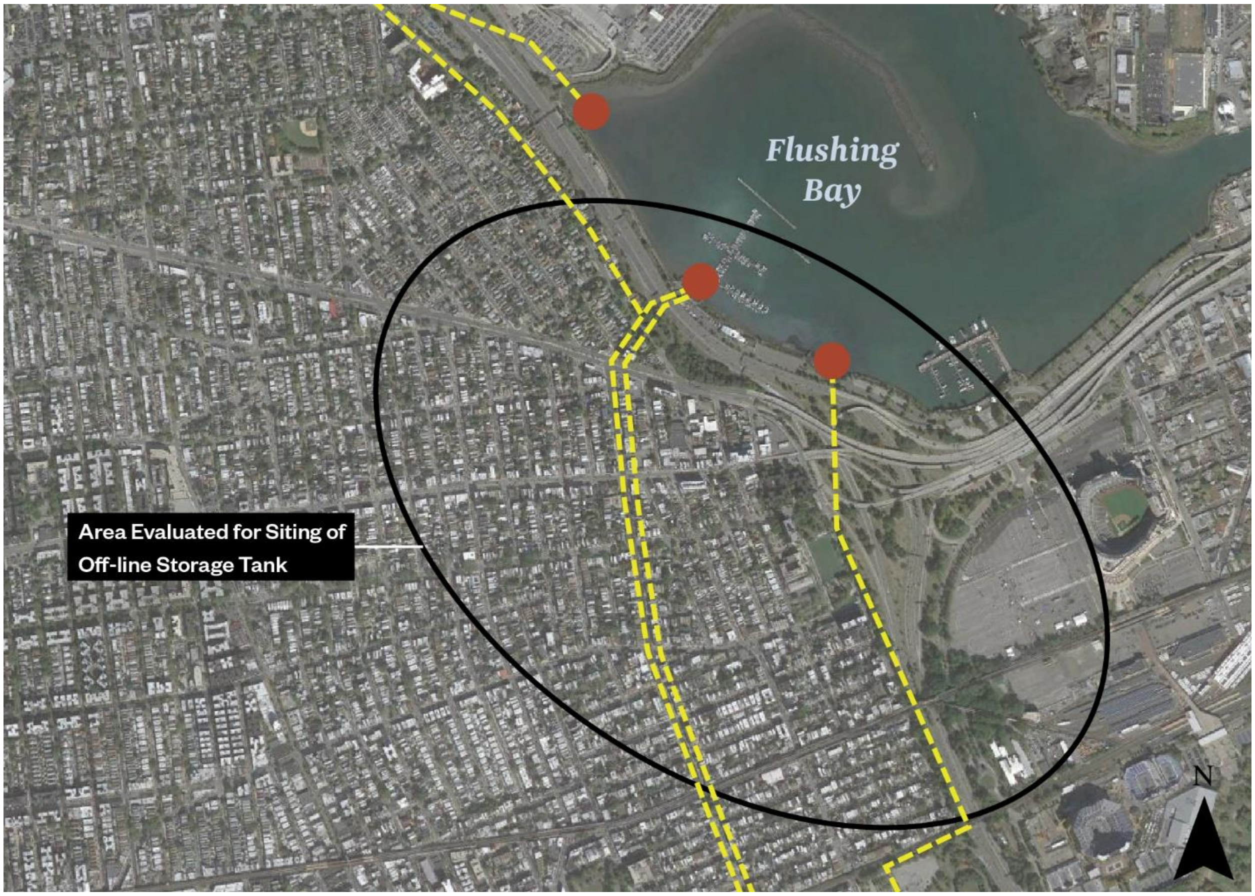

Figure 8-22. Siting Options for Alternative 9-6 – Off-line Storage Tank Outfalls BB-006 and BB-008

The benefits, costs and challenges associated with construction and operation of the CSO storage tank are as follows:

Benefits

The primary benefit of a storage tank is its predicted high degree of volumetric CSO and annual bacterial capture. The operations are simple in comparison to treatment facilities and DEP operations staff are familiar with the maintenance requirements of the equipment used in this type of facility. In addition, the surface of the tank could be designed to provide secondary uses, such as a parking lot, ball fields, a gathering area, a park or other recreational amenities.

Cost

The estimated NPW for this control measure is $750M. Details of the estimate are presented in Section 8.4.

Challenges

The area for siting this facility is driven by the location of the existing sewer infrastructure. This area is made up of primarily multi-family and single family residences and includes schools, parks, museums, Citifield, commercial and other land uses. Depending upon the siting of the storage tank, the large footprint of the tank will require the acquisition of several properties over multiple blocks. During construction, plans for maintenance and protection of traffic will be required, along with coordination of construction methods and schedules with DOT. These issues will need to be addressed not only for the tank site, but for the alignments of the dewatering force main and the outfall sewer diversion piping. As a result, the immediate and long term neighborhood impacts are expected to be widespread and will impact a large area of the community. In addition, past operational experience of off-line CSO storage tanks in other parts of NYC indicates that grit and solids in the pump-back following a wet-weather event has a tendency to drop out of suspension in the interceptor. The deposition of sediment reduces interceptor capacity and increases the risk of flooding and basement back-ups. Frequent cleaning of the interceptor is necessary to manage this problem. Due to the length and relatively flat grade of the HLI from Outfalls BB-006 and BB-008 to the Bowery Bay WWTP, the risk of sediment deposition is high and would require a major maintenance effort.

Citifield was raised at public meetings as a potential site for construction of an off-line storage tank. This site is particularly challenging as it is requires multiple crossings of the Grand Central Parkway to convey CSO to the tank and then pump it back through a force main to the interceptor located in 108th Street following a storm event. Construction of these sewers will result in major neighborhood and traffic impacts, particularly associated with open cut construction for connection to the interceptor in 108th Street and manholes at bends along the sewer routes. In addition, stadium parking will be displaced by construction activities and the completed facility. During construction, it is estimated that over 1200 parking spaces will be temporarily lost to accommodate construction, including staging and laydown area. Permanent loss of about 200 Citifield parking spaces is estimated for an above grade structure to house screening, pumping, and odor control facilities. There are also potential concerns with park alienation in relation to construction of above grade facilities in Flushing Meadows Corona Park.

Considering the political and socioeconomic concerns with acquiring property through eminent domain, Alternative 9-6 has not been carried forward to the next level of evaluation.

Alternatives 9-7 through 9-10 – Tunnel Storage Options for Outfalls BB-006 and BB-008

Tunnel construction would involve the boring of a linear storage conduit deep in soft ground. Shafts would be installed during initial construction for connection of CSO diversion pipes and O&M access. A dewatering pumping station would also be included at the downstream end of the tunnel with pumped discharges being conveyed to the Bowery Bay WWTP for treatment. A mechanical ventilation system would be provided with an activated carbon odor control system. Additional passive odor control systems and/or backdraft dampers would be provided at the drop and intermediate access shafts.

The deep tunnels that were evaluated for the Flushing Bay watershed would begin near the Bowery Bay WWTP and terminate in green space within the Grand Central Parkway right-of-way between Outfalls BB-006 and BB-008. The alignment would run in a southerly direction along 78th Street and bend in an easterly direction along Astoria Boulevard near its westerly crossing of the Grand Central Parkway. The tunnel would continue in an easterly direction along Astoria Boulevard to a point near the intersection of Ditmars Boulevard and the Grand Central Parkway.

Figures and descriptions of the conceptual layouts were evaluated for the tunnel alternatives with siting of the dewatering pumping stations at potential sites including but not limited to Ingraham's Mountain and Luyster Creek. These conceptual layouts and sites were developed for the purposes of developing costs and evaluating the feasibility of the various CSO storage tunnel alternatives. The final siting of the dewatering pumping station, the tunnel alignment and other associated details of the tunnel alternatives presented herein will be further evaluated and finalized during subsequent planning and design stages. An evaluation was performed using the IW model that included several iterations to assess the tunnel sizes necessary to provide the storage volume and/or combination of storage and treatment required for 25%, 50%, 75% and 100% CSO control. The storage volumes, dewatering rates and treatment capacities provided in Table 8-4 were used as a basis for sizing the tunnels. Due to the cost for mobilization of the tunnel boring machine, the tunnel for each alternative would be the same size for the entire length of the 13,300 foot alignment. To provide sufficient cleansing velocities, a tunnel slope of 0.3 percent was assumed.

To control the risk of surface settlement, the depth of a soft ground tunnel must be increased as the tunnel diameter is increased. As risk significantly increases with variable ground conditions, it is also desirable to maintain the tunnel profile completely within soft ground without dropping into a layer of rock located at a depth of about 100-feet below surface grade. Based upon these constraints, a diameter of 18-feet was determined to be the largest tunnel that could be provided without encroaching on the rock layer. Larger diameter tunnels would require launching the tunnel boring machine in rock, and ground treatment in the areas where the soils transition from rock to soft ground. Each of the tunnel alternatives requires either a dewatering pumping station or treatment of the retained CSO volumes during and following a wet-weather event. The capacities of the required dewatering pumping station or treatment systems are shown in Table 8-4 for each of these alternatives. The dewatering pumping station capacity is based on a 24 hour dewatering period, while the treatment system capacity is based upon the peak capacity required to achieve the level of control for the typical year.

Table 8-4. Pumping Station or Treatment System Capacity of Retention Alternatives Based on 24-hour Dewatering of CSO Tunnel

Alternative/Level of CSO Control	Required Storage Volume (MG)	Required Tunnel Diameter (ft.)	Storage Volume (MG)	PS Capacity (MGD)	RTB Capacity (MGD)
9-7a: 25% CSO Control at Ingraham's Mountain	12	10	8	15	N/A
9-7b: 25% CSO Control at Luyster Creek	12	9	8	15	N/A
9-8a: 50% CSO Control at Ingraham's Mountain	25	18	25	25	N/A
9-8b: 50% CSO Control at Luyster Creek	25	16	25	25	N/A
9-9a: 75% CSO Control at Ingraham's Mountain	65	29	66	70	N/A
9-9b: 75% CSO Control at Luyster Creek	65	29	66	N/A	60
9-10a: 100% CSO Control at Ingraham's Mountain	161	29	66	N/A	400
9-10: 100% CSO Control at Luyster Creek	161	29	66	N/A	400

Alternative 9-7 – 25% CSO Control Tunnel Options for Outfalls BB-006 and BB-008

The tunnels designated as Alternatives 9-7a and 9-7b would provide 25% CSO control with the tunnel launching shaft and dewatering pumping station to be located at Ingraham's Mountain or near Luyster Creek, respectively. Alternative 9-7a would consist of a 13,300 foot long,10-foot diameter tunnel, while Alternative 9-7b would consist of a 16,600 foot long 9-foot diameter tunnel. Upon completion of the tunnel, a dewatering pumping station would be constructed within the launch shaft at the downstream end of the tunnel. The dewatering pumping station capacity would be 15 MGD. The layout of the tunnel and pumping station for Ingraham's Mountain conceptual alignment is shown on Figure 8-23. The conceptual tunnel alignment and layout of facilities for the Luyster Creek Site is provided in Figure 8-24. The tunnel alignments include a drop shaft with a trash rack and odor control at the upstream terminus to collect flows from Outfalls BB-006 and BB-008. These connections would consist of 108-inch diameter sewers constructed using microtunneling techniques. Table 8-5 summarizes the features of Alternatives 9-7a and 9-7b.

Figure 8-23. Conceptual Layout of Alternatives 9-7a, 9-8a and 9-9a – Tunnel Storage for 25%, 50% and 75% CSO Control at the Ingraham's Mountain Site

Figure 8-24. Conceptual Layout of Alternatives 9-7b and 9-8b– Tunnel Storage for 25% and 50% CSO Control at the Luyster Creek Site

The benefits, costs and challenges associated with tunnel storage are as follows:

Benefits

The primary benefit of tunnel storage is the high level of CSO volume reduction with minimal permanent above-ground land requirements. The pump-back to the interceptor maximizes the flow to the Bowery Bay WWTP and the level of treatment received. Also, because disinfection would not be involved, siting of the chemical storage and feed equipment would not be required.

Cost

The estimated NPW for this control measure is $443M for Alternative 9-7a and $457M for Alternative 9-7b . Details of the estimates are presented in Section 8.4.

Challenges

The primary challenge for this alternative is the acquisition of the properties for construction of the dewatering pumping station. The Ingraham's Mountain Site is currently the subject of a long term lease between New York City and the PANYNJ, which recently constructed a parking lot on the site for airport employees. The Luyster Creek Site is privately owned and would need to be acquired. As a result of past site uses, both properties may require environmental cleanup. In addition, other property rights will need to be acquired for the tunnel. Another major challenge with tunnel storage is the required O&M in deep, confined spaces. Other challenges include the need to construct shafts in green space along major highways, avoidance of support columns of the Grand Central Parkway, sediment deposition in the tunnel, potential for hydraulic surge conditions, unforeseen geotechnical conditions and operation of the deep tunnel dewatering pumping station. Providing electrical power to the mining shaft during construction would also present a challenge.

Alternatives 9-7a and 9-7b were carried forward to the next level of evaluation for inclusion in the basin-wide alternatives.

Alternative 9-8 – 50% CSO Control Tunnel Options for Outfalls BB-006 and BB-008

Designated as Alternative 9-8a, the storage tunnel to Ingraham's Mountain would be 13,300 foot long and have an 18-foot diameter for 50% CSO control. Alternative 9-8b would consist of a 16,600 foot long, 16-foot diameter tunnel to the Luyster Creek Site. The launching shaft would be located on the Ingraham's Mountain or Luyster Creek properties. Upon completion of the tunnel, a dewatering pumping station would be constructed within the launch shaft at the downstream end of the tunnel. The dewatering pumping station would have a capacity of 25 MGD. The layout of the tunnel and pumping station for 50% CSO control is shown on Figures 8-23 (Ingraham's Mountain) and 8-24 (Luyster Creek). The tunnel alignment includes a drop shaft with a trash rack and odor control at the upstream terminus to collect flows from Outfalls BB-006 and BB-008. These connections would consist of 108-inch diameter sewers constructed using microtunneling techniques. Table 8-5 summarizes the features of Alternatives 9-8a and 9-8b.

The benefits, costs and challenges associated with tunnel storage are as follows:

Benefits

The benefits of tunnel storage for 50% CSO control are similar to those for 25% CSO control, but with a higher level of CSO control.

Cost

The estimated NPW for this control measure is $683M for Alternative 9-8a and $842M for Alternative 9-8b. Details of the estimates are presented in Section 8.4.

Challenges

The primary challenges for this alternative are the same as those for 25% CSO control noted above.

Alternatives 9-8a and 9-8b will be carried forward to the next level of evaluation for inclusion in basin-wide alternatives.

Alternative 9-9 – 75% CSO Control Tunnel Options for Outfalls BB-006 and BB-008

Designated as Alternative 9-9a, the storage tunnel to Ingraham's Mountain would be 13,300 feet long and have a 29-foot diameter providing 66 MG storage capacity for 75% CSO control. The launching shaft would be located on the Ingraham's Mountain property at the east end of Berrian Boulevard near the Bowery Bay WWTP. Upon completion of the tunnel, a dewatering pumping station would be constructed within the launch shaft at the downstream end of the tunnel. The dewatering pumping station would have a capacity of 70 MGD. The layout of the tunnel and pumping station for 75% CSO control is shown on Figure 8-23.

Due to the width of road rights-of-way along the alignment of a tunnel to Luyster Creek, a 29-foot diameter tunnel is not feasible. For the Luster Creek Site, Alternative 9-9b would consist of a 16,600 foot long, 16-foot diameter tunnel. Due to capacity constraints at the WWTP and the reduced attenuation of the smaller tunnel, a retention treatment basin would be required to treat the flow conveyed by the tunnel. The launching shaft would be located on the Luyster Creek property and upon completion of the tunnel, a dewatering pumping station would be constructed within the launch shaft at the downstream end of the tunnel. The dewatering pumping station would discharge to a retention treatment basin. Both facilities would have a capacity of 60 MGD. The layout of the tunnel and pumping station for 75% CSO control for Luyster Creek is shown on Figure 8-25.

For both conceptual layouts, the tunnel alignment includes a drop shaft with a trash rack and odor control at the upstream terminus to collect flows from Outfalls BB-006 and BB-008. These connections would consist of 108-inch diameter sewers constructed using microtunneling techniques. Table 8-5 summarizes the features of Alternatives 9-9a and 9-9b.

The benefits, costs and challenges associated with tunnel storage are as follows:

Benefits

The benefits of tunnel storage for 75% CSO control are similar to those for 25% and 50% CSO control, but with a higher level of CSO control.

Cost

The estimated NPW for Alternative 9-9a is $1,136M, while Alternative 9-9b is $1,306M. Details of the estimates are presented in Section 8.4.

Challenges

The primary challenges for this alternative are the same as those for 25% and 50% CSO control noted above. The risk of settlement increases with the larger diameter tunnel but can be mitigated by deepening the tunnel, ground treatment and other measures. The deeper tunnel would require the tunnel boring machine to be launched in rock with ground treatment provided along the transition from rock to soft ground conditions. The larger tunnel will require larger radius bends and may encroach on more private properties along the tunnel alignment. Additional measures may be required along streets with narrower rights-of-way to protect businesses and residences located along these streets. Based upon currently available information, construction of a 29-foot tunnel appears to be feasible, however, more detailed evaluations of geotechnical conditions, location and impacts to existing infrastructure, acquisition of property and easements, access and modifications to construction sites, as well as other project design features will need to be performed during the Basis of Design Phase to further identify and manage project risks.

Alternatives 9-9a and 9-9b will be carried forward to the next level of evaluation for inclusion in basin-wide alternatives.

Alternative 9-10 –100% CSO Control Tunnel Options for Outfalls BB-006 and BB-008

Designated as Alternative 9-10a, the tunnel to Ingraham's Mountain would be 29-foot in diameter and 13,300 feet long for 100% CSO control. The launching shaft would be located on the Ingraham's Mountain property at the east end of Berrian Boulevard near the Bowery Bay WWTP. Due to capacity constraints at the WWTP that would significantly extend the time for dewatering of a 161 MG storage tunnel and increase the risk of odors, a retention treatment basin would be necessary to provide the 100 percent level of control without a major expansion of the Bowery Bay WWTP. The retention treatment basin for 100% CSO control would have a capacity of 400 MGD. This facility would be constructed on the Ingraham's Mountain Site with a new effluent outfall to Bowery Bay. The conceptual layout of the tunnel for 100% CSO control to the Ingraham's Mountain Site is provided in Figure 8-26.

Designated as Alternative 9-10b, the tunnel to the Luyster Creek would be 16-foot in diameter and 16,600 feet long for 100% CSO control. The tunnel launching shaft would be located on the Luyster Creek Site. A retention treatment basin would be necessary to provide the 100 percent level of control without a major expansion of the Bowery Bay WWTP. The retention treatment basin for 100% CSO control would have a capacity of 400 MGD. This facility would be constructed on the Luyster Creek Site with a new effluent outfall to Luyster Creek. The conceptual layout of Alternative 9-10b is provided in Figure 8-25.

Both tunnel alignments include a drop shaft with a trash rack and odor control at the upstream terminus to collect flows from Outfalls BB-006 and BB-008. The connections from the outfall diversion structures to the drop shaft would consist of a 108-inch diameter sewer constructed using microtunneling techniques. Table 8-5 contains the features of each of the four conceptual layouts for the Ingraham's Mountain and Luyster Creek Sites.

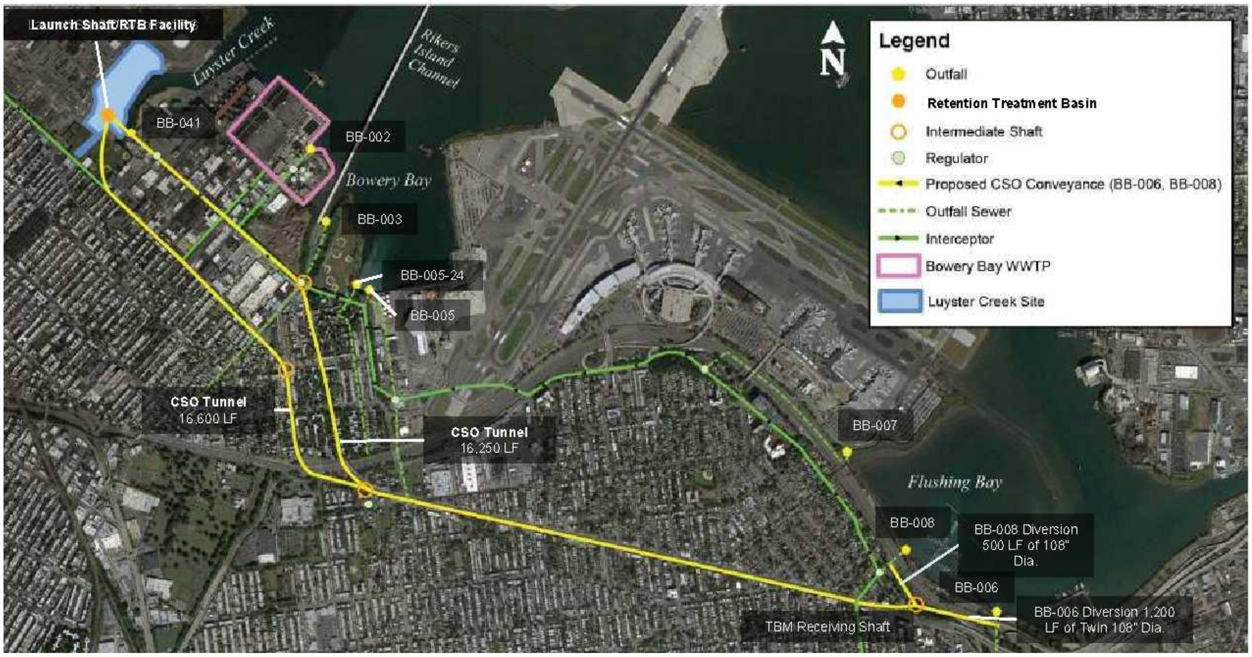

Figure 8-25. Layout of Alternatives 9-9b and 9-10b – Tunnel Storage and RTB for 75% and 100% Control at the Luyster Creek Site

Figure 8-26. Layout of Alternative 9-10a – Tunnel Storage and RTB for 100% CSO Control at the Ingraham's Mountain Site

Table 8-5. Tunnel Storage Characteristics

Tunnel Options	Level of Service (CSO Volumetric Capture)							
	Ingraham's Mountain Site				Luyster Creek Site			
	25%	50%	75%	100%	25%	50%	75%	100%
Tunnel Volume (MG)	9	25	66	66	8	25	25	25
Tunnel Length (lf)	13,300	13,300	13,300	13,300	16,600	16,600	16,600	16,600
Tunnel Diameter (ft)	10	18	29	29	9	16	16	16
Dewatering PS (MGD)	15	25	70	N/A	15	25	N/A	N/A
RTB Facility (MGD)	N/A	N/A	N/A	400	N/A	N/A	60	400
NPW ($ Millions)	$443	$683	$1136	$3,493	$457	$842	$1306	$2,923

The benefits, costs and challenges associated with tunnel storage are as follows:

<u>Benefits</u>

The benefits of tunnel storage for 100% CSO control are similar to those for 25%, 50% and 75% CSO control alternatives, but with a higher level of CSO control. The addition of a retention treatment basin provides the necessary treatment capacity to accommodate the peak flows associated with larger storms, while protecting the Bowery Bay WWTP processes from being overloaded.

<u>Cost</u>

The estimated NPW for this control measure is between $2,932M and $3,493M. Details of the estimates are presented in Section 8.4.

<u>Challenges</u>

The primary challenges for this alternative are the same as those for the 25%, 50% and 75% CSO control alternatives noted above. The addition of a retention treatment basin increases operations and maintenance requirements for WWTP operations staff during wet-weather conditions.

Alternatives 9-10a and 9-10b will be carried forward to the next level of evaluation for inclusion in basin-wide alternatives.

8.2.b Future Synergies of Tunnel Alternatives with the Open Waters CSO LTCP

The tunnel alternatives provide for possible future synergies with the Open Waters CSO LTCP. Each of these alternatives could potentially be modified during facilities planning to address Bowery Bay and East River CSOs. In addition, these alternatives could be retrofitted with treatment facilities in the future if a higher level of CSO control is needed to address future changes to the WQS.

Additional storage capacity, dewatering pumping station capacity or provision of a satellite treatment facility could offer opportunities for connecting additional CSO outfalls along the alignment of the tunnel. Figure 8-27 provides an illustration of the three main branches of the sewer system tributary to the Bowery Bay WWTP. While each tunnel alternative would initially serve the Flushing Bay Sewer System, it could be expanded to address CSOs associated with the Bowery Bay Central Corridor and East River/Newtown Creek Sewer Systems. Future synergies for addressing other CSOs associated with these additional branches of the combined sewer system tributary to the Bowery Bay WWTP will be further evaluated as part of the Open Waters CSO LTCP.

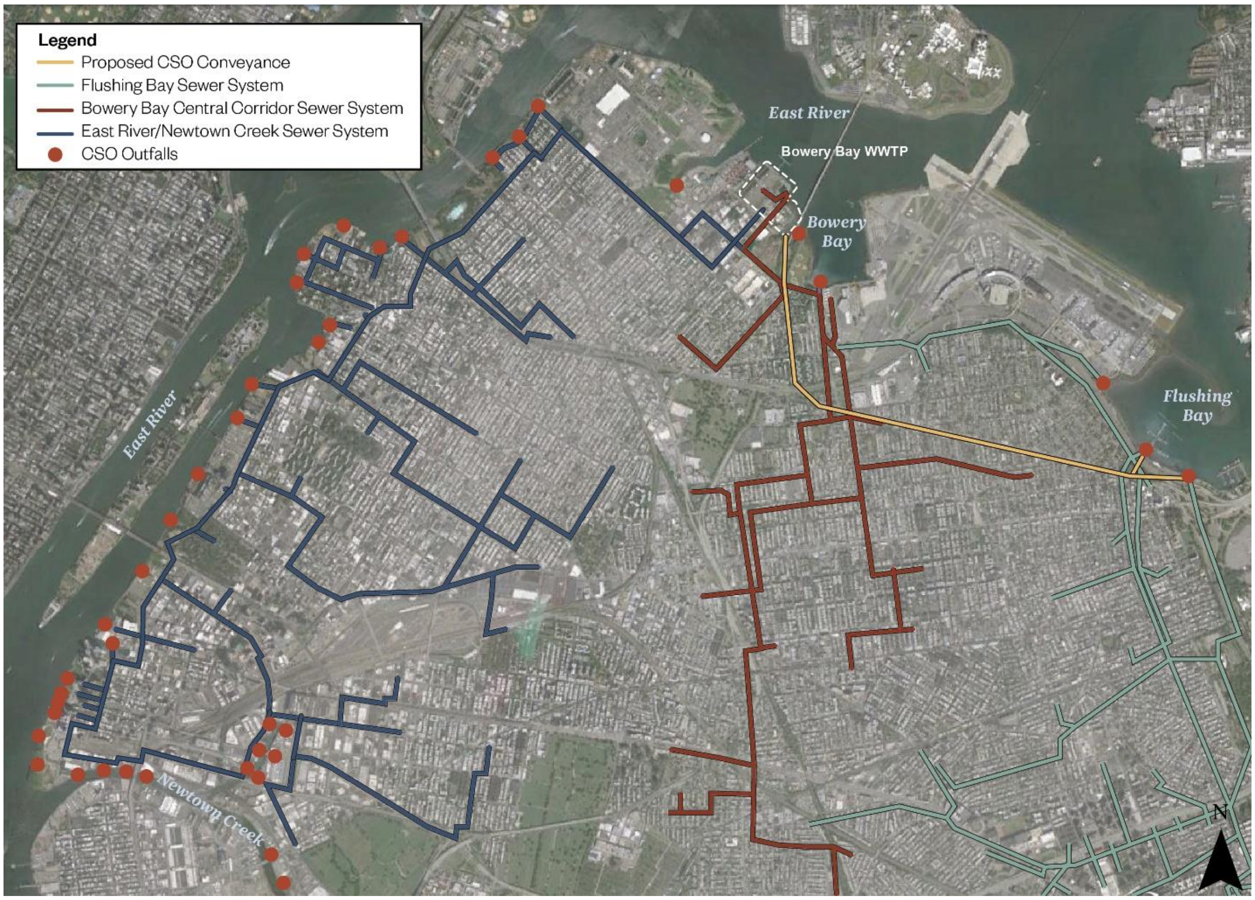

Figure 8-27. Future Synergies with CSO Control Tunnel Alternatives

8.2.c Other Future Green Infrastructure (Various Levels of Penetration)

As discussed in Section 5, DEP projects that GI penetration rates would manage 2.8 percent of the impervious surfaces within the Flushing Bay portion of the Bowery Bay combined sewer service area. This GI has been included as part of the baseline model projections, and is thus not categorized as an LTCP alternative.

For the purpose of this LTCP, “Other Future Green Infrastructure” is defined as GI alternatives that are in addition to those implemented under previous facility plans and those included in the baseline conditions. Because DEP is working on the implementation of GI area-wide contracts in the Flushing Bay watershed, additional GI beyond the baseline is not being considered for this LTCP at this time. DEP intends to saturate each targeted tributary drainage area with as much GI as feasible, as discussed in Section 5. Should conditions show favorable feasibility for penetration rates above the current targets, DEP will seek to take advantage of those opportunities as they become known.

8.2.d Hybrid Green/Grey Alternatives

Hybrid green/grey alternatives are those that combine traditional grey control measures with GI control measures, to achieve the benefits of both. However, as discussed above, development of the baseline GI projects for this watershed is already underway and further GI is not planned at this time. Therefore, no controls in this category are proposed for the Flushing Bay LTCP.

8.2.e Retained Alternatives

The intended outcome of the previous evaluations was the development of a list of retained control measures for Outfalls BB-006, BB-007 and BB-008 to Flushing Bay. These control measures, whether individually or in combination, will form the basis of basin-wide alternatives that will be assessed using the more rigorous cost-performance and cost-attainment analyses. That list is presented in Table 8-6. The reasons for excluding the non-retained control measures from further consideration are also noted in the table.

Table 8-6. Summary of Next Level of Control Measure Screening

Control Measure	Category	Retained for Further Analysis?	Remarks
High Level Sewer Separation	Source Control	NO	Alternative 7-1 showed limited effectiveness in reducing flooding. Concern with resulting stormwater related pollution.
Sewer Enhancements	System Optimization	NO	Alternatives 7-2a, 7-2b and 7-3 cause increases in CSO discharges to other tributaries.
In-line Storage	Storage	YES	Designated as Alternative 9-3 and 9-4.
Off-line Storage (Tanks)	Storage	NO	Evaluation of Alternative 9-6 found limited space to locate a tank and a low ratio of benefit to cost.
Off-line Storage (Shafts)	Storage	NO	Limited space found for local or upstream shafts and low benefit to cost ratio.
Off-line Storage (Tunnels)	Storage	YES	Tunnels were evaluated under Alternatives 9-7, 9-8, 9-9 and 9-10.
Retention/Treatment Basins	Treatment	YES	Alternative 9-5 evaluated an in-water system. Considered as a parallel treatment train to supplement the BB WWTP wet-weather capacity for Alternative 9-10.
Outfall and Direct Disinfection	Treatment	YES	Evaluated under Alternatives 9-1, 9-2 and 9-4.
In-Stream Aeration	WQ/ Ecological Enhancement	NO	Not a CSO control measure. Average DO levels are in attainment.

Table 8-6. Summary of Next Level of Control Measure Screening

Control Measure	Category	Retained for Further Analysis?	Remarks
Floatables Control	Floatables Control	NO	Not evaluated as a separate CSO control measure. Capture of floatables has been incorporated into each retained alternative.
Additional GI Build-out	Source Control	NO	Planned GI build-out in the watershed (included in the baseline) is in development. Unlikely that additional sites will be identified due to site constraints in publicly owned properties.

As shown, the retained control measures include in-line storage, retention/treatment, deep tunnel storage and a variety of disinfection measures for the two largest outfalls, BB-006 and BB-008. Measures for improved floatables control are included in the retained alternatives.

Table 8-7 presents the resulting basin-wide alternatives along with their new sequential numbering system. As shown, seven basin-wide alternatives were included, with a focus on the largest, most active outfalls, BB-006 and BB-008. The 100% CSO control alternatives also address CSO BB-007. In addition, the alignment and shaft placement for the tunnel alternatives consider future synergies with downstream smaller CSOs tributary to receiving waters to be addressed under the Open Waters CSO LTCP.

Table 8-7. Basin-Wide Alternatives with New Sequential Numbering

Alternative	Description
1. Disinfection of Outfalls BB-006 and BB-008	Outfall BB-006: Install disinfection facilities at the CAVF Outfall BB-008: Install disinfection facilities at Regulator BB-09
2. Re-purpose the CAVF as a RTB	Outfall BB-006 (Lower Level only): Convert the CAVF to a RTB with disinfection facilities
3. In-line Storage Outfalls BB-006 & BB-008	Outfalls BB-006 and BB-008 • Install bending weirs for control and capture of CSO • Install dewatering pumping station to convey captured flow back to the interceptor following a storm event
4. Combination of Alternatives 2 and 3	Disinfection of Outfall BB-006 • Install disinfection facilities at the CAVF Outfalls BB-006 and BB-008 • Install bending weirs for control and capture of CSO • Install dewatering pumping station to convey captured flow back to the interceptor following a wet-weather event
5. In-Water RTB	• 72 MGD In-Water RTB with disinfection facilities
6. 25% CSO Control Tunnel	• Ingraham's: 13,300-LF, 10-ft diameter tunnel (8 MG storage), and 15 MGD dewatering pumping station • Luyster Creek: 16,600-LF, 9-ft diameter tunnel (9 MG storage) and 15 MGD dewatering pumping station

Table 8-7. Basin-Wide Alternatives with New Sequential Numbering

Alternative	Description
7. 50% CSO Control Tunnel	• Ingraham's: 13,300-LF long, 18-ft diameter tunnel (25 MG storage), and 25 MGD dewatering pumping station • Luyster Creek: 16,600-LF, 16-ft diameter tunnel (25 MG storage), and 25 MGD dewatering pumping station
8. 75% CSO Control Tunnel	• Ingraham's: 13,300-LF long, 29-ft diameter tunnel (66 MG storage), and 70 MGD dewatering pumping station • Luyster Creek: 16,600-LF, 16-ft diameter tunnel (25 MG storage) and 60 MGD RTB
9. 100% CSO Control Tunnel	• Ingraham's:13,300-LF long, 29-ft diameter tunnel (66 MG storage) and 400 MGD RTB • Luyster Creek: 16,600 LF, 16-ft diameter tunnel (25 MG storage) and 400 MGD RTB

Note:
The Luyster Creek Site and Ingraham's Mountain Site were used for the purposes of developing conceptual layouts for evaluation of 25%, 50%, 75% and 100% CSO Control Tunnel alternatives. The final siting of the dewatering pumping station or RTB, the tunnel alignment and other associated details of the tunnel alternatives presented herein will be further evaluated and finalized during subsequent planning and design stages.

These nine Flushing Bay retained basin-wide alternatives, Alternatives 1 through 9, were then analyzed on the basis of their cost-effectiveness in reducing loads and improving water quality. These more advanced analyses are described in Sections 8.3, 8.4 and 8.5.

8.3 CSO Reductions and Water Quality Impact of Retained Alternatives

To evaluate their effects on the loadings and water quality impacts, the retained basin-wide alternatives listed in Table 8-7 were analyzed using both the Flushing Bay watershed (IW) and receiving water quality (ERTM) models. Evaluations of levels of CSO control for each alternative are presented below. In all cases, the predicted reductions shown are relative to the baseline conditions using 2008 JFK rainfall as described in Section 6. The baseline assumptions were described in detail in Section 6 and assume that the grey infrastructure projects from the WWFP have been implemented, along with the GI penetration identified in Section 5.

8.3.a CSO Volume and Bacteria Loading Reductions of Retained Alternatives

Table 8-8 summarizes the projected Flushing Bay untreated CSO volumes and percent reductions in untreated CSO volume and bacteria loads for the retained alternatives. These data are plotted on Figure 8-28. The bacteria loading reductions shown in Table 8-8 were computed on an annual basis. Later in the section, both annual and recreational season (May 1st through October 31st) reductions are evaluated.

Because the Flushing Bay alternatives serve outfalls in predominantly combined areas, the predicted bacteria loading reductions of the alternatives are aligned with their projected CSO volume reductions.

8.3.b Water Quality Impacts Within Flushing Bay

This section describes the levels of attainment with applicable current and possible future bacteria criteria within Flushing Bay that would be achieved through implementation of the retained CSO control alternatives listed in Table 8-8. The previous discussion focused on the predicted level of volumetric or bacteria pollution reductions.

Flushing Bay is a Class I waterbody. Based on the analysis presented in Section 6.0, and supported by the 10 year ERTM runs, historic and recent water quality monitoring, along with baseline condition modeling, all locations within the waterbody are currently in attainment with the Primary Contact WQ Criteria for fecal coliform. A review of the Potential Future Primary Contact Water Quality Criteria for enterococci indicates that under baseline conditions, Flushing Bay would be in attainment of the rolling 30-day geomean criterion of 30cfu/100mL during the recreational season. However, attainment of the 90^{th} percentile standard threshold value criterion of 110 cfu/100mL would not be met during the recreational season. Percentage of attainment ranges from a low of 9 percent at sampling sites OW-7B and OW-7C to a high of 78 percent at site OW-11. Upon applying 100% CSO control, attainment would be achieved 81 percent and 87 percent of the time respectively at sites OW-8 and OW-14, while other sites would achieve attainment between 93 percent and 100 percent in the recreational season.

The relationship between levels of CSO control through implementation of the retained alternatives, including 100 percent, and predicted levels of WQS attainment, are discussed in greater detail in Section 8.5. Unlike the previously described analyses based on the 10 year ERTM runs, these latter analyses are based on 2008 typical year ERTM runs.

Table 8-8. Flushing Bay Retained Alternatives Summary (2008 Rainfall)

Alternative(1)	Untreated CSO Volume(3) (MGY)	Frequency of Overflow(5)	Untreated CSO Volume Reduction(3) (%)	Fecal Coliform Reduction(2) (%)	Enterococci Reduction (%)(2)
Baseline Conditions(3)	1,405	47	-	-	-
1. Disinfection of Outfalls BB-006 and BB-008	1,405	47	0	27	27
2. Re-purpose CAVF as a RTB	1,189	26/47(4)	15	17	17
3. In-line Storage Outfalls BB-006 and BB-008	1,208	40	14	14	14
4. Combination Alternatives 2 and 3	1,189	40	15	17	17
5. In-Water RTB	1,020	29	27	27	27
6. 25% CSO Control Tunnel	1,056	35	25	25	25
7. 50% CSO Control Tunnel	659	14	53	53	53
8. 75% CSO Control Tunnel	346	8	75	75	75
9. 100% CSO Control Tunnel	0	0	100	100	100

Notes:

(1) Alternatives 2 through 9 include floatables control using an underflow baffle and static or bending weirs. The existing containment booms would be retained under Alternative 1.
(2) Bactria reduction is computed on an annual basis.
(3) Based upon 2008 Typical Year. As the TI outfalls are planned for separation, Untreated CSO Volumes are based upon CSO discharges from Outfalls BB-006, BB-007 and BB-008. May differ from results reported in Section 6.0, which were based on 10 year simulations and include discharge from the TI outfalls.
(4) Seasonal disinfection of CSOs for Outfall BB-006. No disinfection of Outfall BB-008.
(5) Frequency of Overflow includes remaining CSO discharges to the Inner Flushing Bay from CSOs BB-006 and BB-008 that are not captured or receive primary treatment.

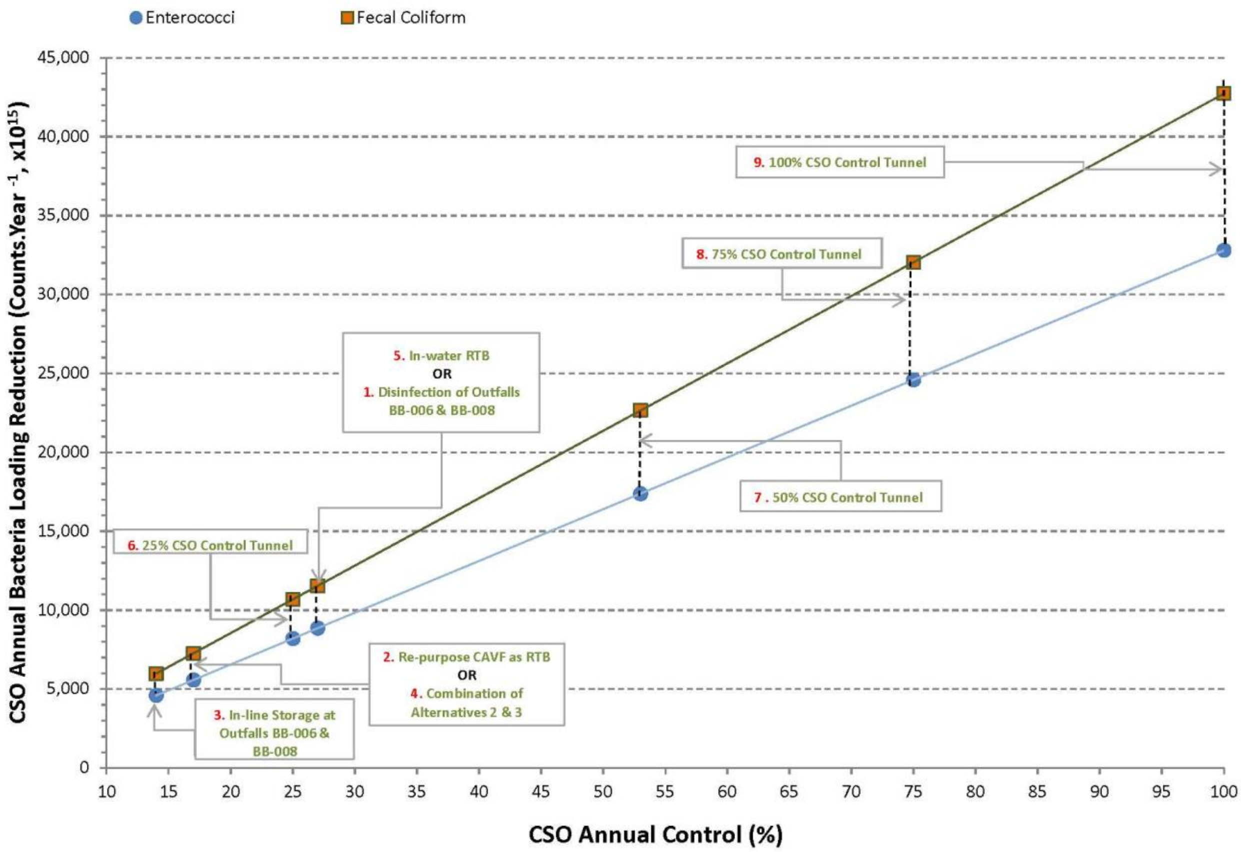

Figure 8-28. Untreated CSO Volume Reductions (as % CSO Annual Control) vs. Annual CSO Bacteria Loading Reduction (2008 Rainfall)

8.3.c Water Quality Impacts Within Flushing Creek

Due to the proximity of Flushing Bay and Flushing Creek, there is potential for CSOs in one waterbody to affect water quality in the other waterbody. The Flushing Bay baseline analysis assumes that the seasonal disinfection applied to CSOs TI-010 and TI-011 in Flushing Creek is operational. Since the preferred alternative in Flushing Bay includes a substantial reduction of CSO volume from CSOs BB-006 and BB-008, there is potential that the planned seasonal disinfection in the creek could be reduced. Water quality modeling was completed to evaluate the impact of CSO controls in Flushing Bay on Flushing Bay and Flushing Creek water quality with Flushing Creek under its original baseline conditions without disinfection. The Flushing Creek baseline conditions, as described in the Flushing Creek LTCP (with the exception of the modified GI percentages), are as follows:

- The dry-weather sanitary flows and loads to the wastewater treatment plants (WWTPs) are based on CY2040 projections.
- The Tallman Island and Bowery Bay WWTPs receiving peak flows at 2xDDWF.
- Updated satellite flyover impervious data and recalibrated landside models based on updated impervious data in conjunction with additional flow monitoring.
- The typical rainfall conditions are based on NOAA precipitation data from JFK.

- Grey infrastructure includes those projects recommended in the 2011 WWFP.
- GI in 2.8 percent of the impervious surfaces within the Flushing Creek/Bay portion of the Tallman Island combined sewer service area and 2.8 percent of the impervious surfaces in the Flushing Creek/Bay portion of the Bowery Bay WWTP combined sewer service area.

CSO controls of 50 percent, 75 percent and 100 percent were applied to Flushing Bay CSOs BB-006, BB-007 and BB-008 with no seasonal disinfection in Flushing Creek. The annual and recreational season (May 1st through October 31st) attainment results from these scenarios are presented in Table 8-9. The results clearly show the CSO controls in Flushing Bay only do not result in attainment in Flushing Creek on either a recreational season or annual basis. The recreational season and annual attainment is unchanged between the baseline non-disinfection scenario and the 100% CSO control of the Flushing Bay CSOs. The head end of Flushing Creek has only 33 percent attainment on an annual basis and 50 percent attainment on a recreational season basis for all four of the scenarios analyzed. The proposed disinfection of CSO volume in the creek during the recreational season is required to meet the primary contact fecal coliform criterion during the recreational season.

Recreational season attainment of the enterococci criteria using the four evaluation scenarios provides additional evidence that seasonal disinfection is necessary to achieve standards in the creek as shown in Table 8-10. Attainment of the 30-day rolling GM of 30 cfu/100mL improves from baseline conditions through the 100% CSO control scenarios, but the head end of the creek only improves from 39.9 percent under baseline non-disinfection conditions to 44.0 percent attainment with 100% CSO control in the Bay. The improvement in attainment at the mouth of the creek at Station OW6 is greater, as would be expected due to its proximity to CSOs in the Bay. There the improvement is from 79.2 percent under baseline non-disinfection conditions to 90.1 percent under 100% Flushing Bay CSO control conditions. CSO controls in the Bay clearly result in improvement in attainment of the 90th Percentile STV concentration of 110 cfu/100mL in the Bay. However, there is very little change to the attainment of the STV concentration in the creek when CSOs are controlled in the Bay. Station OW8, outside of the mouth of Flushing Creek, shows indications that attainment of the STV concentration remains low due to the influence of CSO discharges from the creek. This provides evidence that the application of disinfection in Flushing Creek provides benefits to water quality in the Bay, at least in areas near the mouth of Flushing Creek.

Table 8-9. Annual and Recreational Season Attainment of Primary Contact Fecal Coliform Criterion without CSO Controls in Flushing Creek and Varying Levels of CSO Volume Control in Flushing Bay

Station		Fecal Coliform Attainment							
		Baseline		50% FB CSO Control		75% FB CSO Control		100% FB CSO Control	
		Annual % <=200	Rec. Season % <= 200	Annual % <=200	Rec. Season % <= 200	Annual % <=200	Rec. Season % <= 200	Annual % <=200	Rec. Season % <= 200
OW03	Flushing Creek	B	50%	33%	50%	33%	50%	33%	50%
OW04		50%	67%	50%	67%	50%	67%	50%	67%
OW05		58%	83%	58%	83%	58%	83%	58%	83%
OW06		83%	100%	83%	100%	83%	100%	83%	100%
OW07	Flushing Bay	100%	100%	100%	100%	100%	100%	100%	100%
OW7A		100%	100%	100%	100%	100%	100%	100%	100%
OW7B		100%	100%	100%	100%	100%	100%	100%	100%
OW7C		100%	100%	100%	100%	100%	100%	100%	100%
OW08		100%	100%	100%	100%	100%	100%	100%	100%
OW09		100%	100%	100%	100%	100%	100%	100%	100%
OW10		100%	100%	100%	100%	100%	100%	100%	100%
OW11		100%	100%	100%	100%	100%	100%	100%	100%
OW12		100%	100%	100%	100%	100%	100%	100%	100%
OW13		100%	100%	100%	100%	100%	100%	100%	100%
OW14		100%	100%	100%	100%	100%	100%	100%	100%
OW15		100%	100%	100%	100%	100%	100%	100%	100%

Table 8-10. Recreational Season Attainment of Primary Contact Enterococci Criteria without CSO Controls in Flushing Creek and Varying Levels of CSO Volume Control in Flushing Bay

Station		Enterococci Attainment							
		Baseline		50% FB CSO Control		75% FB CSO Control		100% FB CSO Control	
		Geomean % <=30	STV % <= 110	Geomean % <=30	STV % <= 110	Geomean % <=30	STV % <= 110	Geomean % <=30	STV % <= 110
OW03	Flushing Creek	40%	3%	43%	2%	43%	3%	44%	3%
OW04		55%	2%	57%	2%	57%	2%	58%	2%
OW05		59%	2%	63%	2%	64%	2%	65%	2%
OW06		79%	5%	90%	5%	90%	5%	90%	5%
OW07	Flushing Bay	100%	9%	100%	31%	100%	33%	100%	40%
OW7A		100%	9%	100%	49%	100%	72%	100%	75%
OW7B		100%	9%	100%	35%	100%	48%	100%	48%
OW7C		100%	9%	100%	35%	100%	44%	100%	55.%
OW08		100%	8%	100%	14%	100%	16%	100%	16%
OW09		100%	9%	100%	50%	100%	70%	100%	73%
OW10		100%	28%	100%	77%	100%	78%	100%	78%
OW11		100%	78%	100%	90%	100%	92%	100%	98%
OW12		100%	55%	100%	79%	100%	80%	100%	80%
OW13		100%	55%	100%	74%	100%	79%	100%	79%
OW14		100%	77%	100%	83%	100%	84%	100%	84%
OW15		100%	72%	100%	80%	100%	83%	100%	84%

8.4 Cost Estimates for Retained Alternatives

Evaluation of the retained alternatives requires cost estimation. The methodology for developing these costs is dependent upon the type of technology and its O&M requirements. The construction costs were developed as PBC and the total NPW costs were determined by adding the estimated PBC to the NPW of the projected annual O&M costs at an assumed interest rate of 3 percent over a 20-year life cycle. Design, construction management and land acquisition costs are not included in the cost estimates. All costs are in February 2016 dollars and are considered Level 5 cost estimates by AACE International with an accuracy of -50% to +100%.

8.4.a Alternative 1 – Disinfection of Outfalls BB-006 and BB-008

Costs for Alternative 1 include planning-level estimates of the costs to retrofit the CAVF with the various components of direct disinfection of Outfall BB-006 at the CAVF. The costs also include the construction of a remote disinfection facility at Regulator BB-R09 for disinfection of Outfall BB-008. This alternative is described in detail in Section 8.2. Site acquisition costs are not included. The total cost, expressed as NPW, for Alternative 1 is $49M as shown in Table 8-11.

Table 8-11. Costs for Alternative 1 – Disinfection of Outfalls BB-006 and BB-008

Item	February 2016 Cost ($ Million)
Probable Bid Cost	32
Annual O&M Cost	1.1
Total Net Present Worth	49

8.4.b Alternative 2 – Re-purpose of CAVF as a Retention Treatment Basin

Costs for Alternative 2 include planning-level estimates of the costs to construct the various components of re-purposing the Corona Avenue Vortex Facility as a retention treatment basin. This alternative is described in detail in Section 8.2. Site acquisition costs are not included. The total cost for Alternative 2 is $61M as shown in Table 8-12.

Table 8-12. Costs for Alternative 2 – Re-purpose of CAVF as a Retention Treatment Basin

Item	February 2016 Cost ($ Million)
Probable Bid Cost	52
Annual O&M Cost	0.7
Total Net Present Worth	61

8.4.c Alternative 3 – Outfall Storage (Outfalls BB-006 and BB-008)

Costs for Alternative 3 include planning-level estimates of the costs to construct the various components for storage of CSO within existing Outfalls BB-006 and BB-008. This alternative is described in detail in Section 8.2. Site acquisition costs are not included. The total cost for Alternative 3 is $118M as shown in Table 8-13.

Table 8-13. Costs for Alternative 3 – Outfall Storage (Outfalls BB-006 and BB-008)

Item	February 2016 Cost ($ Million)
Probable Bid Cost	114
Annual O&M Cost	0.2
Total Net Present Worth	118

8.4.d Alternative 4 - Combination of Alternatives 2 and 3

Costs for Alternative 4 include planning-level estimates of the costs to construct the various components of re-purposing the CAVF as a RTB and providing in-line storage within Outfalls BB-006 and BB-008. These alternatives are described in detail in Section 8.2. Site acquisition costs are not included. The total cost for Alternative 4 is $179M as shown in Table 8-14.

Table 8-14. Costs for Alternative 4 – Combination of Alternatives 2 and 3

Item	February 2016 Cost ($ Million)
Probable Bid Cost	166
Annual O&M Cost	0.9
Total Net Present Worth	179

8.4.e Alternative 5 – In-Water Retention Treatment Basin

Costs for Alternative 5 include planning-level estimates of the costs to construct the various components of an in-water retention treatment basin in Flushing Bay. This alternative is described in detail in Section 8.2. Site acquisition costs are not included. The total cost for Alternative 5 is $552M as shown in Table 8-15.

Table 8-15. Costs for Alternative 5 – In-Water Retention Basin

Item	February 2016 Cost ($ Million)
Probable Bid Cost	533
Annual O&M Cost	1.3
Total Net Present Worth	552

8.4.f Alternatives 6, 7 and 8 –CSO Control Tunnels with a Dewatering Pumping Station

Cost estimates for CSO control tunnels, Alternatives 6a, 7a, 8a, 6b and 7b, are summarized in Table 8-16. The costs include the boring of the deep tunnel, multiple shafts, dewatering pumping stations, odor control systems and other ancillary facilities as described in Section 8.2. Site acquisition costs are not included.

Table 8-16. Cost for Alternatives 6a, 6b, 7a, 7b and 8a – CSO Control Tunnel and Dewatering Pumping Station

Tunnel Control Level	Ingraham's Mountain			Luyster Creek	
	Alternative 6a 25% Tunnel ($ Million)	Alternative 7a 50% Tunnel ($ Million)	Alternative 8a 75% Tunnel ($ Million	Alternative 6b 25% Tunnel ($ Million)	Alternative 7b 50% Tunnel ($ Million)
February 2016 PBC	434	670	1,115	448	829
Annual O&M Cost	0.6	0.9	1.4	0.6	0.9
Total Net Present Worth	443	683	1,136	457	842

8.4.g Alternatives 8 and 9 – CSO Control Tunnels with Retention Treatment Basin

Cost estimates for the CSO control tunnel, Alternatives 8b, 9a and 9b, are summarized in Table 8-17. The costs include the boring of the deep tunnel, multiple shafts, retention treatment basin, odor control systems and other ancillary facilities as described in Section 8.2. Site acquisition costs are not included.

Table 8-17. Costs for Alternatives 8b, 9a and 9b - CSO Control Tunnel and Retention Treatment Basin Alternative Costs

Tunnel Control Level	Ingraham's Mountain	Luyster Creek	
	Alternative 9a 100% Tunnel ($ Million)	Alternative 8b 75% Tunnel ($ Million)	Alternative 9b 100% Tunnel ($ Million)
February 2016 PBC	3,420	1,286	2,850
Annual O&M Cost	4.9	1.3	4.9
Total Net Present Worth	3,493	1,306	2,923

The cost estimates of these retained alternatives are summarized below in Table 8-18 and are then used in the development of the cost-performance and cost- attainment plots presented in Section 8.5.

Table 8-18. Cost of Retained Alternatives

Alternative	February 2016 PBC ($ Million)	Annual O&M Cost ($ Million)	Total Net Present Worth ($ Million)
1. Disinfection of Outfalls BB-006 and BB-008	32	1.1	49
2. Re-purpose CAVF as a RTB	52	0.7	61
3. Outfall Storage (BB-006 and BB-008)	114	0.2	118
4. Combination of Alts. 2 and 3	166	0.9	179
5. In-Water RTB	533	1.3	552

Table 8-18. Cost of Retained Alternatives

Alternative	February 2016 PBC ($ Million)	Annual O&M Cost ($ Million)	Total Net Present Worth ($ Million)
6a. 25% CSO Tunnel & PS at Ingraham's Mountain	434	0.6	443
6b. 25% CSO Tunnel & PS at Luyster Creek	448	0.6	457
7a. 50% CSO Tunnel & PS at Ingraham's Mountain	670	0.9	683
7b. 50% CSO Tunnel & PS at Luyster Creek	829	0.9	842
8a. 75% CSO Tunnel & PS at Ingraham's Mountain	1,114	1.4	1,136
8b. 75% CSO Tunnel & RTB at Luyster Creek	1,286	1.4	1,306
9a. 100% CSO Tunnel & RTB at Ingraham's Mountain	3,420	4.9	3,494
9b. 100% CSO Tunnel & RTB at Luyster Creek	2,850	4.9	2,923

Note:
The Luyster Creek and Ingraham's Mountain Sites were used for the purposes of developing conceptual layouts for evaluation of 25%, 50%, 75% and 100% CSO control tunnel alternatives. The final siting of the dewatering pumping station or RTB, the tunnel alignment and other associated details of the tunnel alternatives presented herein will be further evaluated and finalized during subsequent planning and design stages.

8.5 Cost-Attainment Curves for Retained Alternatives

The final step of the analysis is to evaluate the cost-effectiveness of the retained alternatives based on their NPW and projected impact on CSO loadings and attainment of applicable WQS. Those retained alternatives that did not show incremental gains in performance (shown in red in the figures) were not included in development of the best-fit curve.

8.5.a Cost-Performance Curves

Cost-performance curves were developed by plotting the costs of the retained alternatives against their predicted level of CSO control. For the purposes of this section, CSO control is defined as the degree or rate of bacteria reduction through volumetric capture, disinfection or combinations of the two. Both the cost-performance and subsequent cost-attainment analyses focus on bacteria loadings and bacteria WQ criteria.

A linear best-fit cost curve was developed based on those alternatives judged most cost-effective for a defined level of CSO control as estimated by IW modeling for the typical year rainfall (2008). The retained alternatives included some with recreational season (May 1^{st} through October 31^{st}) disinfection, some with year-round volumetric reduction and combinations thereof. Therefore, the best-fit lines were based on annual levels of control for those with year-round volumetric reduction exclusively and annual equivalent levels of control for the remainder.

The goal of the LTCP is to reduce CSO solids in addition to bacteria loadings to the receiving waters. While compliance is achieved during baseline conditions for the 30-day geometric mean standards for fecal coliform and enterococci, there are recognized issues with solids deposition, floatables and odors that impact the waterbody uses within the Bay. Figure 8-29 shows the percent reductions on a volumetric basis achieved by each alternative whereas Figure 8-30 illustrates the CSO events remaining upon implementation of each alternative. These curves are particularly important for this LTCP as they illustrate the reduction in solids, floatables and frequency of CSO events that have impacts to waterbody uses in addition to pathogens.

Bacteria load reduction plots are presented in Figures 8-31 (enterococci) and 8-32 (fecal coliform). These curves plot the cost of the alternatives against their associated projected annual CSO enterococci and fecal coliform loading reductions, respectively. The primary vertical axis shows percent CSO bacteria loading reductions. The secondary vertical axis shows the corresponding total bacteria loading reductions, as a percentage, when loadings from other non-CSO sources of bacteria are included.

The evaluation of the retained alternatives focused on cost-effective reduction of the frequency of CSO discharge in addition to CSO volume and pathogen load reductions to address current impacts to waterbody uses and issues raised by the public. While many of the lower cost alternatives provide cost-effective seasonal reduction of fecal coliform and enterococci loads, they provide little to no benefit in the reduction of solids and floatables discharges to the Bay. As shown on Figures 8-29 through 8-32, Alternatives 6 through 9 (Tunnel Alternatives for 25%, 50%, 75% and 100%% CSO control) reflect the cost-effectiveness of tunnel-based CSO controls in comparison to other retained basin-wide control alternatives. The tunnel alternatives cost-effectively provide high levels of CSO and pathogen reduction and are applied year-round as opposed to the seasonal disinfection based controls.

8.5.b Cost-Attainment Curves

The cost-performance plots shown in Figures 8-29 through 8-32 indicate that most of the retained alternatives represent incremental gains in marginal performance. Those retained alternatives that do not show incremental gains in WQS attainment (shown in red in the figures) were not included in development of the best-fit curve.

This section evaluates the relationship of the costs of the retained alternatives versus their expected level of attainment of Existing WQ Criteria (Class I), Primary Contact WQ Criteria and Potential Future Primary Contact WQ Criteria as modeled using ERTM with 2008 rainfall. Those retained alternatives that did not show incremental gains in marginal performance on the cost-performance curves are not included in the cost-attainment curves as they were deemed to be not cost-effective relative to other alternatives.

In addition to the current Class I WQS, the cost-attainment analysis considered Potential Future Primary Contact WQ Criteria. As was noted in Section 2.0, under the BEACH Act of 2000, enterococci criteria do not currently apply to tributaries such as Flushing Bay. The Class I evaluations thus only considered the fecal coliform criterion, specifically the monthly GM of 200 cfu/100mL both on an annual and recreational season (May 1st through October 31st) basis. The resultant curves for all of the applicable standards and relevant criteria are presented as Figures 8-33 through 8-44 for twelve locations (Sampling Stations OW-7 through OW-15) within Flushing Bay.

Attainment of the Existing WQ Criterion (Class I) for fecal coliform is met 100 percent of the time at all stations and thus Flushing Bay is in compliance with the designated criterion. Based on the 2008 typical year WQ simulations, annual attainment of the Primary Contact WQ Criteria under baseline conditions is also satisfied 100 percent year-round.

The most tangible benefits of a hypothetical implementation of 100% CSO control within the Flushing Bay watershed would be realized at Stations OW-7B and OW-7C in regards to attainment of the STV Potential

Future Primary Contact WQ Criteria. In this case, attainment would increase from 9 percent under baseline conditions, to 100 percent with CSO discharges fully eliminated under typical year rainfall conditions. However, at a cost of $3.5B for 100% CSO control, it is difficult to justify such a large expenditure to achieve attainment of Potential Future WQS. The preferred alternative should provide opportunities for future expansion to accommodate more stringent WQS and/or synergies with other LTCPs.

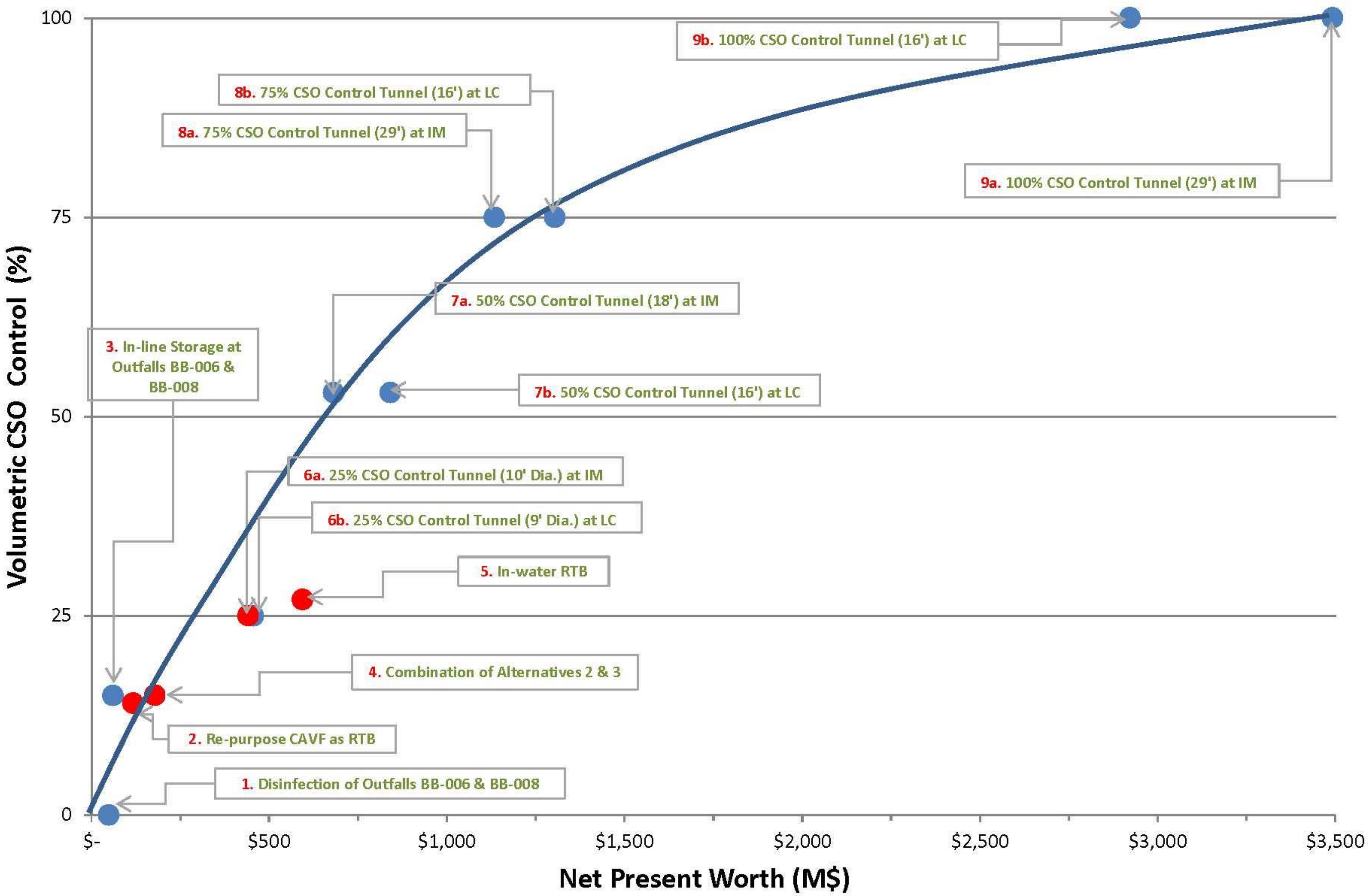

Figure 8-29. Cost vs. CSO Control (2008 Rainfall)

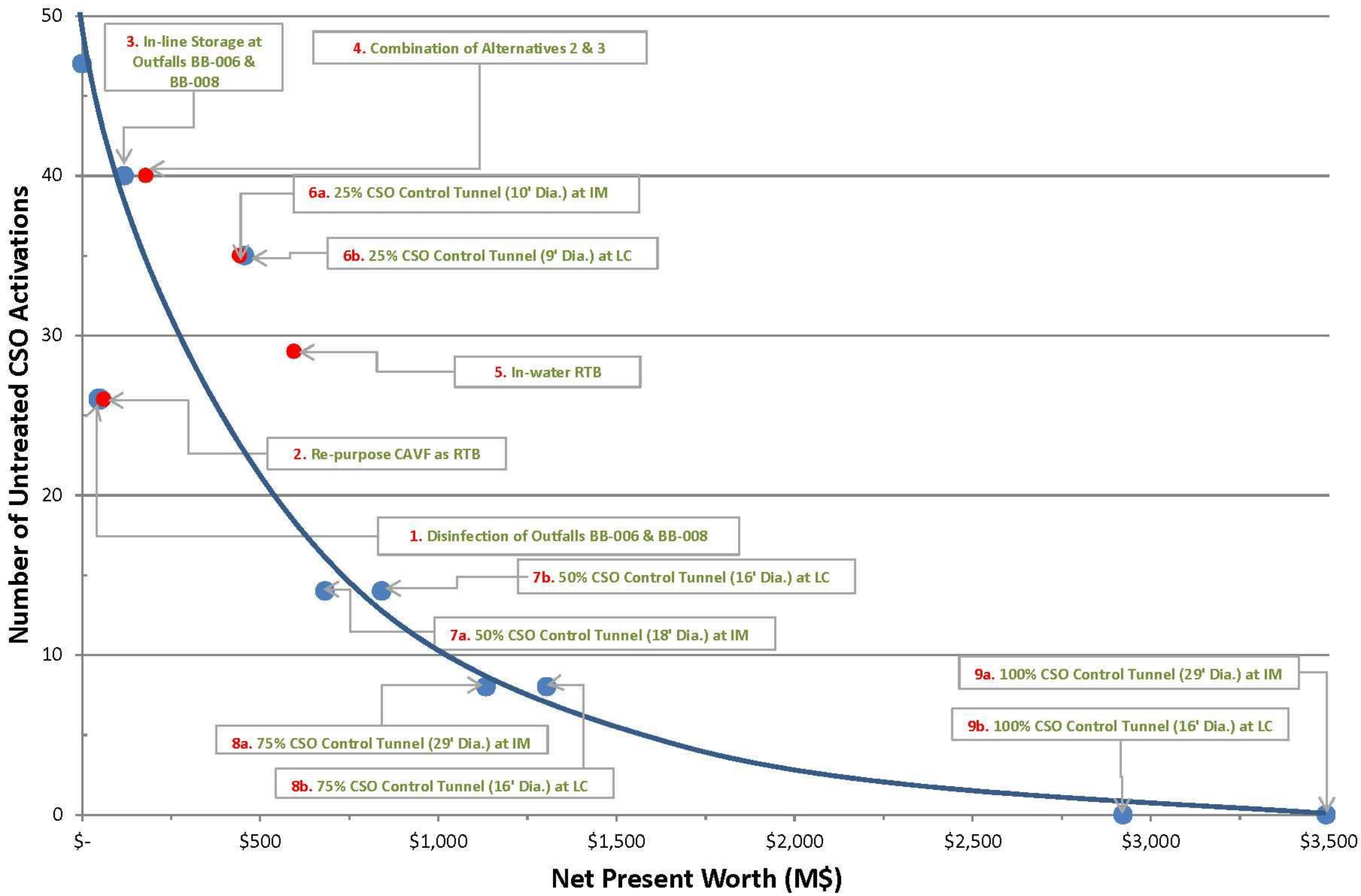

Figure 8-30. Cost vs. Remaining CSO Events (2008 Rainfall)

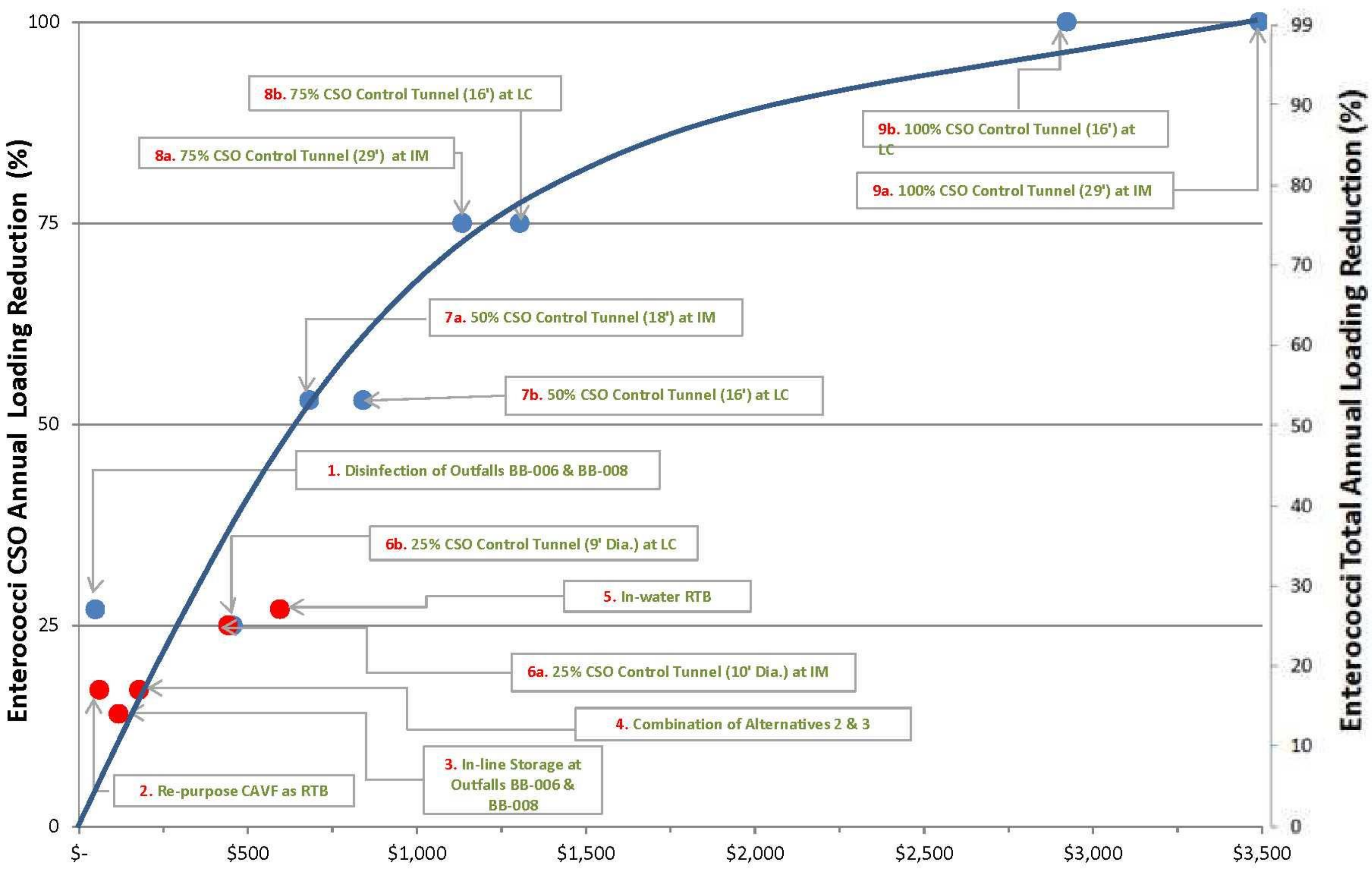

Figure 8-31. Cost vs. Enterococci Loading Reduction (2008 Rainfall)

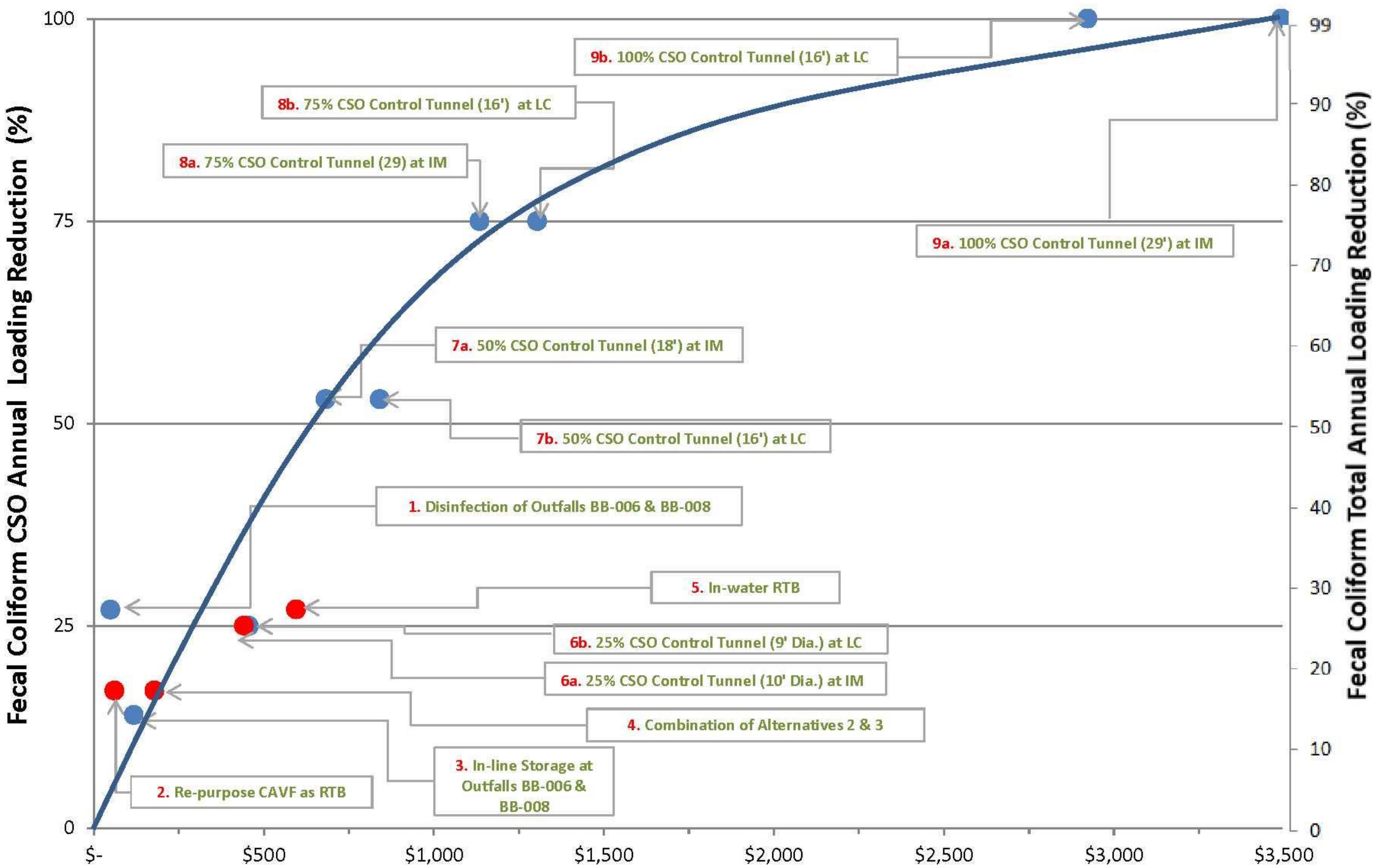

Figure 8-32. Cost vs. Fecal Coliform Loading Reduction (2008 Rainfall)

AECOM with Hazen

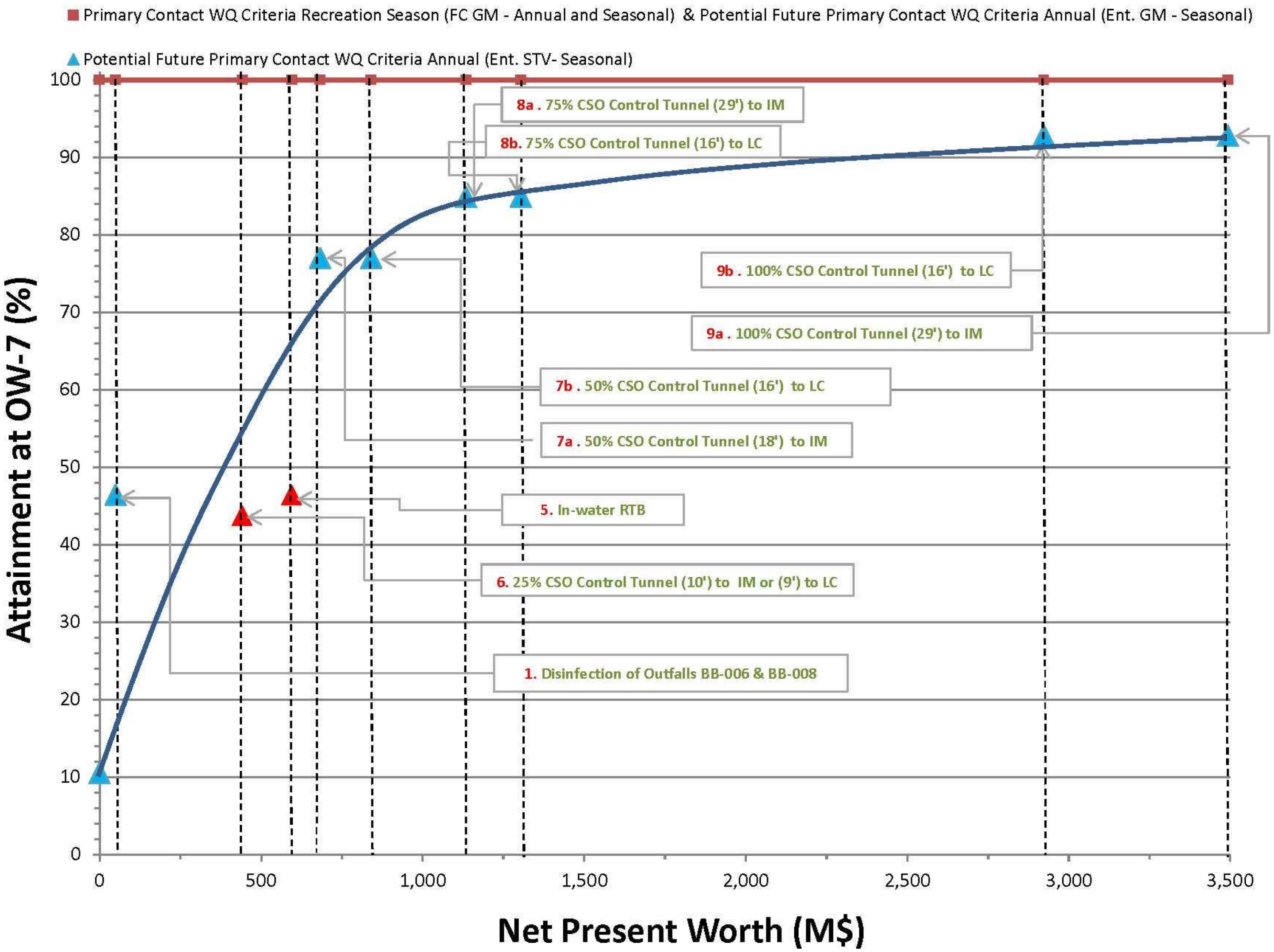

Figure 8-33. Cost vs. Bacteria Attainment at Station OW-7 (2008 Rainfall)

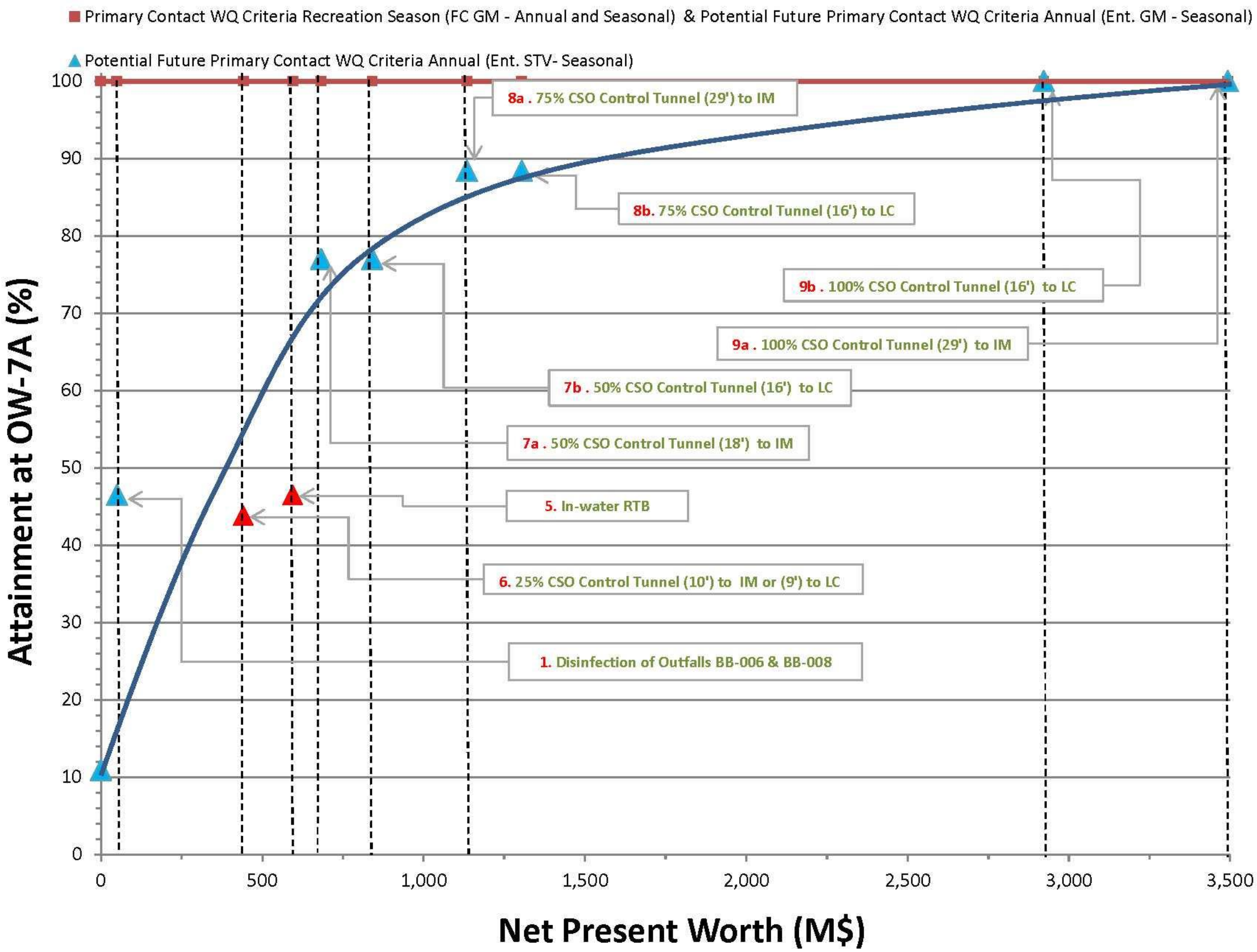

Figure 8-34. Cost vs. Bacteria Attainment at Station OW-7A (2008 Rainfall)

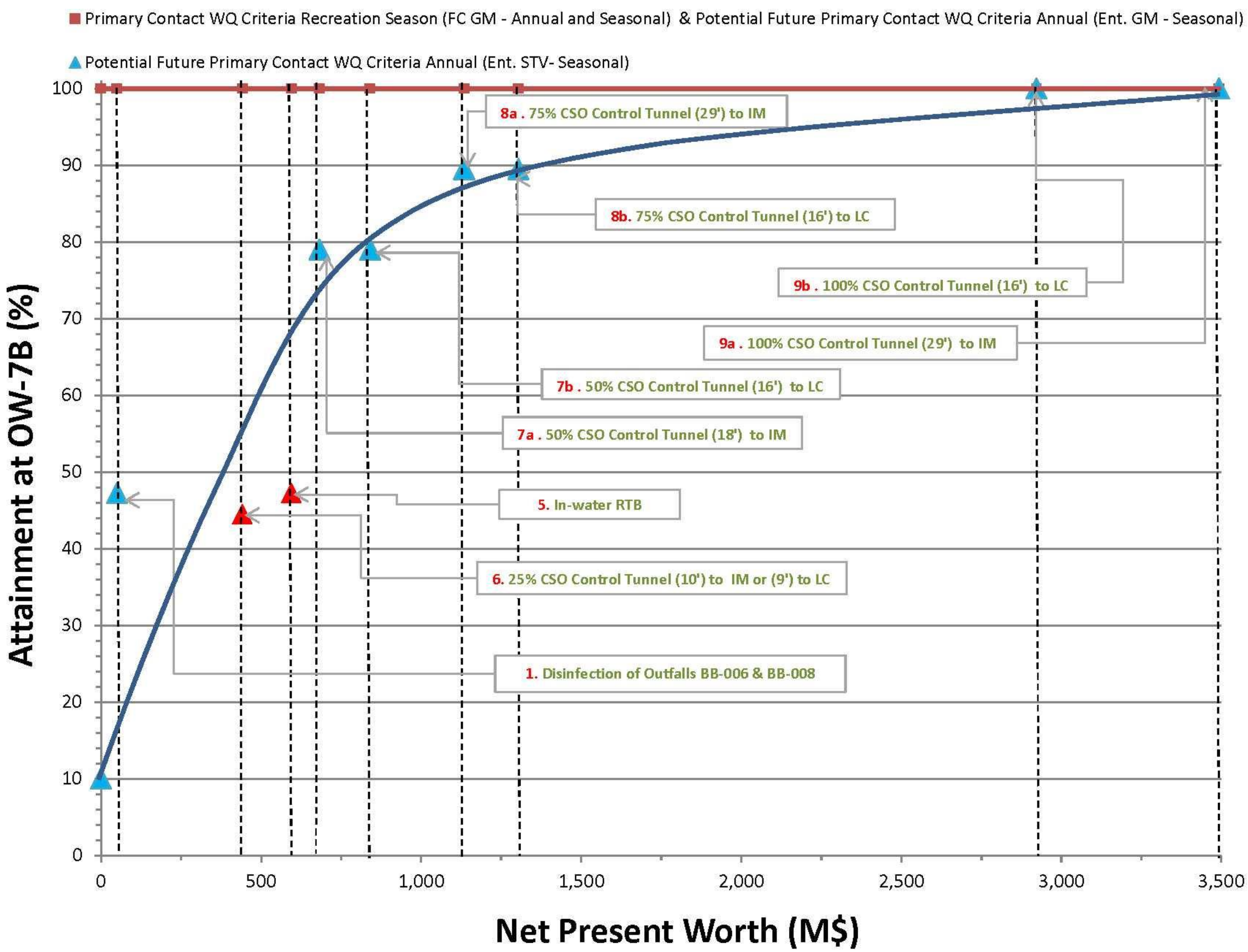

Figure 8-35. Cost vs. Bacteria Attainment at Station OW-7B (2008 Rainfall)

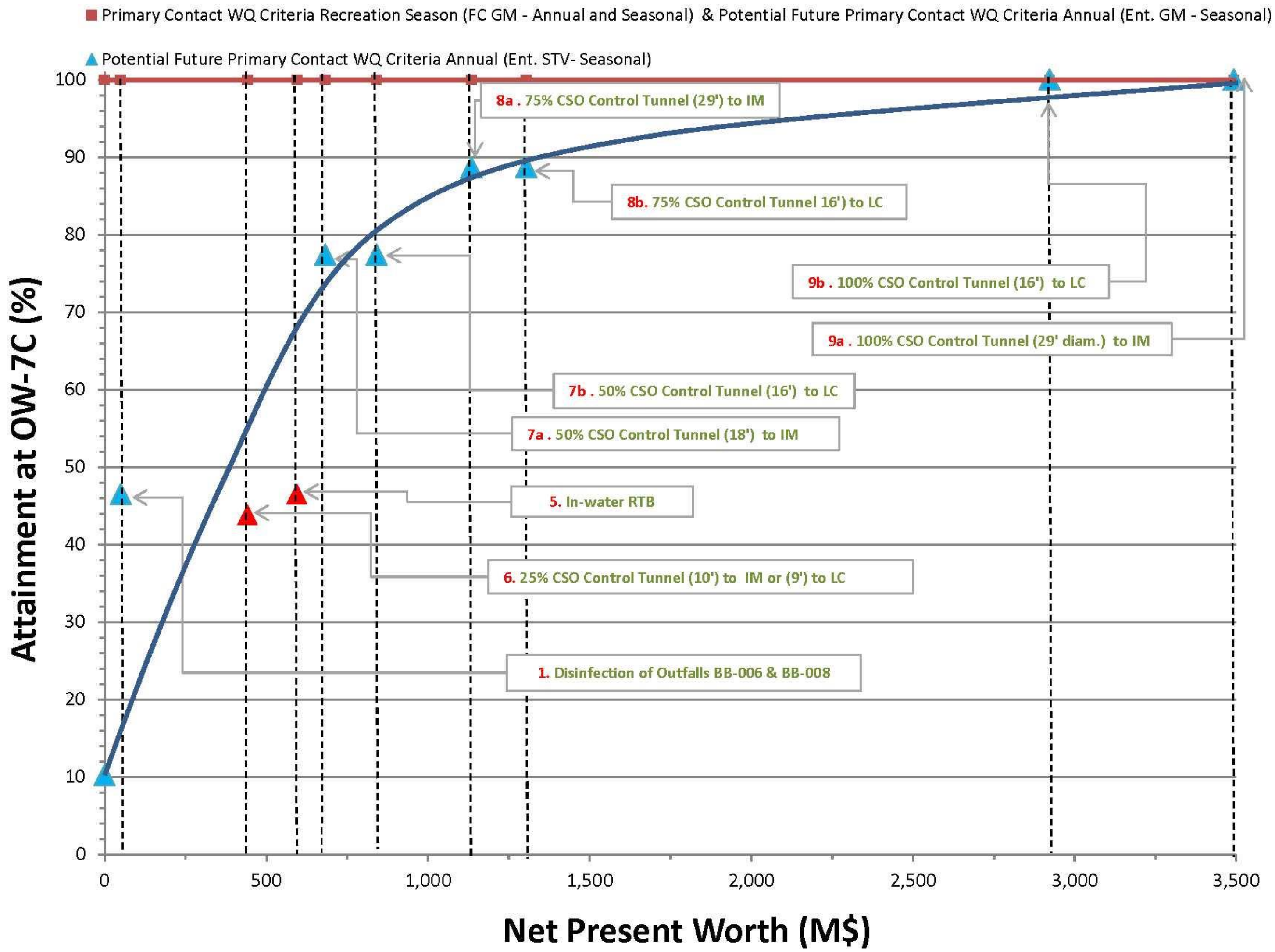

Figure 8-36. Cost vs. Bacteria Attainment at Station OW-7C (2008 Rainfall)

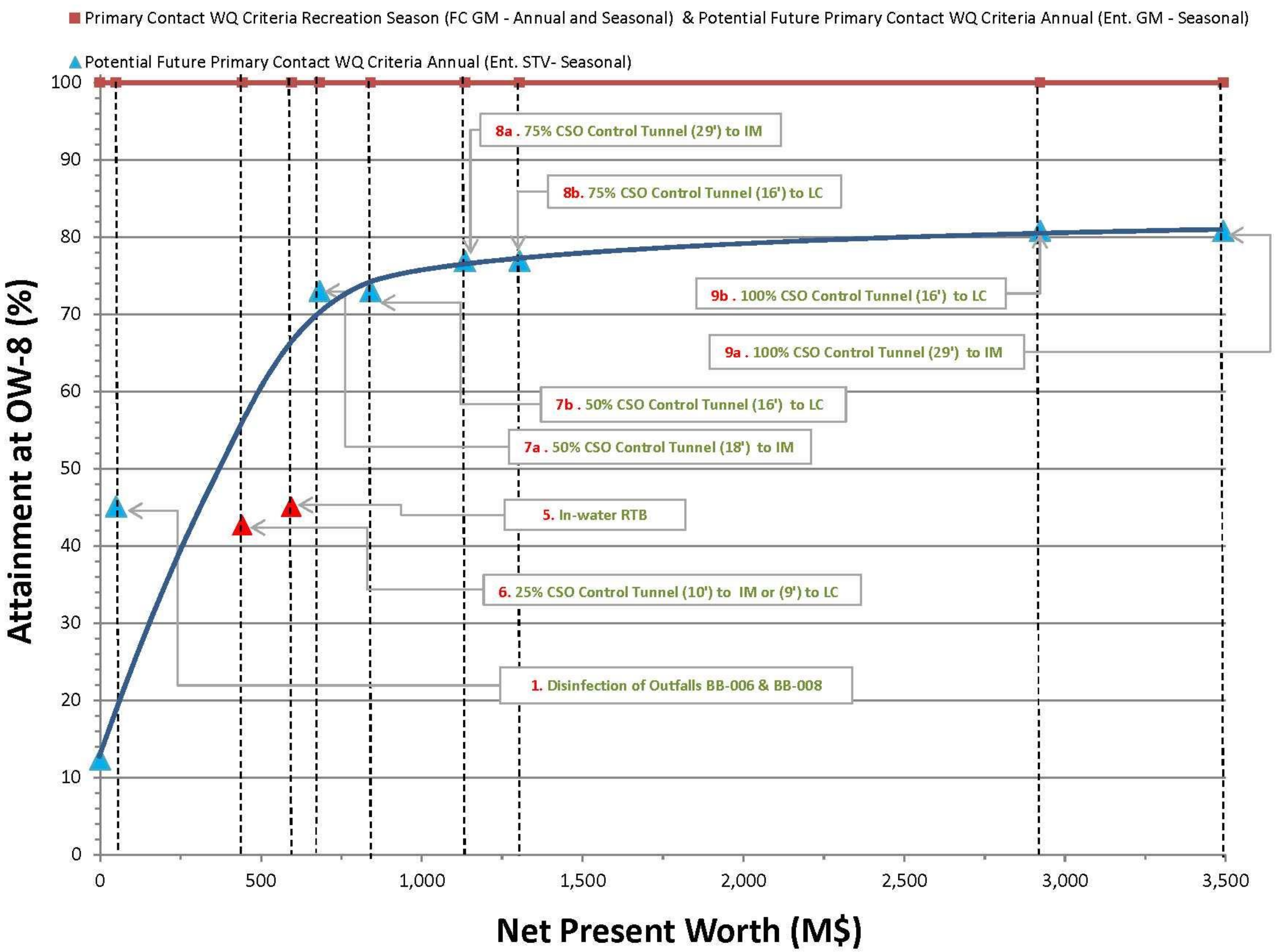

Figure 8-37. Cost vs. Bacteria Attainment at Station OW-8 (2008 Rainfall)

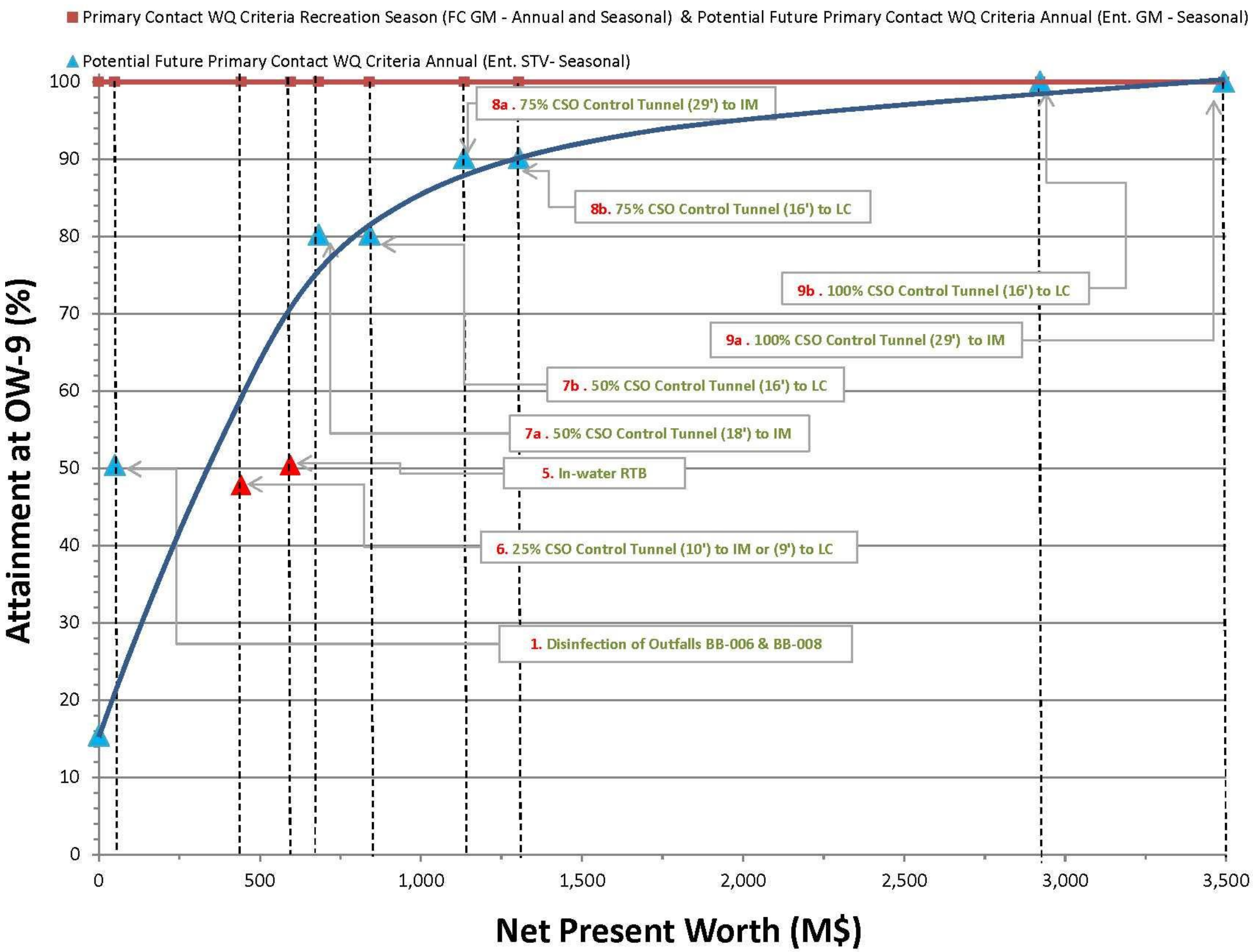

Figure 8-38. Cost vs. Bacteria Attainment at Station OW-9 (2008 Rainfall)

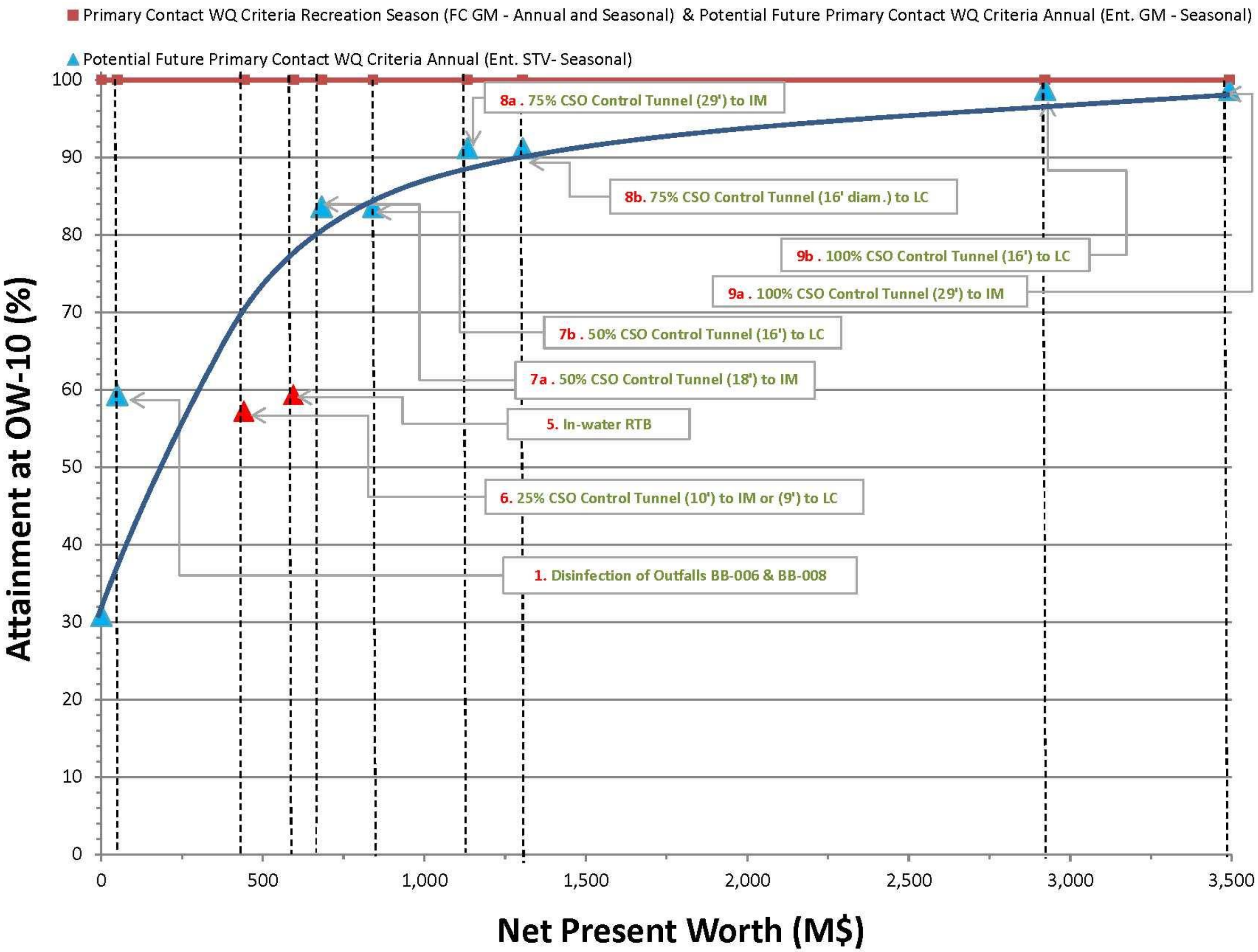

Figure 8-39. Cost vs. Bacteria Attainment at Station OW-10 (2008 Rainfall)

AECOM with Hazen

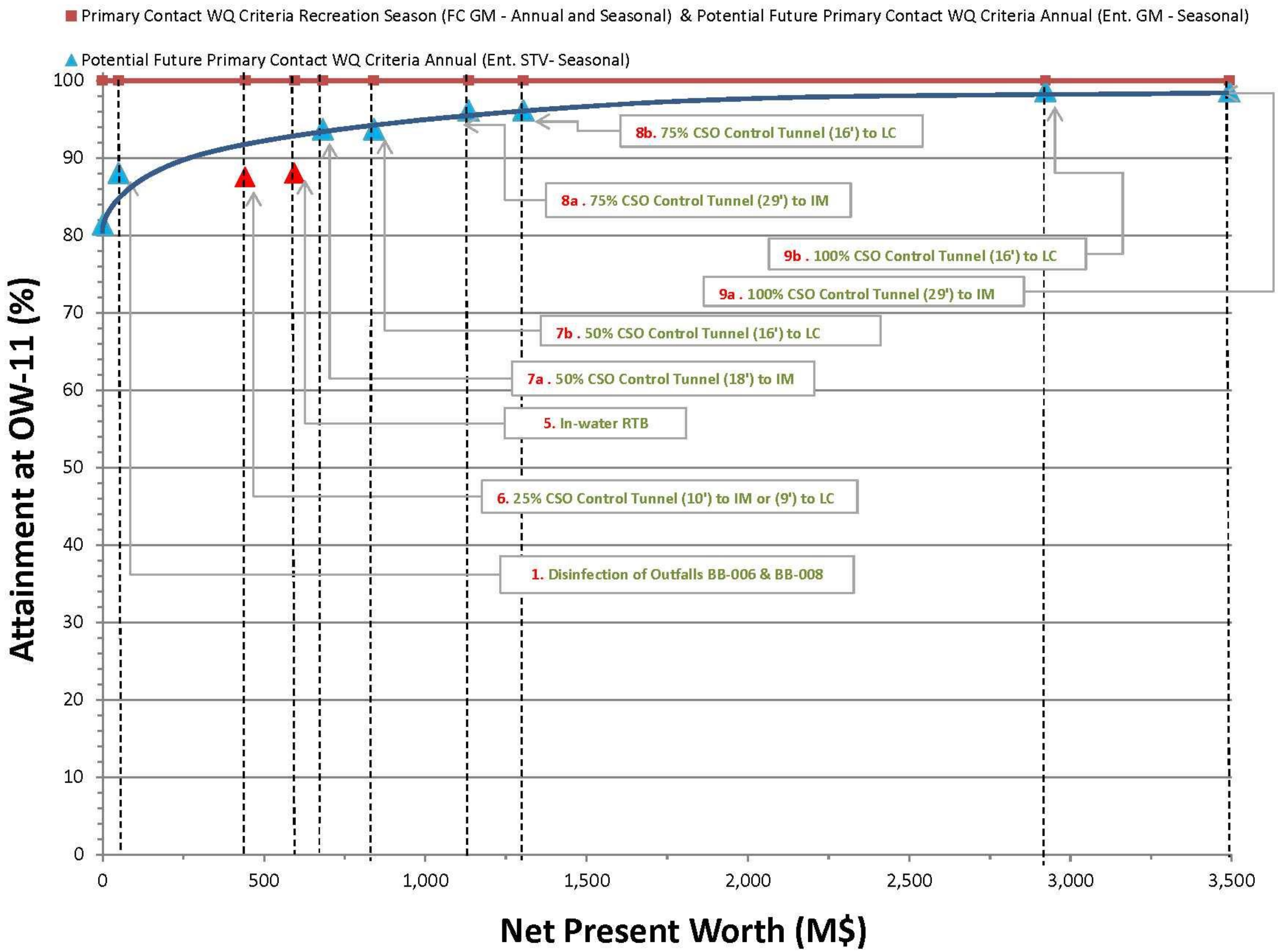

Figure 8-40. Cost vs. Bacteria Attainment at Station OW-11 (2008 Rainfall)

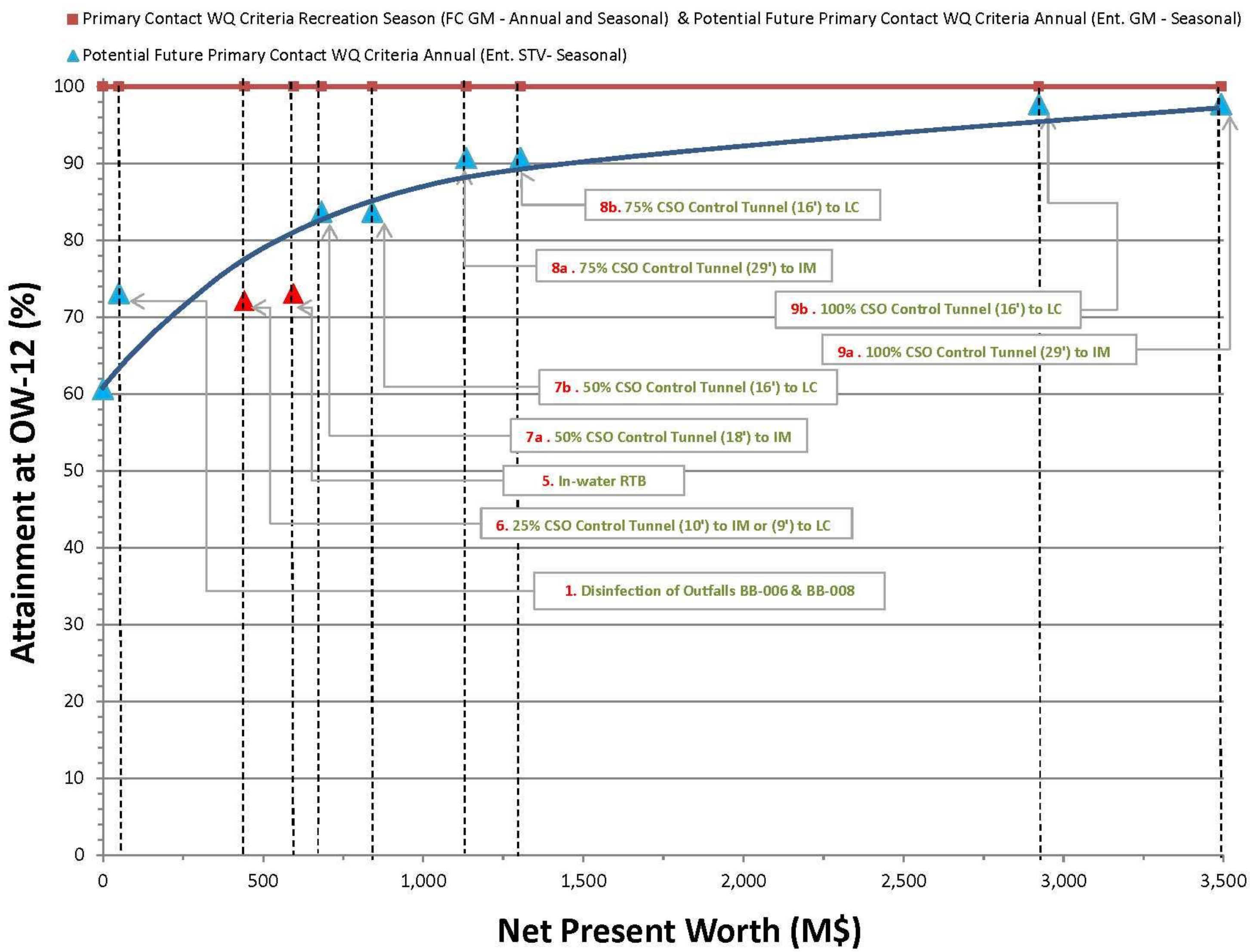

Figure 8-41. Cost vs. Bacteria Attainment at Station OW-12 (2008 Rainfall)

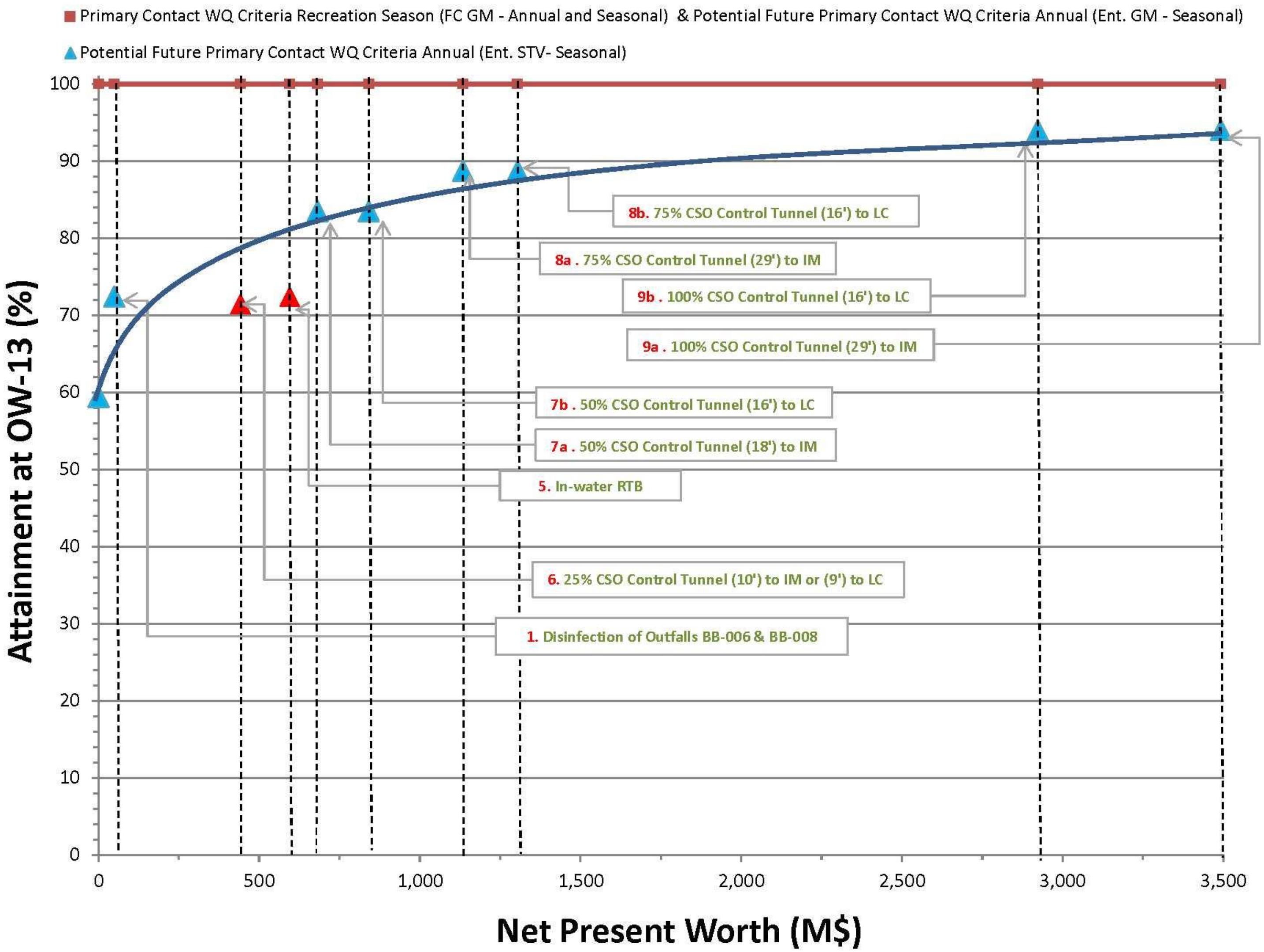

Figure 8-42. Cost vs. Bacteria Attainment at Station OW-13 (2008 Rainfall)

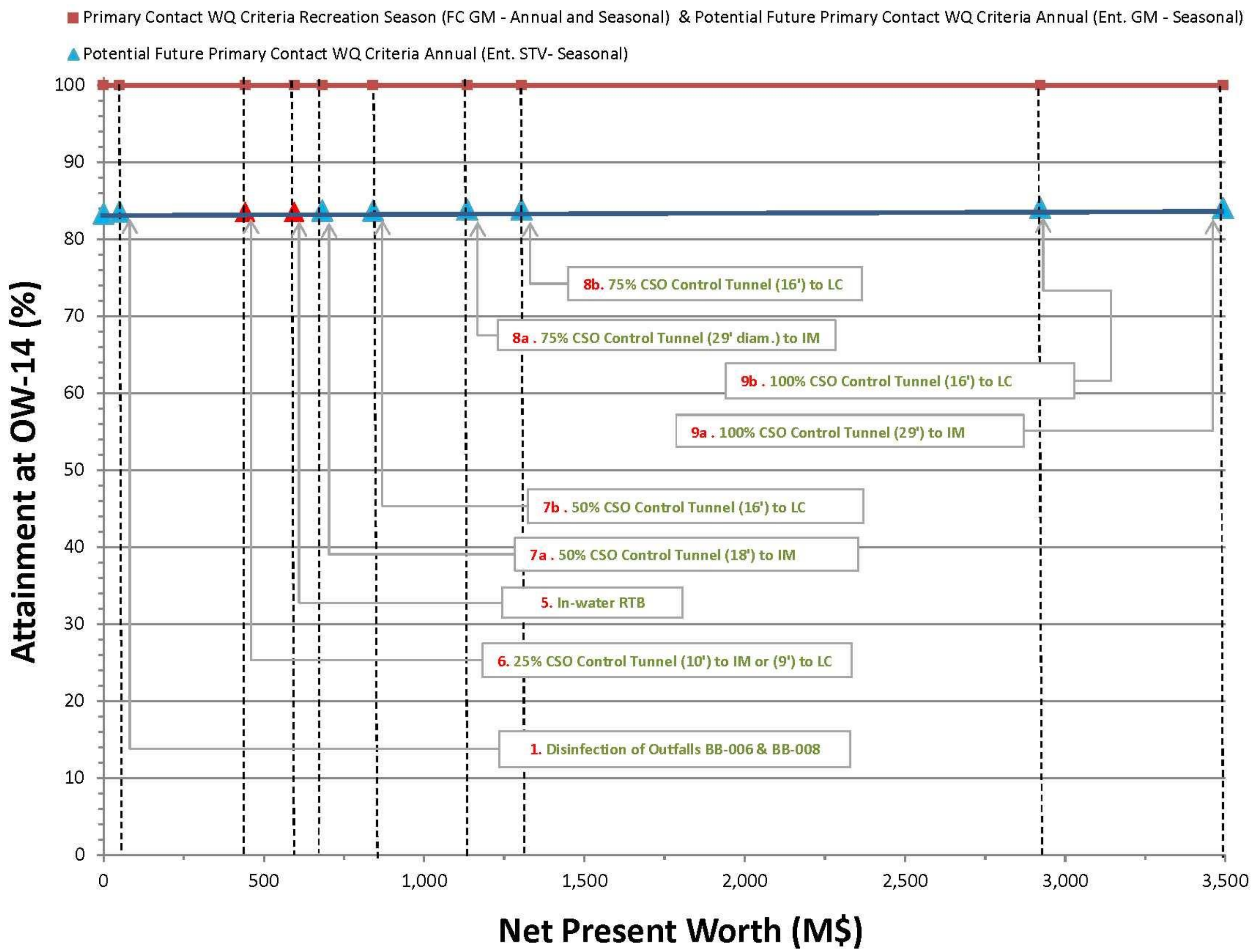

Figure 8-43. Cost vs. Bacteria Attainment at Station OW-14 (2008 Rainfall)

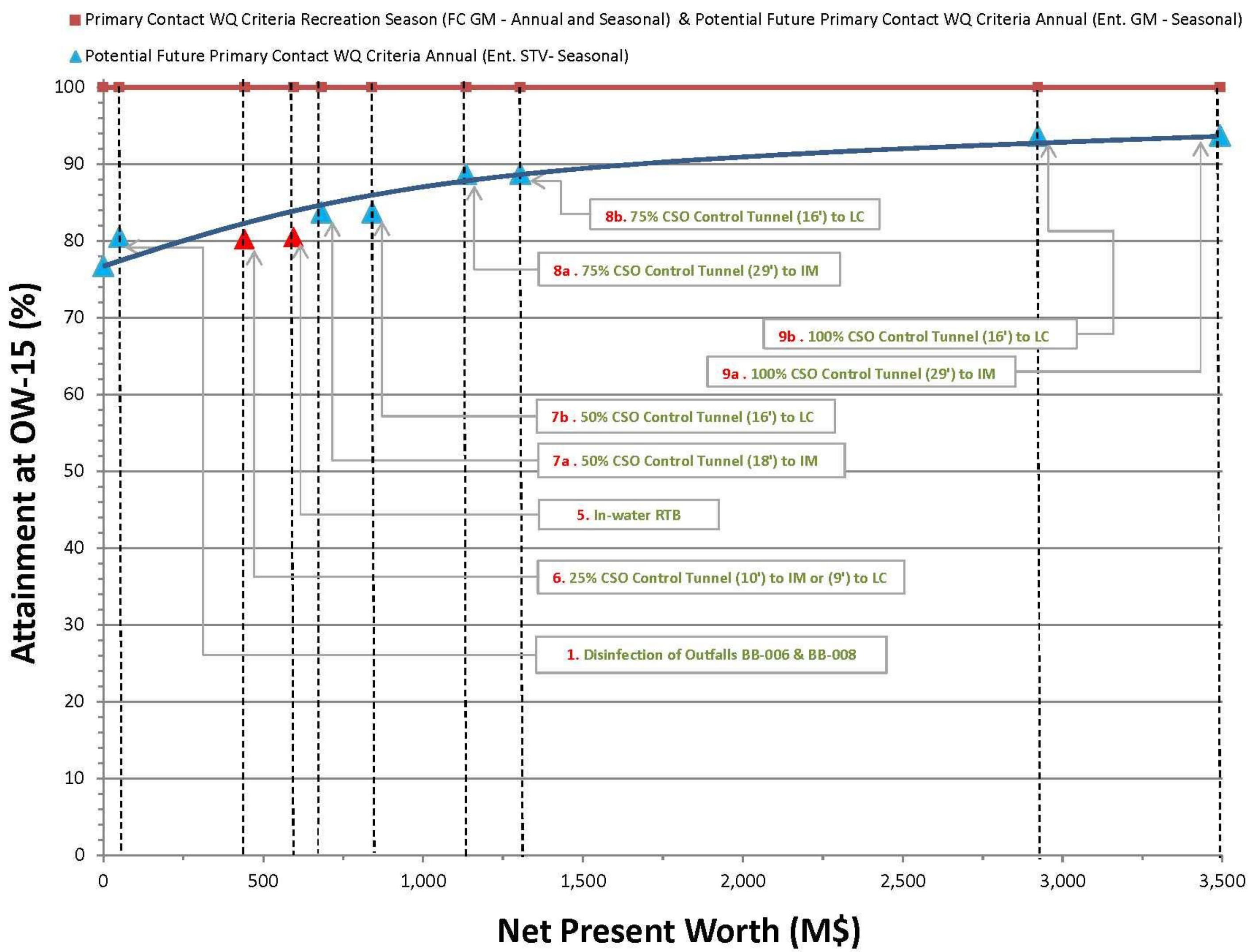

Figure 8-44. Cost vs. Bacteria Attainment at Station OW-15 (2008 Rainfall)

8.5.c Conclusion on Preferred Alternative

The selection of the Preferred Alternative for the Flushing Bay LTCP (25 MG CSO Storage Tunnel) involved multiple considerations including public input, predicted environmental and water quality benefits and costs. The following discussion includes the rationale for selecting the retained alternative that was deemed the most preferred alternative.

The previous sections described the results of the cost-performance and cost-attainment analyses that were performed on the retained alternatives for the Flushing Bay LTCP. The cost-performance curves show a 25 MG Storage Tunnel as a cost-effective alternative with respect to the level of CSO control. As demonstrated in Figures 8-29 through 8-32, CSO tunnels are an effective method of reducing CSO volume and frequency in addition to bacteria loads to the waterway. The reduction in overflows and high level CSO capture provides benefits beyond pathogen reduction that the other alternatives do not cost-effectively provide.

The LTCP alternatives were presented to the general public and stakeholders by DEP during the public participation process described in Section 7. During these public meetings and others held for previously completed LTCPs, comments were made that disinfection was a less desirable CSO control measure than those involving volumetric reduction. One of the stated reasons for this included the desire of not having chemicals stored in the neighborhoods which would require new facilities and result in additional heavy commercial traffic. Another was the opposition to the concept of seasonally adding a disinfectant to Flushing Bay when nearly the same levels of annual equivalent loading reduction could be achieved through year-round volumetric control. Impacts associated with floatables and solids were also raised as a major concern of the rowing teams and recreational boaters.

Figures 8-33 through 8-44 reflect compliance with geomean pathogen WQS at all sampling stations for each of the retained alternatives within Flushing Bay under baseline conditions for existing, primary contact and Potential Future WQS. However, these figures show that incremental attainment of the STV for enterococci under the Potential Future WQS is achieved through an implementation of alternatives providing a higher level of CSO control. Upon considering the impacts to the current recreational waterbody uses, despite the high level of pathogen attainment under baseline conditions, DEP strongly considered alternatives providing benefits beyond pathogen control in the selection of the preferred alternative. Figures 8-29 and 8-30 indicate major reductions in annual CSO discharge volume and frequency of CSO events remaining upon implementation of alternatives providing higher levels of CSO control.

DEP strives to implement the most cost-effective CSO abatement strategy for each waterbody. In the case of Flushing Bay, the preferred alternative (25MG CSO Storage Tunnel) is projected to reduce annual CSO volume from 1,405 MG to 659 MG and CSO events from 47 to 14 per year based upon a typical year (2008 rainfall). Alternatives 7a and 7b have a total NPW costs ranging from $683M to $842M, which is significantly more costly than Alternatives 1 through 4. However, a 25 MG CSO Storage Tunnel provides additional benefits associated with protecting the current waterbody uses that warrant the additional investment, namely a high level of volumetric control without the need for disinfection, which stakeholders have expressed a desire to avoid. In addition, the tunnel alternatives provide opportunities for synergies with the Open Waters CSO LTCP currently scheduled for completion by December 2017. The 25 MG CSO Storage Tunnel also provides opportunities to expand the facilities in response to more stringent WQ standards in the future. Therefore, DEP has selected the 25 MG CSO Storage Tunnel as the preferred alternative. This preferred alternative has an estimated probable bid cost ranging from

$670M to $829Mand NPW costs ranging from $683M to $842M. The annual O&M costs for this alternative were estimated to be $900,000.

The ERTM WQ model was used to characterize WQS attainment for this preferred alternative by running the model for the full 10-year (2002-2011) simulation period to assess pathogen WQ criteria, while the 2008 rainfall was used for the evaluation of DO compliance. The results of these runs are summarized in Tables 8-19 through 8-23 for the Existing WQ Criteria, Primary Contact WQ Criteria and the Potential Future Primary Contact WQ Criteria. Results are present for fecal coliform and DO on an annual basis. Fecal coliform and enterococci results relative to primary contact are presented on a recreational season (May 1^{st} through October 31^{st}) basis as well.

All WQ sampling stations throughout Flushing Bay are projected to achieve attainment for both the fecal coliform and DO concentrations as shown in Tables 8-19 and 8-20. As noted above, 95 percent attainment of applicable water quality criteria is what DEC has stated is the target for compliance with the WQS. When compared to the Primary Contact WQ Criteria for fecal coliform (Tables 8-21), attainment of the fecal coliform geomean standard is projected to be achieved at all WQ sampling stations for the recreational season and annually.

The attainment of the DO Class SC criteria for the entire water column is presented in Table 8-22, for the preferred alternative. As discussed in Section 6, determination of attainment with Class SC DO criteria can be very complex since the standard allows for excursions from the daily average limit of 4.8 mg/L for a limited number of consecutive calendar days. To simplify the analysis, attainment was based solely upon attainment of the daily average without the allowed excursions. While the analysis performed was conservative, the results indicate full attainment at all stations, except for Station OW-14. Under baseline conditions, stations in the Inner Flushing Bay have a greater than 95 percent attainment of the chronic DO criterion (greater than or equal to 4.8 mg/L), while Station OW14 in the Outer Blushing Bay has attainment less than 95 percent on an annual basis. All of the stations achieve 100 percent attainment of the acute criterion (never less than 3.0 mg/L) under baseline conditions based on the entire water column. As discussed in Section 6, the gap analysis indicates that 100% CSO control does not result in improvements in attainment of the Class SC criterion, and as such there is no gap between attainment and non-attainment at all monitoring locations within Flushing Bay.

Table 8-23 summarizes the projected levels of attainment for the Potential Future Primary WQ Criteria. Attainment of the 30-day rolling GM for enterococci is projected to range from 98 percent to 99 percent for all stations. Attainment of the 90^{th} Percentile STV criterion is projected to range from 48 percent to 62 percent for sampling stations located within the Inner Flushing Bay and 66 percent to 81 percent for stations within the Outer Flushing Bay.

Table 8-19. Model Calculated (10-year) Preferred Alternative Attainment of Existing WQ Criteria

Station		Fecal Coliform % Attainment	
		Annual GM <200 cfu/100mL	Recreational Season(1) GM <200 cfu/100mL
OW-7	Inner Flushing Bay	100	100
OW-7A		100	100
OW-7B		100	100
OW-7C		100	100
OW-8		100	100
OW-9		100	100
OW-10	Outer Flushing Bay	100	100
OW-11		100	100
OW-12		100	100
OW-13		100	100
OW-14		100	100
OW-15		100	100

Note:
(1) The Recreational Season is from May 1st through October 31st.

Table 8-20. Model Calculated (2008) Preferred Alternative DO Attainment – Existing WQ Criteria

Station		DO Annual Attainment (%)
		Entire Water Column
		≥ 4.0 mg/L
OW-7	Inner Flushing Bay	100
OW-7A		100
OW-7B		100
OW-7C		100
OW-8		100
OW-9		100
OW-10	Outer Flushing Bay	99
OW-11		99
OW-12		99
OW-13		99
OW-14		97
OW-15		98

Table 8-21. Model Calculated (10-year) Preferred Alternative Attainment of Primary Contact WQ Criteria

Station		Fecal Coliform % Attainment	
		Annual GM <200 cfu/100mL	Recreational[(1)] Season GM <200 cfu/100mL
OW-7	Inner Flushing Bay	100	100
OW-7A		100	100
OW-7B		100	100
OW-7C		100	100
OW-8		100	100
OW-9		100	100
OW-10	Outer Flushing Bay	100	100
OW-11		100	100
OW-12		100	100
OW-13		100	100
OW-14		100	100
OW-15		100	100

Note:
(1) The Recreational Season is from May 1st through October 31st.

Table 8-22. Model Calculated (2008) Preferred Alternative DO Attainment of Class SC WQ Criteria

Station		DO Annual % Attainment (Water Column)	
		Chronic[(1)]	Acute [(2)]
OW-7	Inner Flushing Bay	100	100
OW-7A		100	100
OW-7B		100	100
OW-7C		100	100
OW-8		100	100
OW-9		100	100
OW-10	Outer Flushing Bay	100	100
OW-11		97	100
OW-12		100	100
OW-13		100	100
OW-14		83	100
OW-15		97	100

Notes:
(1) Chronic Criteria: 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.

Table 8-23. Model Calculated (10-year) Preferred Alternative Attainment of Potential Future Primary Contact WQ Criteria

Station		Enterococci Attainment During the Recreational Season (%)	
		GM <30 cfu/100mL	90th Percentile STV <110 cfu/100mL
OW-7	Inner Flushing Bay	98	57
OW-7A		99	48
OW-7B		98	55
OW-7C		98	57
OW-8		98	52
OW-9		98	62
OW-10	Outer Flushing Bay	99	66
OW-11		99	81
OW-12		99	71
OW-13		99	69
OW-14		99	73
OW-15		99	72

The preferred alternative is based on multiple considerations including public input, and environmental and water quality benefits and costs. This preferred alternative is projected to result in full attainment of the existing pathogen criteria and to provide significant reduction in CSO volume and frequency of overflow. The preferred alternative is also projected to reduce CSO discharges at Outfalls BB-006 and BB-008 by a combined 53 percent, from 1,405 MG/year to 659 MG/year. CSO events are projected to be reduced by a combined 70 percent, from 47 to 14 events annually.

The key components of the preferred alternative include:

- A tunnel with 25 MG storage capacity;
- A dewatering pumping station; and
- Appurtenant near-surface connecting conduits and structures.

The implementation of these elements has a NPW ranging from $683M to $842M, reflecting $0.9M of annual O&M over the course of 20 years. The final tunnel alignment and dewatering pumps station site will be further evaluated and finalized during subsequent planning and design phases.

The proposed schedule for the implementation of 25 MG CSO Storage Tunnel is presented in Section 9.2.

8.5.d Bowery Bay Wastewater Treatment Plant Performance During CSO Pump-back

This section provides an analysis of the impacts to the Bowery Bay WWTP of a 25 MG CSO Storage Tunnel in terms of total nitrogen loadings. During wet-weather events, CSO is prevented from overflowing into Flushing Bay by diverting it into a CSO storage tunnel for subsequent treatment after the rain event subsides. A 24-hour pump-back was considered in evaluating plant impacts from the captured CSO, and that pump-back contributes an additional hydraulic and mass loading to the Bowery Bay WWTP.

First, an analysis of historical data from 2008-2012 was performed to estimate the potential process impacts and limitations. Next, a calibrated Biowin model was used to estimate changes to the total nitrogen effluent discharges from the plant during CSO pump-back. A conservative worst-case analysis provided an upper limit on the potential CSO storage volume recognizing that the impacts will be of limited duration.

However, there are significant process concerns over the WWTP being able to adequately treat the additional CSO loads because of increased nitrogen loadings. The stored CSO increases the total influent nitrogen load and subsequent effluent load during pump-back of the tunnel. The increased nitrogen load to the WWTP thereby reduces the margin of safety in meeting the final Upper East River (UER) total nitrogen (TN) TMDL step-down limits. Although the impacts can be mitigated by using the operating 'tools' outlined below, any process limitations during pump-back, such as tanks out of service or poor DO levels, can increase the risk to BNR treatment process. These impacts could be further exacerbated during critical conditions such as colder weather that could effectively limit the ability for the plant to completely nitrify. For these reasons, a conservative limitation should be considered on the ultimate CSO storage volume to mitigate TN discharges while appropriately managing the risks of maintaining permit compliance.

8.5.d.1 Historical Data Analysis

The Bowery Bay WWTP has a DDWF capacity of 150 MGD and a peak wet-weather capacity of 300 MGD (2xDDWF). The capacity of the secondary process is 225 MGD (1.5xDDWF) with an additional 75 MGD receiving primary treatment and disinfection. The Bowery Bay plant completed upgrades to the BNR process in June 2012. The historical plant influent concentrations for key pollutant parameters are shown below in Table 8-24.

Table 8-24. Bowery Bay WWTP Historical Data Analysis 2008-2012- Plant Influent

Parameter	Historical Average (Total)	Wet Weather Average
TSS, mg/L	133	128
CBOD, mg/L	158	99
TKN, mg/L	35	19

8.5.d.2 Biowin Modeling

A calibrated Biowin model for the Bowery Bay WWTP was used as a second approach for analyzing process impacts on TN discharges from CSO pump-back. From a loading perspective, CSO storage will increase the process loadings during CSO pump-back. Using plant data, the increase in secondary process loadings is shown in Table 8-25. Overall, it is projected that TN loadings will increase 20percent during pump-back.

Table 8-25. Secondary Process Loadings During CSO Pump-back of 25 MG in 24-hours

Parameter	Primary Effluent	CSO Component	Total Secondary Loading	% Increase
TSS, lbs/d	85,303	30,135	115,438	35
ISS, lbs/d	12,164	9,641	21,805	79
CBOD, lbs/d	113,846	31,901	145,747	28
TKN, lbs/d	31,513	6,259	37,772	20
TKN, million lbs/yr	11.5	2.3	13.8	

For a 25 MG CSO storage volume, the projected TN effluent discharges will increase approximately 430 lbs/d as shown in Table 8-26. This additional loading would occur whenever the CSO storage volume is full (25 MG), which is about 12-14 times a year. If we assume that the CSO storage tunnel will be full once per month and assuming a 50 percent volume utilization for all of the other storms in a month, the pump-back from CSO storage would have only a modest increase of about 85-100 lbs/d (31,000 to 36,500 lbs/year) in the monthly TN levels.

Table 8-26 Total Nitrogen Discharges for the Upper East River Treatment Plants with 25 MG CSO Storage Tunnel to Bowery Bay WWTP

Condition	Total Nitrogen Discharges
Upper East River (UER) TN TMDL Limit (Jan.2017)	44,325 lbs/d
Current Modeled UER TN Performance	43,033 lbs/d
Projected UER TN with 25-MG CSO Storage at Bowery Bay	43,462 lbs/d
Net increase from CSO pump-back	~430 lbs/d total nitrogen increase
Note: TN = Total Nitrogen	

8.6 Use Attainability Analysis

The CSO Order requires that a UAA be included in an LTCP "where existing WQS do not meet the Section 101(a)(2) goals of the CWA, or where the proposed alternative set forth in the LTCP will not achieve existing WQS or the Section 101(a)(2) goals." The UAA shall "examine whether applicable waterbody classifications, criteria, or standards should be adjusted by the State." The UAA process specifies that States can remove a designated use which is not an existing use if the scientific assessment can demonstrate that attaining the designated use is not feasible for at least one of six reasons:

1. Naturally occurring loading concentrations prevent the attainment of the use; or
2. Natural, ephemeral, intermittent or low flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for by the discharge of sufficient volume

of effluent discharges without violating State water conservation requirements to enable uses to be met; or

3. Human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place; or
4. Dams, diversions or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the waterbody to its original condition or to operate such modification in a way that would result in the attainment of the use; or
5. Physical conditions related to the natural features of the waterbody, such as the lack of a proper substrate, cover, flow, depth, pools, riffles, and the like, unrelated to water quality, preclude attainment of aquatic life protection uses; or
6. Controls more stringent than those required by Sections 301(b) and 306 of the Act would result in substantial and widespread economic and social impact.

As part of the LTCP, elements of a UAA, including the six conditions presented above, will be used to determine if changes to the designated use are warranted, considering a potential adjustment to the designated use classification as appropriate.

As noted in previous sections, Flushing Bay is predicted to fully meet the primary contact fecal coliform bacteria criterion of 200 cfu/100mL with the implementation of the 2008 WWFP and other control measures included in the Section 6 description of baseline conditions. As discussed above, DO criteria are achieved for the existing WQS under the existing classification (Class I). However, Class SC DO criteria, the next higher classification above Class I, would not be fully achieved. Although acute DO levels (never less than 3.0 mg/l) are projected to be attained, chronic DO levels (greater than or equal to 4.8 mg/L) will not satisfy the 95 percent attainment goal at one Outer Flushing Bay Station (OW-14). DO levels appear to be influenced by non-CSO related conditions in Outer Flushing Bay. Based on the projected fecal coliform bacteria and the acute DO levels for baseline conditions, it is anticipated that Flushing Bay could be upgraded to a higher classification, although a variance for chronic DO levels would be required. However, considering the small deviation in attainment of chronic DO levels, upgrading the Flushing Bay to Class SC should await completion of construction of the preferred alternative and the results of the Post-Construction Compliance Monitoring.

8.6.a Use Attainability Analysis Elements

The objectives of the CWA include providing for the protection and propagation of fish, shellfish, wildlife and recreation in and on the water. Cost-effectively maximizing the water quality benefits associated with CSO reduction is a cornerstone of this LTCP.

To simplify this process, DEP and DEC have developed a framework that outlines the steps taken under the LTCP in two possible scenarios:

1. Waterbody meets WQ requirements. This may either be the existing WQS (where primary contact is already designated) or for an upgrade to the Primary Contact WQ Criteria (where the existing standard is not a Primary Contact WQ Criteria). In either case, a high level assessment of the factors that define a given designated use is performed, and if the level of control required to meet this goal can be reasonably implemented, a change in designation may be pursued following implementation of CSO controls and Post-Construction Compliance Monitoring.

2. Waterbody does not meet WQ requirements. In this case, if a higher level of control is not feasible, the UAA must justify the shortcoming using at least one of the six criteria (see Section 8.6 above). It is assumed that if 100 percent elimination of CSO sources does not result in attainment, the UAA would include factor number 3 at a minimum as justification (human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied, or would cause more environmental damage to correct than to leave in place).

As indicated in Tables 6-5 and 6-8 of Section 6.2, the modeled fecal coliform maximum monthly geomeans are within the limits for the existing Class I and Potential Future Primary Contact Criteria (Class SC) under baseline conditions. As a result, Flushing Bay currently achieves annual attainment for bacteria. Although the DO standard of 4.0 mg/L is attained annually under the existing Class I criteria, the daily average of 4.8 mg/L under the SC criteria would not be attained greater than 95 percent of the time for all monitoring stations within Flushing Bay. However, considering the small deviation in attainment of chronic DO levels, upgrading the Flushing Bay to Class SC should await completion of construction of the preferred alternative and the results of the Post-Construction Compliance Monitoring.

8.6.b Fishable/Swimmable Waters

The goal of this LTCP is to identify appropriate CSO controls necessary to achieve waterbody-specific WQS, consistent with EPA's CSO Control Policy and subsequent guidance. DEC considers that compliance with Class I WQS, the current classification for Flushing Bay, as fulfillment of the CWA's fishable/swimmable goal.

The preferred alternative summarized in Section 8.5 results in the levels of attainment with fishable/swimmable criterion as follows. The 10-year water quality modeling analyses, conducted for Flushing Bay and summarized in Tables 8-19, 8-21 and 8-23, shows that, upon implementation of the preferred alternative, the waterbody is predicted to fully comply with the Existing WQ Criteria (Class I) and Primary Contact WQ Criteria (Class SC). Compliance with the Potential Future Primary Contact WQ Criteria of a geometric mean of 30 cfu/100mL for enterococci is predicted, as shown in Table 8-23, to be attained annually. However, attainment of the 110 cfu/100mL STV concentration annually is projected to be below the DEC target of 95 percent attainment.

8.6.c Assessment of Highest Attainable Use

The 2012 CSO Order Goal Statement stipulates that, in situations where the proposed alternatives presented on the LTCP will not achieve the CWA Section 101(a)(2) goals, the LTCP will include a UAA. Because the analyses developed herein indicate that Flushing Bay is projected to fully attain primary contact water quality criteria, fully attain the Existing DO Criteria and largely attain the Primary Contact DO Criteria, a UAA is not required under the 2012 CSO Order. Table 8-27 summarizes the compliance for the identified plan.

Table 8-27. Recommended Plan for Compliance with Bacteria Water Quality Criteria

Location	Meets Existing WQ Criteria (Class I)	Meets Primary Contact WQ Criteria (Class SC)	Meets Potential Future Primary Contact WQ Criteria
Flushing Bay	YES(1)	YES(1)	NO(2)

Notes:
YES indicates attainment is calculated to occur ≥ 95 percent of time.
NO indicates attainment is calculated to be less ≤ 95 percent of time.
(1) Annual attainment achieved.
(2) STV criteria not met annually or during the recreational season (May 1st through October 31st). GM Criteria attained annually at all monitoring stations.

8.7 Water Quality Goals

Based on the analyses of Flushing Bay and the WQS associated with the designated uses, the following conclusions can be drawn:

8.7.a Existing Water Quality

Flushing Bay is a highly productive Class I waterbody that can fully support existing uses, kayaking and wildlife propagation. The waterbody is in full attainment with its current classifications for bacteria and DO criteria.

8.7.b Primary Contact Water Quality Criteria

As presented in Section 8.5, this LTCP incorporates assessments for attainment with the proposed primary contact recreational WQS, both spatially and temporally, using 10-year simulations for bacteria runs and a typical year (2008) run for DO. Projected bacteria levels fully comply with primary contact standards. DO levels largely comply with the primary contact standards except at Station OW-14 at which attainment with the chronic standard is 83 percent.

8.7.c Potential Future Water Quality Criteria

DEP is committed to improving water quality in Flushing Bay. Toward that end, DEP has identified instruments for Flushing Bay that will allow DEP to continue to improve water quality in the system over time. Wet-weather advisories based on Time to Recovery analysis are recommended for consideration while advancing towards the numerical criteria established, or others under consideration by DEC, including Potential Future Primary Contact WQ Criteria consistent with the 2012 EPA RWQC.

Also as noted above, DEP does not believe that adoption of the STV portions of the proposed 2012 EPA RWQC is warranted at this time. Analyses presented herein clearly show that attainment of the STV value of 110 cfu/100mL is not possible through CSO control alone.

8.7.d Time to Recovery

Although Flushing Bay could possibly be protective of primary contact use during the recreational season (May 1st through October 31st), it will not be capable of supporting primary contact 100 percent of the time. Even with anticipated reductions in CSO overflows resulting from grey and green infrastructure, the waterbody cannot support primary contact during and following rainfall events. Toward the goal of maximizing the amount of time that the Flushing Bay can achieve water quality levels to support primary contact, DEP has performed an analysis to assess the amount of time following the end of a rainfall event required for Flushing Bay to recover and return to fecal coliform concentrations less than 1,000 cfu/100mL.

The analyses consisted of examining the water quality model output for calculated Flushing Bay pathogen concentrations for recreational periods (May 1st through October 31st) that were abstracted from a model simulation of the August 15, 2008 storm. Details on the selection of this storm are provided in Section 6. The time to return to 1,000 cfu/100mL was then tabulated for each sampling location along Flushing Bay. The results of this analysis for implementation of the preferred alternative are summarized in Table 8-28 for Flushing Bay. These results also account for implementation of the preferred alternative identified in the Flushing Creek CSO LTCP. As noted, the duration of time within which pathogen concentrations are expected to be higher than the DOH considers safe for primary contact varies by location within Flushing Bay. The model predicted time to recovery is within the DEC desired target of 24 hours at all of the sampling locations for the preferred alternative.

Table 8-28. Time to Recovery within Flushing Bay (August 15, 2008)

Sampling Location and Waterbody Conditions		Preferred Alternative Time to Recovery (hrs) Fecal Coliform Target (1,000 cfu/100mL)
OW-7	Inner Flushing Bay	21
OW-7A		21
OW-7B		22
OW-7C		21
OW-8		17
OW-9		19
OW-10	Outer Flushing Bay	19
OW-11		8
OW-12		11
OW-13		11
OW-14		9
OW-15		10

8.8 Recommended LTCP Elements to Meet Water Quality Goals

Water quality in Flushing Bay will be improved with the preferred alternative and other actions identified herein.

The actions identified in this LTCP include:

- A 25 MG CSO Storage Tunnel to reduce CSO discharges to Inner Flushing Bay.

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- A pumping station for dewatering the tunnel following a wet-weather event.
- Ranges of costs (in February 2016 dollars) for the recommended alternative are: NPW $683M to $842M, PBC of $670M to $829M, and O&M of $0.9M.
- Compliance with Primary Contact WQ Criteria under baseline conditions and based on the model projected performance of the selected CSO controls. As a result, a UAA is not included as part of this LTCP.
- DEP will establish with the DOHMH through public notification a wet-weather advisory during the recreational season (May 1st through October 31st) during which swimming and bathing would not be recommended in Flushing Bay. The LTCP includes a recovery time analysis that can be used to establish the duration of the wet-weather advisory for public notification.

DEP is committed to improving water quality in this waterbody, which will be advanced by the improvements and actions identified in this LTCP. A preliminary constructability analysis was conducted and DEP has deemed these improvements to be implementable. These identified actions have been balanced with input from the public and awareness of the cost to the citizens of NYC.

9.0 LONG-TERM CSO CONTROL PLAN IMPLEMENTATION

The evaluations performed for this Flushing Bay LTCP concluded that with the recommendations from previous planning work that have been implemented, Flushing Bay meets its current water quality classification of Class I for bacteria 100 percent of the time. Upon implementation of this LTCP, Flushing Bay will attain the Primary Contact WQ Criteria for fecal coliform annually and during the recreational season (May 1st through October 31st). The selection of the preferred alternative is based on multiple considerations including public input, environmental benefits, water quality improvements and cost. A traditional KOTC analysis was performed to identify the most cost-effective alternative for reducing the frequency and volume of CSOs to Flushing Bay. The preferred LTCP alternative for Flushing Bay is a 25 MG CSO Storage Tunnel, with a dewatering pumping station and associated near-surface connecting conduits and structures. The analyses developed herein indicate that upon implementation of the preferred alternative, Flushing Bay will fully attain Primary Contact Water Quality Criteria, fully attain the Existing DO Criteria and largely attain the Class SC DO Criteria.

9.1 Adaptive Management (Phased Implementation)

Adaptive management, as defined by the EPA, is the process by which new information about the characteristics of a watershed is incorporated into a watershed management plan on a continuing basis. The process relies on establishing a monitoring program, evaluating monitoring data and trends and making adjustments or changes to the plan. DEP will continue to apply the principles of adaptive management to this LTCP based on its annual evaluation of monitoring data, which will be collected to sustain the operation and effectiveness of the currently operational CSO controls.

NYC will also develop a program to further address stormwater discharges as part of its MS4 permit. This program, along with the actions identified in this LTCP, may further improve water quality in Flushing Bay.

DEP will also continue to monitor the water quality of Flushing Bay through its ongoing monitoring and initiatives, discussed in Section 2.0. For example, if evidence of dry-weather sources of pollution is found, track downs will be initiated. Such activities will be reported to DEC on a quarterly basis as is currently required under the Bowery Bay WWTP SPDES permit.

9.2 Implementation Schedule

The implementation schedule to construct the facilities associated with a 25 MG CSO Storage Tunnel is presented in Figure 9-1. The schedule is based on conceptual plans and was developed with assistance from local tunneling experts. This schedule represents our best estimate at this conceptual level given the size, complexity, and multiple site acquisitions and access coordination needed to support such a massive project. The schedule includes the estimated duration of time needed to perform the engineering design, advertise and bid the construction contracts, and complete construction. This schedule will be further refined as the tunnel design progresses and more detailed information becomes available. During the design process, DEP will use its best efforts to identify opportunities to expedite the schedule. In addition, during this time, DEP will be investing in other water quality improvement projects in Flushing Bay including the dredging project and sewer enhancements. These projects will improve aesthetic conditions in Flushing Bay and reduce CSO discharges by about 20%.

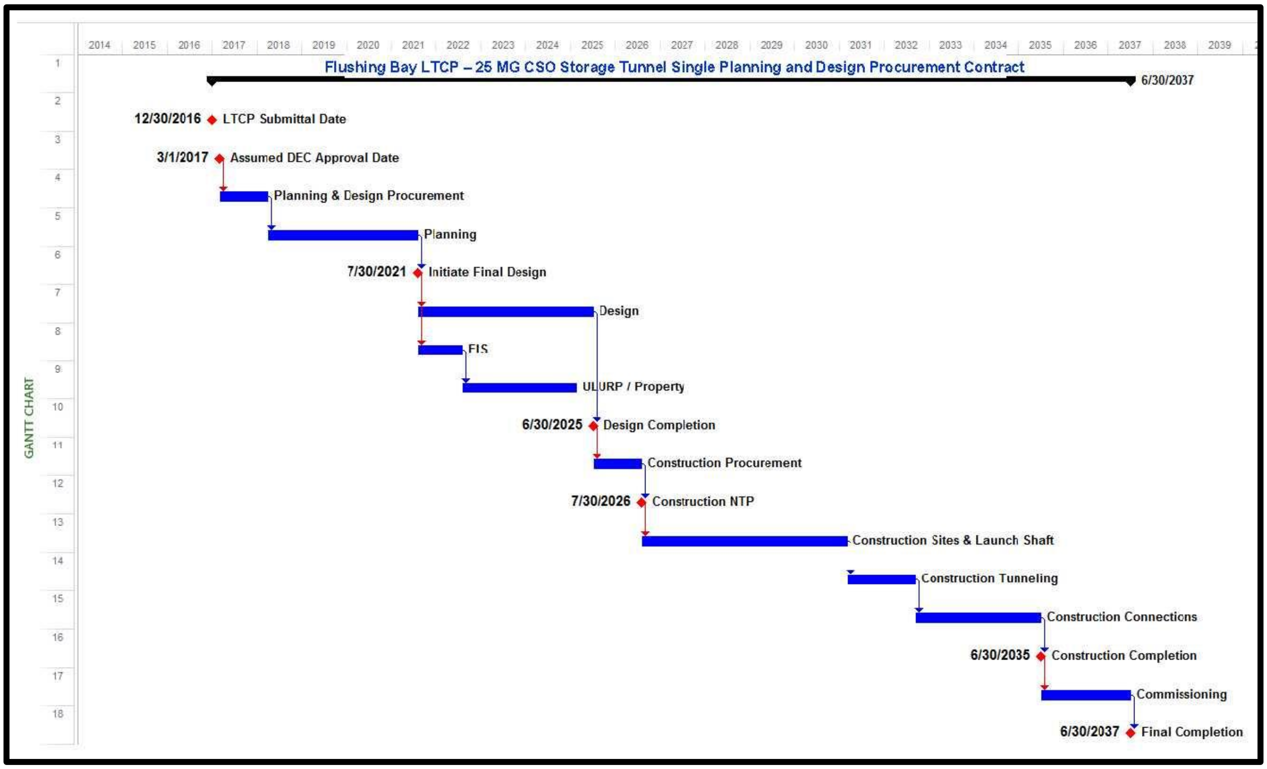


Figure 9-1. Implementation Schedule

9.3 Operational Plan/O&M

DEP is committed to effectively incorporating Flushing Bay LTCP components into the Bowery Bay and Tallman Island collection and transport systems as they are built-out during the implementation period. O&M of the near-surface components of the Flushing Bay Recommended Plan (diversion structures, connecting conduits) will be consistent with similar existing sewers and CSO regulator structures within DEP's sewer system. Site-specific O&M plans will be developed for the dewatering pumping station and the tunnel.

9.4 Projected Water Quality Improvements

As described in Section 8.4, the 25 MG CSO Storage Tunnel will result in improved water quality in Flushing Bay including reduction of the human or CSO-derived bacteria, as well as other CSO-related loadings both annually and during the recreational season. Improvements in water quality will also be realized as GI projects are built-out.

Additional water quality are expected to continue as the result of implementation of NYC's MS4 program.

9.5 Post-Construction Monitoring Plan and Program Reassessment

Ongoing DEP monitoring programs such as the HSM and SM Programs will continue. Harbor Survey data collected from Stations E15, FB1 and E6 will be used to periodically review and assess the water quality trends in Flushing Bay. Depending on the findings, the data from these programs could form the basis of additional recommendations for inclusion in the Citywide LTCP.

9.6 Consistency with Federal CSO Policy

The Flushing Bay LTCP was developed to comply with the requirements of the EPA CSO Control Policy and associated guidance documents, and the CWA.

The modeling of Baseline Conditions shows that Flushing Bay exhibits a high level of attainment of the Class I fecal coliform Primary Contact WQ criterion and DO criterion on an annual basis. Attainment of the Class SC fecal coliform Primary Contact WQ criterion is also fully achieved on an annual basis. While the Class SC Acute DO Criterion is fully attained during baseline conditions, the chronic DO criteria is not fully attained under baseline conditions or 100% CSO control on an annual daily basis but the actual chronic DO WQS is a complex duration based criteria and basing the analysis on a daily average is very conservative. The projected improvement in the chronic DC WQS attainment is less than 1 percent between the baseline scenario and 100% CSO reduction indicating that there is minimal performance benefit for DO through control of CSO alone. Attainment of the geometric mean for enterococci under the Potential Future Primary Contact WQ Criteria is fully achieved. However, attainment of the 90th Percentile STV falls well short of the 95 percent DEP goal, particularly within Inner Flushing Bay. While significant improvement in attainment of this criterion is observed at 9 of the 12 monitoring stations, the results indicate that non-CSO sources of bacteria contribute to the bacteria levels in the Bay and prevent compliance with this potential future criterion through CSO control.

The selection of the preferred alternative is based on multiple considerations including public input, environmental and water quality benefits, and costs. A traditional KOTC analysis is presented in Section 8.5 of the LTCP. Based on that analysis, a 25 MG CSO Storage Tunnel was identified as the most cost-effective alternative for reducing the frequency and volume of CSOs discharged to Flushing Bay.

This preferred alternative is projected to result in full attainment of the existing pathogen criteria and will reduce CSO discharges at Outfalls BB-006 and BB-008 to Flushing Bay by 53 percent from 1,405 MG/year to 659 MG/year. CSO events will be reduced by 70 percent from 47 to 14 events annually.

9.6.a Affordability and Financial Capability Introduction

EPA has recognized the importance of taking a community's financial status into consideration, and in 1997, issued "Combined Sewer Overflows: Guidance for Financial Capability Assessment and Schedule Development." EPA's financial capability guidance contains a two-phased assessment approach. Phase I examines affordability in terms of impacts to residential households. This analysis applies the residential indicator (RI), which examines the average cost of household water pollution costs (wastewater and stormwater) relative to a benchmark of two percent of service area-wide Median Household Income (MHI). The results of this preliminary screening analysis are assessed by placing the community in one of three categories:

- Low economic impact: average wastewater bills are less than one percent of MHI;
- Mid-range economic impact: average wastewater bills are between one percent and two percent of MHI; and
- High economic impact: average wastewater bills are greater than two percent of MHI.

The second phase develops the Permittee Financial Capability Indicators, which examine several metrics related to the financial health and capabilities of the impacted community. The indicators are compared to national benchmarks and are used to generate a score that is the average of six economic indicators: bond rating; net debt; MHI; local unemployment; property tax burden; and property tax collection rate within a service area. Lower Financial Capability Indicators (FCI) scores imply weaker economic conditions, and thus the increased likelihood that additional controls would cause substantial economic impact.

The results of the RI and the FCI are then combined in a Financial Capability Matrix to give an overall assessment of the permittee's financial capability. The result of this combined assessment can be used to establish an appropriate CSO control implementation schedule.

Significantly, EPA recognizes that the procedures set out in its guidance are not the only appropriate analyses to evaluate a community's ability to comply with CWA requirements. EPA's 2001 "Guidance: Coordinating CSO Long-term Planning with Water Quality Standards Reviews" emphasizes this by stating:

> *The 1997 Guidance "identifies the analyses States may use to support this determination [substantial and widespread impact] for water pollution control projects, including CSO LTCPs. States may also use alternative analyses and criteria to support this determination, provided they explain the basis for these alternative analyses and/or criteria* (U.S. EPA, 2001, p. 31)".

Likewise, EPA has recognized that its RI and FCI metrics are not the sole socioeconomic basis for considering an appropriate CSO compliance schedule. EPA's 1997 guidance recognizes that there may be other important factors in determining an appropriate compliance schedule for a community, and contains the following statement that authorizes communities to submit information beyond that which is contained in the guidance:

> *It must be emphasized that the financial indicators found in this guidance might not present the most complete picture of a permittee's financial capability to fund the CSO controls. … Since flexibility is an important aspect of the CSO Policy, permittees are encouraged to submit any additional documentation that would create a more accurate and complete picture of their financial capability* (U.S. EPA, 1997, p. 7).

Furthermore, in 2012, EPA released its "Integrated Municipal Stormwater and Wastewater Planning Approach Framework," which is supportive of a flexible approach to prioritizing projects with the greatest water quality benefits and the use of innovative approaches like GI (U.S. EPA, 2012). In November of 2014, EPA released its "Financial Capability Assessment Framework" clarifying the flexibility within their CSO guidance. Although EPA did not modify the metrics established in the 1997 guidance, the 2014 Framework reiterates that permittees are encouraged to supplement the core metrics with additional information that would "create a more accurate and complete picture of their financial capability" that may "affect the conclusion" of the analysis.

For example, EPA will consider:

- All CWA costs presented in the analysis described in the 1997 Guidance; and

- Safe Drinking Water Act obligations as additional information about a permittee's financial capability.

EPA will also consider alternative disaggregation of household income (e.g., quintiles), as well as economic indicators including, but not limited to:

- Actual poverty rates;
- Rate of home ownership;
- Absolute unemployment rates; and
- Projected, current, and historical wastewater (sewer and stormwater costs) as a percentage of household income, quintile, geography, or other breakdown.

The purpose of presenting these data is to demonstrate that the local conditions facing the municipality deviate from the national average to the extent that the metrics established in the 1997 guidance are inadequate for accurately assessing the municipality's financial capacity for constructing, operating, and implementing its LTCP Program in compliance with its regulatory mandates.

This section begins to explore affordability and financial capability concerns as outlined in the 1997 and 2001 guidance documents and the 2014 Framework, and analyzes the financial capability of NYC to make additional investments in CSO control measures, in light of the relevant financial indicators, the overall socioeconomic conditions in NYC, and the need to continue spending on other water and sewer projects. The analysis is presented both in terms of the EPA's Financial Capability Guidance framework and by applying several additional factors that are relevant to NYC's unique socioeconomic This affordability and financial capability section will be refined in each LTCP as project costs are further developed, and to reflect the latest available socioeconomic metrics.

9.6.b Residential Indicator (RI)

As discussed above, the first economic test from EPA's 1997 CSO guidance is the RI, which compares the average annual household water pollution control cost (wastewater and stormwater related charges) to the MHI of the service area. Average household wastewater cost can be estimated by approximating the residential share of wastewater treatment and dividing it by total number of households. In NYC, the wastewater bill is a function of water consumption. Therefore, average household costs and the RI are estimated based on application of Fiscal Year (FY) 2017 rates (which are the same as FY2016 rates), to consumption rates by household type, as shown in Table 9-1.

Table 9-1. Residential Water and Wastewater Costs compared to Median Household Income (MHI)

	Average Annual Wastewater Bill ($/year)	Wastewater RI (Wastewater Bill/MHI(1)) (%)	Total Water and Wastewater Bill ($/Year)	Water and Wastewater RI (Water and Wastewater Bill/MHI) (%)
Single-family(2)	648	**1.14**	1,056	**1.86**
Multi-family(3)	421	**0.74**	686	**1.21**
Average Household Consumption(4)	531	**0.94**	865	**1.52**
MCP(5)	617	**1.09**	1,005	**1.77**

Notes:
(1) Latest MHI data is $55,752 based on 2015 ACS data, estimated MHI adjusted to 2016 is $56,718.
(2) Based on 80,000 gallons/year consumption and Fiscal Year (FY) 2017 Rates.
(3) Based on 52,000 gallons/year consumption and FY2017 Rates.
(4) Based on average consumption across all metered residential units of 65,534 gallons/year and FY2017 Rates.
(5) Multi-family Conservation Plan (MCP) is a flat fee per unit for customers who will implement certain conservation measures.

As shown in Table 9-1, the RI for wastewater costs varies between 0.74 percent of MHI to 1.14 percent of MHI, depending on household type. Because DEP is a water and wastewater utility and ratepayers receive one bill for both charges, it is also appropriate to look at the total water and wastewater bill in considering the RI, which varies from 1.21 percent to 1.86 percent of MHI.

Based on this initial screen, current wastewater costs pose a low to mid-range economic impact according to the EPA's 1997 guidance. Several factors, however, limit using MHI as a financial indicator for a city like New York. NYC has a large population and more than three million households. Even if a relatively small percentage of households were facing unaffordable water and wastewater bills, there would still be a significant number of households experiencing this hardship. For example, more than 668,000 households in NYC (about 21 percent of NYC's total households) earn less than $20,000 per year and have estimated wastewater costs well above 2 percent of their household income. Therefore, there are several other socioeconomic indicators to consider in assessing residential affordability, as described later in this section.

9.6.c Financial Capability Indicators (FCI)

The second phase of the 1997 CSO guidance develops the Permittee FCI, which examine several metrics related to the financial health and capabilities of the impacted community. The indicators are compared to national benchmarks and are used to generate a score that is the average of six economic indicators: bond rating, net debt, MHI, local unemployment, property tax burden, and property tax collection rate within a service area. Lower FCI scores imply weaker economic conditions and thus an increased likelihood that additional controls would cause substantial economic impact.

Table 9-2 summarizes the FCI scoring as presented in the 1997 CSO guidance. NYC's FCI score based on this test is presented in Table 9-3 and is further described below.

Table 9-2. Financial Capability Indicator Scoring

Financial Capability Metric	Strong (Score = 3)	Mid-range (Score = 2)	Weak (Score = 1)
Debt Indicator			
Bond rating (G.O. bonds, revenue bonds)	AAA-A (S&P) Aaa-A (Moody's)	BBB (S&P) Baa (Moody's)	BB-D (S&P) Ba-C (Moody's)
Overall net debt as percentage of full market value	Below 2%	2–5%	Above 5%
Socioeconomic Indicator			
Unemployment rate	More than 1 percentage point below the national average	+/- 1 percentage point of national average	More than 1 percentage point above the national average
MHI	More than 25% above adjusted national MHI	+/- 25% of adjusted national MHI	More than 25% below adjusted national MHI
Financial Management Indicator			
Property tax revenues as percentage of Full Market Property Value (FMPV)	Below 2%	2–4%	Above 4%
Property tax revenue collection rate	Above 98%	94–98%	Below 94%

Table 9-3. NYC Financial Capability Indicator Score

Financial Capability Metric	Actual Value	Score
Debt Indicators		
Bond rating (G.O. bonds)	AA (S&P) AA (Fitch) Aa2 (Moody's)	Strong/3
Bond rating (Revenue bonds)	AAA (S&P) AA+ (Fitch) Aa1 (Moody's)	
Overall net debt as percentage of FMPV	3.6%	Mid-range/2
G.O. Debt	$37.9B	
Market value	$1,053.8B	
Socioeconomic Indicators		
Unemployment rate (2015 annual average)	0.4% above the national average	Mid-range/2
NYC unemployment rate	5.7%	
United States unemployment rate	5.3%	
MHI as percentage of national average	100.0%	Mid-range/2
Financial Management Indicators		
Property tax revenues as percentage of FMPV	2.3%	Mid-range/2
Property tax revenue collection rate	98.6%	Strong/3
Permittee Indicators Score		2.3

Notes:
Debt and Market Value Information as of June 30, 2016.

9.6.c.1 Bond Rating

The first financial benchmark is NYC's bond rating for both general obligation (G.O.) and revenue bonds. A bond rating performs the isolated function of credit risk evaluation. While many factors go into the investment decision-making process, bond ratings can significantly affect the interest that the issuer is required to pay, and thus the cost of capital projects financed with bonds. According to EPA's criteria – based on the ratings NYC has received from all three rating agencies [Moody's, Standard & Poor's (S&P), and Fitch Ratings] – NYC's financing capability is considered "strong" for this category.

NYC's G.O. rating and Municipal Water Finance Authority's (MWFA) revenue bond ratings are high due to prudent fiscal management, the legal structure of the system, and the Water Board's historic ability to raise water and wastewater rates. However, mandates over the last decade have significantly increased the leverage of the system, and future bond ratings could be impacted by further increases to debt beyond what is currently forecasted.

9.6.c.2 Net Debt as a Percentage of Full Market Property Value (FMPV)

The second financial benchmark measures NYC's outstanding debt as a percentage of FMPV. At the end of FY2016, NYC had more than $37.9B in outstanding G.O. debt, and the FMPV within NYC was $1,053.8B. This results in a ratio of outstanding debt to FMPV of 3.6 percent and a "mid-range" rating for this indicator. If $29.7B of MWFA revenue bonds that support the system are included, net debt as a percentage of FMPV increases to 6.4 percent, which results in a "weak" rating for this indicator. Furthermore, if NYC's $48.2B of additional debt that is related to other services and infrastructure is also included, the ratio further increases to 11.0 percent.

9.6.c.3 Unemployment Rate

For the unemployment benchmark, the 2015 annual average unemployment rate for NYC was compared to that for the U.S. NYC's 2015 unemployment rate of 5.7 percent is 0.4 percent higher than the national average of 5.3 percent. Based on EPA guidance, NYC's unemployment benchmark would be classified as "mid-range." It is important to note that over the past two decades, NYC's unemployment rate has generally been significantly higher than the national average. Due to the recession, the national unemployment is now closer to NYC's unemployment rate. Additionally, the unemployment rate measure identified in the 1997 financial guidance is a relative comparison based on a specific snapshot in time. It is difficult to predict whether the unemployment gap between the United States and NYC will further widen, and it may be more relevant to look at longer term historical trends of the service area.

9.6.c.4 Median Household Income (MHI)

The MHI benchmark compares the community's MHI to the national average. Using American Community Survey (ACS) 2015 single-year estimates, NYC's MHI is $55,752 and the nation's MHI is $55,775. Thus, NYC's MHI is nearly 100 percent of the national MHI, resulting in a "mid-range" rating for this indicator. However, as discussed above, MHI does not provide an adequate measure of affordability or financial capability. MHI is a poor indicator of economic distress and bears little relationship to poverty, or other measures of economic need. In addition, reliance on MHI alone can be a misleading indicator of the affordability impacts in large and diverse cities like NYC.

9.6.c.5 Tax Revenues as a Percentage of Full Market Property Value (FMPV)

This indicator, which EPA also refers to as the "property tax burden," attempts to measure "the funding capacity available to support debt based on the wealth of the community," as well as "the effectiveness of management in providing community services." According to the NYC Property Tax Annual Report issued for FY2016, NYC had billed $24.1B in real property taxes against a $1,053.8B FMPV, which amounts to 2.3 percent of FMPV. For this benchmark, NYC received a "mid-range" score. This figure does not include water and wastewater revenues. Including FY2016 system revenues ($3.9B) would increase the ratio to 2.7 percent of FMPV.

This indicator, whether including or excluding water and wastewater revenues, is misleading because NYC obtains a relatively low percentage of its tax revenues from property taxes. In 2007, property taxes accounted for less than 41 percent of NYC's total non-exported taxes, meaning that taxes other than property taxes (e.g., income taxes, sales taxes) account for nearly 60 percent of the locally-borne NYC tax burden.

9.6.c.6 Property Tax Collection Rate

The property tax collection rate is a measure of "the efficiency of the tax collection system and the acceptability of tax levels to residents." The FY2016 NYC Property Tax Annual Report indicates NYC's total property tax levy was $24.1B, of which 98.6 percent was collected, resulting in a "strong" rating for this indicator.

It should be noted, however, that the processes used to collect water and wastewater charges and the enforcement tools available to water and wastewater agencies differ from those used to collect and enforce real property taxes. The NYC Department of Finance (DOF), for example, can sell real property tax liens on all types of non-exempt properties to third parties, who can then take action against the delinquent property owners. DEP, in contrast, can sell liens on multi-family residential and commercial buildings whose owners have been delinquent on water bills for more than one year, but it cannot sell liens on single-family homes. Thus, the real property tax collection rate does not accurately reflect DEP's ability to collect the revenues used to support water supply and wastewater capital spending.

9.6.d Summary of the Phase 1 and Phase 2 Indicators

The results of the Phase 1 (Residential Indicator) and the Phase 2 (Permittee Financial Capability Indicators) evaluations are combined in the Financial Capability Matrix (see Table 9-4), to evaluate the level of financial burden the current CWA program costs may impose on NYC. Based on a RI score of 0.94 percent (using average household consumption), and a FCI score of 2.3, NYC's Financial Capability Matrix score is "Low Burden." The score falls in the "Medium Burden" category when considering the higher RI scores of 1.14 percent and 1.09 percent for single-family and multi-family conservation plan households, respectively.

Table 9-4. Financial Capability Matrix

Permittee Financial Capability Indicators Score (Socioeconomic, Debt, and Financial Indicators)	Residential Indicator (Cost Per Household as a % of MHI)		
	Low Impact (Below 1.0%)	**Mid-Range (Between 1.0 and 2.0%)**	**High Impact (Above 2.0%)**
Weak (Below 1.5)	Medium Burden	High Burden	High Burden
Mid-Range (Between 1.5 and 2.5)	**Low Burden**	Medium Burden	High Burden
Strong (Above 2.5)	Low Burden	Low Burden	Medium Burden

9.6.e Socioeconomic Considerations in the New York City Context

As encouraged by EPA's financial capability assessment guidance, several additional factors of particular relevance to NYC's unique socioeconomic character are provided in this section to aid in the evaluation of affordability implications of the costs associated with anticipated CWA compliance on households in NYC.

9.6.e.1 Income Levels

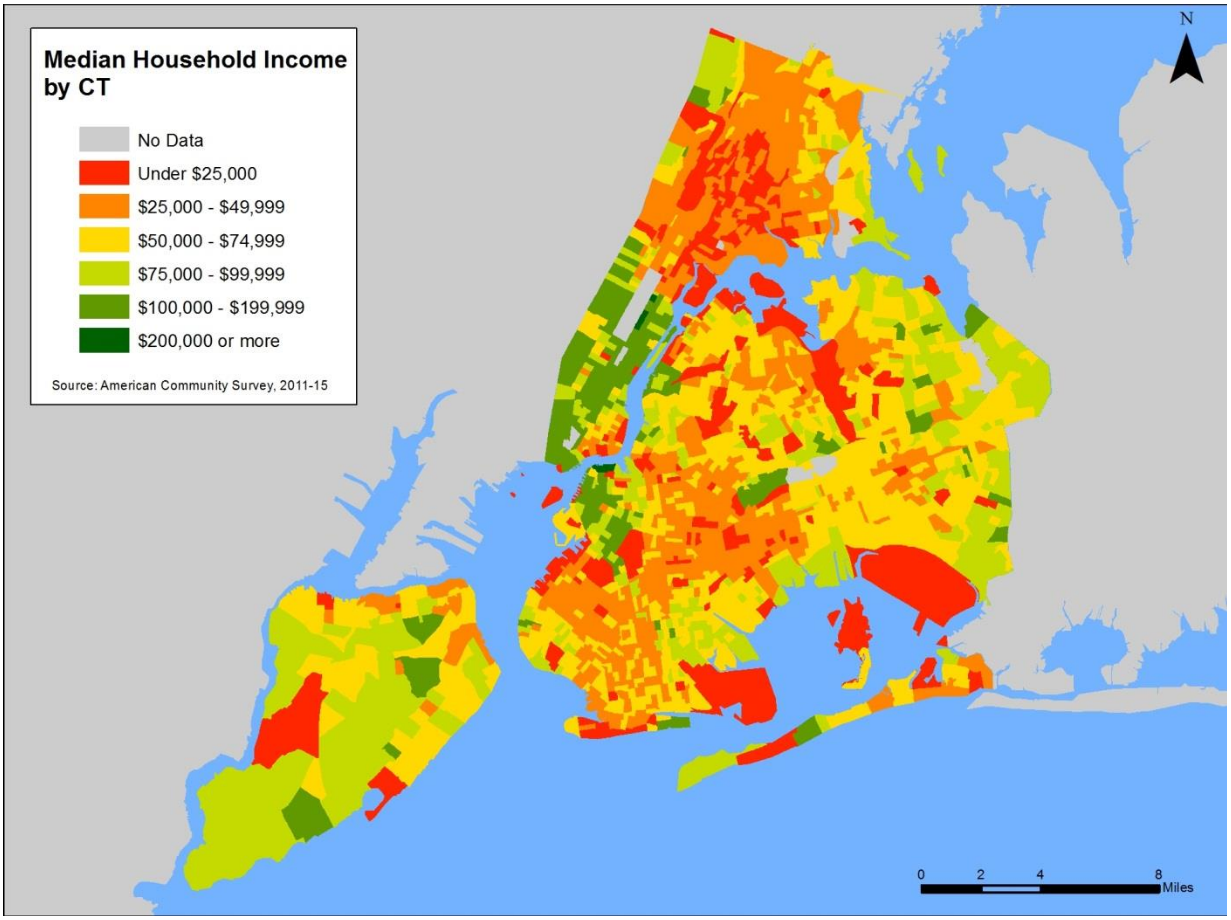
In 2015, the latest year for which Census data is available, the MHI in NYC was $55,752. As shown in Table 9-5, across the NYC boroughs, MHI ranged from $35,176 in the Bronx to $75,575 in Manhattan. Figure 9-2 shows that income levels also vary considerably across NYC neighborhoods, and there are several areas in NYC with high concentrations of low-income households.

As shown in Figure 9-3, after 2008, MHI in NYC actually decreased for several years, and it took several years to recover to the 2008 level. In addition, the cost of living continued to increase during this period.

Table 9-5. Median Household Income

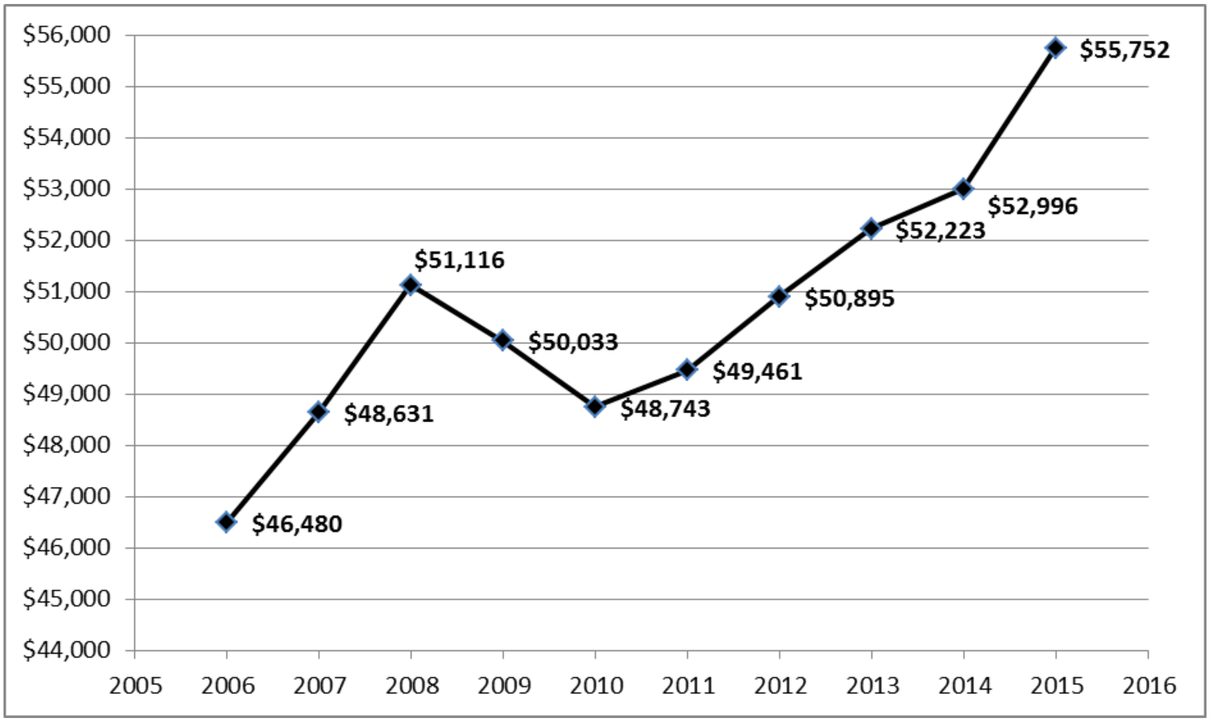
Location	2015 (MHI)
United States	$55,775
New York City	$55,752
Bronx	$35,176
Brooklyn	$51,141
Manhattan	$75,575
Queens	$60,422
Staten Island	$71,622

Source: U.S. Census Bureau 2015 ACS 1-Year Estimates.



Source: U.S. Census Bureau 2011-2015 ACS 5-Year Estimates.

Figure 9-2. Median Household Income by Census Tract



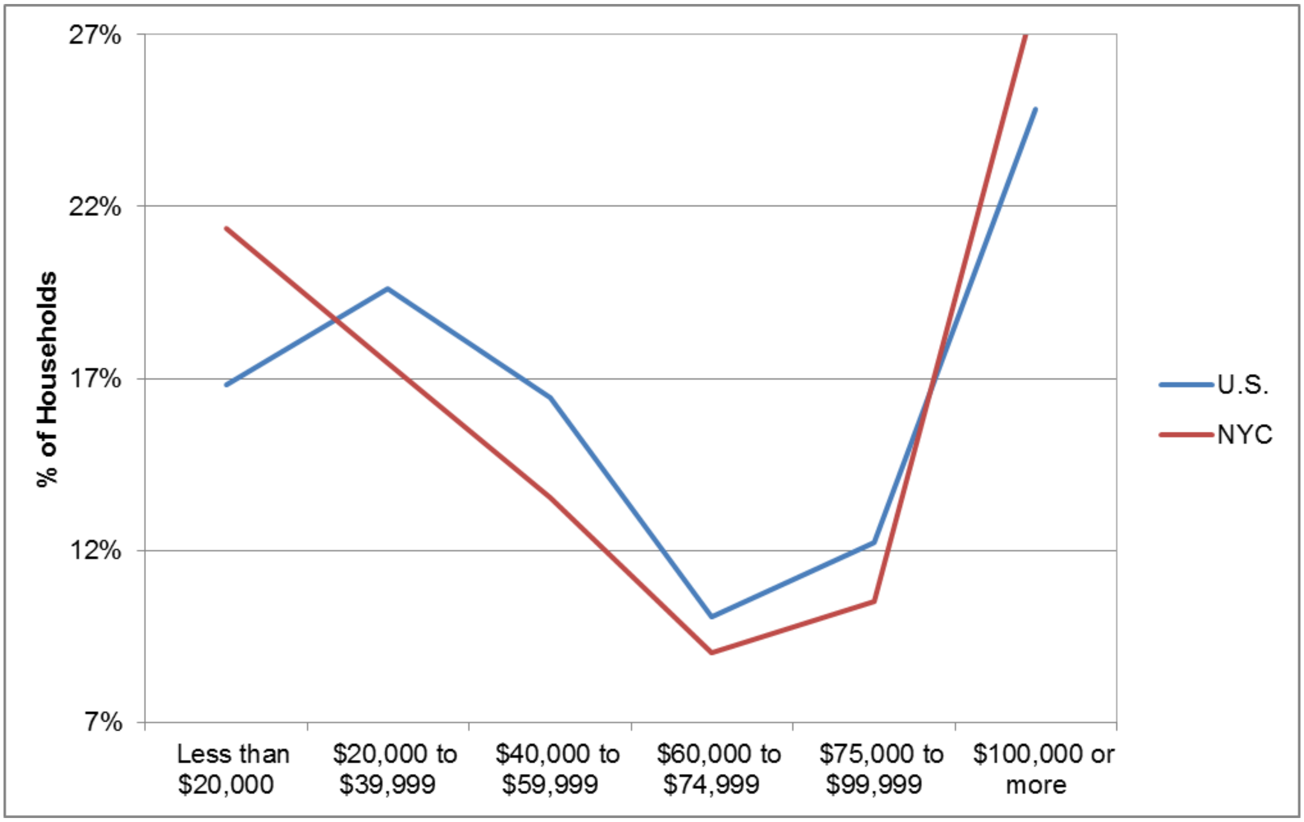
Source: U.S. Census Bureau 2006 through 2015 ACS 1-Year Estimates.

Figure 9-3. NYC Median Household Income over Time

9.6.e.2 Income Distribution

NYC currently ranks as one of the most unequal cities in the United States (U.S.) in terms of income distribution. NYC's income distribution highlights the need to focus on metrics other than citywide MHI to capture the disproportionate impact on households in the lowest income brackets. It is clear that MHI does not represent "the typical household" in NYC. As shown in Figure 9-4, incomes in NYC are not clustered around the median. Rather, a greater percentage of NYC households exist at either end of the economic spectrum. Also, the percentage of the population with middle-class incomes between $20,000 and $100,000 is 7.8 percent less in NYC than in the United States.

As shown in Table 9-6, the income level that defines the upper end of the Lowest Quintile (i.e., the lowest 20 percent of income earners) in NYC is $18,681, compared to $22,824 nationally. This further demonstrates that NYC has a particularly vulnerable, and sizable, lower income population. Table 9-7 compares the average household consumption RI for the Lowest Quintile, Second Quintile, and MHI for NYC using FY2017 rates. As shown in this table, households in the Lowest Quintile have a RI of at least 2.8 percent, which easily exceeds EPA's "High Financial Impact" threshold of 2.0 percent.



Source: U.S. Census Bureau 2015 ACS 1-Year Estimates.

Figure 9-4. Income Distribution for NYC and U.S.

Table 9-6. Household Income Quintile Upper Limits in New York City and the United States (2015 Dollars)

Quintile	New York City	United States
Lowest Quintile	$18,681	$22,824
Second Quintile	$41,260	$43,576
Third Quintile	$72,007	$70,323
Fourth Quintile	$124,848	$112,145
Lower Limit of Top 5 Percent	$250,000	$210,737

Source: U.S. Census Bureau 2015 ACS 1-Year Estimates.

Table 9-7. Average Household Consumption Residential Indicator for Different Income Levels using FY2017 Rates

Income Level	RI(1)
Lowest Quintile Upper Limit	2.79%
Second Quintile Upper Limit	1.26%
MHI	0.94%

Note:
(1) RI calculated by dividing average household consumption annual wastewater bill of $531 (using FY 2017 rates) by income level values adjusted to 2016 dollars.

9.6.e.3 Poverty Rates

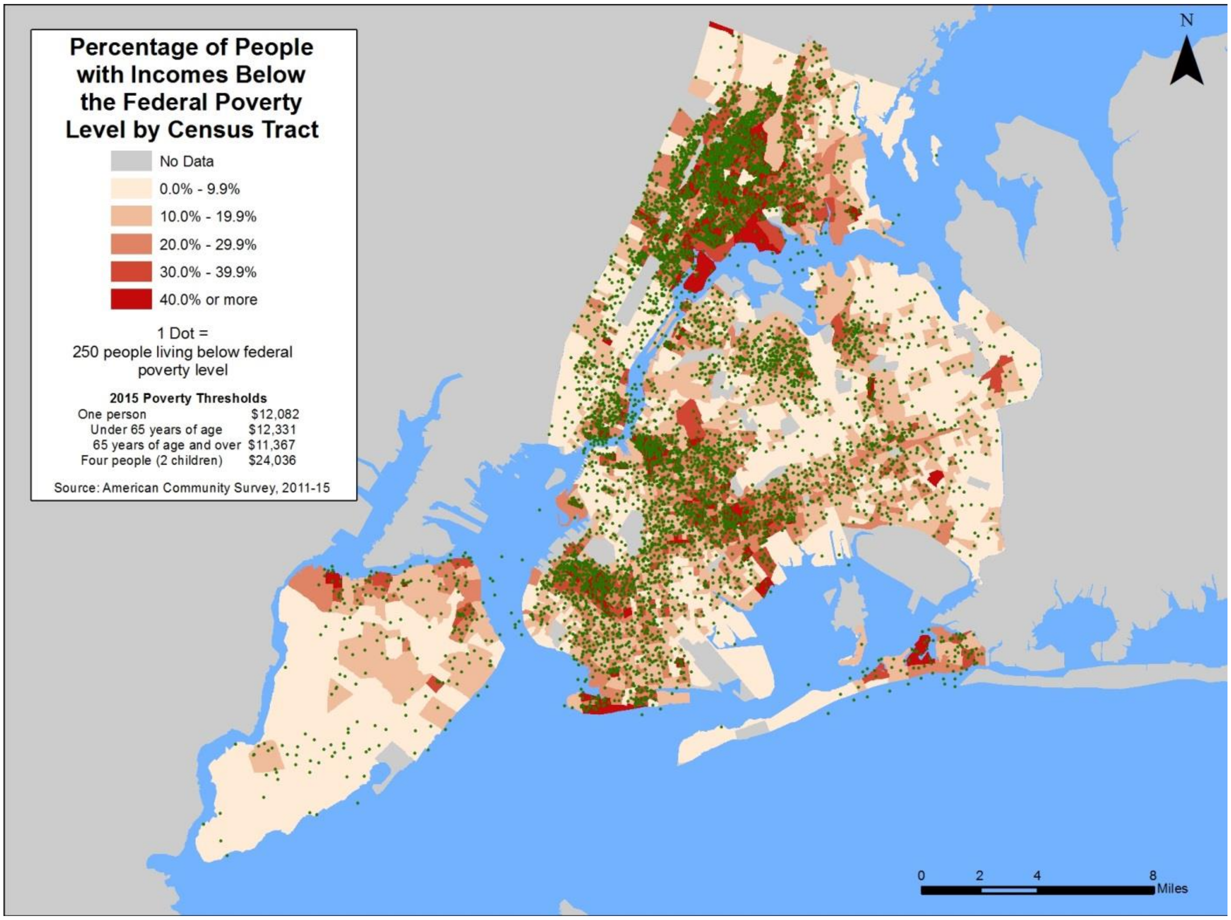
Based on the latest available Census data, 20 percent of NYC residents are living below the federal poverty level (almost 1.7 million people, which, for reference, is greater than the entire population of Philadelphia). This is significantly higher than the national poverty rate of 14.7 percent, despite similar MHI levels for NYC and the U.S. as a whole. As shown in Table 9-8, across the NYC boroughs, poverty rates vary from 14.4 percent in Staten Island to 30.4 percent in the Bronx.

Table 9-8. NYC Poverty Rates

Location	Percentage of Residents Living Below the Federal Poverty Level
United States	14.7
New York City	20.0
Bronx	30.4
Brooklyn	22.3
Manhattan	17.6
Queens	13.8
Staten Island	14.4

Source: U.S. Census Bureau 2015 ACS 1-Year Estimates.

Figure 9-5 shows that poverty rates also vary across neighborhoods, with several areas in NYC having a relatively high concentration of people living below the federal poverty level. Each green dot represents 250 people living in poverty. While poverty levels are highly concentrated in some areas, smaller pockets of poverty exist throughout NYC. Because an RI that relies on MHI alone fails to capture these other indicators of economic distress, two cities with similar MHI could have disparate levels of poverty.

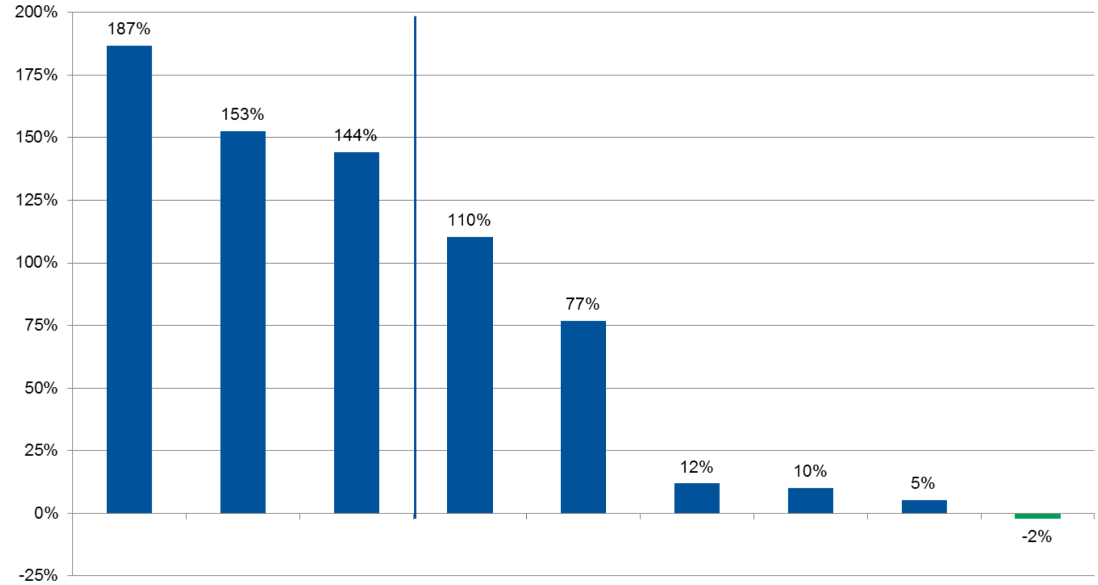


Source: U.S. Census Bureau 2011-2015 ACS 5-Year Estimates

Figure 9-5. Poverty Clusters and Rates in NYC

9.6.e.4 Cost of Living and Housing Burden

NYC residents face relatively high costs for nondiscretionary items (e.g., housing, utilities) compared to individuals living almost anywhere else in the nation, as shown in Figure 9-6. While water costs are slightly less than the average for other major United States cities, the housing burden is significantly higher.



	Apartment Rental	Condo/Co-op Sale	1- to 3-Family Home Sale	Electricity	Utility (Natural) Gas	Internet	Heating Oil (Fuel Oil #2)	Unleaded Gasoline	Water & Wastewater
	(average monthly rent)	(median per sale)	(median per sale)	(average per year; 6,000 kwh)	(average per year)	(average per year, 25-50 Mbps)	(average per gallon)	(average per gallon)	(average per year; 80,000 gallons)
NYC	$3,223	$516,000	$510,000	$1,741	$1,269	$795	$3.10	$2.22	$1,025
U.S. Cities	$1,124	$204,300	$208,900	$828	$718	$711	$2.81	$2.11	$1,048

Source: Wall Street Journal and New York Times (apartment rental); The Real Estate Board of New York and National Association of Realtors (condo/co-op and 1-3 family home sale); Consolidated Edison and U.S. Bureau of Labor Statistics "BLS" (electricity); National Grid and American Gas Association (natural gas); The Open Technology Institute (internet); New York State Energy Research and Development Authority and U.S. BLS (heating oil); U.S. BLS (gasoline); NYC FY 2015 Water and Wastewater Rate Report (water & wastewater)

Figure 9-6. Comparison of Costs between NYC and other U.S. Cities

Approximately 68 percent of all households in NYC are renter-occupied, compared to about 37 percent of households nationally. In recent years, affordability concerns have been compounded by the fact that gross median rents in NYC have increased, while median renter income has declined. Although renter households may not directly receive water and wastewater bills, these costs are often indirectly passed on to them in the form of rent increases. Increases in water and sewer costs that are born by landlords and property owners could also indirectly impact tenants, as it may limit the ability to perform necessary maintenance. Although it can be difficult to discern precisely how much the water and sewer rates impact every household, particularly those in multi-family buildings and affordable housing units, EPA's 1997 Guidance requires that all households in the service area be identified and used to establish an average cost per household for use in financial capability and affordability analyses. This LTCP financial capability assessment applies a lower average annual wastewater bill for households in multi-family buildings, due to a lower annual consumption value as compared to single-family households, and also examines average consumption across the board.

Most government agencies consider housing costs of between 30 percent and 50 percent of household income to be a moderate burden in terms of affordability; costs greater than 50 percent of household income are considered a severe burden.

A review of 2015 ACS Census data shows approximately 18 percent of NYC households (over 176,000 households) spent between 30 percent and 50 percent of their income on housing, while about 19 percent (almost 184,000 households) spent more than 50 percent. This compares to 14 percent of households nationally that spent between 30 percent and 50 percent of their income on housing and 10 percent of households nationally that spent more than 50 percent. This means that 36 percent of households in NYC versus 24 percent of households nationally spent more than 30 percent of their income on housing costs.

New York City Housing Authority (NYCHA) is responsible for 177,634 affordable housing units, which accounts for 9 percent of the total renter households in NYC. NYCHA paid approximately $188M for water and wastewater in FY2016. This total represents approximately 5.6 percent of its $3.38B operating budget. More than 90 percent of NYCHA billings are calculated under the Multi-family Conservation Program (MCP) rate. Even a small increase in rates could potentially impact the agency's ability to provide affordable housing and/or other programs and, in recent years, NYCHA has experienced funding cuts and operational shortfalls, further exacerbating its operating budget.

In sum, the financial capability assessment for NYC must look beyond the EPA 1997 Guidance, and must additionally consider the socioeconomic conditions discussed in this section including NYC's income distribution, water and wastewater rate impacts on households with income below the median level, poverty rates, housing costs, total tax burden, and long-term debt. Because many utilities provide both drinking and wastewater services and households often pay one consolidated bill, financial capability and affordability must consider total water and wastewater spending. Scheduling and priorities for future spending should consider the data presented here and below with respect to historical and future commitments.

9.6.f Background on Historical DEP Spending

As the largest water and wastewater utility in the nation, DEP provides over a billion gallons of drinking water daily to more than eight million NYC residents, visitors and commuters, as well as to one million upstate customers. DEP maintains over 2,000 square miles of watershed comprised of 19 reservoirs, three controlled lakes, several aqueducts, and 6,600 miles of water mains and distribution pipes. DEP also collects and treats wastewater. Averaged across the year, the system treats approximately 1.3 billion gallons of wastewater per day collected through 7,500 miles of sewers, 95 pumping stations and 14 in-NYC WWTPs. During wet-weather conditions, the system can treat up to 3.5 billion gallons per day of combined storm and sanitary flow. In addition to its WWTPs, DEP also has four CSO storage facilities. In 2010, DEP launched a 20-year, $2.4B GI program, of which $1.5B will be funded by DEP, with the remainder funded through private partnerships.

9.6.f.1 Historical Capital and Operations and Maintenance Spending

As shown in Figure 9-7, from FY2007 through FY2016, 51 percent of DEP's capital spending was for wastewater and water mandates. Figure 9-8 identifies associated historical wastewater and water operating expenses from FY2007 through FY2016, which have generally increased over time reflecting the additional operational costs associated with NYC's investments. Many projects have been important investments that safeguard our water supply and improve the water quality of our receiving waters in the Harbor and its estuaries. These mandates and associated programs are described below.

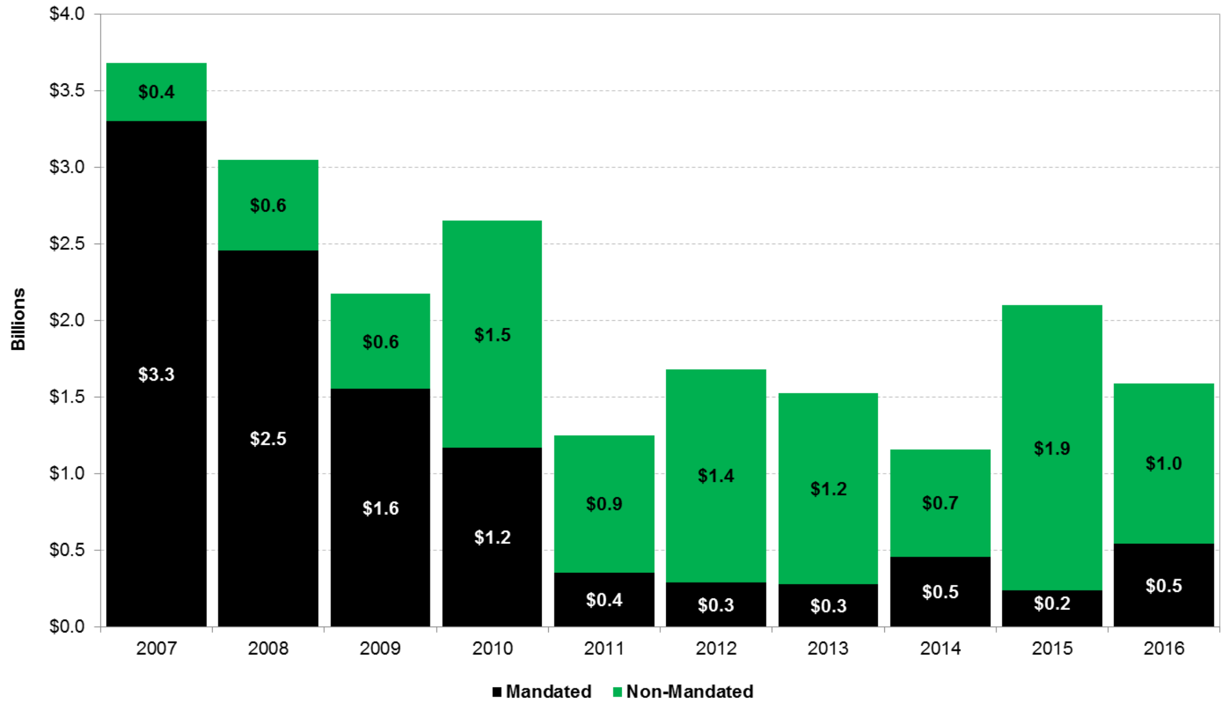


Figure 9-7. Historical Capital Commitments

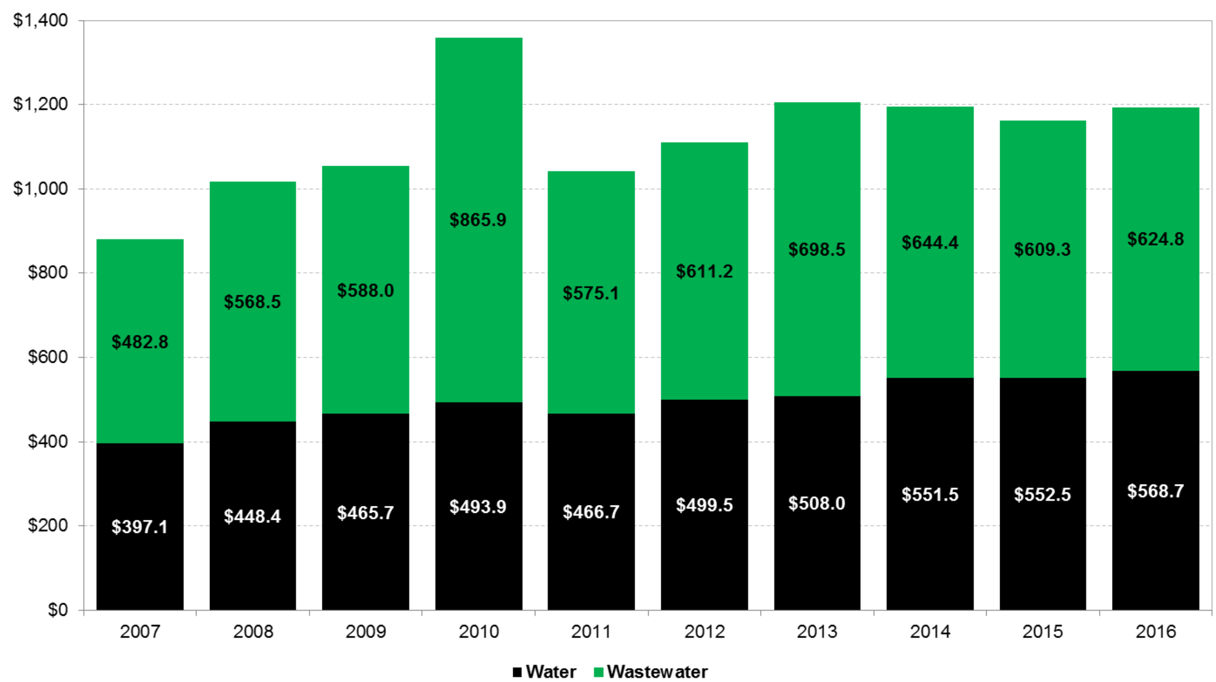


Figure 9-8. Historical Operating Expenses

9.6.f.2 Wastewater Mandated Programs

DEP is subjected to multiple mandates to comply with federal and state laws and permits. The following wastewater programs and projects represent a few of the more significant projects that have been initiated, but is not an exhaustive list of all currently mandated projects:

- CSO Abatement and Stormwater Management Programs

  DEP has initiated a number of projects to reduce CSOs, including construction of CSO abatement facilities, optimization of the wastewater system to reduce the volume of CSO discharge, controls to prevent floatables and debris that enters the combined wastewater system from being discharged, dredging of CSO sediments that contribute to low DO and poor aesthetic conditions, and other water quality-based enhancements to enable attainment of the WQS. These initiatives impact both the capital investments that DEP must make, and its O&M expenses. Historical commitments and those currently in DEP's ten-year capital plan for CSOs are estimated to cost $4.4B. DEP expects that additional investments in stormwater controls will be required of it, as they will be for other NYC agencies, pursuant to MS4 requirements.

- Biological Nitrogen Removal

  In 2006, NYC entered into a Consent Judgment with DEC, which required DEP to upgrade five WWTPs to reduce nitrogen discharges and comply with draft SPDES nitrogen limits. Pursuant to a modification and amendment to the Consent Judgment in 2011, DEP agreed to upgrade three additional WWTPs and to install additional nitrogen controls at one of the WWTPs included in the original Consent Judgment. As in the case of CSOs and stormwater, these initiatives include capital investments made by DEP (over $1B to-date and an additional $107M in the 10-year capital plan) as well as O&M expenses. (Chemicals alone in FY2017 are estimated to be about $16M per year.)

- Wastewater Treatment Plant Upgrades

  The Newtown Creek WWTP has been upgraded to secondary treatment pursuant to the terms of a Consent Judgment with DEC. The total cost of the upgrade is estimated to be $5B. In 2011, DEP certified that the Newtown Creek WWTP met the effluent discharge requirements of the CWA, bringing all 14 WWTPs into compliance with the secondary treatment requirements.

9.6.f.3 Drinking Water Mandated Programs

Under the federal Safe Drinking Water Act (SDWA) and the New York State Sanitary Code, water suppliers are required to either filter their surface water supplies or obtain and comply with a determination from EPA that allows them to avoid filtration. In addition, EPA promulgated a rule known as Long Term 2 (LT2) that required that unfiltered water supplies receive a second level of pathogen treatment (e.g., ultraviolet [UV] treatment in addition to chlorination) by April 2012. LT2 also requires water suppliers to cover or treat water from storage water reservoirs. The following DEP projects have been undertaken in response to these mandates:

- Croton Watershed - Croton Water Treatment Plant

  Historically, NYC's water has not been filtered because of its good quality and long retention times in reservoirs. However, more stringent federal standards relating to surface water treatment resulted in a federal court consent decree, which mandated the construction of a full-scale water treatment facility to filter water from NYC's Croton watershed. Construction on the Croton Water Treatment Plant began in late 2004, and the facility began operating in 2015. To-date, DEP has spent roughly $3.2B in capital costs. Since commencement of operations, DEP is also now incurring annual expenses for labor, power, chemicals, and other costs associated with plant O&M. For FY2015, O&M costs are estimated to be about $12M.

- Catskill/Delaware Watershed - Filtration Avoidance Determination

  Since 1993, DEP has been operating under a series of Filtration Avoidance Determinations (FADs), which allow NYC to avoid filtering surface water from the Catskill and Delaware systems. In 2007, EPA issued a new FAD (2007 FAD), which requires NYC to take certain actions over a ten-year period to protect the Catskill and Delaware water supplies. In 2014, the DOH issued mid-term revisions to the 2007 FAD. Additional funding was added to the Capital Improvement Plan (CIP) to support these mid-term FAD revisions. DEP has committed about $1.7B to-date and anticipates that expenditures for the next FAD will amount to $900M.

- UV Disinfection Facility

  In January 2007, DEP entered into an Administrative Consent Order (UV Order) with EPA pursuant to EPA's authority under LT2 requiring DEP to construct a UV facility by 2012. Since late 2012, water from the Catskill and Delaware watersheds has been treated at DEP's new UV disinfection facility in order to achieve Cryptosporidium inactivation. To-date, capital costs committed to the project amount to $1.6B. DEP is also incurring related annual expenses for property taxes, labor, power, and other costs related to plant O&M. FY2016 O&M costs were $23M, including taxes.

9.6.f.4 Other: State of Good Repair Projects

In addition to mandated water and wastewater programs, DEP has invested in critical projects related to maintenance and repair of its assets and infrastructure.

9.6.f.5 Initiatives to Reduce Operational Expenditures

To mitigate rate increases, DEP has diligently managed operating expenses and has undertaken an agency-wide program to review and reduce costs and to improve the efficiency of the agency's operations. DEP has already implemented changes through this program that will result in a financial benefit of approximately $98.2M in FY2016.

9.6.g History of DEP Water and Sewer Rates

9.6.g.1 Background on DEP Rates

The NYC Water Board is responsible for setting water and wastewater rates sufficient to cover the costs of operating NYC's water supply and wastewater systems (the System). Water supply costs include those associated with water treatment, transmission, distribution, and maintaining a state of good repair. Wastewater service costs include those associated with wastewater conveyance and treatment, stormwater service, and maintaining a state of good repair. The NYC MWFA issues revenue bonds to finance NYC's water and wastewater capital programs, and the costs associated with debt service consume a significant portion of the system revenues. As shown in Figure 9-9, increases in capital expenditures have resulted in increased debt. While confirmed expenditures may decline over the next few years, debt service continues to be on the rise in future years, and will continue to do so with future spending commitments. In FY2016, debt service represented a large percentage (approximately 44 percent) of the System's operating budget.

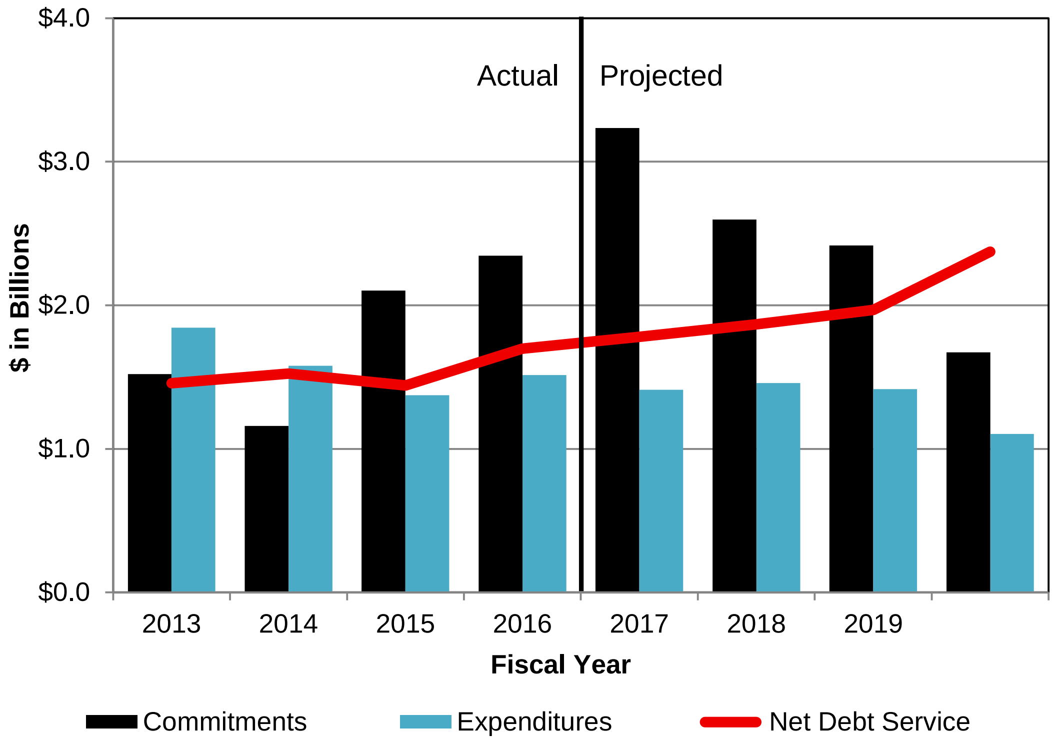


Figure 9-9. Past Costs and Debt Service

For FY2017, most customers will be charged a proposed uniform water rate of $0.51 per 100 gallons of water. Wastewater charges are levied at 159 percent of water charges ($0.81 per 100 gallons). These are the same as FY2016 rates. A small percentage of properties are billed a fixed rate. Under the MCP, some properties are billed at a fixed per-unit rate if they comply with certain conservation measures. Some non-profit institutions are also granted exemptions from water and wastewater charges on the condition that their consumption is metered and falls within specified consumption threshold levels. Select properties can also be granted exemption from wastewater charges (i.e., pay only for water services) if they can prove that they do not burden the wastewater system (e.g., they recycle wastewater for subsequent use on-site).

9.6.g.2 Historical Rate Increases to meet Cost of Service

Figure 9-10 shows how water and sewer rates have increased over time and how that compares with system demand and population. Despite a rise in population, water consumption rates have been falling since the 1990s due to metering and increases in water efficiency measures. The increase in population has not kept pace with the increase in the cost of service associated with DEP's capital commitments over the same time period. Furthermore, the total cost of service is spread across a smaller demand number due to the decline in consumption rates. As a result, DEP has had to increase its rates to meet the cost of service. DEP operations are funded almost entirely through rates paid by our customers. From FY2000 to FY2017, water and sewer rates have risen 193 percent, almost tripling. This is despite the fact that DEP has diligently reduced operating costs and improved the efficiency of the agency's operations

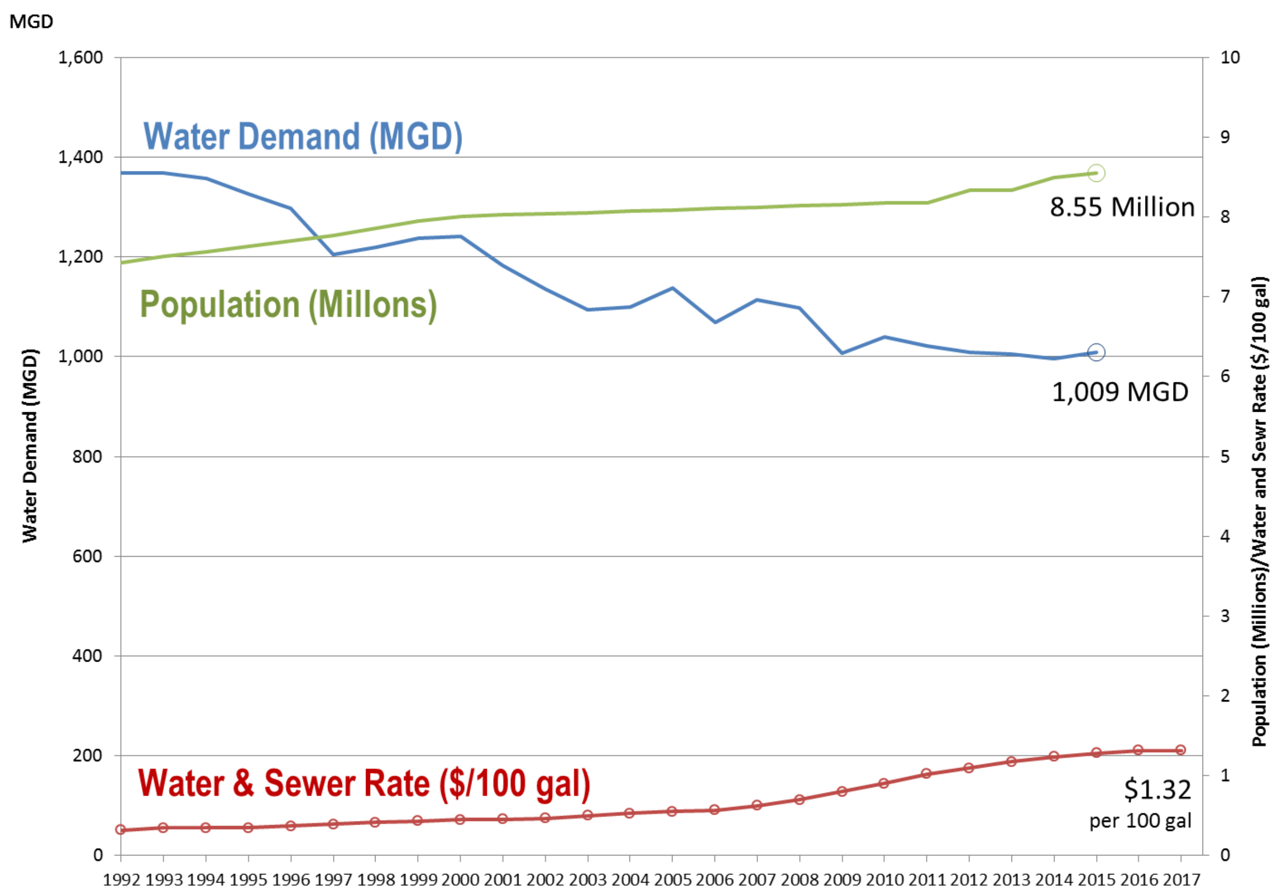


Figure 9-10. Population, Consumption Demand, and Water and Sewer Rates over Time

9.6.g.3 Customer Assistance Programs

Several programs provide support and assistance for customers in financial distress, and DEP continues to expand these programs. The Safety Net Referral Program uses an existing network of NYC agency and not-for-profit programs to help customers with financial counseling, low-cost loans, and legal services. The Water Debt Assistance Program provides temporary water debt relief for qualified property owners who are at risk of mortgage foreclosure. While water and wastewater charges are a lien on the property served, and NYC has the authority to sell these liens to a third party (lienholder) in a process called a lien sale, DEP offers payment plans for customers who may have difficulty paying their entire bill at one time. DEP and the Water Board also recently created a Home Water Assistance Program to assist low-income homeowners. For this program, DEP partnered with the NYC Human Resources Administration, which administers the Federal Home Energy Assistance Program (HEAP), and DOF, which provides tax exemptions to senior and disabled homeowners, to identify low-income homeowners who receive HEAP assistance and/or tax exemptions and, thus, are automatically eligible to receive a credit on their DEP bill. DEP is proposing to expand HWAP to include as many as 68,200 additional seniors with annual income of less than $50,000 based on DOF verification (approximately 14 percent of total accounts).

In addition, approximately 58.5 percent of NYCHA customers are on the MCP and pay a flat fee, provided they implement certain conservation measures. There is also a proposed Multi-family Water Assistance Program for Affordable Housing, where a $250 credit per housing unit would be issued for qualified projects identified by the NYC Housing Preservation and Development. The credit reflects 25 percent of the MCP rate, on which many of the eligible properties are billed. Up to 40,000 housing units will receive this credit, providing $10M of assistance. The proposals to expand these customer assistance programs have not yet been approved.

9.6.h Future System Investment

Over the next decade, the percentage of mandated project costs already identified in the CIP is anticipated to decrease, but DEP will be funding critical state of good repair projects and other projects needed to maintain NYC's infrastructure to deliver clean water and treat wastewater. Accordingly, as of September 2016, DEP's capital budget for FY2016 through FY2026 is $17.6B. This budget includes projected capital commitments averaging $1.7B per year through FY2026, which is similar to the average spending from FY2007 through FY2016 shown in Figure 9-7 above. In addition, DEP anticipates that there will be additional mandated investments as a result of MS4 compliance, proposed modifications to DEP's in-City WWTP SPDES permits, Superfund remediation, and the 2014 CSO BMP Order. It is also possible that DEP will be required to construct a cover for Hillview Reservoir, as well as other additional wastewater and drinking water mandates. This additional spending is identified as encouraged by the EPA financial capability assessment guidance to create a more accurate and complete picture of NYC's financial capability. Additional details for anticipated future mandated and non-mandated programs are provided below.

9.6.h.1 Potential or Unbudgeted Wastewater Regulations

- Municipal Separate Storm Sewer System (MS4) Permit Compliance

  DEC issued a citywide MS4 permit to NYC for all City agencies, effective on August 1, 2015, that covers NYC's municipal separate stormwater system.

DEP is required to coordinate efforts with other NYC agencies and to develop a stormwater management program plan for NYC to facilitate compliance with the permit. This plan will include the necessary legal authority to implement and enforce the stormwater management program, and will develop enforcement and tracking measures and provide adequate resources to comply with the MS4 permit. Some of the stormwater control measures identified through this plan may result in increased costs to DEP, and those costs will be more clearly defined upon completion of the plan. The permit also requires NYC to conduct fiscal analysis of the capital and O&M expenditures necessary to meet the requirements of this permit, including any required development, implementation and enforcement activities, within three years of the effective permit date.

The full MS4 permit compliance costs are yet to be estimated. DEP's annual historic stormwater capital and O&M costs have averaged $131.6M. However, given the more stringent requirements in the MS4 permit, future MS4 compliance costs are anticipated to be significantly higher than DEP's current stormwater program costs. The future compliance costs will also be shared by other NYC agencies that are responsible for managing stormwater. The projected cost for stormwater and CSO programs in other major urban areas such as Philadelphia and Washington, D.C. are $2.4B and $2.6B, respectively. According to preliminary estimates completed by Washington District Department of Environment, the MS4 cost could be $7B (green build-out scenario) or as high as $10B (traditional infrastructure) to meet the TMDLs. In FY2014, Philadelphia reported $95.4M for MS4 spending, whereas Washington, D.C. reported $19.5M as part of these annual reports (Philadelphia, 2014; Washington, D.C., 2014).

Existing data for estimating future NYC MS4 compliance costs is limited. Based on estimates from other cities, stormwater retrofit costs are estimated between $25,000 and $35,000 per impervious acre on the low end, to between $100,000 and $150,000 on the high end. Costs would vary based on the type and level of control selected. For the purposes of this analysis, a stormwater retrofit cost of $35,000 per impervious acre was assumed, which results in estimated MS4 compliance costs of about $2B for NYC.

- SPDES Permit Compliance

  On November 1, 2015, newly modified SPDES permits for DEP's 14 WWTPs went into effect. These modifications to the SPDES permits may have significant monetary impacts to DEP and include the following requirements:

  - New effluent ammonia limits at many WWTPs, which may require upgrades at the North River, 26th Ward, and Jamaica WWTPs.

  - Monthly sampling for free cyanide with results submitted in report form to DEC. After review, DEC may reopen the permits to add a limit or action level for free cyanide.

  - Beginning three years from the effective date of the Permit (11/01/2018), maintain and implement an Asset Management Plan (AMP) covering DEP's WWTPs, pumping stations, and CSO control facilities to prioritize the rehabilitation and replacement of capital assets that comprise the AMP Treatment System.

- Develop, implement, and maintain a Mercury Minimization Program (MMP). The MMP is required because the 50 nanograms/liter (ng/L) permit limit exceeds the statewide water quality-based effluent limit (WQBEL) of 0.70 ng/L for Total Mercury. The goal of the MMP will be to reduce mercury effluent levels in pursuit of the WQBEL.

- DEC has also advised DEP that fecal coliform, which is the parameter that has been historically used to evaluate pathogen kills and chlorination performance/control, will be changing to enterococcus in accordance with the requirements under the EPA RWQC. This change could result in additional compliance costs.

- The BMPs for CSOs section of the permit has been revised as follows:

  - Additional requirements related to DEP's CSOs to maximize flow were added to the permit as a new Additional CSO BMP Special Condition section, as required pursuant to the 2014 CSO BMP Order. The SPDES Additional CSO Special Conditions include monitoring of any CSOs from specified regulators, reporting requirements for bypasses, and providing notification of equipment out-of-service at the WWTPs during rain events. DEP to assess compliance with requirements to "Maximize Flow to the WWTP" using CSO data from key regulators and to identify options for reducing or eliminating CSOs that occur prior to the WWTP achieving twice design flow. A schedule for reasonable and cost-effective options that can be completed within two years must be submitted to DEC for review and approval. Other projects that cannot be completed within two years shall be considered as part of the LTCP process. The costs for compliance for this new permit requirement have not yet been determined, but DEP expects this program will require the expenditure of additional capital and expense dollars.

- Total Residual Chlorine (TRC) Consent Order

  As part of the TRC Consent Order effective October 8, 2015, DEP is required to construct alternate disinfection at six WWTPs. In addition, following completion of ambient water quality monitoring for TRC, DEP may also need to develop TRC Facility Plans for the WWTPs that may require further upgrades to disinfection to comply with the TRC SPDES limit.

- Superfund Remediation

  Two major Superfund sites in NYC may affect DEP's Long Term Control Plans, and are at different stages of investigation. The Gowanus Canal Remedial Investigation/Feasibility Study (RI/FS) is complete, and remedial design work will take place in the next three to five years. Completion of the Newtown Creek RI/FS is anticipated for 2018.

  DEP's ongoing costs for these projects are estimated to total approximately $50-60M for the next ten years, excluding design or construction costs. EPA's selected remedy for the Gowanus Canal requires that NYC build two combined sewage overflow retention tanks. Potential Superfund costs for the Gowanus Canal total approximately $825M. Similar Superfund mandated CSO controls at Newtown Creek could add costs of over $1B.

9.6.h.2 Potential, Unbudgeted Drinking Water Regulation

- Hillview Reservoir Cover

  LT2 also mandates that water from uncovered storage facilities, including DEP's Hillview Reservoir, be treated or that the reservoir be covered. DEP has entered into an Administrative Order with the NYSDOH and an Administrative Order with EPA, both of which mandate NYC to begin work on a reservoir cover by the end of January 2017. In August 2011, EPA announced that it would review LT2 and its requirement to cover uncovered finished storage reservoirs such as Hillview. DEP has spent significant funds analyzing water quality, engineering options, and other matters relating to the Hillview Reservoir. Potential costs affiliated with construction are estimated to be $1.6B. EPA expects to formalize a decision regarding the LT2 review by the end of 2016. DEP submitted a request to EPA in April 2013 for suspension of the January 2017 milestone. This request was made to avoid use of limited resources for a contract that may be rescheduled or eliminated pending the outcome of the LT2 review. DEP has not yet received a response to this request.

9.6.h.3 Other: State of Good Repair Projects and Sustainability/Resiliency Initiatives

Wastewater Projects

- Climate Resiliency

  In October 2013, on the first anniversary of Hurricane Sandy, DEP released the NYC Wastewater Resiliency Plan, the nation's most detailed and comprehensive assessment of the risks that climate change poses to a wastewater collection and treatment system. The groundbreaking study, initiated in 2011 and expanded after Hurricane Sandy, was based on an asset-by-asset analysis of the risks from storm surge under new flood maps at all 14 WWTPs and 58 of NYC's pumping stations, representing more than $1B in infrastructure.

  DEP estimates that it will spend $407M in cost-effective upgrades at these facilities to protect valuable equipment and to minimize disruptions to critical services during future storms. It is estimated that investing in these protective measures today will help protect this infrastructure from over $2B in repeated flooding losses over the next 50 years. DEP is currently pursuing funding through the EPA State Revolving Fund Storm Mitigation Loan Program for these upgrades.

  DEP will coordinate this work with the broader coastal protection initiatives, such as engineered barriers and wetlands, described in the 2013 report, "A Stronger, More Resilient New York," and continue to implement the energy, drinking water, and drainage strategies identified in the report to mitigate the impacts of future extreme events and climate change. This includes ongoing efforts to reduce CSOs with GI as part of LTCPs and build-out of high level storm sewers that reduce both flooding and CSOs. It also includes build-out of storm sewers in areas of Queens with limited drainage and continued investments and build-out of the Bluebelt system.

- Energy projects at WWTPs

  NYC's blueprint for sustainability, PlaNYC 2030: A Greener, Greater New York, set a goal of reducing NYC's greenhouse gases (GHG) emissions from 2006 levels by 30 percent. This goal was codified in 2008 under Local Law 22. In April 2015, NYC launched an update to PlaNYC called One New York: The Plan for a Strong and Just City (OneNYC), which calls for reducing NYC's greenhouse gas emissions by 80 percent below 2005 levels by 2050. In order to meet the OneNYC goal, DEP is working to reduce energy consumption and GHG emissions through reduction of fugitive methane emissions; investment in cost-effective, clean energy projects; and investment in energy efficiency improvements. DEP has approximately $732M allocated in its CIP to make additional system repairs to flares, digester domes, and digester gas piping, in order to maximize capture of fugitive emissions for beneficial use or flaring. A 12 megawatt cogeneration and electrification system is currently in design for the North River WWTP and is estimated to be in operation in winter 2020. The total project cost is estimated at $271M. To reduce energy use and increase energy efficiency, DEP has completed energy audits at all 14 in-City WWTPs. Close to 150 energy conservation measures (ECMs) relating to operational and equipment improvements to aeration, boilers, dewatering, digesters, heating, ventilation and air conditioning, electrical, thickening, and main sewage pumping systems have been identified and accepted for implementation. Energy reductions from these ECMs have the potential to reduce greenhouse gas emissions by over 160,000 metric tons of carbon emissions at an approximate cost of $140M.

Water Projects

- Water for the Future

  In 2011, DEP unveiled Water for the Future, a comprehensive program to permanently repair the leaks in the Delaware Aqueduct, which supplies half of New York's drinking water. Based on a 10-year investigation and more than $200M of preparatory construction work, DEP is designing a bypass for a section of the Delaware Aqueduct in Roseton and internal repairs for a tunnel section in Wawarsing. Since DEP must shut down the Aqueduct when it is ready to connect the bypass tunnel, DEP is also working on projects that will supplement NYC's drinking water supply during the shutdown, such as implementing demand reduction initiatives, such as offering a toilet replacement program, replacing municipal fixtures, and providing demand management assistance to the wholesale customers located north of NYC. Construction of the shafts for the bypass tunnel is underway, and the project will culminate with the connection of the bypass tunnel in 2022. The cost for this project is estimated to be approximately $1.5B.

- Gilboa Dam

  DEP is currently investing in a major rehabilitation project at Gilboa Dam at Schoharie Reservoir. Reconstruction of the dam is the largest public works project in Schoharie County, and one of the largest in the entire Catskills. The rehabilitation of Gilboa Dam is part of an approximately $451M program to build and improve other facilities near the dam.

- Kensico Eastview Connection 2

  To ensure the resilience and provide critical redundancy of infrastructure in NYC's water supply system, DEP will be constructing a new tunnel between the Kensico Reservoir and the Ultraviolet Disinfection Facility. The cost for this project is estimated at approximately $1.24B.

- Activation of City Tunnel No. 3 Brooklyn/Queens

  The Brooklyn/Queens leg of City Tunnel No. 3 is a 5.5-mile section in Brooklyn that connects to a 5-mile section in Queens. The project is scheduled for completion in the 2020s. When activated, the Brooklyn/Queens leg will deliver water to Staten Island, Brooklyn, and Queens and provide critical redundancy in the system. This project is estimated at $696M.

9.6.i Potential Impacts of CSO LTCPs to Future Household Costs

As previously discussed, DEP is facing significant future wastewater spending commitments associated with several regulatory compliance programs. This section presents the anticipated CSO LTCP implementation costs for NYC and describes the potential resulting impacts to future household costs for wastewater service, when coupled with DEP's current and future investments. As described below, estimating the future rate and income increases through 2042 based on the cumulative impacts of this investment and DEP's other future spending, up to 52 percent of households could pay two percent or more of their income for wastewater services. The information in this section will be refined in future LTCP waterbody submittals.

9.6.i.1 Estimated Costs for Waterbody CSO Preferred Alternative

As discussed in Section 8.8, the preferred LTCP alternative for Flushing Bay is a 25 MG CSO Storage Tunnel which will include construction of the following:

- 25 MG CSO Storage Tunnel to reduce CSO discharges to Inner Flushing Bay
- A pumping station for dewatering the tunnel following a wet weather event
- Appurtenant near-surface connecting conduits and structures

This alternative will reduce the CSO frequency by 70 percent and volume by 53 percent at Outfalls BB-006 and BB-008, with comparable reductions in floatables, bacteria and other pollutants associated with CSOs. DEP will conduct PCM to determine bacteria reduction and DO benefits from the preferred LTCP alternative.

The preferred LTCP alternative also includes management of approximately 115 impervious acres of combined sewer impervious area by implementing GI in the Flushing Bay watershed by 2030. To-date, approximately $86M has been committed to grey CSO control infrastructure in the Flushing Bay system.

The total present worth cost for the grey component of the LTCP alternative, which reflects the Probable Bid Cost and O&M costs over the projected useful life of the project, ranges from $683M to $842M.

9.6.i.2 Overall Estimated Citywide CSO Program Costs

DEP's LTCP planning process was initiated in 2012 and will advance pursuant to the 2012 CSO Order schedule and any subsequent amendments. Overall anticipated CSO program costs for NYC will be unknown until each LTCP is developed and approved. Capital costs for the LTCP preferred alternatives that have been identified to-date are presented in Table 9-9. Additionally, GI is a major component of the 2012 CSO Order. The overall GI program cost is estimated at $2.4B, of which $1.5B will be spent by DEP. The GI program costs are in addition to the grey CSO program costs and are therefore presented as a separate line item.

As illustrated in Table 9-9, from FY2002-FY2016, DEP has incurred about $2.2B for CSO control projects, and approximately $2.9B has been committed towards CSO investments from FY2017-FY2026, which could be some combination of grey, green, and treatment options. Costs associated with the LTCP process will be in addition to these investments. Estimated LTCP costs are provided in Table 9-9 for waterbodies where a LTCP has been completed. Costs for waterbodies where a LTCP has not yet been prepared will be identified in future LTCP waterbody submittals. The LTCP preferred alternatives for these waterbodies could be a mix of treatment and storage options.

Table 9-9. Committed Costs and Range of Future CSO Program Costs and Water Quality Improvements[1]

Waterbody / Watershed	Historical and Current CIP Commitments	Incurred Cost FY2002-FY2016	Committed Cost FY2017-FY2026[4]	Total Existing CSO Program Cost	LTCP Costs[5]	CSO Reductions from LTCP	
						CSO Volume Reduced (Million Gallons)	CSO Volume Treated (Million Gallons)
Alley Creek and Little Neck Bay	CSO Abatement Facilities and East River CSO	$139,131,521	$13,874,000	$153,005,521	$7,600,000	0	131
Westchester Creek	Hunts Point WWTP Headworks, Regulator Modification, Pugsley Creek Parallel Sewer	$7,800,000	$0	$7,800,000	$0	0	0
Hutchinson River	Hunts Point WWTP Headworks	$3,000,000	$112,000,000	$115,000,000	$90,000,000	0	584
Flushing Creek	Flushing Bay Corona Avenue Vortex Facility, Flushing Bay CSO Retention, Flushing Bay CSO Storage	$357,015,599	$32,981,000	$389,996,599	$6,890,000	0	82
Bronx River	Installation of Floatable Control Facilities, Hunts Point WWTP Headworks	$46,866,831	$0	$46,866,831	$110,100,000	170	0
Gowanus Canal	Gowanus Flushing Tunnel Reactivation, Gowanus Facilities Upgrade	$176,165,050	$732,310,000	$908,475,050	Included in Superfund Costs [6]	90	0
Coney Island Creek	Avenue V Pumping Station, Force Main Upgrade	$196,885,560	$0	$196,885,560	$0	0	0
Jamaica Bay	Improvements of Flow Capacity to 26th Ward Drainage Area, Hendrix Creek Canal Dredging, Shellbank Destratification, Spring Creek AWCP Upgrade, 26 Ward Wet Weather Improvements	$161,378,669	$11,156,000	$172,534,669			
Flushing Bay[2]	High Level Regulator Mods, Low Level Diversion Sewer (See Flushing Creek for Costs)	$0	$0	$0	$670,000,000	746	0
Newtown Creek	English Kills Aeration, Newtown Creek Headworks, Bending Weirs and Floatables Control	$159,639,614	$26,138,000	$185,777,614			
East River and Open Waters	Bowery Bay Headworks, Inner Harbor In-Line Storage, Port Richmond Throttling Facility, Tallman Island Conveyance Improvements, Outer Harbor CSO Regulator Improvements	$153,145,476	($69,000)	$153,076,476			
Bergen and Thurston Basins[3]	Warnerville Pumping Station and Force Main, Bending Weirs	$41,876,325	$0	$41,876,325			
Paerdegat Basin	Retention Tanks, Paerdegat Basin Water Quality Facility	$397,046,298	($2,408,000)	$394,638,298			
Green Infrastructure Program	Miscellaneous Projects Associated with Citywide Green Infrastructure Program	$348,740,089	$ 829,873,000	$1,178,613,089			
Other CSO Controls		$11,579,652	$ 1,141,477,000	$1,153,056,652			
Total Grey		$1,851,530,595	$2,067,459,000	$3,918,989,595			
Total Grey + Green		$ 2,200,270,684	$ 2,897,332,000	$5,097,602,684			

Notes:
(1) All costs reported in this table reflect estimated capital costs only (i.e., probable bid cost). Projected O&M costs are not included. Capital costs are based on estimates from December 2016.
(2) Committed costs for Flushing Bay are captured in the committed costs reported for Flushing Creek.
(3) Bergen and Thurston Basins and Paerdegat Basin are not part of the current LTCP effort; thus, no LTCP detail is provided for them.
(4) Negative values reflect de-registration of committed funds.
(5) LTCP Construction Costs are based on 2015 dollars and are not escalated out to mid-point of construction. None of the LTCPs have been approved and the costs are subject to change.
(6) Potential Superfund costs for the Gowanus Canal total approximately $825M.

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9.6.i.3 Potential Impacts to Future Household Costs

The potential future rate impacts of the possible future CSO control capital costs were determined by considering capital investments in the current CIP (FY2016-2026); estimated future DEP investments from 2027 to 2042 of $2.0B per year, which is based on DEP's proposed CIP (currently under development) average of $2.0B per year, inflated by 3 percent per year beginning in 2027; and a conceptual $5.7B in LTCP spending through 2042, a portion of which is included in the current CIP. This potential $5.7B in LTCP spending is in addition to the $4.2B in existing commitments associated with the WWFP grey CSO control projects and the citywide GI program, resulting in a potential total CSO program financial commitment of $9.9B (see Table 9-10). The cost estimates presented will evolve over the next year as the LTCPs are completed for the remaining waterbodies and will be updated as the LTCPs are completed.

Table 9-10. Financial Commitment to CSO Reduction

New York City's CSO Program	Financial Commitment ($B)
Waterbody/Watershed Facility Plan and other CSO Projects	$2.7
Green Infrastructure Program	$1.5
LTCP	$5.7(1)
Total	**$9.9**

Note:
(1) Total LTCP costs are not currently known. For conceptual purposes, up to $5.7B in LTCP spending through 2042 is assumed. Actual costs will be determined as part of the LTCP planning process.

A 4.75 percent interest rate was used to determine the estimated annual interest cost associated with the capital costs, and the annual debt service was divided by the FY2017 Revenue Plan value to determine the resulting percent rate increase. This also assumes bonds are structured for a level debt service amortization over 32 years. Note that interest rates on debt could be significantly higher in the future. For illustration purposes, future annual O&M increases and other incremental costs were estimated based on historical data.

As Table 9-11 shows, implementation of the current CIP (FY2016-2026) would result in a 69 percent rate increase by 2026. Additional potential mandates and CIP investments from 2027 to 2042 (using an average of $2.0B per year, inflated by 3 percent per year), as well as the up to $5.7B in total LTCP spending, could add an additional 175 percent. Cumulatively the rates could increase on the order of 244 percent higher than 2016 values.

Table 9-12 shows the potential range of future spending and its impact on household cost compared to MHI for the analysis years of 2016 (current conditions), 2026 (end of current CIP), and 2042 (accounts for anticipated additional spending and an assumed commitment of the total $5.7B in CSO Order and associated spending). The projected MHI for the analysis years of 2026 and 2042 was estimated by applying an annual inflation rate of 1.59 percent. This rate is based on the average annual inflation rate from 2010 to 2015 according to Consumer Price Index data for the New York Metro Area, as obtained from the Bureau of Labor Statistics. While these estimates are preliminary, it should be noted (as discussed in detail earlier in this section), that comparing household cost to MHI alone does not tell the full story since a large percentage of households below the median could be paying a larger percentage of their income on these costs.

Table 9-11. Potential Future Spending Incremental Additional Household Cost Impact

Analysis Year	Percent Incremental Rate Increase from FY 2017 Rates	Additional Annual Household Cost		
		Single-family Home	Multi-family Unit	Average Cost
2026[(1)]	69%	$732	$476	$600
2042[(2)]	175%	$1,845	$1,199	$1,512
Cumulative Total	**244%**	**$2,577**	**$1,675**	**$2,112**

Notes:

(1) Includes costs for the current $17.6B 2016-2026 CIP, which is estimated to include up to $1.8B in LTCP spending.

(2) Includes an estimated $2.0B per year in capital commitments based on DEP's proposed CIP, inflated by 3.0 percent per year for 2027-2042. Total LTCP costs are not currently known. For conceptual purposes, up to $5.7B in LTCP spending from 2017 through 2042 is assumed.

Figure 9-11 shows the average estimated household cost for wastewater services compared to household income, versus the percentage of households in various income brackets for 2016 (using FY2017 rates) and projected future rates for 2026 and 2042 (based on detail included in Table 9-11). As shown, roughly 27 percent of households are estimated to pay two percent or more of their income on wastewater service alone in 2016. Estimating the future rate and income increases to 2026 and 2042 (based on the projected costs in Table 9-11 and historic CPI data, respectively), up to 52 percent of households could be paying more than 2 percent of their income on wastewater services when all future spending scenarios would be in place – the average wastewater bill is estimated to be about 2.1 percent of MHI in 2042). This is summarized in Table 9-13.

Table 9-12. Total Estimated Cumulative Future Household Costs / Median Household Income

Year	Total Projected Annual Household Cost(1)			Projected MHI(2)	Total Water and Wastewater HH Cost / MHI			Total Wastewater HH Cost / MHI		
	Single-family Home	Multi-family Unit	Average HH Cost		Single-family Home	Multi-family Unit	Average HH Cost	Single-family Home	Multi-family Unit	Average HH Cost
2016	$1,056	$686	$865	$56,718	1.86%	1.21%	1.52%	1.14%	0.74%	0.94%
2026	$1,788	$1,162	$1,465	$66,303	2.70%	1.75%	2.21%	1.66%	1.08%	1.36%
2042	$3,633	$2,361	$2,977	$85,315	4.26%	2.77%	3.49%	2.61%	1.70%	2.14%

Notes:
(1) Projected household costs are estimated from rate increases presented in Table 9-11.
(2) Costs were compared to assumed MHI projection which was estimated using Census and Consumer Price Index data.

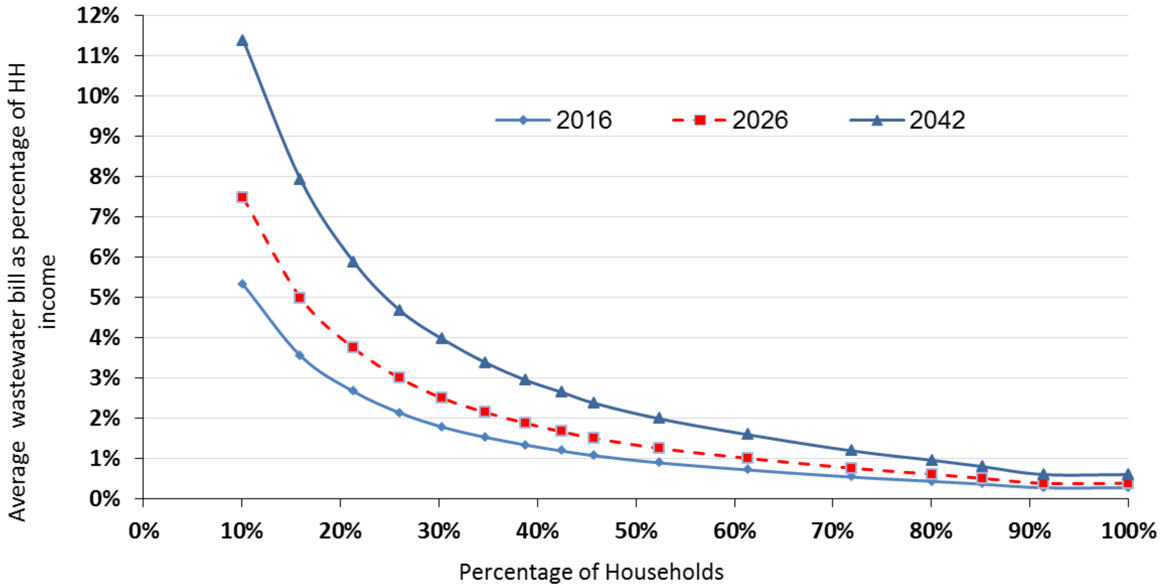

Figure 9-11. Estimated Average Wastewater Household Cost Compared to Household Income (2016, 2026, and 2042)

Table 9-13. Average Household Wastewater Bill / Income Snapshot over Time

Year	RI using Average Wastewater Cost/MHI	RI using Average Wastewater Cost/Upper Limit of Lowest Quintile	RI using Average Wastewater Cost/Upper Limit of Second Quintile	Percent of HH estimated to be paying more than 2% of HH income on Wastewater Services
2016	0.9%	2.8%	1.3%	27%
2026	1.4%	4.0%	1.8%	36%
2042	2.1%	6.4%	2.9%	52%

DEP, like many utilities in the nation, provides both water and wastewater service, and its rate payers see one bill. Currently the average combined water and sewer bill is around 1.5 percent of MHI, but approximately 20 percent of households are estimated to be paying more than 4.5 percent of their income, and that could increase to about 40 percent of households in future years by 2042 as shown in Figure 9-12.

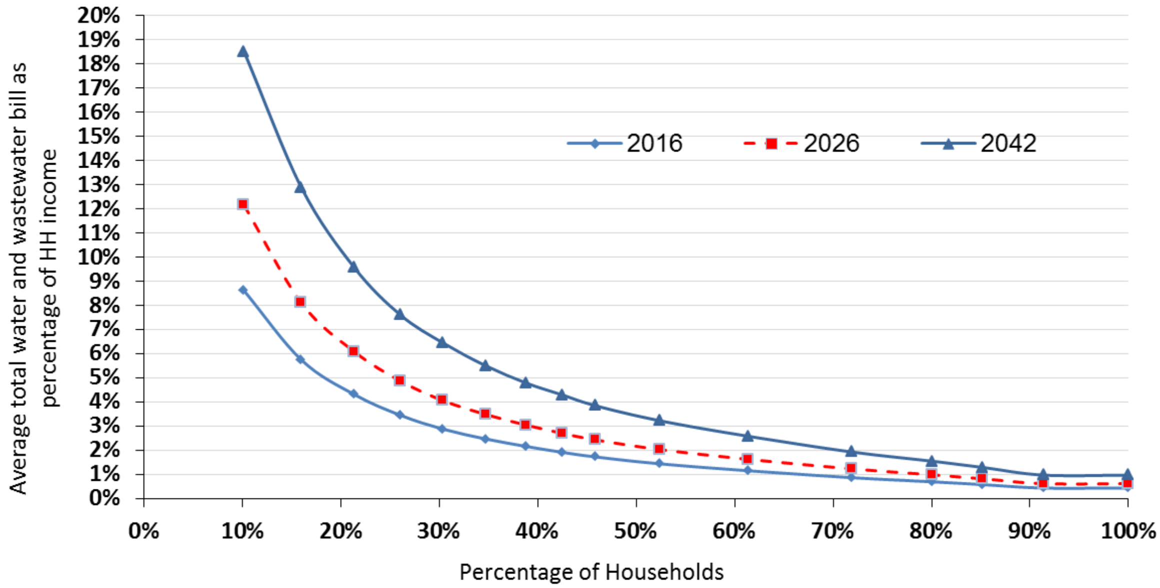

Figure 9-12. Estimated Average Total Water and Wastewater Household Cost Compared to Household Income (2016, 2026, and 2042)

9.6.j Benefits of Program Investments

DEP has been in the midst of an unprecedented period of investment to improve water quality in New York Harbor. Projects worth almost $10B have been completed or are underway since 2002 alone, including projects for nutrient removal, CSO abatement, marshland restoration in Jamaica Bay, and hundreds of other projects. In-city investments are improving water quality in the Harbor and restoring a world-class estuary while creating new public recreational opportunities and inviting people to return to NYC’s 578 miles of waterfront. A description of citywide water quality benefits resulting from previous and ongoing programs is provided below, followed by the anticipated benefits of water quality improvements to Flushing Bay resulting from implementation of the baseline projects.

9.6.j.1 Citywide Water Quality Benefits from Previous and Ongoing Programs and Anticipated Flushing Bay Water Quality Benefits

Water quality benefits have been documented in the Harbor and its tributaries resulting from the almost $10B investment that NYC has already made in grey and GI since 2002. Approximately 95 percent of the Harbor is available for boating and kayaking, and 14 of NYC’s beaches provide access to swimmable waters in the Bronx, Brooklyn, Queens and Staten Island.

Figure 9-13 shows the historical timeline of DEP’s investments in wastewater infrastructure since the CWA of 1972. Of the $10B invested since 2002, almost 20 percent has been dedicated to controlling CSOs and stormwater. That investment has resulted in NYC capturing and treating over 70 percent of the combined stormwater and wastewater that otherwise would be directly discharged to our waterways during periods of heavy rain or runoff. Projects that have already been completed include: GI projects in 26th Ward, Hutchinson River and Newtown Creek watersheds; area-wide GI contracts; Avenue V

Pumping Station and Force Main; and the Bronx River Floatables Control. Several other major projects are in active construction or design. The water quality improvements already achieved have allowed greater access of the waterways and shorelines for recreation, as well as enhanced environmental habitat and aesthetic conditions in many of NYC's neighborhoods.

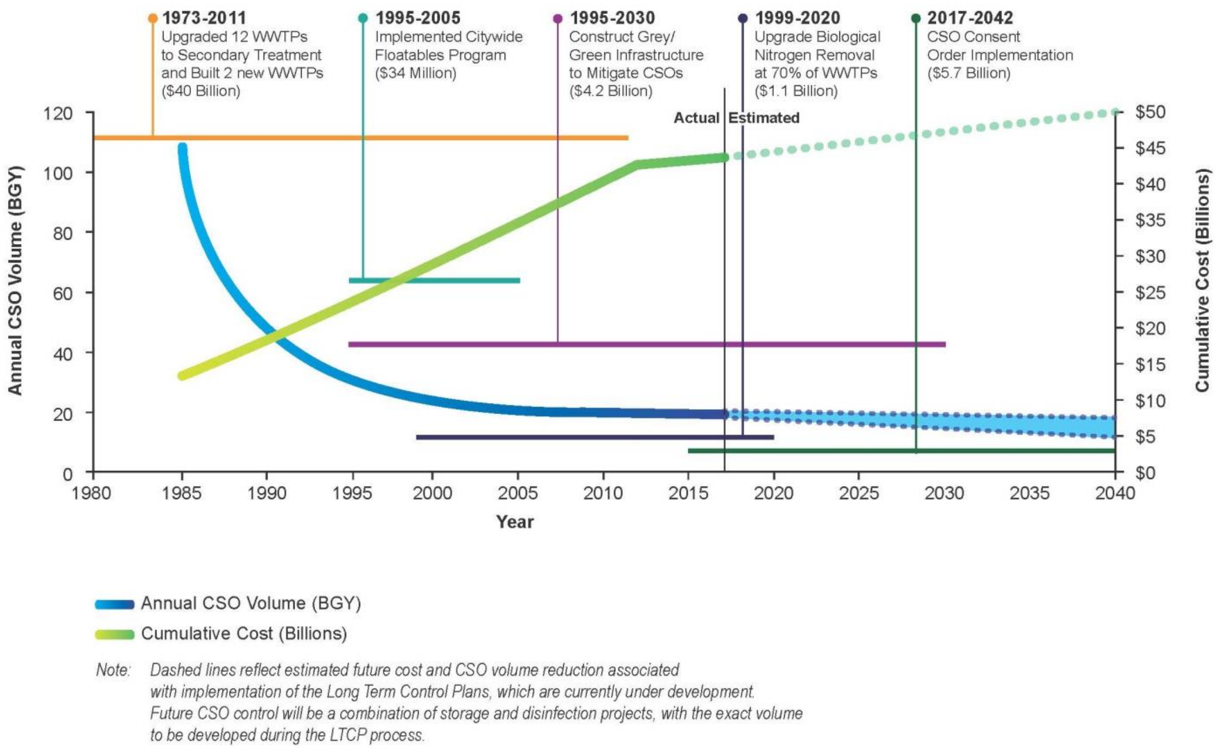

Figure 9-13. Historical Timeline for Wastewater Infrastructure Investments and CSO Reduction Over Time

Although significant investments have been made for water quality improvements Harbor-wide, more work is needed. DEP has committed to working with DEC to further reduce CSOs and make other infrastructure improvements to gain additional water quality improvements. The 2012 CSO Order between DEP and DEC outlines a combined grey and green approach to reduce CSOs. This LTCP for Flushing Bay is just one of the detailed plans that DEP is preparing to evaluate and identify additional control measures for reducing CSOs and improving water quality in the Harbor. DEP is also committed to extensive water quality monitoring throughout the Harbor which will allow better assessment of the effectiveness of the controls implemented.

As noted above, a major component of the 2012 CSO Order that DEP and DEC developed is GI stormwater control measures. DEP is targeting implementing GI in priority combined sewer areas citywide. GI will take multiple forms, including green or blue roofs, bioinfiltration systems, right-of-way bioswales, rain barrels, and porous pavement. These measures provide benefits beyond their associated water quality improvements. Depending on the measure installed, they can recharge groundwater, provide localized flood attenuation, provide sources of water for non-potable use (such as watering lawns or gardens), reduce heat island effect, improve air quality, enhance aesthetic quality, and provide recreational opportunities. These benefits contribute to the overall quality of life for residents of NYC.

A detailed discussion of anticipated water quality improvements to Flushing Bay is included in Section 8.0.

9.6.k Conclusions

As part of the LTCP process, DEP will continue to develop and refine the affordability and financial capability assessments for each individual waterbody as it works toward an expanded analysis for the citywide LTCP. In addition to what is outlined in the Federal CSO guidance on financial capability, DEP has presented in this section a number of additional socioeconomic factors for consideration in the context of affordability and assessing potential impacts to our ratepayers. Furthermore, it is important to include a fuller range of future spending obligations and DEP has presented an initial picture of that in this section. Ultimately, the environmental, social, and financial benefits of all water-related obligations should be considered when priorities for spending are developed and implementation of mandates are scheduled, so that resources can be focused where the community will get the most environmental benefit.

9.7 Compliance with Water Quality Goals

Flushing Bay is a highly productive Class I waterbody that can fully support existing uses, kayaking and wildlife propagation. Upon implementation of the WWFP, the waterbody will achieve full attainment with its current classifications for bacteria and DO criteria. Upon implementation of this LTCP, Flushing Bay will attain the Primary Contact WQ Criteria for fecal coliform annually and during the recreational season (May 1st through October 31st). DO levels largely comply with the Class SC standards except at Station OW-14, where attainment with the chronic standard is 83 percent.

The 2012 CSO Order Goal Statement stipulates that, in situations where the proposed alternatives presented in the LTCP will not achieve the CWA Section 101(a)(2) goals, the LTCP is to include a UAA. Because the analyses developed herein indicate that Flushing Bay is projected to fully attain Primary Contact Water Quality Criteria, fully attain the Existing DO Criteria and largely attain the Class SC DO Criteria, a UAA is not required under the 2012 CSO Order.

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11.0 GLOSSARY

1.5xDDWF:	One and One-half Times Design Dry Weather Flow
2xDDWF:	Two Times Design Dry Weather Flow
AACE:	Association for the Advancement of Cost Engineering
ACS:	American Community Survey
AEMLSS:	Aerator Effluent Mixed Liquor Suspended Solids
AMP:	Asset Management Plan
AWPCP:	Auxiliary Water Pollution Control Plant
BB:	Bowery Bay
BBH:	Bowery Bay High-level
BBL:	Bowery Bay Low-level
BEACH:	Beaches Environmental Assessment and Coastal Health
BGY:	Billon Gallons Per Year
BMP:	Best Management Practice
BNR:	Biological Nutrient Removal
BOD:	Biochemical Oxygen Demand
CAVF:	Corona Avenue Vortex Facility
CEG:	Cost Effective Grey
CFS:	Cubic Feet Per Second
CIP:	Capital Improvement Plan
CPK:	Central Park
CSO:	Combined Sewer Overflow
CSS:	Combined Sewer System
CWA:	Clean Water Act
DCIA:	Directly Connected Impervious Areas

DCP:	New York City Department of City Planning
DDWF:	Design Dry Weather Flow
DEC:	New York State Department of Environmental Conservation
DEP:	New York City Department of Environmental Protection
DO:	Dissolved Oxygen
DOE:	New York City Department of Education
DOF:	New York City Department of Finance
DOH:	New York State Department of Health
DOHMH:	New York City Department of Health and Mental Hygiene
DOT:	New York City Department of Transportation
DPR:	New York City Department of Parks and Recreation
DWF:	Dry Weather Flow
E. Coli:	Escherichia Coli.
EBP:	Environmental Benefit Project
ECM:	Energy Conservation Measure
EFH:	Essential Fish Habitat
EPA:	United States Environmental Protection Agency
ERTM:	East River Tributaries Model
ET:	Evapotranspiration
EWR:	Newark Liberty International Airport
FAD:	Filtration Avoidance Determination
FBM:	Flushing Bay Model
FCI:	Financial Capability Indicators
FMPV:	Full Market Property Value
FT:	Abbreviation for “Feet”
FY:	Fiscal Year

GHG:	Greenhouse Gases
GI:	Green Infrastructure
GIS:	Geographical Information System
GM:	Geometric Mean
G.O.:	General Obligation
GRTA:	NYC Green Roof Tax Abatement
HEAP:	Home Energy Assistance Program
HH:	Household
HLI	High Level Interceptor
HLSS:	High Level Storm Sewers
HRC:	High Rate Classification
HSM:	Harbor Survey Monitoring Program
HVAC:	Heating, Ventilation and Air Conditioning
HWAP:	Home Water Assistance Program
IEC:	Interstate Environmental Commission
in.:	Abbreviation for "Inches".
in/hr:	Inches per hour
IW:	InfoWorks CS™
JFK:	John F. Kennedy International Airport
KOTC:	Knee-of-the-Curve
L1OWHh:	Lacustrine, Limnetic, Open Water/Unknown Bottom, Permanent, Diked/Impounded
lbs/day:	pounds per day
lf:	Linear feet
LGA:	LaGuardia Airport
LL:	Lower level

LLI:	Low Level Interceptor
LT2:	Long Term 2
LTCP:	Long Term Control Plan
MCP:	Multifamily Conservation Program
mg/L:	milligrams per liter
MG:	Million Gallons
MGD:	Million Gallons Per Day
MHI:	Median Household Income
MLW:	Mean Low Water
MLSS:	Mixed Liquor Suspended Solids
MMP:	Mercury Minimization Program
MOU:	Memorandum of Understanding
MPN:	Most probable number
MS4:	Municipal separate storm sewer systems
MWFA:	New York City Municipal Water Finance Authority
NEIWPCC:	New England Interstate Water Pollution Control Commission
NMC:	Nine Minimum Control
NOAA:	National Oceanic and Atmospheric Administration
NPDES:	National Pollutant Discharge Elimination System
NPW:	Net Present Worth
NWI:	National Wetlands Inventory
NYC:	New York City
NYCHA:	New York City Housing Authority
NYCRR:	New York Codes, Rules and Regulations
NYS:	New York State
NYSDOT:	New York State Department of Transportation

O&M:	Operation and Maintenance
OLTPS:	Mayor's Office of Long Term Planning and Sustainability
ONRW:	Outstanding National Resource Waters
PANYNJ:	Port Authority of New York and New Jersey
PBC:	Probable Bid Cost
PCM:	Post-Construction Compliance Monitoring
POTW:	Publicly Owned Treatment Plant
PS:	Pump Station or Pumping Station
RAS:	Return Activated Sludge
RFI:	Request for Information
RI:	Residential Indicator
ROD:	Record of Decision
ROW:	Right-of-Way
ROWB:	Right-of-way bioswales
ROWRG:	Right-of-way rain gardens
RTB:	Retention Treatment Basin
RWQC:	Recreational Water Quality Criteria
S&P:	Standard and Poor
SCA:	NYC School Construction Authority
SDWA:	Safe Drinking Water Act
SGS:	Stormwater Greenstreets
SM:	Sentinel Monitoring
SNWA:	Significant Natural Waterfront Area
SPDES:	State Pollutant Discharge Elimination System
SRT:	Solid Retention Time
SSS:	Sanitary Sewer Systems

STV:	Statistical Threshold Value
SVA:	Sludge Volume Index
S.W.I.M.:	Stormwater Infrastructure Matters Coalition
SWMM:	Stormwater Management Model
SYNOP:	Synoptic Surface Plotting Models
TBD:	To Be Determined
TDA:	Tributary Drainage Area
TI:	Tallman Island
TMDL:	Total Maximum Daily Load
TN:	Total Nitrogen
TOC:	Total Organic Carbon
TPL:	Trust for Public Land
TRC:	Total Residual Chlorine
UAA:	Use Attainability Analysis
UER-WLIS:	Upper East River – Western Long Island Sound
UL:	Upper level
U.S.:	United States
USFWS:	United States Fish and Wildlife Service
USTA:	United States Tennis Association
UV:	Ultraviolet Light
WQ:	Water Quality
WQBEL:	Water Quality Based Effluent Limitations
WQS:	Water Quality Standards
WWFP:	Waterbody/Watershed Facility Plan
WWOP:	Wet Weather Operating Plan

Appendix A: Supplemental Tables

Annual CSO, Stormwater, Direct Drainage, Local Source Baseline Volumes (2008 Rainfall)

Combined Sewer Outfalls			
Waterbody	**Outfall**	**Regulator**	**Total Discharge (MG/Yr)**
Flushing Bay	BB-006	10,12,13,20,26	889
Flushing Bay	BB-007	5	38
Flushing Bay	BB-008	6,7,8,9	478
Flushing Bay	TI-012	29th Ave.	0
Flushing Bay	TI-014	67	10
Flushing Bay	TI-015	56	3
Flushing Bay	TI-016	45	29
Flushing Bay	TI-017	4	2
Flushing Bay	TI-018	3	4
		Total CSO	**1,453**

MS-4 Outfalls			
terbody	**Outfall**	**Regulator**	**Total Discharge, (MG/Yr)**
Flushing Bay	BB-601	NA	26
Flushing Bay	BB-602	NA	55
Flushing Bay	TI-670	NA	15
Flushing Bay	TI-673	NA	8
Flushing Bay	TI-672	NA	6
		Total MS-4	**110**

Stormwater Outfalls			
Waterbody	**Outfall**	**Regulator**	**Total Discharge, (MG/Yr)**
Flushing Bay	DD-601	NA	35
Flushing Bay	DD-602	NA	3
Flushing Bay	BB-519	NA	5
Flushing Bay	BB-522	NA	4
Flushing Bay	BB-524	NA	5
Flushing Bay	BB-528	NA	3
Flushing Bay	BB-532	NA	28
Flushing Bay	TI-639	NA	16
Flushing Bay	TI-641	NA	6
Flushing Bay	TI-608	NA	13
Flushing Bay	TI-013	NA	1
		Total Stormwater	**119**

Direct Runoff Outfalls			
Waterbody	**Outfall**	**Regulator**	**Total Discharge, (MG/Yr)**
Flushing Bay	BB--48	NA	87
Flushing Bay	BB--54	NA	13
Flushing Bay	BB--55	NA	11
Flushing Bay	BB--86	NA	43
Flushing Bay	TI--64	NA	4
Flushing Bay	TI--65	NA	2
Flushing Bay	TI--71	NA	1
		Total Direct Runoff	**163**

Airport Outfalls			
Waterbody	**Outfall**	**Regulator**	**Total Discharge (MG/Yr)**
Flushing Bay	BB-LG10		53
Flushing Bay	BB-LG11		19
Flushing Bay	BB-LG12		12
Flushing Bay	BB-LG13		133
Flushing Bay	BB-LGA		3
		Total Airport	**220**

Totals by Waterbody			
Waterbody	**Outfall**	**Regulator**	**Total Discharge (MG/Yr)**
Flushing Bay			2,065

Totals by Source			
Source	**Outfall**	**Regulator**	**Total Discharge (MG/Yr)**
CSO			1,453
MS-4			110
Stormwater			119
Direct Runoff			163
Airport			220

Totals by Source by Waterbody			
Waterbody	**Source**	**Percent %**	**Total Discharge (MG/Yr)**
Flushing Bay	CSO	70.4	1,453
	MS-4	5.3	110
	Stormwater	5.8	119
	Direct Runoff	7.8	163
	Airport	10.7	220
		Total	**2,065**

Annual CSO, Stormwater, Direct Drainage,
Local Sources Enterococci Loads (2008 Rainfall)

Combined Sewer Outfalls			
Waterbody	**Outfall**	**Regulator**	**Total Load (10^{12} cfu/Yr)**
Flushing Bay	BB-006	10,12,13,20,26	20,919
Flushing Bay	BB-007	5	267
Flushing Bay	BB-008	6,7,8,9	11,407
Flushing Bay	TI-012	29th Ave.	0
Flushing Bay	TI-014	67	62
Flushing Bay	TI-015	56	13
Flushing Bay	TI-016	45	120
Flushing Bay	TI-017	4	4
Flushing Bay	TI-018	3	12
		Total CSO	**32,804**

MS-4 Outfalls			
Waterbody	**Outfall**	**Regulator**	**Total Load (10^{12} cfu/Yr)**
Flushing Bay	BB-601	NA	15
Flushing Bay	BB-602	NA	31
Flushing Bay	TI-670	NA	8
Flushing Bay	TI-673	NA	4
Flushing Bay	TI-672	NA	3
		Total MS-4	**62**

Stormwater Outfalls			
Waterbody	**Outfall**	**Regulator**	**Total Load (10^{12} cfu/Yr)**
Flushing Bay	DD-601	NA	20
Flushing Bay	DD-602	NA	2
Flushing Bay	BB-519	NA	3
Flushing Bay	BB-522	NA	2
Flushing Bay	BB-524	NA	3
Flushing Bay	BB-528	NA	2
Flushing Bay	BB-532	NA	16
Flushing Bay	TI-639	NA	9
Flushing Bay	TI-641	NA	3
Flushing Bay	TI-608	NA	7
Flushing Bay	TI-013	NA	0
		Total Stormwater	**68**

Direct Runoff Outfalls			
Waterbody	**Outfall**	**Regulator**	**Total Load (10^{12} cfu/Yr)**
Flushing Bay	BB--48	NA	20
Flushing Bay	BB--54	NA	3
Flushing Bay	BB--55	NA	2
Flushing Bay	BB--86	NA	10
Flushing Bay	TI--64	NA	1
Flushing Bay	TI--65	NA	1
Flushing Bay	TI--71	NA	0
		Total Direct Runoff	**37**

Airport Outfalls			
Waterbody	**Outfall**	**Regulator**	**Total Load (10^{12} cfu/Yr)**
Flushing Bay	BB-LG10		16
Flushing Bay	BB-LG11		6
Flushing Bay	BB-LG12		4
Flushing Bay	BB-LG13		40
Flushing Bay	BB-LGA		1
		Total Airport	**66**

Totals by Waterbody			
Waterbody	**Outfall**	**Regulator**	**Total Load (10^{12} cfu/Yr)**
Flushing Bay			33,037

Totals by Source			
Source	**Outfall**	**Regulator**	**Total Load (10^{12} cfu/Yr)**
CSO			32,804
MS-4			62
Stormwater			68
Direct Runoff			37
Highway			66

Totals by Source by Waterbody			
Waterbody	**Source**	**Percent %**	**Total Load (10^{12} cfu/Yr)**
Flushing Bay	CSO	99.3	32,804
	MS-4	0.2	62
	Stormwater	0.2	68
	Direct Runoff	0.1	37
	Highway	0.2	66
		Total	**33,037**

Annual CSO, Stormwater, Direct Drainage,
Local Sources Fecal Coliform Loads (2008 Rainfall)

Combined Sewer Outfalls			
Waterbody	**Outfall**	**Regulator**	**Total Load (10^{12} cfu/Yr)**
Flushing Bay	BB-006	10,12,13,20,26	25,764
Flushing Bay	BB-007	5	1,713
Flushing Bay	BB-008	6,7,8,9	14,028
Flushing Bay	TI-012	29th Ave.	0
Flushing Bay	TI-014	67	395
Flushing Bay	TI-015	56	51
Flushing Bay	TI-016	45	741
Flushing Bay	TI-017	4	19
Flushing Bay	TI-018	3	70
		Total CSO	**42,781**

MS-4 Outfalls			
Waterbody	**Outfall**	**Regulator**	**Total Load (10^{12} cfu/Yr)**
Flushing Bay	BB-601	NA	34
Flushing Bay	BB-602	NA	73
Flushing Bay	TI-670	NA	19
Flushing Bay	TI-673	NA	10
Flushing Bay	TI-672	NA	8
		Total MS-4	**144**

Stormwater Outfalls			
Waterbody	**Outfall**	**Regulator**	**Total Load (10^{12} cfu/Yr)**
Flushing Bay	DD-601	NA	47
Flushing Bay	DD-602	NA	4
Flushing Bay	BB-519	NA	7
Flushing Bay	BB-522	NA	5
Flushing Bay	BB-524	NA	7
Flushing Bay	BB-528	NA	4
Flushing Bay	BB-532	NA	38
Flushing Bay	TI-639	NA	21
Flushing Bay	TI-641	NA	8
Flushing Bay	TI-608	NA	17
Flushing Bay	TI-013	NA	1
		Total Stormwater	**158**

Direct Runoff Outfalls			
Waterbody	**Outfall**	**Regulator**	**Total Load (10^{12} cfu/Yr)**
Flushing Bay	BB--48	NA	13
Flushing Bay	BB--54	NA	2
Flushing Bay	BB--55	NA	2
Flushing Bay	BB--86	NA	7
Flushing Bay	TI--64	NA	1
Flushing Bay	TI--65	NA	0
Flushing Bay	TI--71	NA	0
		Total Direct Runoff	**25**

Airport Outfalls			
Waterbody	**Outfall**	**Regulator**	**Total Load (10^{12} cfu/Yr)**
Flushing Bay	BB-LG10		40
Flushing Bay	BB-LG11		15
Flushing Bay	BB-LG12		9
Flushing Bay	BB-LG13		100
Flushing Bay	BB-LGA		2
		Total Airport	**166**

Totals by Waterbody			
Waterbody	**Outfall**	**Regulator**	**Total Load (10^{12} cfu/Yr)**
Flushing Bay			43,274

Totals by Source			
Source	**Outfall**	**Regulator**	**Total Load (10^{12} cfu/Yr)**
CSO			42,781
MS-4			144
Stormwater			158
Direct Runoff			25
Highway			166

Totals by Source by Waterbody			
Waterbody	**Source**	**Percent %**	**Total Load (10^{12} cfu/Yr)**
Flushing Bay	CSO	98.9	42,781
	MS-4	0.3	144
	Stormwater	0.3	158
	Direct Runoff	0.1	25
	Highway	0.4	166
		Total	**43,274**

Annual CSO, Stormwater, Direct Drainage,
Local Sources BOD_5 Loads (2008 Rainfall)

Combined Sewer Outfalls			
Waterbody	**Outfall**	**Regulator**	**Total Load (Lbs/Yr)**
Flushing Bay	BB-006	10,12,13,20,26	282,457
Flushing Bay	BB-007	5	15,313
Flushing Bay	BB-008	6,7,8,9	202,704
Flushing Bay	TI-012	29th Ave.	12
Flushing Bay	TI-014	67	4,362
Flushing Bay	TI-015	56	701
Flushing Bay	TI-016	45	8,708
Flushing Bay	TI-017	4	431
Flushing Bay	TI-018	3	998
		Total CSO	**515,687**

MS-4 Outfalls			
Waterbody	**Outfall**	**Regulator**	**Total Load (Lbs/Yr)**
Flushing Bay	BB-601	NA	3,219
Flushing Bay	BB-602	NA	6,847
Flushing Bay	TI-670	NA	1,826
Flushing Bay	TI-673	NA	976
Flushing Bay	TI-672	NA	713
		Total MS-4	**13,582**

Stormwater Outfalls			
Waterbody	**Outfall**	**Regulator**	**Total Load (Lbs/Yr)**
Flushing Bay	DD-601	NA	4,427
Flushing Bay	DD-602	NA	399
Flushing Bay	BB-519	NA	636
Flushing Bay	BB-522	NA	481
Flushing Bay	BB-524	NA	615
Flushing Bay	BB-528	NA	392
Flushing Bay	BB-532	NA	3,548
Flushing Bay	TI-639	NA	1,958
Flushing Bay	TI-641	NA	716
Flushing Bay	TI-608	NA	1,631
Flushing Bay	TI-013	NA	71
		Total Stormwater	**14,876**

Direct Runoff Outfalls			
Waterbody	**Outfall**	**Regulator**	**Total Load (Lbs/Yr)**
Flushing Bay	BB--48	NA	10,912
Flushing Bay	BB--54	NA	1,682
Flushing Bay	BB--55	NA	1,323
Flushing Bay	BB--86	NA	5,402
Flushing Bay	TI--64	NA	561
Flushing Bay	TI--65	NA	303
Flushing Bay	TI--71	NA	176
		Total Direct Runoff	**20,359**

Airport Outfalls			
Waterbody	**Outfall**	**Regulator**	**Total Load (Lbs/Yr)**
Flushing Bay	BB-LG10		6,570
Flushing Bay	BB-LG11		2,408
Flushing Bay	BB-LG12		1,512
Flushing Bay	BB-LG13		16,568
Flushing Bay	BB-LGA		372
		Total Airport	**27,430**

Totals by Waterbody			
Waterbody	**Outfall**	**Regulator**	**Total Load (Lbs/Yr)**
Flushing Bay			591,934

Totals by Source			
Source	**Outfall**	**Regulator**	**Total Load (Lbs/Yr)**
CSO			515,687
MS-4			13,582
Stormwater			14,876
Direct Runoff			20,359
Highway			27,430

Totals by Source by Waterbody			
Waterbody	**Source**	**Percent %**	**Total Load (Lbs/Yr)**
Flushing Bay	CSO	87.1	515,687
	MS-4	2.3	13,582
	Stormwater	2.5	14,876
	Direct Runoff	3.4	20,359
	Highway	4.6	27,430
		Total	**591,934**

Appendix B: Long Term Control Plan (LTCP) Flushing Bay and Flushing Creek Meeting #3 – Summary of Meeting and Public Comments

On September 30, 2015 DEP hosted the third public meeting for the water quality planning process for long term control of combined sewer overflows (CSOs) in Flushing Bay and Flushing Creek. The two-hour event, held at the Al Oerter Recreation Center in Flushing, Queens, provided information about DEP's Long Term Control Plan (LTCP) development for Flushing Bay and Flushing Creek. For Flushing Creek, DEP presented a summary of previous public meetings and the LTCP's proposed final recommendations. For Flushing Bay, DEP presented information on the watershed characteristics and the LTCP process. DEP also provided opportunities for public input. The presentation can be found at http://www.nyc.gov/dep/ltcp.

Approximately eighty people from the public attended the event as well as representatives from the Department of Environmental Protection and the New York State Department of Environmental Conservation. The following summarizes the questions and comments from attendees as well as responses given.

Flushing Creek

Q. An attendee asked why fecal coliform is being measured against over enterococci?

A. DEP stated that the current regulations are for fecal coliform.

Q. An attendee asked how much rain constitutes a wet weather event?

A. DEP stated that an overflow typically occurs with a quarter to 1-inch of rain. Samples are collected for several days after the rainfall to also observe the recovery period.

Q. An attendee asked when construction is expected to begin in the watershed?

A. DEP stated that construction is expected to being about one year after the design is complete.

Q. An attendee noted the amount of construction occurring in the area and asked if there is any mandate or incentives related to green infrastructure to mitigate the problems from the construction?

A. DEP stated that there are regulations for construction and significant reconstruction that limit stormwater runoff from the site. The development may implement green infrastructure to reduce stormwater runoff. There is also a Grant Program to encourage green infrastructure for private sites.

Q. An attendee asked why the underground storage tank constructed 15 years ago didn't solve the CSO problem in the area?

A. The DEP speaker stated that he was not the program manager at the time the tank designed so he is not familiar with the goal of the tank. DEP also replied that there are slides later in the presentation that show the CSO reduction achieved by the tank.

Q. An attendee asked about regulations on homeowners regarding green infrastructure and creating impervious area.

A. DEP explained that they have released a homeowner's guide regarding flood prevention to make recommendations to homeowners regarding 'softening' their property but the Department of Buildings has authority to make any changes.

Q. An attendee asked what prevents a homeowner from paving over a bioswale?

A. DEP explained that bioswales are located within the City's public right-of-ways which are not private property. DEP is responsible for maintaining the bioswales.

Q. An attendee stated that this moment, there is not a plan to reduce CSO volume to Flushing Creek by even 1 gallon, instead DEP has chosen disinfection. The attendee asked what DEP is going to do differently for Flushing Bay to reduce CSOs into the Bay?

A. DEP stated that the City of New York has made significant investments towards reducing the amount of CSOs into Flushing Creek. While green infrastructure may not have the same impact as grey infrastructure, green infrastructure is being used to reduce CSOs in a sustainable and beneficial manner. This involves meeting a balance between effective solutions while keeping costs down.

Q. An attendee asked why it seems that DEP was not expecting the level of development around the Flushing Bay Area.

A. DEP explained that they do look at development projections, future population and the zoning densities. At the time the Flushing Creek tank was sized, it was based on 2045 population projections which is greater than the area's current population. However designs are now based on 2030 population projections which may be more accurate than 2045 projections and appropriately account for unexpected growth.

Q. An attendee asked if there is any way to speed up the design and construction of the LTCP solutions including green infrastructure?

A. DEP stated that currently New York City's green infrastructure program is one of the largest in the country and believes that the targets that are set are aggressive which includes plans for 6,000 bioswales to be installed by the end of 2016. This involves maximizing the amount of bioswales that can be installed in a given area based on the available space. DEP also explained there are funding incentives available for private developers which goes unused each year.

Q. An attendee asked if the rainfall projections lined up with the predicted results from large rain events?

A. DEP explained that the typical rainfall has been updated multiple times in the past 20 years and currently, rainfall data from 2008 is used as a typical rainfall year. A 10-year period is also considered for alternatives analysis.

Q. An attendee asked about cement trucks pouring cement into sewers. (44:30)

A. DEP stated these occurrences should be reported to 311. This is a big concern and DEP very much wants address this problem. Document the location and associated parties.

Q. An attendee asked why the Flushing Creek LTCP used JFK Airport rainfall data and not LGA which is closer and LaGuardia rainfall experienced a greater number of storms and greater amount of rain than JFK based on historic rainfall data. The attendee also asked why 2002-2011 rainfall data is used as opposed to 2004-2014?

A. DEP stated that at the time analysis was done, 2011 was the most recent rainfall data. DEP has been looking into rain data a lot because DEP is one of the early adopters of the City's panel on climate change projections. The 2011 was probably the wettest year. DEP is already breaking standard engineering practices which is to go back 50 years and look at an average condition. DEP decided they would not do that because when you look at central park data, we already know we are getting 5-10 inches greater rainfall than the last 50 years. In fact half of the largest rain events in recorded history have occurred since 1974. So we are definitely trying to weight the more recent rainfall years. By using the latest 10 years 2002-2011 rainfall data, DEP is confident they are capturing the latest weather cycle

Q. An attendee asked if the TI-010 contracts include more than bioswales and why there is not consideration for diverting and treating combined sewer that intersects the interceptor in Kissena Park?

A. DEP stated that bioswales are an efficient solution since they have control over the right-of-ways where the bioswales are installed. DEP could not take the flow from the interceptor and direct it through the park because it contains sewage but acknowledged that they could direct the stormwater.

Q. An attendee asked if DEP will require separated sewers in Flushing West as part of the city's rezoning? (56:00)

A. DEP responded that they don't think they will be separating sewers because developments on the waterfront often have direct discharge to the waterfront and the developer obtains the permit from DEC. Under the existing sewer code, the department requires 90% of the stormwater to be detained on site.

Q. An attendee asked why seasonal disinfection was chosen? (58:38)

A. DEP stated that in discussions with DEC, it was determined that most of the contact time with the waterbody occurs during the recreational season.

Q. An attendee asked if there are any examples of chlorination which show that there is not an adverse effect on the environment?

A. DEP responded that at the moment there is not a disinfection facility currently operating within their facilities. However, DEP is conducting a pilot study on chlorination at the CSO facility at Spring Creek and those results will help in the design for Flushing Creek.

Q. An attendee asked how information from the chlorination pilot study at Spring Creek can be used since it has not been completed yet?

A. DEP explained that there is information available towards the desired disinfection. The pilot study will be completed before the start of design at Flushing Creek and any waterbodies that may use chlorination.

Q. An attendee asked why chlorination is being used since it is not effective against viruses?

A. DEP stated they are focused on the effect the chlorine will have on the bacteria as directed from the EPA and the Clean Water Act.

Q. An attendee asked if there is a plan for treating nitrogen from the CSOs?

A. DEP stated that there has been a program to reduce nitrogen loads for 10 years, but the nitrogen loads coming from the CSOs are much smaller than those from the sewage treatment plants and nitrogen limits are being met throughout the City.

Q. An attendee asked how the model for Flushing Creek will be adjusted based on what is learned from Flushing Bay?

A. DEP stated that the effects Flushing Bay may have on Flushing Creek were considered and data is still being collected for Flushing Bay. It is also possible that any attainment achieved in Flushing Creek may influence attainment in Flushing Bay.

Flushing Bay

Q. An attendee asked why the Dragon boat is considered a secondary contact when there is a high level of contact with the water?

A. DEP stated that they will assess the ability to meet the higher classification.

Q. An attendee asked why bacterial data was collected from October 2013 - May 2014?

A. DEP stated that data was collected during a small portion of the recreational season. Dry and wet weather events were conducted and the only difference from the recreational season may be seen in dissolved oxygen levels.

Long Term Control Plan (LTCP) Flushing Bay and Flushing Creek Meeting #2 Alternatives Evaluation – Summary of Meeting and Public Comments

On October 26, 2016 DEP hosted the second public meeting for the water quality planning process for long term control of combined sewer overflows (CSOs) in Flushing Bay. The over three-hour event, held at the USTA Billie Jean King National Tennis Center Chase Center Hospitality Pavilion in Flushing, Queens, provided information about DEP's Long Term Control Plan (LTCP) development for Flushing Bay. DEP presented information on the LTCP process, Bronx River watershed characteristics, and the status of engineering alternatives evaluations, and provided opportunities for public input. The presentation can be found at http://www.nyc.gov/dep/ltcp.

Approximately 40 - 50 people from the public attended the event as well as representatives from the Department of Environmental Protection and the New York State Department of Environmental Conservation. The following summarizes the questions and comments from attendees as well as responses given.

Below is a summary of the general concerns expressed during the meeting as well as Comments related specifically to the slides within the presentation. A full audio and video recording of the entire meeting can be found on the DEP's website.

General Concerns

- There is concern with the timeline to implement and complete projects. It was requested that GI and MS4 work be expanded to continue WQ benefits while the recommended alternative is being constructed. Angela Licata advised that GI will continue and DEP will look to expand its application.

- Complaints were expressed about the failure of booms to capture floatables. Issues were raised with MS4 contributions and floatables discharging from the Tallman Island WWTP. It was suggested that DEP develop educational programs to reach out to encourage people to not flush condoms, feminine products, wipes, etc.. Angela advised that the City is performing a floatables survey to better characterize and identify sources of floatables. Baltimore's skimmer boats were discussed. DEP noted that they use their own boats to collect floatables from the booms. The issue appears to be with the effectiveness of the booms in capturing floatables.

- Concern were raised that other CSOs outside of BB-006 and BB-008 will not be addressed. DEP advised that GI will prioritize areas where CSOs remain.

- Concerns were expressed with groundwater infiltration to the tunnel and loss of storage capacity. DEP noted that the same concern exists with tanks or any below grade infrastructure. Current tanks are dewatered. The same is done by CSO tunnel operators to maintain the available storage capacity.

- Audience members felt that the consideration of a tunnel is a real step forward compared to the last meeting, however they are still concerned with the impacts of chlorine byproducts associated with the outfall disinfection project proposed for Flushing Creek. They feel that although pathogen compliance may be achieved the Flushing Creek LTCP overlooks other pollutants contained within the CSO discharges. It was requested that a marine biologist/chemist/pathologist review the concerns. They believe there is a need to implement treatment that protects marine biology in addition to controlling pathogens.

- Concerns were expressed that Flushing Creek influences the water quality in the bay and more needs to be done. Jim noted that the first investment in CSO control was the Flushing Creek tank. Decisions need to be made to provide the most effective capture and water quality benefit with the limited funds available. DEP believes that the current uses in these waters justify the expenditures being considered for the Flushing Bay LTCP.

Comments related specifically to the slides within the presentation

- On slide, 7 the residential and commercial area is shown as 62% of the drainage area. Please identify the split as it may influence the runoff and the constituents (primarily floatables) in the overflows.
- A concern was expressed with the location of sampling points. The commenter felt that primary contact was more likely to occur near the shoreline and sampling locations should be added or moved accordingly.
- The comment was made that continuous data loggers have indicated that dissolved oxygen levels drop below 3.0 on a daily basis. The low dissolved oxygen levels tend to occur at low tide during the early morning hours.
- How much of the $1.5B in Citywide GI is committed to Flushing Bay?
- Concerns were raised with how rain gardens or bioswales are being designed and constructed. It is difficult for people, particularly the elderly, to get out of their cars without tripping over the curb or stepping in the planters. Tree planters with grates were preferred in residential areas with bioswales applied in parking lots.
- Concerns were expressed relating to the small number of park and school GI facilities that have been constructed (1) or are in construction (1). How does NYCDEP plan to ramp up its GI program in schools and playgrounds?
- It was suggested that signage be added to GI installations to educate the public on what was put in and why.
- It was suggested by audience members that GI be considered for CitiField and other large privately owned parking lots. DEP responded that they cannot force private properties to install GI. They can address new developments through stormwater design ordinances and can provide incentives for application of GI. Incentive programs are under development
- Slide 31 indicates that Baseline Conditions will reduce CSOs by 20%. Slide 26 indicates that the regulator improvements will reduce CSOs by 10%. Please breakdown and identify the reduction in CSO associated with each of the projects included in the Baseline Conditions. A timeline was requested for completion of each of the projects under Baseline Conditions, the Flushing Creek LTCP and the Flushing Bay LTCP.
- An audience member noted the current emphasis on an Enterococcus Standard Threshold Value by USEPA. Instantaneous measurement is believed to be reflective of sporadic CSO discharges.
- Audience members questioned the elimination of Citi Field site. They felt with political pressure this would be a good site due to its close proximity to outfall. Jim Mueller responded that the issue is that dewatering of the tank would require capacity within the interceptor for conveyance

to the WWTP. The sites near the WWTP are preferred as captured CSO can be pumped directly to the WWTP without utilizing interceptor capacity.

- Some audience members questioned why a tank would not be pumped back to Tallman Island WWTP. Jim explained that Tallman Island is a smaller WWTP and already receives pump back after storms from the 53 MG Flushing Bay Retention Facility. Bowery Bay has greater capacity for receiving CSO pump back. The audience seemed satisfied with the response.

- Concerns were expressed relating to the timeline for construction of a tunnel.

Email from Mariana. Flushing Bay, October 30, 2015.

As a member of women in canoe I can Attest to the fear that while enjoying in what should be a healthy sport I am endangering my health.Please help a wonderful facility to Live againg!

Email from Marne Asia. How much Flushing can the Flushing Bay take? October 30, 2015.

I am writing this letter in hopes that it will be read and taken into consideration on the future of the water conditions of Flushing Bay. I have no expertise on what the water conditions should or should not be according to local or state laws.

The water that my crew, Women In Canoe,has paddled on for the last 16 years has been neglected for lack of interest on behalf of the city of NewYork. Politics are only major obstacles that get in the way of doing the right thing.

It's simple, the water is not well with the present way it is being addressed, we all know this is the case. There is no question about that. It's sad that letter writing, meetings, paper pushing , he said, she said, that department or agency, on and on and on.....

Fix it, make it better, DO THE RIGHT THING, it's worth it. 16 years ago the big thing was not to be attacked by the swans. They are have long since been gone, perhaps smart enough to know if they stood their they would perish.

Together we may accomplish tremendous events, let's all be able to reminisce about how we took the time now to make a change that made a difference.

Thank you
Women in Canoe
Marne Asia .,.
Sent by marlene

Email from Cody Ann Hermann. Flushing Creek LTCP. October 30, 2015.

Hello,

My name is Cody Ann Herrmann. I am a lifelong resident of Flushing with a background in ecology and urban design. I feel the proposed LTCP for Flushing Creek is not acceptable. There is no effort to decrease CSO flow, we should be working towards full CSO retention.

Flushing Bay and Creek should be examined through a joint process. The only acceptable outcome for the Flushing Bay LTCP should be full CSO retention.

I expect the community to be informed of project timelines and reasoning behind them.

Thank you,
Cody Ann Herrmann
codyannherrmann.com/flushing

Email from Korin Tangtrakul. CSO Discharge in Flushing Bay – discrepancy in the data. December 13, 2015.

Hello,

I'm doing research for educational material regarding CSOs in Flushing Bay for the S.W.I.M. Coalition. I see on the Flushing Creek/Flushing Bay LTCP Kick-off meeting presentation that BB-006 is modeled to discharge 714 MG/yr pre-waterbody/watershed facility plan, and 617 MG/yr with grey and green WWFP infrastructure recommendations. However, I see in the Waterbody Watershed Facility Plan, chapter 8, that BB-006 is modeled to have 1,539 MG/yr annual overflow for the baseline, and post WWFP would have 1,236 MG/yr annual overflow. Could you explain the discrepancy in these two findings? I am assuming the LTCP presentation reflects the most recent modeling, but am curious what accounts for the discharge to be less than half of what had been previously modeled.

Please contact me via phone at 609-651-1288 or email at korin.tangtrakul@gmail.com.

Thank you for your time,
Korin Tangtrakul

GREATER FLUSHING
CHAMBER OF COMMERCE

October 30, 2015

Emily Lloyd
Commissioner
NYC Department of Environmental Protection
59-17 Junction Boulevard, 13th Floor
Flushing, NY 11373

Re: DEP's Long Term Control Plan for Flushing Creek

Dear Commissioner Lloyd:

The Greater Flushing Chamber of Commerce is a membership association that advocates for the needs of the diverse business and civic community of greater Flushing. On behalf of our members and local residents, we urge you to revise DEP's proposed LTCP for Flushing Creek and create a plan that lead to full CSO retention.

DEP's current plan for Flushing Creek as inadequate; the proposed LTCP makes no commitment to decreasing the amount of raw sewage pumped into Flushing Creek during CSO events. The proposed disinfection method, chlorination during recreational boating season, will not foster the change in water quality our community demands and deserves. The Chamber, instead, urges revisions be made to meet full CSO retention goals with full CSO retention as the only acceptable outcome. Moving forward, we request increased coordination between the Flushing Creek and Bay LTCPs, or better yet, that the two waterways be combined in a single LTCP. We expect that the DEP will keep our community updated with proposed dates of action related to the Flushing Creek and Bay LTCPs, as well as the reasoning behind proposed dates.

Furthermore, during the planning stages of new waterfront developments at Flushing West and Willets Point, we hope that City incorporates a separate sewage system that will not add to the current CSO problem in addition to the installation of storage tanks similar to those at the Al Oerter Recreation Center. Now is the time to get involved in these planning efforts.

We see this type of coordination and planning to be an opportunity to create a potential model for sustainable development throughout New York City and other urban center dealing with the similar stormwater management issues. Please feel free to contact me if you have any questions at John@FlushingChamber.NYC or 646-783-8985.

Sincerely,

John Choe
Executive Director

• Chamber of Commerce Building • 39-01 Main Street, Suite 511 • Flushing NY 11354 •
• (646) 783-8985 • (718) 961-2122 fax • John@FlushingChamber.NYC •

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October 27, 2015

Commissioner Emily Lloyd
New York City Department of Environmental Protection
9605 Horace Harding Expressway
Corona, New York 11368
via email: ltcp@dep.nyc.gov

Re: Comments on Proposed Final Recommendations --Flushing Creek CSO Long Term Control Plan

Dear Commissioner Lloyd:

This written comment is submitted on behalf of the Empire Dragon Boat Team on the proposed final recommendations-Flushing Creek CSO Long Term Control Plan, to set forth fundamental objections to the Plan as it will not result in meaningful reduction of raw sewage into Flushing Creek and its connected waterway, Flushing Bay. The Plan does not advance meaningful action to comply with the City's obligations under the Clean Water Act.

Founded in 2009, the Empire Dragon Boat Team is New York City's first and only women's cancer survivor racing team and one of over 140 women's breast cancer teams worldwide that serve to promote the sport of dragon boating as part of a healthy lifestyle, and provide a unique support for all women fighting cancer. We are a competitive racing team and practice several times a week at the World's Fair Flushing Bay Marina during the spring, summer and fall. We are part of the thriving dragon boat community that calls Flushing Bay our home. In season, Flushing Bay hosts at least fifteen dragon boat teams for regular practice and over one thousand people use the Bay regularly for some sort of human powered boating.

Flushing Creek flows into Flushing Bay and because of tidal action, water from Flushing Bay flows into Flushing Creek as well. Consequently, as the Creek and the Bay are connected, the impacts on one water body will affect the water quality of the other water body and efforts on one should take into account potential impacts on the other.

For the following reasons, the proposed Flushing Creek LTCP in inadequate.

1. The LTCP planning process did not assure meaningful community participation due to language access issues--the notices of the various hearings were not translated into Chinese, Korean, and Spanish, the languages of the communities surrounding Flushing Creek and translation was not available at the meetings.

2. The Flushing Creek LTCP and the Flushing Bay LTCP were separate and distinct, and on consecutive time lines. DEP should have done long-term planning for both waterways simultaneously as they are intrinsically linked. The health of the creek and the health of the bay are dependent on each other. The Flushing Bay LTCP planning process already begins with the fait accompli of the final plan for Flushing Creek—no reduction of sewage discharge

into Flushing Creek and the introduction of another chemical, chlorine, which has consequences for the wildlife, plant life and human contact.

3. The plan calls for no reduction of combined sewage overalls into Flushing Creek (and therefore Flushing Bay). The City should reduce the actual flow from Combined Sewers into the Creek and not merely disinfect the effluent. Combined Sewers do more than transport pathogens, they are also important sources of nutrients that can disrupt natural ecosystems through biological oxygen demand, and toxic chemicals that can make fish unsafe to eat. By merely disinfecting, the City is also doing nothing to reduce the trash, often disgusting, that enters the creek from combined sewers. Is a water swimmable if it is full of condoms, tampons and toilet paper? Also, the City should consider the human aspect of what they're proposing. Would you swim in sewage if we told you that all the bacteria in it were dead? Or would swimming among feces and toilet paper be unacceptable to you, even if it wouldn't make you sick? That's what your plan means for us.

4. Disinfection of the sewage overflow is untested in terms of its effect of the environment. It is our understanding that no study of a comparable water body has been done. DEP admitted that data on its pilot project in Spring Creek to study effects of chlorination will not be available for a few more years. The effect on fish, birds, plant life and human users has not been studied. To our knowledge, the City has not accounted for the effectiveness of their disinfection on viruses or protozoa, which are in many ways vastly different from bacteria. Nor has the city released information on whether their disinfection method will produce persistent organic chlorinated compounds that are not removed by disinfection. We are trading one pollutant for several others. In addition, the sewage overflow will be discharged without treatment for many months (November 1 to April 30) and will remain in the sediment thereafter. In short, the community believes is a clear error of judgment, law, and public process to decide upon a strategy without knowing whether that strategy will work, what impacts it will have.

5. The time-line for the development of green infrastructure is too protracted, and not adequate for the enormity of the problem.
We see Flushing Creek and Flushing Bay as a valuable community and municipal resource. The City should use the CSO Long Term Control Plan as a way of increasing the quality of life and sustainable economic development. The extraordinary growth of downtown Flushing and the attention that Queens is enjoying as a tourist destination could create opportunities to develop the waterfront for recreational purposes. Instead, the DEP is continuing to allow Flushing Creek and through the water flow Flushing Bay as a dumping ground for sewage. We urge the DEP to come up with a plan which will result in a significant reduction of sewage into these waterways.

Please do not hesitate to contact the Empire Dragon Boat Team. We can be reached at Empiredragonboat@gmail.com

Sincerely yours,

Donna Wilson, RN
Captain, Empire Dragon Boat Team

October 29, 2015

Commissioner Emily Lloyd
New York City Department of Environmental Protection
9605 Horace Harding Expressway
Corona, New York 11368
via email: ltcp@dep.nyc.gov

Re: Comments on Proposed Final Recommendations --Flushing Creek CSO Long Term Control Plan

Dear Commissioner:

This written comment is submitted on behalf of the Guardians of Flushing Bay ("Guardians"), on the proposed final recommendations-Flushing Creek CSO Long Term Control Plan, to set forth fundamental objections to the Plan as it will not result in meaningful reduction of raw sewage into Flushing Creek and its connected waterway, Flushing Bay. The Plan does not advance meaningful action to comply with the City's obligations under the Clean Water Act.

Guardians is a coalition of Dragon Boat teams and their members, other human-powered boaters, environmentalists, and area residents whose mission is to advocate for and promote a clean and healthy Flushing Bay. The World's Fair Flushing Bay Marina, adjoining Flushing Creek, is the home of a very vibrant human-powered boating community. In season (spring, summer and the fall), at least ten dragon boat teams use Flushing Bay for regular practice multiple times during the week and over one thousand people use the Bay every summer for some form of human powered boating. Human-powered boating such as dragon boating, kayaking and outrigger canoeing are active sports that involve extensive contact with the water. People are therefore exposed to the same risks of polluted water as swimming and the water standards must be improved to protect existing users of these water bodies. Guardians works to improve the environment, and our members have organized a number of initiatives focused on cleaning up Flushing Bay, including community environmental awareness trainings, shoreline clean-ups, citizens water quality testing and oyster gardening in collaboration.

Flushing Creek flows into Flushing Bay and because of tidal action, water from Flushing Bay flows into Flushing Creek as well. Consequently, as the Creek and the Bay are connected, the impacts on one waterbody will affect the water quality of the other waterbody and efforts on one should take into account potential impacts on the other.

For the following reasons, the Flushing Creek LTCP in inadequate.

1. The LTCP planning process did not assure meaningful community participation due to language access issues--the notices of the various hearings were not translated into Chinese, Korean, and Spanish, the languages of the communities surrounding Flushing Creek and translation was not available at the meetings.

2. The Flushing Creek LTCP and the Flushing Bay LTCP were separate and distinct, and on consecutive time lines. DEP should have done long-term planning for both waterways simultaneously as they are intrinsically linked. The health of the creek and the health of the bay area dependent on one

and other. The Flushing Bay LTCP planning process already begins with the fait accompli of the final plan for Flushing Creek—no reduction of sewage discharge into Flushing Creek and the introduction of another chemical, chlorine, which has consequences for the wildlife, plant life and human contact.

3. The plan calls for no reduction of combined sewage overalls into Flushing Creek (and therefore Flushing Bay). The City should reduce the actual flow from Combined Sewers into the Creek and not merely disinfect the effluent. Combined Sewers do more than transport pathogens, they are also important sources of nutrients that can disrupt natural ecosystems through biological oxygen demand, and toxic chemicals that can make fish unsafe to eat. By merely disinfecting, the City is also doing nothing to reduce the trash, often disgusting, that enters the creek from combined sewers. Is a water swimmable if it is full of condoms, tampons and toilet paper? Also, the City should consider the human aspect of what they're proposing. Would you swim in sewage if we told you that all the bacteria in it were dead? Or would swimming among feces and toilet paper be unacceptable to you, even if it wouldn't make you sick? That's what your plan means for us.

4. Disinfection of the sewage overflow is untested in terms of its effect of the environment. It is our understanding that no study of a comparable water body has been done. DEP admitted that data on its pilot project in Spring Creek to study effects of chlorination will not be available for a few more years. The effect on fish, birds, plant life and human users has not been studied. To our knowledge, the City has not accounted for the effectiveness of their disinfection on viruses or protozoa, which are in many ways vastly different from bacteria. Nor has the city released information on whether their disinfection method will produce persistent organic chlorinated compounds that are not removed by disinfection. We are trading one pollutant for several others. In addition, the sewage overflow will be discharged without treatment for many months (November 1 to April 30) and will remain in the sediment thereafter. In short, the community believes is a clear error of judgment, law, and public process to decide upon a strategy without knowing whether that strategy will work, what impacts it will have.

5. The time-line for the development of green infrastructure is too protracted.

We see Flushing Creek and Flushing Bay as a valuable community and municipal resource. The City should use the CSO Long Term Control Plan as a way of increasing the quality of life and sustainable economic development. The extraordinary growth of downtown Flushing and the attention that Queens is enjoying as a tourist destination could create opportunities to develop the waterfront for recreational purposes. Instead, the DEP is continuing to allow Flushing Creek and through the water flow Flushing Bay as a dumping ground for sewage.

We urge the DEP to come up with a plan which will reduce in a significant reduction of sewage overflow into Flushing Creek and then Flushing Bay. We may be reached at GuardiansofFlushingBay@gmail.com.

Yours truly,

s/

Hillary Exter
for Guardians of Flushing Bay

cc.: Gary Kline, NYS DEC,
Venetia Lannon, DEC Region 2
Congressperson Joseph Crowley
City Councilperson Julissa Ferreras-Copeland