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.

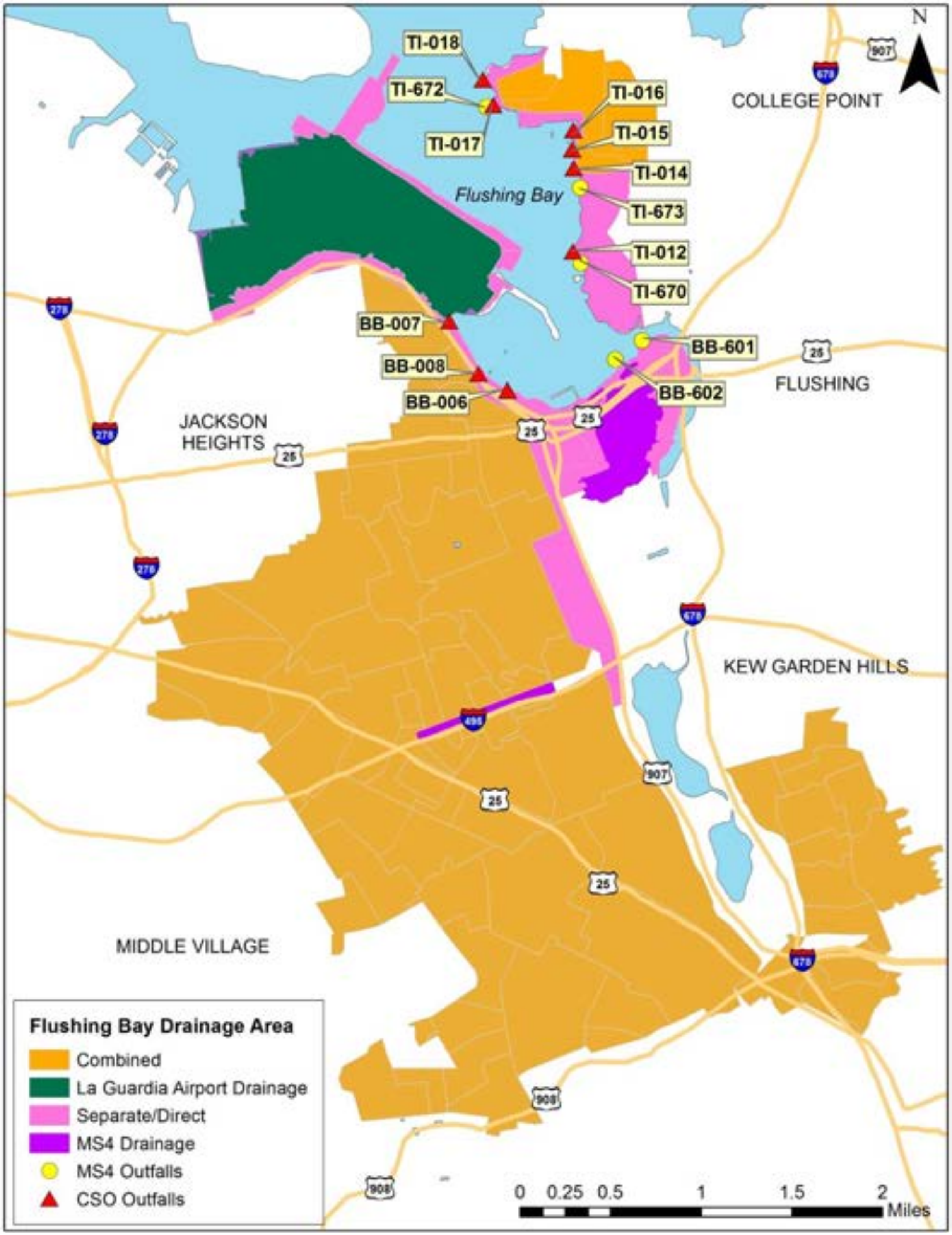

Figure 8-1. CSO Discharges to Flushing Bay

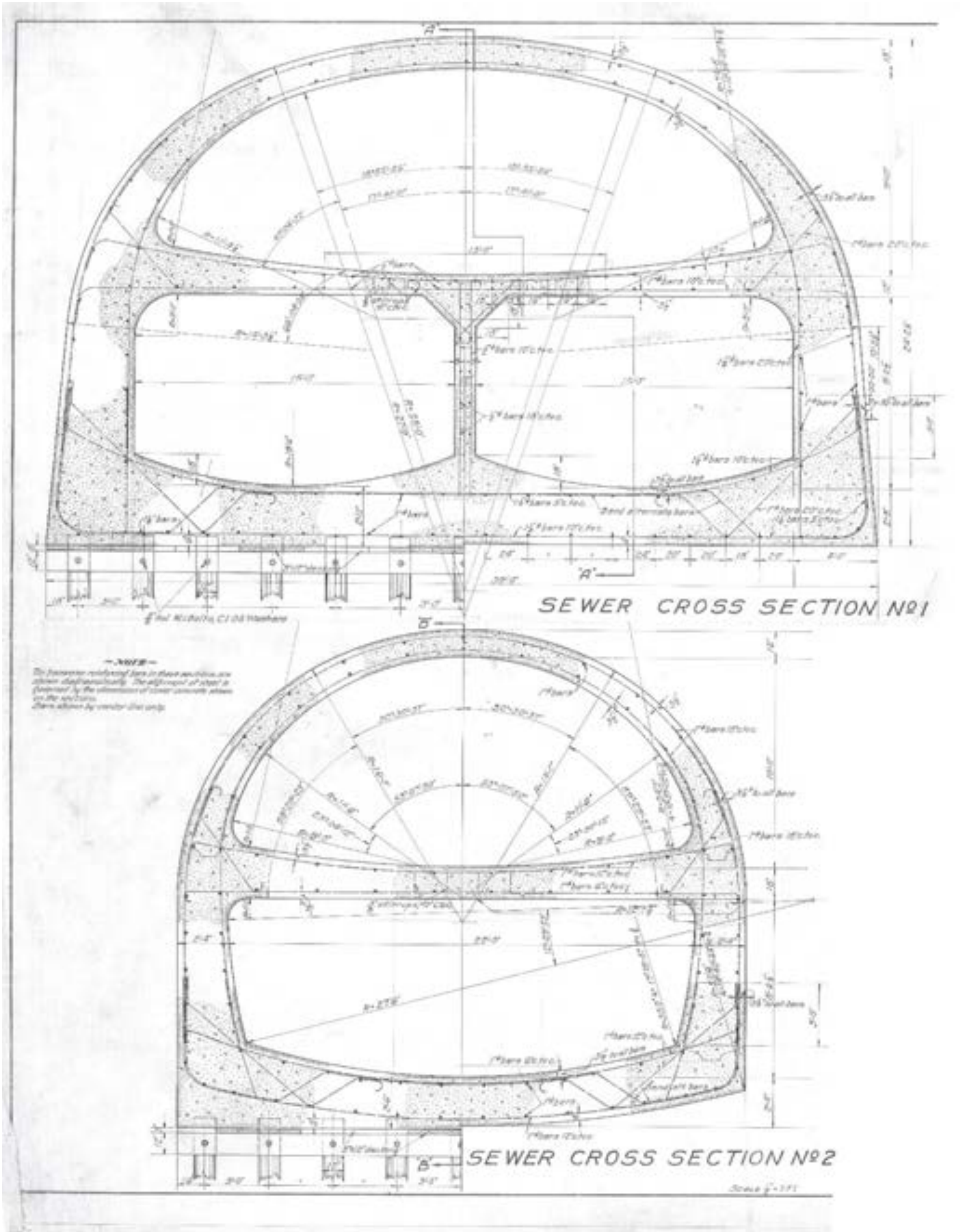

Figure 8-2. CSO Outfall BB-006 Cross Sectional Views

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 90th 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 90th 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.

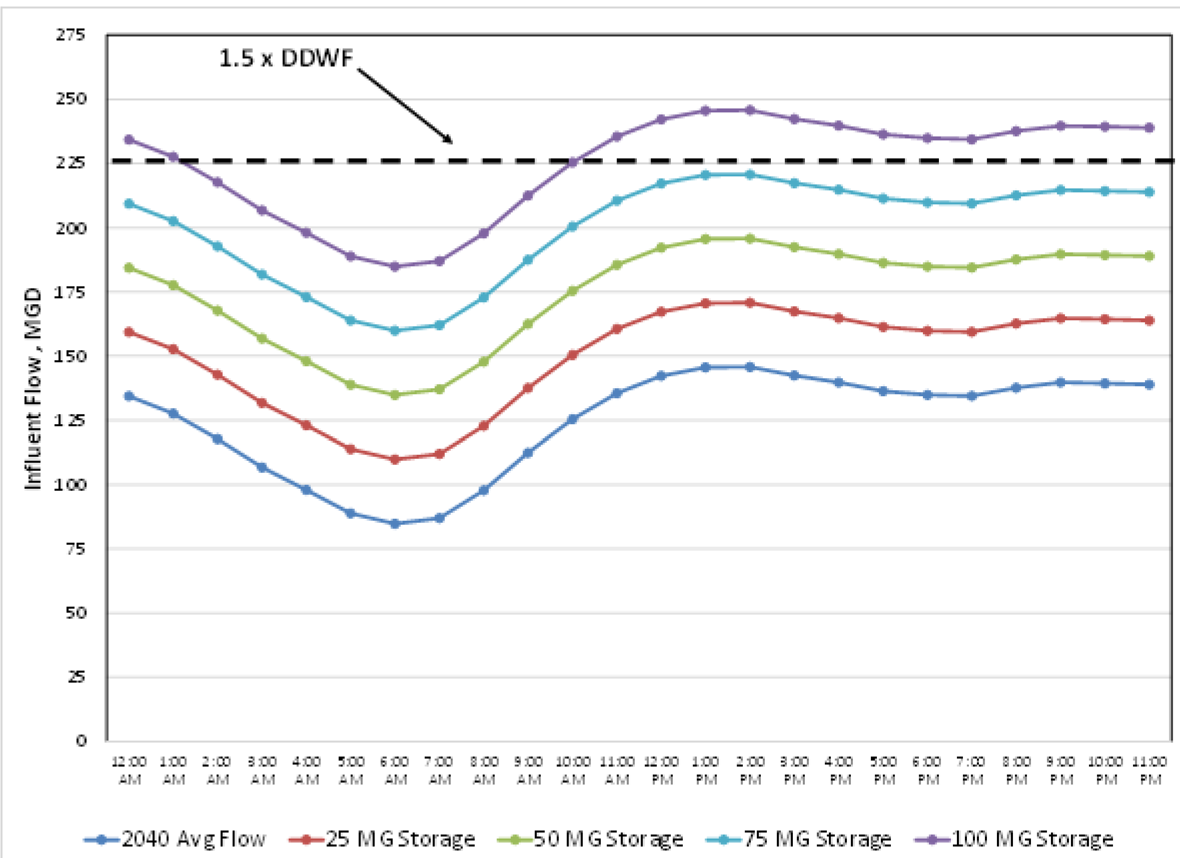

Figure 8-3. Impact of CSO Pump-Back on Diurnal Influent Flow to Bowery Bay WWTP

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 108th 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.

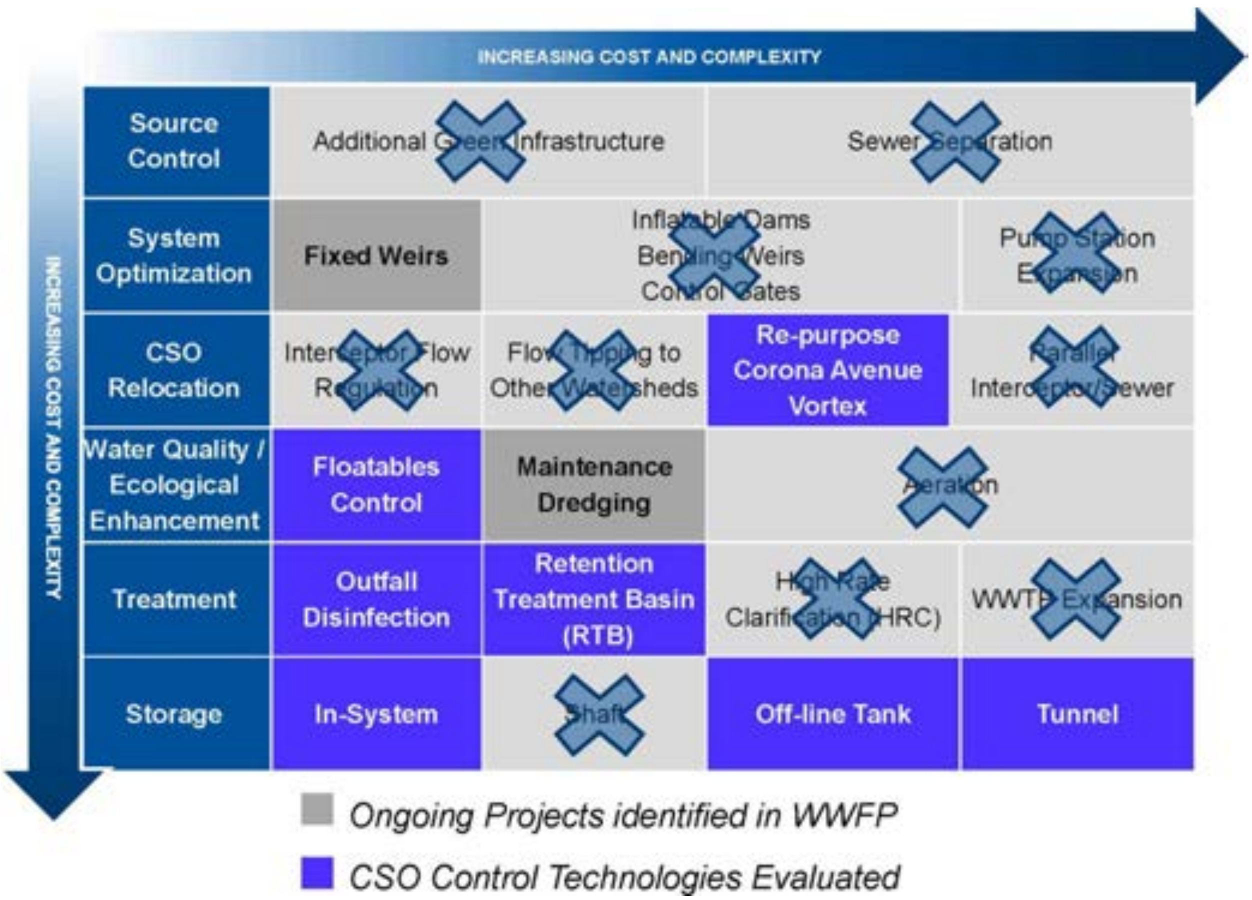

Figure 8-4. Matrix of CSO Control Measures for the Flushing Bay

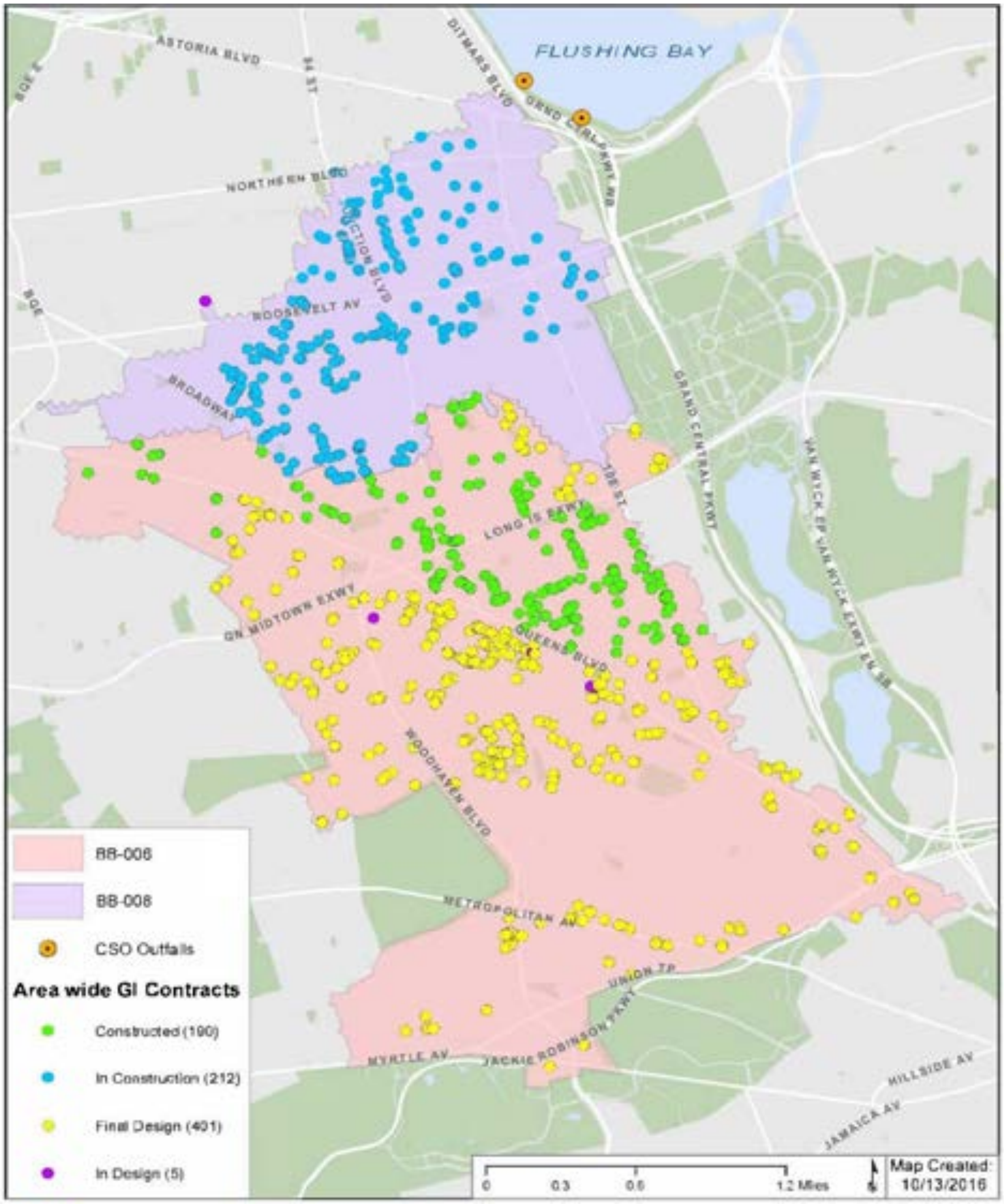

Figure 8-5. Built and Planned Green Infrastructure Projects

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).

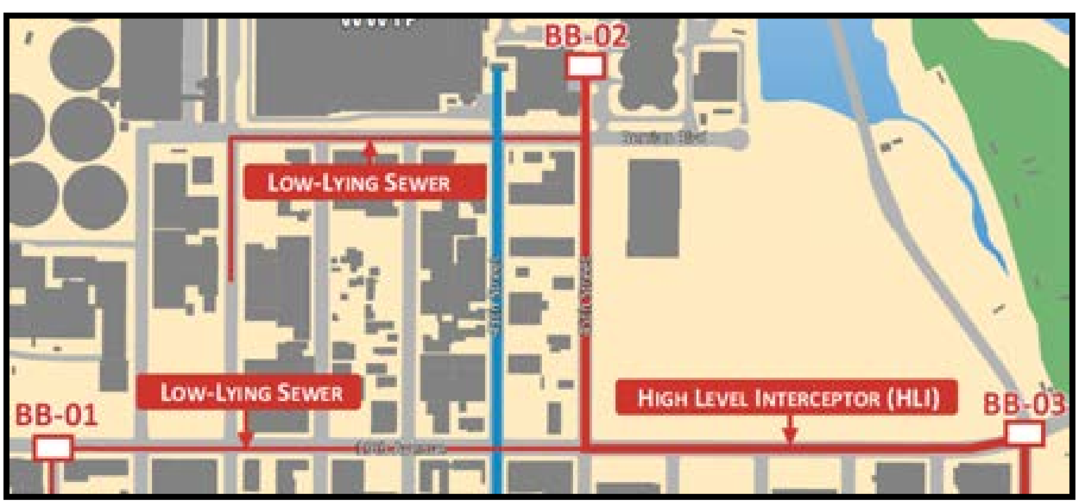

Figure 8-6. Diversion of Low Lying Sewers

Figure 8-7. Regulator Weir Modifications

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.

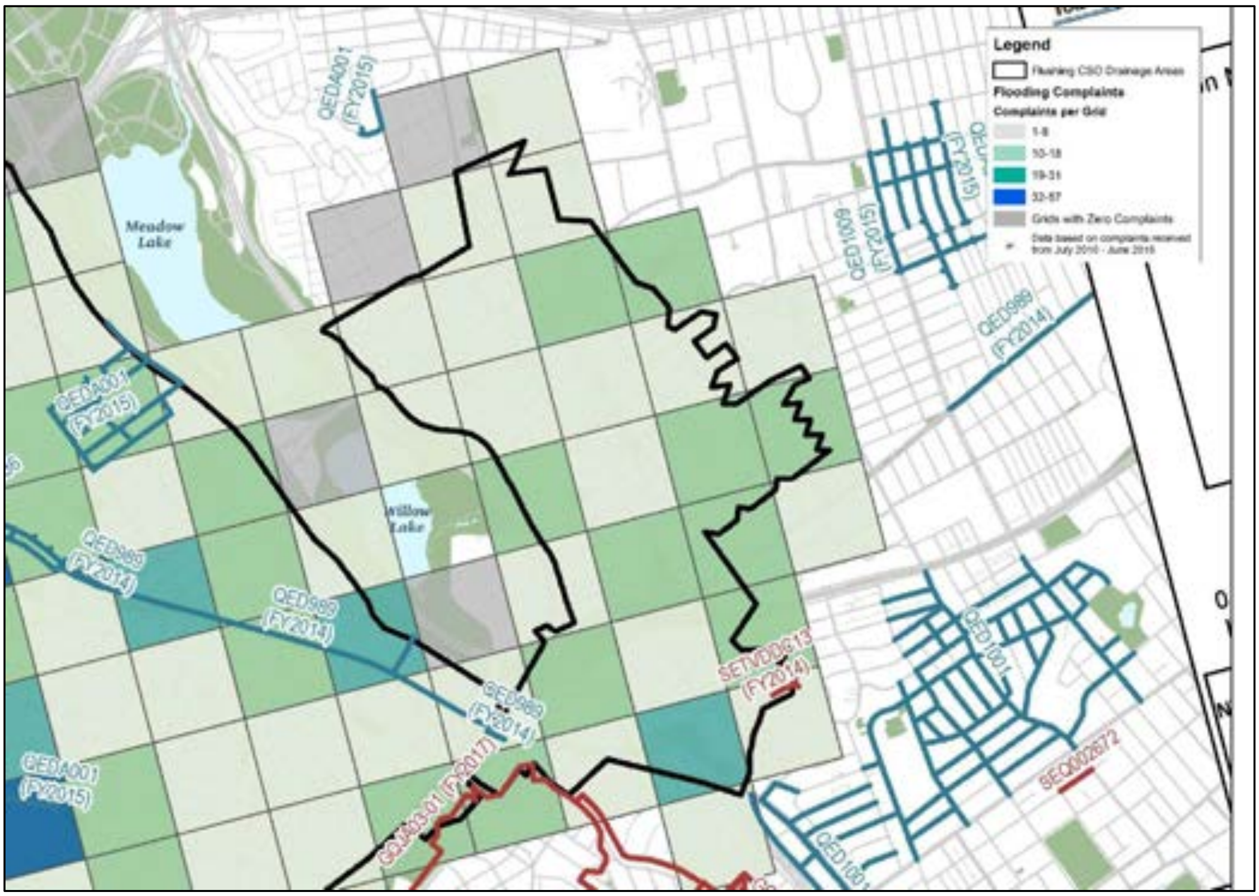

Figure 8-9. Flushing Bay CSO Drainage Area Flooding Complaints

AECOM *with* Hazen

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.

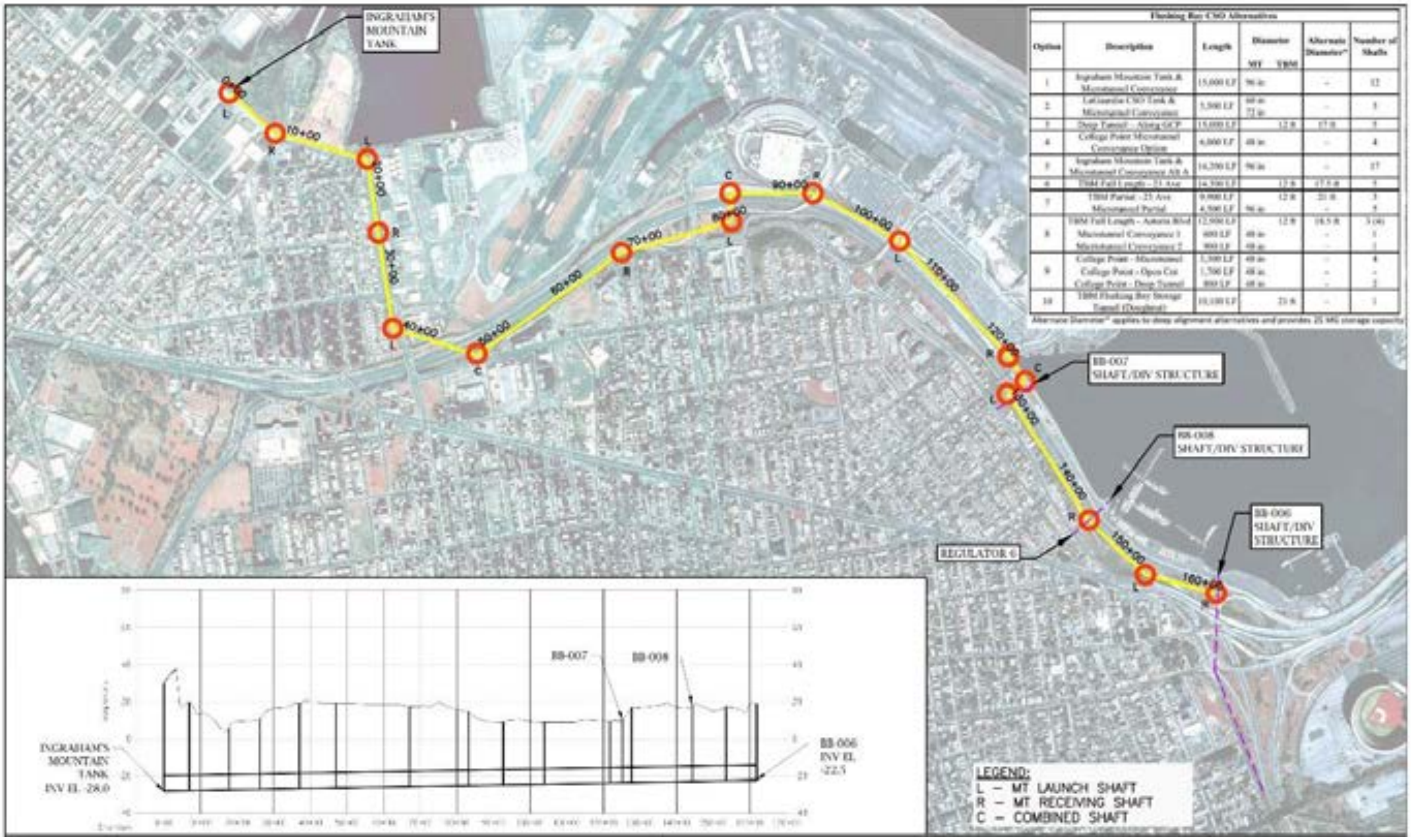

Figure 8-11. Routing of Alternative 7-2a - Hydraulic Relief Sewer for the BB HLI from Regulator BB-R06 to Bowery Bay WWTP

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

Challenges

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:

<u>Benefits</u>

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.

<u>Cost</u>

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.

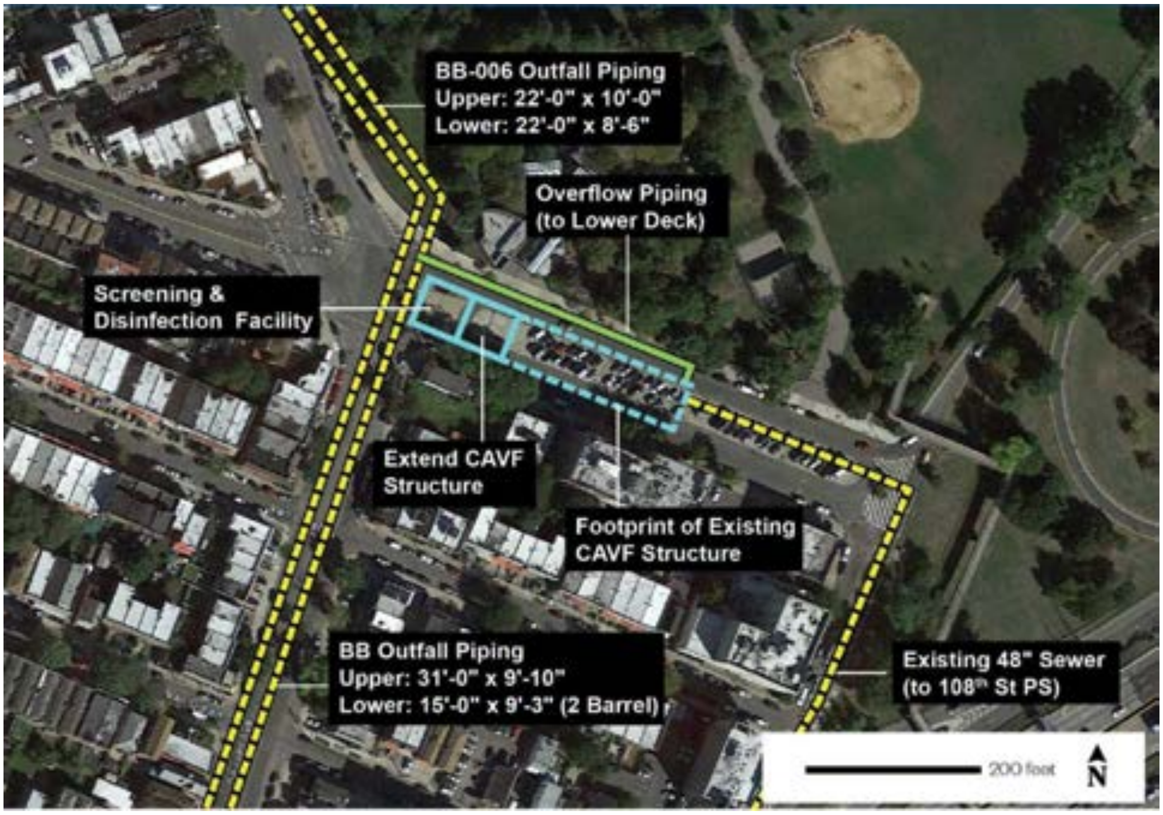

Figure 8-15. Layout of Alternative 9-2 – Re-purpose the CAVF as a Retention Treatment Basin

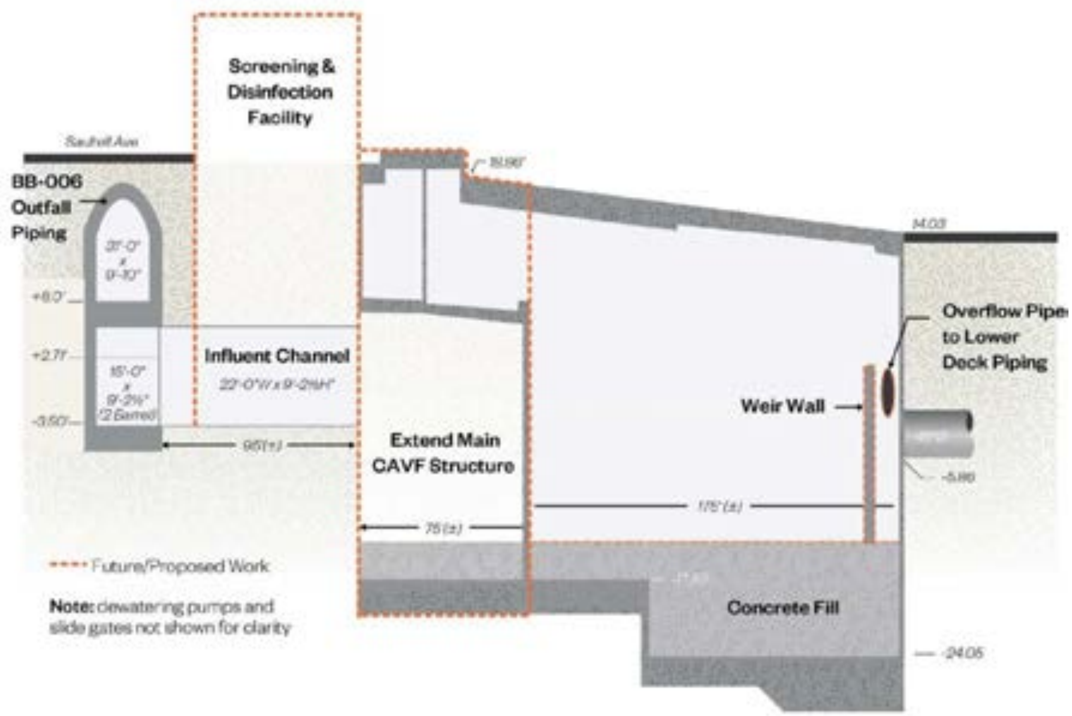

Figure 8-16. Section View of Alternative 9-2 – Re-purpose the CAVF as a Retention Treatment Basin

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with Hazen

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.

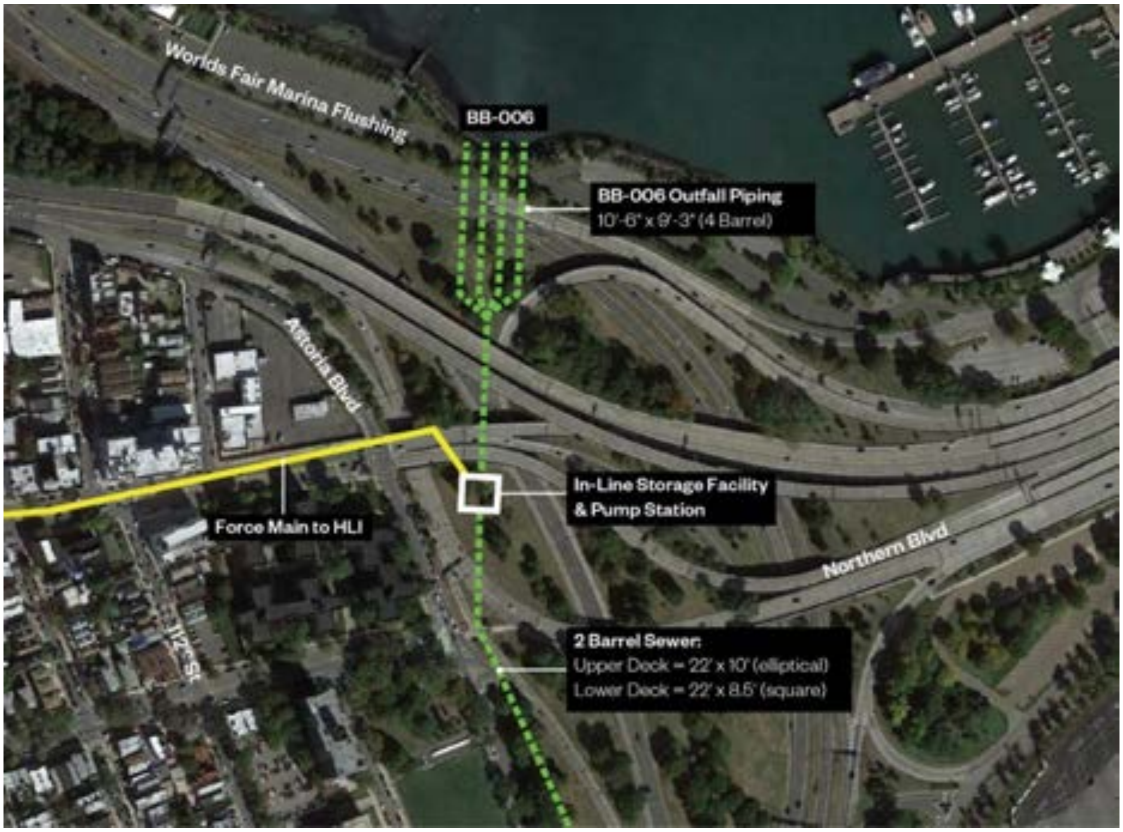

Figure 8-17. Layout of Alternative 9-3 – Outfall Storage for BB-006

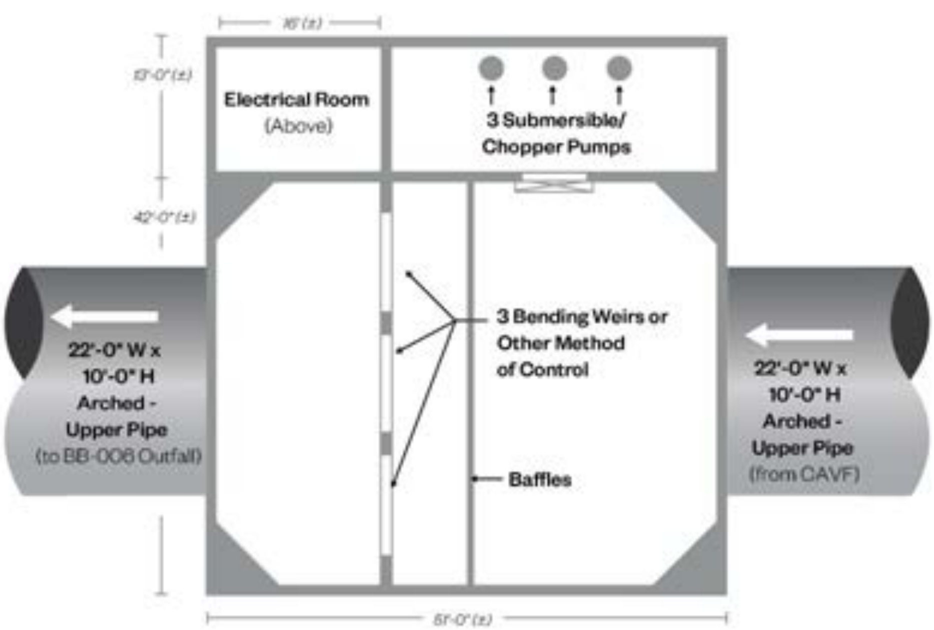

Figure 8-18. Layout of Alternative 9-3 – Outfall Storage Pumping Station for BB-006

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

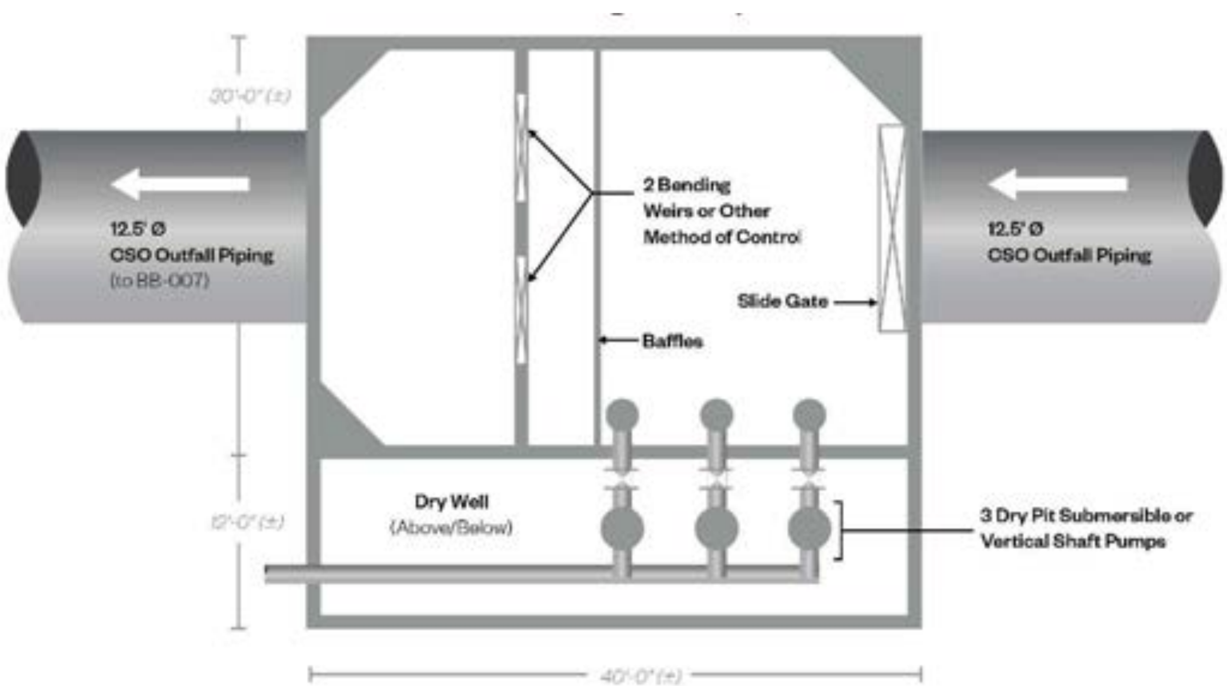

Figure 8-20. Layout of Alternative 9-3 – Outfall Storage Pumping Station for BB-008

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:

Benefits

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.

Cost

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

Challenges

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).

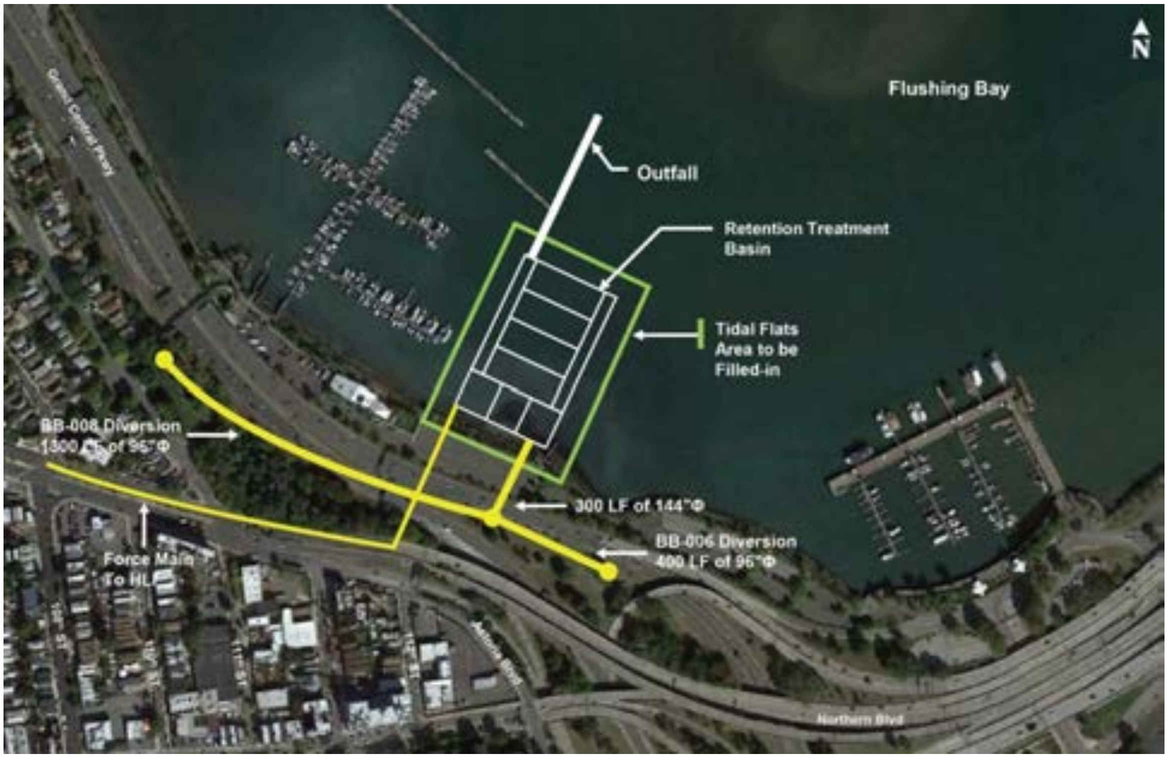

Figure 8-21. Layout of Alternative 9-5 – In-water Retention Treatment Basin

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:

<u>Benefits</u>

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.

<u>Cost</u>

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

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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:

Benefits

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.

Cost

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

Challenges

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 90th 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.

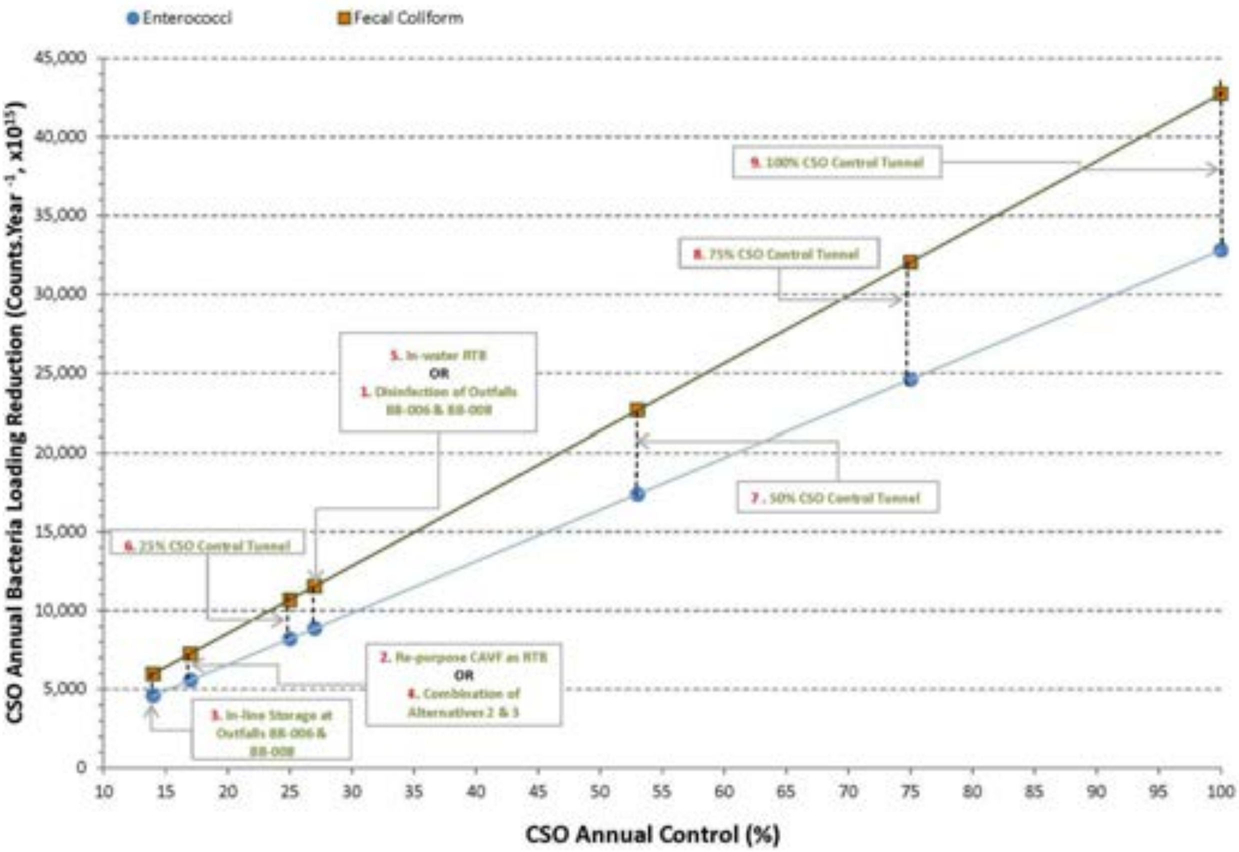


Figure 8-28. Untreated CSO Volume Reductions (as % CSO Annual Control) vs. Annual CSO Bacteria Loading Reduction (2008 Rainfall)

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 1st through October 31st) 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.

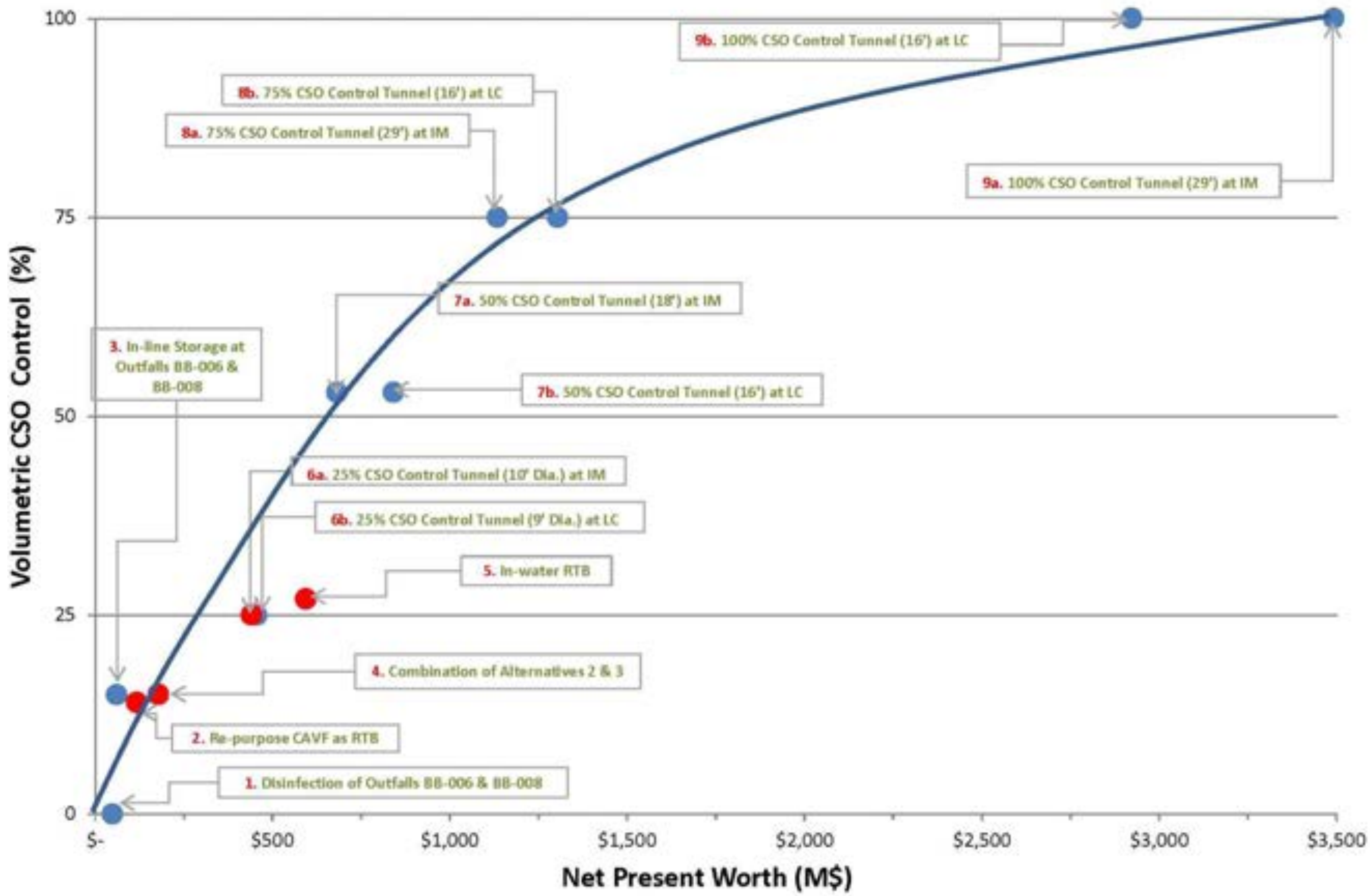


Figure 8-29. Cost vs. CSO Control (2008 Rainfall)

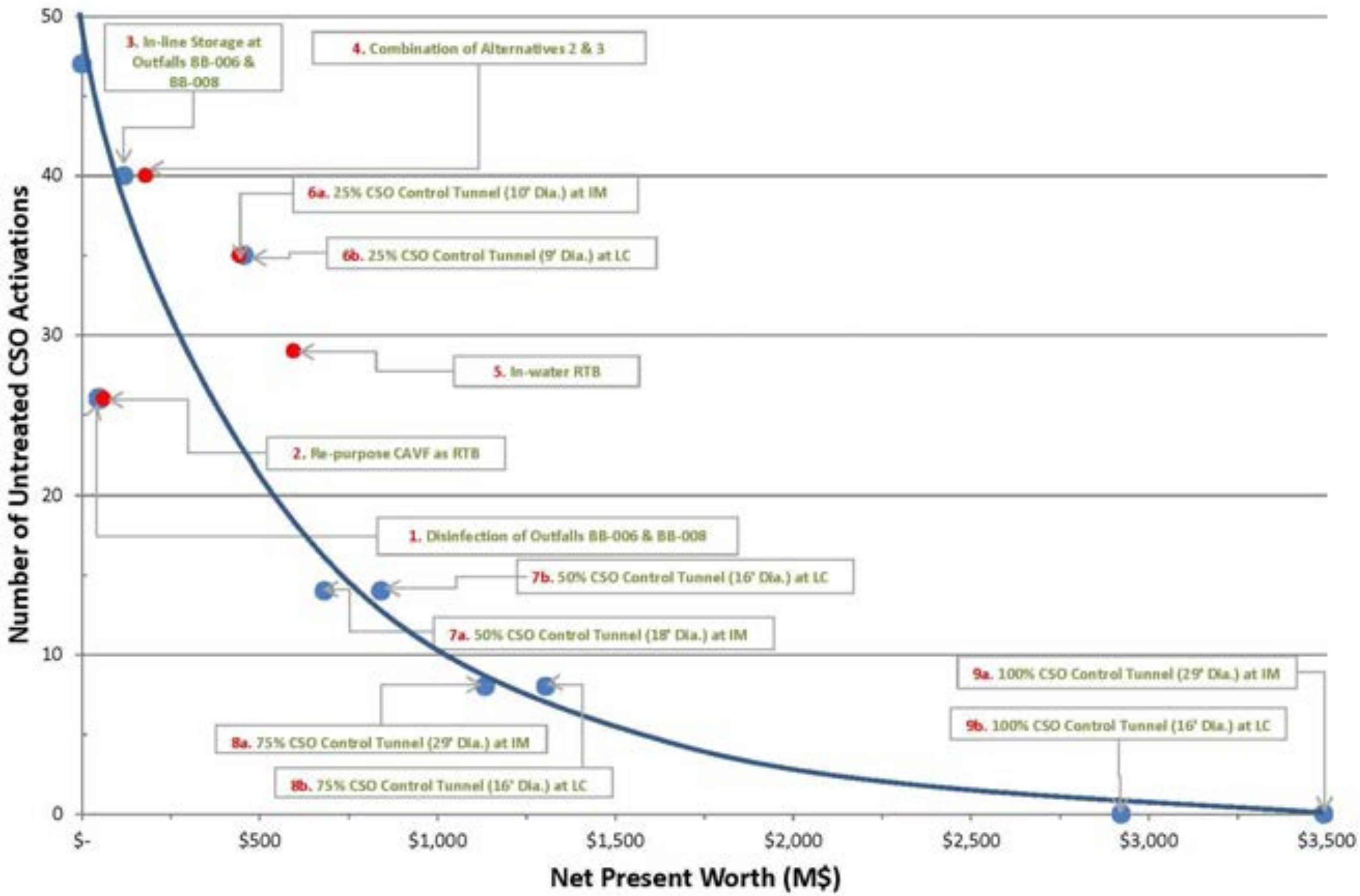


Figure 8-30. Cost vs. Remaining CSO Events (2008 Rainfall)

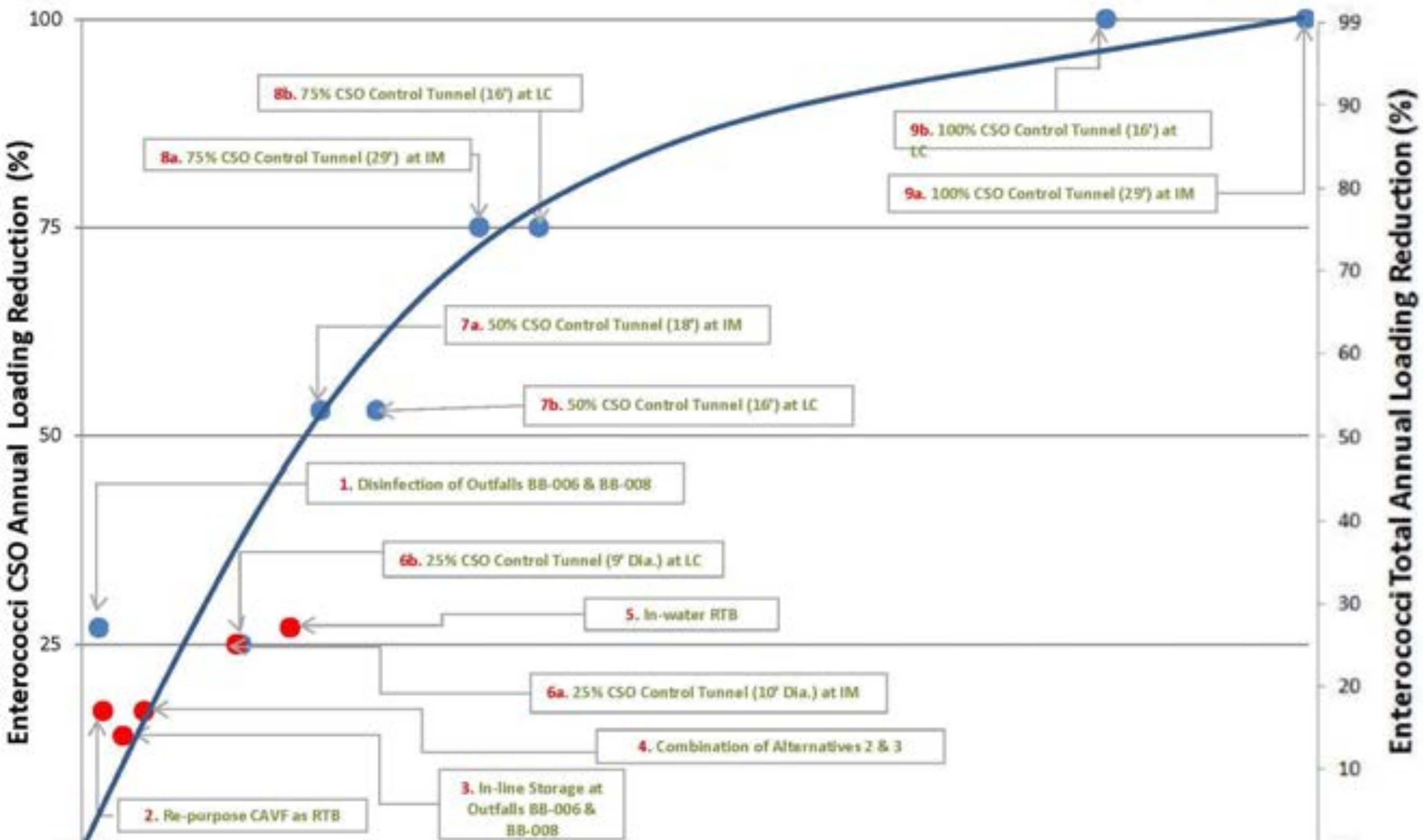


Figure 8-31. Cost vs. Enterococci Loading Reduction (2008 Rainfall)

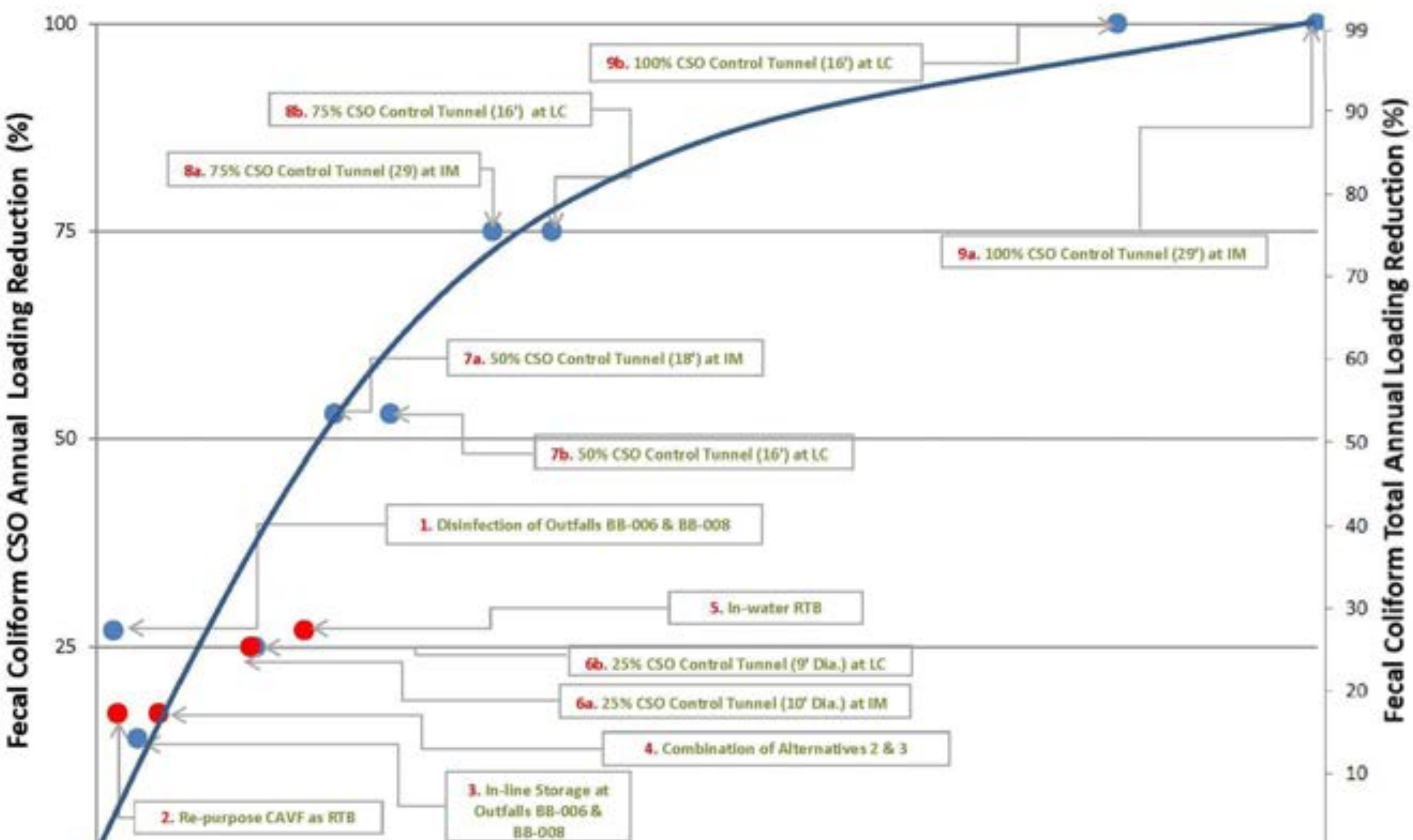


Figure 8-32. Cost vs. Fecal Coliform Loading Reduction (2008 Rainfall)

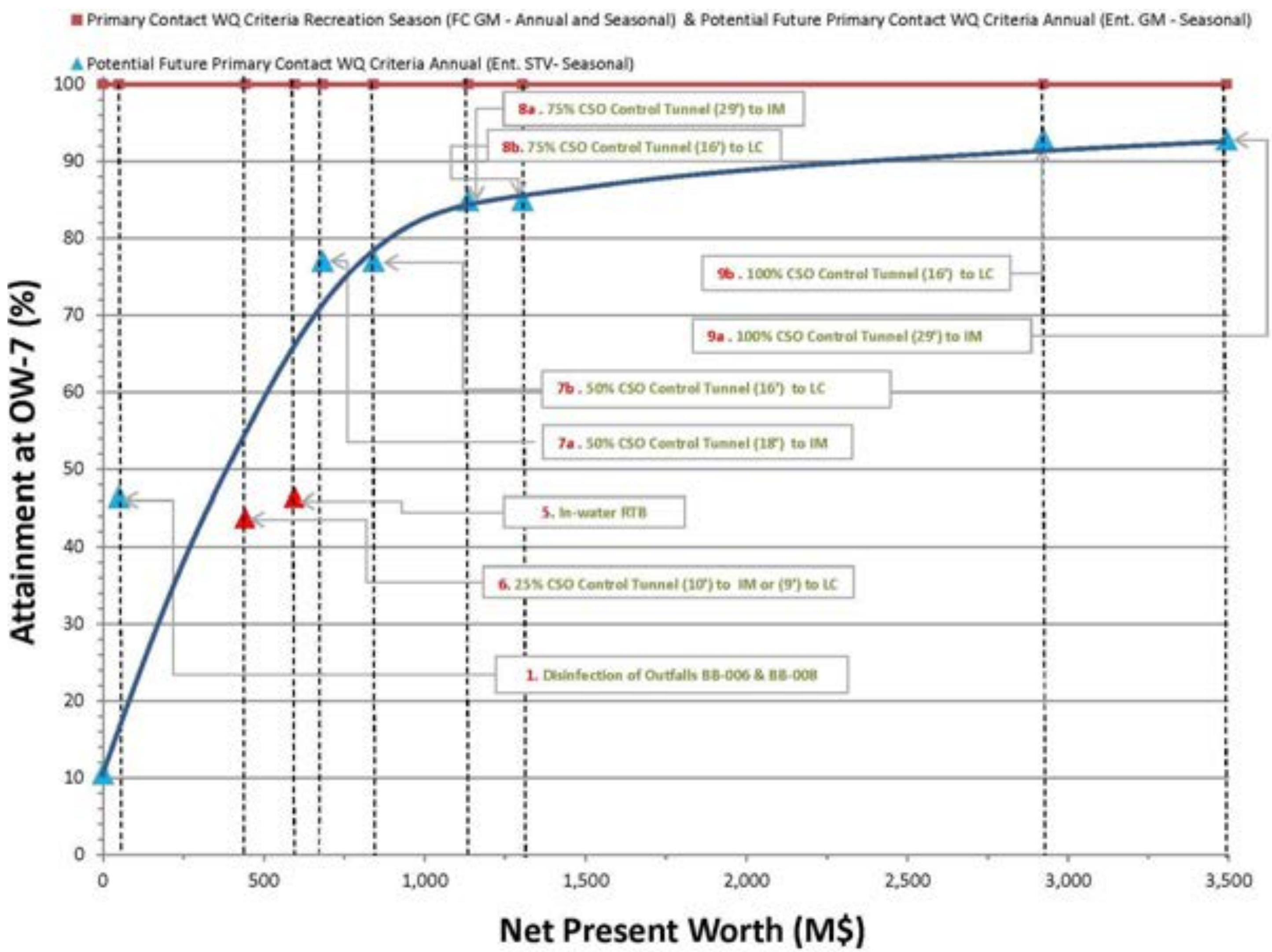


Figure 8-33. Cost vs. Bacteria Attainment at Station OW-7 (2008 Rainfall)

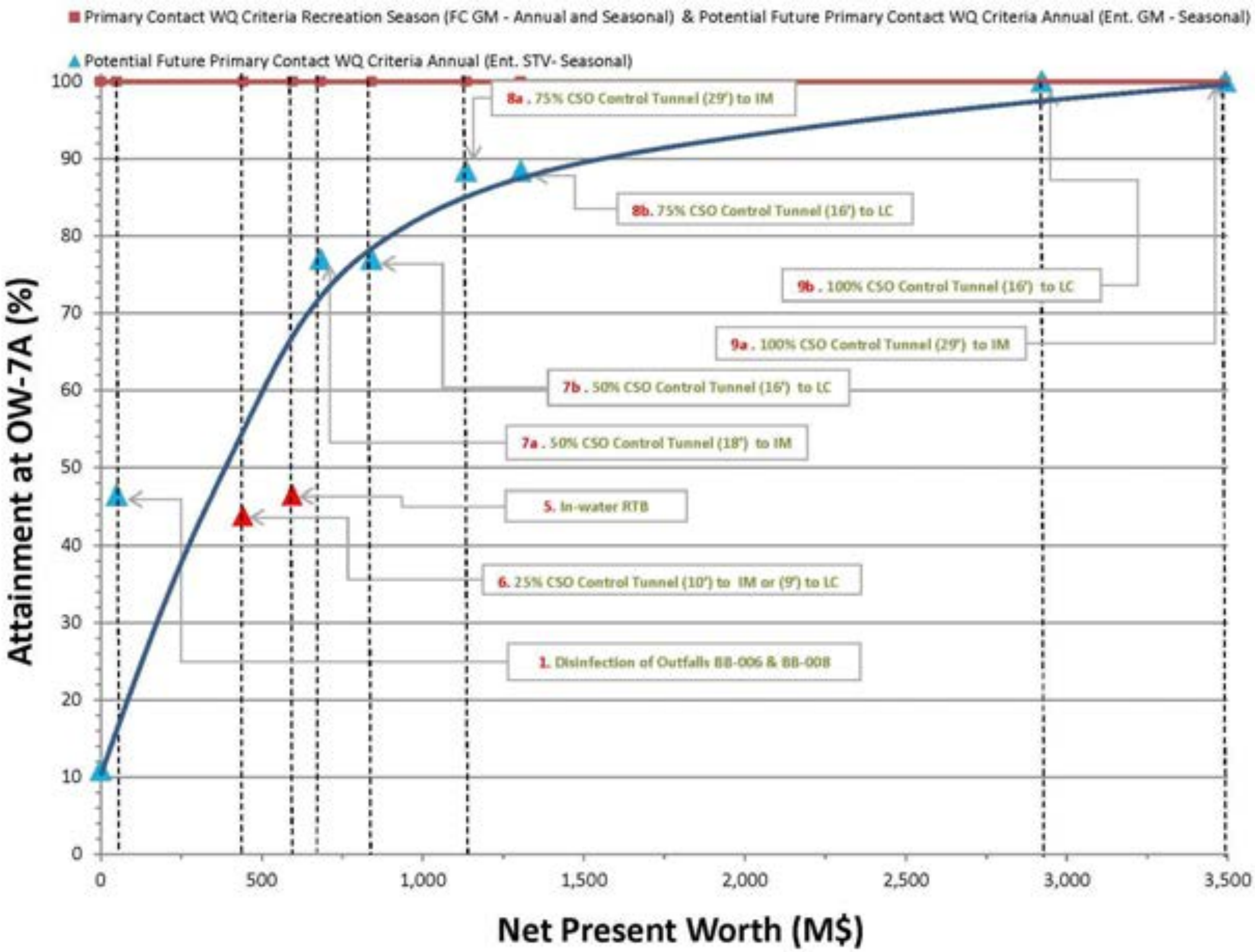


Figure 8-34. Cost vs. Bacteria Attainment at Station OW-7A (2008 Rainfall)

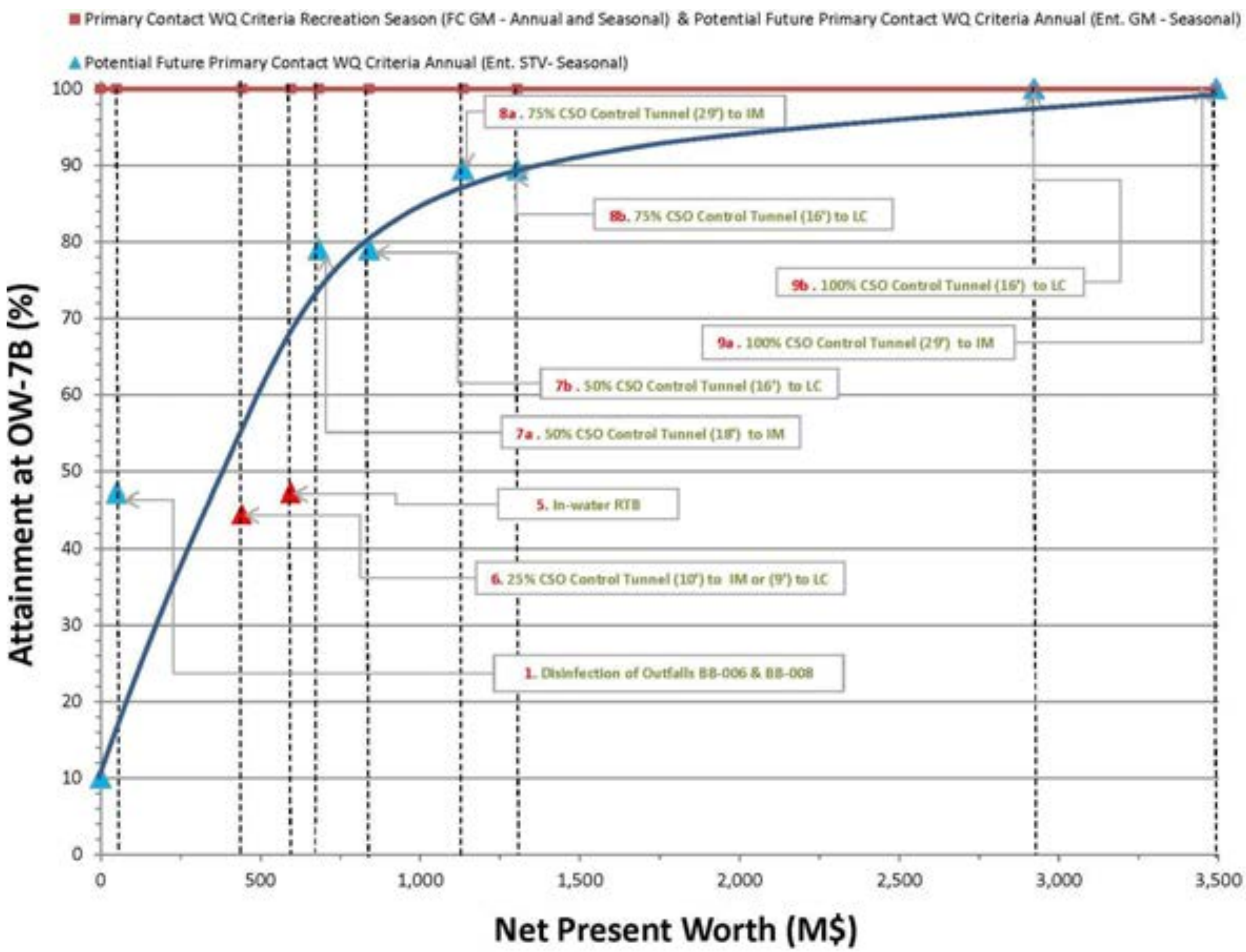


Figure 8-35. Cost vs. Bacteria Attainment at Station OW-7B (2008 Rainfall)

AECOM with Hazen

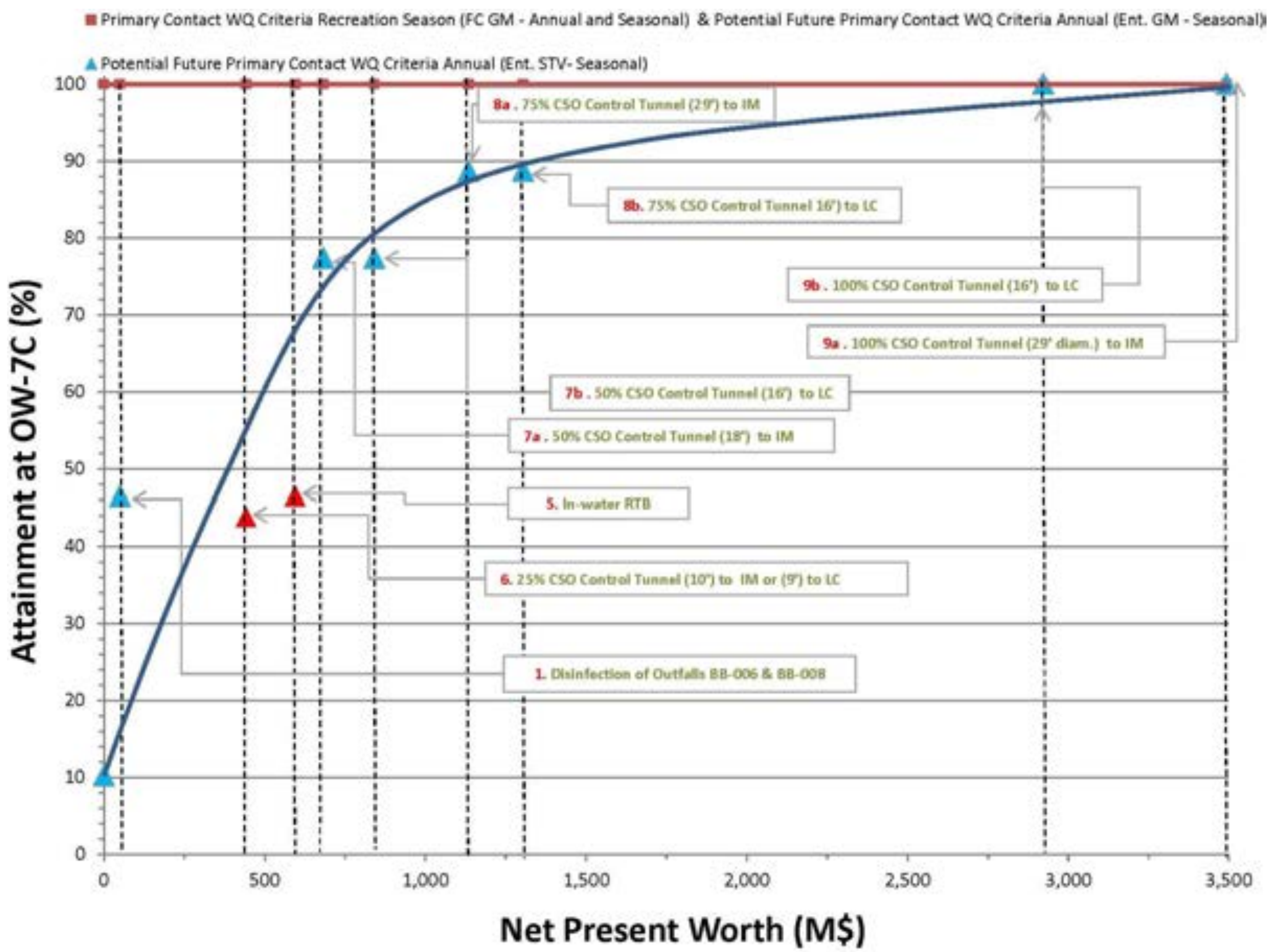


Figure 8-36. Cost vs. Bacteria Attainment at Station OW-7C (2008 Rainfall)

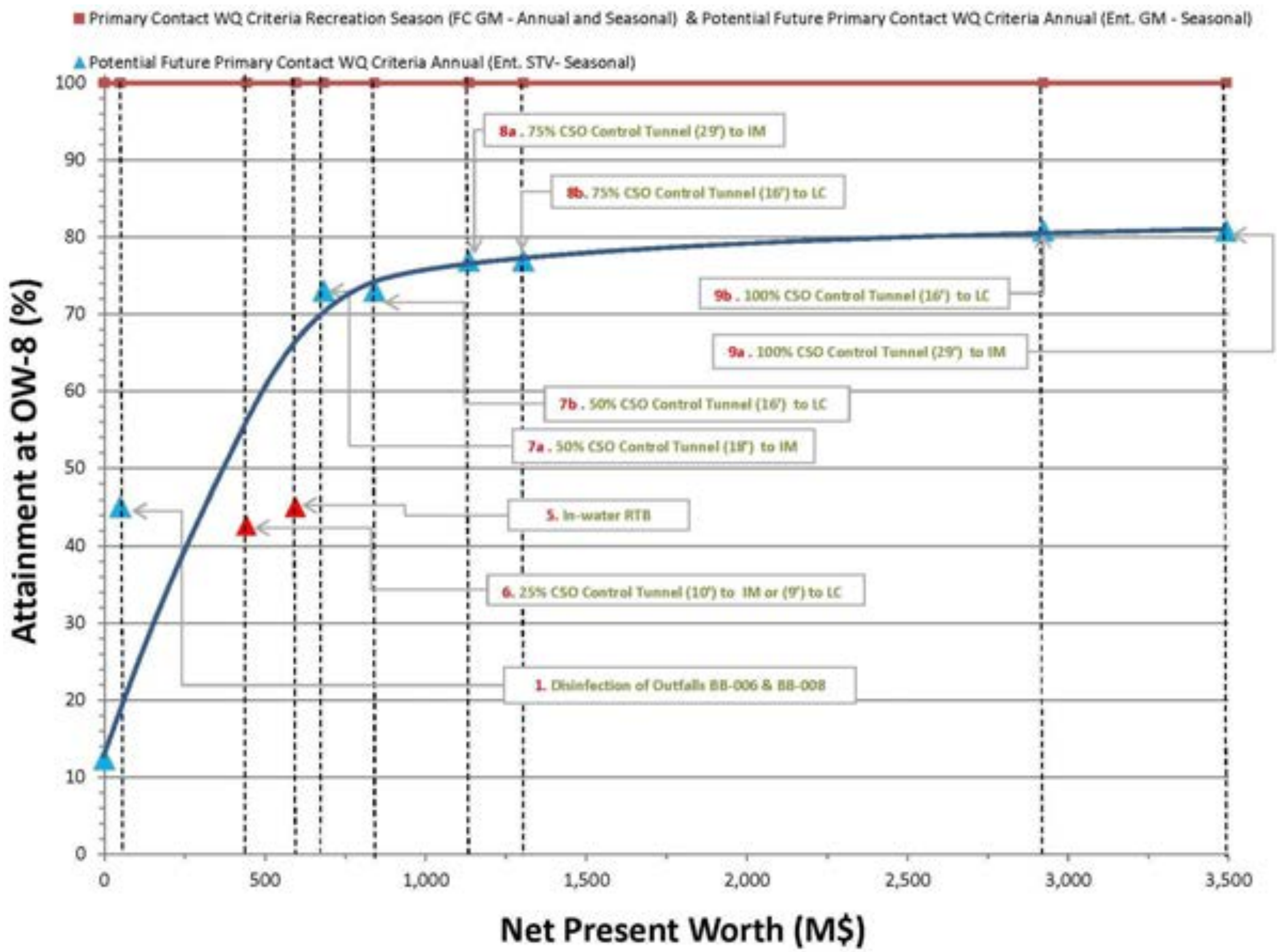


Figure 8-37. Cost vs. Bacteria Attainment at Station OW-8 (2008 Rainfall)

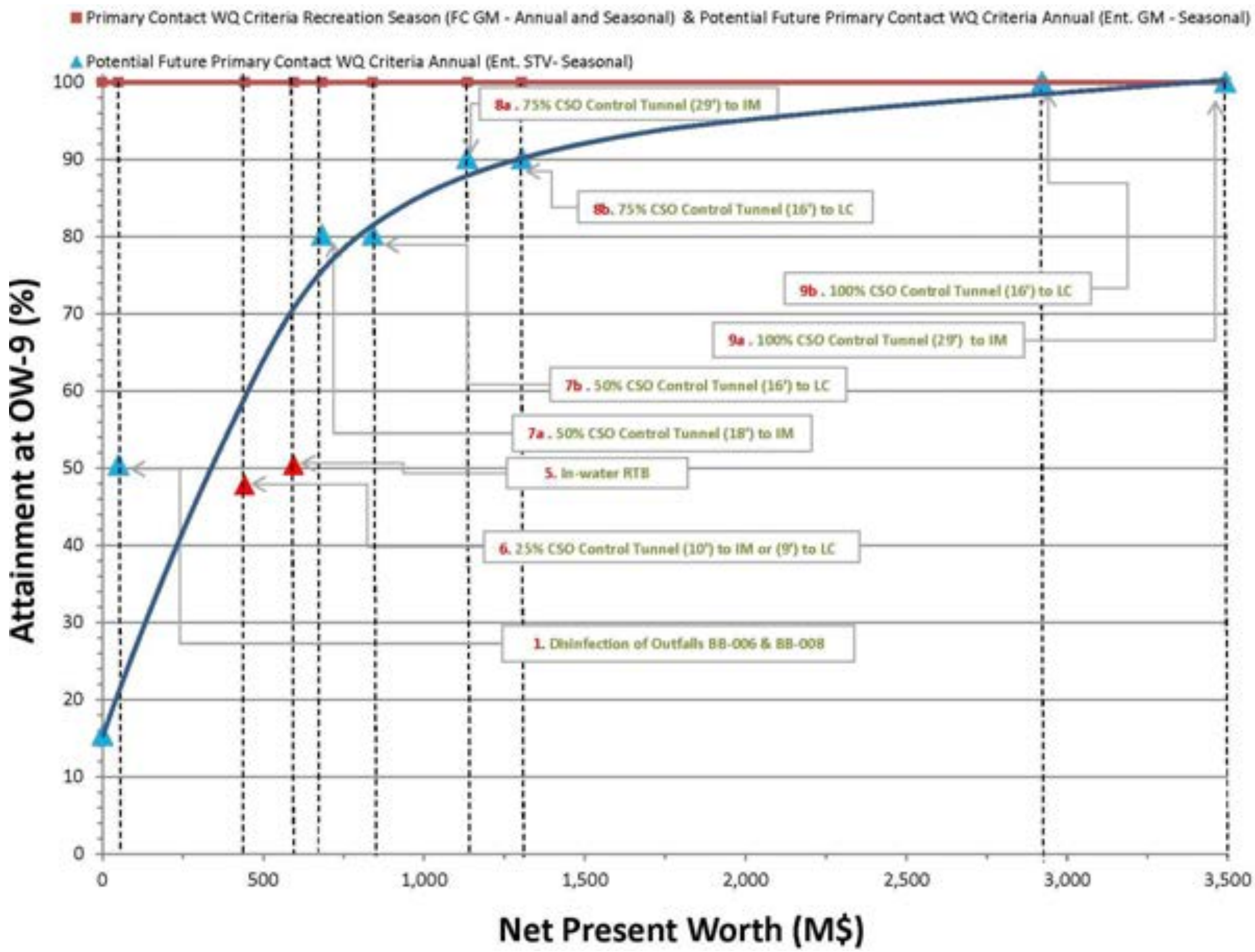


Figure 8-38. Cost vs. Bacteria Attainment at Station OW-9 (2008 Rainfall)

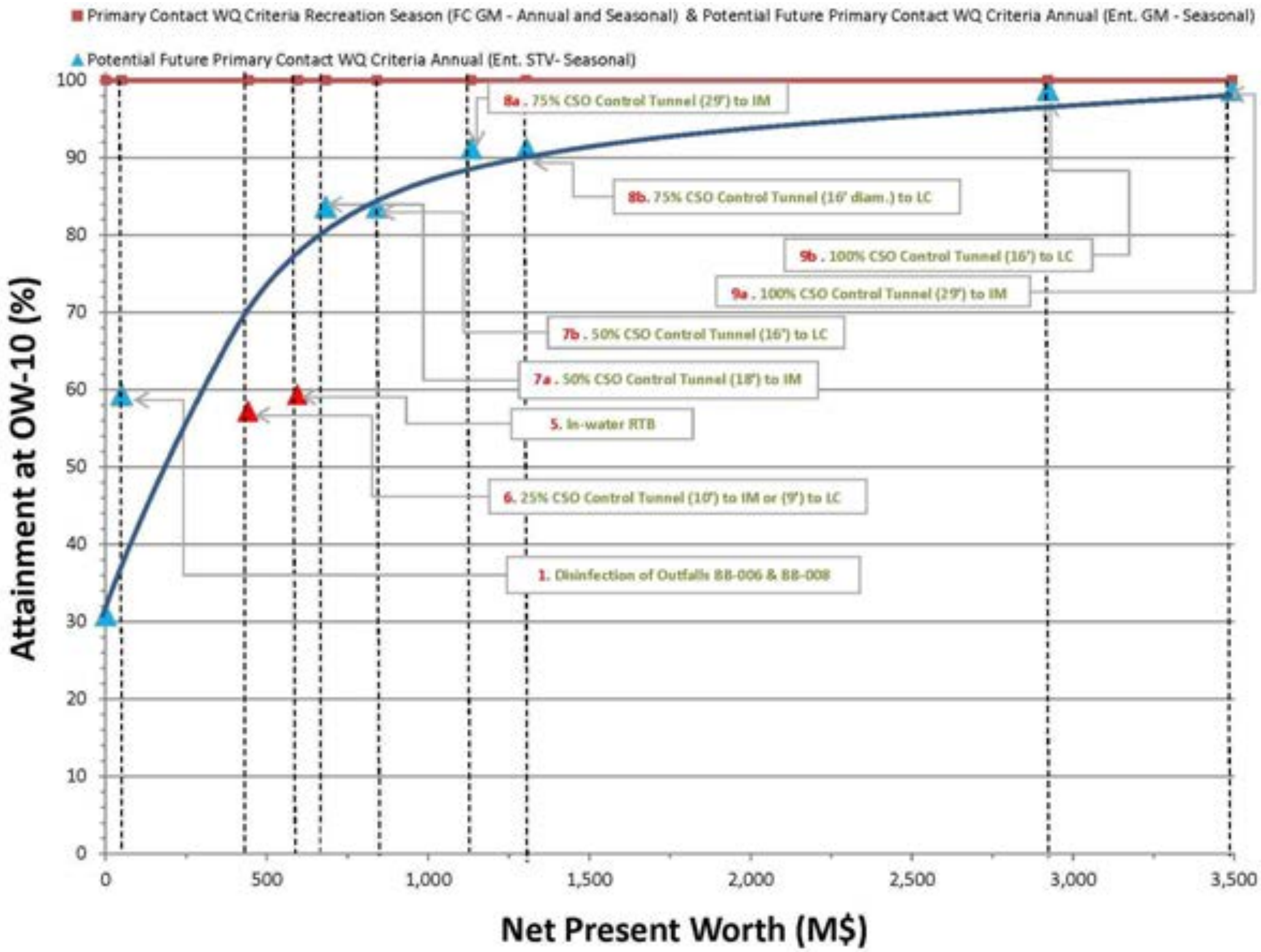


Figure 8-39. Cost vs. Bacteria Attainment at Station OW-10 (2008 Rainfall)

AECOM *with* Hazen

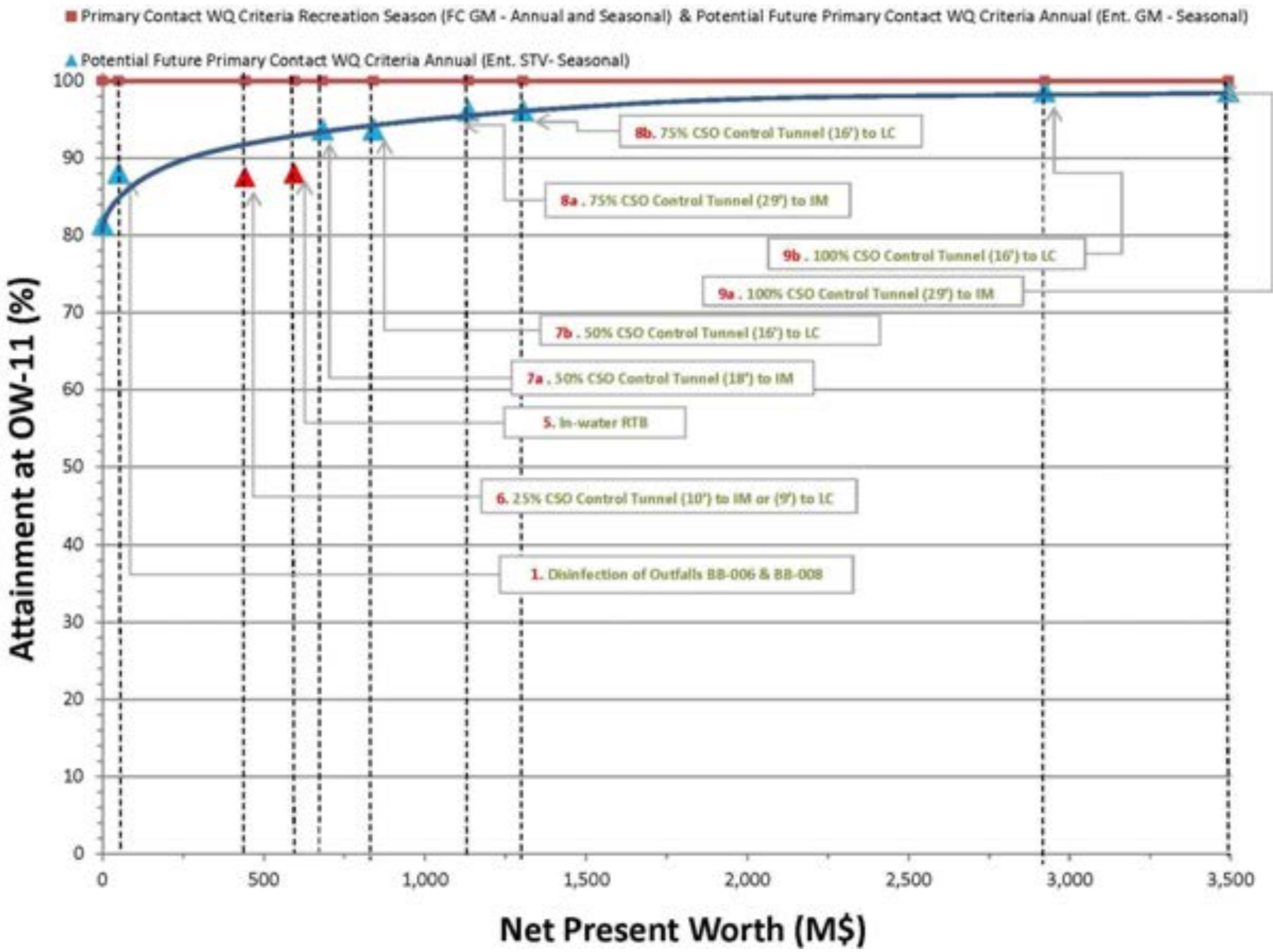


Figure 8-40. Cost vs. Bacteria Attainment at Station OW-11 (2008 Rainfall)

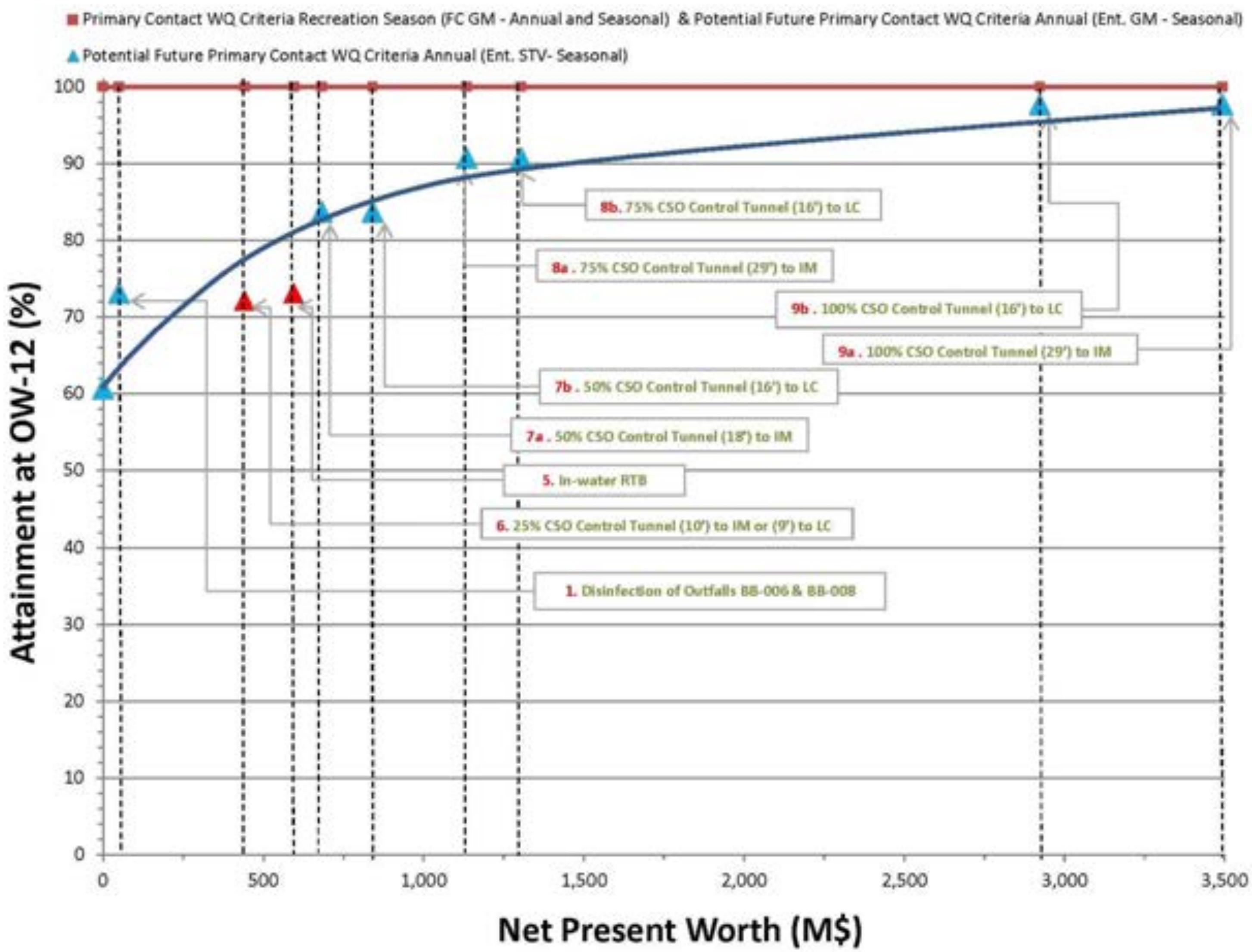


Figure 8-41. Cost vs. Bacteria Attainment at Station OW-12 (2008 Rainfall)

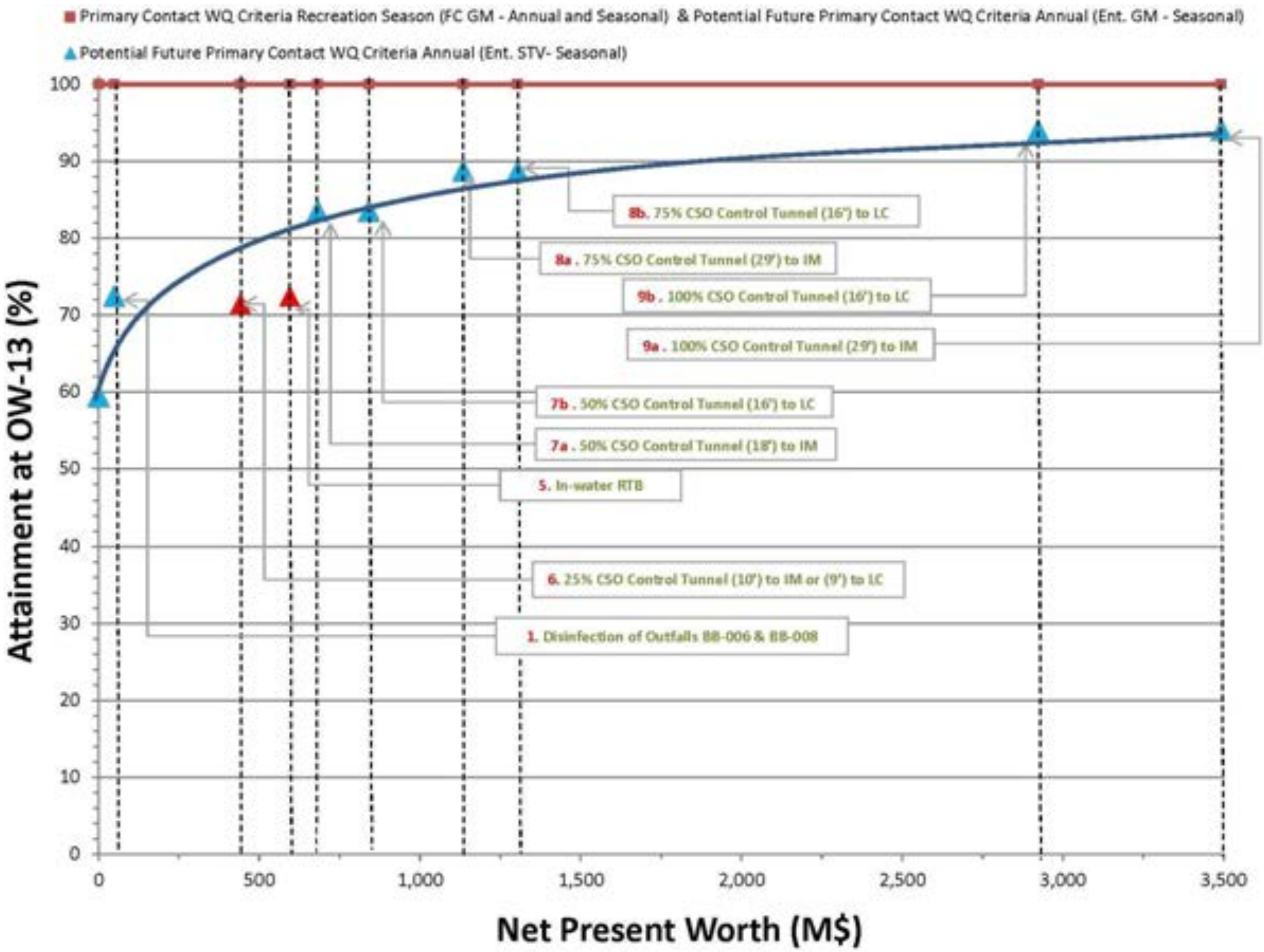


Figure 8-42. Cost vs. Bacteria Attainment at Station OW-13 (2008 Rainfall)

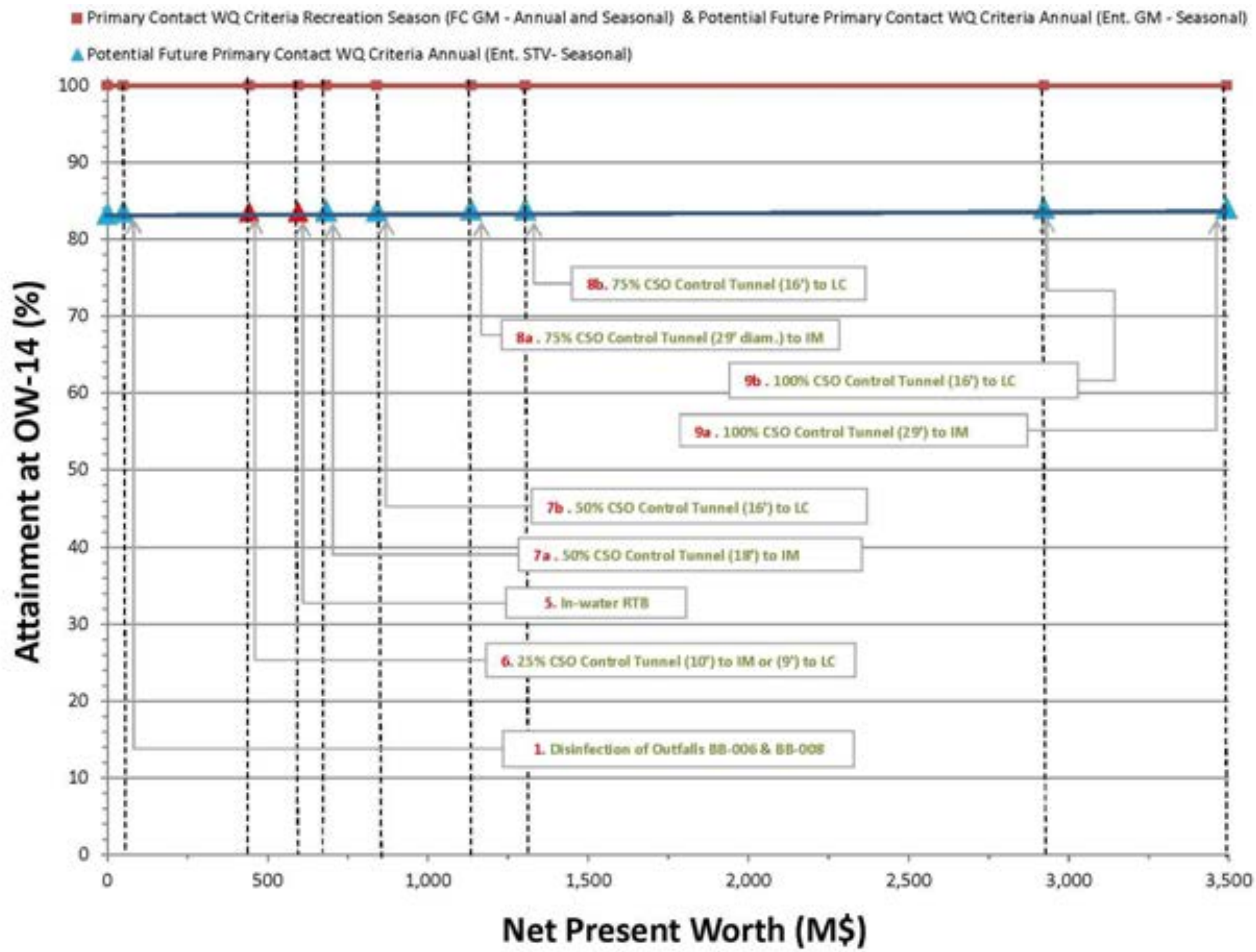


Figure 8-43. Cost vs. Bacteria Attainment at Station OW-14 (2008 Rainfall)

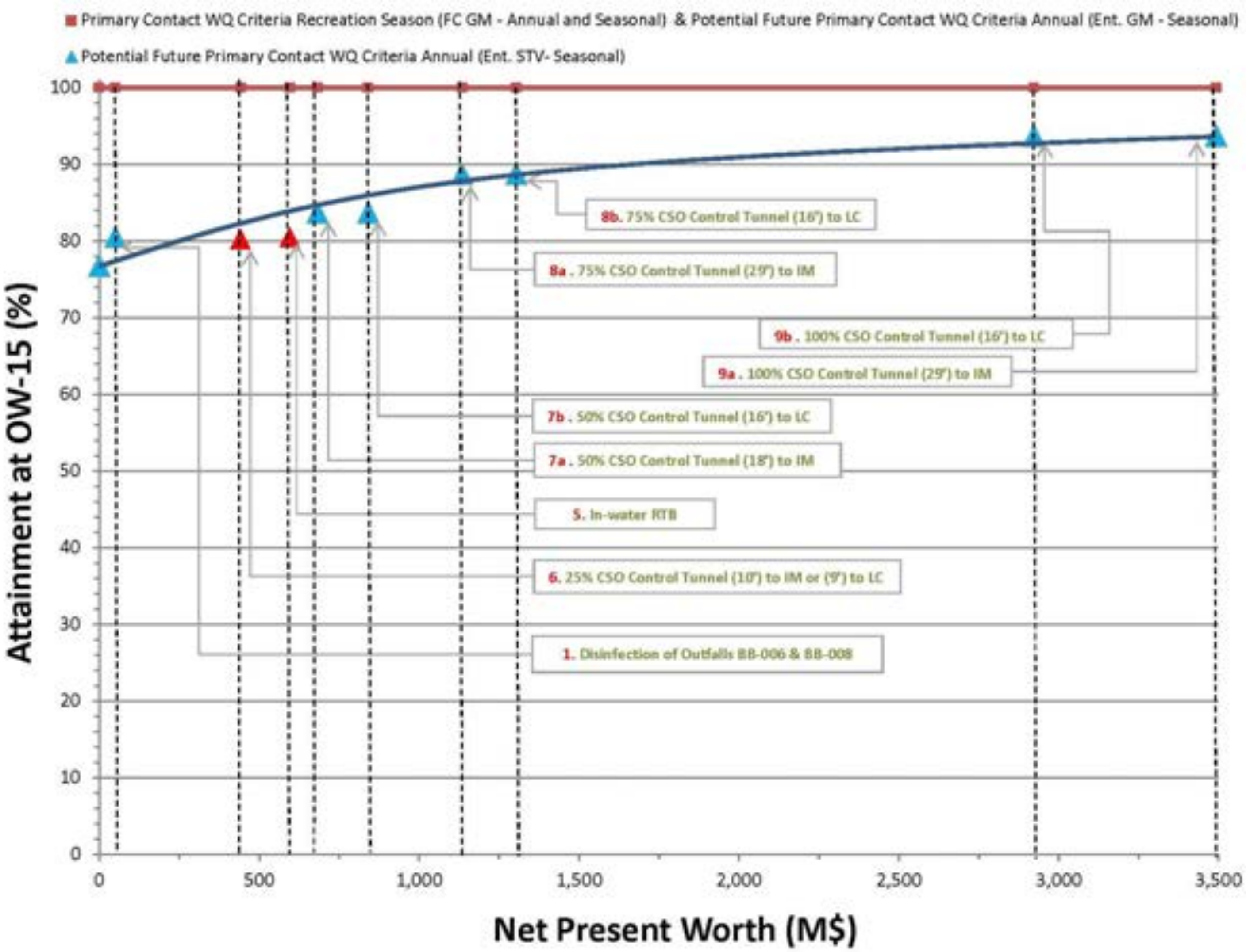


Figure 8-44. Cost vs. Bacteria Attainment at Station OW-15 (2008 Rainfall)

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 1st through October 31st) 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 90th 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	90^{th} 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.

- 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 1^{st} through October 31^{st}) 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%.

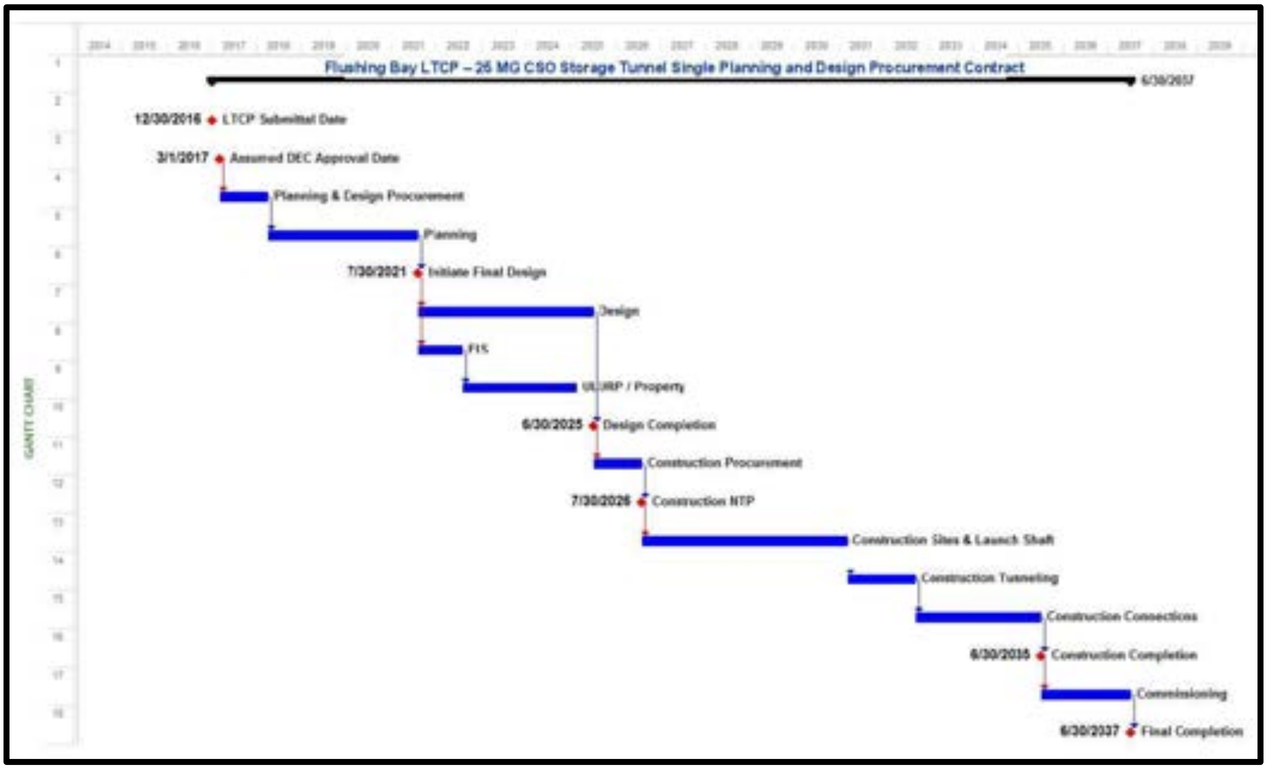


Figure 9-1. Implementation Schedule

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

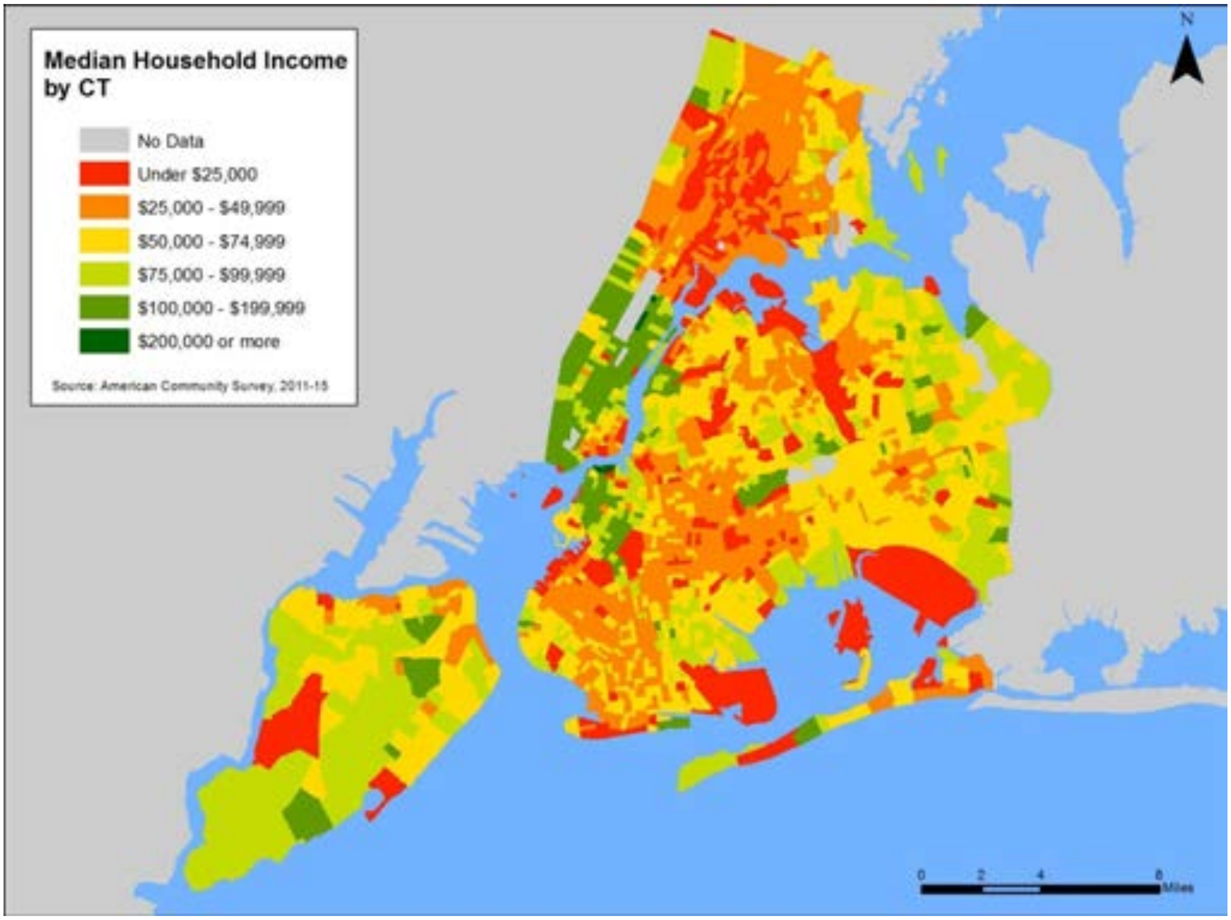
In 2015, the latest year for which Census data is available, the MHI in NYC was $55,752. As shown in Table 9-5, across the NYC boroughs, MHI ranged from $35,176 in the Bronx to $75,575 in Manhattan. Figure 9-2 shows that income levels also vary considerably across NYC neighborhoods, and there are several 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

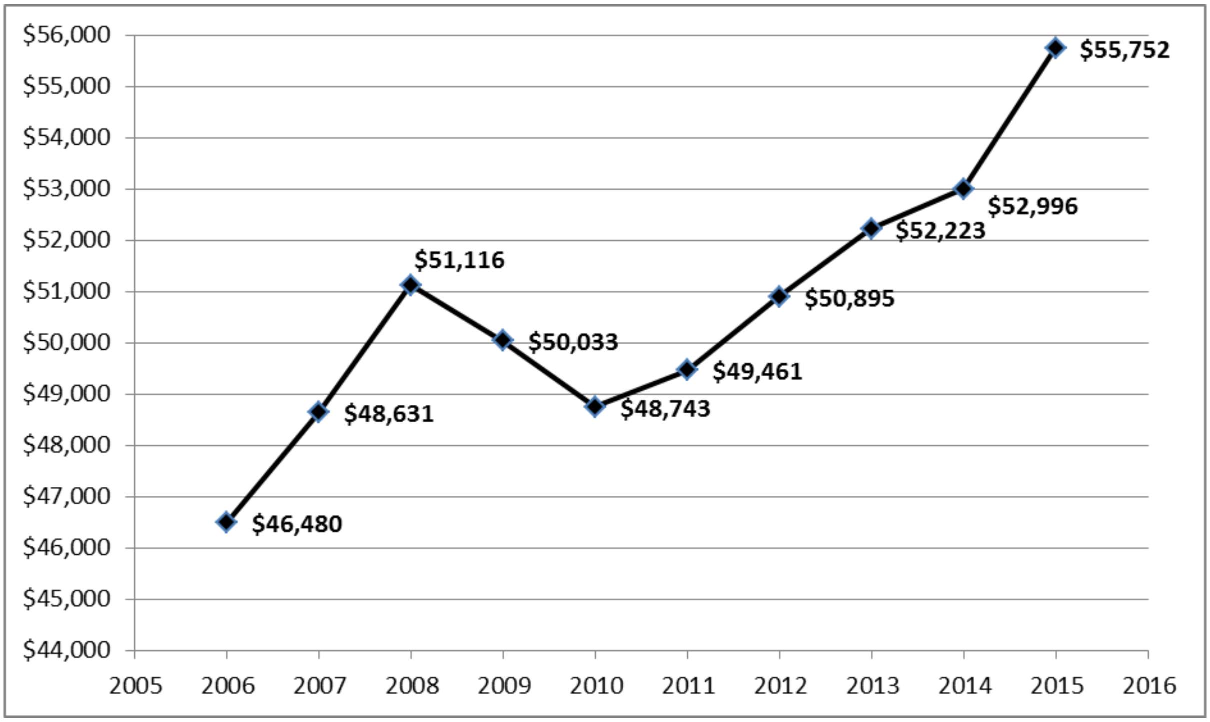
Location	2015 (MHI)
United States	$55,775
New York City	$55,752
Bronx	$35,176
Brooklyn	$51,141
Manhattan	$75,575
Queens	$60,422
Staten Island	$71,622

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



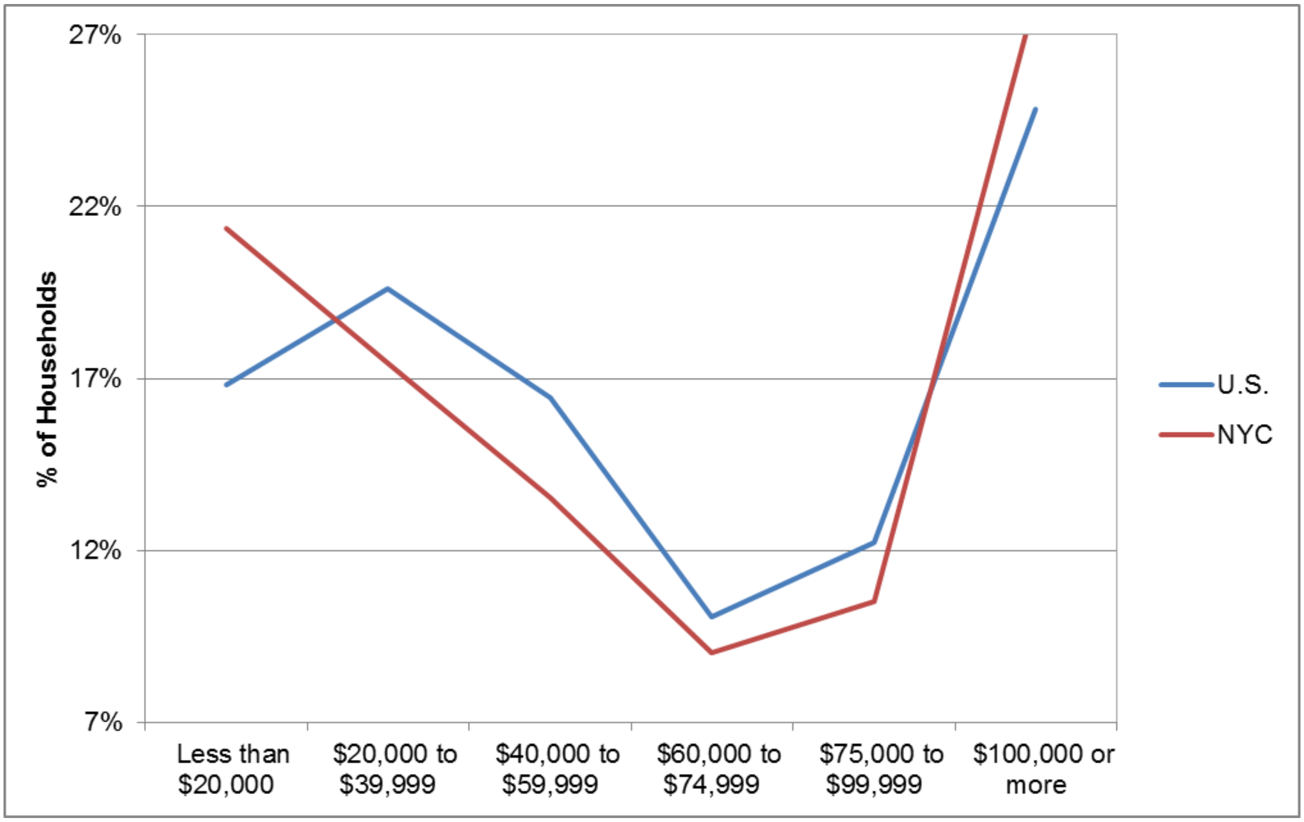
Source: U.S. Census Bureau 2006 through 2015 ACS 1-Year Estimates.

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

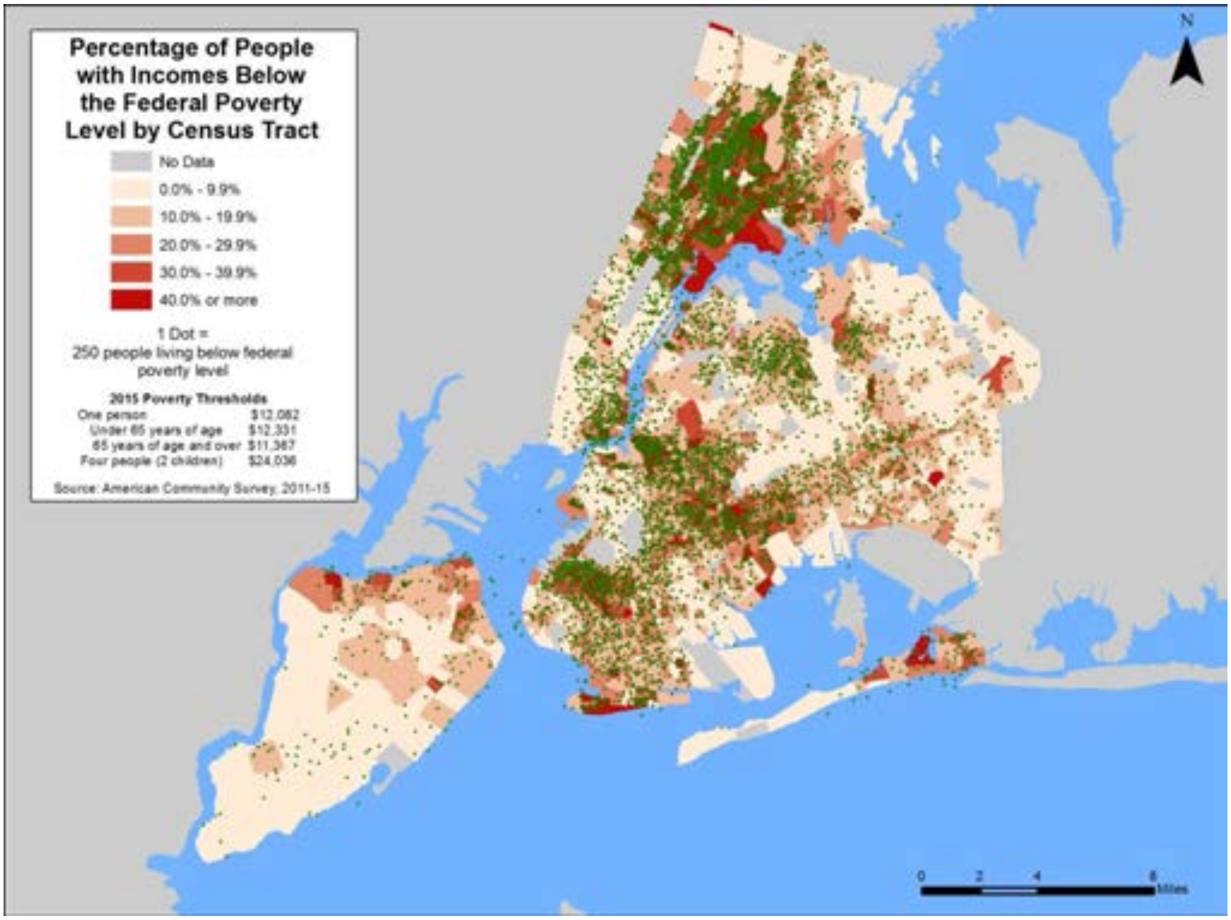
Based on the latest available Census data, 20 percent of NYC residents are living below the federal poverty level (almost 1.7 million people, which, for reference, is greater than the entire population of Philadelphia). This is significantly higher than the national poverty rate of 14.7 percent, despite 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.

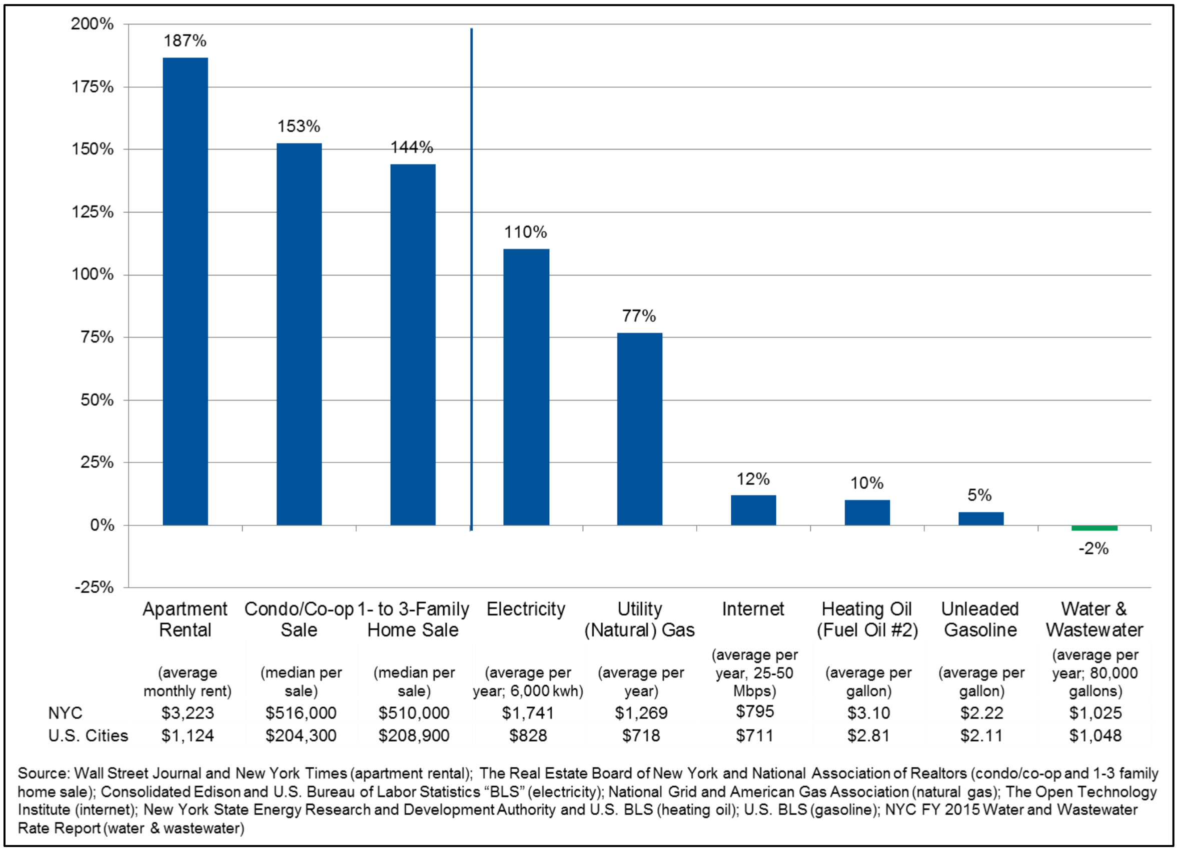


Figure 9-6. Comparison of Costs between NYC and other U.S. Cities

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.

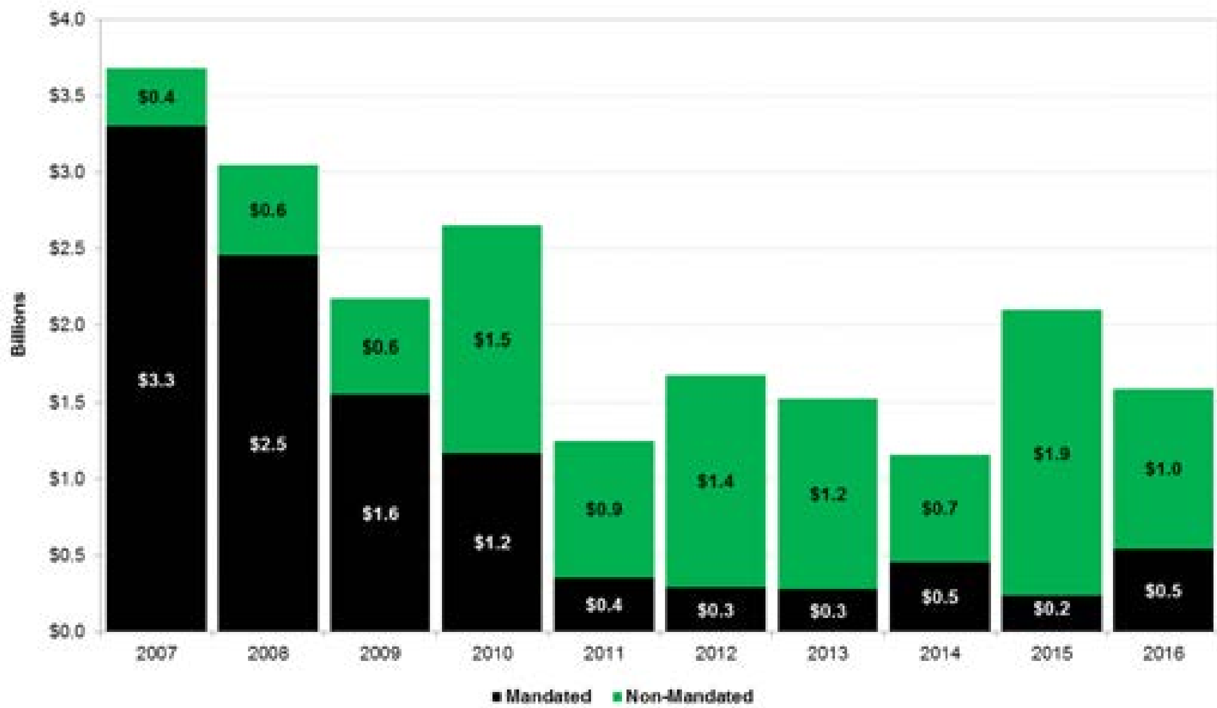


Figure 9-7. Historical Capital Commitments

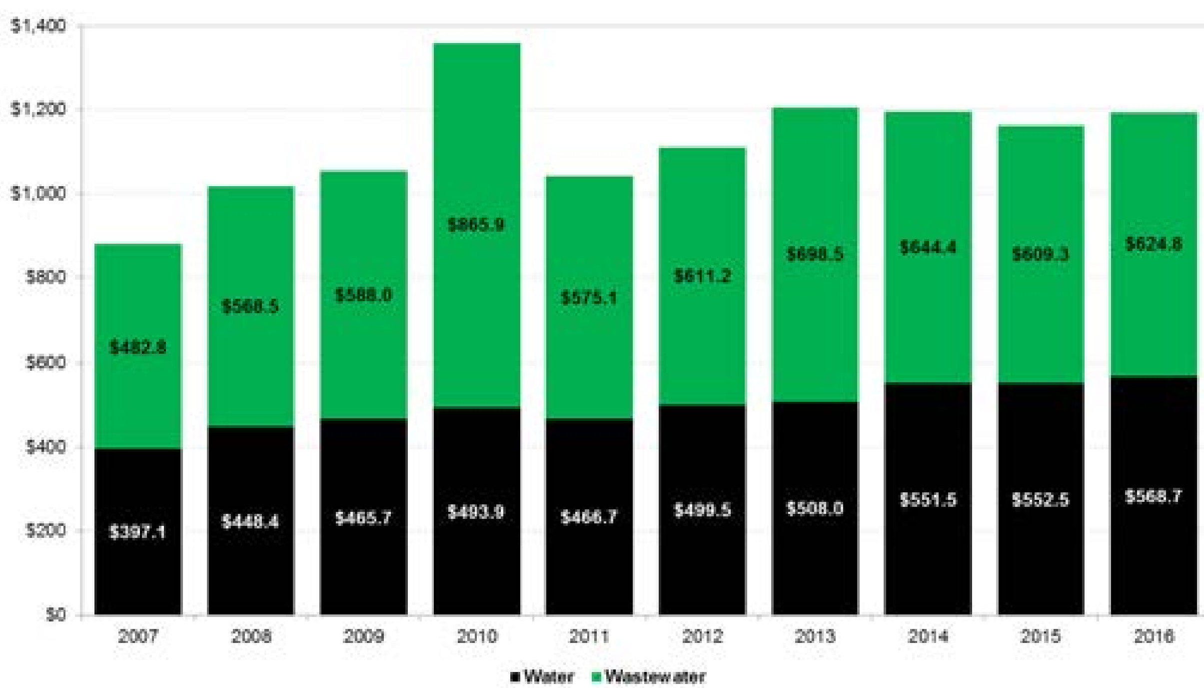


Figure 9-8. Historical Operating Expenses

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.

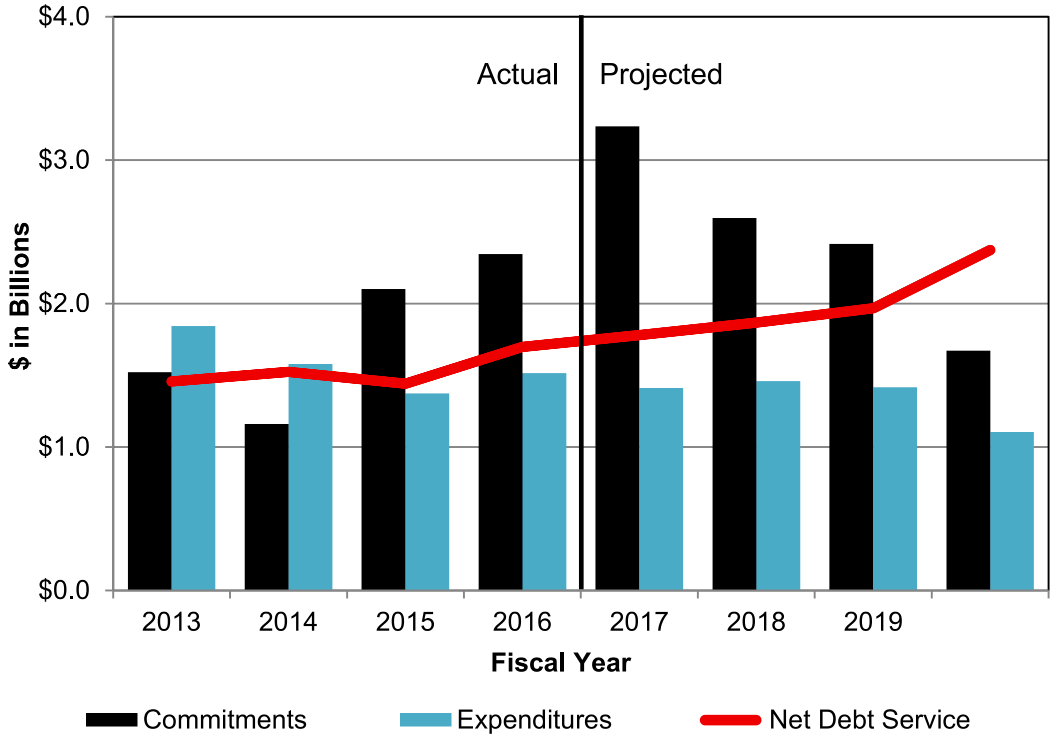


Figure 9-9. Past Costs and Debt Service

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

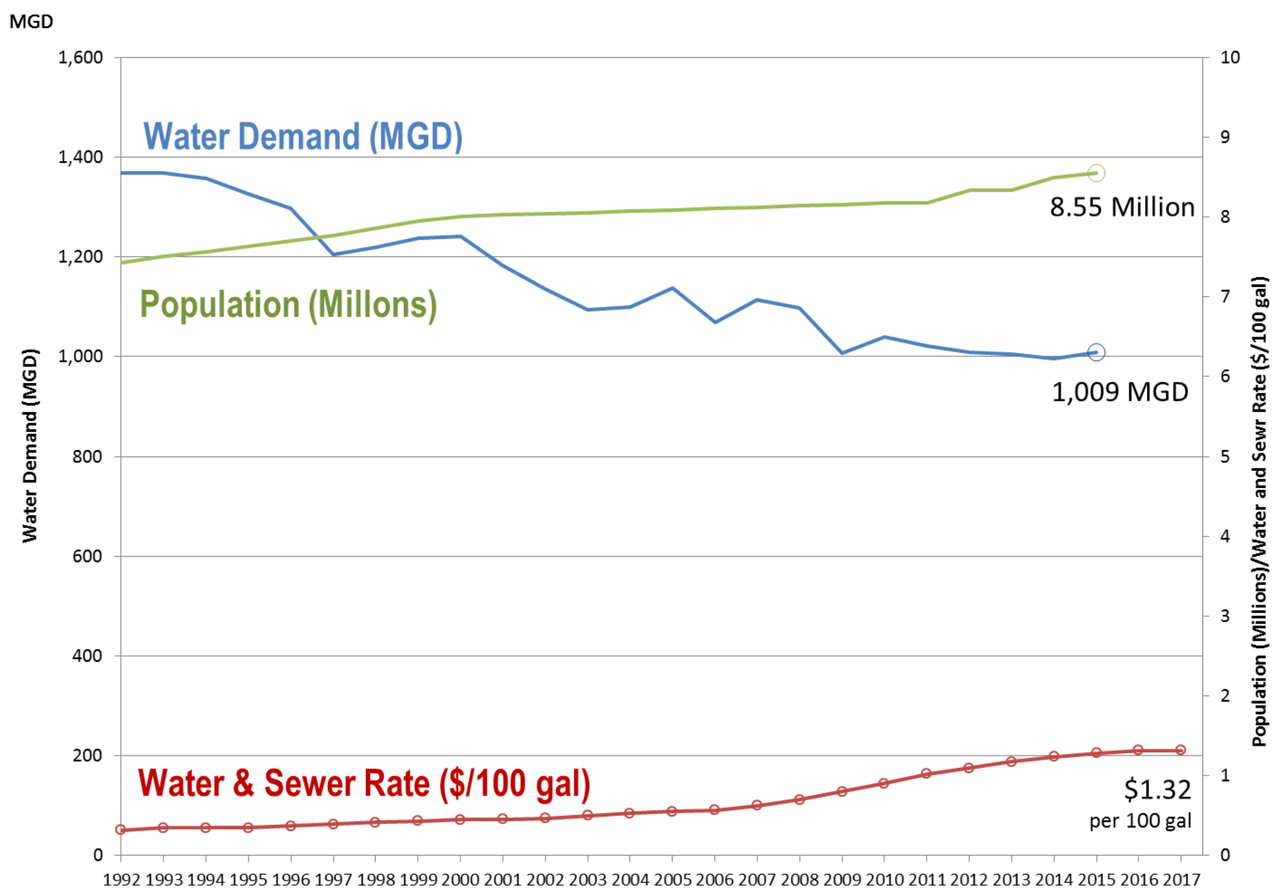


Figure 9-10. Population, Consumption Demand, and Water and Sewer Rates over Time

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.

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.

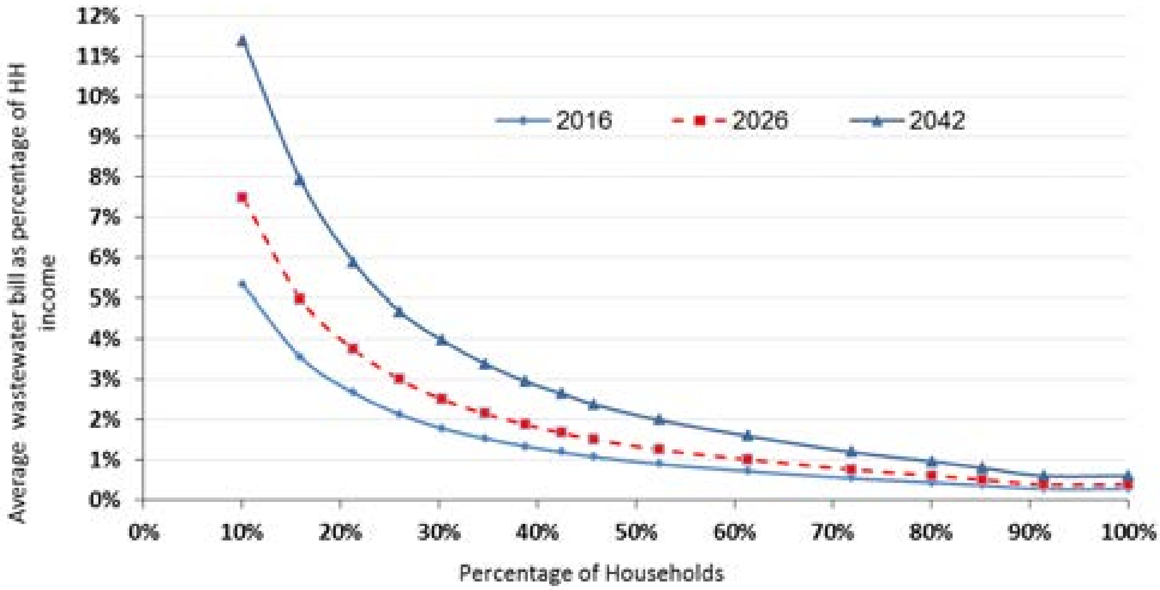


Figure 9-11. Estimated Average Wastewater Household Cost Compared to Household Income (2016, 2026, and 2042)

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.

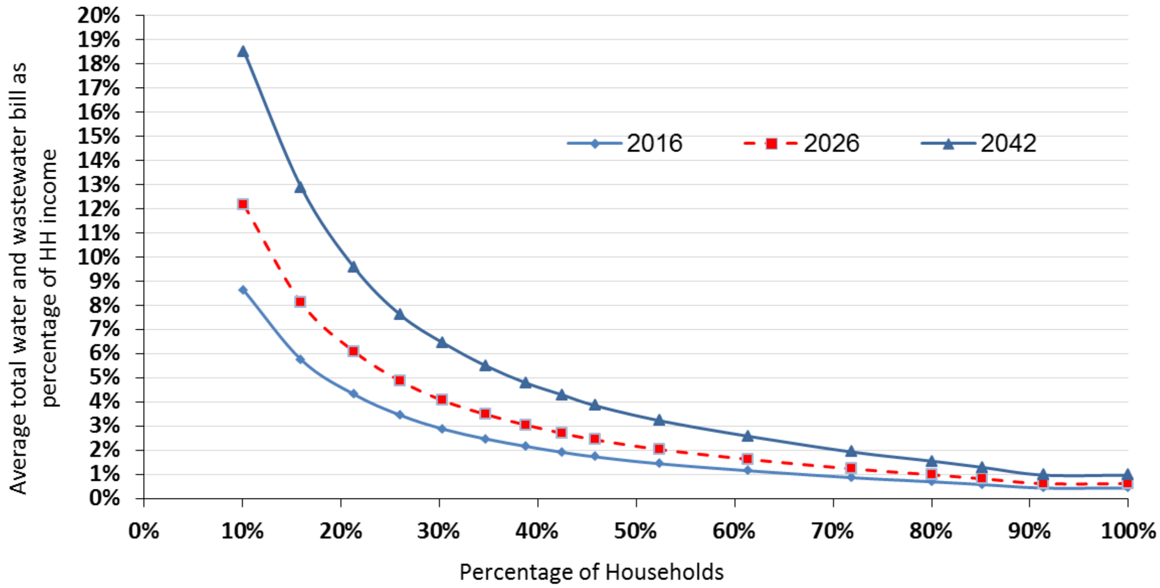


Figure 9-12. Estimated Average Total Water and Wastewater Household Cost Compared to Household Income (2016, 2026, and 2042)

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.

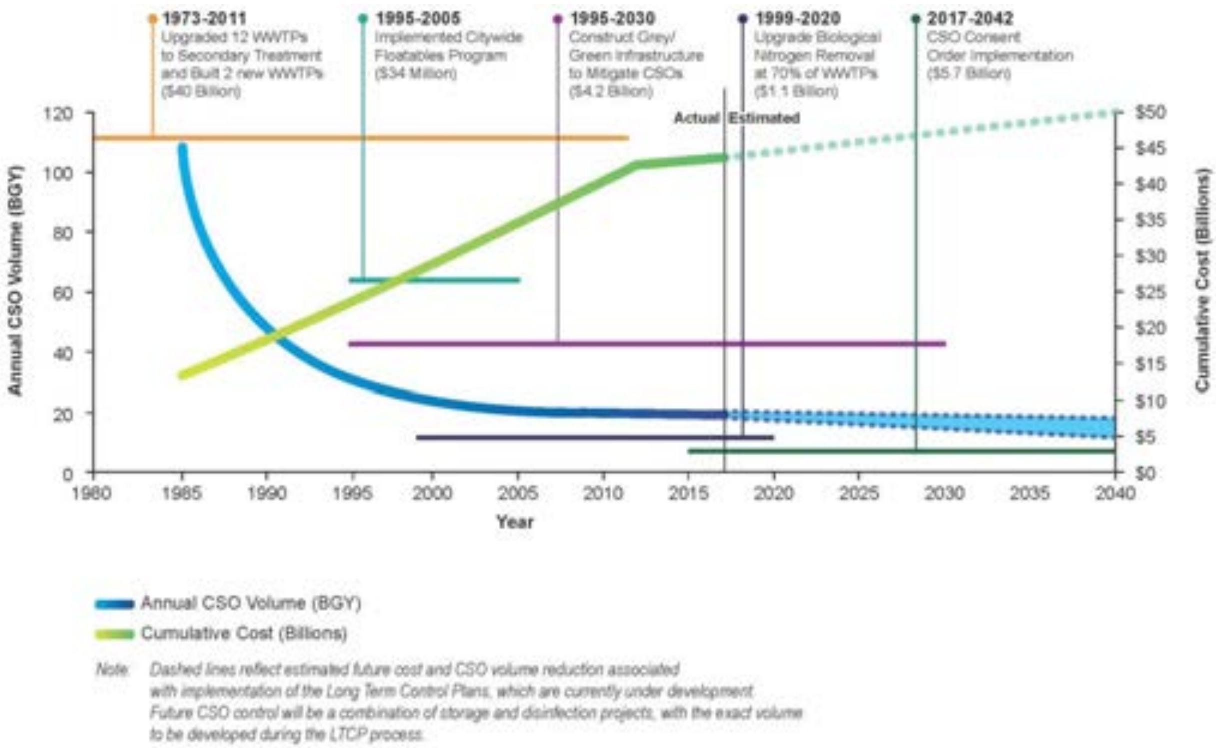


Figure 9-13. Historical Timeline for Wastewater Infrastructure Investments and CSO Reduction Over Time

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.

10. REFERENCES

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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.

<u>General Concerns</u>

- 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

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TEAM 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