Task 4: Semiannual CSO Discharge Report No. 6
July 1, 2020 – December 31, 2020

CSO Post Construction Monitoring and Performance Assessment

MWRA Contract No. 7572

April 30, 2021

Project number: 60559027

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Definitions

Clean Water Act (CWA): Federal legislation that established the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters.

Combined Sewer: A sewer that conveys stormwater and wastewater of domestic, commercial, and industrial origin. When wastewater and stormwater flows exceed the sewer capacity, overflows can occur. These overflows are called Combined Sewer Overflows (CSOs).

Combined Sewer Regulator: A CSO regulator controls flow by directing normal dry weather flow and a portion of wet weather flow to an interceptor for conveyance to full treatment. Excess wet weather flow is directed to an overflow conduit.

Continuity: A term used in fluid mechanics to describe the principle of conservation of mass. The continuity equation states that the flow rate for an incompressible fluid can be calculated by multiplying the area of flow by the average flow velocity.

Discharge Permits (NPDES): A permit issued by the U.S. EPA or a State regulatory agency under the National Pollutant Discharge Elimination System (NPDES) that sets specific limits on the type and amount of pollutants that a municipality or industry can discharge to a receiving water. It also includes a compliance schedule for achieving those limits. The NPDES process was established under the Federal Clean Water Act.

Diversion Structure: A structure that diverts flow to either the associated control facility (i.e., tunnel, storage tank, etc.) or the CSO outfall if the capacity of the control measure is exceeded.

Doppler Velocity Meter: A velocity measurement device using sound pulses emitted in the upstream direction. The device records the reflection of these pulses on particles in the water from which the flow velocity can be quantified

Depth and Velocity Sensor: A device used to measure velocity and water level at a monitoring location from which the flowrate can be quantified.

Hydrograph Analysis: Analysis of graphical plots comparing the rate of flow versus time.

Hyetograph: A graphical plot of precipitation data over time. Graph of rainfall intensity during a storm event.

Inclinometer: A measurement device that is mounted on a tide gate and used to measure the angle of opening of a tide gate as a function of time.

Intensity-Duration-Frequency (IDF) Curve: A mathematical function that relates the rainfall intensity with its duration and frequency of occurrence. These curves are commonly used in hydrology for flood forecasting and civil engineering for urban drainage design. IDF curves are also analyzed in hydrometeorology because of the interest in the time-structure of rainfall.

Intrusion Velocity: A velocity measurement made with a Peak Velocity sensor in which the sensor is facing towards a tide gate to spot reverse flow through a tide gate.

Level Sensor (or Level Meter): A device used to measure flow depth at a monitoring location.

Long-Term Control Plan: A phased approach required under the Environmental Protection Agency's CSO Control Policy and part of the strategy to control CSOs. LTCPs aim to reduce the frequency, duration, and volume of CSO events through system characterization, development and evaluation of alternatives, and selection and implementation of controls. For this report, the term LTCP refers to the plan developed by MWRA in the 1990s to reduce CSO volumes in the cities of Boston, Cambridge, Somerville and Chelsea.

Manning's Equation: An empirical equation for calculating flow rate or velocity that applies to uniform flow in open channels and is a function of the channel roughness, flow area, wetted perimeter and channel slope.

Meter: An instrument for measuring and recording data such as water level, velocity, or both. Flow meters typically measure water level and velocity from which the flowrate can be calculated.

Nine Minimum Controls (NMCs): Technology-based controls that address CSOs without extensive engineering studies or significant construction costs.

Precipitation: The process by which atmospheric moisture falls onto a land or water surface as rain, snow, hail, or other forms of moisture.

Pressure Sensor (Dp): A device used to measure the depth of water by determining the force acting on the sensor based on the water level above the sensor.

Rain Gauge: An instrument that measures the amount of rain that has fallen in a particular place at a set time interval.

Regression Analysis: A statistical process that produces a mathematical function (regression equation) that relates a dependent variable to independent variable.

Scattergraph: A plot of individual measurements of different values used to evaluate whether metered data adheres to hydraulic theory and forms expected hydraulic patterns. For this project, scattergraphs show either flow velocity vs. water depths for a flow monitor or the depth and intensity of rainfall required to generate overflows according to available data.

SCADA: An acronym for 'supervisory control and data acquisition,' a computer system in which real time data is gathered and analyzed to control and monitor equipment.

Sediment: Particulate material deposited at the bottom of a conduit.

Tributary: The area that contributes flow to a point in the sewer system.

Typical Year Rainfall or Typical Year: The performance objectives of MWRA's approved Long-Term CSO Control Plan include annual frequency and volume of CSO discharge at each outfall based on "Typical Year" rainfall from 40 years of rainfall records at Logan Airport, 1949-1987 plus 1992.
The Typical Year was a specifically constructed rainfall series that was based primarily on a single year (1992) that was close to the 40-year average in total rainfall and distribution of rainfall events of different sizes. The rainfall series was adjusted by adding and subtracting certain storms to make the series closer to the actual averages in annual precipitation, number of storms within different ranges of depth and storm intensities. The development of the Typical Year is described in MWRA's System Master Plan Baseline Assessment, June 15, 1994. The Typical Year consists of 93 storms with a total precipitation of 46.8 inches.

Ultrasonic Sensors (Du): A device used to measure depth of water by the use of ultrasonic waves, determined by the travel time between the emission and reception of the wave reflected back from the target.

Weir: A wall or plate placed perpendicular or parallel to the flow. The depth of flow over the weir can be used to quantify the flow rate through a calculation or use of a chart or conversion table.

1. Executive Summary

1.1 Introduction to this Semiannual Progress Report

On November 8, 2017, the Massachusetts Water Resources Authority (MWRA) commenced a multi-year study to measure the performance of what is now a $912.5 million long-term combined sewer overflow ("CSO") control plan (the "Long-Term Control Plan" or "LTCP"). This is the sixth of seven planned semiannual reports on the progress of the performance assessment (Table 1-1).

Table 1-1. Semiannual CSO Discharge Reports

Report #	Data Collection Period	Schedule
1 - link	April 15 to June 30, 2018 (2.5 months)	Nov. 2018 - complete
2 - link	July 1 to December 31, 2018 (6 months)	Apr. 2019 - complete
3 - link	January 1 to June 30, 2019 (6 months)	Oct. 2019 - complete
4 - link	July 1 to December 31, 2019 (6 months)	Apr. 2020 - complete
5 - link	January 1 to June 30, 2020 (6 months)	Oct. 2020 - complete
6	July 1 to December 31, 2020 (6 months)	Apr. 2021
7	January 1 to June 30, 2021 (6 months)	Oct. 2021

Submission of a final report on MWRA's CSO performance assessment is the last scheduled milestone in the nearly 35-year-old Federal District Court Order in the Boston Harbor Case (U.S. v. M.D.C., et al, No. 85-0489 MA). MWRA has addressed 183 CSO-related court schedule milestones, including completion of the thirty-five (35) wastewater system projects that comprise the LTCP by December 2015 and commencement of the CSO performance assessment by January 2018 (which, as noted above, MWRA met in November 2017). The last court milestone requires MWRA to submit the results of its performance assessment to the U.S. Environmental Protection Agency (EPA) and the Massachusetts Department of Environmental Protection (DEP) by December 2021[1].

The performance assessment will demonstrate whether the levels of CSO control specified in the LTCP have been achieved. MWRA's obligations for CSO control under the Court Order are defined in the March 15, 2006, *Second Stipulation of the United States and the Massachusetts Water Resources Authority on Responsibility and Legal Liability for Combined Sewer Overflow Control*, as amended on April 30, 2008 (the "Second Stipulation"). For more information about MWRA's federal court obligations for CSO control, including the LTCP levels of control, see Section 1.3.5 in Semiannual CSO Discharge Report No. 2, May 3, 2019. The LTCP levels of control are also presented in Chapter 6 of this report.

The CSO performance assessment includes the following key scope elements:

- Inspections at all CSO regulators addressed in the LTCP to confirm closed or active status and to confirm or update the physical and hydraulic conditions of the CSO regulators and outfalls that remain active;

[1] On July 19, 2019, Federal District Court Judge Richard G. Stearns issued an order extending the milestone for submission of the final report by one year, from December 31, 2020 to December 31, 2021. MWRA had requested the extension to provide the time necessary to perform receiving water quality modeling to support water quality assessments for the Lower Charles River/Charles Basin and the Alewife Brook/Upper Mystic River.

- Collection of extensive rainfall data and overflow related data (field measurements) at remaining CSO regulators;
- Upgrade and improvement of the calibration of MWRA's hydraulic model of the wastewater system using inspection information and overflow related data;
- Assessment of system performance for CSO control, and the consideration of performance improvements; and
- Assessment of the water quality impacts of remaining CSOs and compliance with Massachusetts Water Quality Standards.

Given that the final submission on the CSO performance assessment is due to the Court in just eight months, emphasis on this report will be on the last two bullets noted above – system performance and improvements and water quality impacts of remaining CSOs. MWRA includes in this sixth progress report an update on the potential for specific outfall locations to achieve - or not to achieve - the LTCP activation and volume goals by December 2021. For locations forecast not to meet the LTCP goals by December 2021, MWRA and the CSO communities - Boston Water and Sewer Commission (BWSC), Cambridge, Chelsea and Somerville - have made significant progress investigating the causes of higher overflow activity and evaluating alternative measures to further reduce CSO activation and/or volume toward the LTCP goals (see Chapter 4). At some of these locations, MWRA is now able to identify - and in some cases recommend - specific system modifications that can reduce Typical Year CSO activation and/or volume and attain the LTCP goals for volumes and activations. For these identified measures, this report includes estimated implementation schedules. Further, as described in more detail in Section 1.2 below, and in Chapter 2 of this report, the receiving water models are predicting high levels of CSO compliance with state water quality standards in the variance waters. Water quality improvements in non-variance waters, due to CSO reductions and other pollution controls, are well documented by MWRA's water quality monitoring program.

This update provides detail on locations where it is not reasonable to expect that volume and activation goals will be met by December 2021 and either additional system improvements have been identified that can attain the goals after December 2021 or investigations as to the feasibility of meeting those goals are ongoing. MWRA, the communities, regulatory agencies, and stakeholders are all evaluating whether CSO mitigation is the appropriate solution for achieving improved compliance at all locations.

MWRA notes here, as it described in Semiannual Report No. 4 sections 2.1 and 4.1 and noted in Semiannual Report No. 5, that the LTCP levels of control were proposed by MWRA and approved for specific locations utilizing different versions of the hydraulic model at different times in the development of the LTCP. LTCP levels were established at some locations as early as 1997 (Final CSO Facilities Plan and Environmental Impact Report), and at others as late as 2008 from subsequent project reevaluations. The various MWRA planning reports that describe the hydraulic modeling and water quality evaluations that led to the site-specific LTCP goals, including Typical Year activations and volumes and associated water quality improvement, and that together form the LTCP are referenced in the Boston Harbor Case and listed in Exhibit A to the Second CSO Stipulation[2]. In now assessing the performance of the system relative to those LTCP goals, MWRA is utilizing a hydraulic model that includes technological improvements, CSO and non-CSO sewer system updates, a much improved full-model calibration that took advantage of extensive meter data collected in 2018, and more recent calibration refinements as sewer system improvements continue to be made by MWRA or the CSO communities and as other new system information is obtained.

CSO locations already achieving activation and volume goals by December 2021 and locations that MWRA (based on currently available data) can reasonably anticipate will achieve the goals by December 2021 are identified in Section 1.3 and discussed in Chapter 3. Locations where Typical Year CSO activation and volume are within reasonable metering and modeling margins of error (BOS013,

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[2] March 15, 2006, *Second Stipulation of the United States and the Massachusetts Water Resources Authority on Responsibility and Legal Liability for Combined Sewer Overflow Control*, as amended on April 30, 2018.

BOS057, BOS060, BOS064, MWR023, MWR203 and CAM007) are also presented in Section 1.3 and Chapter 3 as consistent with the LTCP goals. Section 1.3 and Chapter 3 also identify locations where MWRA is now forecasting that LTCP goals can be attained after December 2021. For each of these locations, the measure(s) MWRA has identified to achieve attainment and a preliminary implementation schedule are presented. For locations where MWRA cannot yet forecast attainment of the LTCP goals, information in Section 1.3 summarizes the progress of continuing site specific investigations and alternatives evaluations by MWRA in coordination with the respective CSO community, and more detail about these investigations and evaluations is presented in Chapter 4.

Also notable in this sixth progress report is information presented in Chapter 2 and summarized below regarding MWRA's now completed development and calibration of the receiving water quality models of the Charles River Basin and the Alewife Brook/Upper Mystic River. In accordance with the CSO variances issued by DEP in 2019 and a related agreement between MWRA and the EPA and DEP (see Section 1.2), MWRA is now using the calibrated models to perform water quality assessments for these waters, including assessing the remaining impacts of CSO and non-CSO sources of bacterial pollution.

1.2 Receiving Water Quality Modeling and Water Quality Assessments

The scope of MWRA's post-construction monitoring and CSO performance assessment also includes assessments of whether remaining CSO discharges comply with Massachusetts Surface Water Quality Standards. For the waters designated Class B (CSO Variance), including the Lower Charles River/ Charles Basin and the Alewife Brook/Upper Mystic River, limited CSO discharges are authorized for the period that CSO variances to Water Quality Standards are in effect (currently through August 31, 2024). For these variance waters, MWRA reached agreement with EPA and DEP in 2019 to add receiving water quality modeling and supporting water quality sampling to its CSO performance assessment. MWRA will use receiving water model results to assess the water quality impacts of remaining CSO discharges to these waters. Chapter 2 of this report describes MWRA's progress with development and calibration of the receiving water quality models and use of the calibrated models to perform water quality assessments.

Looking ahead, the receiving water model simulations described in this report will be critical in demonstrating whether the water quality objectives of the LTCP have been satisfied for the CSO variance waters. MWRA expects that the results of the water quality assessment will demonstrate that the relative impacts of the remaining CSO discharges are small. The specific water quality issues to be addressed by the models are to:

- Assess the relative impact of CSO (compared to non-CSO sources) on water quality in the Charles River and Alewife Brook/Mystic River.
- Provide information about impacts of stormwater and boundary conditions.
- Predict resulting *Enterococcus* and *E. coli* counts during the 3-month and 1-year storms as well as the Typical Year.

MWRA submitted the *Draft Receiving Water Quality Model Development and Calibration Report* to DEP and EPA on September 8, 2020, for their review and comment, and issued the *Final Receiving Water Quality Model Development and Calibration Report* in November 2020. Since then, MWRA has been using the calibrated hydrodynamic and water quality models for the Lower Charles River and Alewife Brook/Upper Mystic River to assess the water quality impacts of CSOs and other discharges to these water bodies. The Charles River model is two-dimensional (based on Delft3D) and the Alewife Brook/ Upper Mystic River model is one-dimensional (based on InfoWorks ICM). These models receive flows derived from USGS gauges and from separate collection system models. The models were calibrated using extensive monitoring data primarily collected by MWRA from receiving waters, storm drains, and CSO outfalls.

The Charles River and Alewife Brook/Upper Mystic River hydrodynamic and water quality models were run for the entire Typical Year. The Typical Year rainfall series included storms representative of 1-year and 3-month, 24-hour recurrence interval storms ("design storms") that had been used in the LTCP and other previous planning documents for assessing pollutant loadings and attainment of water quality criteria. Bacterial loadings were input to the model from treated and untreated CSOs, stormwater, and upstream boundaries. Because the mass balance equations solved by the models are linear, in-stream bacterial counts from different sources are additive. Therefore, impacts from different sources can be assessed separately and together by specifying zero or actual bacterial counts to the different inputs, but keeping their flows unchanged.

To assess compliance with the current water quality standards for bacteria, the model was used to compute the total duration that the bacteria count in each model cell was predicted to exceed the single-sample maximum criteria for *E. coli* and *Enterococcus* over the course of the Typical Year.

For both the Charles River and the Alewife Brook/Upper Mystic River the following general observations were made:

- Loadings due to stormwater and upstream boundaries were the two largest sources of *E. coli* and *Enterococcus* in both the 1-year and 3-month design storms and for the Typical Year.
- CSOs contribute loadings only during the larger storms, 8 times during the Typical Year for the Charles and 10 times for the Alewife/Upper Mystic, respectively (based on 2019 system conditions).
- For all sources, single sample maximum criteria compliance for the Typical Year over the entire water bodies is summarized in Table 1-2. For example, in the Charles River, the model predicted that 48% of the time, at least one model cell of the 4,400 model cells used to represent the river was predicted to exceed the single-sample maximum criterion for *E. coli*. It should be noted that at any one point in the waterbodies, compliance would be significantly greater than the values listed in Table 1-2.

Table 1-2. Summary of Annual Compliance with Single-Sample Maximum *E. coli* Criteria, Typical Year, All Sources

Waterbody	Annual Compliance with Single-Sample Maximum Criteria, Typical Year, All Sources *E. coli*
Charles River	**48%**
Alewife Brook	**39%**
Upper Mystic River	**45%**

- For CSOs only, single sample maximum criteria compliance for the Typical Year over the entire water bodies is summarized in Table 1-3 on the following page. As noted above for the "All Sources" case, at fixed points, compliance would be even greater than for the entire water body.

Table 1-3. Summary of Annual Compliance with Single-Sample Maximum *E. coli* Criteria, Typical Year, CSO Sources Only

Waterbody	Annual Compliance with Single-Sample Maximum Criteria, Typical Year, CSO Sources Only *E. coli*
Charles River	**99.6%**
Alewife Brook	**98.6%**
Upper Mystic River	**96.9%**

An initial set of sensitivity evaluations was conducted to assess the relative impacts of changes in stormwater and CSO bacterial counts. The model condition assessing the impact of only stormwater bacteria loads was assessed with stormwater bacterial counts decreased by factors of 2 and 5, and to the 25th percentile value from the sampling data (possibly representing stormwater quality improvements). The "CSO bacteria loads only" condition was assessed with CSO bacterial counts increased by a factor of two. The stormwater loading reductions increased the percent compliance with the single-sample maximum *E.coli* criterion of 235#/mL for the stormwater-only modeled condition, but considerable non-compliance remained (approximately 1,500 hours (17% of the year) for the Charles River, and 4,000 hours (46% of the year) for the Alewife Brook/Upper Mystic River for the factor-of-5 reductions). The doubled CSO loadings only marginally decreased compliance with the standards for the CSO-only condition (the Charles River remained above 99%, while Alewife Brook/Upper Mystic River remained in the 95-96% range).

MWRA submitted the Draft Water Quality Assessment Report to DEP and EPA, Mystic River Watershed Association, Charles River Watershed Association, and the CSO communities in April 2021 for review and comment.

1.3 Updated System Performance Assessment and Comparison with LTCP Levels of Control

With the completion of an extensive recalibration of MWRA's hydraulic model in early 2020, MWRA was able to present in Semiannual Progress Report No. 4 (April 30, 2020) and Semiannual Progress Report No. 5 (October 30, 2020) interim assessments of the existing system's Typical Year CSO performance relative to the LTCP activation and volume goals by outfall and receiving water segment. An updated interim assessment of Typical Year performance for current system conditions and comparison with the LTCP activation and volume goals is presented in Chapter 3 and summarized below.

1.3.1 Hydraulic Model and Typical Year Simulation Updates

Updates to MWRA's hydraulic model from "Mid-2020 System Conditions" to current system conditions ("Q1-2021 System Conditions") are described in Section 3.2. The sources of the model updates included new information from MWRA or community wastewater system inspections; operation, maintenance or capital improvements made to the MWRA or community wastewater systems; and other model adjustments to improve the characterization and/or simulation of hydrologic or hydraulic conditions.
A comparison of the Typical Year results from the Mid-2020 System Conditions and Q1-2021 System Conditions models are presented and described in Chapter 3. At most discharge locations, Typical Year activation and volume predictions did not change or changed very little. At several locations, Typical Year activation and/or volume changed more significantly. Table 1-4 identifies the reasons for several key model updates and the outfalls and outfall performance most affected by each model change.
The updated Typical Year simulation results for all outfalls, utilizing the Q1-2021 System Conditions Model, are presented in Table 1-5. The Q1-2021 model results in Table 1-5 provide an outfall-by-outfall assessment of current CSO performance compared with the LTCP activation and volume goals.

Table 1-4. Recent Hydraulic Model Updates and Effects on Typical Year Predictions

<table>
<tr><th rowspan="3">Reason for Model Update</th><th rowspan="3">Affected Outfall(s)</th><th colspan="4">Typical Year Performance</th></tr>
<tr><th colspan="2">Mid-2020 System Conditions Model</th><th colspan="2">Q1-2021 System Conditions Model</th></tr>
<tr><th>Activation Frequency</th><th>Volume (MG)</th><th>Activation Frequency</th><th>Volume (MG)</th></tr>
<tr><td rowspan="2">BWSC completed East Boston Sewer Separation Contract 1, raised the weir associated with Outfall BOS010, and provided MWRA with additional East Boston model updates.</td><td>BOS010</td><td>7</td><td>0.77</td><td>7</td><td>0.44</td></tr>
<tr><td>BOS012</td><td>13</td><td>1.34</td><td>0</td><td>0.00</td></tr>
<tr><td>MWRA revised the modeled configuration of the weir at CAM005 based on review of field data</td><td>CAM005</td><td>8</td><td>0.73</td><td>7</td><td>0.66</td></tr>
<tr><td>Cambridge completed the Cambridgeport Partial Sewer Separation Improvements upstream of Cottage Farm CSO Facility.</td><td>Cottage Farm</td><td>4</td><td>12.64</td><td>2</td><td>8.95</td></tr>
<tr><td>MWRA has modified the Alewife Brook Pumping Station wet weather operation strategy as recommended in the Alewife Brook Pumping Station Optimization Evaluation Report.</td><td colspan="5">The modified pumping strategy improves pumping operation and results in only minor CSO discharge reduction at upstream Alewife Brook outfalls (see Section 4.6.3).</td></tr>
<tr><td>City of Cambridge completed a contract to remove sediments in sewers related to Alewife Brook regulator RE401A.</td><td>CAM401A</td><td>16</td><td>2.17</td><td>5</td><td>0.66</td></tr>
<tr><td rowspan="3">MWRA conducted further surveys and internal inspections of the regulator structures associated with outfalls MWR018, MWR019 and MWR020. MWRA also removed from the model a 36-inch pipe restriction between the Boston Marginal Conduit and the Prison Point CSO Facility that inspection confirmed does not exist.</td><td>MWR018</td><td>2</td><td>1.93</td><td>2</td><td>1.14</td></tr>
<tr><td>MWR019</td><td>2</td><td>0.56</td><td>2</td><td>0.51</td></tr>
<tr><td>MWR020</td><td>2</td><td>0.31</td><td>2</td><td>0.57</td></tr>
<tr><td rowspan="3">MWRA updated the modeled configuration and refined the model calibration at outfalls BOS060, BOS062 and BOS065</td><td>BOS060</td><td>2</td><td>0.17</td><td>3</td><td>0.47</td></tr>
<tr><td>BOS062</td><td>4</td><td>0.98</td><td>5</td><td>1.26</td></tr>
<tr><td>BOS065</td><td>3</td><td>0.91</td><td>1</td><td>0.62</td></tr>
<tr><td>City of Chelsea raised the weir at Outfall CHE004 1.5 feet.</td><td>CHE004</td><td>7</td><td>1.01</td><td>3</td><td>0.30</td></tr>
<tr><td>MWRA revised the representation of head losses in regulator RE-081 to better reflect the causes of the head losses, and recalibrated the model in the vicinity of the regulator. MWRA then removed the protrusion of the interceptor connection pipe into the regulator structure that had contributed to higher entry head loss.</td><td>CHE008</td><td>11</td><td>3.81</td><td>6</td><td>1.95</td></tr>
<tr><td>MWRA updated the model in Charlestown based on recent BWSC field inspections, including the existence of a direct stormwater connection BWSC is now planning to remove. The volume at Prison Point also increased as a result of the model updates noted above for outfalls MWR018, MWR019 and MWR020 and the removal of the restriction upstream of Prison Point.</td><td>Prison Point</td><td>17</td><td>242.90</td><td>17</td><td>253.66</td></tr>
</table>

Table 1-5. Typical Year Performance: Baseline 1992, Current (Q1-2021) and LTCP (1 of 3)

Outfall achieves LTCP activation and volume goals.	Outfall is forecast to achieve LTCP goals after Dec 2021.
Investigations continue for forecast of LTCP attainment potential	Model prediction is greater than LTCP value.

OUTFALL	1992 SYSTEM CONDITIONS (1)		Q1-2021 SYSTEM CONDITIONS		LONG TERM CONTROL PLAN (2)	
	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)
ALEWIFE BROOK						
CAM001	5	0.15	1	0.02	5	0.19
CAM002	11	2.73	0	0.00	4	0.69
MWR003	6	0.67	3	0.61	5	0.98
CAM004	20	8.19	Closed	N/A	Closed	N/A
CAM400	13	0.93	Closed	N/A	Closed	N/A
CAM401A	18	2.12	5	0.66	5	1.61
CAM401B			4	0.50	7	2.15
SOM001A	10	11.93	8	4.47	3	1.67
SOM001	0	0.00	Closed	N/A	Closed	N/A
SOM002	0	0.00	Closed	N/A	N/I(3)	N/I(3)
SOM002A	0	0.00	Closed	N/A	Closed	N/A
SOM003	0	0.00	Closed	N/A	Closed	N/A
SOM004	5	0.09	Closed	N/A	Closed	N/A
TOTAL		**26.81**		**6.26**		**7.29**
UPPER MYSTIC RIVER						
SOM007A/MWR205A	9	7.61	5	4.50	3	3.48
SOM006	0	0.00	Closed	N/A	N/I(3)	N/I(3)
SOM007	3	0.06	Closed	N/A	Closed	N/A
TOTAL		**7.67**		**4.50**		**3.48**
MYSTIC/CHELSEA CONFLUENCE						
MWR205 (Somerville-Marginal CSO Facility)	33	120.37	30	100.58	39	60.58
BOS013*	36	4.40	8	0.27	4	0.54
BOS014	20	4.91	8	1.45	0	0.00
BOS015	76	2.76	Closed	N/A	Closed	N/A
BOS017	49	7.16	6	0.34	1	0.02
CHE002	49	2.51	Closed	N/A	4	0.22
CHE003	39	3.39	0	0.00	3	0.04
CHE004	44	18.11	3	0.30	3	0.32
CHE008	35	22.35	6	1.95	0	0.00
TOTAL		**185.96**		**104.89**		**61.72**
UPPER INNER HARBOR						
BOS009	34	3.60	10	0.73	5	0.59
BOS010	48	11.83	7	0.44	4	0.72
BOS012	41	7.90	0	0.00	5	0.72
BOS019	107	4.48	1	0.07	2	0.58
BOS050	No Data		Closed	N/A	N/A	N/A
BOS052	0	0.00	Closed	N/A	Closed	N/A
BOS057*	33	14.71	2	1.32	1	0.43
BOS058	17	0.29	Closed	N/A	Closed	N/A
BOS060*	64	2.90	2	0.47	0	0.00
MWR203 (Prison Point Facility)*	28	261.85	17	253.66	17	243.00
TOTAL		**307.56**		**256.69**		**246.04**

Table 1-5. Typical Year Performance: Baseline 1992, Current (Q1-2021) and LTCP (2 of 3)

OUTFALL	1992 SYSTEM CONDITIONS (1)		Q1-2021 SYSTEM CONDITIONS		LONG TERM CONTROL PLAN (2)	
	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)
LOWER INNER HARBOR						
BOS003	28	18.09	9	6.40	4	2.87
BOS004	34	3.43	2	0.06	5	1.84
BOS005	4	10.23	0	0.00	1	0.01
BOS006	17	1.21	Closed	N/A	4	0.24
BOS007	34	3.93	Closed	N/A	6	1.05
TOTAL		**36.89**		**6.46**		**6.01**
CONSTITUTION BEACH						
MWR207	24	4.00	Closed	N/A	Closed	N/A
TOTAL		4.00		N/A		N/A
FORT POINT CHANNEL						
BOS062	8	4.15	5	1.26	1	0.01
BOS064*	14	0.99	1	0.01	0	0.00
BOS065	11	3.08	1	0.62	1	0.06
BOS068	4	0.62	0	0.00	0	0.00
BOS070	4	281.62				
BOS070/DBC			7	6.14	3	2.19
MWR215 (Union Park Facility)			10	26.62	17	71.37
BOS070/RCC			0	0.00	2	0.26
BOS072	21	3.62	Closed	N/A	0	0.00
BOS073	23	4.73	0	0.00	0	0.00
TOTAL		**298.81**		**34.66**		**73.89**
RESERVED CHANNEL						
BOS076	65	65.94	1	0.10	3	0.91
BOS078	41	14.84	0	0.00	3	0.28
BOS079	18	2.10	0	0.00	1	0.04
BOS080	33	6.21	0	0.00	3	0.25
TOTAL		**89.09**		**0.10**		**1.48**
NORTHERN DORCHESTER BAY						
BOS081	13	0.32	0 / 25 year	N/A	0 / 25 year	N/A
BOS082	28	3.75	0 / 25 year	N/A	0 / 25 year	N/A
BOS083	14	1.05	Closed	N/A	0 / 25 year	N/A
BOS084	15	3.22	0 / 25 year	N/A	0 / 25 year	N/A
BOS085	12	1.31	0 / 25 year	N/A	0 / 25 year	N/A
BOS086	80	3.31	0 / 25 year	N/A	0 / 25 year	N/A
BOS087	9	1.27	Closed	N/A	Closed	N/A
TOTAL		**14.23**		**0.00**		**0.00**
SOUTHERN DORCHESTER BAY						
BOS088	0	0.00	Closed	N/A	Closed	N/A
BOS089 (Fox Pt.)	31	87.11	Closed	N/A	Closed	N/A
BOS090 (Commercial Pt.)	19	10.16	Closed	N/A	Closed	N/A
TOTAL		**97.27**		**0.00**		**0.00**
UPPER CHARLES						
BOS032	4	3.17	Closed	N/A	Closed	N/A
BOS033	7	0.26	Closed	N/A	Closed	N/A
CAM005	6	41.56	7	0.66	3	0.84
CAM007*	1	0.81	2	0.45	1	0.03
CAM009(4)	19	0.19	Closed	N/A	2	0.01
CAM011(4)	1	0.07	Closed	N/A	0	0.00
TOTAL		**46.06**		**1.11**		**0.88**

Table 1-5. Typical Year Performance: Baseline 1992, Current (Q1-2021) and LTCP (3 of 3)

OUTFALL	1992 SYSTEM CONDITIONS (1)		Q1-2021 SYSTEM CONDITIONS		LONG TERM CONTROL PLAN (2)	
	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)
LOWER CHARLES						
BOS028	4	0.02	Closed	N/A	Closed	N/A
BOS042	0	0.00	Closed	N/A	Closed	N/A
BOS049	1	0.01	Closed	N/A	Closed	N/A
CAM017	6	4.72	0	0.00	1	0.45
MWR010	16	0.08	0	0.00	0	0.00
MWR018	2	3.18	2	1.14	0	0.00
MWR019	2	1.32	2	0.51	0	0.00
MWR020	2	0.64	2	0.57	0	0.00
MWR021	2	0.50	Closed	N/A	Closed	N/A
MWR022	2	0.43	Closed	N/A	Closed	N/A
MWR201 (Cottage Farm Facility)	18	214.10	2	8.95	2	6.30
MWR023*	39	114.60	1	0.14	2	0.13
SOM010	18	3.38	Closed	N/A	Closed	N/A
TOTAL		**342.98**		**11.31**		**6.88**
NEPONSET RIVER						
BOS093	72	1.61	Closed	N/A	Closed	N/A
BOS095	11	5.37	Closed	N/A	Closed	N/A
TOTAL		**6.98**		**0.00**		**0.00**
BACK BAY FENS						
BOS046	2	5.25	0	0.00	2	5.38
TOTAL		**5.25**		**0.00**		**5.38**
Total Treated		**698**		**390**		**381**
Total Untreated		**759**		**31**		**23**
GRAND TOTAL		**1457**		**421**		**404**

* Model predicted activation and volume for Q1-2021 System Conditions are consistent with LTCP goals when considering metering and modeling margins of error and the chronology of site-specific LTCP plans, plan updates, and approvals.

(1) 1992 System Conditions include completion of Deer Island Fast-Track Improvements, upgrades to headworks, and new Caruso and DeLauri pumping stations. Estimated 1988 Grand Total Typical Year CSO volume (prior to these improvements) is 3,300 million gallons.

(2) From Exhibit B to *Second Stipulation of the United States and the Massachusetts Water Resources Authority on Responsibility and Legal Liability for Combined Sewer Overflows*, as amended by the Federal District Court on May 7, 2008 (the "Second CSO Stipulation").

(3) N/I (Not Included): Outfall was closed prior to 2006 and is not included in Exhibit B to the Second CSO Stipulation.

(4) Tentatively closed pending additional hydraulic evaluation by City of Cambridge.

1.3.2 Locations Where LTCP Activation and Volume Goals are Attained

From the updated Typical Year model simulation results in Table 1-5, MWRA has determined that 70 outfalls now attain the LTCP activation and volume goals, including 40 outfalls where CSO is eliminated (outfall "Closed") or eliminated up to the 25-year storm (North Dorchester Bay - South Boston beaches). The 70 outfalls attaining LTCP goals include seven outfalls where MWRA suggests that the model predicted activation and volume for Q1-2021 System Conditions are consistent with the goals when considering metering and modeling margins of error and the decade-long chronology of site-specific LTCP plans, plan updates, and approvals.

At some of the locations where MWRA had previously reported that the LTCP activation and/or volume goal had not been attained, MWRA and the CSO communities recently implemented additional CSO control measures that were recommended from the site-specific investigations they have been conducting since obtaining early CSO meter data in 2018. The progress and recommendations of the site-specific investigations are discussed in Chapter 4.

- **CAM401A -** Cambridge completed a contract in the winter of 2021 that removed sediments from sewers hydraulically related to Outfall CAM401A. Model results show that this improvement reduced Typical Year activations and volume from the 16 activations and 2.17 MG previously reported to 5 activations and 0.66 MG, bringing this outfall into attainment with the LTCP goals of 5 activations and 1.61 MG.

- **CHE004 -** City of Chelsea raised the overflow weir at Outfall CHE004 by 1.5 feet in December 2020. Model results show that this improvement reduced Typical Year activations and volume from the 7 activations and 1.01 MG previously reported to 3 activations and 0.30 MG, bringing this outfall into attainment with the LTCP goals of 3 activations and 0.32 MG.

- **BOS012, BOS010 -** BWSC completed East Boston sewer separation Contract 1 in May, 2020, will complete Contract 2 this fall, and will soon award Contract 3 (see Figure 1-1). Model results show that completion of Contract 1 reduced Typical Year activations and volume at Outfall BOS012 from the 13 activations and 1.34 MG previously reported to no activation in the Typical Year, bringing this outfall well into attainment with the LTCP goals of 5 activations and 0.72 MG. BWSC also raised the overflow weir at East Boston Outfall BOS010 by 3 inches in February 2021. Once BWSC completes sewer separation Contract 2, the Typical Year performance at Outfall BOS010 is predicted to improve from the 7 activations and 0.44 MG previously reported to 1 activation and 0.07 MG. Evaluations of the benefits of sewer separation Contracts 2 and 3 and other recommended CSO improvements in East Boston are presented in Section 4.1.

1.3.3 Attainment of LTCP Activation and Volume Goals After 2021

The continuing site-specific investigations by MWRA and the CSO communities have also identified CSO control measures that hydraulic model results show can bring additional outfalls into attainment with their LTCP activation and volume goals. Implementation of these additional measures involve design and construction activities already underway or planned that would be completed after December 2021. The locations that could attain LTCP attainment after December 2021 and the respective control measures are shown in

Table 1-6, are summarized below, and are discussed in more detail in Chapter 4.

- **BOS003, BOS009 & BOS014 -** As mentioned above, BWSC will complete East Boston sewer separation Contract 2 in the fall of 2021. BWSC plans to award Contract 3 this summer and complete the contract in the spring of 2023. Contract 3 includes separating combined sewers in part of East Boston (Figure 1-1, next page), and also includes upgrading the restricted interceptor connection at Regulator RE003-12 and reconstructing regulators RE003-2 and RE003-7 as extreme storm high outlet reliefs. Separately, MWRA and BWSC have also identified that constructing a new interceptor connection to relieve the existing connections associated with Outfall BOS014 can bring this outfall into attainment with its LTCP goals. MWRA model results presented in Section 4.1 show that completion of contracts 2 and 3 and the new interceptor connection at BOS014 can bring all East Boston CSO outfalls into attainment with their LTCP activation and volume goals. MWRA has approved a financial assistance agreement whereby the MWRA would reimburse BWSC up to approximately $2.2M for eligible expenses associated with the Contract 3 sewer separation work and CSO improvements to the BOS014 combined sewer system and BWSC would construct the improvements.

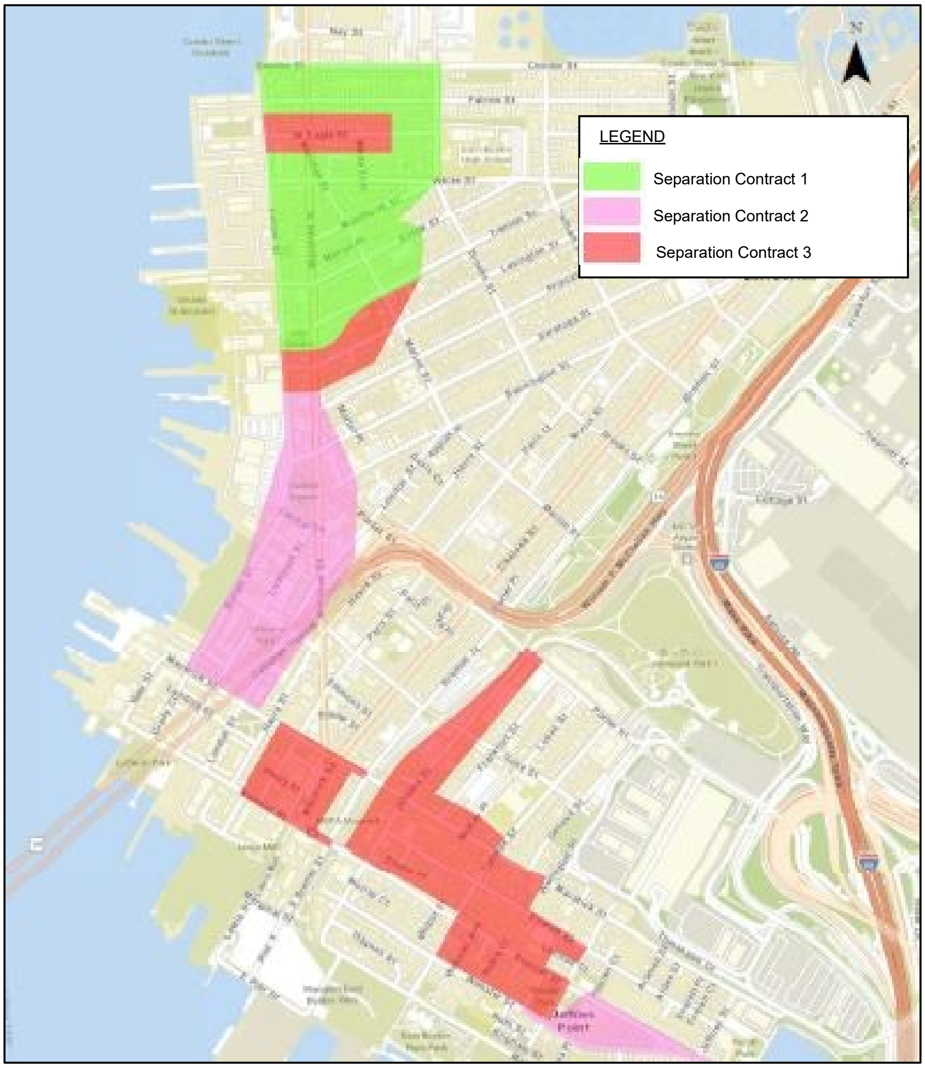

Figure 1-1. BWSC East Boston Sewer Separation Contracts

- **CHE008 -** MWRA completed preliminary design to replace the 30-inch interceptor connection at Outfall CHE008 with a 48-inch pipe, and issued the notice to proceed with final design in March 2021. Figure 1-2 shows the location of the proposed interceptor connection replacement. MWRA's project schedule calls for commencement of construction in February 2022, and completion of the new connection in the fall of 2022. MWRA model results presented in Section 4.7 show that replacement of the connection will bring Outfall CHE008 into attainment with the LTCP activation and volume goals.

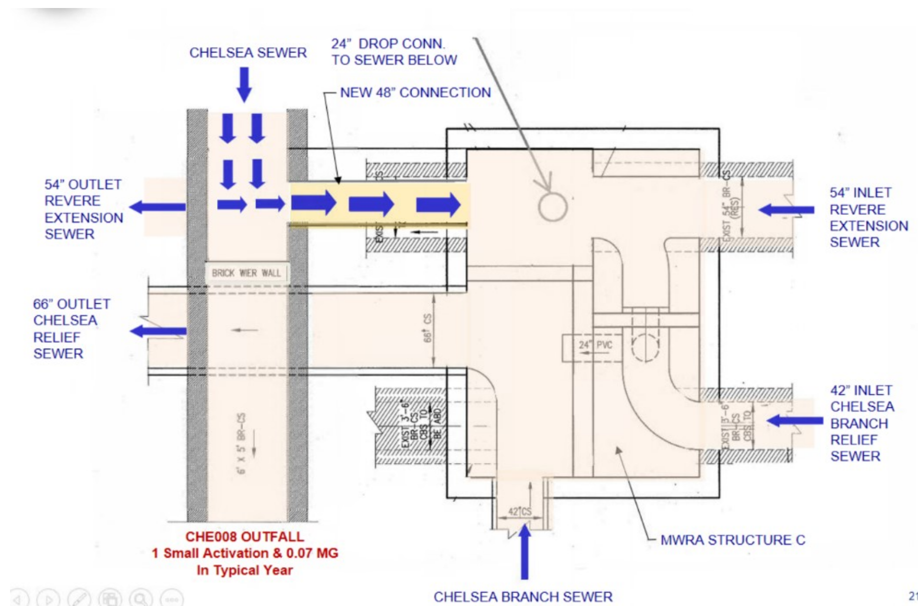

Figure 1-2. CHE008 Connection Relief

MWR205, SOM007A/MWR205A - MWRA conducted an evaluation to assess the benefit of increasing the capacity of the connection to the Somerville-Medford Branch Sewer upstream of the Somerville-Marginal CSO Facility. The existing connection is an 18-inch diameter pipe. Increasing the size of the connection to 24-inch diameter showed promise in terms of reducing activation frequency and volume at Somerville-Marginal CSO Facility during the Typical Year. However, this modification resulted in increased discharge volumes at Prison Point and Cottage Farm because of the hydraulic connectivity between these facilities and the interceptor network downstream of the Somerville-Medford Branch Sewer. In addition, this alternative had adverse impacts on the peak hydraulic grade line in the Somerville-Medford Branch Sewer in larger storms. MWRA is currently investigating the feasibility and impact of constructing a second connection between the influent conduit to Somerville Marginal CSO Facility and the Somerville-Medford Branch Sewer to supplement the existing connection's capacity, along with a control on the dry weather flow connection that would limit peak flows during larger storm events. Construction feasibility, impacts, and costs will also need to be assessed.

In parallel to the interceptor connection relief, evaluations are being conducted into the removal of separate stormwater from the Ten Hills neighborhood and a portion of the elevated I-93 drainage system that is currently tributary to the Somerville-Marginal CSO Facility.

1.3.4 Continuing Site-Specific Investigations

MWRA has continued to track CSO performance and the causes of higher overflow activity at locations where Typical Year CSO activation and/or volume exceed the LTCP goals. MWRA has identified candidate projects or system adjustments that may further mitigate CSO discharges to bring activations and volumes to or closer to the LTCP goals. Table 1-6 on the next page lists these locations and potential mitigation alternatives identified so far. Information on the progress of these evaluations is presented in Chapter 4.

Table 1-6. Investigations Where Attainment of LTCP Goals Cannot Yet be Forecast

OUTFALL	Q1-2021 SYSTEM CONDITIONS MODEL		LONG TERM CONTROL PLAN		POTENTIAL ACTION PLAN(S)
	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	
ALEWIFE BROOK					
SOM001A	8	4.47	3	1.67	• Identify potential upstream flow controls
MYSTIC/CHELSEA CONFLUENCE					
BOS017	6	0.34	1	0.02	• Raise weir • Add weir wall to direct flow to interceptor upstream of regulator
FORT POINT CHANNEL					
BOS062	5	1.26	1	0.01	• Raise weir • Relieve interceptor connection
BOS065	1	0.62	1	0.06	• Raise weir • Relieve interceptor connection
BOS070/DBC	7	6.14	3	2.19	• South Boston Sewer Separation Contracts 1 and 2 (most regulators attain LTCP by 2024) • Evaluate regulator modifications at RE070/7-2
CHARLES RIVER					
MWR201 (Cottage Farm)	2	8.95	2	6.30	• Further optimize Cottage Farm facility operations • Separate upstream areas as currently being planned by Cambridge
CAM005	7	0.66	3	0.84	• Remove pipe obstructions • Raise weir • Separate upstream areas as currently being investigated by Cambridge
MWR018	2	1.14	0	0.00	• Raise weirs • Lower localized BMC head loss • Redirect upstream BWSC separate storm drains
MWR019	2	0.51	0	0.00	
MWR020	2	0.57	0	0.00	

1.4 CSO Data Collection and Analyses

In the period July 1, 2020 through December 31, 2020, MWRA continued to collect and analyze rainfall data from 17 gauges within the MWRA wastewater service area it has utilized for the CSO performance assessment since the beginning of the data collection efforts in April 2018. Three temporary project gauges MWRA had utilized in previous performance assessment periods were decommissioned on June 30, 2020. Most of the 17 gauges are located in or near areas served by combined sewers. The rainfall data are analyzed to assess the rainfall characteristics of each storm in the collection period, including storm duration, total volume/depth of rain, average rainfall intensity, peak rainfall intensities and storm recurrence interval (e.g., 3-month storm, 1-year storm, etc.). Rainfall measurements in the period July 1, 2020 through December 31, 2020 are presented in Appendices C and D. The rainfall characteristics for this period, together with the rainfall characteristics of storms that occurred in the first half of 2020 support a comparison of the storms in 2020 to the Typical Year (see Section 5.1.2). The rainfall data are also necessary inputs to the calibrated model to produce storm-by-storm model-predicted CSO discharges (Section 5.3).

Comparisons of storms in 2020 to storms in the Typical Year are shown in Table 1-7 on the next page. The comparison shows that 2020 had 6% fewer number of storms and 14% less total rainfall than the Typical Year. More important in terms of CSO impacts, 2020 had fewer storms of rainfall depth greater than 2.0 inch and, at some gauge locations, fewer storms of peak hourly intensity greater than 0.4 inch/hour. As described further in Section 5, Table 5-6 shows the largest rainfall accumulation measured at the gauges was 2.2 inches at Chelsea Creek Headworks. The Typical Year, in comparison, had five storms with greater than 2.2 inches, including one storm with 3.89 inches. A similar pattern was noted for storms with peak intensities greater than 0.6 inches/hour. It is the larger and more intense storms that can contribute an even larger fraction of total CSO discharge for the year.

Table 1-7. Comparison of Rainfall January 1, 2020 through December 31, 2020 and Typical Year

	Total Rainfall (in.)	Total No. of Storms	Number of Storms by Rainfall Depth (in.)					No. of Storms >0.4 in/hr. peak hourly intensity
			<0.25	0.25 to 0.5	0.5 to 1.0	1.0 to 2.0	>2.0	
Jan - Dec, 2020[(1)]	40.54	87	41	17	17	8	3	5 to 9[(2)]
Typical Year	46.8	93	49	14	16	8	6	9

Notes:
(1) Values for Jan-Dec 2020 reflect averages from the 17 rain gages assessed, except as noted for number of storms with peak intensity >0.4 in.hr.
(2) Range of data from Ward Street Headworks, Columbus Park Headworks, Chelsea Creek Headworks, and Fresh Pond gauges.

Section 5.2 of this report presents a summary of the CSO metering program and the meter results for the period July 1, 2020 through December 31, 2020. In this period, MWRA continued to employ CSO metering technology at 11 potentially active CSO regulators[3], as well as at five outfalls associated with CSO treatment facilities and outfalls associated with the CSO storage facilities at the South Boston beaches and Outfall BOS019. Temporary meters that MWRA previously utilized in the performance assessment were in place and operational through June 30, 2020, when the temporary metering program came to an end. Temporary meters were then removed at most locations and converted to permanent meters at some locations, as described below.

At 11 regulators associated with MWRA CSO outfalls, the temporary meters now serve as part of a permanent metering program that supports MWRA's public notification of CSO discharges in accordance with a requirement in the CSO variances for the Charles River Basin and the Alewife Brook/Upper Mystic River and recent state legislation. MWRA has implemented a "CSO Alert Notification" using a subscriber-based system to provide details of an MWRA CSO discharge within 4 hours of activation, including information on location and start time and a link to additional details on MWRA's website. This program was initiated in July 2020 (in advance of the requirement in the CSO variances to have the system in place by December 31, 2020). This program provides rapid notification for the 6 untreated and 5 treated MWRA CSO outfalls and the BWSC outfalls associated with the MWRA storage facilities at Little Mystic Channel (BOS019) and the South Boston beaches (BOS081-BOS086).

MWRA will continue to collect, analyze and use data from these permanent CSO meters, along with data from permanent meters in MWRA's interceptor system. The CSO communities (BWSC and the cities of Cambridge, Chelsea and Somerville) either already have or will soon have equipment in place to measure CSO activations and/or volumes at regulators associated with their permitted outfalls.

Section 5.3 of this report presents a comparison of measured CSO activations and/or volumes for storms in the period July 1, 2020 through December 31, 2020 with the predictions of MWRA's hydraulic model as configured to represent system conditions that then existed, where MWRA meters were available. The comparison (Table 5-9) shows closeness of the metered and modeled discharges, with greater differences at the locations shown in Table 1-8 on the next page.

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[3] To support the performance assessment and recalibration of MWRA's hydraulic model, MWRA employed temporary meters to measure overflow activations and/or volumes at 57 CSO regulators beginning in April 2018. With adequate data collected in 2018 to support hydraulic model recalibration, MWRA removed the temporary meters at 21 of the 57 locations on March 1, 2019. See Section 5.2.1 and Semiannual Progress Reports No. 2 and No. 3.

Table 1-8. Notable Differences between Metered and Modeled CSO Discharges, July 1 - December 31, 2020

Location	Meter	Model	Comment
SOM007A/ MWR205A	4 activations 10.99 MG	2 activations 5.61 MG	• The metered activations occurred on: 08/23/2020, 11/30/2020, 12/4/2020 and 12/25/2020. The model activated on 08/23/2020 and 12/5/2020. The 11/30/2020 storm had highly variable rainfall. • The model had less discharge volume mostly tied to missing the activation for the 11/30/2020 storm due to the highly variable rainfall. • The discharge volume at this location is tied to the discharge at the Somerville-Marginal CSO facility, the tide, and the stormwater coming in downstream of the facility. There is some uncertainty in the volume of stormwater entering downstream of the Somerville-Marginal Facility.
Somerville Marginal CSO Facility	13 activations 51.62 MG	13 activations 41.59 MG	• The model had less discharge volume due to rainfall variability mostly tied to the 11/30/2020 storm event.
BOS019 Storage Facility	2 activations 1.07 MG	0 activation 0 MG	• The two metered activations occurred on 12/5/2020 and 12/25/2020. The rainfall on the 12/5/2020 storm was highly variable. • For the both events in the model water entered the storage tanks but it was not enough to cause an overflow.

The total volume of discharge (all outfalls) predicted by the model for storms in the second half of 2020 is 177.9 million gallons. MWRA's model had predicted 87.3 million gallons of CSO discharge in the first half of 2020, as reported in Semiannual Progress Report No. 5, October 30, 2020. Due to a correction in the rainfall data for February 2020, the updated total for the first half of 2020 is now 86.9 MG. Therefore, the MWRA models for the entire 2020 period estimated a total CSO discharge from all outfalls of 264.7 million gallons. The same models estimated total Typical Year discharge of approximately 421 million gallons. As mentioned above, Table 1-7 shows fewer large storms (>2.0 inch) and fewer storms of high peak hourly intensity (>0.4 inch/hour) in 2020 than in the Typical Year. The significantly lower model-predicted CSO volume for 2020 compared to the Typical Year underscores the significant effect of larger and more intense storms on CSO discharges.

1.5 CSO Variances for Lower Charles River/Charles Basin and Alewife Brook/Upper Mystic River

DEP issued CSO variances to Massachusetts Surface Water Quality Standards for the Lower Charles River/Charles Basin and the Alewife Brook/Upper Mystic River on August 30, 2019. Both variances have a term of five years to August 31, 2024.[4] US EPA Region 1 approved these variances on May 29, 2020. MWRA and the cities of Cambridge and Somerville are subject to the conditions in the variances for their outfalls to these waters. MWRA has been meeting the conditions in the variances, including collection system maintenance, water quality sampling, and reporting requirements carried over from earlier variances, as well as newly added conditions requiring receiving water quality modeling, public notification of CSO discharges, performance assessment reporting, and the evaluation of specific CSO mitigation projects. In addition to what is described above in Section 1.2 and in Chapter 2 regarding the receiving water quality models, the following summarizes MWRA's recent efforts to comply with variance condition milestones.

1.5.1 Public Notification of CSO Discharges

The variances require MWRA, Cambridge and Somerville to implement, by December 31, 2020, a subscriber and web-based system to alert the public of CSO discharges from their permitted outfalls.

[4] DEP issued the Charles River variance to the Authority and the City of Cambridge and issued the Alewife Brook/Upper Mystic River variance to the Authority and the cities of Cambridge and Somerville.

MWRA launched the public notification system in July 2020, and has since been issuing and posting notices of CSO activations for its outfalls. The subscriber notices include links to the MWRA website https://www.mwra.com/harbor/html/cso_reporting.htm, which MWRA updated to include detailed information on discharge locations, affected water body segments, and recent CSO activation history. MWRA also developed procedures for estimating and reporting discharge volume as required within five days of an activation at any of its outfalls, and implemented volume reporting on the website by the end of December 2020. Cambridge and Somerville have also set up their systems for reporting CSO activations and estimated discharge volumes.

1.5.2 Evaluation of Additional CSO Mitigation Projects

The variances also require MWRA to evaluate specific "additional CSO mitigation projects" in accordance with schedule milestones. MWRA's progress with these required evaluations is summarized below and further discussed in Chapter 4.

1.5.2.1 MWR205 & SOM007/MWR205A Somerville-Marginal CSO Reduction, Study/Preliminary Design

MWRA commenced the investigations in June 2020 to evaluate: 1) construction of dry weather connection relief/control from the City of Somerville's CSO regulator RE071A to MWRA's Somerville-Medford Branch Sewer, and 2) relocation of MassDOT I-93 drainage from upstream to downstream of the Somerville Marginal CSO Facility to reduce the frequency and volume of facility activations. Preliminary MWRA model results show that increasing the size of the existing 18-inch connection or supplementing the 18-inch connection capacity with an additional connection can lower Typical Year activations and treated discharge volumes at both outfalls downstream of the Somerville Marginal CSO Facility to the LTCP goals. Additional investigations and model runs are underway to determine an effective connection upgrade approach and size along with potentially necessary hydraulic control that can attain LTCP goals and avoid any adverse hydraulic impacts to other parts of MWRA's interceptor system in larger storms. MWRA also plans to evaluate engineering, construction and permitting requirements and potential cost as part of this feasibility study.

Through coordinated investigations with the City of Somerville, MWRA has determined that portions of the piping system upstream of the 72-inch MassDOT connection collect sanitary flow and stormwater from certain combined sewer areas of the city, including Winter Hill. Redirecting all flow entering the 72-inch MassDOT connection to the City's sewer system is thus not an appropriate solution as it would require extensive sewer separation and storm drain construction in addition to redirecting the 72-inch storm drain to the downstream side of the facility.

MWRA and the City are now conducting investigations into whether separate stormwater segments tributary to the 72-inch MassDOT connection can be redirected away from the sewer system and the Somerville Marginal CSO Facility. These evaluations are currently focusing on two separate storm drains, one that serves a portion of Somerville's Ten Hills neighborhood and a 30-inch MassDOT storm drain that serves portions of I-93 and Mystic Avenue. Both of these storm drains currently convey stormwater to the 72-inch MassDOT connection. Preliminary modeling by MWRA shows that removing the Ten Hills storm drain flows will provide a small reduction in Typical Year discharge volume at the Somerville Marginal CSO Facility and no reduction in activation frequency. MWRA is working with the City to evaluate the feasibility and potential CSO benefits of removing the 30-inch MassDOT storm drain from the sewer system, separately and together with removal of the Ten Hills stormwater. If a substantial CSO benefit is predicted, MWRA and the City will evaluate the engineering, construction and permitting requirements, potential cost and water quality benefit of redirecting these flows around the Somerville-Marginal CSO Facility or to existing or new stormwater outfalls as part of this feasibility study.

1.5.2.2 Evaluation of Alewife Brook Pumping Station Optimization

In April 2020, MWRA commenced evaluations of the feasibility of further optimizing the operation of its Alewife Brook Pump Station and the potential for reducing upstream CSO discharges to Alewife Brook. By the fall of 2020, MWRA and its consultant completed pump inspections, pump performance evaluations, and dry weather and wet weather pump testing. With the results of these evaluations and tests, MWRA selected a set of modified pump control settings intended to keep the pump station wet well at a lower elevation during storms. MWRA then operated the station utilizing these modified settings during the storms of December 5, 2020 and January 16, 2021. From these tests, MWRA concluded that the modified pumping strategy can maintain a lower wet well elevation during storms and also improves on/off cycling of the pumps.

MWRA incorporated the modified pump control settings into its hydraulic model and performed a Typical Year simulation to determine whether maintaining the lower wet well elevation has an effect on the upstream CSOs. The model results showed a small upstream CSO reduction from maintaining a lower wet well elevation. As a sensitivity analysis, MWRA also performed model simulations of free discharge at the downstream ends of the MWRA interceptors (no Alewife Brook Pump Station capacity or elevation limitation). Again, the model results showed little upstream CSO reduction. This is because the lower wet well elevation has only a slight effect on lowering the hydraulic grade line upstream in the interceptor system at the CSOs. While the upstream regulators at CAM401B and MWR003 are affected by the interceptor hydraulic grade line in the largest storm in the Typical Year, modifications to the pumping at Alewife Brook Pump Station are predicted to reduce Typical Year CSO activations and volumes by only small amounts at SOM001A. All of the Alewife Brook regulators are primarily affected by localized hydraulic conditions at the regulators and upstream community flows, and less so by interceptor hydraulic grade, at least in Typical Year storms.

MWRA submitted a report on its Alewife Pumping Station optimization evaluations, results and recommendations to EPA and DEP in April of 2021, in compliance with the schedule milestone in the variances. While the modified pumping strategy and lower wet well elevation provides small upstream CSO benefit under current CSO system conditions, the modified pumping strategy has been put into practice by MWRA operations and is now incorporated into MWRA's hydraulic model. The strategy may provide some benefit with the evaluation of certain Alewife Brook CSO optimization alternatives discussed below.

1.5.2.3 CSO System Optimization for Alewife Brook, Study and Preliminary Design

Using the calibrated hydraulic model and coordinating technical evaluations with the cities of Cambridge and Somerville, MWRA has commenced system optimization evaluations at the remaining active regulators tributary to CSO outfalls discharging to the Alewife Brook watershed. MWRA commenced the investigations in August 2020, ahead of the variance's December 2020 milestone. These efforts are intended to identify regulator modifications or upstream flow controls that may further reduce CSO activations and/or volume. MWRA initially focused attention on Outfall CAM401A, where past inspections and hydraulic modeling had determined that backwater in the downstream sewer system was contributing to higher overflow activity, and at Outfall SOM001A, the sole Alewife Brook outfall MWRA forecasts as likely not attaining the LTCP goals by December 2021.

For Outfall CAM401A, Cambridge recently completed extensive sediment cleaning and some repairs along the combined sewer that conveys flows from the 401A regulator to the City's Rindge Avenue sewer and MWRA's interceptor system. MWRA hydraulic modeling shows that removing the backwater effect caused by the sediment would result in attainment of the LTCP activation and volume goals at Outfall CAM401A. For SOM001A, MWRA's consultant has performed preliminary modeling of potential regulator modifications, including raising the weir and relieving the existing connection to MWRA's interceptor, with and without the modified pumping strategy at Alewife Brook Pump Station mentioned above. The preliminary modeling results showed that raising the weir either 3 inches or 6 inches would not reduce Typical Year overflow activations and would reduce overflow volume by a small amount relative to the overflow volume exceeding the LTCP goal. Adding an 18-inch connection to the MWRA interceptor, to supplement the existing 36-inch connection, would have only a moderate effect on overflow activations and volumes, while adding a second 36-inch connection could lower activations and volume to close to the LTCP goals. However, several factors cause concern in further pursuing this alternative, including: the potential to shift a portion of SOM001A's CSO discharge in large storm events to CSOs in the potentially more sensitive upstream reaches of Alewife Brook; the addition of a significant amount of additional Tannery Brook flow to MWRA's interceptor system that can experience SSOs during large storm events; and significant construction impacts given the location of the SOM001A regulator and MWRA's interceptor adjacent to Alewife Brook Parkway.

MWRA is continuing its evaluations and coordination with Cambridge and Somerville. Future work will include optimization evaluations at the other outfalls that discharge CSO to the Alewife Brook. The variances require MWRA to complete these evaluations and preliminary design of any recommended improvements, and submit a report to EPA and DEP by December 2022.

1.5.2.4 CSO System Optimization for Lower Charles River, Study and Preliminary Design

Using the calibrated hydraulic model and coordinating technical evaluations with the City of Cambridge and the BWSC, MWRA is conducting system optimization evaluations at the remaining active regulators tributary to CSO outfalls discharging to the Charles River watershed. MWRA commenced the CSO optimization investigations for Charles River CSO outfalls in August 2020, ahead of the variance's December 2020 milestone. MWRA has reviewed the configurations of regulators tributary to the Charles River CSO outfalls and the hydraulic performance of these regulators from MWRA model simulations. To support these efforts, MWRA recently conducted surveys to confirm manhole rim elevations and performed internal inspections and measurements of the MWR018, MWR019 and MWR020 regulators along the Boston Marginal Conduit (BMC). These MWRA efforts are intended to identify regulator modifications or upstream flow controls that may further reduce CSO activations and/or volume.

MWRA is initially focusing efforts on outfalls that it forecasts likely will not attain the LTCP activation and volume goals by December 2021. For outfalls MWR018, MWR019 and MWR020 along the Esplanade, MWRA is evaluating the feasibility and benefits of raising the weirs in these regulator structures. MWRA is also evaluating the potential to reduce head losses within the BMC from these outfalls to the Prison Point facility, and MWRA is considering whether flows from upstream BWSC systems can be controlled to reduce flow levels in the BMC. For Outfall CAM005 in Cambridge, MWRA is coordinating with the City of Cambridge to confirm regulator configuration and elevations, further evaluate the factors contributing to overflows, and evaluate the feasibility and benefit of raising the overflow weir and/or reducing potential downstream head losses. For Outfall MWR201 (Cottage Farm Facility), MWRA is evaluating the potential benefits of sewer separation work planned by the City of Cambridge, in addition to the City's completion of partial sewer separation improvements in Cambridgeport in August 2020. Future evaluations will consider optimization alternatives at the other outfalls that discharge CSO to the Charles River, including MWR023, CAM007 and CAM017. The variances require MWRA to complete these evaluations and preliminary design of any recommended improvements, and submit a report to EPA and DEP by December 2022.

1.6 Conclusions and Remaining Work

This report presents an updated interim system performance assessment, i.e., Typical Year model results for current (Q1-2021) system conditions compared with the LTCP activation and volume goals. All outfalls required to be closed by the LTCP and court order are confirmed closed, permanently. Several additional outfalls are also closed, permanently. The South Boston CSO Storage Tunnel's successful and consistent performance since MWRA brought it into operation on May 4, 2011, provides assurance that it is capable of preventing CSO discharges to the beaches up to the 25-year storm.

Of the 46 discharge locations that remain active (Table 1-5), MWRA concludes from the model results that LTCP volume and activation goals are achieved at 30 locations, and MWRA now expects from the recent recommendations of site-specific investigations that the goals will be achieved at an additional six locations by December 2025. At 10 other locations, MWRA and the CSO communities continue with investigations and evaluations, including project evaluations required by the CSO variances, that are intended to identify system adjustments and projects to bring CSO discharges closer to or in line with the LTCP activation and volume goals.

Some system adjustments and projects recommended from the site-specific investigations are already completed or underway, such as the City of Cambridge's partial sewer separation improvements that reduce treated discharges at the Cottage Farm CSO Facility and its sediment removal contract at has brought Outfall CAM401A into attainment with the LTCP goals; the City of Chelsea's raising of the overflow weir at Outfall CHE004; BWSC's sewer separation contracts in East Boston and South Boston; and MWRA's project to upgrade the interceptor connection at Outfall CHE008.

Addition projects are being designed and implemented by the CSO communities that have not yet been evaluated for their CSO benefit. This includes the City of Somerville's ongoing construction of a major new storm drain through Union Square. This project will provide for the removal of large volumes of stormwater from the sewer system, potentially reducing CSO discharges at the Prison Point CSO Facility and other hydraulically related outfalls. All of the CSO communities continue to pursue sewer separation work. Some of these projects will produce water quality benefits by December 2021, while others will produce benefits several years beyond. As MWRA continues to evaluate these locations, system adjustments and projects, it will also give consideration to whether further investments in CSO mitigation will result in meaningful water quality improvements and whether emphasis on non-CSO contributions of pollution would be more cost-effective.

2. Receiving Water Quality Modeling and Water Quality Assessments

Hydrodynamic and water quality models of the Lower Charles River/Charles Basin and the Alewife Brook/Upper Mystic River were developed and calibrated to support the assessment of the performance of the current MWRA system in comparison to the goals identified in the Second Stipulation for the CSO variance waters. These models are intended to assess the benefits to bacterial water quality in these receiving waters resulting from the improvements made by implementing the MWRA CSO Long Term Control Plan over the last 30 years, as well as the remaining impacts of CSO and non-CSO bacteria sources.

Specifically, these models are intended to:

- Assess the relative impact of remaining CSO on water quality in the Charles River and Alewife Brook/Mystic River,
- Provide information about impacts of stormwater and boundary conditions; and
- Predict resulting *E. coli and Enterococcus* counts during 3-month and 1-year storms as well as the Typical Year.

This section presents a summary of the water quality modeling evaluations for the Charles River and Alewife Brook/Upper Mystic River for the Typical Year rainfall under 2019 collection system conditions. Additional details related to these water quality evaluations will be presented in a Water Quality Assessment Report to be released later in 2021. This summary provides a snapshot of where these waterbodies stand in terms of attainment of numeric water quality criteria for *E. coli,* and the relative contributions of the various loading sources to the bacteria counts in the waterbodies.

2.1 Current Water Quality Standards and Criteria

Massachusetts Surface Water Quality Standards (314 CMR 4.00) are the regulations that set the minimum water quality applicable to waters of the Commonwealth of Massachusetts. They are adopted by the Massachusetts Department of Environmental Protection (MassDEP) to designate the most sensitive uses (e.g., swimming, aquatic life, public water supply) for which surface waters are to be regulated, prescribe the minimum water quality criteria required to sustain those uses, and outline steps necessary to achieve designated uses and maintain high quality waters. The Clean Water Act (CWA) and federal regulations require MassDEP to periodically review and update its surface water quality standards, and to adopt any new or updated criteria recommended by EPA.

The Charles River and Alewife Brook/Upper Mystic River are each currently under a Variance for CSO Discharges. *A water quality standards variance (WQS variance) is a time-limited designated use and criterion for a specific pollutant(s) or water quality parameter(s) that reflect the highest attainable condition during the term of the WQS variance*[5]. This Variance authorizes limited CSO discharges from the MWRA and the Cities of Cambridge and Somerville subject to their National Pollutant Discharge Elimination System (NPDES) permits. During wet weather events where the limited CSO discharges are authorized, Class B requirements for bacteria, solids, color and turbidity, and taste and odor may not be met. The Variance is a water quality standards revision subject to EPA review and approval. On May 29, 2020, EPA approved the current Variances for the Charles River and Alewife Brook/Upper Mystic River.

For the Water Quality Assessment summarized below, attainment with water quality criteria was based on attainment of the existing Class B criteria for non-bathing beach waters. DEP is currently going through the process of modifying the Class B criteria for bacteria, but as of the date of this report these new criteria have not been promulgated. Table 2-1 presents the existing Class B criteria for non-bathing beach waters.

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[5] 40 CFR 131.3 (o)

The model results presented are based on attainment with the existing Class B single sample maximum criteria for non-bathing beach waters. This approach is consistent with the approach taken in the 1997 *Combined Sewer Overflow Facilities Plan and Environmental Impact Report* (FP/EIR) (Metcalf & Eddy, 1997) and the 2003 *Final Variance Report for Alewife Brook/Upper Mystic River* (Metcalf & Eddy, 2003), where compliance was based on a single-sample maximum of 200 #/100mL for fecal coliform. Since the Variance waters are freshwater waterbodies, the summary of the water quality assessment presented here focuses on the *E. coli* criteria. Attainment with the *Enterococcus* criteria will also be presented in the pending Water Quality Assessment Report.

Table 2-1. Existing Class B Criteria

Parameter	Existing Class B Criteria for Non-Bathing Beach Waters (#/100 ml)	
	6-month Geometric Mean	Single Sample Maximum
E. coli	126	235
Enterococcus	33	61

2.2 Overview of Water Quality Models

The water quality models of the Charles River and Alewife Brook/Upper Mystic River compute time-varying and spatially-varying concentrations of *E. coli* and *Enterococcus* in the rivers, taking into account the influence of river flow and geometry, and the impacts of dilution, dispersion, and die-off.

The Charles River model is a horizontally two-dimensional model based on the Delft3D software. The model includes a hydrodynamic part, which calculates water levels and depth-averaged velocities, and a water quality part, which calculates depth-averaged *E. coli* and *Enterococcus* counts. The model extends from the New Charles River Dam and locks to the Watertown Dam (Figure 2-1).

The Alewife Brook/Upper Mystic River model is a one-dimensional model based on the InfoWorks ICM software. The model includes a hydrodynamic part, which calculates water levels and cross section-averaged velocities, and a water quality part, which calculates cross section-averaged *E. coli* and *Enterococcus* counts. The model extends from the Amelia Earhart Dam to the Lower Mystic Lake and covers the Alewife Brook in its entirety (Figure 2-1).

The various sources of flows and bacteria loads into the receiving waters represented in the models include the following:

- Stormwater
- Untreated and treated CSO
- Dry weather base flow (infiltration flow from storm drains or groundwater flow directly to a waterbody; can also include flow from illicit sanitary connections to storm drains)
- Boundary conditions

The basis for the modeled flows and loads from these sources was described in detail in the *Task 5.2 Receiving Water Quality Model Development and Calibration Report* (AECOM 2020) and was summarized in *Semiannual CSO Discharge Report No. 5*

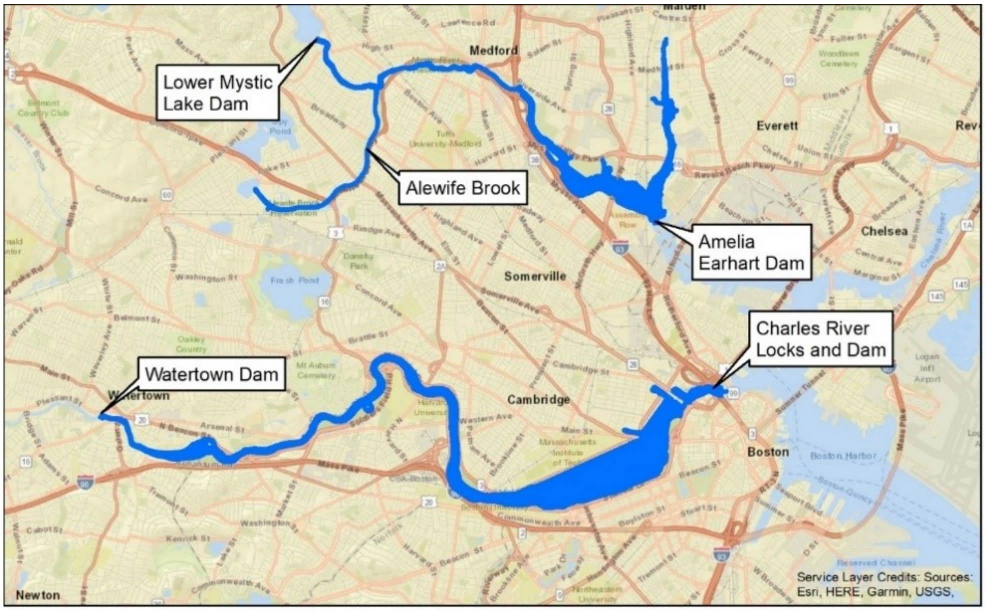


Figure 2-1. Extent of the Charles River and Alewife Brook/Upper Mystic River Models

2.3 Approach to Assessing Compliance with Current Water Quality Criteria

The baseline water quality assessments for the Charles River and Alewife Brook/Upper Mystic River were based on a continuous simulation of the Typical Year rainfall, with MWRA system conditions as represented by the 2019 Conditions version of the MWRA's hydraulic model of its wastewater system (see *Semiannual CSO Discharge Report No. 4*, April 30, 2020, for further details on 2019 system conditions). Output from the baseline assessments included tabulations of the volumes and bacterial loadings from the various sources for the Typical Year, as well as for the 3-month and 1-year storms that are embedded within the Typical Year.

For the Charles River, 2-dimensional isopleth plots of bacterial counts at specific time increments for the 1-year storm were developed, along with 2-dimensional isopleths of hours of exceedance of the existing single-sample maximum criteria for *E. coli* and *Enterococcus*. The hours of exceedance plots were developed for conditions representing all sources, non-CSO sources only, and CSO sources only. The results from the isopleth plots were also summarized in tabular format. Initial sensitivity analyses using varying bacterial counts in the stormwater or CSO were also conducted. Similar information was developed for the Alewife Brook/Upper Mystic River, with the exception that the plots of bacterial counts and hours of exceedance were 1-dimensional along the length of Alewife Brook and the Upper Mystic River. As noted above, the summary presented below focuses on results for *E. coli*. The pending Water Quality Assessment Report will include the results for *Enterococcus*.

2.3.1 Baseline Water Quality Assessment - Charles River

2.3.1.1 CSO Activations

CSO discharges to the Charles River in the Typical Year based on 2019 system conditions are summarized in Table 2-2. It should be noted that the 2019 system conditions did not include the partial sewer separation project in Cambridgeport completed by the City of Cambridge in 2020. That project has reduced the predicted activation frequency of the treated discharges from the Cottage Farm CSO Facility from 4 to 2 and reduced the volume from 12.36 MG to 8.95 MG. Minor impacts from this partial sewer separation and additional model adjustments based on further system information has also resulted in smaller decreases to model predictions of untreated CSOs to the Charles, decreasing the maximum activation frequency from 8 to 7 and the total untreated volume from 4.06 MG to 3.47 MG.

Table 2-2. Typical Year CSO Discharges to the Charles River, 2019 System Conditions

Outfall	Activation Frequency	Untreated Volume (MG)	Treated Volume (MG)
CAM005	8	0.73	--
CAM007	2	0.39	--
CAM017	0	0	--
MWR010	0	0	--
MWR018	2	1.92	--
MWR019	2	0.56	--
MWR020	2	0.32	--
MWR201 (Cottage Farm Treated Discharge)	4	--	12.36
MWR023	1	0.14	--
Totals	8 (max.)	4.06	12.36

2.3.1.2 Source Volume and Bacterial Loadings

Table 2-3 presents the volumetric loadings and Table 2-4 presents the *E. coli* loadings from the various sources to the Charles River for the 3-month storm, 1-year storm, and the Typical Year. Note that the dry weather and boundary flows for the 3-month storm are slightly higher than those for the 1-year storm because the 3-month storm selected for analysis occurs in March, during high groundwater and upstream river flow, while the 1-year storm selected for analysis occurs in September, when groundwater and upstream flow are low.

Table 2-4 shows that the *E. coli* loadings from untreated CSOs were small fractions of the loadings due to stormwater and upstream boundary sources. This pattern of relative loading was generally consistent with the findings from the 1997 CSO FP/EIR for the Charles River.

Table 2-3. Source Volumes to the Charles River

Source	Source Volumes					
	3-Month Storm		1-Year Storm		Typical Year	
	Volume (MG)	Percent of Total	Volume (MG)	Percent of Total	Volume (MG)	Percent of Total
Untreated CSOs(1)	0.0	0%	1.4	0.2%	4.7	<0.01%
Treated CSOs(1)	0.0	0%	8.5	1%	12.7	0.01%
Stormwater	264	38%	430	58%	7,016	6%
Dry Weather	64	9%	38	5%	9,238	8%
Boundary	363	53%	259	35%	98,825	86%
Total	691	100%	737	100%	115,096	100%

Notes:

(1) CSO volumes based on MWRA 2019 System Conditions collection system model.

Table 2-4. Bacterial Loadings to the Charles River

Source	*E. coli* Loadings					
	3-Month Storm		1-Year Storm		Typical Year	
	counts (x 10^{12})	Percent of Total	counts (x 10^{12})	Percent of Total	counts (x 10^{12})	Percent of Total
Untreated CSOs[(1)]						
Sanitary Component	0.00		2.27		4.16	
Non-Sanitary Component	0.00		0.75		1.92	
Total	0.00	0%	3.03	0.8%	6.08	0.1%
Treated CSOs[(1)]	0.00	0%	0.13	0.03%	0.19	<0.01%
Stormwater	145	80%	228	59%	3,518	61%
Dry Weather	0.32	0.2%	0.19	0.05%	47	0.8%
Boundary	37	20%	158	41%	2,235	38%
Total	182	100%	389	100%	5,806	100%

Notes:

(1) CSO loadings based on volumes from MWRA 2019 System Conditions collection system model.

2.3.1.3 Modeled Changes in *E. coli* Counts over Time

Plots of calculated *E. coli* contours at different times during and after the 1-year storm are presented in Figure 2-2 for “All Sources” and in Figure 2-3 for “CSOs Only”. The 1-year storm had untreated CSO discharges at CAM005, CAM007, MWR018, MWR019, MWR020 and MWR023. Note that the color-coding is on a different scale for Figure 2-3 compared to Figure 2-2, due to the difference in the magnitude of the in-stream E. coli counts.

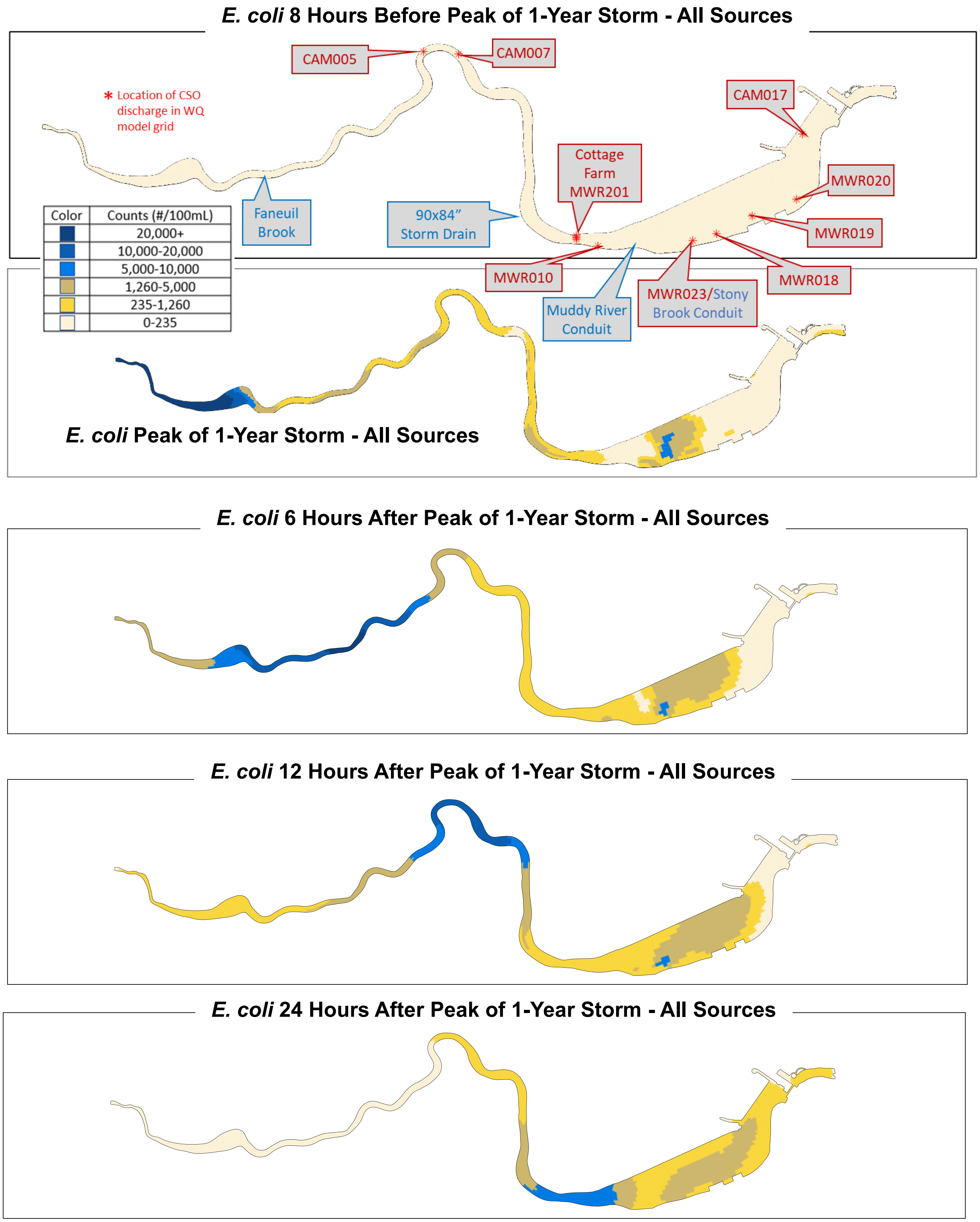


Figure 2-2. *E. coli* Count Contours during the 1-Year Storm for “All Sources”

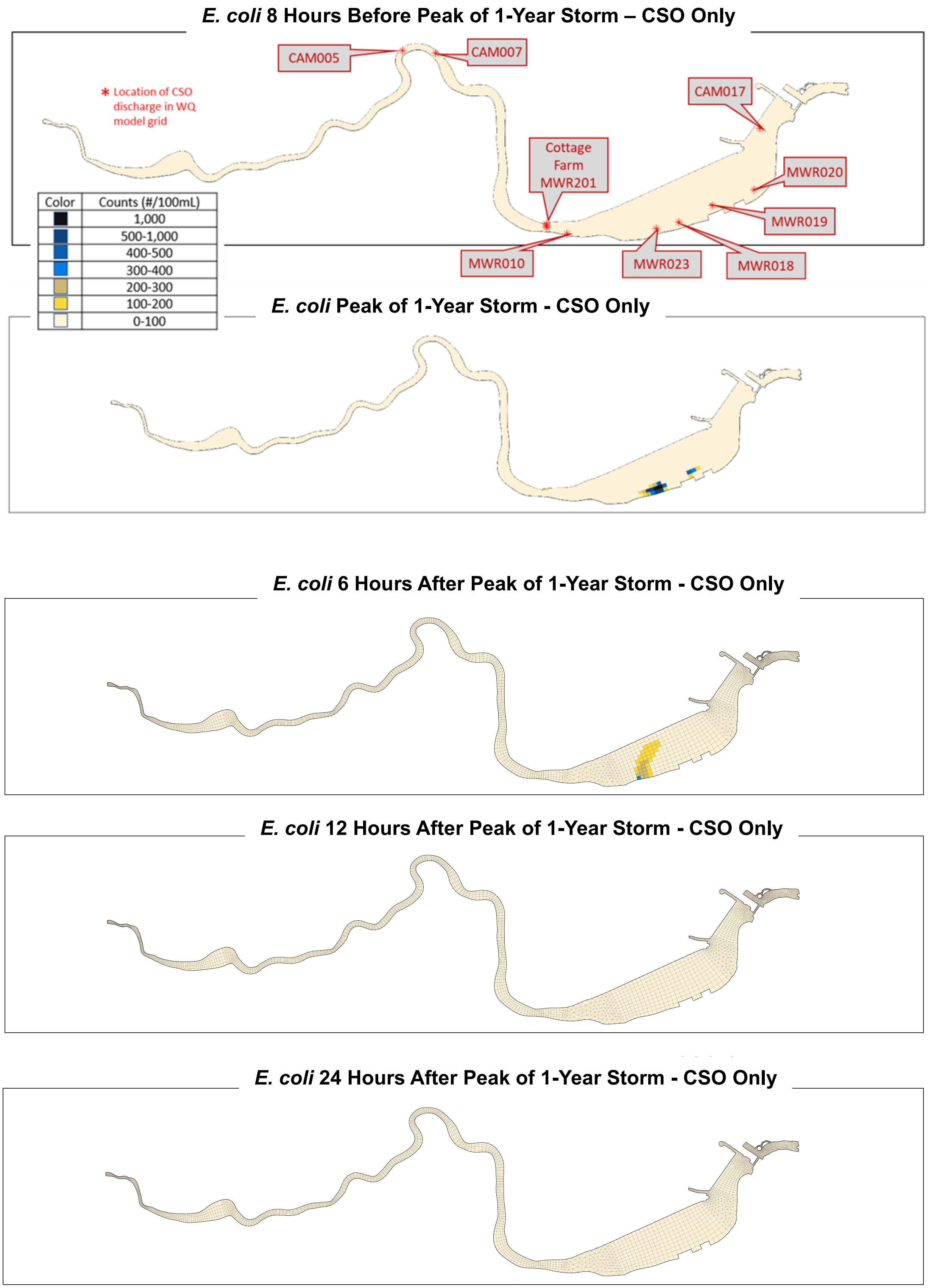


Figure 2-3. *E. coli* Count Contours during the 1-Year Storm for "CSO Only" Sources

2.3.1.4 Criteria Exceedances

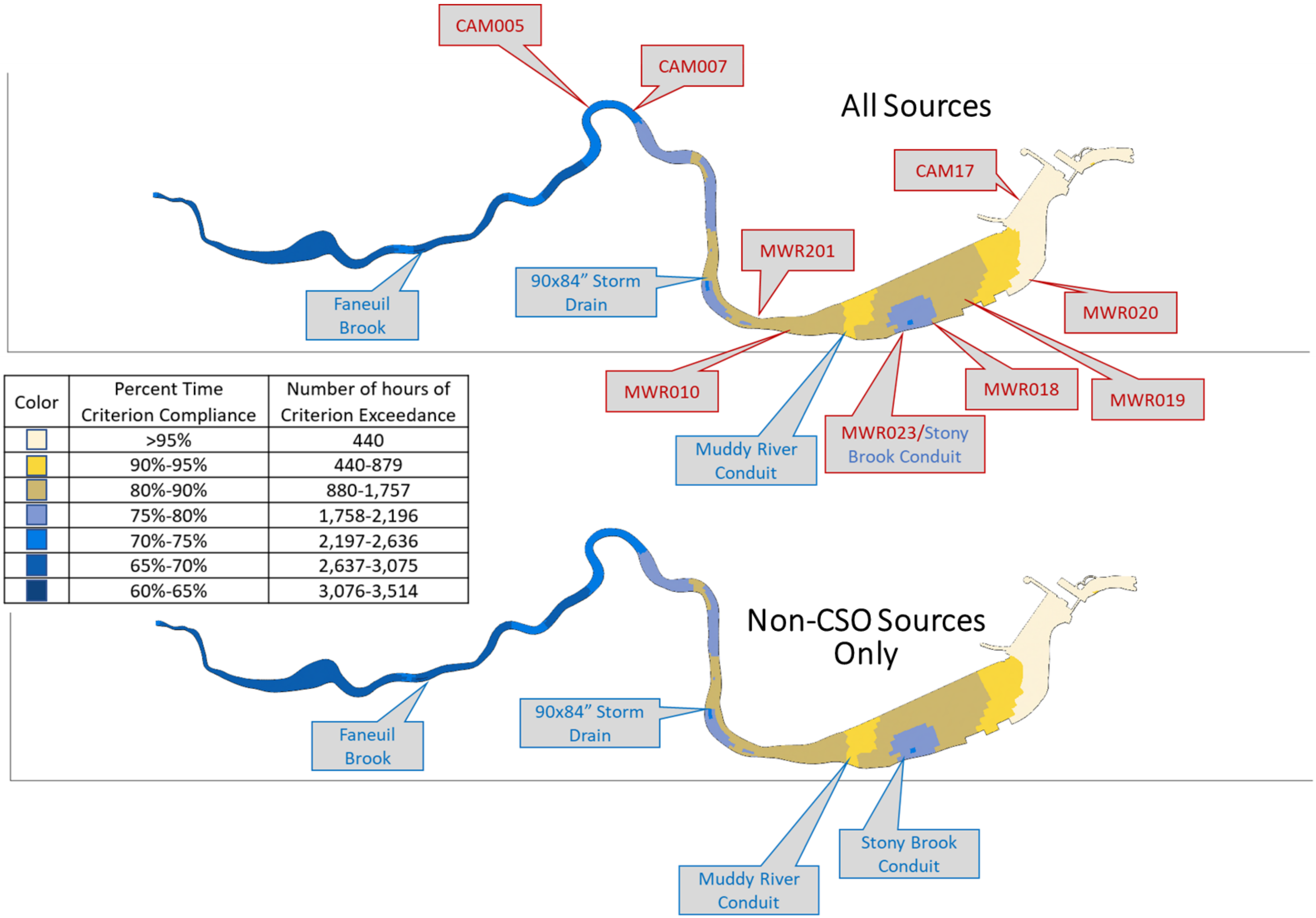
To assess compliance with the current water quality criteria for bacteria, the model was used to compute the total duration that the bacteria count in each model cell was predicted to exceed the single-sample maximum criterion for *E. coli* over the course of the Typical Year. The resulting values for percent annual attainment of the criterion would be generally analogous to the values for annual percent attainment presented in the 1997 FP/EIR. The hours of exceedance and percent annual compliance for *E. coli* are presented in Table 2-5 for six different simulation conditions. The hours shown in Table 2-5 are the number of hours the *E. coli* bacterial counts exceeded the criterion anywhere in the model area. This is extremely stringent, as the model cells where exceedances occur shift in time, and the area of exceedance will nearly always be a fraction of the total river area. At any fixed point in the river, the hours of exceedance would be much less than those listed in the table.

Table 2-5. Hours of the Single Sample Maximum Criteria Exceedance at any point in the Lower Charles River During the Typical Year

Charles River		
	E. coli **Single Sample Maximum Criterion (235 #/100 mL)**	
	Hours of Exceedance	**Percent Annual Compliance**
All Sources	4,570	48%
Non-CSO Sources Only	4,561	48%
Stormwater Only	3,121	64%
Dry Weather sources Only	0	100%
Boundaries Only	3,612	59%
CSOs Only	37	99.6%

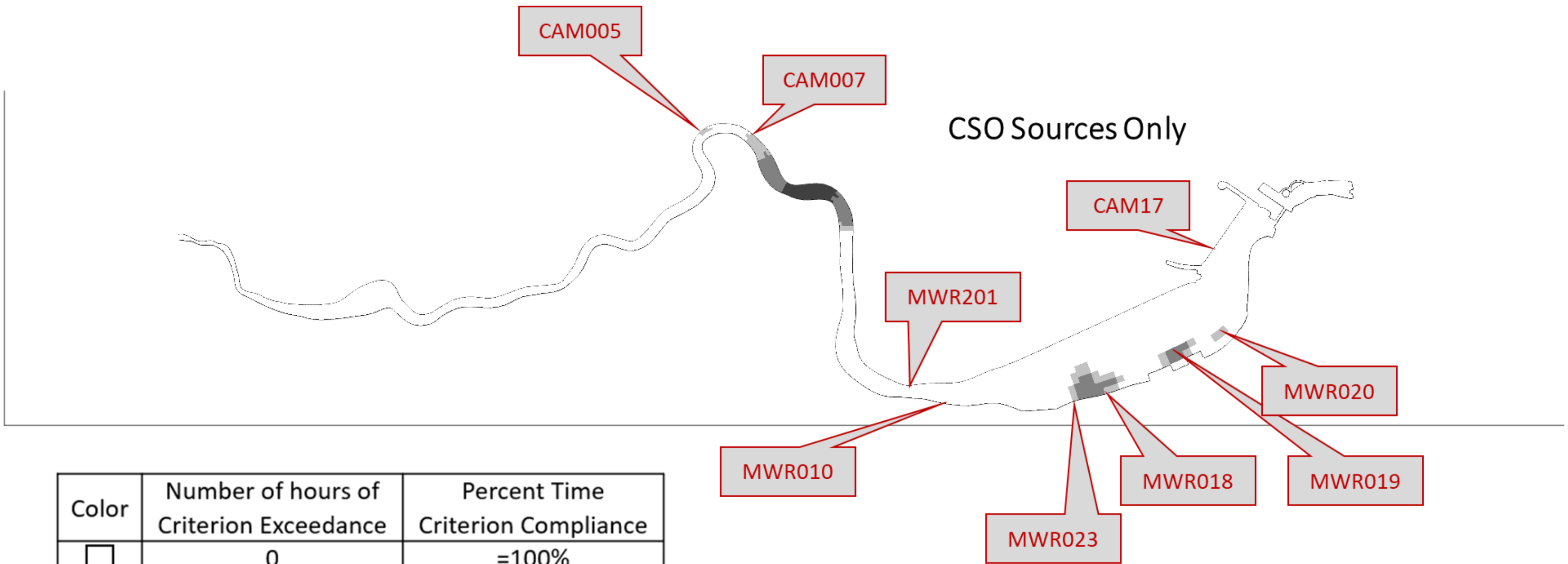
Figure 2-4 presents isopleths of the hours of exceedance of the *E. coli* single sample maximum criterion over the Typical Year for “All Sources” and “Non-CSO Sources Only”. Figure 2-5 presents isopleths of the hours of exceedance of the *E. coli* single sample maximum criterion over the Typical Year for “CSO Sources Only”. The scale in Figure 2-5 is very different from the scale in
Figure 2-4 with hours of exceedance in

Figure 2-5 maximizing at 16 and many areas having 100% criterion compliance over the year. The hours of exceedance displayed in Figure 2-4 and Figure 2-5 are considerably smaller than the numbers listed in Table 2-5 because the figures look at exceedances at fixed points rather than anywhere in the river.



Color	Percent Time Criterion Compliance	Number of hours of Criterion Exceedance
	>95%	440
	90%-95%	440-879
	80%-90%	880-1,757
	75%-80%	1,758-2,196
	70%-75%	2,197-2,636
	65%-70%	2,637-3,075
	60%-65%	3,076-3,514

Figure 2-4. Hours of Exceedance and Percent Compliance with 235#/100mL *E. coli* Single-Sample Max. Criterion for the Typical Year



Color	Number of hours of Criterion Exceedance	Percent Time Criterion Compliance
	0	=100%
	0-4	99.95%-100%
	4-8	99.91%-99.95%
	8-12	99.86%-99.91%
	12-16	99.82%-99.86%

Figure 2-5. Hours of Exceedance and Percent Compliance with 235 #/100mL *E. coli* Single-Sample Max. Criterion for the Typical Year for CSO Sources Only

2.3.1.5 Sensitivity Analysis

An initial set of sensitivity evaluations was conducted to assess the relative impacts of changes in stormwater and CSO bacterial counts. The "stormwater only" condition was assessed with stormwater bacterial counts decreased by factors of 2 and 5, and to the 25th percentile value from the sampling data (possibly representing stormwater quality improvements) and the "CSO only" condition was assessed with CSO bacterial counts increased by a factor of 2. Boundary values were multiplied by 0.5 and 0.2. The results of these sensitivity analyses are presented in Table 2-6.

Table 2-6. Single Sample Maximum Sensitivity Analysis

Charles River				
	Source Count Multiplier	***E. coli* Value (#/100 mL)**	***E. coli* Single Sample Maximum Criterion (235 #/100 mL)**	
			Hours of Exceedance	**Percent Compliance**
Stormwater Only	1.0	14,000	3,121	64%
	0.5	7,000	2,305	74%
	0.2	2,800	1,491	83%
	25th Percentile	1,110	935	89%
CSO Only	1.0	Time varying Computed by Mass Balance	37	99.6%
	2.0	2x Time varying Computed by Mass Balance	67	99.2%
Boundary Only	1.0	Time varying Computed by Boundary Condition Model	3,612	59%
	0.5	0.5 x Time varying Computed by Boundary Condition Model	2,727	69%
	0.2	0.2 x Time varying Computed by Boundary Condition Model	1,502	83%

In Table 2-6, the values in the rows associated with "Source Count Multiplier" of 1.0 reflect the baseline stormwater or CSO counts. For the stormwater-only case, the "Source Count Multiplier" of 0.5 reflects a 50 percent reduction in the *E. coli* counts in the stormwater discharges, and the "Source Count Multiplier" of 0.2 reflects an 80 percent reduction in the *E. coli* counts in stormwater. The bacterial counts in the CSO were time-varying based on the sanitary fraction, with the model computing a unique bacterial count for each model timestep at each outfall. For the CSO loading sensitivity analysis, the Source Count Multiplier simply multiplied the computed value at each timestep by a factor of 2. The time-varying boundary source loadings were similarly reduced for the boundary loading sensitivity analysis.

2.3.2 Baseline Water Quality Assessment – Alewife Brook

2.3.2.1 CSO Activations

CSO discharges to Alewife Brook/Upper Mystic River in the Typical Year based on 2019 system conditions are summarized in Table 2-7. It should be noted that the 2019 system conditions did not include the removal of sediment in the combined sewer downstream of regulator RE401A completed by the City of Cambridge in 2020 as well as other system improvements and model adjustments based on new system information. These efforts have significantly reduced the predicted activation frequency and volume of the discharges from outfall CAM401A, and for Alewife Brook as a whole, reduced the maximum activation frequency from 10 to 8, and the total volume from 9.5 to 6.26 MG.

Table 2-7. Typical Year CSO Discharges to Alewife Brook/Upper Mystic River, 2019 System Conditions

Outfall	Activation Frequency	Untreated Volume (MG)	Treated Volume (MG)
CAM001	1	0.02	--
CAM002	0	0	--
CAM401A	10	3.59	--
CAM401B	5	0.73	--
SOM001A	6	3.60	--
MWR003	3	1.60	
SOM007A/MWR205A(1)	6	--	4.95
Totals	10 (max.)	9.5	4.95

Notes:

(1) SOM007A/MWR205A is a treated discharge from the Somerville-Marginal CSO Facility into the freshwater reach of the Mystic River upstream of the Amelia Earhart Dam that activates during rain events at high tide.

2.3.2.2 Source Volume and Bacterial Loadings

Table 2-8 presents the volumetric loadings and Table 2-9 presents the *E. coli* loadings from the various sources to Alewife Brook and the Upper Mystic River for the 3-month storm, 1-year storm, and the Typical Year. Note that the dry weather and boundary flows for the 3-month storm are slightly higher than those for the 1-year storm because the 3-month storm selected for analysis occurs in March, during high groundwater and upstream river flow, while the 1-year storm selected for analysis occurs in September, when groundwater and upstream flow are low.

Table 2-9 shows that the *E. coli* loadings from untreated CSOs were small fractions of the loadings due to stormwater and upstream boundary sources. This pattern of relative loading was generally consistent with the findings from the *2003 Final Variance Report for Alewife Brook/Upper Mystic River*.

Table 2-8. Source Volumes to Alewife Brook and Upper Mystic River

Source	Source Volumes – Alewife Brook						Source Volumes – Upper Mystic River					
	3-Month Storm		1-Year Storm		Typical Year		3-Month Storm		1-Year Storm		Typical Year	
	Volume (MG)	Percent of Total	Volume (MG)	Percent of Total	Volume (MG)	Percent of Total	Volume (MG)	Percent of Total	Volume (MG)	Percent of Total	Volume (MG)	Percent of Total
Untreated CSOs(1)	0.003	<0.01%	1.91	5%	8.13	0.5%	N/A	N/A	N/A	N/A	N/A	N/A
Treated CSOs(1)	N/A	N/A	N/A	N/A	N/A	N/A	0.04	0.01%	0.40	0.2%	4.92	0.03%
Stormwater	17	55%	23	62%	383	22%	50	15%	61	31%	1,343	7%
Dry Weather	14	45%	12	32%	1,384	78%	50	15%	44	23%	4,937	27%
Boundary	N/A	N/A	N/A	N/A	N/A	N/A	236	70%	88	45%	12,168	66%
Total	31	100%	37	100%	1,775	100%	337	100%	194	100%	18,453	100%

Notes:
(1) CSO volumes based on MWRA 2019 System Conditions collection system model.

Table 2-9. *E. coli* Loadings to Alewife Brook and Upper Mystic River

	E. coli Loadings											
Source	Alewife Brook						Upper Mystic River					
	3-Month Storm		1-Year Storm		Typical Year		3-Month Storm		1-Year Storm		Typical Year	
	counts (x 10^{12})	Percent of Total	counts (x 10^{12})	Percent of Total	counts (x 10^{12})	Percent of Total	counts (x 10^{12})	Percent of Total	counts (x 10^{12})	Percent of Total	counts (x 10^{12})	Percent of Total
Untreated CSOs(1) Sanitary Component Non-Sanitary Component Total	 0.003 0.82 0.823	 5%	 5.48 2.64 8.12	 28%	 15.8 24.6 40.4	 10%	N/A	N/A	N/A	N/A	N/A	N/A
Treated CSOs(1)	N/A	N/A	N/A	N/A	N/A	N/A	0.00003	<0.01%	0.0003	<0.01%	0.0034	<0.01%
Stormwater	16	94%	21	72%	362	88%	48	94%	57	95%	1,270	93%
Dry Weather	0.074	0.4%	0.067	0.2%	7.0	2%	0.25	0.5%	0.22	0.4%	25	2%
Boundary	N/A	N/A	N/A	N/A	N/A	N/A	2.55	5%	3.2	5%	66	5%
Total	17	100%	29	100%	409	100%	51	100%	60	100%	1,361	100%

Notes:
(1) CSO loadings based on volumes from MWRA 2019 System Conditions collection system model.

2.3.2.3 Modeled Changes in *E. coli* Counts over Time

Under 2019 system conditions, the 1-year storm caused untreated CSO discharges at MWR003 (0.73MG), CAM401A (0.98 MG), CAM401B (0.32 MG) and SOM001A (1.06 MG), as well as a treated discharge at SOM007A/MWR205A (0.47 MG). As indicated in Figure 2-6, the untreated CSOs to Alewife Brook started at about 5:30 and ended at 8:00, while the treated discharge at SOM007A/MWR205A occurred approximately four hours later, as a result of tidal impacts redirecting some of the discharge from MWR205 to this discharge upstream of the Amelia Earhart Dam.

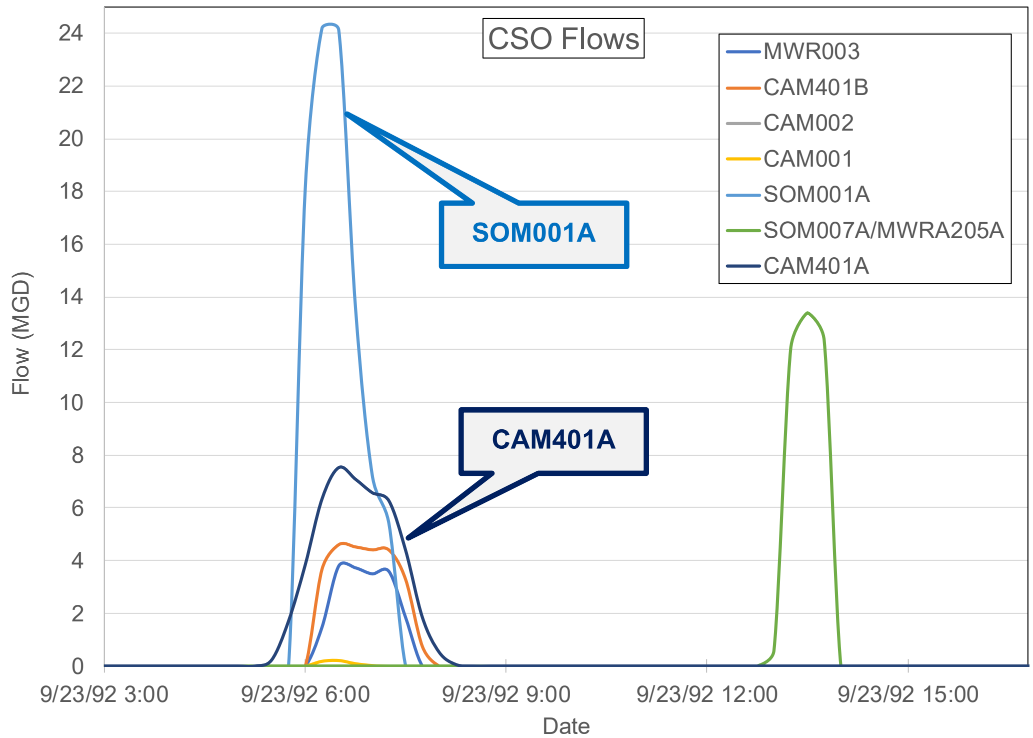


Figure 2-6. CSO Flows during the September 23, 1992 Storm

The longitudinal *E. coli* profiles for all sources at 3-hour intervals starting prior to the start of the 1-year storm are shown in Figure 2-7 and Figure 2-8. Profiles are shown on each plot for the Alewife Brook and sections of the Mystic River upstream and downstream of the Alewife Brook confluence.

Longitudinal *E. coli* profiles for CSO sources only at 3-hour intervals starting prior to the start of the 1-year storm are shown in Figure 2-9 to Figure 2-10.

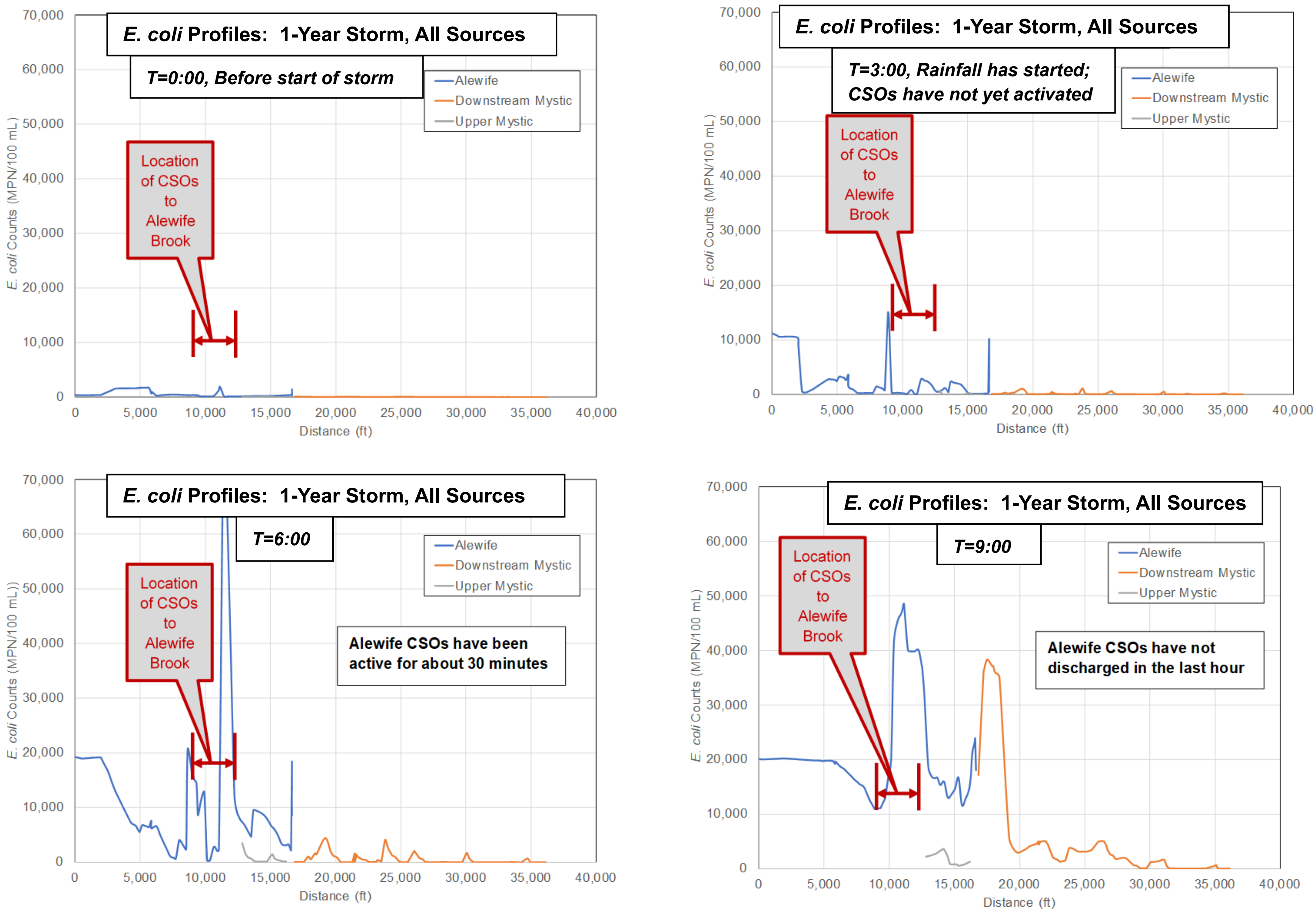


Figure 2-7. ***E. coli*** **Profiles for 1-Year Storm – All Sources**

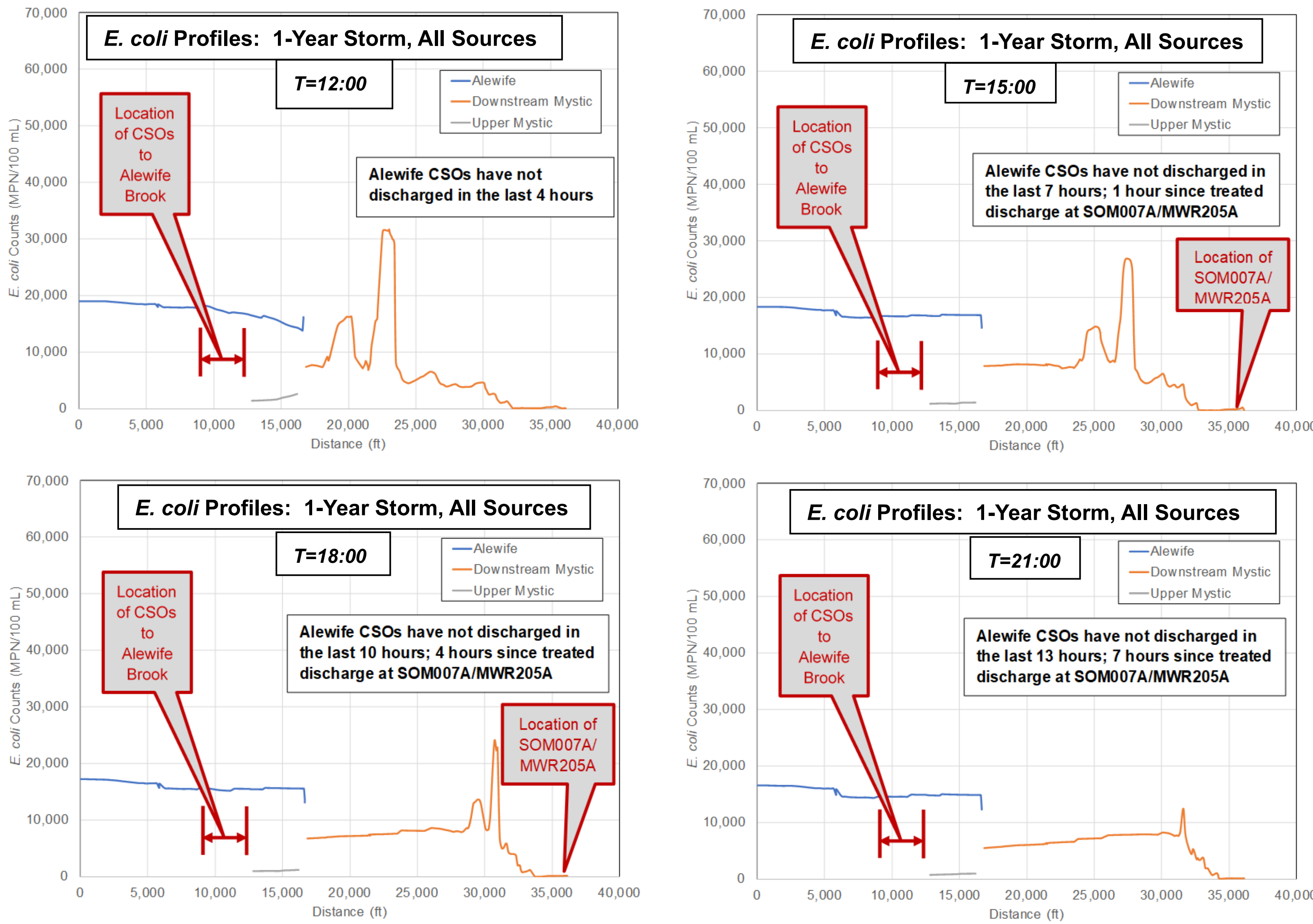


Figure 2-8. *E. coli* Profiles for 1-Year Storm– All Sources

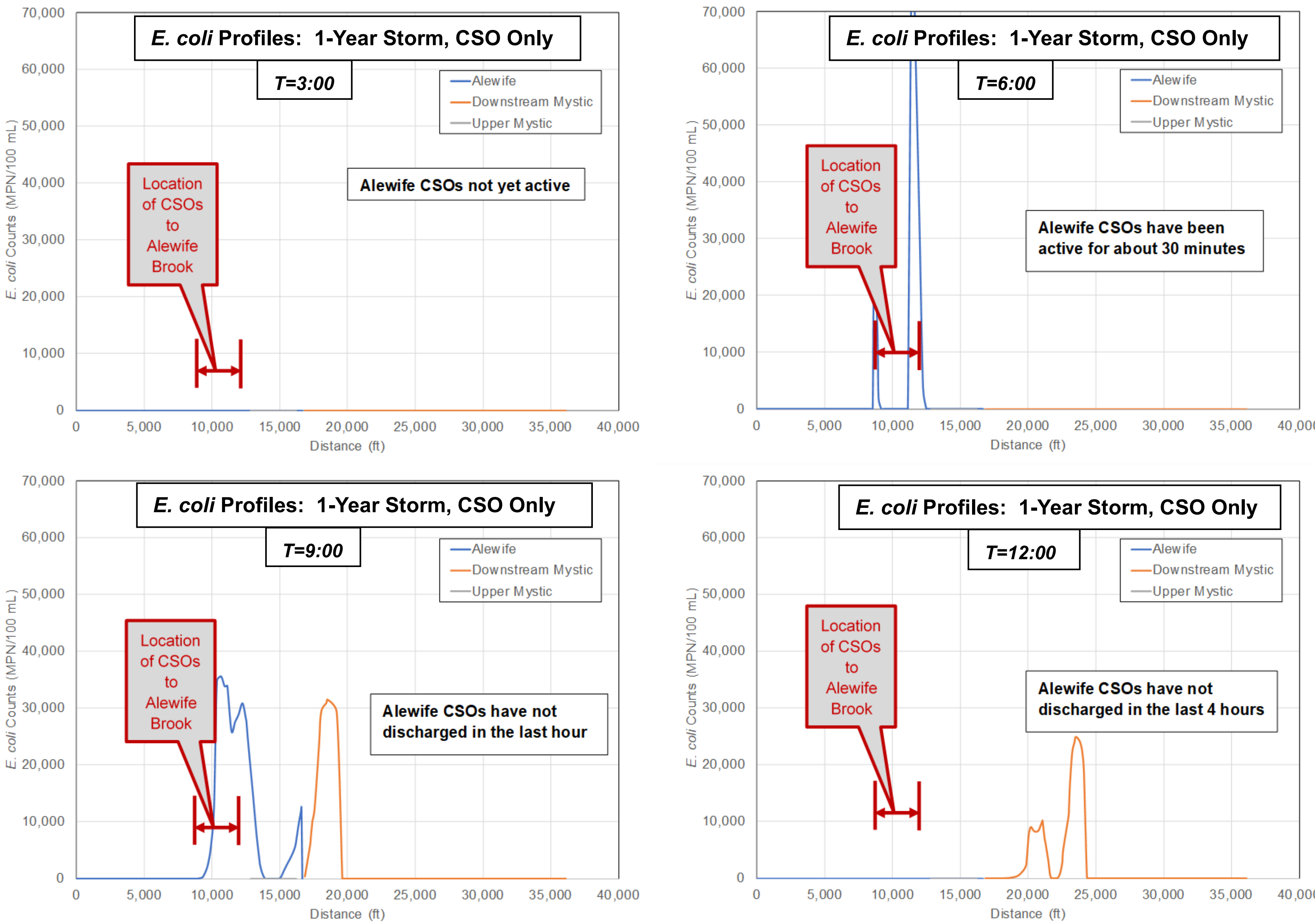


Figure 2-9. *E. coli* Profiles for 1-Year Storm– CSO Only

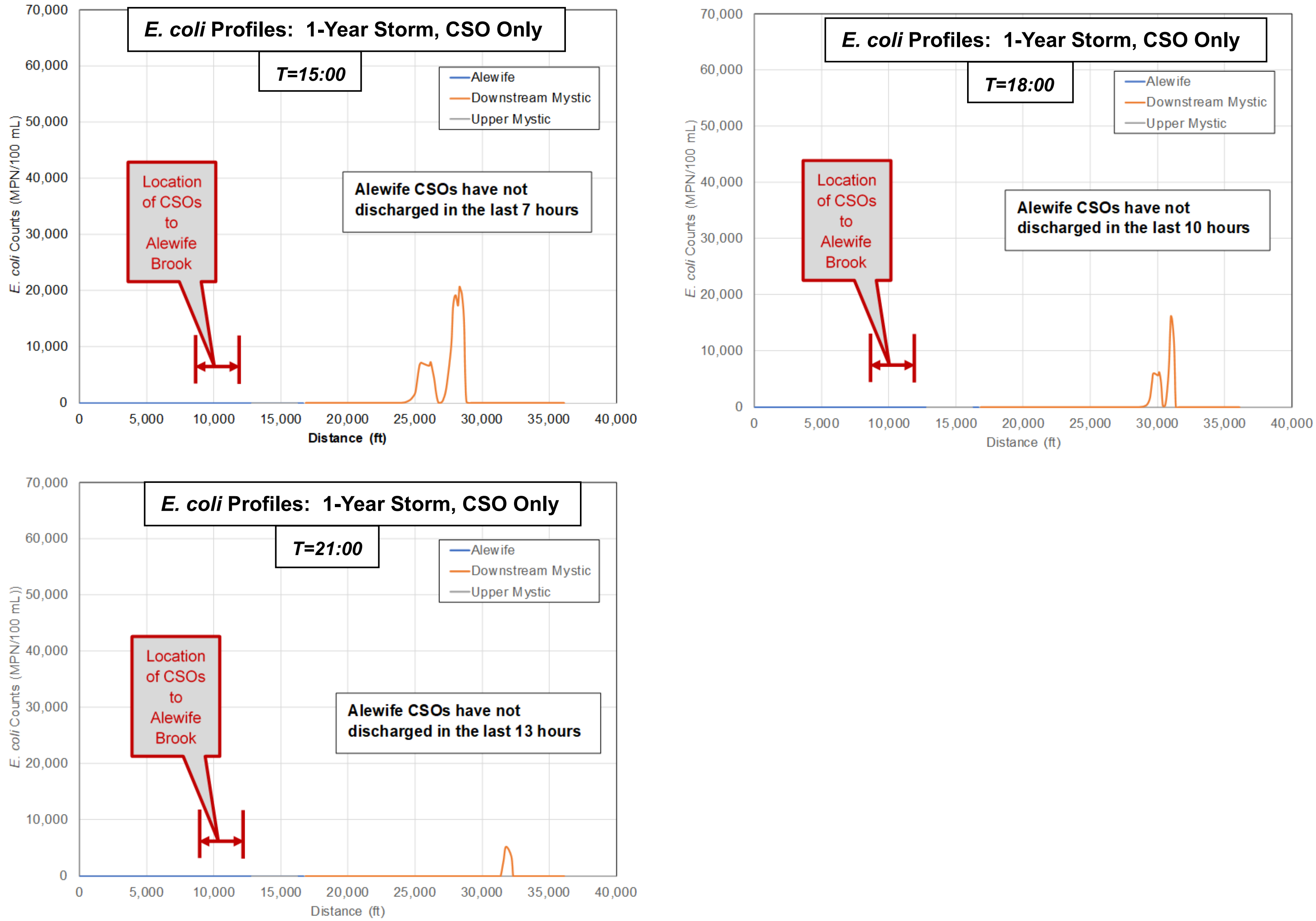


Figure 2-10. *E. coli* Profiles for 1-Year Storm– CSO Only

2.3.2.4 Criteria Exceedances

To assess compliance with the current water quality criteria for bacteria, the model was used to compute the total duration that the bacteria count in each segment along the linear model was predicted to exceed the single-sample maximum criterion for *E. coli* over the course of the Typical Year. The resulting values for percent annual attainment of the criteria would be generally analogous to the values for annual percent attainment presented in the *2003 Final Variance Report for Alewife Brook/Upper Mystic River*. The hours of exceedance and percent annual compliance for *E. coli* criteria in Alewife Brook and the Upper Mystic River are presented in Table 2-10 for six different simulation conditions. The hours shown in Table 2-10 are the number of hours the *E. coli* bacterial counts exceed the criterion anywhere along the linear model of the Alewife Brook or Mystic River, respectively. As noted for the Charles River, this is extremely stringent, as the model segments where exceedances occur shift in time, and the area of exceedance is almost always a fraction of the river. At any fixed point in the river, the hours of exceedance would be less than those listed in the tables.

Table 2-10. Hours of the Single Sample Maximum Criterion Exceedance at any point in the Alewife Brook and Upper Mystic River During the Typical Year

	Alewife Brook		Upper Mystic River	
	E. coli Single Sample Maximum Criterion (235 #/100 mL)		*E. coli* Single Sample Maximum Criterion (235 #/100 mL)	
	Hours of Exceedance	Percent Annual Compliance	Hours of Exceedance	Percent Annual Compliance
All Sources	5,367	39%	4,807	45%
All Sources – No CSO	5,367	39%	4,807	45%
Stormwater Only	5,188	41%	4,640	47%
Dry Weather sources Only	0	100%	0	100%
Boundaries Only	0	100%	0	100%
CSOs Only	120	98.6%	272	96.9%

Plots of hours of *E. coli* criteria exceedances over the Typical Year along Alewife Brook and Upper Mystic River for all sources are presented in Figure 2-11, and for CSO sources only in Figure 2-12. Similar to the Charles River, plots of criteria exceedances over the Typical Year for the condition of all sources except CSO were identical to the “all sources” plots, so the plots are not repeated here. In addition, the scale for Figure 2-12 covers a much lower range of values than the scale for Figure 2-11, as the maximum hours of exceedance for the “CSO Only” case was only approximately 40 hours.

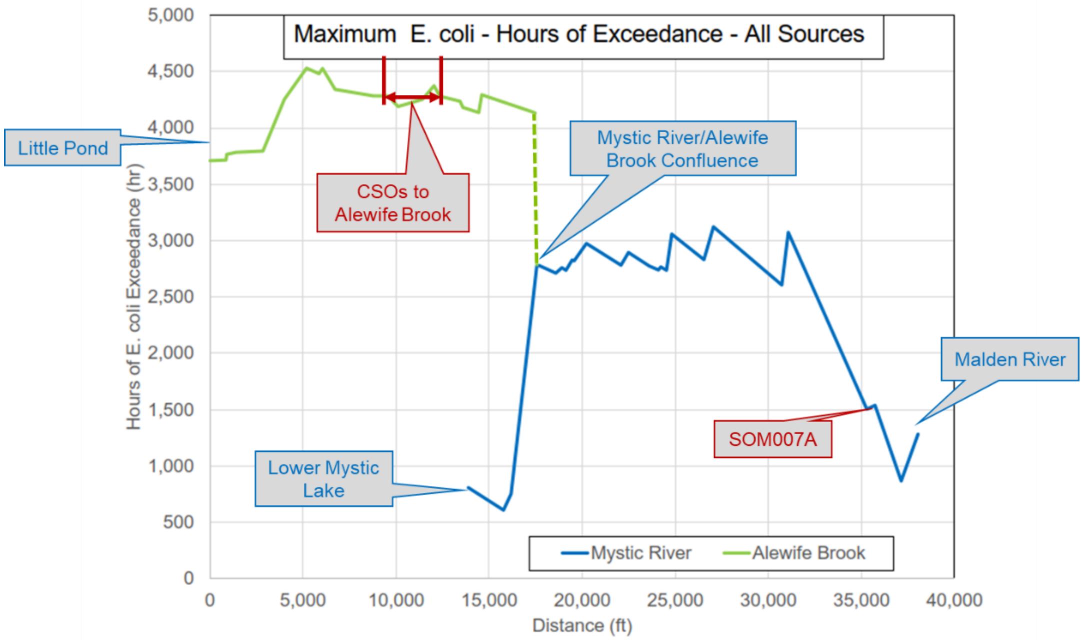


Figure 2-11. Hours of Exceedance of Single Sample Max Criterion *E. coli*, All Sources, Typical Year

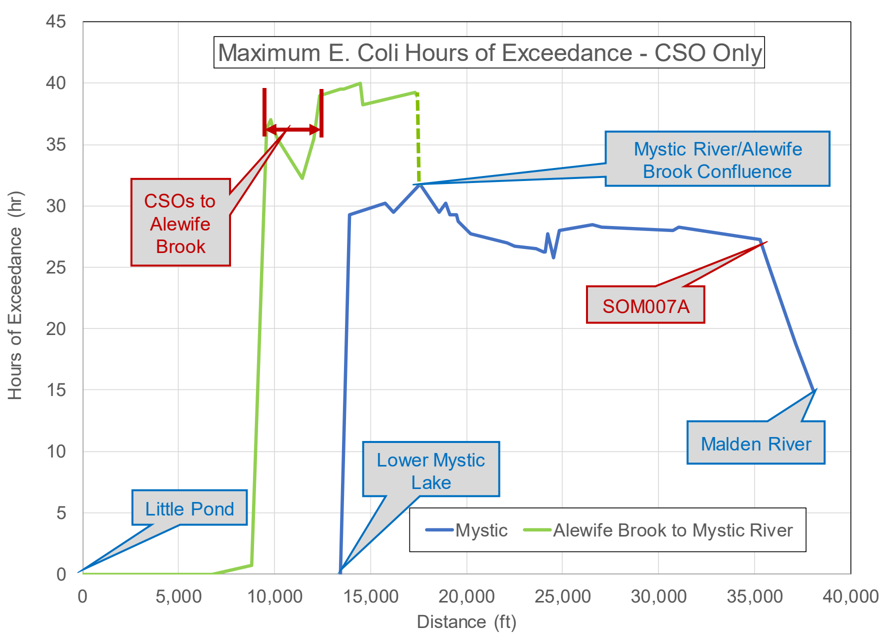


Figure 2-12. Hours of Exceedance of Single Sample Max Criterion *E. coli*, CSOs Only, Typical Year. Note change in scale from "All Sources".

2.3.2.5 Sensitivity Analysis

As was done for the Charles River, hours of exceedance of the *E. coli* criterion were calculated for variations in the bacterial counts in stormwater and CSOs. This initial set of sensitivity evaluations is summarized in Table 2-11, where stormwater bacterial counts were decreased by factors of 2 and 5, and to the 25th percentile value from the sampling data (possibly representing stormwater quality improvements) and CSO bacterial counts were increased by a factor of 2 (to gauge the robustness of the CSO impact assessment).

Table 2-11. Single Sample Maximum Sensitivity Analysis

Alewife Brook and Upper Mystic River				
	Source Count Multiplier	*E. coli* Value (#/100 mL)	*E. coli* Single Sample Maximum Criterion (235 colonies/100 mL)	
			Hours of Exceedance	Percent Compliance
Stormwater Only	1.0	25,000	5,384	39%
	0.5	12,500	4,820	45%
	0.2	5,000	4,087	53%
	25th Percentile	1,110	2,177	75%
CSO Only	1.0	Time varying Computed by Mass Balance	367	96%
	2.0	2x Time varying Computed by Mass Balance	419	95%

In Table 2-11, the values in the rows associated with "Source Count Multiplier" of 1.0 reflect the baseline stormwater or CSO counts. For the stormwater-only case, the "Source Count Multiplier" of 0.5 reflects a 50 percent reduction in the *E. coli* and *Enterococcus* counts in the stormwater discharges, and the "Source Count Multiplier" of 0.2 reflects and 80 percent reduction in the bacterial counts in stormwater. As described in Section 2, the bacterial counts in the CSO were time-varying based on the sanitary fraction, with the model computing a unique bacterial count for each model timestep at each outfall. For the CSO loading sensitivity analysis, the Source Count Multiplier simply multiplied the computed value at each timestep by a factor of 2.

2.3.3 Next Steps

The results of the Water Quality Assessment will be documented in a Water Quality Assessment Report. The models will then be applied to assess the potential benefits of additional CSO reduction alternatives in terms of improvement in attainment of water quality criteria. Alternatives based on specific system improvements will be simulated, and additional sensitivity runs may be conducted. MWRA intends to coordinate with EPA and DEP to identify the additional evaluations to be conducted as part of the alternatives evaluations. The schedule for remaining activities associated with the Water Quality Assessment is as follows:

- Submit Draft Water Quality Assessment Report to DEP/EPA: April 2021
- Submit Final Water Quality Assessment Report to DEP/EPA: August 2021
- Submit Draft Alternatives Simulation Report to DEP/EPA: October 2021
- Submit Final Alternatives Simulation Report to DEP/EPA: December 2021

3. Typical Year Discharges: Updated System Performance Assessment and Comparison with LTCP Levels of Control

3.1 Description, Purpose and Use of the Hydraulic Model

MWRA's hydraulic model is the primary tool used to evaluate the performance of the MWRA system and MWRA and community CSOs against the LTCP Typical Year levels of control. Environmental variables such as rainfall, tide, and evaporation serve as inputs to the model. These inputs are used by the model to estimate the flow entering the sewer system, as well as the hydraulic performance of the system at CSO regulators. The hydraulic model includes the entire MWRA regional collection and transport system, broken into the north system (flows to Deer Island via the Columbus Park, Ward Street, Chelsea Creek and Winthrop Terminal Headworks) and the south system (flows to Deer Island via the Nut Island Headworks). The CSO system is part of the north system model and includes many of the local sewers within the four CSO communities of Boston, Cambridge, Chelsea, and Somerville. Therefore, the north system model, as shown in Figure 3-1 is used in model predictions of CSO performance. The north system model includes approximately 8,670 links, 8,930 nodes, and 2,500 subcatchments.

Hydraulic modeling has historically served as the basis for evaluating performance of the CSO system. The hydraulic model was first established in 1992 during early development of the LTCP using the USEPA Storm Water Management Model (SWMM) software. It was then updated and converted to InfoWorks CS in the early 2000's to improve the simulation of hydraulic conditions and better serve MWRA's needs during LTCP implementation. The InfoWorks CS model was recently converted to InfoWorks ICM, the successor modeling software to InfoWorks CS, for this post-construction assessment. The MWRA and CSO community wastewater collection systems are continuously improving, and even routine inspections can yield details of these systems that were lost over time - parts of these systems were constructed as early as the mid-1800s. As a result, the model continues to be updated to reflect completed improvements and inspection results.

In 2019 through early 2020, MWRA upgraded and calibrated its 2017 system conditions model with extensive inspection information and meter data collected in 2018, as described in semiannual progress reports No. 4 and No. 5 (https://www.mwra.com/cso/pcmapa.html). Subsequent to this extensive calibration effort, additional modifications have been made to the model based on new information.

Figure 3-1. MWRA InfoWorks ICM North System Model

3.2 Hydraulic Model Updates

Updates to MWRA's hydraulic model are necessary to estimate CSO discharges as improvements are made to the MWRA and community sewer systems; to compare or verify model predictions against meter data; and to update Typical Year CSO performance for comparison with the LTCP activation and volume goals. The following text describes recent updates to MWRA's Mid-2020 system conditions model to predict CSO discharges during the storms that occurred in the period July 1, 2020 through December 31, 2020 (the "Q3Q4-2020 system conditions model") and to update the system's Typical Year CSO performance for current system conditions (the "Q1-2021 system conditions model").

Table 3-1 documents the changes made to the Mid-2020 system conditions model to create the Interim Q3Q4-2020 system conditions model, the Q3Q4-2020 system conditions model and the Q1-2021 system conditions model. The table provides the **Location** of the part of the model that was modified. The **Summary of Change** provides information on what was changed in the model. **Supporting Information** provides additional context on the justification/source of information about the modification that was made to the model. The last three columns indicate which version(s) of the model into which the change(s) are incorporated. The **Interim Q3Q4-2020** system conditions model was used to evaluate alternatives before the Q3Q4-2020 Model was available. The **Q3Q4-2020** model is used to simulate the storm events from July 1-December 31, 2020 with the measured rainfall. **Q1-2020** Model is the model that is used for the Typical Year simulation that reflects the system conditions as of the end of the first quarter of 2021.

Table 3-1. Recent Model Changes

Location	Summary of Change	Supporting Information	Interim Q3Q4-2020	Q3Q4-2020 Model	Q1-2021 Model
Full Model- CSO Facilities	Updated the RTC to include the storm by storm operation of the facilities based on MWRA provided data of facility operation.	The updated RTC was added for the July 1-December 31, 2020 period based on MWRA provided data.	Yes	Yes	N/A
Outfalls BOS060, BOS062, BOS064, and BOS065	Minor adjustments were made to the physical configuration of the regulators tributary to outfalls BOS060, BOS062, BOS064, and BOS065, and subsequent minor calibration adjustments were made.	Based on further review of the model and basemaps, minor adjustments were made to the physical configuration of the regulators tributary to outfalls BOS060, BOS062, BOS064, and BOS065. The model was re-run for the 2018 calibration and verification periods. This comparison resulted in some minor adjustments to the hydrology and roughness factors so that the model could more closely match the meters.	Yes	Yes	Yes
Alewife Brook Pump Station	Updated wet weather pump station operation strategy.	The ABPS wet weather operation strategy was updated to incorporate the changes recommended in the Task 8.1 ABPS Optimization Evaluation.	Yes	Yes	Yes
East Boston	Incorporated Contract 1 Sewer Separation (BWSC) and BWSC model updates received on February 4, 2021	Additional information on these modifications is documented in Chapter 4 of SAR 6. BWSC changes included removing the interconnection between RE010-2 and RE003-12 and adjusting rim elevations.	Yes	Yes	Yes
East Boston	Refined the representation of certain sewer separation areas	Based on review of sewer separation areas, adjustments were made to better reflect the anticipated inflow removal in previously separated areas.	No	Yes	Yes
East Boston	Updated model to reflect changes from BWSC received 02/04/2021	Updated model to remove interconnection between RE003-12 and RE010-2, 2 rim changes and 1 pipe diameter change	Yes	Yes	Yes

Table 3-1. Recent Model Changes

Location	Summary of Change	Supporting Information	Interim Q3Q4-2020	Q3Q4-2020 Model	Q1-2021 Model
BOS010	Raised the weir by 3 inches at RE010-2	BWSC raised the weir 3 inches at RE010-2 in February 2021. Additional information is provided in Chapter 4.	No	No	Yes
CAM401A	Removed sediment at CAM401A	Cambridge completed removal of the sediment in the combined sewer between CAM401A and the Alewife Brook Branch Sewer on November 30, 2020. Sediment in the model was removed per inspection reports and field measurements taken following the sediment removal.	Yes	Yes	Yes
CHE004	Raised the weir at CHE004 by 1.5 feet.	The City of Chelsea raised this weir in the field in December 2020.	No	No	Yes
CHE008	Updated the representation of the regulator configuration to better reflect field conditions. Recalibrated the model to account for the removal of the protrusion of the dry weather flow connection into the regulator.	The protrusion was removed on October 1, 2020. The model was recalibrated with meter data collected following the removal of the protrusion.	Yes	Yes	Yes
Charlestown (BOS017)	Updated the model based on an investigation of the piping network associated with regulator RE017-3 and outfall BOS017 conducted by BWSC.	Model changes included: • Updated the configuration of siphon chambers at Sullivan Square to include the 36-inch connection from the 24x30-inch combined sewer to MWRA's Cambridge Branch Sewer and to adjust the fully opened siphon barrel to half open • Added connections on Middlesex Street and Tibbet's Town Way between Main Street and Rutherford Ave • Updated invert elevations on the Main Street Sewer • Added a subcatchment feeding stormwater into the BWSC combined sewer on Rutherford Avenue • Updated the configuration of the overflow structure and dry weather connection at regulator RE028-2	No	Yes	Yes
Cottage Farm	Incorporated Cambridgeport Partial Sewer Separation into the model.	Additional information on the Cambridgeport Partial Sewer separation is provided in Chapter 4.	Yes	Yes	Yes
CAM005	Revised the modeled configuration of the weir at CAM005.	Removed a restriction over the top of the weir and adjusted the weir discharge coefficient based on review of field inspection data.	No	Yes	Yes
MWR018/ 019/020	Updates to regulator structures	Updates were made to regulators per January 2021 field inspections conducted by MWRA.	No	Yes	Yes
CAM017	Removed dry weather pipe that the City of Cambridge indicated did not to exist. The calibration was reviewed.	The City of Cambridge confirmed that a dry weather flow pipe that was included in the model did not exist in the field. The pipe was removed from the model.	Yes	Yes	Yes
Influent conduit to Prison Point downstream of Charles River siphon	Increased the diameter of a single 3-foot diameter pipe located on influent conduit to Prison Point downstream of Charles River siphon to match the downstream pipe diameter	As part of the Task 8.3 efforts a pipe with a significantly smaller diameter than the upstream and downstream pipes was identified in the model. MWRA investigated and identified that the pipe has the same diameter as the downstream pipe.	Yes	Yes	Yes

Table 3-1. Recent Model Changes

Location	Summary of Change	Supporting Information	Interim Q3Q4-2020	Q3Q4-2020 Model	Q1-2021 Model
Prison Point pumping configuration	Pump settings were adjusted to better correlate with observed flows following updates to regulators MWR018, 019, 020 and RE0017-3.	SCADA data provided by MWRA were used for pump adjustments.	No	Yes	Yes
Somerville-Marginal CSO Facility/ Ten Hills Stormwater	Adjusted the model to match meter data collected from a stormwater area upstream of Somerville-Marginal CSO Facility and incorporate information provided by the City of Somerville on highway drainage. The model calibration resulted in a significant decrease in the quantity of water from these stormwater areas, which in turn required adjustment of the runoff parameters in the combined sewer area upstream of the facility. Model adjustments also included more accurate representation of dry weather connection at two upstream regulators.	Additional model information and meter data downstream of Ten Hills was used to calibrate the area. Additional information is provided in Chapter 4.	No	Yes	Yes

3.3 Updated Interim CSO Performance Assessment Relative to Attainment of LTCP Goals

The performance objectives of MWRA's approved LTCP include annual frequency and volume of CSO discharge at each outfall based on "Typical Year" rainfall. The Court Order - specifically Exhibit B to the Second Stipulation - defines the LTCP levels of control by outfall and by receiving water segment. The sources of these levels of control are included in the historical MWRA reports that documented the various CSO control planning efforts MWRA conducted from 1992 to 2008. These source documents, all submitted to and accepted by EPA and DEP, are listed in Exhibit A to the Second Stipulation and presented in Semiannual Report No. 4 (April 30,2020), Table 4-1.

MWRA used the Q1-2021 System Conditions Model to simulate current system performance under Typical Year rainfall and produce an updated interim performance assessment compared to the LTCP goals. These results are presented in Table 3-2 on the following pages, along with the LTCP Typical Year levels of control and previously modeled CSO discharge levels for 1992 system conditions when MWRA commenced planning for the LTCP. In Table 3-2, Q1-2021 System Conditions activations or volumes that exceed the LTCP goals are shaded in grey.

3.3.1 Closed CSO Outfalls

Table 3-2 presents a full accounting of the status and Typical Year overflow activity for all discharge locations addressed by MWRA's CSO planning efforts and projects since MWRA assumed responsibility for system-wide CSO control in the mid-1980s. A few CSO outfalls listed in Table 3-2 were closed prior to the Federal Court's integration of LTCP levels of control into the Court Order in 2006 and are not listed in Exhibit B to the Second Stipulation. Table 3-2 shows that 35 outfalls active in the 1980s are now "closed," i.e., CSO discharges are eliminated. The closed outfalls include all 28 outfalls required to be closed by the approved LTCP and the Court Order and several additional outfalls. These additional closed outfalls include:

- SOM002, SOM002A and SOM003 on the Alewife Brook and SOM006 on the Upper Mystic River, closed by the City of Somerville in the 1980s and 1990s;

- CHE002 on the Inner Harbor, closed by the City of Chelsea in 2014;
- BOS006 and BOS007 in East Boston, closed by BWSC in 2008;
- BOS072 on Fort Point Channel, closed by BWSC in 2014;
- BOS083 on the South Boston beaches, closed by MWRA in 2008 with construction of the South Boston CSO storage tunnel; and
- CAM009 and CAM011 on the Charles River, which are tentatively closed by the City of Cambridge pending additional hydraulic evaluations to ensure no upstream risk of flooding.

3.3.2 Outfalls along the South Boston Beaches

MWRA has "effectively eliminated" CSO discharges at the remaining five outfalls along the South Boston beaches: BOS081, BOS082, BOS084, BOS085 and BOS086. Since May 2011, when MWRA brought the South Boston CSO Storage Tunnel and related facilities on-line, there has been no CSO discharge to the beaches, compared with an average of 20 CSO discharges per year prior to tunnel completion.

The tunnel also captures separate stormwater that prior to tunnel completion discharged to the beaches through the CSO outfalls every time it rained - 90 to 100 storms a year. Over the nine years of tunnel operation, stormwater has discharged to the beaches in only three large storms, including Hurricane Irene in August 2011 and the March 2, 2018 storm surge and coastal flooding event. The tunnel has prevented more than 2 billion gallons of CSO and stormwater from discharging to the beaches since May 2011.

3.3.4 Updated CSO Typical Year Performance at Remaining Active CSO Outfalls

The Typical Year CSO performance based on Q1-2021 System Conditions in Table 3-2 indicate substantial improvements over 1992 conditions at remaining active outfalls as a result of implementing the MWRA's LTCP projects and other actions taken by MWRA and the CSO communities to further control CSOs. A full discussion of the LTCP, its 35 projects (all completed by 2015), and other CSO abatement actions is presented in Semiannual Report No. 1. A similar version of Table 3-2 was previously presented as Table 6-2 in Semiannual Report No. 5 based on mid-2020 system conditions, for comparison. As noted in Section 3.2, the MWRA's hydraulic model is continually being updated to reflect on-going system improvements as well as improvements to the model. At some locations, system improvements and/or model updates have resulted in changes in the Typical Year performance between the mid-2020 and current (Q1-2021) system conditions, as described above, in Section 3.2.

3.4 Forecasted CSO Performance

3.4.1 Current Attainment of the LTCP Goals at Remaining Active Outfalls

In Semiannual Report No. 5, Table 6-2, MWRA forecasted attainment of the LTCP goals by December 31, 2021, at 29 of the 46 CSO outfalls that remain active. These included 26 outfalls where updated Typical Year modeling had shown and continues to show that the LTCP activation and volume goals are met, as well as 3 outfalls where then-recommended improvements were expected to be completed in 2021 to achieve LTCP goals. These three outfalls were CHE004, where the City of Chelsea raised the overflow weir by 1.5 feet earlier this year, and BOS010 and BOS012 in East Boston, where BWSC completed the first of three sewer separation contracts in the fall of 2020. BWSC also raised the overflow weir at BOS010 earlier this year. These improvements were added to MWRA's hydraulic model, and the updated Typical Year model results in Table 3-2 show that LTCP goals are now attained at two of the three locations. Outfall BOS010 is projected to achieve attainment with the LTCP goals upon completion of BWSC sewer separation Contract 2 later in 2021.

At one of the 17 outfalls forecast by MWRA in Semiannual Report No. 5 not to attain the LTCP goals - Outfall CAM401A on Alewife Brook - the City of Cambridge completed an extensive sewer cleaning project in late 2020/early 2021 that removed sediments that had been responsible for restricting sewer capacity and significantly elevating the activation frequency of CSO discharge at this outfall. With recovery of the full capacity of these sewers, MWRA model results show (Table 3-2) that that the LTCP goals are attained at Outfall CAM401A. This leaves 16 of 46 active outfalls that currently do not attain the LTCP activation and/or volume goal (see unshaded and light-blue shaded outfalls in Table 3-2).

3.4.2 Additional Outfalls Forecast to Attain LTCP Activation and Volume Goals by December 2021

The second of three BWSC sewer separation construction contracts in East Boston is well underway, and BWSC expects to complete the work in the fall of 2021. As noted above, MWRA's hydraulic model predicts that completion of Contract 2 will bring Outfall BOS010 into attainment with the LTCP goals. More information about the BWSC sewer separation contracts and their predicted CSO benefits is presented in Section 4.1.

Table 3-2. Typical Year Performance: Baseline 1992, Current (Q1-2021 Conditions) and LTCP (1 of 3)

Outfall achieves LTCP activation and volume goals.	Outfall is forecast to achieve LTCP goals after Dec 2021.
Investigations continue for forecast of LTCP attainment potential	Model prediction is greater than LTCP value.

OUTFALL	1992 SYSTEM CONDITIONS [1]		Q1-2021 SYSTEM CONDITIONS		LONG TERM CONTROL PLAN [2]	
	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)
ALEWIFE BROOK						
CAM001	5	0.15	1	0.02	5	0.19
CAM002	11	2.73	0	0.00	4	0.69
MWR003	6	0.67	3	0.61	5	0.98
CAM004	20	8.19	Closed	N/A	Closed	N/A
CAM400	13	0.93	Closed	N/A	Closed	N/A
CAM401A	18	2.12	5	0.66	5	1.61
CAM401B			4	0.50	7	2.15
SOM001A*	10	11.93	8	4.47	3	1.67
SOM001	0	0.00	Closed	N/A	Closed	N/A
SOM002	0	0.00	Closed	N/A	N/I[3]	N/I[3]
SOM002A	0	0.00	Closed	N/A	Closed	N/A
SOM003	0	0.00	Closed	N/A	Closed	N/A
SOM004	5	0.09	Closed	N/A	Closed	N/A
TOTAL		**26.81**		**6.26**		**7.29**
UPPER MYSTIC RIVER						
SOM007A/MWR205A*	9	7.61	5	4.50	3	3.48
SOM006	0	0.00	Closed	N/A	N/I[3]	N/I[3]
SOM007	3	0.06	Closed	N/A	Closed	N/A
		7.67		**4.50**		**3.48**
MYSTIC/CHELSEA CONFLUENCE						
MWR205* (Somerville-Marginal CSO Facility)	33	120.37	30	100.58	39	60.58
BOS013**	36	4.40	8	0.27	4	0.54
BOS014*	20	4.91	8	1.45	0	0.00
BOS015	76	2.76	Closed	N/A	Closed	N/A
BOS017*	49	7.16	6	0.34	1	0.02
CHE002	49	2.51	Closed	N/A	4	0.22
CHE003	39	3.39	0	0.00	3	0.04
CHE004	44	18.11	3	0.30	3	0.32
CHE008	35	22.35	6	1.95	0	0.00
TOTAL		**185.96**		**104.89**		**61.72**
UPPER INNER HARBOR						
BOS009*	34	3.60	10	0.73	5	0.59
BOS010*	48	11.83	7	0.44	4	0.72
BOS012	41	7.90	0	0.00	5	0.72
BOS019	107	4.48	1	0.07	2	0.58
BOS050	No Data		Closed	N/A	N/A	N/A
BOS052	0	0.00	Closed	N/A	Closed	N/A
BOS057**	33	14.71	2	1.32	1	0.43
BOS058	17	0.29	Closed	N/A	Closed	N/A
BOS060**	64	2.90	2	0.47	0	0.00
MWR203 (Prison Point Facility)**	28	261.85	17	253.66	17	243.00
TOTAL		**307.56**		**256.69**		**246.04**

Table 3-2. Typical Year Performance: Baseline 1992, Current (Q1-2021 Conditions) and LTCP (2 of 3)

OUTFALL	1992 SYSTEM CONDITIONS (1)		Q1-2021 SYSTEM CONDITIONS		LONG TERM CONTROL PLAN (2)	
	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)
LOWER INNER HARBOR						
BOS003*	28	18.09	9	6.40	4	2.87
BOS004	34	3.43	2	0.06	5	1.84
BOS005	4	10.23	0	0.00	1	0.01
BOS006	17	1.21	Closed	N/A	4	0.24
BOS007	34	3.93	Closed	N/A	6	1.05
TOTAL		**36.89**		**6.46**		**6.01**
CONSTITUTION BEACH						
MWR207	24	4.00	Closed	N/A	Closed	N/A
TOTAL		4.00		N/A		N/A
FORT POINT CHANNEL						
BOS062*	8	4.15	5	1.26	1	0.01
BOS064**	14	0.99	1	0.01	0	0.00
BOS065*	11	3.08	1	0.62	1	0.06
BOS068	4	0.62	0	0.00	0	0.00
BOS070	4	281.62				
BOS070/DBC*			7	6.14	3	2.19
MWR215 (Union Park Facility)			10	26.62	17	71.37
BOS070/RCC			0	0.00	2	0.26
BOS072	21	3.62	Closed	N/A	0	0.00
BOS073	23	4.73	0	0.00	0	0.00
TOTAL		**298.81**		**34.66**		**73.89**
RESERVED CHANNEL						
BOS076	65	65.94	1	0.10	3	0.91
BOS078	41	14.84	0	0.00	3	0.28
BOS079	18	2.10	0	0.00	1	0.04
BOS080	33	6.21	0	0.00	3	0.25
TOTAL		**89.09**		**0.10**		**1.48**
NORTHERN DORCHESTER BAY						
BOS081	13	0.32	0 / 25 year	N/A	0 / 25 year	N/A
BOS082	28	3.75	0 / 25 year	N/A	0 / 25 year	N/A
BOS083	14	1.05	Closed	N/A	0 / 25 year	N/A
BOS084	15	3.22	0 / 25 year	N/A	0 / 25 year	N/A
BOS085	12	1.31	0 / 25 year	N/A	0 / 25 year	N/A
BOS086	80	3.31	0 / 25 year	N/A	0 / 25 year	N/A
BOS087	9	1.27	Closed	N/A	Closed	N/A
TOTAL		**14.23**		**0.00**		**0.00**
SOUTHERN DORCHESTER BAY						
BOS088	0	0.00	Closed	N/A	Closed	N/A
BOS089 (Fox Pt.)	31	87.11	Closed	N/A	Closed	N/A
BOS090 (Commercial Pt.)	19	10.16	Closed	N/A	Closed	N/A
TOTAL		**97.27**		**0.00**		**0.00**
UPPER CHARLES						
BOS032	4	3.17	Closed	N/A	Closed	N/A
BOS033	7	0.26	Closed	N/A	Closed	N/A
CAM005	6	41.56	7	0.66	3	0.84
CAM007**	1	0.81	2	0.45	1	0.03
CAM009(4)	19	0.19	Closed	N/A	2	0.01
CAM011(4)	1	0.07	Closed	N/A	0	0.00
TOTAL		**46.06**		**1.11**		**0.88**

Table 3-2. Typical Year Performance: Baseline 1992, Current (Q1-2021 Conditions) and LTCP (3 of 3)

OUTFALL	1992 SYSTEM CONDITIONS (1)		Q1-2021 SYSTEM CONDITIONS		LONG TERM CONTROL PLAN (2)	
	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)
LOWER CHARLES						
BOS028	4	0.02	Closed	N/A	Closed	N/A
BOS042	0	0.00	Closed	N/A	Closed	N/A
BOS049	1	0.01	Closed	N/A	Closed	N/A
CAM017	6	4.72	0	0.00	1	0.45
MWR010	16	0.08	0	0.00	0	0.00
MWR018*	2	3.18	2	1.14	0	0.00
MWR019*	2	1.32	2	0.51	0	0.00
MWR020*	2	0.64	2	0.57	0	0.00
MWR021	2	0.50	Closed	N/A	Closed	N/A
MWR022	2	0.43	Closed	N/A	Closed	N/A
MWR201* (Cottage Farm Facility)	18	214.10	2	8.95	2	6.30
MWR023**	39	114.60	1	0.14	2	0.13
SOM010	18	3.38	Closed	N/A	Closed	N/A
TOTAL		**342.98**		**11.31**		**6.88**
NEPONSET RIVER						
BOS093	72	1.61	Closed	N/A	Closed	N/A
BOS095	11	5.37	Closed	N/A	Closed	N/A
TOTAL		**6.98**		**0.00**		**0.00**
BACK BAY FENS						
BOS046	2	5.25	0	0.00	2	5.38
TOTAL		**5.25**		**0.00**		**5.38**
Total Treated		**698**		**390**		**381**
Total Untreated		**759**		**31**		**23**
GRAND TOTAL		**1457**		**421**		**404**

* See Table 3-4 below for site-specific investigations or projects underway.

**Model predicted activation and volume for Q1-2021 System Conditions are consistent with LTCP goals when considering metering and modeling margins of error and the chronology of site-specific LTCP plans and approvals.

(1) 1992 System Conditions include completion of Deer Island Fast-Track Improvements, upgrades to headworks, and new Caruso and DeLauri pumping stations. Estimated 1988 Grand Total Typical Year CSO volume (prior to these improvements) is 3,300 million gallons.

(2) From Exhibit B to Second Stipulation of the United States and the Massachusetts Water Resources Authority on Responsibility and Legal Liability for Combined Sewer Overflows, as amended by the Federal District Court on May 7, 2008 (the "Second CSO Stipulation").

(3) N/I: Outfall was closed prior to 2006 and is not included in Exhibit B to the Second CSO Stipulation.

(4) Tentatively closed pending additional hydraulic evaluation by City of Cambridge.

3.4.3 Outfalls Forecast to Attain LTCP Activation and Volume Goals after December 2021

The site-specific investigations described in Chapter 4 have also produced system improvement recommendations that are scheduled or expected to be implemented after 2021 by MWRA and the CSO communities and are predicted by MWRA's hydraulic model to result in attainment of the LTCP goals. These outfalls and the recommended improvements are listed in Table 3-3. At some of the locations, further investigations are underway to identify design details and construction requirements, prior to being able to determine an implementation schedule ("TBD").

Table 3-3. Outfalls Forecast to Attain LTCP Goals After 2021

<table>
<tr><th>OUTFALL</th><th>LOCATION</th><th>SYSTEM IMPROVEMENT(S)</th><th>IMPLEMENTED BY</th><th>SCHEDULED COMPLETION</th></tr>
<tr><td>BOS003</td><td rowspan="3">East Boston</td><td rowspan="2">BWSC Sewer Separation Contract 3, including upgrade interceptor connection at regulator RE003-12.</td><td rowspan="3">BWSC</td><td rowspan="3">2023</td></tr>
<tr><td>BOS009</td></tr>
<tr><td>BOS014</td><td>Add interceptor connection</td></tr>
<tr><td>MWR205</td><td rowspan="2">Somerville-Marginal CSO Facility</td><td rowspan="2">Replace/upgrade or add interceptor connection</td><td rowspan="2">MWRA</td><td rowspan="2">2024</td></tr>
<tr><td>SOM007A/ MWR205A</td></tr>
<tr><td>CHE008</td><td>Chelsea Creek</td><td>Replace/upgrade interceptor connection</td><td>MWRA</td><td>2022</td></tr>
</table>

3.4.4 Outfalls Currently Not Forecast to Attain LTCP Activation and/or Volume Goal

MWRA has continued to track CSO performance and the causes of higher overflow activity at locations where Typical Year CSO activation and/or volume exceed the LTCP goals and no system improvement has yet been recommended. MWRA has identified candidate projects or system adjustments that may further mitigate CSO discharges to bring activations and volumes to or closer to the LTCP goals. Table 3-4 lists these locations and potential mitigation alternatives identified so far. Information on the progress of these evaluations is presented in Chapter 4.

Table 3-4. Investigations Where Attainment of LTCP Goals Cannot Yet be Forecast

OUTFALL	Q1-2021 SYSTEM CONDITIONS MODEL		LONG TERM CONTROL PLAN		POTENTIAL ACTION PLAN(S)
	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	
ALEWIFE BROOK					
SOM001A	8	4.47	3	1.67	• Identify potential upstream flow controls
MYSTIC/CHELSEA CONFLUENCE					
BOS017	6	0.34	1	0.02	• Raise weir • Add weir wall to direct flow to interceptor upstream of regulator
FORT POINT CHANNEL					
BOS062	5	1.26	1	0.01	• Raise weir • Relieve interceptor connection
BOS065	1	0.62	1	0.06	• Raise weir • Relieve interceptor connection
BOS070/DBC	7	6.14	3	2.19	• South Boston Sewer Separation Contracts 1 and 2 (most regulators attain LTCP by 2024) • Evaluate regulator modifications at RE070/7-2
CHARLES RIVER					
MWR201 (Cottage Farm)	2	8.95	2	6.30	• Further optimize Cottage Farm facility operations • Separate upstream areas as currently being planned by Cambridge
CAM005	7	0.66	3	0.84	• Remove pipe obstructions • Raise weir • Separate upstream areas as currently being planned by Cambridge
MWR018	2	1.14	0	0.00	• Raise weirs • Lower localized BMC head loss • Redirect upstream BWSC separate storm drains
MWR019	2	0.51	0	0.00	
MWR020	2	0.57	0	0.00	

4. Recommendations and Continuing Work for Outfalls Currently Forecast not to Attain LTCP Activation and Volume Goals

The following sections provide recommendations and continuing work for outfalls which are currently forecast not to attain LTCP levels of control.

4.1 East Boston Outfalls

Eight CSO outfalls (BOS003, BOS004, BOS005, BOS009, BOS010, BOS012, BOS013, and BOS014) are included in the East Boston sub-system and discharge to either the Inner Harbor or Mystic/Chelsea Confluence. The dry weather flows from the regulators associated with these CSO outfalls discharge to either the Condor Street Interceptor or the East Boston Branch Sewer. Dry weather flow is carried by the two interceptors to the Caruso Pump Station. When the hydraulic grade line exceeds the elevation of the overflow points in the regulators along the Condor St. Interceptor and East Boston Branch Sewer, excess flow is discharged to the Inner Harbor and/or the Mystic/Chelsea Confluence. A schematic of the East Boston sub-system is shown in Figure 4-1.

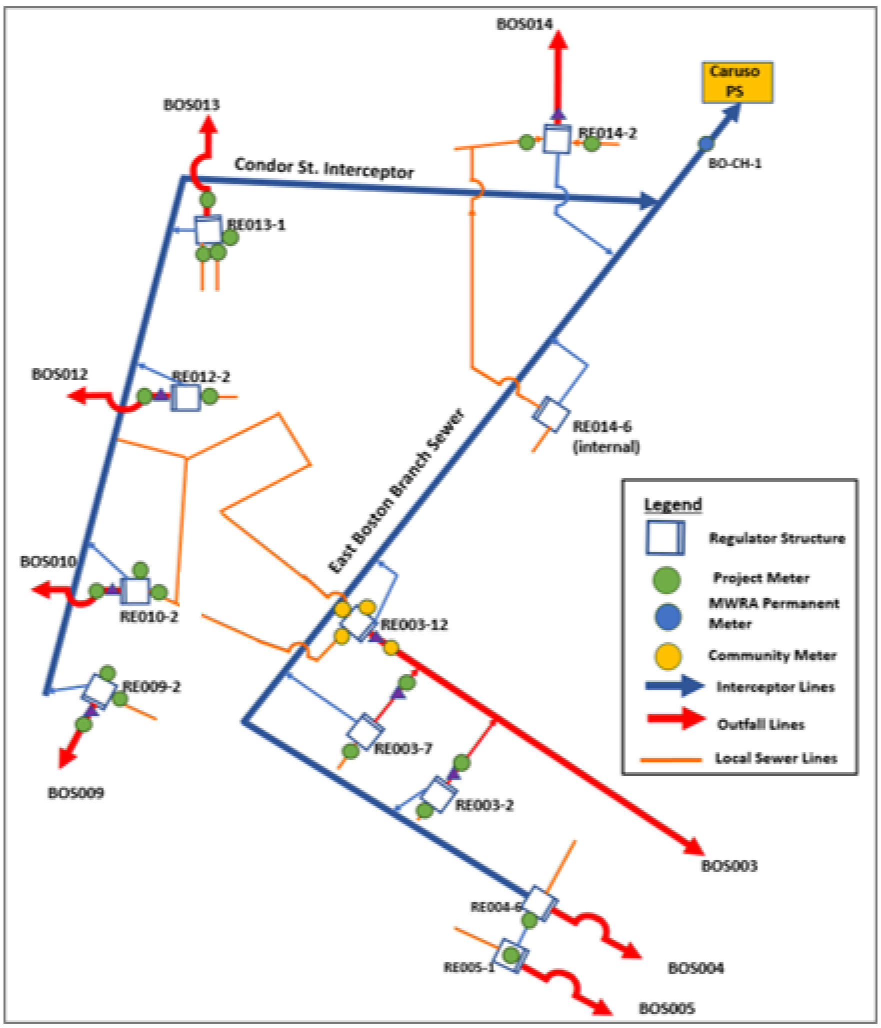


Figure 4-1. East Boston System Schematic

As presented in Semiannual Report No. 5, for Mid-2020 conditions, six of the eight outfalls in East Boston were exceeding the LTCP goals for either activation frequency, volume, or both. However, BWSC has been implementing a multi phased sewer separation project in East Boston, which began a few years ago. The first phase of sewer separation work was completed in the spring of 2020. The Typical Year results, with a comparison of the Mid-2020 system conditions for East Boston are presented in Table 4-1.

The completion of Phase 1 of the BWSC's sewer separation program in East Boston brought outfall BOS012 into compliance for both activation frequency and discharge volume. Additionally, the overall CSO volume decreased from 11.19 MGD to 9.35 MGD, which is a more than 15% reduction in total CSO volume. These changes between Mid-2020 and Q1-2021 system conditions are further discussed below in Section 4.1.2. Additional plans are underway to meet LTCP levels of control at all open and active CSOs by the end of the BWSC's third sewer separation contract as further discussed below in Section 4.1.4.

Table 4-1. Comparison of Mid-2020 and Q1-2021 System Conditions to LTCP

Outfall	Regulator	Mid-2020 System Conditions (1)		Q1-2021 System Conditions (1)		Long Term Control Plan	
		Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)
Mystic/Chelsea Confluence							
BOS013	RE013-1	8	0.37	8	0.27	4	0.54
BOS014	RE014-2	8	1.44	8	1.45	0	0
Upper Inner Harbor							
BOS009	RE009-2	10	0.70	10	0.73	5	0.59
BOS010	RE010-2	7	0.77	7	0.44	4	0.72
BOS012	RE012-2	13	1.34	0	0.00	5	0.72
Lower Inner Harbor							
BOS003 (2)	RE003-2	1	0.02	1	0.02	4	2.87
	RE003-7	8	1.71	8	1.71		
	RE003-12	9	4.4	9	4.67		
BOS004	RE004-6	2	0.06	2	0.06	5	1.84
BOS005	RE005-1	0	0	0	0.00	1	0.01
Total (3)		13 (Max.)	11.19	10 (Max.)	9.35	5 (Max.)	7.29

(1) Grey shading indicates model prediction is greater than LTCP value.
(2) For outfall BOS003, activation frequency shown is the maximum among its three regulators. Volume is the sum of the regulator volumes.
(3) Activation frequency shown is the maximum among East Boston regulators. Volume is the total summed volume.

4.1.1 Update on BWSC East Boston Sewer Separation Contracts

BWSC is currently implementing a three-contract sewer separation program (Figure 4-2) covering approximately 111 acres in East Boston. Contract 1 is complete and separated certain areas tributary to outfalls BOS013 and BOS012; Contract 2 is in progress, and will separate certain areas tributary to outfalls BOS010 and BOS005; Contract 3 is scheduled to begin in late spring of 2021, with an estimated completion date of 2023, and will separate certain areas tributary to outfalls BOS012, BOS009, and BOS003. The purpose of the sewer separation is to remove stormwater inflow from the combined sewer system, thereby improving sewer system performance, reducing flows to MWRA's system, and reducing CSO discharges. BWSC estimates that the sewer separation will reduce inflow into the sewer system from these areas by up to 85%. BWSC has added modifications to the dry weather flow connection at regulator RE003-12 to Contract 3. This modification will increase the dry weather flow pipe diameter from 18 to 24 inches. BWSC will also either close or substantially raise the overflow elevations at regulators RE003-2 and RE003-7 as part of Contract 3. The completion of BWSC's three sewer separation contracts in East Boston is predicted to result in significant reductions in CSO activations and volumes at the CSO outfalls within the sewer separation project areas, and will achieve substantial progress towards meeting the LTCP goals. Additional information on the BWSC sewer separation efforts can be found in Section 2.2.1.1 of Semiannual Report No. 5.

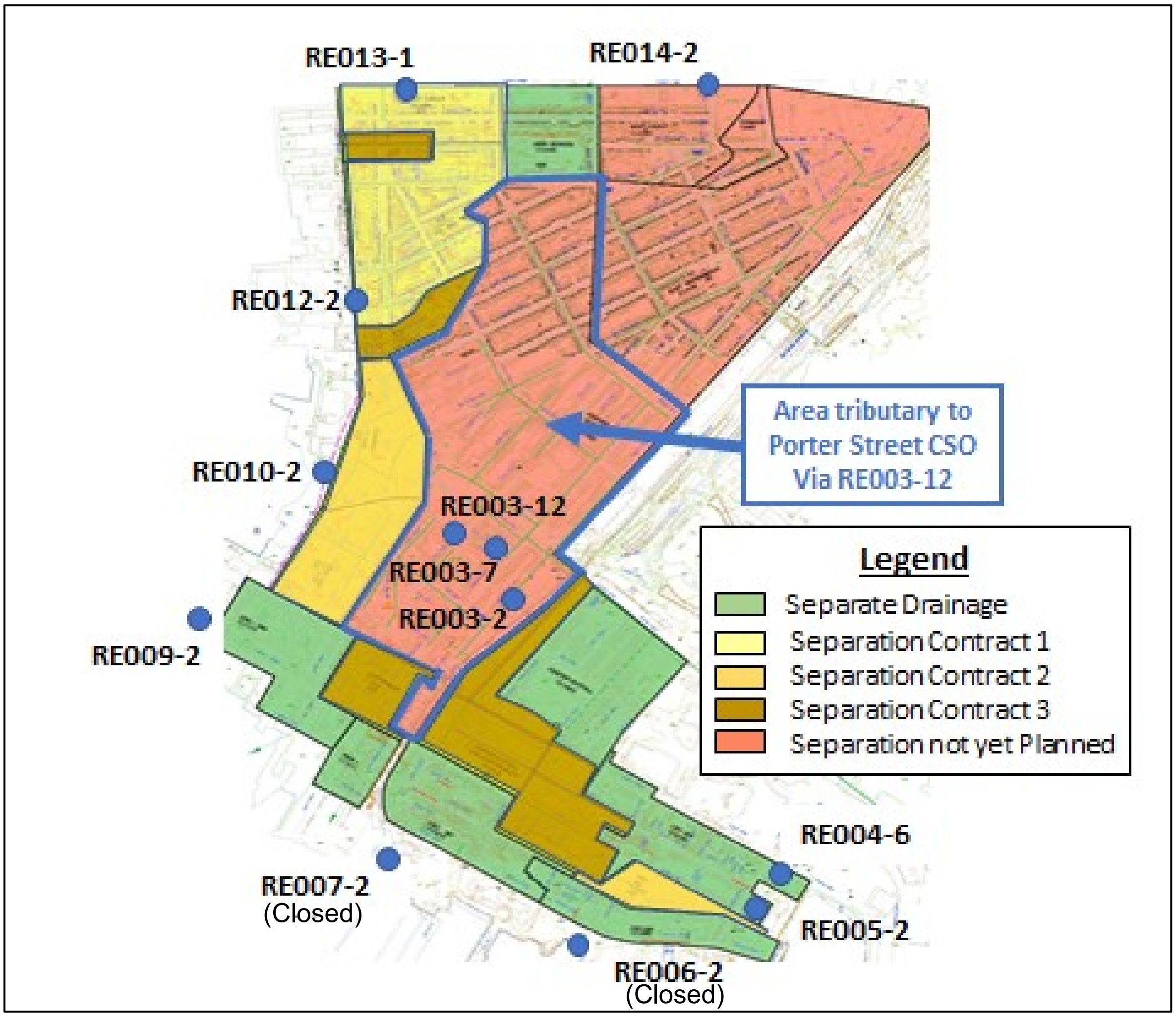


Figure 4-2. East Boston Sewer Separation

4.1.2 Hydraulic Model Updates

As a result of the ongoing investigations into the reduction of CSO activations in East Boston, the hydraulic model has undergone further refinements as more information has become available. The following modifications were included in the Q3Q4-2020 system conditions version of the model for East Boston:

Contract 1 of BWSC Sewer Separation: BWSC completed Contract 1 of sewer separation in the end of the second quarter of 2020. The model was updated to incorporate the sewer separation, assuming 85% inflow removal. The impacts of the sewer separation are seen predominately at regulator RE0012-2 (outfall BOS012), which now meets LTCP levels of control in the Typical Year.

Interconnection between RE010-2 and RE003-12: Based on updated information provided by BWSC, an interconnection that was believed to exist between RE010-2 and RE003-12 was confirmed to not to exist, as it had been removed as part of a past project. The model was revised to remove the pipe and the calibration from 2018 and 2019 was reviewed. The updated model showed minimal impacts on the calibration of RE010-2 and RE003-12 and no additional calibration modifications were made to the model as a result of the pipe removal.

Condor Street Meter Evaluation: A temporary depth sensor was installed by MWRA on the Condor Street interceptor (Figure 4-3) with two goals:

1. Assess whether capacity is available in MWRA's interceptors to accept additional wet weather flow from tributary CSO regulators to further reduce CSO discharges, especially at outfalls BOS003 and BOS014.

2. Identify whether the model is adequately predicting the hydraulic grade line in the interceptor during storm events. Data from this meter, together with data from a permanent meter at the downstream end of the interceptor system (just upstream of Caruso Pumping Station), were used to evaluate the modeled representation of capacity in the interceptors.

The Condor Street meter collected data from June 26 through October 8, 2020. The metering data indicated that the Condor Street interceptor had additional available capacity during the wet weather events that occurred during that period, and that the model was adequately calibrated and slightly conservative in predicting the HGL in the Condor Street interceptor.

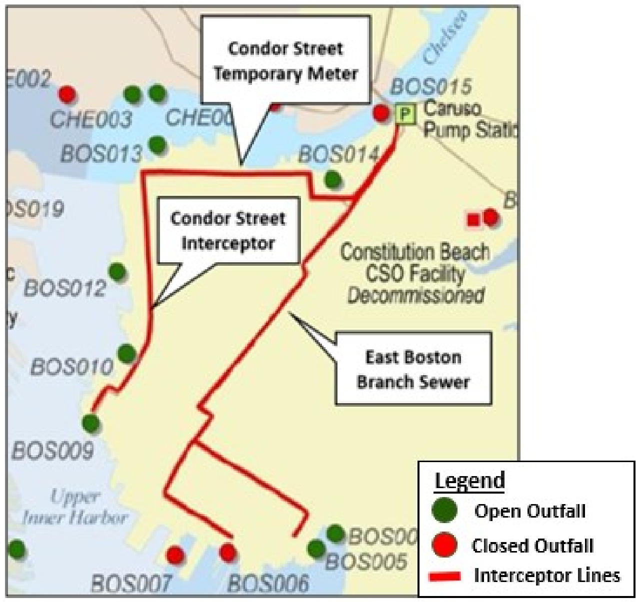


Figure 4-3. Condor Street Temporary Meter Location

Rim Elevations/Overflow Elevations: Minor adjustments were made to some model elevations based on updated information. These adjustments had no impact on the calibration.

4.1.3 Evaluation of Additional System Modifications

Based on the Q3Q4-2020 system conditions version of the model, additional action may be required at BOS003, BOS009, BOS010, BOS013, and BOS014 to meet LTCP levels of control by the end of 2021. MWRA is looking at a combination of short- and long-term solutions to minimized CSO activation frequency and volumes while avoiding adverse impacts on the hydraulic grade lines upstream or downstream of the regulators which could potentially contribute to basement and/or street flooding.

As indicated in Table 4-1, outfall BOS012 currently meets LTCP levels of control with the completion of sewer separation Contract 1. As a result, no further modifications to regulator RE012-2 were evaluated.

At locations not anticipated to meet LTCP levels of control as a result of BWSC sewer separation Contract 1, additional investigations were conducted. These investigations included increasing the weir elevations by three inches or six inches, and increasing the capacity of the dry weather flow connections.

Weir Raising

Model results indicated that raising the weir at regulator RE010-2 by three inches, along with the completion of East Boston sewer separation contracts 1 and 2, would bring outfall BOS010 into compliance with the LTCP goals. As a result, the weir was raised on February 12, 2021. However, the model indicated that raising the weir at the regulators associated with outfalls BOS009, BOS013 and BOS014 by up to six inches would not be sufficient to meet LTCP levels of control for those outfalls.

Increasing Capacity of Dry Weather Flow Connections

A number of regulators in East Boston have nozzles in the dry weather flow connections between the regulators and the interceptor (additional information on these nozzles is provided in Semiannual Report No. 3, Section 5.3.3). These nozzles cause headloss across the dry weather flow connections, restricting flow to the interceptor. The impact of removing these restrictions was evaluated. At regulator RE009-2 and RE013-1 (outfalls BOS009 and BOS013), the removal of the nozzles was predicted to be sufficient to meet the LTCP level of control. At regulator RE014-2 (outfall BOS014) the activation frequency and volume following removal of the nozzle was still predicted to exceed the LTCP goals, and an alternative to further increase the capacity of the dry weather flow connection was developed as described below.

At outfall BOS009, while the removal of the losses in the dry weather flow connection would allow attainment of the LTCP goals for activation frequency and volume, completion of sewer separation Contract 3 is also predicted to bring outfall BOS009 into compliance, without removing the nozzle restriction. Since increasing the capacity of the dry weather flow connection would be a significant construction project that would be rendered unnecessary following completion of sewer separation Contract 3, the dry weather flow connection relief project for regulator RE009-2 (outfall BOS009) was not recommended for implementation.

BOS014 Dry Weather Flow Interceptor Modification

BOS014 was further investigated as weir raising or reducing the loss associated with the nozzle in the dry weather flow connection were not sufficient to meet the LTCP level of control. BOS014 has a relatively long (210 linear feet) existing dry weather flow connection to the East Boston Branch Sewer, and head losses along this connection were identified as contributing to the activation frequency and volume at regulator RE014-2. This connection, however, passes directly over the Condor Street interceptor, which was identified as having available capacity in both dry and wet weather conditions. A number of potential re-configurations of the dry weather flow connection were evaluated in the model. The most effective alternative involved providing a new connection to the combined sewer tributary to regulator RE014-2 from Eagle Square. That connection would then intercept the existing dry weather flow connection and convey the flow directly to an existing manhole on the Condor Street Interceptor along East Eagle Street. Figure 4-4 shows the modeled representation of the existing configuration for regulator RE014-2 on the left, and the proposed alternative configuration on the right. This configuration is predicted to eliminate the CSO discharges at regulator RE014-2 in the Typical Year. BWSC has agreed to design and implement modifications to the BOS014 system and has entered into a Financial Assistance Agreement (FAA) with the MWRA, where the MWRA has agreed to partially fund (up to approx. $2.2M) these improvements at BOS014 as well as the Contract 3 sewer separation improvement in East Boston.

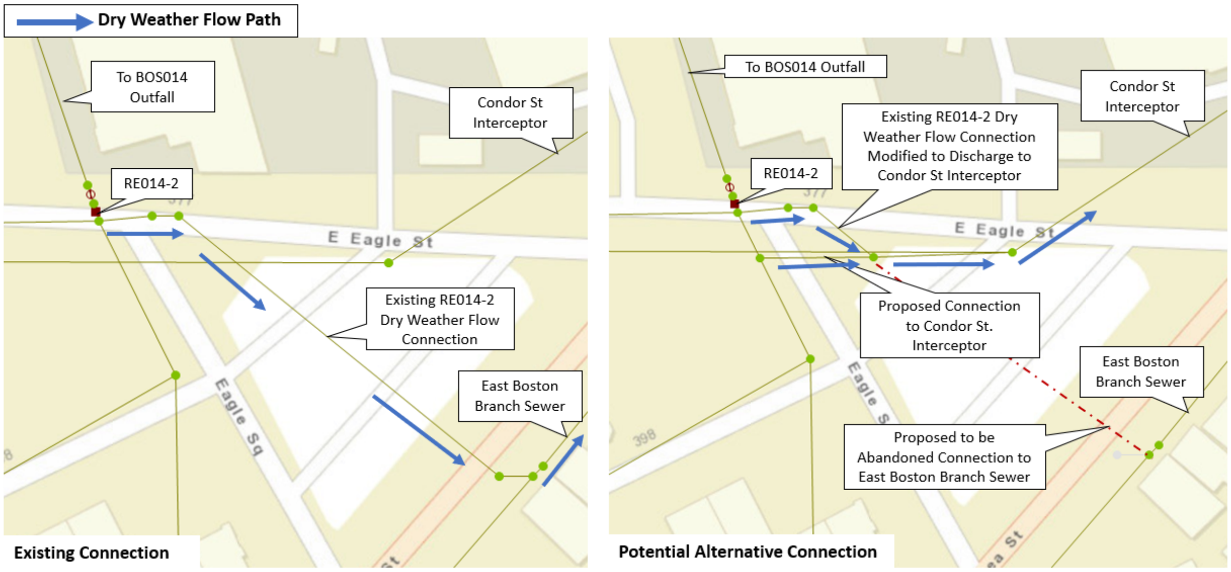


Figure 4-4. BOS014 Dry Weather Flow Connection

BWSC Additional Modifications

In parallel to MWRA's evaluations to meet LTCP levels of control, BWSC has made plans to expand Contract 3 to include increasing the diameter of the dry weather flow connection at regulator RE003-12 from 18 to 24 inches. BWSC is also planning to close regulators RE003-2 and RE003-7 or reconstructing these regulators to allow system relief in extreme events, leaving only regulator RE003-12 discharging to outfall BOS003 during a typical year. The impacts of these projects on the peak hydraulic grade line in the East Boston Branch Sewer are currently being further investigated.

Summary of Existing and Proposed Future Conditions for Proposed Modifications

The combined impacts on CSO activation frequency and volume of the system modifications described above are presented in Table 4-2. The "Q1-2021 System Conditions" column reflects the Q3Q4-2020 system conditions as described above, with the addition of the raising of the weir by three inches at RE010-2. As indicated in Table 4-2, under Q1-2021 System Conditions, outfalls BOS013, BOS014, BOS009, and BOS003 do not meet LTCP levels of control.

Three future conditions are also presented in Table 4-2. "Future Condition 1" includes sewer separation contracts 1, and 2, and raising the weir at regulator RE010-2 by three inches. "Future Condition 2" includes Future Condition 1, plus sewer separation contract 3, closing or raising the overflow elevations at regulators RE003-2 and RE003-7, and increasing the dry weather flow connection at regulator RE003-12 to 24 inches. "Future Condition 3" includes all of the elements in Future Condition 2, with the addition of increasing the capacity of the dry weather flow connection at regulator RE013-1, and the modifications to re-route the dry weather flow connection from regulator RE014-2 to the Condor Street interceptor.

Regarding regulator RE013-1, the cost to relieve the dry weather flow connection may be relatively high, and ongoing efforts are being conducted to further inspect the existing dry weather flow connection to determine the cause of the higher-than-anticipated activation frequency. It should be noted that the BOS013 predicted volume after BWSC sewer separation contract No. 2 will be half of the LTCP goal for that outfall.

As indicated in Table 4-2, under Future Condition 1, the LTCP level of control is predicted to be met at all locations except outfalls BOS013, BOS014, BOS009 and BOS003. For Future Condition 2, the goals for activation frequency would still be exceeded at outfalls BOS013, BOS014, and BOS003, and the goal for CSO volume would still be exceeded at outfall BOS014. For Future Condition 3, all outfalls are predicted

Table 4-2. East Boston Existing and Future Conditions for Proposed Modifications Compared to the LTCP Goals

Outfall	Regulator	Q1-2021 System Conditions [1]		Future Conditions 1		Future Conditions 2		Future Conditions 3		Long Term Control Plan	
		Sewer Separation Contract 1		Sewer Separation Contracts 1 & 2		Sewer Separation Contracts 1, 2 & 3					
		Raised weir 3 inches at RE010-2		Raised weir 3 inches at RE010-2		Closed RE003-2 & RE003-7 Increased DWF connection to 24-inch at RE003-12					
						Raised weir 3 inches at RE010-2		Raised weir 3 inches at RE010-2 Increased DWF Capacity at RE013-1 Relieved and re-routed DWF connection at RE014-2			
		Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)
Mystic/Chelsea Confluence											
BOS013	RE013-1	8	0.27	8	0.27	8	0.27	4	0.11	4	0.54
BOS014	RE014-2	8	1.45	8	1.43	8	1.51	0	0.00	0	0
Upper Inner Harbor											
BOS009	RE009-2	10	0.73	10	0.73	5	0.15	5	0.15	5	0.59
BOS010	RE010-2	7	0.44	1	0.07	1	0.06	1	0.06	4	0.72
BOS012	RE012-2	0	0.00	0	0.00	0	0.00	0	0.00	5	0.72
Lower Inner Harbor											
BOS003	RE003-2	1	0.02	1	0.01	Closed	Closed	Closed	Closed	4[2]	2.87[2]
	RE003-7	8	1.71	8	1.65	Closed	Closed	Closed	Closed		
	RE003-12	9	4.67	9	4.26	5	1.54	4	0.89		
BOS004	RE004-6	2	0.06	0	0.00	2	0.13	2	0.09	5	1.84
BOS005	RE005-1	0	0.00	0	0.00	0	0.00	0	0.00	1	0.01
Total [3]		10 (max)	9.35	10 (max)	8.42	8 (max)	3.66	5 (max)	1.30	5 (max)	7.29

(1) Grey shading indicates model prediction is greater than LTCP value
(2) For the LTCP goals for outfall BOS003, activation frequency shown is the maximum among its three regulators. Volume is the sum of the regulator volumes.
(3) Activation frequency shown is the maximum among East Boston regulators. Volume is the total summed volume.

to meet LTCP levels of control for activation frequency and volume. As noted above, the potential impacts of these modifications on peak hydraulic grade lines is currently being investigated, so the performance results for Future Conditions 1, 2 and 3 are still considered preliminary.

4.2 Somerville-Marginal CSO Facility Discharges

Outfall MWR205 is located in tidal waters of the Mystic River immediately downstream of the Amelia Earhart Dam, and discharges treated CSO from the Somerville-Marginal Facility, along with separate stormwater that enters the Somerville-Marginal Conduit downstream of the CSO facility. Outfall SOM007A/MWR205A is a relief outfall off of the Somerville Marginal Conduit that discharges to the freshwater reach of the Mystic River upstream of the Amelia Earhart Dam when the Somerville-Marginal CSO Facility activates during high tide (see Figure 4-5).

Mid-2020 conditions Typical Year model results presented in Semiannual Report No. 5 showed that the Somerville-Marginal CSO Facility's activation frequency is consistent with the LTCP level of control, but the treated discharge volume (110 MG) is nearly twice the LTCP level (61 MG). Meter data collected in 2018 and 2019 indicate that stormwater flows entering the combined sewer system upstream of the facility are higher than those simulated with prior models. In accordance with a condition in the Alewife Brook/Upper Mystic River CSO Variance, MWRA has commenced evaluations of specific projects that may reduce overflows to the Somerville-Marginal CSO Facility and discharges from outfalls MWR205 and MWR205A/SOM007A. These evaluations include

1) The benefit and feasibility of increasing the capacity of the connection to the Somerville-Medford Branch Sewer.

2) The benefit and feasibility of removing stormwater including the Ten Hills and/or Mystic Avenue/I-93 stormwater flows from the MassDOT 72" drain that enters the combined sewer system upstream of the Somerville Marginal CSO Facility.

Well before the December 2020 required start date, MWRA began preliminary evaluations of the possible benefit of these alternatives. These alternative investigations are further discussed below.

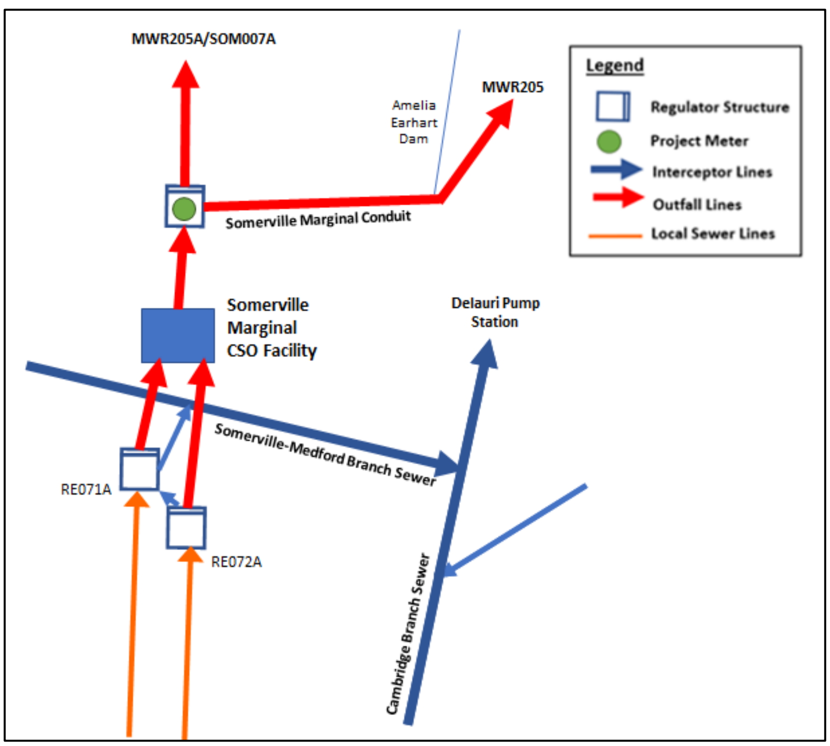


Figure 4-5. Schematic of Somerville-Marginal CSO Facility, MWR205A/SOM007A and MWR205

4.2.1 Interceptor Connection Relief

MWRA conducted an evaluation to assess the benefit of increasing the capacity of the connection to the Somerville-Medford Branch Sewer upstream of the Somerville-Marginal CSO Facility. The existing connection is an 18-inch diameter pipe. The MWRA's model was used to estimate the benefits of increasing the size of the connection to 24-inch diameter, in terms of reducing CSO to move closer towards the LTCP levels of control at outfalls MWR205 and MWR205A/SOM007A. This alternative showed promise in terms of reducing activation frequency and volume at Somerville-Marginal CSO Facility during the Typical Year. However, this modification resulted in increased discharge volumes at Prison Point and Cottage Farm because of the hydraulic connectivity between these facilities and the interceptor network downstream of the Somerville-Medford Branch Sewer. In addition, this alternative had adverse impacts on the peak hydraulic grade line in the Somerville-Medford Branch Sewer in larger storms. MWRA is currently investigating the feasibility and impact of constructing an additional connection between the influent conduit to Somerville Marginal CSO Facility and the Somerville-Medford Branch Sewer to supplement the existing connection's hydraulic capacity, along with a control on the dry weather flow connection that would limit peak flows during larger storm events. Construction feasibility, impacts, and costs will also need to be assessed.

4.2.2 Removal and Relocation of Separate Stormwater

In parallel to the interceptor connection relief, evaluations are being conducted into the removal of separate stormwater that is currently tributary to the Somerville-Marginal CSO Facility.

In particular, two separate stormwater areas that are currently tributary to a 72-inch combined sewer upstream of the Somerville-Marginal CSO Facility were identified as candidates for relocation: an area in the Ten Hills neighborhood, and a portion of the elevated I-93 drainage system. Figure 4-6 shows the modeled representation of the piping in the vicinity of the Somerville-Marginal CSO Facility, and the relative locations of the Ten Hills and I-93 drainage areas. Evaluations are underway to assess the benefit and feasibility of diverting this flow from the 72-inch combined sewer upstream of the Somerville-Marginal CSO Facility and either redirecting this stormwater downstream of the facility or to a new stormwater outfall.

In September 2020, MWRA installed a flow meter at the downstream end of the Ten Hills drainage system to better quantify the stormwater from this area (Figure 4-6). Additional information provided by the City of Somerville was incorporated into the model to refine the delineations of the Ten Hills and I-93 drainage areas, and pipe lengths and losses were also refined to better represent system losses. MWRA is in the process of conducting water quality sampling of the Ten Hills flow during dry and wet weather to see if evidence exists of potential illicit connections to the storm drain. With the updated model, MWRA will continue to evaluate the feasibility of redirecting a portion or all of the Ten Hills or I-93 stormwater away from the Somerville-Marginal CSO facility.

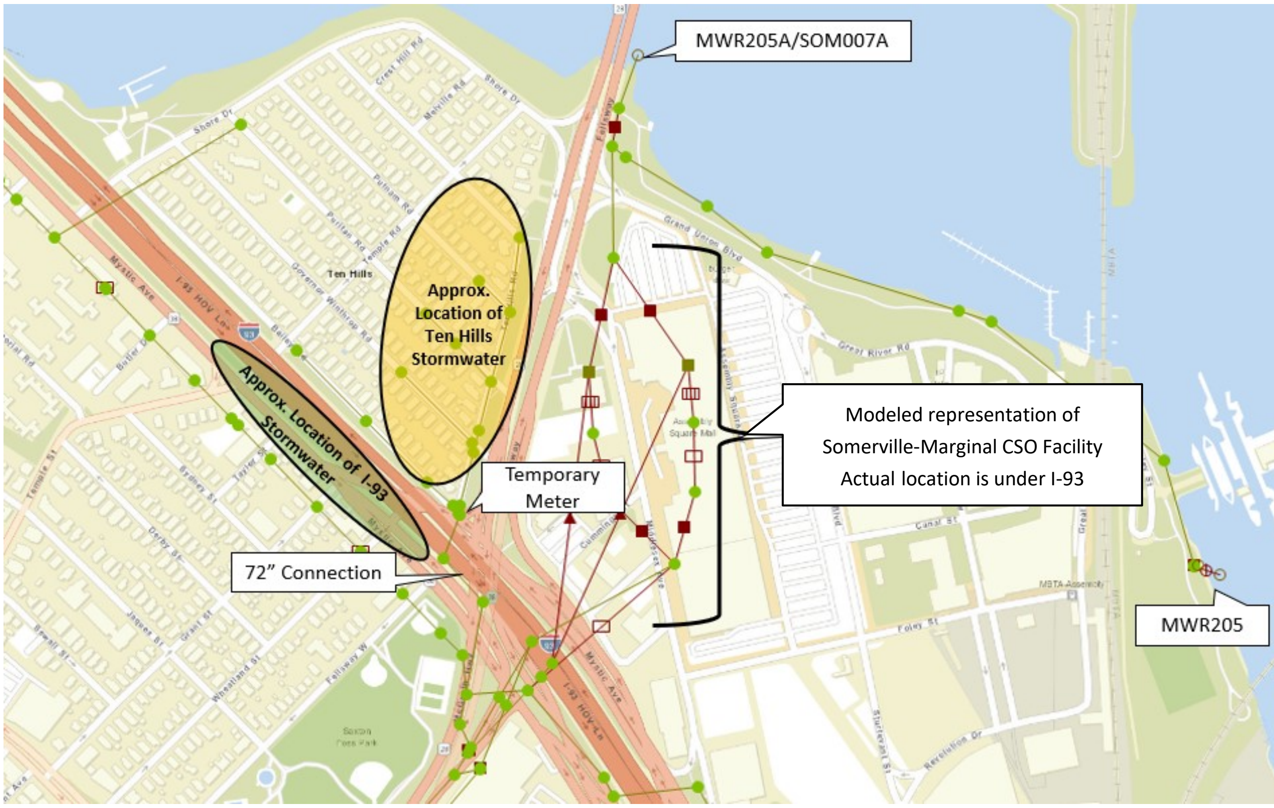


Figure 4-6. Stormwater Tributary to Somerville-Marginal CSO Facility

4.2.3 Preliminary Results of Modeling Evaluations

Table 4-3 below presents a summary of the preliminary evaluations of providing a new connection to the Somerville-Medford Branch Sewer from the influent conduit to the Somerville Marginal CSO Facility, and the impact of removal of separate stormwater from upstream of the Somerville Marginal CSO Facility, as described in Sections 4.2.1 and 4.2.2 above. The results are preliminary, as the model simulations also show that the additional flow to the interceptor through either a 15-inch or an 18-inch additional connection may cause downstream impacts in large storms within the Typical Year and in larger storms. Evaluations are now underway to determine a size of connection and associated hydraulic control that can provide attainment of the LTCP activation and volume goals at outfalls MWR205 and SOM007A/MWR205A while avoiding adverse downstream impacts in large storms.

Table 4-3. Preliminary Results for Alternatives at Somerville Marginal CSO Facility

Outfall	Regulator ID	Preliminary Results - Typical Year Rainfall Under 2021 Q1 System Conditions[1]													
		Existing 18in Connection (Baseline Case)		Existing 18-in connection-Remove-TenHills-Rte93		New 15in Connection (MWRA concept)		New 18in Connection (MWRA concept)		New 15-in Connection (MWRA concept)-Remove-TenHills-Rte93		New 18-in Connection (MWRA concept)-Remove-TenHills-Rte93		Typical-Year Rainfall w/ Long Term CSO Control Plan	
		Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)
Upper Mystic River															
SOM007A/MWR205A		5	4.50	5	4.17	3	3.33	3	3.13	3	3.05	3	2.93	3	3.48
Mystic/Chelsea Confluence															
MWR205 (Somerville Marginal Facility)		30	100.58	30	93.61	24	66.49	21	60.45	23	62.63	18	56.17	39	60.58
Upper Inner Harbor															
BOS019	RE019-2	1	0.07	1	0.07	1	0.12	1	0.12	1	0.12	1	0.12	2	0.58
MWR203 (Prison Point)		17	255.84	17	247.81	17	260.99	17	266.20	17	258.76	17	263.29	17	243
Lower Charles															
MWR018	Charles River	2	1.14	2	1.14	2	1.15	2	1.17	2	1.15	2	1.16	0	0
MWR019	Charles River	2	0.51	2	0.51	2	0.53	2	0.53	2	0.53	2	0.52	0	0
MWR020	Charles River	2	0.57	2	0.57	2	0.58	2	0.60	2	0.57	2	0.59	0	0

Notes:

(1) Grey shading indicates model prediction is greater than LTCP value.

4.3 Cottage Farm CSO Facility Discharges

4.3.1 Update on Cambridge Partial Sewer Separation

During the first half of 2020, The City of Cambridge was in the process of completing a partial sewer separation project to reduce the volume of stormwater entering the North Charles Relief Sewer East Branch at two locations. All work was completed in mid-August 2020 and was incorporated into the Interim Q3Q4-2020 system conditions version of the model. The reduction in flows at these two locations will reduce wet weather flows to the Cottage Farm CSO Facility, where the CSO activations and volumes are currently predicted to exceed LTCP goals. The existing connections where stormwater flows will be reduced are at Pacific and Albany Streets and Talbot and Waverly Streets (Figure 4-7). At Pacific and Albany Streets, a 10-inch connection originally allowed stormwater to be conveyed to the North Charles Relief Sewer. Stormwater that exceeded the capacity of the connection was conveyed to the Endicott Street stormwater outfall. At Talbot and Waverly Streets, an 18-inch connection that entered a short section of 12-inch combined sewer originally conveyed stormwater to the North Charles Relief Sewer.

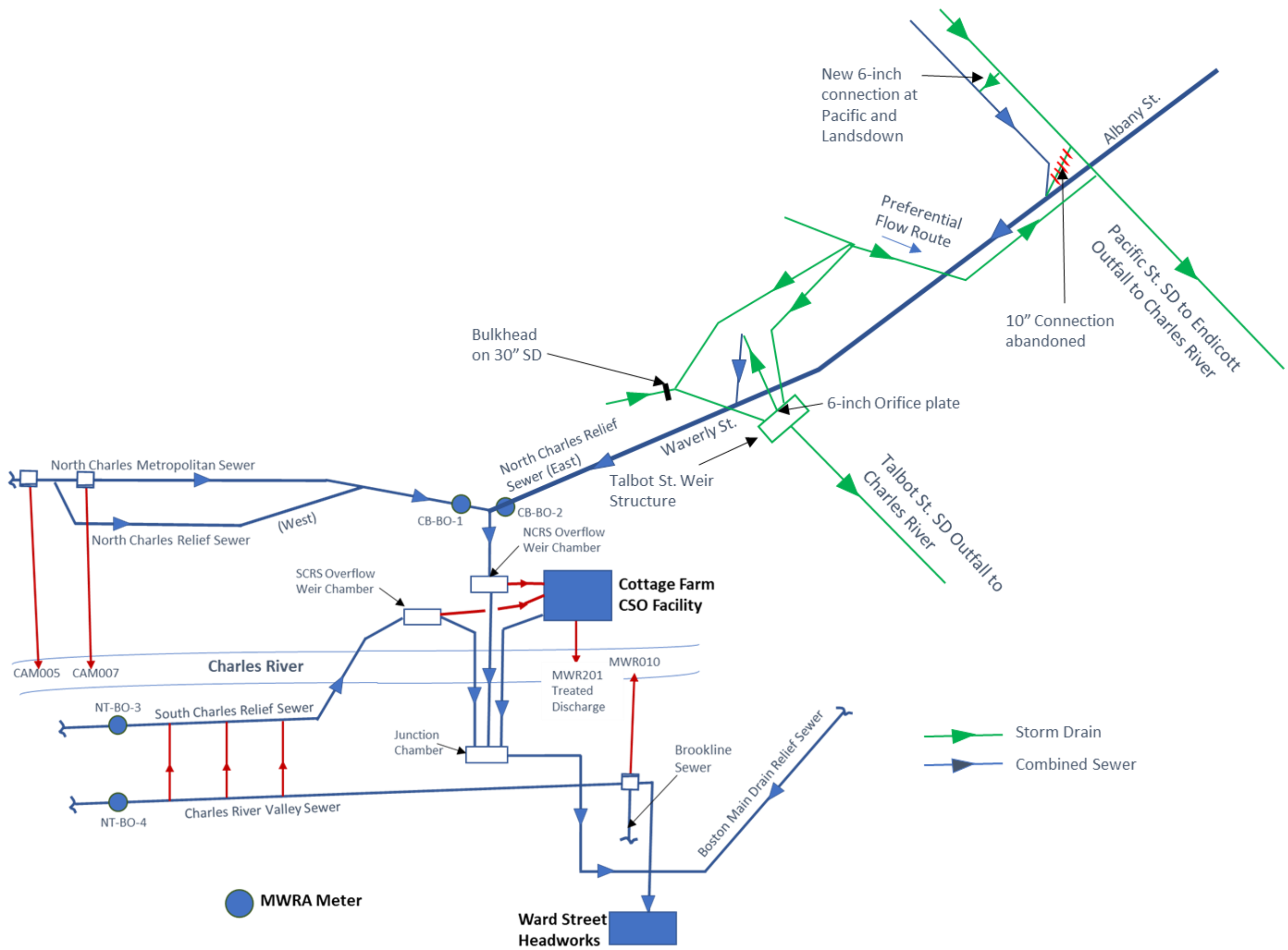


Figure 4-7. Schematic of Cambridge Partial Sewer Separation Work

The partial separation work included the following:

- At Pacific and Albany Streets, the existing 10-inch connection to the North Charles Relief Sewer East Branch was sealed off, and a new 6-inch connection with a backflow preventer was constructed between the Pacific Street storm drain and the adjacent combined sewer at Lansdowne Street that is tributary to the North Charles Relief Sewer. The reduction of connection size from 10-inch to 6-inch will result in a greater volume of stormwater being discharged to the Charles River during larger storm events and less volume conveyed towards Cottage Farm CSO facility.

- At Talbot and Waverly Streets, a new Talbot Street storm drain outfall was constructed to the Charles River. The existing 18-inch connection to the North Charles Relief Sewer was partially blocked off to reduce its capacity with a 6-inch orifice plate, a backflow preventer was installed at the downstream end of the 18-inch pipe, a weir gate was installed on the new Talbot Street storm drain outfall, and the new outfall was put in service.

The intent of the partial sewer separation work is to allow a portion of the stormwater from the Albany/Pacific and Talbot/Waverly tributary areas (in Cambridgeport) to continue to be conveyed to the MWRA's interceptor to support Cambridge's efforts to meet phosphorus discharge limits for the Charles River[6], while providing for some of the stormwater, especially in larger storm events, to be discharged to the Charles River, thereby reducing peak wet weather flows to the MWRA's interceptor and reducing Cottage Farm CSO Facility treated discharges. Refer to Semiannual Report No. 4 Section 5.4 and Semiannual Report No. 5 Section 2.2.3.1 for additional information regarding the partial sewer separation project.

4.3.2 Metering, Updated Modeling, and Performance Assessment

As described in Semiannual Report No. 5, MWRA's model in the areas tributary to the existing Albany/Pacific and Talbot/Waverly connections was checked against flow meter data collected by the City of Cambridge under conditions with both existing connections active. Flow meters were located to measure stormwater flows tributary to MWRA's interceptor from these connections before and after the restricted connections were installed. Using these meters, the upstream hydrology was adjusted to better match the meter data, but the performance following completion of sewer separation presented in Semiannual Report No. 5 was indicated as preliminary, since the meter data was collected in a period prior to completion of the sewer separation work.

Following the completion of the partial sewer separation work, the City of Cambridge continued to meter the flow in the pipes tributary to the modified connections to the MWRA's interceptor at Talbot/Waverly and Pacific/Landsdown. The first two activations at Cottage Farm following the completion of the partial sewer separation occurred on November 23, and December 1, 2020. These storms were used to assess the calibration of the model after it was updated to reflect the completed partial sewer separation work. The model was also revised to include modifications to upstream interconnections between stormwater drainage areas based on information provided by the City of Cambridge. These modifications included adding a 1-foot weir on the Hamilton Street storm drain at Pearl Street and adding a storm drain connection between Magazine and Pearl Streets along Cottage Street. Based on the assessment of the model and the metered data, no further calibration adjustments were made.

Following completion of the calibration check, the performance of the completed separation project as described above was assessed for the Typical Year. For comparison purposes, Table 4-4 presents the results for Mid-2020 conditions prior to completion of the partial separation project, Interim Q3Q4-2020 conditions with the completed partial separation project, and Interim Q3Q4-2020 conditions but with the 6-inch connections at Talbot/Waverly and Pacific/Landsdown simulated as closed. This last case would represent a "full" separation alternative, where no stormwater from the Talbot/Waverly and Pacific/Landsdown tributary areas is diverted to the MWRA's interceptor.

As indicated in Table 4-4, the completed partial separation project is projected to reduce the activation frequency at Cottage Farm from four to two, and reduce the treated discharge volume from 12.6 to 8.9 MG. The activation frequency would therefore meet the LTCP goal, but the volume would still exceed the goal. Closing off the 6-inch connections under the "full" separation alternative would only reduce the annual volume at Cottage Farm by 0.2 MG and would not change the activation frequency. Keeping the 6-inch connections open, however, would reduce the discharge of untreated stormwater to the Charles River from the Talbot and Endicott Street drains by a total of 12.3 MG.

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[6] In 2007, DEP issued Total Maximum Daily Load (TMDL) phosphorus limits for the Charles River Basin which in part require Cambridge to reduce phosphorus loading from its stormwater discharges.

Table 4-4. Cottage Farm Sewer Separation Results

Location		No Partial Sewer Separation Mid-2020 System Conditions(1)		Partial Sewer Separation Interim Q3Q4-2020 System Conditions With Cambridge 6-inch Connections(1)		Full Sewer Separation Interim Q3Q4-2020 System Conditions Without Cambridge 6-inch Connections(1)		LTCP	
		Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)
Cottage Farm Treated Discharge	MWR201	4	12.64	2	8.90	2	8.70	2	6.30
CSOs	CAM005	8	0.73	8	0.70	8	0.70	3	0.84
	CAM007	2	0.42	2	0.70(2)	2	0.40(2)	1	0.03
Storm Drains	Pleasant St			59	59.0	59	59.4		
	Amesbury St			44	48.2	44	48.2		
	Endicott St			28	16.6	33	22.4		
	Talbot St			26	9.3	33	15.8		

Notes:

(1) Grey shading indicates model prediction is greater than LTCP value.

(2) Some of the volume difference at CAM007 appears to be due to model sensitivity not directly related to the Cambridge 6-inch connections.

4.4 Other Charles River Outfalls

In addition to the Cottage Farm CSO Facility, four other outfalls to the Charles River are currently projected to exceed the LTCP goals for annual activations and/or volume (CAM005, MWR018, MWR019, and MWR020). The following section identifies efforts that are underway at these outfalls to meet LTCP levels of control.

4.4.1 Outfalls MWR018, MWR019, and MWR020

4.4.1.1 System Description and Performance

Outfalls MWR018, MWR019 and MWR020 are located along the Boston Marginal Conduit (BMC) upstream of the Prison Point CSO Facility (Figure 4-8). These outfalls overflow to the Charles River when the hydraulic grade line in the BMC exceeds the controlling weir elevations at each structure.

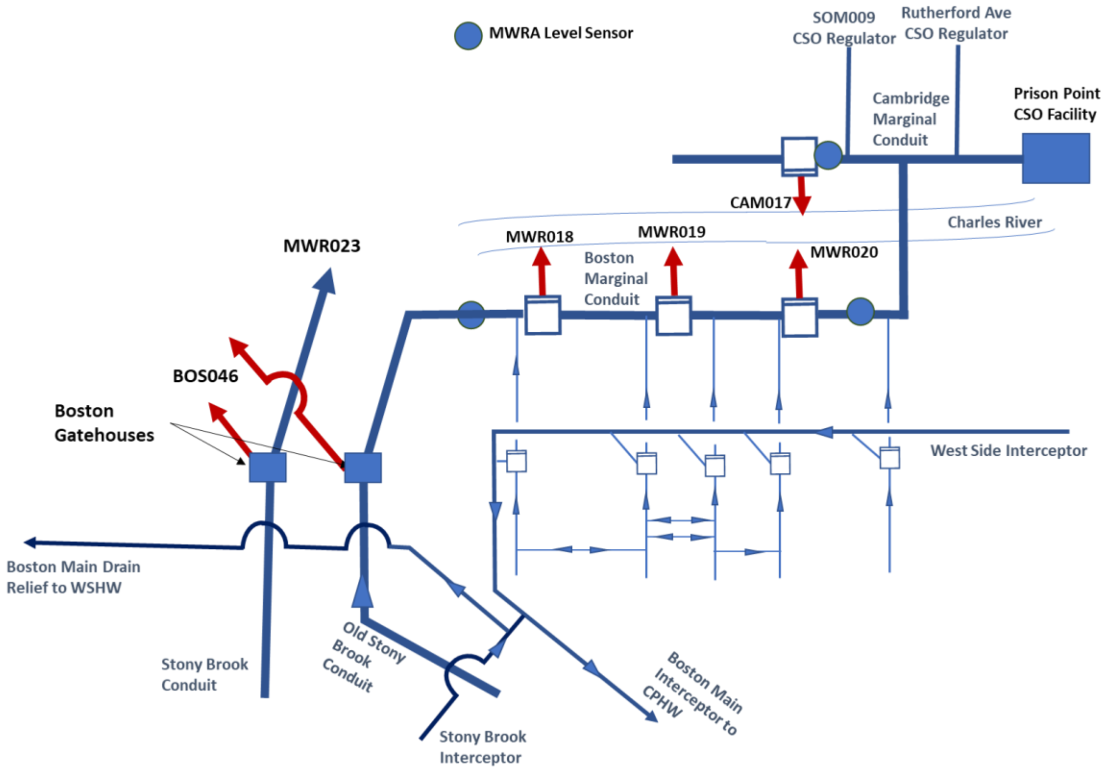

Figure 4-8. MWR018, MWR019, MWR020 System Schematic

The LTCP goal for these outfalls is to have no discharges in the Typical Year. Table 4-5 presents the Typical Year activation frequency and volumes for all of the outfalls to the Charles River for Mid-2020 system conditions, Q1-2021 system conditions, and the LTCP goals. As indicated in Table 4-5, the LTCP goals for activation frequency and volume are projected to be exceeded for the Q1-2021 conditions at outfalls MWR018, MWR019 and MWR020.

The differences between the Mid-2020 and Q1-2021 system conditions for outfalls MWR018 to MWR020 reflect updates to the model based on field inspections conducted by the MWRA. The MWR018, MWR019, and MWR020 regulator structures have similar configurations. They each have a large regulator structure with multiple trough weirs discharging to a downstream stop log structure. The stop logs help prevent the river from flowing back into the regulator structures. However, the tops of the stop logs are set at elevations above the crests of the trough weirs in the regulator structures, and thus the stop logs define the overflow elevations for each outfall. Field inspections by the MWRA found that in the stop log structures associated with outfalls MWR018 and MWR019, limited clearances between the stop logs and the walls of the stop log structures created potential hydraulic restrictions. The elevation and

Table 4-5. Comparison of Mid-and Q1-2021 System Conditions to LTCP

Outfall	Mid-2020 System Conditions (1)		Q1-2021 System Conditions (1)		Long Term Control Plan	
	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)
Lower Charles						
CAM017	0	0	0	0	1	0.45
MWR010	0	0	0	0	0	0
MWR018	2	1.93	2	1.14	0	0
MWR019	2	0.56	2	0.51	0	0
MWR020	2	0.31	2	0.57	0	0
MWR201 (Cottage Farm Facility)	4	12.64	2	8.95	2	6.3
MWR023(2)	1	0.14	1	0.14	2	0.13
Total (3)	4(Max.)	15.58	(Max.)	11.31	2 (Max.)	6.88

(1) Grey shading indicates model prediction is greater than LTCP value.

(2) Model predicted activation and volume for Mid-2020 System Conditions are consistent with LTCP goals when considering metering and modeling margins of error and the chronology of site-specific LTCP plans and approvals.

(3) Activation frequency shown is the maximum among Lower Charles regulators. Volume is the total summed volume.

position of the stop logs in the structure associated with outfall MWR020 did not appear to create a restriction. The Mid-2020 conditions model did not include this level of detail in the regulator/stop log structures.

Figure 4-9 presents an example of the inspection information developed for outfall MWR019. The sketch on the left calls out a 6-inch clearance between the stop logs and the structure wall. The photo on the

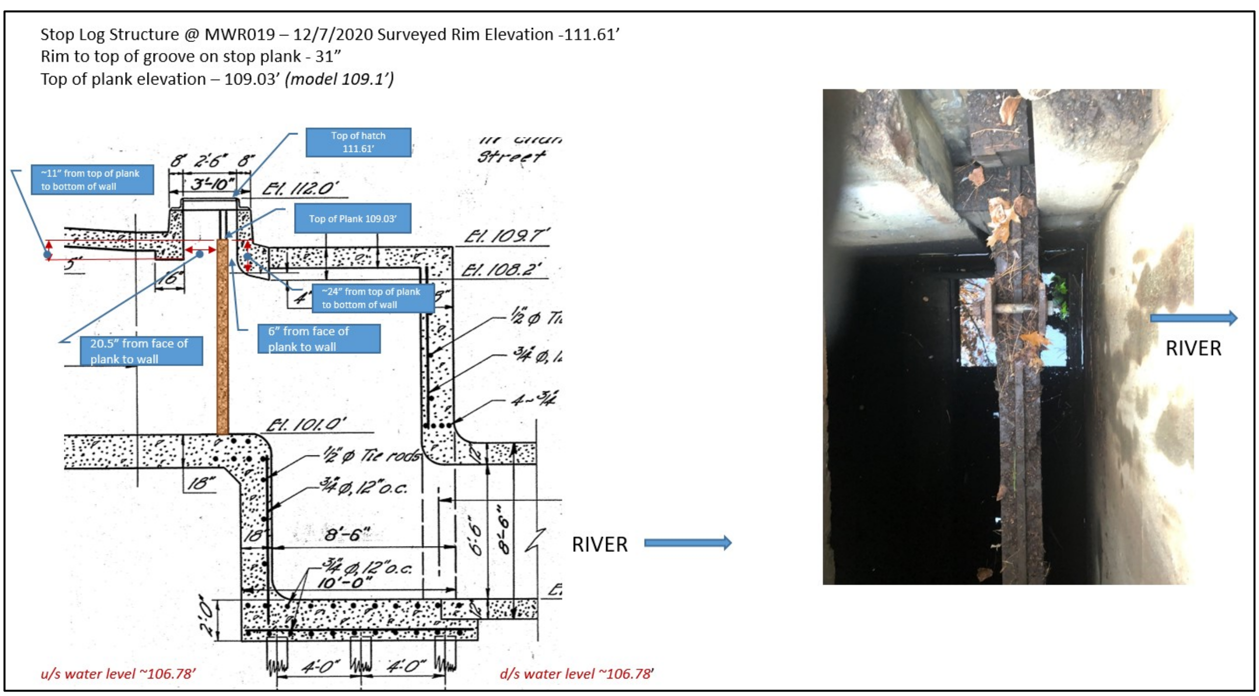

Figure 4-9. MWR019 Stop Log Structure Field Investigations, Section View (left), Plan View (right)

right is looking down on the top of the stop logs, with the 6-inch opening on the downstream side to the right of the stop logs. The stop log structures were updated in the model to reflect the field conditions.

In addition to the updates to the MWR018 to MWR020 regulator configurations, a review of the model identified a short section of 36-inch diameter pipe that appeared to be creating a restriction in the 84-inch diameter influent conduit to Prison Point just downstream of the Charles River siphon. An MWRA field inspection found no evidence of the 36-inch diameter pipe, so it was removed from the model. Similarly, the City of Cambridge confirmed that a dry weather flow pipe associated with outfall CAM017 that was included in the model did not exist in the field. The pipe was removed from the model but it had no impact on the discharges to the Charles River.

The model calibration was then updated to reflect these revisions. These updates result in a more accurate representation of the regulator structures in the model that can be used for evaluating alternatives to reduce activation frequency and discharge volume in the Typical Year. These alternatives will include weir raising, opportunities to reduce headloss in the BMC, and relocating separate stormwater tributary to the BMC.

4.4.2 Outfall CAM005

Under Q3Q4-2020 system conditions, the annual volume at outfall CAM005 is predicted to meet the LTCP level of control, but the annual activation frequency still exceeds the target. Table 4-6 presents a preliminary assessment of the impact of raising the weir at regulator RE-051 on the annual activation frequency and volume at outfall CAM005. As indicated in Table 4-6, raising the weir elevation by six inches was predicted to reduce the activation frequency from seven to five, and reduce the annual volume from 0.65 to 0.48 MG. Raising the weir an additional six inches further reduced the discharge volume to 0.38 MG but was not predicted to further reduce the activation frequency. This is an indication that the interceptor connection at CAM005 regulator is causing a restriction, and/or there is little available upstream in-system storage capacity. Raising the weir by six inches could improve the performance at outfall CAM005, but would not meet the LTCP target of three activations in the Typical Year. It is noted that the average volume per activation with the weir raised six inches would be less than 0.10 MG. The feasibility of raising the weir by six inches in terms of impacts during larger storm events such as the 5-year storm is currently being evaluated.

The City of Cambridge is currently evaluating the potential to disconnect a storm drain in the area of Willard and Mount Auburn Streets that is discharging to the MWRA system. Disconnecting this storm drain may have potential benefits to outfall CAM005. Once the scope of this work is defined, the benefits to outfall CAM005 overflows will be evaluated.

Table 4-6. Typical Year Results with Raising the Weir at CAM005

Location		Q3Q4-2020 System Conditions(1)		Raise Weir 6 in at CAM005(1)		Raise Weir 1 ft at CAM005(1)		LTCP	
		Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)
CAM005	RE-051	7	0.65	5	0.48	5	0.38	3	0.84

(1) Grey shading indicates model prediction is greater than LTCP value.

4.5 Fort Point Channel Outfalls

4.5.1 Outfall BOS070

4.5.1.1 Existing System Improvement

In March 2020, BWSC completed a program to remove sediment in South Boston sewers that are tributary to CSO regulators that allow overflow to the Fort Point Channel by way of the Dorchester Brook Conduit (DBC) and Outfall BOS070. As part of this program, BWSC discovered and removed a temporary maintenance weir inadvertently left in the South Boston Interceptor-North Branch.
The locations of the maintenance weir that was removed and the tributary systems where sediment was

removed are shown schematically in Figure 4-10. The cleaning operation removed approximately 250 tons of sediment from approximately 12,000 linear feet of sewer ranging in size from 10 inches diameter to 57 x 66 inches.

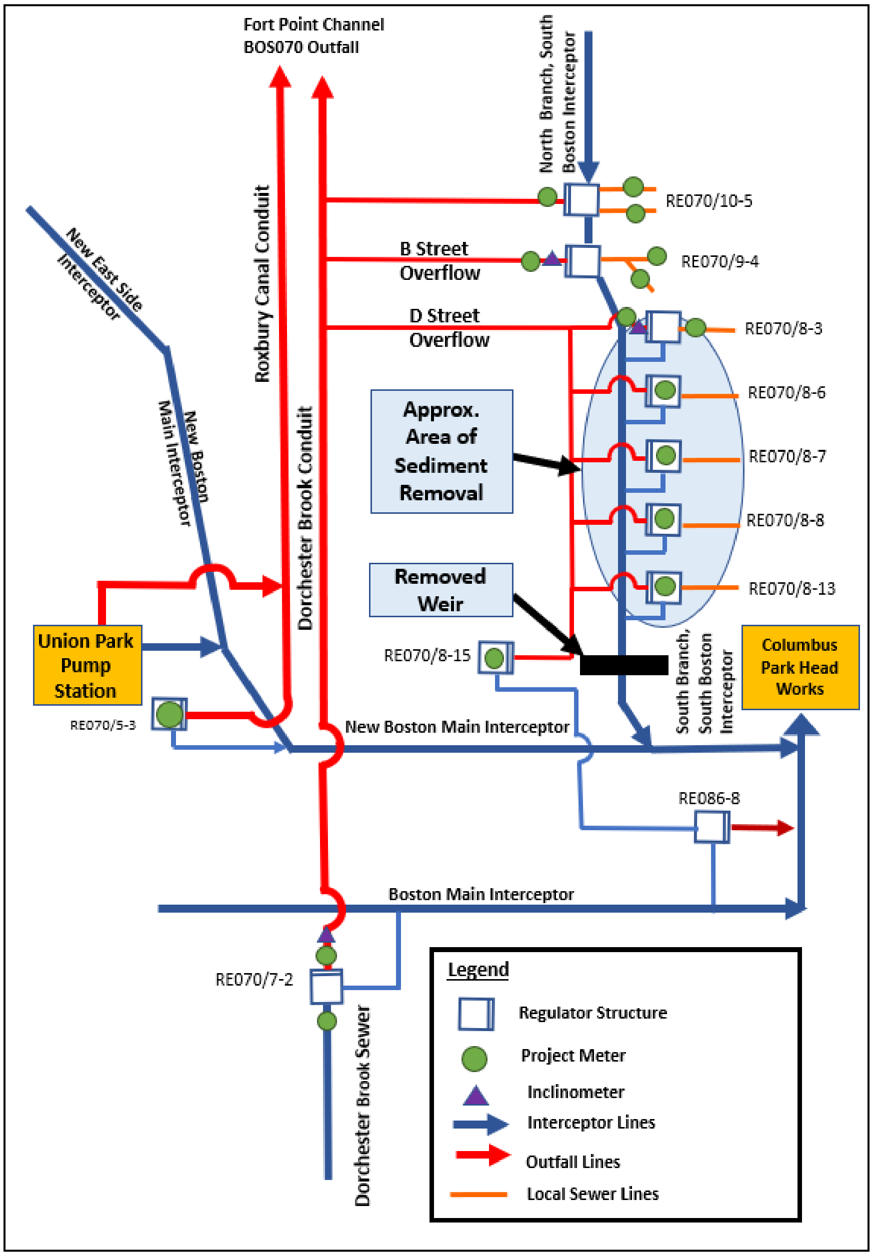

Figure 4-10. Schematic of South Boston Interceptor System Showing Location of Removed Maintenance Weir and Approximate Location of Sediment Removal

Following completion of the sediment removal, MWRA conducted a hydraulic assessment utilizing the MWRA model to estimate the effects of removing the sediment and maintenance weir on CSO discharges at the BOS070/DBC regulators. MWRA's model had been calibrated using flow meter data collected at the regulators in 2018 (see project meter locations in Figure 4-10), before the sediment and maintenance weir were removed. Using data collected at these meters after March 2020, MWRA recalibrated the model for the system condition after sediment and weir removal.

Table 4-7 shows the LTCP goals along with the predicted CSO activation frequency and volume for the Typical Year with 2019 system conditions before and after removal of the sediment and the maintenance weir.

Table 4-7. Typical Year Model Results before and after Sediment and Weir Removal

Outfall	Regulator	2019 System Conditions (prior to Sediment/ Maintenance Weir Removal)(1)		Mid-2020 System Conditions (with Sediment/ Maintenance Weir Removal) (1)		Long Term CSO Control Plan	
		Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)
BOS070/DBC	RE070/8-3	7	1.65	7	1.56	3	2.19
	RE070/8-6	0	0.00	0	0.00		
	RE070/8-7	2	0.05	2	0.05		
	RE070/8-8	0	0.00	0	0.00		
	RE070/8-13	0	0.00	0	0.00		
	RE070/8-15	0	0.00	0	0.00		
	RE070/9-4	5	1.80	5	1.32		
	RE070/10-5	2	0.11	1	0.04		
	RE070/7-2	2	2.60	2	2.87		
Total, BOS070/DBC		**7 (Max.)**	**6.21**	**7 (Max.)**	**5.84**		

1. Grey shading indicates model prediction is greater than LTCP value.

The improvements in performance resulting from the sediment and maintenance weir removal in the SBI-NB were not sufficient to meet the LTCP goals for the BOS070/DBC regulators. MWRA decided to investigate other opportunities to reduce CSO activation frequency and discharge at the BOS070/DBC regulators, including regulator modifications, such as raising overflow weirs. MWRA also planned to evaluate the CSO benefits of BWSC's planned multi-phased "South Boston Sewer Separation Project" that involves the removal of stormwater from combined sewers serving approximately 400 acres of area tributary to the BOS070 system.

4.5.1.2 BWSC South Boston Sewer Separation

Several years ago, BWSC commenced planning and hydraulic evaluations to separate combined sewers in areas of South Boston along the Dorchester Avenue corridor, tributary to the portion of the South Boston Interceptor - North Branch (SBI-NB) associated with the BOS070/DBC regulators. The South Boston Sewer Separation Project includes five construction contracts that BWSC plans to phase over a 20-year period. The location of the sewer separation projects are shown in Figure 4-11 and the contract areas are shown in Figure 4-12. BWSC has completed design and advertised construction bids for Contract 1, and expects to award the construction contact and issue notice to proceed in May 2021. The Contract 1 work is scheduled to be completed in May 2023. Design of Contract 2 is in progress, and BWSC expects construction of Contract 2 to commence in 2022 and be completed in 2024. BWSC has not yet commenced design of the remaining three contracts.

MWRA recently evaluated the potential CSO control benefits of contracts 1 and 2 using its hydraulic model. The Typical Year model results are presented in Table 4-8 for each of the BOS070/DBC regulators, and the BOS070/DBC regulator volumes are totaled for comparison with the LTCP activation and volume goals.

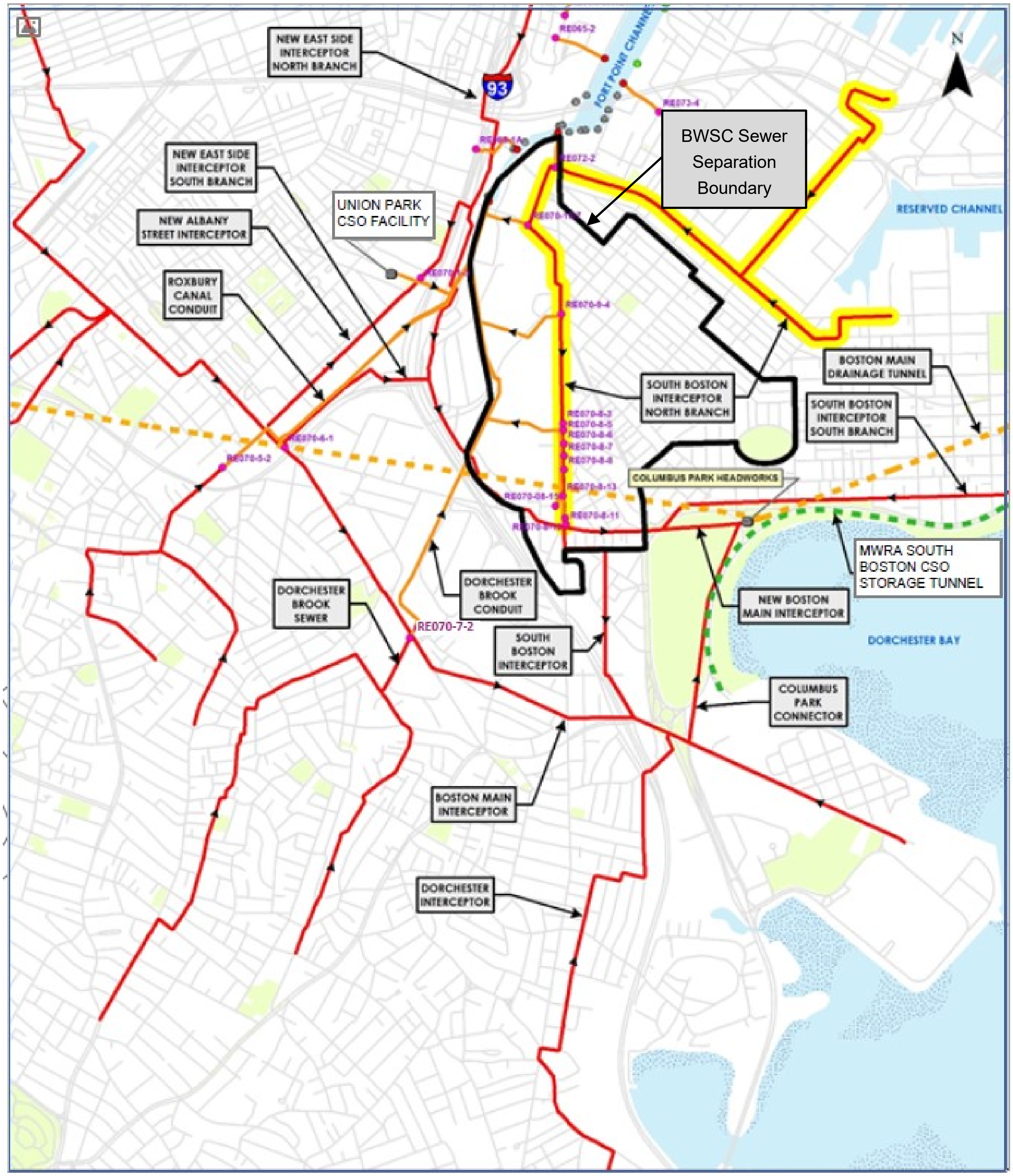

Figure 4-11. South Boston Sewer Separation Boundary and BWSC Sewer System

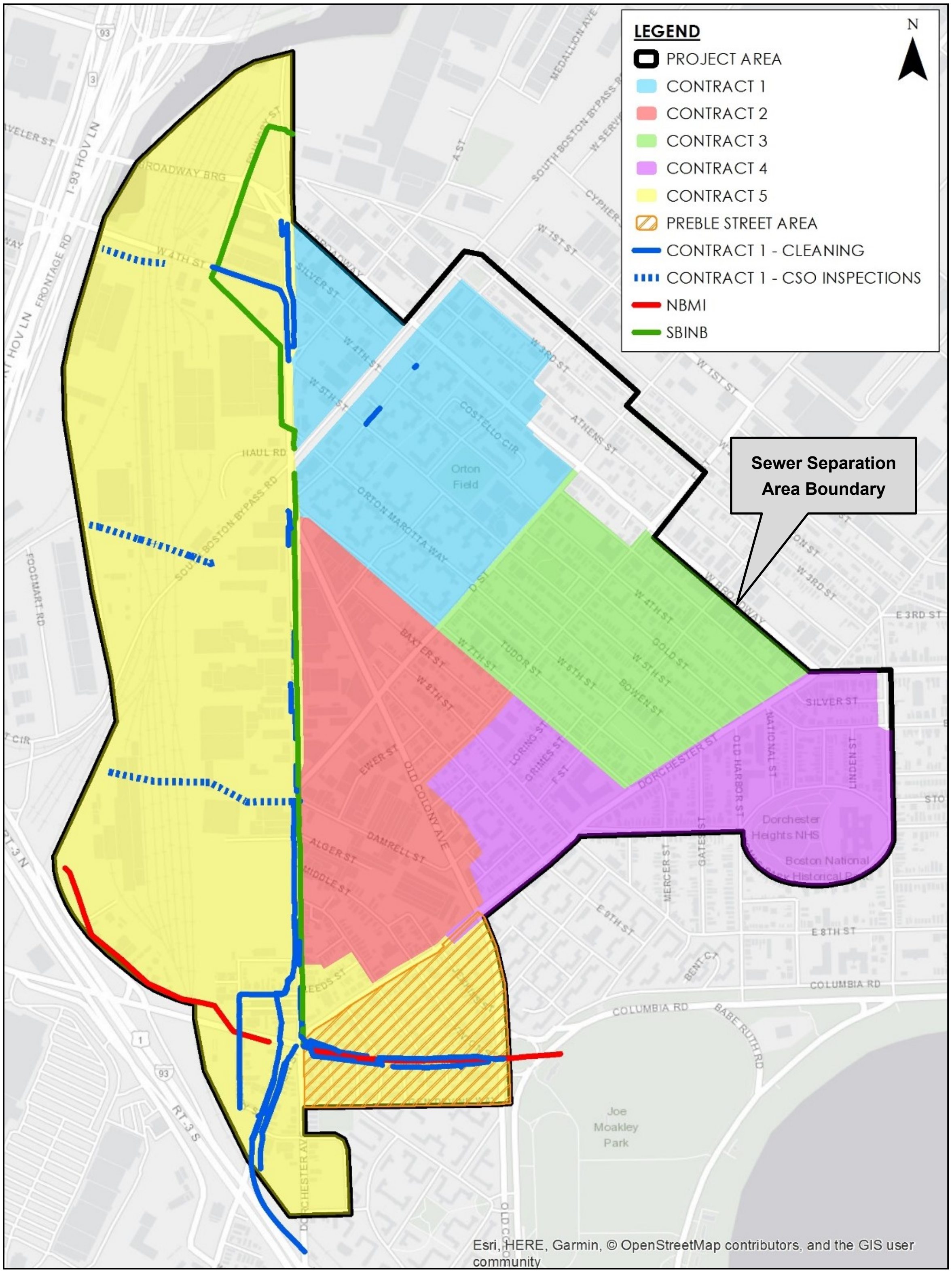

Figure 4-12. South Boston Sewer Separation Contracts

Table 4-8. Typical Year Model Simulations of South Boston Sewer Separation Contracts 1 & 2

Outfall	Regulator	Interim Q3Q4-2020 System Conditions(1)		Interim Q3Q4-2020 System Conditions w/Contract 1 (Completion 2023)(1)		Interim Q3Q4-2020 System Conditions w/Contracts 1 & 2 (Completion 2024)(1)		Long Term CSO Control Plan	
		Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)
Fort Point Channel									
BOS070/ DBC	RE070/8-3	7	1.31	6	0.79	1	0.02	3	2.19
	RE070/8-6	0	0.00	0	0.00	0	0.00		
	RE070/8-7	2	0.05	2	0.05	0	0.00		
	RE070/8-8	0	0.00	0	0.00	0	0.00		
	RE070/8-13	0	0.00	0	0.00	0	0.00		
	RE070/8-15	0	0.00	0	0.00	0	0.00		
	RE070/9-4	6	1.93	3	0.40	1	0.05		
	RE070/10-5	1	0.04	0	0.00	0	0.00		
	RE070/7-2	2	2.77	2	2.66	2	2.41		
SUM BOS070/DBC		**7 Max**	**6.10**	**6 Max**	**3.90**	**2 Max**	**2.48**	**3 Max**	**2.19**
BOS062	RE062-4	5	1.25	5	1.25	5	1.23	1	0.01
BOS064	RE064-4	0	0.00	0	0.00	0	0.00	0	0
	RE064-5	1	0.01	0	0.00	0	0.00		
BOS065	RE065-2	1	0.60	1	0.53	1	0.40	1	0.06
BOS068	RE068-1A	0	0.00	0	0.00	0	0.00	0	0

(1) Grey shading indicates model prediction is greater than LTCP value.

The model results in Table 4-8 show that sewer separation Contract 1 will reduce CSO discharges at RE070/9-4 and RE070/10-5 and have little or no effect at the other BOS070/DBC regulators. Importantly, Contract 1 is predicted to reduce Typical Year CSO discharge volume from the BOS070/DBC regulators from 6.10 MG to 3.90 MG, a significant reduction toward attaining the 2.19 MG LTCP goal. These benefits are expected to be achieved by the spring of 2023 when BWSC has scheduled completion of Contract 1.

Furthermore, the model results show that the completion of Contract 2 will reduce CSO discharges at RE070/8-3, RE070/8-7 and RE070/9-4 to the point of improving upon the LTCP's Typical Year activation goal (zero to 2 activations compared with the goal of 3). It is notable that the only regulator predicted to activate two times in the Typical Year following completion of sewer separation Contract 2 is RE070/7-2. While all of the other BOS070/DBC regulators are tributary to the South Boston Interceptor-North Branch, RE070/7-2 is tributary to the Boston Main Interceptor (see Figure 4-11, and is the subject of a separate MWRA investigation, discussed below. The combined benefits of sewer separation contracts 1 and 2 are expected to be realized in 2024 when BWSC has scheduled completion of Contract 2.

The small benefits of contracts 1 and 2 on CSO discharges at RE070/7-2 shown in Table 4-8 are believed to be the result of these contracts reducing the downstream peak hydraulic grade lines where the South Boston Interceptor-North Branch, the Boston Main Interceptor, and the New Boston Main Interceptor come together immediately upstream of MWRA's Columbus Park Headworks (see Figure 4-11) — and reducing peak hydraulic grade line at the influent to the headworks. Table 4-8 also shows some benefit of Contracts 1 and 2 on Typical Year CSO discharges at Fort Point Channel regulators along the New East

Side Interceptor, including BOS064-5 and BOS065-2, due to the same downstream hydraulic grade line reduction.

4.5.1.3 Investigations into Regulator Modifications

MWRA also considered whether regulator modifications such as raising weirs or enlarging interceptor connections could reduce CSO discharges. In its coordination with BWSC, MWRA learned that BWSC had conducted an evaluation of weir raising at the BOS070/DBC regulators (not including RE070/7-2) during planning of its South Boston Sewer Separation Project. BWSC determined that raising any of the weirs would carry significant risk of upstream flooding. Therefore, MWRA is limiting the evaluation of weir raising to regulator RE070/7-2. As for upgrading the capacities of the interceptor connections at these regulators, any such design and construction would not be completed any earlier than BWSC's sewer separation contracts 1 and 2 and could pose difficult construction due to the potentials for traffic impacts and utility relocations. As shown in Table 4-8, the LTCP activation and volume goals at all of the BOS070/DBC regulators except for regulator RE070/7-2 can be attained with sewer separation contracts 1 and 2.

MWRA is continuing with investigations to understand the factors contributing to higher overflow activity at regulator RE070/7-2 and to identify potential mitigating measures, including weir raising and interceptor connection relief. These investigations are conducted in coordination with BWSC.

4.5.2 Outfalls BOS062 and BOS065

4.5.2.1 Hydraulic Model Updates

Figure 4-13 presents a schematic of the upstream end of the New East Side Interceptor system. Minor adjustments were made to the physical configuration of the regulators tributary to outfalls BOS060, BOS062, BOS064, and BOS065 based on further review of the model and basemap information. After the changes were made the model was re-run for the 2018 calibration and verification periods. This comparison resulted in some minor adjustments to the hydrology and roughness factors so that the model could more closely match the meters. Table 4-9 present a comparison of the Typical Year results for the Mid-2020 system conditions model and the Interim Q3Q4-2020 system conditions model. There were some minor changes in activation frequency and volume.

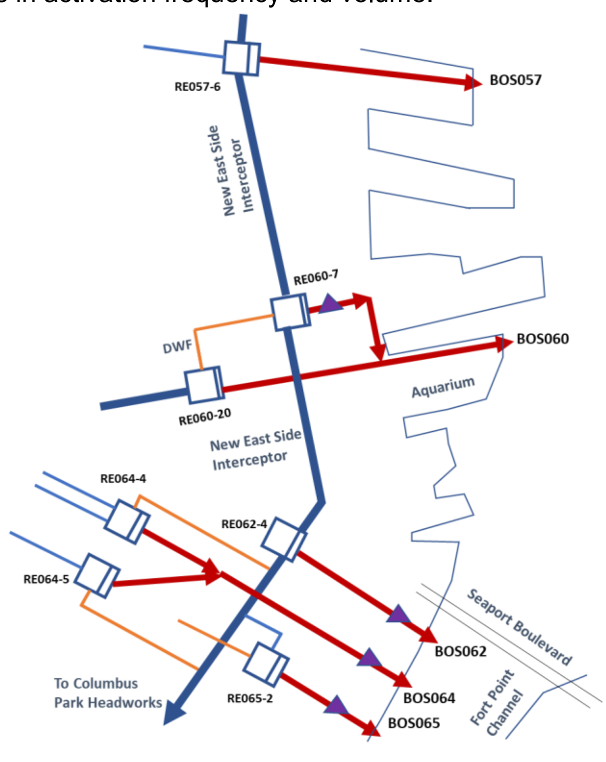

Figure 4-13. Schematic of New East Side Interceptor System

Table 4-9. Comparison of Mid-2020 and Interim Q3Q4-2020 System Conditions to LTCP

Outfall	Regulator	Mid-2020 System Conditions (1)		Interim Q3Q4-2020 System Conditions (1)		Long Term Control Plan	
		Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)
BOS060	RE060-7	1	0.09	2	0.46	3	0.06
	RE060-20	2	0.08				
BOS062	RE062-4	4	0.98	5	1.26	1	0.01
BOS064	RE064-4	0	0.00	0	0	0	0.00
	RE064-5	1	0.02	1	0.01	0	0.00
BOS065	RE065-2	3	0.91	1	0.60	1	0.06
BOS068	RE068-1A	0	0.00	0	0.00	0	0.00

(1) Grey shading indicates model prediction is greater than LTCP value.

4.5.2.2 Evaluation of Regulator Modifications

With the completion of updates to the BOS060, BOS062 and BOS064 subsystems in the MWRA hydraulic model (described above), MWRA used the updated model to identify and evaluate system modifications that may further lower CSO discharges toward attainment of the LTCP activation and volume goals at outfalls BOS062 and BOS065. Potentially beneficial alternatives that MWRA initially considered included raising the overflow weirs and upgrading interceptor connection capacities at the BOS62 and BOS65 regulators: RE062-4 and RE065-2. The results for the initial weir and interceptor connection modifications MWRA modeled are presented in Table 4-10 and include the effect on Typical Year discharges at these and other hydraulically related Fort Point Channel outfalls. The outfalls and regulators listed in Table 4-10 are hydraulically related to BWSC's New East Side Interceptor.

Table 4-10 Typical Year Model Simulations of Initial Regulator Modifications at BOS062 and BOS065

Outfall	Regulator	Current Weir Elevation	Interim Q3Q4-2020		BOS062 & BOS065 Weirs Raised 6 inches		BOS062 & BOS065 Interceptor Connection Relief		Long-Term Control Plan	
			Activations	Volume (MG)	Activations	Volume (MG)	Activations	Volume (MG)	Activations	Volume (MG)
BOS062	RE062-4	106.69	5	1.25	4	0.85	2	0.34	1	0.01
BOS065	RE065-2	102.83	1	0.60	1	0.62	1	0.70	1	0.06
BOS064	RE064-4	107.73	0	0.00	0	0.00	0	0.00	0	0.00
	RE064-5	104.32	1	0.01	1	0.02	1	0.02		
BOS068	RE068-1A	105.97	0	0.00	0	0.00	0	0.00	0	0.00

(1) Grey shading indicates model prediction is greater than LTCP value.

The model results indicate that raising the weir 6 inches at RE062-4 would reduce activations by 1 and reduce discharge volume by 0.4 MG, but not come close to attaining the LTCP activation and volume goals for Outfall BOS062. At regulator RE065-2, where the weir elevation is lowest among the five regulators, raising the weir 6 inches was shown to have a slight negative effect on performance. Both results were an indication that the interceptor connection at each regulator is causing a significant restriction, and/or there is little available upstream in-system storage capacity. At RE062-4, the flow to the interceptor is through an 18-inch drop connection. At RE065-2, the first portion of an otherwise 18-inch connection is only 10-inch diameter. Furthermore, a closer look at the model results showed that the Typical Year peak hydraulic grade line in the New East Side Interceptor rises above the weir elevation at RE065-2 and also contributes to the overflow volume in the one Typical Year storm activation.

Simulating interceptor connection relief at BOS062-4 involved increasing the 18-inch drop connection to a 24-inch drop connection. The model results, presented in Table 4-10, indicate that this change by itself would significantly lower both activation frequency and volume, but still not attain the LTCP goals for Outfall BOS062. Greater connection relief with a larger replacement connection or supplemental connection might result in attainment of LTCP goals.

Simulating interceptor connection relief at BOS065-2 involved upsizing the 10-inch diameter section of the connection to 18-inch diameter, to match the downstream portions of the connection. The model results show this would have the negative impact of increasing the Typical Year discharge volume from 0.60 MG to 0.70 MG. As mentioned above, the hydraulic grade line in the New East Side Interceptor rises above the weir elevation, resulting in flow reversal through the connection. Enlarging the 10-inch connection increases the backup of flow from the interceptor and the attendant amount of interceptor flow contributing to the overflow.

MWRA scrutinized the model results in part to determine factors that may have limited CSO benefit with the initial modifications discussed above, and whether a larger increase in weir elevation or interceptor connection might provide greater benefit at each location. MWRA decided to model an even larger interceptor connection at RE062-4 and a higher than 6-inch rise in weir elevation at RE065-2. MWRA modeled enlarging the drop connection at RE062-4 to 36-inch diameter and modeled raising the weir at RE065-2 to 3 inches over the peak hydraulic grade line in the New East Side Interceptor, which was elevation 105.3, or approximately 2.5 feet above the current weir elevation of 102.83. The model results are shown in Table 4-11.

In this same review of initial model results, MWRA also evaluated the modeled flows within a 48-inch sewer that interconnects the BOS064 and BOS65 systems, upstream of regulators RE064-4 and RE065-2. Previous model results showed that outfall BOS064 is attaining the LTCP activation and volume goals and that regulator RE064-4 does not activate in the Typical Year. The model results showed that in the Typical Year storm that activates regulator RE065-2, flows are moving from the BOS064-4 system to the BOS065 system, putting more burden on regulator RE065-2 as well as on an upstream regulator (RE065-3) that lets flows into the New East Side Interceptor and directs overflows to RE065-2. MWRA pondered whether restricting flow transfer from the BOS064-4 system might provide relief to the BOS065 system while maintaining the level of control at RE064-4 (i.e., no activation in the Typical Year). Table 4-11 includes the results of simulating a weir at elevation 104.5 installed at the upstream end of 48-inch pipe interconnecting the BOS064-4 and BOS065 systems.

Table 4-11 Typical Year Model Simulations of Additional Modifications at BOS062 and BOS065

Outfall	Regulator	Interim Q3Q4-2020		BOS062 36-inch Interceptor Connection		BOS065 Weir Raised 2.5 feet to El. 105.3		Weir Installed at El. 104.5 between BOS064 & BOS065 Systems		Long-Term Control Plan	
		Activations	Volume (MG)	Activations	Volume (MG)	Activations	Volume (MG)	Activations	Volume (MG)	Activations	Volume (MG)
BOS062	RE062-4	5	1.25	0	0.00	5	1.28	5	1.25	1	0.01
BOS065	RE065-2	1	0.60	1	0.68	1	0.16	1	0.60	1	0.06
BOS064	RE064-4	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
	RE064-5	1	0.01	1	0.02	1	0.03	1	0.01		
BOS068	RE068-1A	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00

(1) Grey shading indicates model prediction is greater than LTCP value.

The model results show that increasing the interceptor connection at RE062-4 from 18 inches to 36 inches would bring CSO discharges at BOS062 into attainment with the LTCP goals and result in no activation in the Typical Year. The model results also show that allowing more flow to enter the New East Side Interceptor at this regulator would not significantly affect overflows at hydraulically related regulators, including RE065-2 where the discharge volume increases from 0.60 MG to 0.68 MG. Separate results show that raising the BOS065-2 weir by 2.5 feet would reduce the volume of the one CSO discharge in the Typical Year to just slightly above the LTCP goal (from 0.60 MG to 0.16 MG, vs. 0.06 MG LTCP).

MWRA is investigating why the installation of a weir in the interconnection between the BOS064 and BOS065 systems apparently would have no effect on discharge volume at RE065-2. A possible reason is that, while the weir may restrict flow transfer to the BOS065 system in dry weather and some storms, it has no effect during the high flow period in the large Typical Year storm that causes the activation at RE065-2. MWRA intends to evaluate whether a higher new weir in the interconnection may provide benefit at RE065-2 without causing activation at RE064-4 in the Typical Year.

Ongoing investigations include MWRA's identification and modeling of additional system modifications and combinations of modifications at outfalls BOS062 and BOS065. MWRA is coordinating these investigations with BWSC, in part to confirm that system changes, including increasing or adding interceptor connection capacity at RE062-4 and raising with weir at RE065-2 are feasible and will not cause downstream or upstream hydraulic impacts such as flooding.

4.6 Alewife Brook Outfalls

MWRA has continued to make progress with the evaluation of the Alewife Brook outfalls. A schematic of the Alewife Brook system is shown in **Error! Reference source not found.**Figure 4-14. In Semiannual Report No. 5, it was reported that outfalls CAM001, CAM002, MWR003, and CAM401B were meeting the LTCP goals for activation frequency and discharge volume. The remaining outfalls include CAM401A and SOM001A which were both reported not to be meeting the LTCP goals. At outfall CAM401A sediment in the combined sewer running between the regulator and the Alewife Brook Branch Sewer was thought to be contributing to the CSO activation frequency and volume. In the fall of 2020, the City of Cambridge completed a sewer cleaning program in this area resulting in improvements at outfall CAM401A which are discussed below. Investigations into alternatives that could reduce the activation frequency and volume at outfall SOM001A are underway and are also discussed below. In addition, MWRA has completed the evaluation of the potential CSO benefits of modifying the pump operation strategy at the Alewife Brook Pumping Station which was a condition of the Alewife Brook/Upper Mystic River Variance. The conclusions from this evaluation are presented below.

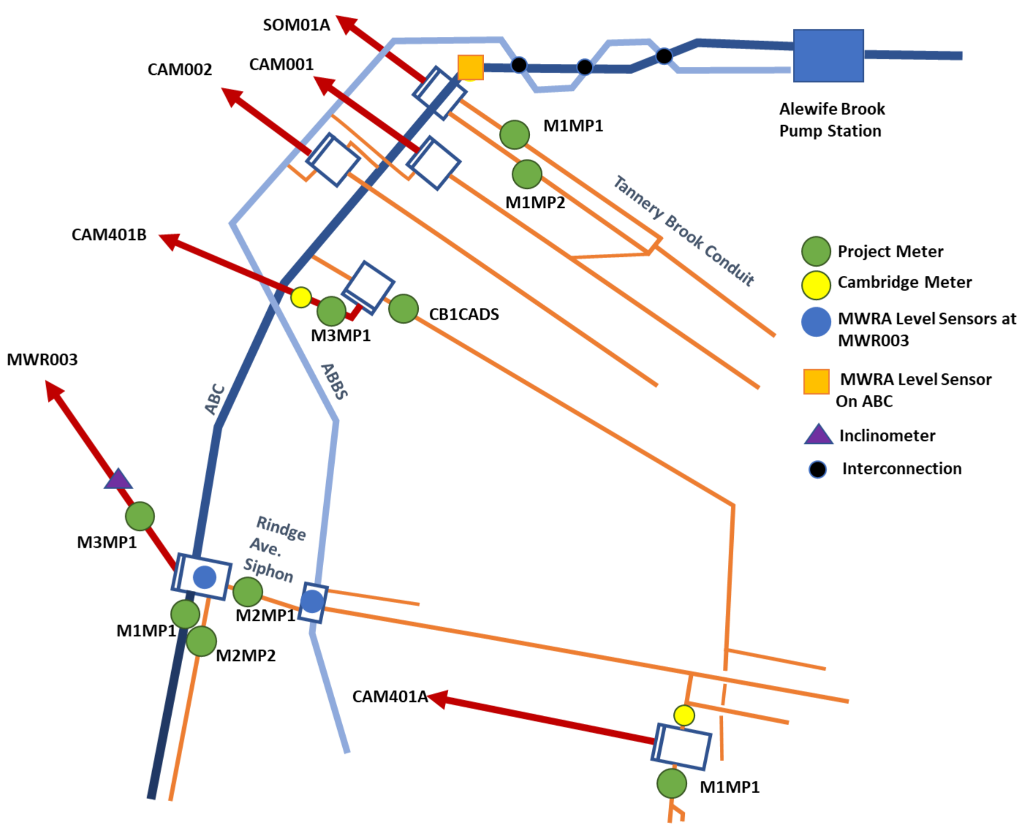

Figure 4-14. Schematic of Alewife Sub-System

MWRA is focused on working to meet the LTCP goals at outfall SOM001A, the one remaining outfall not in compliance with the LTCP goals. In addition, as a condition of the Alewife Brook/Upper Mystic River Variance, MWRA will continue to investigate opportunities to further reduce CSO activation frequency and/or volume at the remaining Alewife Brook CSO outfalls that are currently meeting the LTCP level of control.

4.6.1 Hydraulic Model Updates and CSO Performance

The model was updated to include the sediment removal in the combined sewer downstream of regulator RE401A (outfall CAM401A) as well as the alternative operation plan at the Alewife Brook Pump Station. These changes were incorporated in the model and the results are presented in Table 4-12. The sections to follow provide additional information on the modifications that were made. As indicated in Table 4-12, under Q1-2021 conditions, outfall SOM001A remains the only outfall not in compliance with the LTCP targets. It is noted that the total volume to Alewife Brook under the Q1-2021 conditions now meets the LTCP total volume target for Alewife Brook.

Table 4-12. Comparison of Mid-2020 and Q1-2021 System Conditions to LTCP

Outfall	Mid-2020 System Conditions(1)		Mid-2020 System Conditions With CAM401A Sediment Removed(1)		Q1-2021 System Conditions(1)		Long Term Control Plan	
	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)
Alewife Brook								
CAM001	1	0.02	1	0.02	1	0.02	5	0.19
CAM002	0	0.00	0	0.00	0	0.00	4	0.69
MWR003	3	0.49	3	0.69	3	0.61	5	0.98
CAM401A	16	2.17	5	0.69	5	0.66	5	1.61
CAM401B	4	0.53	4	0.56	4	0.50	7	2.15
SOM001A	8	4.51	8	4.55	8	4.47	3	1.67
Total	**16 (max)**	**7.71**	**8(max)**	**6.51**	**8 (max)**	**6.26**	**7 (max)**	**7.29**

Notes: (1) Grey shading indicates model prediction is greater than LTCP value.

4.6.2 Update on CAM401A Sediment Removal

Semiannual Report No. 5 included a preliminary assessment of the potential benefits of removing the sediment in the combined sewer downstream of regulator RE401A (outfall CAM401A). During 2018 inspections and metering, the City of Cambridge and MWRA observed standing water in the dry weather connection (Sherman Street sewer) downstream of regulator RE401A. The City of Cambridge confirmed the presence of sediment in the Sherman Street sewer and other downstream pipes and issued a contract for sediment cleaning and inspections. The City of Cambridge completed the majority of sediment removal in Fall 2020 and measurements taken after the sediment was removed confirmed that the standing water previously observed at regulator RE401A had been eliminated. As indicated in Table 4-12 above, removal of the sediment downstream of regulator RE401A substantially reduced the activation frequency and volume at outfall CAM401A, bringing this location into compliance with LTCP levels of control. That reduction was accompanied by slight increases in predicted volume at outfalls MWR003, CAM401B and SOM001A, likely due to the increase in flow into the interceptor from regulator RE401A.

4.6.3 Alewife Brook Pump Station Optimization

The Alewife Brook Pump Station (ABPS) is located at the downstream end of the Alewife Brook Conduit (ABC) and Alewife Brook Branch Sewer, and is therefore downstream of the six CSO outfalls that discharge to Alewife Brook.

In accordance with the Variance requirements, the ABPS pump operational control strategy was investigated to assess if adjusting pump operation could reduce or eliminate upstream CSOs without adversely affecting downstream conditions. The investigation of alternative pump operation strategies focused on pump sequencing, on-off level setpoints, and pump speed versus the pump suction-side wet well elevation settings.

The work for this evaluation included:

- Field testing of the single dry weather pump to assess its field performance and ability to safely operate at low wet well levels.
- Evaluating new operating level and pumping strategies to potentially reduce or eliminate upstream CSOs without adversely affecting the downstream system using the MWRA's collection system model.
- Field testing of the wet weather pumps to assess the feasibility of operational changes if the model indicated such changes could result in CSO reduction benefits.
- Documenting the modeling and field testing performed and the predicted and observed results.

A summary of the evaluation, an analysis of the CSO benefits of the proposed pumping modifications as well as the conclusions and recommendations for the ABPS are presented in the sections to follow. This work is documented in the *Task 8.1: Alewife Brook Pump Station Optimization Evaluation Report* (AECOM 2021).

4.6.2.1 Evaluation Summary

The ABPS optimization evaluation included the following steps:

1. Reviewed available data sources and current ABPS operating strategy.
2. Conducted hand calculations for pump properties such as submergence requirements and potential impeller upgrades.
3. Updated the existing model to reflect Mid-2020 system conditions (Subsequently the model was updated to reflect Q3Q4-2020 system conditions).
4. Conducted initial evaluations of alternative operating strategies using the updated model.
5. Conducted a dry weather pump test to test performance and operational limits.
6. Conducted a wet weather pump test to assess operational limits.
7. Updated the existing model to reflect pump field performance identified during the field tests.
8. Updated and revised an alternative operation strategy and assessed impact on upstream regulators.
9. Tested and revised the recommended alternative operating strategy, implemented during a wet weather storm event.
10. Developed conclusions and recommendations based on the preceding steps.

As a result of this work, a new operating strategy was developed for wet weather. Compared to the existing ABPS operating strategy, all pumps have ON setpoints at relatively lower wet well levels allowing for the pumps to ramp up to full speed sooner. The speed bands of each pump were also updated from a one-foot band to a two-foot band. A larger speed band dampens the transient response of the VFDs, reduces pump and pump-motor shaft fatigue, and would allow for the wet weather pumps to operate at higher speeds for wet well levels above 98 feet. The wet weather operational strategy setpoints are shown in Figure 4-15. No changes were proposed to the current operational setpoints for dry weather operation.

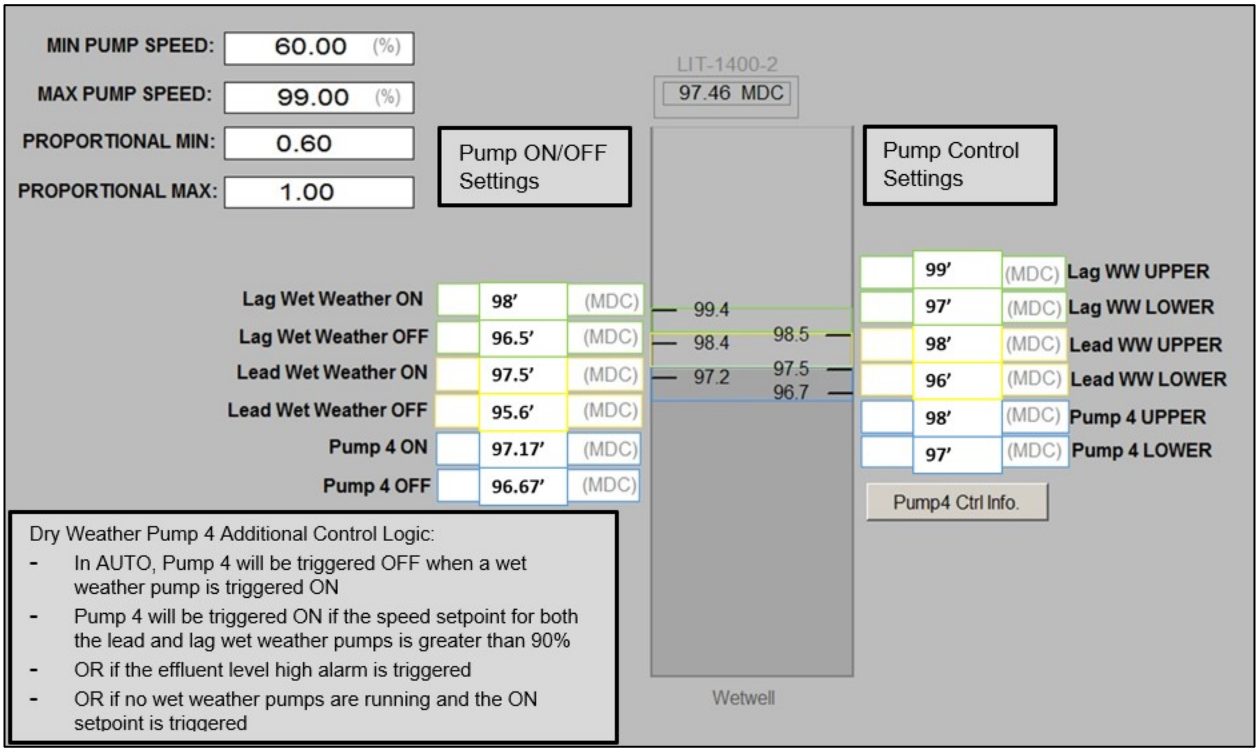

Figure 4-15. Final Wet Weather ABPS Operating Strategy Displayed on the Manager Setpoint Screen

4.6.2.2 CSO Benefits of Pumping Modifications

Modeling results indicated that the alternative operating strategy would only result in marginal improvements to the reduction of CSO activation frequency and discharge volume for the six outfalls tributary to Alewife Brook. Of the six outfalls discharging to Alewife Brook, outfall SOM001A is the only outfall currently predicted to be out of compliance with the LTCP performance goals. A comparison of the typical year model results between the baseline model using the existing ABPS operating strategy (Table 4-12 columns labeled Mid-2020 conditions with sediment removed) and the model using the final wet weather ABPS operating strategy (Table 4-12 columns labeled Q1-2020 conditions) indicate a total reduction in CSO volume of 0.25 MG to Alewife Brook.

Comparative plots of HGL in the ABPS wet well versus the HGL in the ABC at the connection from the SOM001A regulator indicated that lowering the wet well elevation prior to the start of a storm had very little impact on the HGL upstream at the SOM001A connection. As a result, little change was seen in the upstream CSO volumes. Two model scenarios were evaluated where the pumps were set to maintain a constant wetwell elevation of 96.0 and 98.0 feet. The results of these scenarios indicated that keeping the wet well at a constant lower elevation during wet weather would only be feasible if the capacity of the ABPS was increased. Under these two scenarios, capacity limitations in the ABC resulted in only a 0.75-foot reduction in peak HGL for the largest storm in the typical year (10/23/1992) at the SOM001A connection associated with reductions in ABPS wet well depth of four feet. The two constant lower wet well scenarios did not change the activation frequency at outfall SOM001A, and only marginally reduced the volume. The maximum influent flow for the constant wet well model runs is approximately 107 mgd, approximately 15 mgd greater than the total ABPS pumping capacity. Thus, it would not be possible to implement an operating strategy that could successfully maintain an ABPS wet well level of 98 feet or lower with the existing pumps. Since increasing the capacity of ABPS would not meaningfully improve the performance of outfall SOM001A relative to the LTCP goals and would also have adverse impacts on downstream HGLs during large storms, the constant wet well scenarios were not pursued further.

Although the CSO control benefits of the alternative operating strategy for ABPS were minimal, the operating strategy has been implemented into the station controls. As indicated during the December 5, 2020 field trial, the wet weather pump operation was greatly improved with no observed pump cycling as the wet well level fluctuated. A reduction in cycling provides a more stable operation and should result in reduced fatigue wear of the pumps which can extend their service life, reducing station maintenance costs. An additional benefit is a reduction in the risk of the wet weather pumps being simultaneously triggered OFF, followed by a quick rise in the wet well that could potentially impact upstream CSOs.

4.6.2.3 Conclusions and Recommendations

This new operating strategy has been incorporated in the station controls. The station now has two operating strategies: the existing operating strategy for dry weather flow conditions and the final wet weather ABPS operating strategy for storm events.

MWRA is in the process of making updates to the human-machine interface Manager Setpoint Screen and the PLC programming to simplify the process when switching from the dry weather ABPS operating strategy to the final alternative ABPS operating strategy. In-house SCADA Engineers are working to create a single button allowing for station operators to quickly select the appropriate operating strategy.

The final wet weather ABPS operating strategy has been incorporated into the baseline configuration for the model. This updated baseline model will be used for the subsequent evaluations of system optimization measures to further reduce CSO frequency and activation volumes for outfalls tributary to Alewife Brook as required by the Variance.

4.6.4 Outfall SOM001A

4.6.4.1 System and Performance

As indicated above in Table 4-12 (Section 4.6.1), outfall SOM001A is currently not meeting the LTCP goal of 3 activations and 1.67 MG of CSO discharge in the Typical Year. MWRA is currently investigating a range of alternatives to potentially reduce the activation frequency and volume and work towards achieving the LTCP goals. These alternatives currently include:

- Raising the weir in the SOM001A regulator
- Increasing the conveyance of flow between the SOM001A regulator and the interceptor system
- Diverting upstream flows away from the Tannery Brook Drain, towards regulator SOM009 and the Prison Point system
- Utilizing in-system storage within the Tannery Brook Drain to attenuate peak flows to the regulator

For promising alternatives, MWRA will further develop the cost, hydraulic impacts, and implementation feasibility.

4.6.4.2 Evaluation of Regulator Modifications

In addition to alternatives targeted at outfall SOM001A, MWRA is continuing to evaluate CSO system optimization measures at other outfalls within the Alewife Brook system, which were required by the Alewife Brook/Upper Mystic River Variance to commence by December 2020. Evaluations include considering regulator adjustments, such as raising overflow weirs and upgrading dry weather connections. At each regulator, the adjustments being considered will also be evaluated for potential impacts to upstream systems (flooding) and other outfalls.

4.7 Chelsea Outfalls

4.7.1 Update on Raising the Overflow Weir at CHE004

In Semiannual Report No. 5 it was reported that outfall CHE004 was predicted to activate seven times in the Typical Year under Mid-2020 conditions, with an annual overflow volume of 1.01 MG. This level of performance exceeds the LTCP goal for outfall CHE004 of three activations and 0.32 MG in the Typical

Year. To help move closer to the LTCP goal, MWRA and Chelsea evaluated the benefit raising the weir in regulator RE041, which overflows to outfall CHE004. Flows from the area tributary to regulator RE041 are conveyed into the Chelsea Trunk Sewer. The Chelsea Trunk Sewer ties into the MWRA's Metropolitan Sewer which ultimately conveys flow to the Chelsea Screen House (Figure 4-16).

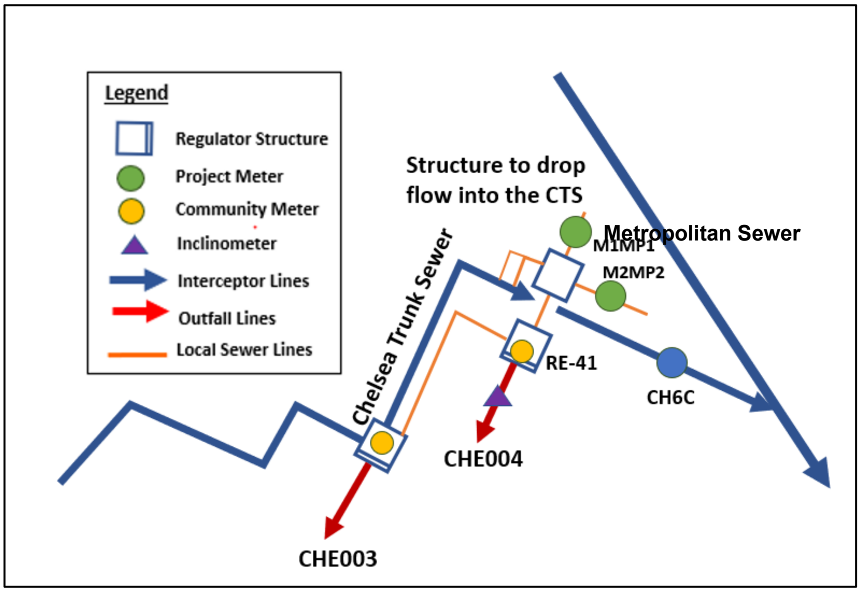

Figure 4-16. Schematic of CHE004 Model Configuration

Raising the weir at regulator RE041 by 1.5 feet was predicted to result in three activations and 0.30 MG at outfall CHE004 in the Typical Year, which would meet the LTCP goals of three activations and 0.32 MG.

As a result of the evaluation, the City of Chelsea was able to quickly implement the weir raising at regulator RE041, increasing the height by 1.5 feet on December 1, 2020.

4.7.2 Update on Upgrading the Interceptor Connection at Outfall CHE008

In Semiannual Report No. 5, it was reported that outfall CHE008 is predicted to activate 11 times in the Typical Year under Mid-2020 conditions, with an annual overflow volume of 3.81 MG. This level of performance exceeds the LTCP goals for outfall CHE008 of zero activations and volume in the Typical Year. Based on this difference, MWRA initiated an investigation as to why the actual performance differed from the expected performance at this location. The results of the desktop analysis that was done initially were reported in Semiannual Report No. 5. The text below describes the process of updating the calibration to reflect updated information on the configuration of regulator RE-081, and evaluating alternatives to increase the capacity of the dry weather flow connection.

Figure 4-17 shows a schematic of outfall CHE008 system. Regulator RE-081 receives flow from an upstream flow diversion on Crescent Avenue. During dry weather, flow in the Crescent Avenue combined sewer is routed via an 18-inch sewer through meter CH8 to the Revere Extension Sewer.   During wet weather, a weir set at the crown of the 18-inch Crescent Avenue combined sewer diverts flow to the 61 x 72 inch combined sewer tributary to regulator RE-081.   During dry weather and small storms, flows entering regulator RE-081 are routed through meter CH7 to Structure C via a 30-inch sewer. Structure C is located at the confluence of the Revere Extension Sewer, the Chelsea Branch Sewer and the Chelsea Branch Sewer Relief. From Structure C the flow is routed through the MWRA interceptor system towards the Chelsea Screen House and ultimately to the Caruso Pump Station. During larger storms, the flow can overtop the weir in regulator RE-081 and flow to outfall CHE008. A temporary flow meter (M1MP1) was installed by ADS on the influent line to regulator RE-081 from April 2018 through June 2020. Flow Assessment Services also operates CSO overflow meters on behalf of the City of Chelsea.

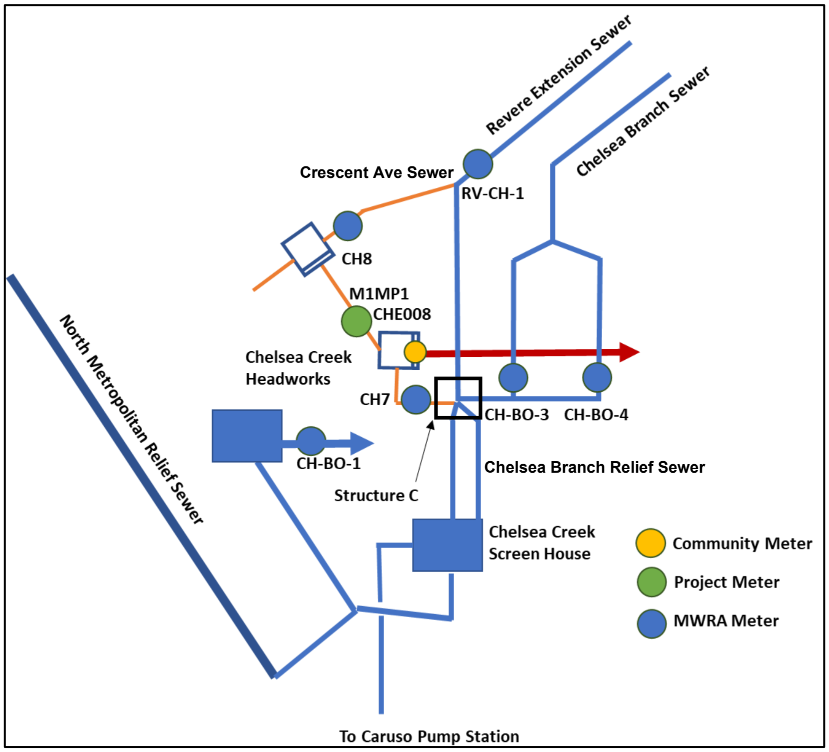

Figure 4-17. System Schematic for CHE008

As noted in Semiannual Report No. 5, on October 1, 2020 MWRA performed field work to cut away a portion of the protrusion of the 30-inch dry weather flow connection pipe into the CHE008 regulator structure (approximate location shown in Figure 4-18), with the expected benefit of reducing head loss and increasing flow to the interceptor. MWRA and the City of Chelsea continued to collect flow meter data to assess the benefit of the removal of the protrusion and to support recalibration of the model in the vicinity of outfall CHE008.

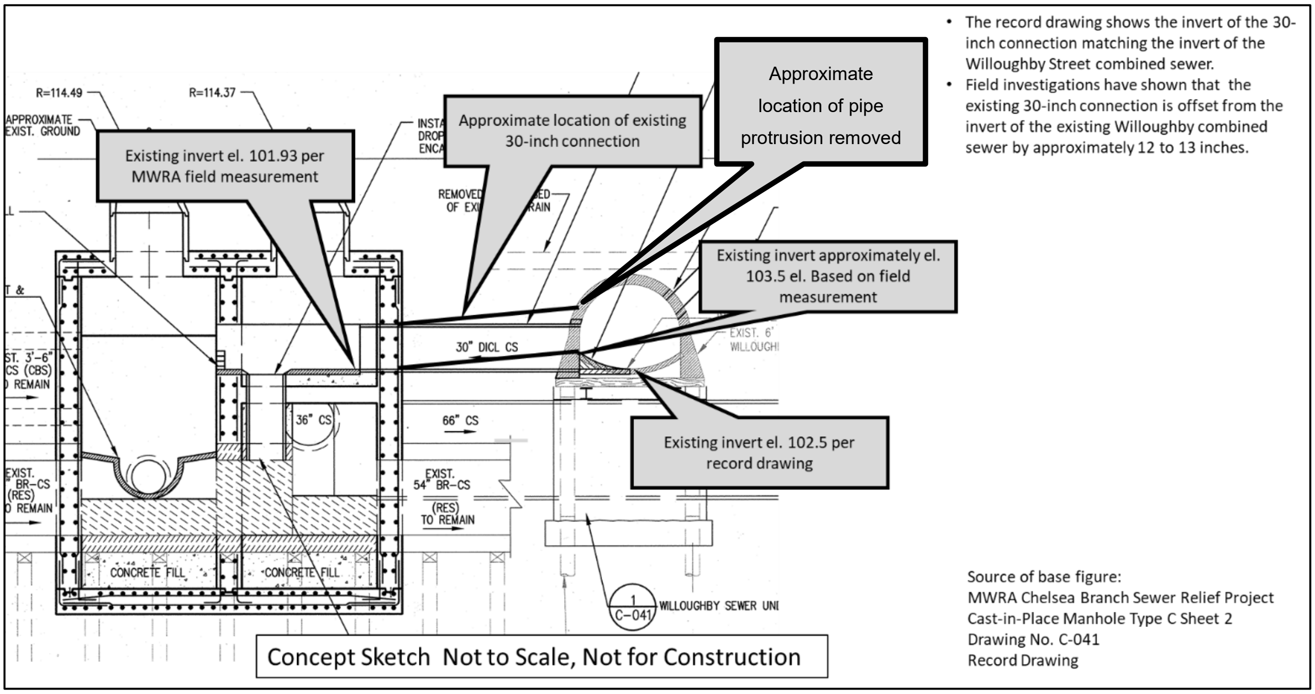

Figure 4-18. Section View of Dry Weather Flow Connection from Regulator RE081 to Structure C

The model was updated to reflect new information on the configuration of the dry weather flow connection at regulator RE-081 (Figure 4-18) and to account for the inlet-controlled head losses as described in Semiannual Report No. 5. The flow meter data collected for storm events before and after the protrusion was removed was then used to recalibrate the model. The impacts of the recalibration and removing the protrusion are summarized in Table 4-13. As indicated in Table 4-13, the recalibration reduced the predicted activation frequency and volume at outfall CHE008 in the Typical Year for conditions with the protrusion still in place, while removal of the protrusion was predicted to further reduce the annual activation frequency at outfall CHE008 from eight to six, and reduce the volume by 0.1 MG. The performance with the protrusion removed, however, was still predicted to exceed the LTCP goals for outfall CHE008. As a result, a series of alternatives was evaluated that included various combinations of increasing the size and lowering the upstream invert of the existing 30-inch dry weather flow connection. These evaluations indicated that increasing the size of the dry weather flow connection to 48 inches and lowering the upstream invert to match the existing invert elevation in regulator RE-081 would be required to eliminate the activations at outfall CHE008 in the Typical Year.

Table 4-13. Impact of Recalibration and Removal of Protrusion on Dry Weather Flow Connection at RE-081 on Typical Year Activation Frequency and Volume at Outfall CHE008

Simulation	Protrusion	Outfall CHE008 Typical Year	
		Activation Frequency	Total volume (MG)
Mid-2020 Conditions Before Recalibration	Yes	11	3.81
Mid-2020 Recalibrated Baseline with Protrusion	Yes	8	2.06
Mid-2020 Recalibrated Baseline No Protrusion	No	6	1.96

However, when this alternative was evaluated with a 5-year storm, it was found to allow too much flow into the interceptor resulting in adverse HGL impacts in the interceptors upstream of the connection from regulator RE-081. To avoid the need to mechanically throttle the flow during the 5-year storm, a potential solution was to provide an orifice on the downstream end of the 48-inch connection, with the invert elevation of the orifice set to match the downstream invert elevation of the 48-inch connection. A series of model runs was conducted to assess the performance of a range of fixed orifice sizes. A 36-inch orifice resulted in one activation and 0.07 MG in the Typical Year, but this configuration still resulted in adverse HGL impacts along the Chelsea Branch Sewer.

Manhole 22 is a junction chamber on the Chelsea Branch Sewer, approximately 4,500 feet upstream of Structure C, where flow in the 36-inch interceptor can either continue in the 30-inch interceptor, or divert into the 42-inch relief interceptor (Figure 4-19). Dry weather flow would continue into the downstream 30-inch interceptor, while in wet weather, flow would need to pass over a weir at elevation 106 to enter the 42-inch relief interceptor. A second series of model runs was conducted to see if lowering the weir in Manhole 22 to elevation 105 would help to mitigate the HGL increase in the 5-year storm. For these runs, the weir in Structure C was also removed (Figure 4-20).

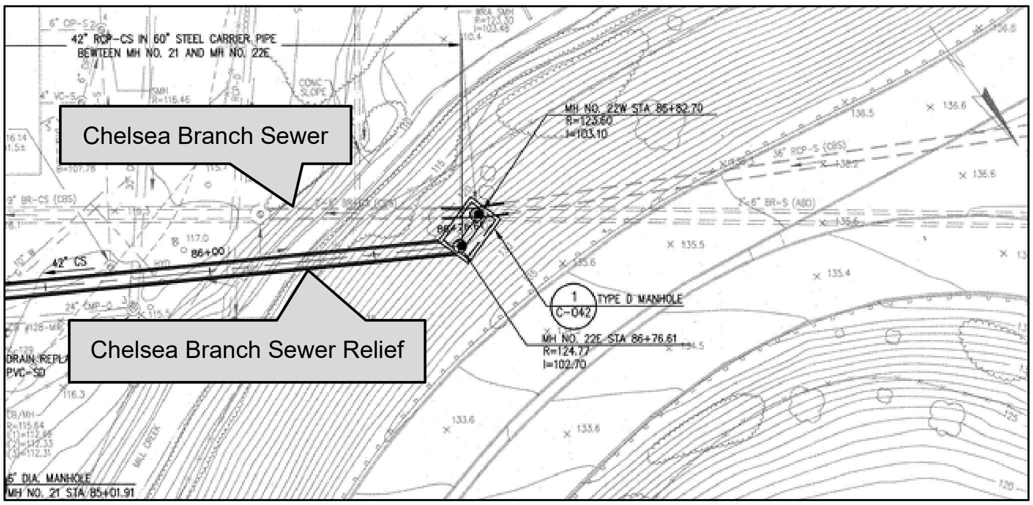

Figure 4-19. Manhole 22 on the Chelsea Branch Sewer (from MWRA Chelsea Branch Sewer Relief Project Drawing No. C-027 Record Drawing)

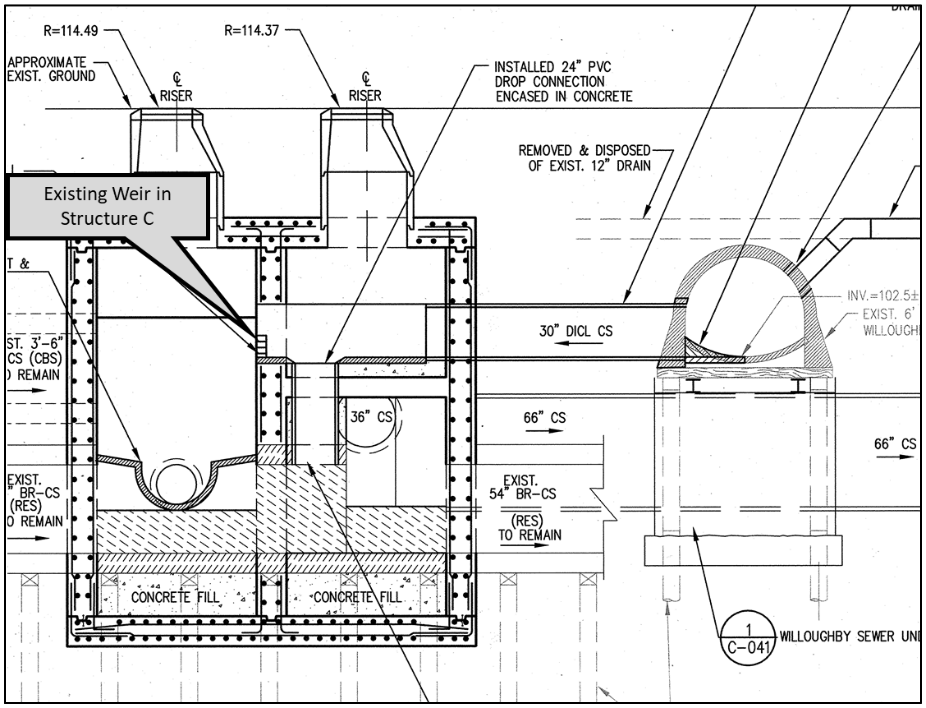

Figure 4-20. Section View of Structure C Showing Interior Weir (from MWRA Chelsea Branch Sewer Relief Project Drawing No. C-041 Record Drawing)

With this configuration and the 36-inch orifice, the activation frequency and volume at outfall CHE008 did not change, but the adverse HGL impacts on the Chelsea Branch Sewer were mitigated.

While this alternative came very close to eliminating the CSO discharges in the Typical Year at CHE008, the one remaining discharge at 0.07 MG would still exceed the LTCP target of zero discharges. If the orifice were increased to 39-inch diameter, the remaining discharge in the Typical Year was predicted to be eliminated. However, even with the weir at MH22 lowered to elevation 105, adverse HGL impacts were predicted at more than ten locations along the Chelsea Branch Sewer. Thus, of the alternatives evaluated, the 48-inch dry weather flow connection with 36-inch diameter orifice would provide the highest level of CSO control in the Typical Year without creating adverse HGL impacts during the 5-year storm. This alternative would bring outfall CHE008 to within one 0.07 MG activation of meeting its LTCP goals.

As a result of these evaluations, the following configuration was recommended:

- Replace existing 30-inch DWF connection between regulator RE-081 and Structure C with a 48-inch connection along the same route
- Match the upstream invert elevation of the 48-inch connection with the existing invert in regulator RE-081
- Match the downstream invert elevation of the 48-inch connecting with the downstream invert of the existing 30-inch connection
- Provide an orifice plate at the downstream end of the 48-inch connection, with a 36-inch diameter orifice set with the invert of the orifice at the downstream invert of the 48-inch connection
- Eliminate the existing interior weir within Structure C
- Lower the weir in MH22 on the Chelsea Branch Sewer from elevation 106 to elevation 105

Figure 4-21 and Figure 4-22 provide conceptual sketches for the elements of the recommended alternative as described above.

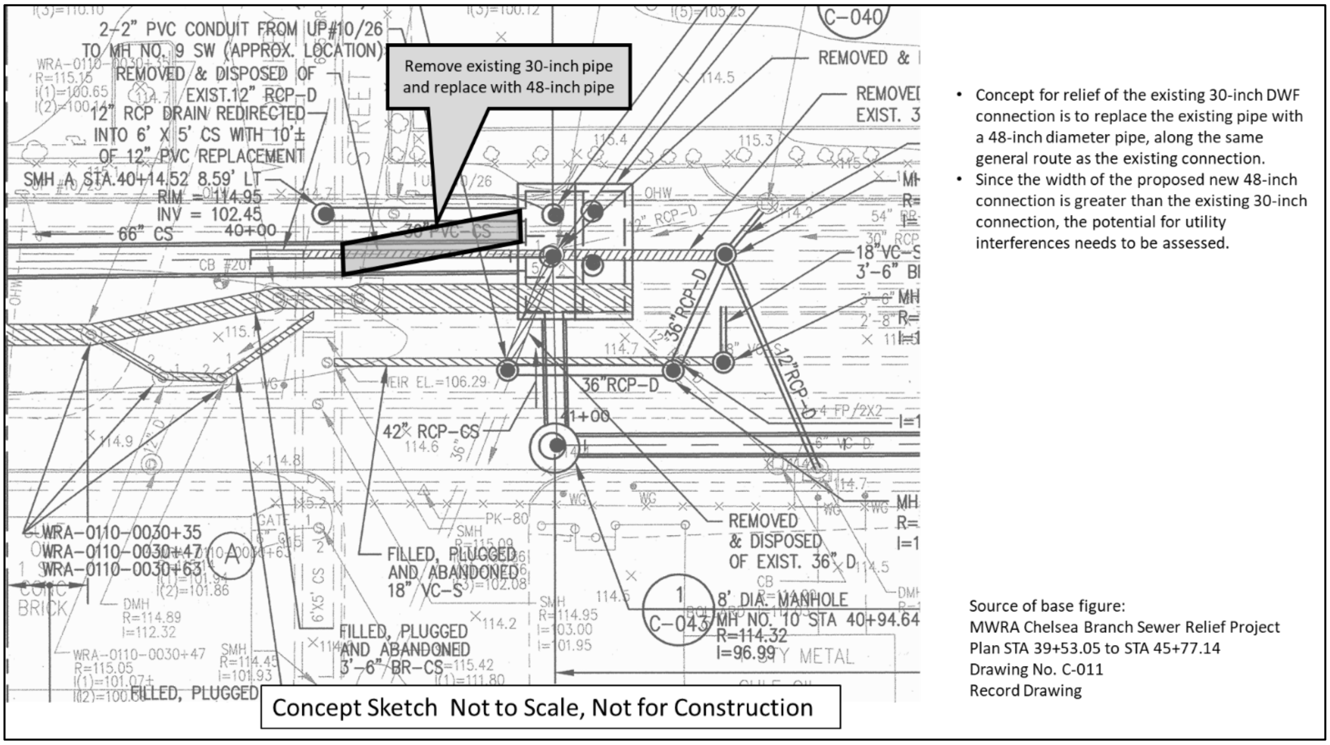

Figure 4-21. Concept Sketch Plan View of CHE008 Proposed DWF Connection

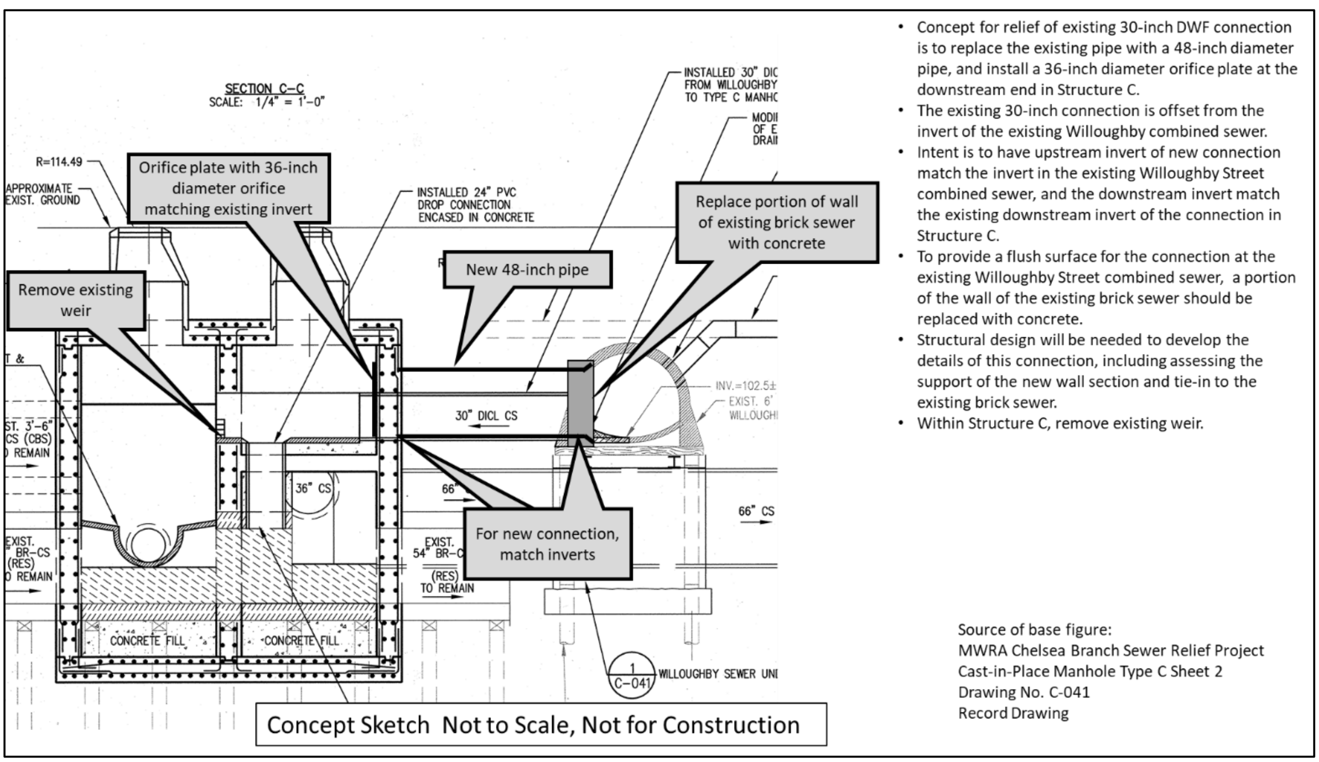

Figure 4-22. Sketch Section View of CHE008 Proposed DWF Connection

4.7.2.2 Ongoing Design Effort and Construction Plan and Schedule

MWRA completed preliminary design and commenced final design of CHE008 connection replacement in March 2021. The Project schedule calls for the completion of deign design in Fall 2021, commencement of construction in early 2022, and completion of construction of Spring August 2022.

5. Data Collection and Analyses July 1, 2020-December 31, 2020

5.1. Rainfall Analyses

Rainfall is a driving factor in the analysis of CSOs, as the occurrence of overflows within the MWRA sewer system is dependent on rainfall intensity and/or depth. This section presents the rainfall data measured during the period of July 1 through December 31, 2020. It also describes the analysis of the rainfall data used to characterize the return period of each storm event and a comparison of measured rainfall for this period and the full 2020 period to the rainfall included in the Typical Year

5.1.1 Rainfall Data Collection and Processing

Rainfall has been quantified for this analysis using 15-minute rainfall data collected at rain gauges distributed over the MWRA system. Rain gauges are listed in Table 5-1 and the locations are shown in Figure 5-1, on the following page.

Table 5-1. Rain Gauges

Gauge Code	Name	Owner	Gauge Code	Name	Owner
BO-DI-1	Ward St.	MWRA	BWSC006	Dorchester -Talbot	BWSC
BO-DI-2	Columbus Park	MWRA	Rox	Roxbury	BWSC
BWSC001	Union Park Pump Sta.	BWSC	CH-BO-1	Chelsea Ck.	MWRA
BWSC002	Roslindale	BWSC	FRESH_POND	USGS Fresh Pond	USGS
BWSC003	Dorchester Adams St.	BWSC	HF-1C	Hanscom AFB	MWRA
BWSC004	Allston	BWSC	RG-WF-1	Hayes Pump Sta.	MWRA
BWSC007	Charlestown	BWSC	SOM	Somerville Remote	MWRA
EB	East Boston	BWSC	Lex	Lexington Farm	Project (1)
BWSC008	Longwood Medical	BWSC	SP	Spot Pond	Project (1)
BWSC005	Hyde Park	BWSC	WF	Waltham Farm	Project (1)

(1) Project gauges were removed as of July 1, 2020. Project gauge data has been replaced with the nearest rain gauge, following the QA/QC procedures and closest rain gauges substitution table.

Quality assurance and quality control are provided by reviewing the data based on geographic location, comparing total rainfall depth and rainfall intensity values by month and for individual storm events. The shape of rainfall hyetographs is reviewed for irregularities. Rain gauges with significantly higher or lower total rainfall depths than other gauges, and unusual hyetograph shapes, are flagged as suspect and further reviewed.

Suspect or missing rain gauge data were replaced with data from the rain gauge in closest linear proximity. If the closest gauge also had suspect data, the second closest rain gauge was used. Figure 5-2 identifies the two closest rain gauges to each of the rain gauges. Replacement of suspect data was recorded in Table 5-3. Rainfall data used for the analysis are provided in Appendix A.

Intensity-Duration-Frequency (IDF) analysis was used to characterize the return periods of the storm events in the July 1 through December 31, 2020 metering period. Storm recurrence intervals for 1-hour, 24-hour, and 48-hour durations were identified for each storm event based on the IDF analysis. Storm recurrence intervals were based on Technical Paper 40, Rainfall Frequency Atlas of the United States (TP-40), and Technical Paper 49, Two-To Ten-Day Precipitation for Return Periods of 2 to 100 Years in the Contiguous United States (TP-49), with values extrapolated for the 3- and 6-month storms.

Additional information on the methodologies for rainfall data collection and processing can be found in Semiannual Report Nos. 1 and 2.

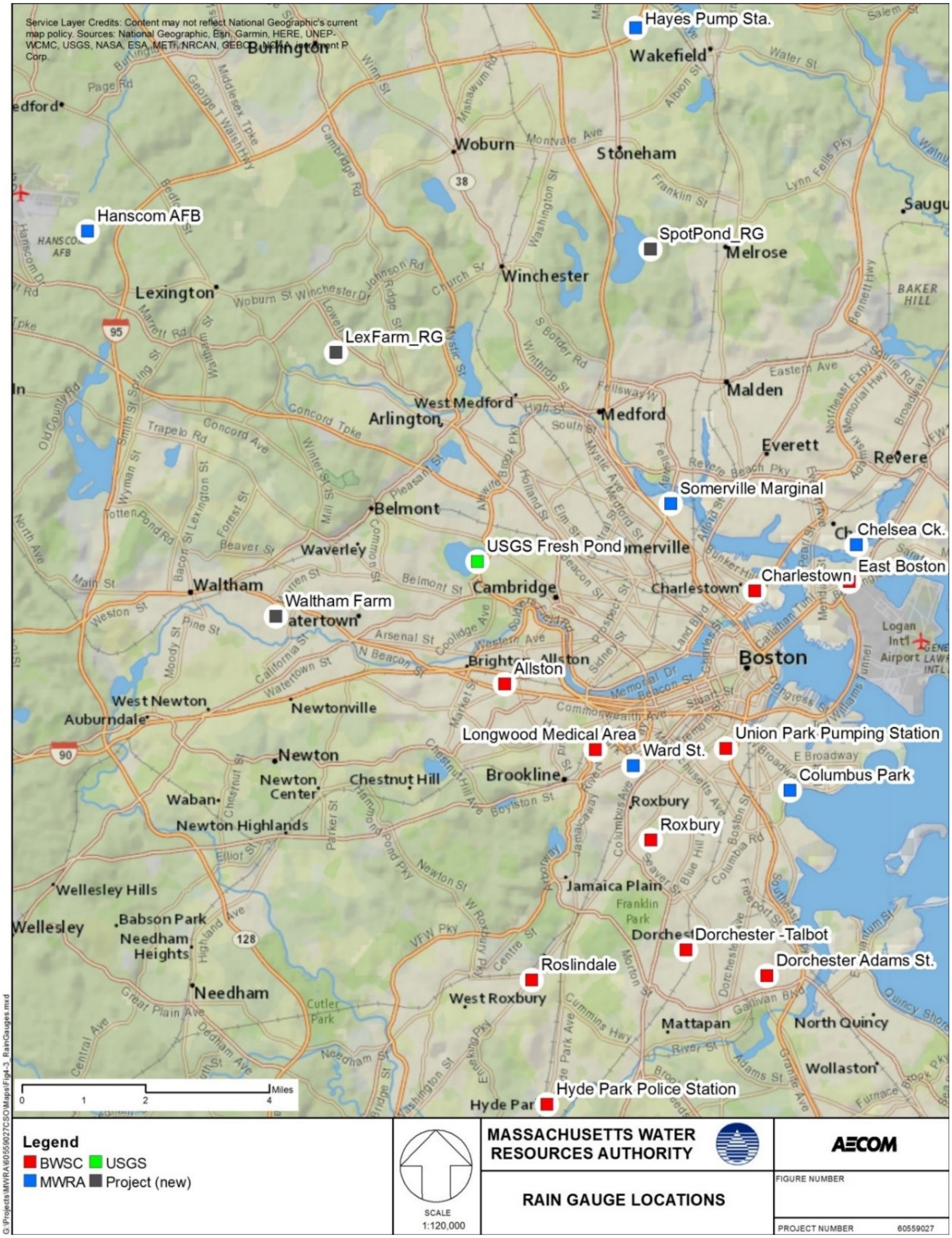

Figure 5-1. Rain Gauge Location Plan

Table 5-2. Closest Rain Gauges for Data Substitution

Origin Gauge		Closest Gauge		Second Closest Gauge	
Gauge Name	**Gauge Code**	**Gauge Code**	**Distance (mi)**	**Gauge Code**	**Distance (mi)**
Ward Street	BO-DI-1	BWSC008	0.66	Rox	1.23
Columbus Park	BO-DI-2	BWSC001	1.24	Rox	2.39
Union Park Pumping Station	BWSC001	BO-DI-2	1.24	BO-DI-1	1.52
Roslindale	BWSC002	BWSC005	2.02	BWSC006	2.54
Dorchester Adams St.	BWSC003	BWSC006	1.37	Rox	2.88
Allston	BWSC004	BWSC008	1.81	FRESH_POND	2.03
Hyde Park Police Station	BWSC005	BWSC002	2.02	BWSC006	3.36
Dorchester -Talbot	BWSC006	BWSC003	1.37	Rox	1.86
Charlestown	BWSC007	EB	1.53	CH-BO-1	1.80
Longwood Medical Area	BWSC008	BO-DI-1	0.67	Roxbury	1.71
Chelsea Creek	CH-BO-1	EB	0.60	BWSC007	1.80
East Boston	EB	CH-BO-1	0.60	BWSC007	1.53
USGS Fresh Pond	FRESH_POND	BWSC004	2.21	SOM	3.26
Hanscom AFB	HF-1C	Lex	4.47	WF	6.92
Lexington Farm	Lex	FRESH_POND	4.08	WF	4.37
Hayes Pump Sta.	RG-WF-1	SP	3.58	Lex	7.13
Roxbury	Rox	BO-DI-1	1.23	BWSC008	1.71
Somerville	SOM	BWSC007	1.95	CH-BO-1	3.07
Spot Pond	SP	SOM	4.12	Lex	5.34
Waltham Farm	WF	FRESH_POND	3.37	BWSC004	3.86

Table 5-3. Summary of Rainfall Data Replacement, July - December 2020 (Page 1 of 2)

Rain Gauge	Replacement Data Start Time	Replacement Data End Time	Replacement Rain Gauge
Dorchester Adams	07/01/2020 0:00	12/1/2020 0:00	Roxbury
Dorchester Talbot	07/01/2020 0:00	12/1/2020 0:00	Roxbury
Charlestown	09/01/2020 0:00	12/31/2020 0:00	East Boston
Chelsea Creek (CH-BO-1)	08/02/2020 16:30	08/16/2020 12:30	East Boston
	09/14/2020 5:15	09/14/2020 10:00	East Boston
	10/04/2020 7:45	10/04/2020 8:00	East Boston
	10/23/2020 7:00	10/23/2020 7:15	East Boston
	11/1/2020 0:00	12/1/2020 23:45	East Boston
Roslindale	9/16/2020 10:00	9/16/2020 10:15	Roxbury
Columbus Park (BO-DI-2)	08/09/2020 16:15	08/09/2020 16:30	Union Park
	08/28/2020 6:15	08/28/2020 6:30	Union Park
	10/20/2020 10:00	10/20/2020 10:15	Union Park
	10/23/2020 0:00	10/29/2020 0:00	Union Park
	11/1/2020 15:15	11/4/2020 23:45	Union Park
	11/30/2020 7:30	11/30/2020 7:45	Union Park

Table 5-3. Summary of Rainfall Data Replacement, July-December 2020 (Page 2 of 2)

Rain Gauge	Replacement Data Start Time	Replacement Data End Time	Replacement Rain Gauge
Ward St.	08/15/2020 19:15	08/15/2020 19:30	Roxbury
	10/24/2020 5:15	10/24/2020 5:30	Roxbury
	11/1/2020 15:15	11/2/2020 6:00	Roxbury
	11/30/2020 10:00	11/30/2020 10:15	Roxbury
Somerville	12/2/2020 0:00	12/11/2020 23:45	CH-BO-1
Longwood Medical Area	07/01/2020 0:00	09/30/2020 23:45	Ward Street
	10/01/2020 0:00	10/31/2020 23:45	Ward Street
	11/1/2020 15:15	11/1/2020 22:15	Roxbury
	11/2/2020 22:30	12/31/2020 23:45	Ward Street
	11/30/20 10:00	11/30/2020 10:15	Roxbury
Hyde Park	10/06/2020 6:00	10/06/2020 6:15	Roslindale
	10/18/2020 5:30	10/18/2020 5:45	Roslindale
USGS Fresh Pond	07/01/2020 0:00	10/31/2020 23:45	Allston
	11/1/2020 15:15	11/1/2020 22:00	Allston
Hanscom AFB (HF-1C)	07/01/2020 0:00	07/31/2020 23:45	Allston
	09/28/2020 13:00	09/28/2020 13:15	Allston
	10/01/2020 1:45	10/01/2020 2:00	Somerville Remote
	10/24/2020 10:45	10/31/2020 23:45	Somerville Remote
	11/1/2020 14:45	11/1/2020 22:00	Somerville
	11/1/2020 22:15	12/24/2020 23:45	USGS Fresh Pond
Lexington Farm	07/01/2020 0:00	07/31/2020 23:45	USGS Fresh Pond
	08/01/2020 0:00	08/31/2020 23:45	Somerville Remote
	09/01/2020 0:00	09/30/2020 23:45	Allston
	10/01/2020 0:00	10/31/2020 23:45	Somerville Remote
	11/1/2020 15:15	11/1/2020 22:00	Allston
	11/1/2020 22:15	12/31/2020 23:45	USGS Fresh Pond
Hayes Pump Sta. (RG-WF-1) Spot Pond	08/01/2020 0:00	08/31/2020 23:45	Allston
	07/01/2020 0:00	12/31/2020 23:45	Somerville
	12/2/2020 0:00	12/11/2020 23:45	CH-BO-1
	12/12/2020 0:00	12/31/2020 23:45	Somerville
Waltham Farm	07/01/2020 0:00	07/31/2020 23:45	USGS FRESH POND
	08/01/2020 0:00	10/31/2020 23:45	Allston
	11/1/2020 15:15	11/1/2020 22:00	Allston
	11/2/2020 22:00	12/31/2020 23:45	USGS Fresh Pond

5.1.2 Monitored Storms and Comparison with Typical Year

For the period of July 1 to December 31, 2020, the rainfall data at each rain gauge were analyzed and summarized, providing the date and time, duration, volume, average intensity, peak 1-hour, 24-hour, and 48-hour intensities and storm recurrence intervals for each storm. The storm recurrence intervals were assigned values of <3 months, 3 months, 3-6 months, 6 months, 1 year, or the nearest year, based on comparison to the IDF values from TP-40/TP-49. Table 5-4 presents the summary of storm events for Ward Street Headworks for the period of July to December 2020. These data show that 44 storm events occurred in the 6-month period July to December 2020 at the Ward Street Headworks rain gauge (BO-DI-1). The majority of events had less than 3-month recurrence intervals at 1-hour or 24-hour durations. Three storm events had a 24-hour recurrence interval of 3 months (October 16, 2020, November 23, 2020, and December 4, 2020). Tables summarizing the storm events from July to December 2020 for the other rain gauges are provided in Appendix B.

Table 5-4. Summary of Storm Events at Ward Street Headworks Rain Gauge (BO-DI-1) for July to December 2020 (Page 1 of 2)

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval [1]		
								1-hr	24-hr	48-hr
1	7/1/2020 6:15	0.25	0.01	0.04	0.01	0.00	N/A	<3m	<3m	N/A
2	7/5/2020 21:15	1.5	0.19	0.13	0.17	0.01	N/A	<3m	<3m	N/A
3	7/10/2020 17:00	6.25	0.11	0.02	0.10	0.00	N/A	<3m	<3m	N/A
4	7/13/2020 13:15	0.25	0.19	0.76	0.19	0.01	N/A	<3m	<3m	N/A
5	7/14/2020 9:45	0.5	0.11	0.22	0.11	0.01	N/A	<3m	<3m	N/A
6	7/15/2020 4:00	1	0.03	0.03	0.03	0.01	N/A	<3m	<3m	N/A
7	7/17/2020 5:15	2	0.15	0.08	0.10	0.01	N/A	<3m	<3m	N/A
8	7/22/2020 5:30	17	0.42	0.02	0.33	0.02	N/A	<3m	<3m	N/A
9	7/23/2020 15:30	0.75	0.49	0.65	0.49	0.04	N/A	<3m	<3m	N/A
10	7/31/2020 8:30	0.25	0.69	2.76	0.69	0.03	N/A	6m	<3m	N/A
11	8/2/2020 16:15	0.25	0.03	0.12	0.03	0.00	N/A	<3m	<3m	N/A
12	8/4/2020 15:30	1.25	0.19	0.15	0.17	0.01	N/A	<3m	<3m	N/A
13	8/16/2020 18:00	5.25	0.22	0.04	0.11	0.01	N/A	<3m	<3m	N/A
14	8/18/2020 1:15	1.25	0.07	0.06	0.06	0.00	N/A	<3m	<3m	N/A
15	8/19/2020 17:45	0.25	0.03	0.12	0.03	0.00	N/A	<3m	<3m	N/A
16	8/23/2020 15:45	4	0.62	0.16	0.50	0.03	N/A	<3m	<3m	N/A
17	8/27/2020 12:30	2.25	0.25	0.11	0.20	0.01	N/A	<3m	<3m	N/A
18	8/29/2020 9:30	2.5	0.07	0.03	0.04	0.00	N/A	<3m	<3m	N/A
19	9/2/2020 11:00	25.25	0.25	0.01	0.12	0.01	0.01	<3m	<3m	<3m
20	9/10/2020 13:45	6	0.32	0.05	0.15	0.01	N/A	<3m	<3m	N/A
21	9/30/2020 1:45	8.25	0.98	0.12	0.47	0.04	N/A	<3m	<3m	N/A
22	10/7/2020 16:45	0.5	0.17	0.34	0.17	0.01	N/A	<3m	<3m	N/A
23	10/13/2020 4:30	17.5	1.69	0.10	0.41	0.07	N/A	<3m	<3m	N/A
24	10/16/2020 12:00	20	1.94	0.10	0.30	0.08	N/A	<3m	3m	N/A
25	10/20/2020 9:00	0.25	0.19	0.76	0.19	0.01	N/A	<3m	<3m	N/A
26	10/21/2020 4:30	0.25	0.01	0.04	0.01	0.00	N/A	<3m	<3m	N/A
27	10/28/2020 3:45	0.25	0.01	0.04	0.01	0.00	N/A	<3m	<3m	N/A
28	10/29/2020 8:15	22.75	0.17	0.01	0.03	0.01	N/A	<3m	<3m	N/A
29	10/31/2020 10:00	0.25	0.01	0.04	0.01	0.00	N/A	<3m	<3m	N/A
30	11/1/2020 15:15	7.25	0.63	0.09	0.23	0.00	N/A	<3m	<3m	N/A
31	11/11/2020 23:30	0.25	0.01	0.04	0.01	0.00	N/A	<3m	<3m	N/A
32	11/13/2020 0:15	17.5	0.34	0.02	0.08	0.01	N/A	<3m	<3m	N/A
33	11/15/2020 20:45	4.5	0.51	0.11	0.34	0.02	N/A	<3m	<3m	N/A
34	11/23/2020 4:00	9	1.80	0.20	0.44	0.08	N/A	<3m	3m	N/A
35	11/25/2020 20:15	17.5	0.27	0.02	0.08	0.01	N/A	<3m	<3m	N/A
36	11/30/2020 11:45	26	1.77	0.07	0.23	0.04	N/A	<3m	<3m	N/A

Table 5-4. Summary of Storm Events at Ward Street Headworks Rain Gauge (BO-DI-1) for January to June 2020 (Page 2 of 2)

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
37	12/4/2020 22:45	23	2.01	0.09	0.25	0.08	N/A	<3m	3m	N/A
38	12/12/2020 12:30	7.5	0.45	0.06	0.16	0.02	N/A	<3m	<3m	N/A
39	12/14/2020 9:45	7.25	0.04	0.01	0.01	0.00	N/A	<3m	<3m	N/A
40	12/16/2020 23:30	39.25	0.59	0.02	0.11	0.02	0.01	<3m	<3m	<3m
41	12/19/2020 10:15	4	0.09	0.02	0.04	0.00	N/A	<3m	<3m	N/A
42	12/20/2020 10:45	6.75	0.19	0.03	0.04	0.01	N/A	<3m	<3m	N/A
43	12/25/2020 2:45	15.75	1.63	0.10	0.30	0.07	N/A	<3m	<3m	N/A
44	12/31/2020 4:30	2	0.11	0.06	0.09	0.00	N/A	<3m	<3m	N/A

(1) Recurrence intervals given in ranges of less than 3 months (<3m), 3-months, (3m), 3-6 months (3-6m), 6 months (6m), 6 months-1year (6m-1yr) or the nearest year.

The characteristics of the rain events that occurred in the January 1 through December 31, 2020 monitoring period were compared to rainfall characteristics from the Typical Year to help interpret the measured CSO activations and volumes in comparison to Typical Year performance.

The total rainfall and number of storms at each rain gauge were identified for the period of January 1 through December 31, 2020, and the number of storms by depth identified. These values were then compared to the values from the Typical Year. Table 5-5 presents this comparison. As indicated in Table 5-5, during 2020, rain gauges measured an average of 87 storms with total rainfall volume of 40.5 inches, compared with 93 storms and 46.8 inches in the Typical Year. Storm frequencies for the 0.5 to 1.0-inch and 1.0 to 2.0-inch ranges were equal to the Typical Year, while the numbers of storms in the >2-inch range were less than the Typical Year. Significantly fewer storm events occurred in the <0.25-inch range in 2020 as compared to the Typical Year, while slightly more storm events in the 0.25 to 0.5-inch range occurred in 2020 as compared to the Typical Year. In terms of potential impact on CSO activations and volume, the key finding from this analysis was that 2020 had fewer storms in the >2-inch range than the Typical Year.

Storms with >2 inches of total rainfall at the Ward Street, Columbus Park, Chelsea Creek Headworks, and USGS Fresh Pond rain gauges were identified and compared to storms with >2 inches of total rainfall in the Typical Year (Table 5-6). Experience has shown that large storms often account for a disproportionate volume of CSO. Table 5-6 indicates that there were five storm events (March 23, 2020, June 28, 2020, October 16, 2020, November 30, 2020, December 4-5, 2020) where rainfall depths observed at Ward Street, Columbus Park, Chelsea Creek and/or USGS Fresh Pond were >2 inches.

The December 4-5, 2020 storm had recorded rain depths >2 inches at Ward Street, Chelsea Creek, and USGS Fresh Pond rain gauges, indicating a storm event with uniform rainfall in contrast to the March 23, 2020 storm for which 2.15 inches of rain was recorded only at Columbus Park. This suggests that the March storm was a more geographically isolated rain event. The 2020 monitoring period had a lower frequency of 2-inch or greater storm events compared to the Typical Year. In addition, while the largest storm for the rain gauges presented below recording 2.20 inches of rainfall, the Typical Year had five storms with greater than 2.20 inches, and the largest storm in the Typical Year had 3.89 inches of rainfall.

Table 5-5. Frequency of Events within Selected Ranges of Total Rainfall for January-December, 2020

Rain Gauge	Total Rainfall (inches)	Total Number of Storms	Number of Storms by Depth				
			Depth < 0.25 inches	Depth 0.25 to 0.5 inches	Depth 0.5 to 1.0 inches	Depth 1.0 to 2.0 inches	Depth ≥2.0 inches
Typical Year	46.8	93	49	14	16	8	6
January- December 2020 Metering Data							
Average of Rain Gauges							
Average	40.5	87	41	17	17	8	3
MWRA Rain Gauges							
Ward Street	40.3	89	44	16	20	6	3
Columbus Park	37.93	84	39	16	20	7	2
Chelsea Creek	35.41	92	51	16	16	6	3
Hanscom Air	38.54	77	36	14	17	6	4
Hayes PS	36.77	84	42	13	19	10	0
BWSC Rain Gauges							
Allston	38.71	89	45	18	16	8	2
Charlestown	39.47	85	38	18	17	10	2
Dorchester-Adams	43.3	85	35	22	14	9	5
Dorchester-Talbot	43.3	85	38	19	14	9	5
Hyde Park	50.32	99	48	21	16	7	7
East Boston	40.08	86	40	17	18	9	2
Longwood	40.24	89	44	16	20	7	2
Roslindale	47.17	92	43	21	13	10	5
Roxbury	42.95	88	39	21	15	9	4
Union Park	40.79	84	38	17	17	10	2
USGS Rain Gauge							
Fresh Pond	38.45	79	37	13	19	8	2
MWRA Rain Gauges							
Lexington Farm	40.07	82	39	13	17	11	2
Spot Pond	37.95	91	46	19	13	12	1
Somerville	36.04	92	48	19	17	6	2
Waltham Farm	41.6	81	36	18	14	9	4

Table 5-6. Comparison of Storms Between January 1 and December 31, 2020 and Typical Year with >2 Inches of Total Rainfall

Rain Gauge	Date	Duration (hr)	Total Rainfall (in)	Average Intensity (in/hr)	Peak Intensity (in/hr)	Storm Recurrence Interval (24-hr)
Typical Year	12/11/1992	50	3.89	0.08	0.20	1y
	8/15/1992	72	2.91	0.04	0.66	3m
	9/22/1992	23	2.76	0.12	0.65	1y
	11/21/1992	84	2.39	0.03	0.31	3m
	5/31/1992	30	2.24	0.07	0.37	3m-6m
	10/9/1992	65	2.04	0.03	0.42	< 3m
January-December 2020 Gauge Data						
Ward Street	6/28/2020	48.5	2.04	0.04	1.09	3m
	12/4/2020	23	2.01	0.09	0.25	3m
Columbus Park	3/23/2020	23.25	2.15	0.09	0.55	3m-6m
	10/16/2020	19.5	2.11	0.11	0.31	3m-6m
Chelsea Creek	6/28/2020	48.25	2.11	0.04	0.7	3m
	10/16/2020	20	2.20	0.11	0.32	3m-6m
	12/5/2020	18.5	2.10	0.11	0.32	3m-6m
Fresh Pond (USGS)	11/30/2020	14.25	2.08	0.15	0.34	<3m
	12/5/2020	17.5	2.03	0.12	0.22	3m

Storms with peak rainfall intensities greater than 0.40 in/hr at the Ward Street, Columbus Park, Chelsea Creek Headworks, and USGS Fresh Pond rain gauges were identified and compared to storms with greater than 0.40 in/hr of peak intensity in the Typical Year (Table 5-7). Storms with intensities greater than 0.40 in/hr are of importance because higher intensity storms have been found to produce more CSO activations and volumes than lower intensity storms. The Typical Year has nine storm events with intensities greater than 0.40 inches per hour, while the 2020 monitoring period had ten storm events with intensities greater than 0.40 inches per hour. However, while the Typical Year had five storms with greater than 0.60 inches/hour peak intensity, the frequency of those higher-intensity storms was lower for 2020. For example, as shown in Table 5-7, the Ward Street Headworks gage had one storm greater than 0.60 inches/hour; Columbus Park Headworks and Chelsea Creek Headworks gauges each had three storms greater than 0.60 inches/hour, and the Fresh Pond gauge had two storms greater than 0.60 inches/hour.

For storms with peak rainfall intensities greater than 0.4 in/hr at Ward Street Headworks, Columbus Park Headworks, Chelsea Creek Headworks, and USGS Fresh Pond rain gauges, hyetographs were developed. These hyetographs show the 15-minute rainfall intensities and show the distribution of rainfall during the storm. Rainfall distribution during a storm can impact the behavior of system hydraulics due to soil saturation. For example, a storm where the peak rainfall occurs towards the end of the event will generally create more CSO than a storm with similar total rainfall and peak intensity, where the peak occurs at the beginning of the storm. An example hyetograph is shown in Figure 5-2, with the remaining hyetographs in Appendix C.

Table 5-7. Comparison of Storms Between January 1 and December 31, 2020 and the Typical Year with Peak Intensities Greater than 0.40 inches/hour

Rain Gauge	Date	Duration (hours)	Total Rainfall (inches)	Average Intensity (inch/hour)	Peak Hourly Intensity (inch/hour)	Storm Recurrence Interval (1-hour)
Typical Year	10/23/1992	4	1.18	0.29	1.08	1-2y
	8/11/1992	11	0.87	0.08	0.75	6m-1y
	8/15/1992	72	2.91	0.04	0.66	3m-6m
	9/22/1992	23	2.76	0.12	0.65	3m-6m
	5/2/1992	7	1.14	0.16	0.63	3m-6m
	9/9/1992	1	0.57	0.57	0.57	3m
	9/3/1992	13	1.19	0.09	0.51	< 3m
	6/5/1992	18	1.34	0.07	0.44	< 3m
	10/9/1992	65	2.04	0.03	0.42	< 3m
January-December 2020 Metering Data						
Ward Street Headworks (BO-DI-1)	3/23/2020 14:30	15	2	0.13	0.50	< 3m
	6/6/2020 14:30	6.5	0.69	0.11	0.60	3m
	6/11/2020 12:15	5.75	0.67	0.12	0.47	< 3m
	6/28/2020 12:30	48.5	2.04	0.04	1.09	1-2y
	7/23/2020 15:30	0.75	0.49	0.65	0.49	<3m
	7/31/2020 8:30	0.25	0.69	2.76	0.69	6m
	8/23/2020 15:45	4	0.62	0.16	0.50	<3m
	9/30/2020 1:45	8.25	0.98	0.12	0.47	<3m
	10/13/2020 4:30	17.5	1.69	0.10	0.41	<3m
	11/23/2020 4:00	9	1.80	0.05	0.44	<3m
Columbus Park Headworks (BO-DI-2)	3/23/2020 14:30	23.25	2.15	0.09	0.55	3m
	6/6/2020 14:30	6.75	0.67	0.10	0.62	3m-6m
	6/11/2020 12:15	5.5	0.57	0.10	0.43	< 3m
	6/28/2020 12:30	48.5	1.33	0.03	0.60	3m
	7/23/2020 15:45	0.5	0.72	1.44	0.72	6m
	8/23/2020 16:00	4	0.82	0.21	0.70	6m
	11/23/2020 0:45	9	1.76	0.05	0.50	<3m
	12/25/2020 2:45	15.75	1.37	0.02	0.41	<3m
Chelsea Creek Headworks (CH-BO-1)	3/23/2020 14:30	14.5	1.78	0.12	0.49	< 3m
	6/28/2020 12:30	48.25	2.11	0.04	0.70	6m
	7/14/2020 9:45	18.25	1.10	0.06	0.90	1y
	8/23/2020 15:45	4	0.97	0.24	0.93	1-2y
	12/25/2020 3:00	20.5	1.45	0.02	0.42	<3m
Fresh Pond (USGS)	3/23/2020 14:30	15	1.96	0.13	0.48	< 3m
	6/11/2020 12:15	22.75	0.68	0.03	0.50	< 3m
	6/28/2020 12:15	29.25	1.32	0.05	1.05	1y-2y
	7/23/2020 15:00	0.75	0.61	0.81	0.61	3m-6m
	8/23/2020 16:00	4	0.54	0.14	0.46	<3m
	9/30/2020 1:30	8	0.56	0.07	0.43	<3m
	11/23/2020 4:15	8.75	1.77	0.05	0.43	<3m

In summary, comparisons of the 2020 monitoring period to the Typical Year suggest that 2020 was similar, but slightly drier than the Typical Year rainfall and had fewer larger storms. The following is a summary of the rainfall comparison of January to December 2020 to the Typical Year:

- The Typical Year has 93 storm events, while the 2020 averaged 87 storm events (Table 5-5).
- The total average rainfall depth for 2020 (40.43 inches) was similar to but slightly less than the Typical Year (46.8 inches) (Table 5-5).
- 2020 had similar storm events with depths between 0.5 to 2.0 inches compared to the Typical Year. (Table 5-5).
- 2020 had fewer storm events with a total rainfall depth greater than 2 inches than the Typical year. In addition, while the largest storm for the rain gauges presented in Table 5-6 had 2.20 inches of rainfall, the Typical Year had five storms with greater than 2.20 inches, and the largest storm in the Typical Year had 3.89 inches of rainfall.
- 2020 had a generally similar number of events with intensities greater than 0.40 inches per hour compared with the Typical Year. However, while the Typical Year had five storms with greater than 0.60 inches/hour peak intensity, the frequency of those higher-intensity storms was lower for 2020.

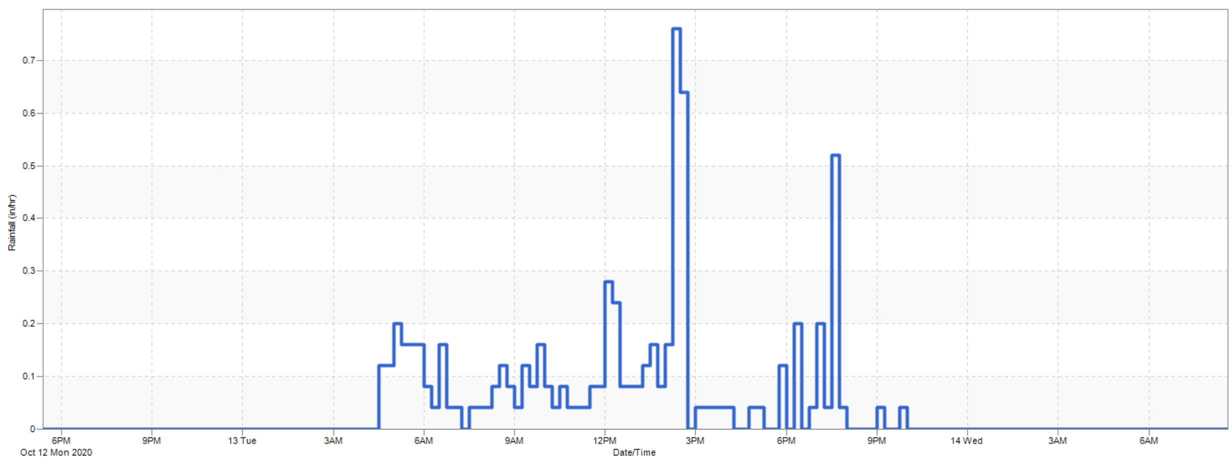

Figure 5-2. Hyetograph from the Ward Street Headworks Gauge for October 13, 2020

5.2. CSO Data Collection and Analyses

Permanent and temporary metering throughout the MWRA system provides a check of the model's ability to simulate system conditions as well as activation frequencies and volumes for remaining active CSO regulators. Meters can measure depth or depth and velocity. In locations where depth and velocity meters are installed the flows can be estimated.

5.2.1 Meter Locations and Purposes

Three primary types of metering are conducted within the MWRA system: (1) interceptor metering; (2) temporary metering, and (3) CSO regulator monitoring.

Interceptor meters provide measurement of the water levels and/or computation of flows within the MWRA's interceptors. MWRA has a number of interceptor meters throughout the system that identify flows and water levels through major pipes.

Temporary meters were installed as part of the evaluations of specific areas of the MWRA system as described below:

- **Downstream of SOM001A in the Alewife Brook Conduit:** This meter was installed for the purpose of evaluating the HGL in the Alewife Brook Conduit.
- **Condor Street Level Meter near BOS013:** This meter was installed for the purpose of evaluating the capacity of the Condor Street interceptor as part of ongoing efforts to reduce CSO activations in the East Boston area.

- **Somerville Ten Hills:** This meter was installed for the purpose of quantifying the flows and evaluating the model's ability to replicate incoming flows tributary to Somerville-Marginal CSO Facility from the Ten Hills area.

CSO regulator metering is configured to identify the CSO activation frequency, duration, and in some cases volumes.

The MWRA monitors all active CSO outfalls that are owned and operated by MWRA. Recently, the MWRA successfully initiated the CSO public notification program. This program provides notification of active CSO regulators within 2 hours of a regulator activating, informing the public of the location, frequency, and duration of CSO activations. The notification program provides subscribers with text and/or email notifications of CSO activations. Table 5-8 identifies the CSO outfalls that MWRA monitors and are part of the CSO notification program. An example of the CSO notification website is shown in Figure 5-3 with the locations monitored (See Table 5-1Table 5-8 for letter key).

Table 5-8. MWRA Monitored CSOs in the MWRA Notification Program

CSO Outfall	Outfall Location	Potentially Affected Area	Location (Figure 5-3)
SOM007A/ MWR205A	Baxter Park/Assembly Row, just downstream of Rte. 28 Bridge	Mystic River	A
MWR205	Draw Seven Park	Lower Mystic River (marine)	B
BOS019	Charlestown, near mouth of Little Mystic Channel	Little Mystic Channel and confluence of Mystic and Chelsea Rivers	C
MWR203	Upper Inner Harbor, upstream of N. Washington St. bridge	Boston Inner Harbor	D
MWR215	Head of Fort Point Channel near the Broadway Street Bridge	Fort Point Channel	E
BOS081-086	South Boston beaches along Day Boulevard	South Boston beaches, North Dorchester Bay	F
MWR020	Downstream end of Charles R. Esplanade	Charles River between Esplanade and Science Museum	G
MWR019	Middle of Charles River Esplanade	Charles River between Esplanade and Science Museum	H
MWR018	Upstream end of Charles R. Esplanade	Charles River between Esplanade and Science Museum	I
MWR023	Boston side of river, near Fenway exit from Storrow Drive	Charles River from just upstream of Harvard Bridge (Mass. Ave.) to Science Museum	J
MWR010	Charles River near Boston University	Charles River between the Boston University Bridge and Science Museum	K
MWR201	Cottage Farm CSO Storage and Treatment Facility, Between Magazine Park and BU Bridge	Charles River from just upstream of the Boston University Bridge to Science Museum	L
MWR003	Alewife Brook Reservation near Alewife T station	Little River and Alewife Brook	M

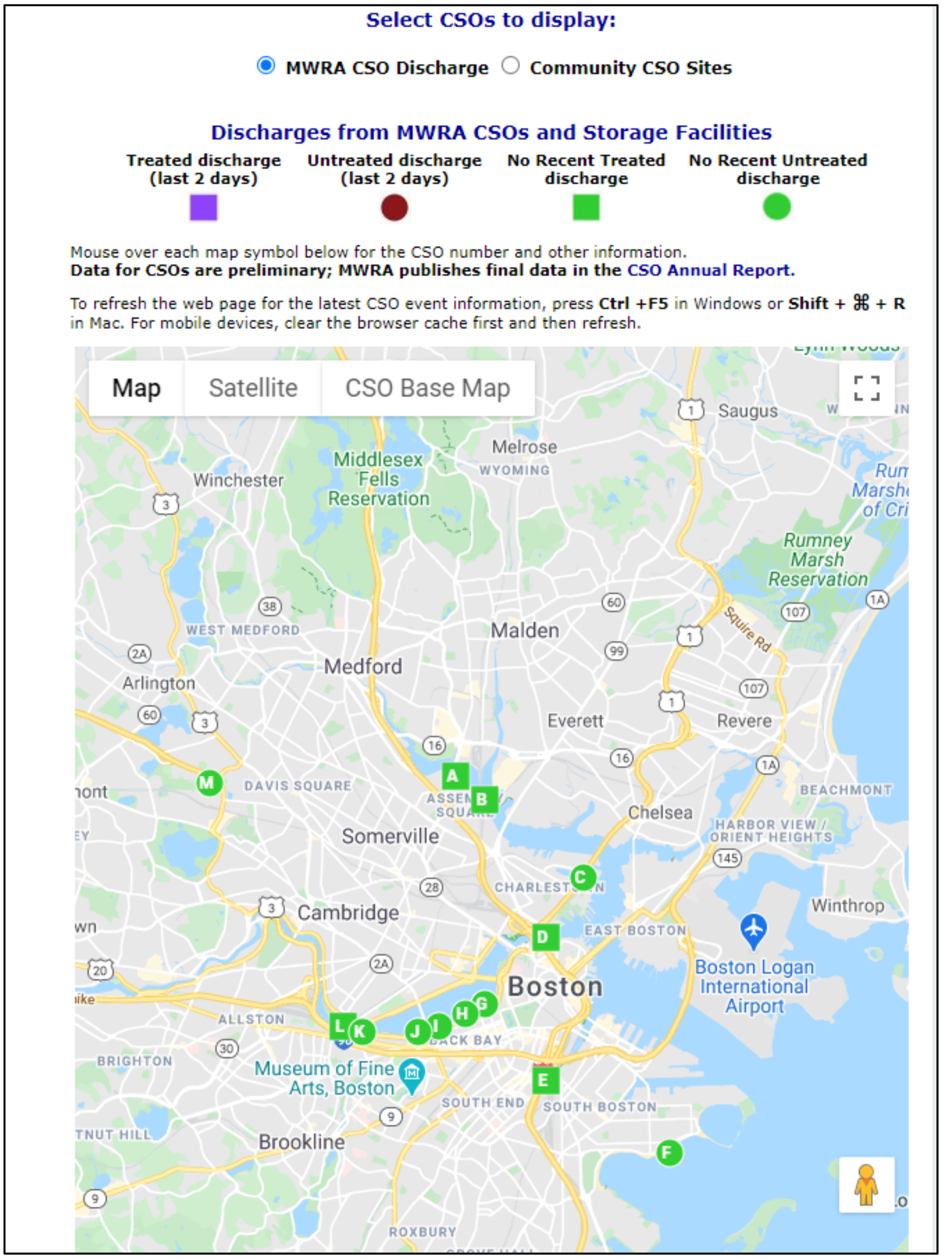

Figure 5-3. MWRA CSO Notification Reporting

5.3. Modeled Estimates of CSO Discharges July 1, 2020 - December 31, 2020

MWRA's recently calibrated model, updated to the Q3Q4-2020 system conditions, was used to simulate the storm events from July 1, 2020 to December 31, 2020. The comparison of metered and modeled CSO discharges from July 1, 2020 to December 31, 2020 is presented in Table 5-9. The model was able to replicate the storm responses for the majority of storm events in the Q3Q4-2020 period. However, it is not possible to match all of the modeled and metered activations for every meter and storm event due to rainfall data quality and rainfall spatial variation, unknown transient conditions in the collection system, and the accuracy of metering data (see Section 4.2, *Model Calibration and Factors Affecting Model Results*). For example, the November 30-December 1, 2020 storm event had significant rainfall variation that was not successfully captured by both the rain gauges and the model. As a result, in some locations the model over-predicted the activations, while in other locations the model did not predict activations where the meter indicated activations occurred. Additional information on differences between modeled and metered CSO activations can be found in Semiannual Report No. 5, Section 4.2.

Table 5-9. Summary of July 1-December 31, 2020 Modeled and Metered CSO Discharges (1 of 2)

Outfall	Regulator	July 1-December 31, 2020			
		Meter		Model	
		Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)
Alewife Brook					
CAM001	RE-011	-	-	0	0.00
CAM002	RE-021	-	-	0	0.00
MWR003	RE-031	1	0.01	0	0.00
CAM401A	RE-401	-	-	2	0.10
CAM401B	RE-401B	-	-	1	0.04
SOM001A	RE-01A	-	-	1	0.00
Upper Mystic River					
SOM007A/MWR205A		4	10.99	2	5.61
Mystic/Chelsea Confluence					
MWR205 (Somerville-Marginal CSO Facility)		13	51.62	13	41.59
BOS013	RE013-1	-	-	5	0.08
BOS014	RE014-2	-	-	12	0.48
BOS017	RE017-3	-	-	1	0.03
CHE003	RE-031	-	-	0	0.00
CHE004	RE-041	-	-	2	0.64
CHE008	RE-081	-	-	11	0.58
Upper Inner Harbor					
BOS009	RE009-2	-	-	14	0.28
BOS010	RE010-2	-	-	4	0.17
BOS012	RE012-2	-	-	1	0.01
BOS019	RE019-2	2	1.07	0	0.00
BOS057	RE057-6	-	-	2	0.02
BOS060	RE060-7	-	-	2	0.03
	RE060-20	-	-	1	0.08
MWR203 (Prison Point)		8	102.62	9	113.56
Lower Inner Harbor					
BOS003	RE003-2	-	-	1	0.02
	RE003-7	-	-	5	0.58
	RE003-12	-	-	5	1.45
BOS004	RE004-6	-	-	3	0.01
BOS005	RE005-1	-	-	0	0.00
Fort Point Channel					
BOS062	RE062-4	-	-	4	0.04
BOS064	RE064-4	-	-	0	0.00
	RE064-5	-	-	3	0.02
BOS065	RE065-2	-	-	3	0.11
BOS068	RE068-1A	-	-	0	0.00
BOS070/DBC	RE070/8-3	-	-	3	0.39
	RE070/8-6	-	-	0	0.00
	RE070/8-7	-	-	4	0.07

Table 5-9. Summary of July 1-December 31, 2020 Modeled and Metered CSO Discharges (2 of 2)

Outfall	Regulator	July 1-December 31, 2020			
		Meter		Model	
		Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)
Fort Point Channel (cont.)					
BOS070/DBC (*cont.)*	RE070/8-8	-	-	0	0.00
	RE070/8-13	-	-	0	0.00
	RE070/8-15	-	-	0	0.00
	RE070/9-4	-	-	3	0.39
	RE070/10-5	-	-	0	0.00
	RE070/7-2	-	-	13	0.62
MWR215 (Union Park)		5	10.4	6	13.65
BOS070/RCC	RE070/5-3	-	-	0	0.00
BOS073	RE073-4	-	-	0	0.00
Reserved Channel					
BOS076	RE076/2-3	-	-	0	0.00
	RE076/4-3	-	-	1	0.00
BOS078	RE078-1 RE078-2	-	-	0	0.00
BOS079	RE079-3	-	-	0	0.00
BOS080	RE080-2B	-	-	0	0.00
Upper Charles					
CAM005	RE-051	-	-	4	0.09
CAM007	RE-071	-	-	0	0.00
Lower Charles					
CAM017	CAM017	-	-	0	0.00
MWR010	RE036-9	0	0	0	0.00
	RE037	0	0	0	0.00
MWR018		0	0.00	0	0.00
MWR019		0	0.00	0	0.00
MWR020		0	0.00	0	0.00
MWR201 (Cottage Farm)		2	2.04	1	2.73
MWR023	RE046-19	-	-	0	0.00
	RE046-30	-	-	0	0.00
	RE046-50	-	-	0	0.00
	RE046-54	-	-	0	0.00
	RE046-55	-	-	0	0.00
	RE046-62A	-	-	0	0.00
	RE046-90	-	-	0	0.00
	RE046-100	-	-	0	0.00
	RE046-105	-	-	0	0.00
	RE046-381	-	-	0	0.00
	RE046-192	-	-	0	0.00
Back Bay Fens					
BOS046	Boston Gatehouse #1	-	-	0	0
GRAND TOTAL			-	14 (max)	177.86

The comparison in Table 5-9 shows closeness of the metered and modeled discharges, with greater differences at the locations shown in Table 1-8.

Table 5-10. Notable Differences between Metered and Modeled CSO Discharges, July 1 -December 31, 2020

Location	Meter	Model	Comment
SOM007A/MWR205A	4 activations 10.99 MG	2 activations 5.61 MG	• The metered activations occurred on: 08/23/2020, 11/30/2020, 12/4/2020 and 12/25/2020. The model activated on 08/23/2020 and 12/5/2020. The 11/30/2020 had highly variable rainfall. • The model had less discharge volume mostly tied to missing the activation for the 11/30/2020 storm due to the highly variable rainfall. • The discharge volume at this location is tied to the discharge at the Somerville-Marginal CSO facility, the tide, and the stormwater coming in downstream of the facility. There is some uncertainty in the volume of stormwater entering downstream of the Somerville-Marginal CSO Facility.
Somerville Marginal CSO Facility	13 activations 51.62 MG	13 activations 41.59 MG	• The model had less discharge volume due to rainfall variability mostly tied to the 11/30/2020 storm event.
BOS019 Storage Facility	2 activations 1.07 MG	0 activation 0 MG	• The two metered activations occurred on 12/5/2020 and 12/25/2020. The rainfall on the 12/5/2020 storm was highly variable. • For the both events in the model water entered the storage tanks but it was not enough to cause and overflow.

6. Remaining Work and Assessments

6.1 Investigations at Outfalls Not Forecast to Attain LTCP Activation and Volume Goals

MWRA continues to make progress with the site-specific investigations that are intended to identify and develop additional CSO mitigation measures at outfalls which are not forecast to attain LTCP activation and volume goals by December 2021. These include outfalls where MWRA is further developing or implementing specific measures recommended from the investigations so far (Table 6-1), as well as outfalls where additional investigations continue to identify and evaluate potential CSO reduction alternatives (Table 6-2). More information on these investigations, along with recommended or potential CSO control measures and their estimated CSO reduction benefits, was presented in Chapter 0.

Table 6-1. Implementation of Recommended Additional CSO Control Measures

OUTFALL	CSO CONTROL MEASURE	IMPLEMENTATION SCHEDULE
Somerville Marginal*		
MWR205 (Somerville Marginal CSO Facility)	Relieve interceptor connection; redirect separate stormwater; and replace tide gate	MWRA continues to identify and evaluate alternatives that replace or relieve the existing 18-inch interceptor connection. MWRA and City of Somerville also continue to coordinate investigations into the feasibility of removing separate stormwater connections to the sewer system. MWRA plans to award the construction contract to replace the tide gate in the MWR205 outfall in July 2021 and complete the work by February 2022.
SOM007A/MWR205A		
East Boston		
BOS003	Replace/upsize restricted interceptor connection at regulator RE003-12; close regulators RE003-2 and RE003-7.	BWSC has added the CSO control measures at BOS003 to Contract 3 Sewer Separation. BWSC plans to award Contract 3 by June 2021 and complete the work by June 2023.
BOS009	BWSC Contract 3 Sewer Separation	
BOS014	Construct new interceptor connection	MWRA and BWSC are coordinating the establishment and scheduling of design and construction contracts.
Chelsea		
CHE008	Replace/upsize interceptor connection	MWRA completed preliminary design and issued notice to proceed with final design in March 2021. MWRA plans to commence construction in February 2022 and complete construction in August 2022.
Fort Point Channel		
BOS070/DBC (all regulators except RE070/7-2)	BWSC South Boston Sewer Separation Contract 1 and Contract 2	BWSC recently awarded Contract 1 and expects to complete the work in 2023. BWSC is making progress with design of Contract 2 and plans to award the contract in 2022 and complete the work in 2024.

*The listed outfalls and all other active outfalls in these areas are the subject of CSO optimization evaluations required by conditions in the CSO variances.

Table 6-2. Continuing CSO Control Investigations and Evaluations

OUTFALL	POTENTIAL CSO CONTROLS	PROGRESS AND REMAINING WORK
ALEWIFE BROOK*		
SOM001A	• Identify potential upstream flow controls	MWRA has evaluated regulator modifications, including weir raising and interceptor connection relief. MWRA is coordinating with City of Somerville to investigate, identify and evaluate upstream flow controls in the Tannery Brook Conduit system.
MYSTIC/CHELSEA CONFLUENCE		
BOS017	• Remove sources of tidal inflow • Raise weir • Improve interceptor connection capacity	MWRA has updated and recalibrated its hydraulic model to incorporate the results of recent BWSC inspections. MWRA is now identifying and evaluating potential CSO reduction alternatives using the recalibrated model. MWRA is also conducting system inspections to attempt to locate the sources of tidal inflow.
FORT POINT CHANNEL		
BOS062	• Raise weir • Relieve interceptor connection	MWRA has modeled preliminary weir raising and interceptor connection relief alternatives for both outfalls, and continues to evaluate these and other system modifications.
BOS065	• Raise weir • Relieve interceptor connection	
BOS070/DBC (regulator RE070/7-2)	• Modify the regulator structure	With the modeling of South Boston Sewer Separation contracts now complete and showing little or no benefit at regulator RE070/7-2, MWRA is moving to evaluate regulator modifications.
CHARLES RIVER*		
MWR201 (Cottage Farm)	• Evaluate benefits of Cambridge's planned sewer separation projects • Further optimize Cottage Farm facility operations • Optimize Ward Street Headworks capacity	Following Cambridge's completion of its partial sewer separation improvements (and gaining related CSO benefits) in August 2020, MWRA is working with the City of Cambridge to evaluate the potential CSO benefits of City-planned sewer separation projects in tributary areas. MWRA also plans to evaluate whether wet weather operations at the Cottage Farm facility and the Ward Street Headworks can be further optimized.
CAM005	• Remove pipe obstructions • Raise weir • Separate upstream areas	Cambridge plans to remove pipe segment obstructions that may be causing head loss downstream of the CAM005 regulator. Recent MWRA modeling shows some benefit by raising the overflow weir, and is evaluating the results and feasibility with Cambridge. MWRA is working with the City of Cambridge to evaluate the potential CSO benefits of City-planned sewer separation projects in tributary areas.
MWR018 MWR019 MWR020	• Raise weirs • Lower localized BMC head loss • Redirect upstream BWSC separate storm drains	MWRA updated and recalibrated its hydraulic model with information from recent survey and internal inspections, and is now identifying potential regulator and system adjustments. MWRA is working with BWSC to identify the feasibility of removing certain upstream separate storm drain connections.

*The listed outfalls and all other active outfalls in these areas are the subject of CSO optimization evaluations required by conditions in the CSO variances.

6.2 Water Quality Monitoring, Receiving Water Modeling, and Water Quality Assessments

MWRA continues to collect water quality data in each of the receiving waters. This data will continue to be analyzed to assess the water quality in the receiving waters.

As discussed in Chapter 2, MWRA submitted the Draft Water Quality Assessment Report to DEP and EPA in April 2021. The CSO communities will also have the opportunity to review the draft submittal in parallel with DEP and EPA. MWRA intends to schedule meetings with DEP, EPA and the CSO communities to provide an overview of the contents of the report and an opportunity for comments. These meetings will also provide an opportunity to identify suggestions for additional water quality model runs to be conducted for sensitivity analyses and to assess the impact of additional CSO control measures. The Final Water Quality Assessment Report will be submitted to DEP and EPA in August 2021.

The water quality models will also be applied to assess the potential benefits of additional CSO reduction alternatives in terms of improvement in attainment of water quality criteria. Alternatives based on specific system improvements will be simulated, and additional sensitivity runs may be conducted. MWRA intends to coordinate with EPA and DEP to identify the additional evaluations to be conducted as part of the alternatives evaluations. The results of the alternative evaluations will be documented in the Alternatives Simulation Report which will be submitted in draft form to DEP and EPA in October 2021 for review. Similar to the Water Quality Assessment, the CSO communities will also have the opportunity to review the draft submittal in parallel with DEP and EPA. MWRA intends to schedule meetings with DEP, EPA and the CSO communities to provide an overview of the contents of the report and an opportunity for comments. The Final Alternatives Simulation Report will be submitted to DEP and EPA in December 2021.

6.3 Continued Data Collection and Analysis

MWRA will continue to collect data including rainfall, receiving water quality sampling, and meter data throughout the collection system. This data will continue to be used to analyze rain events, monitor receiving water quality, identify and quantify volumes for CSO activations, and provide a verification of the model's ability to continue to replicate system conditions. The information on active MWRA CSO outfalls can be obtained within two hours of a CSO event through the MWRA CSO Notification Program.

In addition, data will continue to be collected to update the model for the January 1, 2021 through June 30, 2021 period. The model will be used to prepare the meter versus model comparison table as it has been for previous reports. Data for environmental variables such as rainfall, tide and evaporation will be collected because they serve as inputs to the model. Rainfall data will continue to be analyzed from the 17 gauges within the MWRA wastewater service area that have been used for the CSO performance assessment since the beginning of the data collection efforts in April 2018. Most of these gauges are located in or near areas served by combined sewers. CSO Facility gate operation data from MWRA's SCADA system will also be collected for storm events. The model will be updated to include these data for the January 1, 2021 through June 30, 2021 period to reflect actual operating conditions as it has been for the past reporting periods.

6.4 Other Efforts and Projects Expected to Improve CSO Performance

In addition to the projects and system adjustments that have been implemented or recommended or continue to be identified and evaluated within the scope of MWRA's CSO performance assessment, MWRA is tracking other system improvements that may also contribute to CSO reduction. These system improvements, while beyond the scope of the performance assessment, nonetheless are the subject of regular discussion and coordination with the CSO communities. MWRA intends to evaluate the potential CSO benefits of these system improvements when sufficient information regarding design and operational criteria and construction schedule is available.

The City of Somerville expects to complete over the next few years a large stormwater conduit along Somerville Avenue and Union Square and a related pumping station on Poplar Street that will allow the City to remove large quantities of stormwater from its sewer system. The separated stormwater will be pumped into a storm drain recently constructed by the MBTA to serve portions of the Green Line Extension (GLX). The GLX drain conveys stormwater to the Charles River Basin via the Millers River. While this City project is intended to lower the risk of flooding in the Union Square area and offset the impacts of major planned development projects, it will also reduce wet weather burden on MWRA's Cambridge Branch Sewer, thereby reducing overflows from the Somerville system to MWRA's Prison Point CSO facility and potentially reducing Prison Point's treated discharges.

The City of Chelsea has begun to implement a sewer separation master plan that among its long-term goals includes the closing of its three CSO outfalls: CHE003, CHE004 and CHE008. The City is focusing its efforts first in areas tributary to CHE004, and initial construction projects in the master plan are already underway.

MWRA also tracks the efforts by the CSO communities (as well as efforts by its other communities) to remove infiltration and inflow (I/I) from their sewer systems in part to comply with I/I mitigation requirements in Massachusetts Department of Environmental Protection regulations. The requirements are intended to offset the potential wastewater impacts, including potential CSO impacts, of new wastewater flows from larger development projects. In the CSO communities, I/I mitigation is often accomplished with sewer separation. When significant I/I removal work is planned or completed, MWRA incorporates the flow reduction as an update to its hydraulic model.

All of the CSO communities - BWSC, Cambridge, Chelsea and Somerville - are continuing with substantial efforts at great cost to improve their sewer system records, maps and models. New information from their efforts are a regular topic of discussion during MWRA and community CSO coordination meetings. The communities' sewer system investigations and improved modeling capabilities have supported new maintenance and capital improvements that reduce wet weather burdens on their and MWRA's sewer systems.

6.5 Progress Updates and Related Reports

Table 6-3Table 6-3. Scheduled Progress Updates and Related Reports identifies remaining progress updates on the CSO performance assessment, as well as scheduled MWRA reports directly or indirectly related to the performance assessment.

Table 6-3. Scheduled Progress Updates and Related Reports

Report/Progress Update	Date
Annual CSO Discharge Report - 2020	April 30, 2021
Annual CSO Public Briefing	May 21, 2021
Receiving Water Quality Monitoring Report - 2020	July 15, 2021
Final Water Quality Assessment Report	August 2021
Semiannual Progress Report No. 7	October 31, 2021
Final Alternatives Simulation Report	December 2021
Final Water Quality Impact Report	December 2021
Final CSO Post-Construction Monitoring and Performance Assessment	

6.6 Progress Toward Semiannual Progress Report No. 7 (October 2021)

MWRA plans to issue the next semiannual report (Semiannual CSO Discharge Report No. 7) in October 2021. The following efforts are underway or are planned to be conducted over the next several months.

- Continued coordination of CSO performance assessment activities with the CSO communities, including updates to the MWRA hydraulic model with any new system information that becomes available, review of MWRA and community measured and modeled CSO discharges, and evaluation of CSO mitigation alternatives.
- Continued collection and analysis of data from rainfall gauges, remaining MWRA CSO and sewer system meters, and MWRA facility operational records.
- Monitoring of receiving water quality in waters potentially impacted by CSO.
- Use of receiving water quality models of the Charles River and the Alewife Brook/Upper Mystic River to assess alternatives and conduct sensitivity analyses.
- Recommendation of further short-term and long-term CSO mitigation measures from site-specific evaluations.

Appendix A Rainfall Data for January 1 through June 30, 2020

Appendix B Rainfall Summary Tables

Rain Gauge 1: Allston

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval [(1)]		
								1-hr	24-hr	48-hr
1	7/1/2020 3:00	0.25	0.01	0.04	0.01	0.00	N/A	<3m	<3m	N/A
2	7/5/2020 21:30	1.25	0.21	0.17	0.19	0.01	N/A	<3m	<3m	N/A
3	7/10/2020 14:30	9.75	0.16	0.02	0.11	0.01	N/A	<3m	<3m	N/A
4	7/13/2020 13:00	0.5	0.08	0.16	0.08	0.00	N/A	<3m	<3m	N/A
5	7/14/2020 10:00	0.25	0.01	0.04	0.39	0.00	N/A	<3m	<3m	N/A
6	7/15/2020 4:15	3.5	0.02	0.01	0.01	0.00	N/A	<3m	<3m	N/A
7	7/17/2020 5:15	2	0.14	0.07	0.09	0.01	N/A	<3m	<3m	N/A
8	7/22/2020 5:45	17	0.33	0.02	0.22	0.01	N/A	<3m	<3m	N/A
9	7/23/2020 15:45	0.75	0.39	0.52	0.39	0.03	N/A	<3m	<3m	N/A
10	8/2/2020 16:30	0.75	0.02	0.03	0.02	0.00	N/A	<3m	<3m	N/A
11	8/4/2020 15:45	1.25	0.18	0.14	0.17	0.01	N/A	<3m	<3m	N/A
12	8/16/2020 18:15	5.5	0.19	0.03	0.08	0.01	N/A	<3m	<3m	N/A
13	8/17/2020 22:45	4	0.07	0.02	0.05	0.00	N/A	<3m	<3m	N/A
14	8/19/2020 14:45	3.5	0.06	0.02	0.46	0.00	N/A	<3m	<3m	N/A
15	8/23/2020 16:00	4	0.54	0.14	0.46	0.02	N/A	<3m	<3m	N/A
16	8/27/2020 12:45	1.25	0.21	0.17	0.18	0.01	N/A	<3m	<3m	N/A
17	8/29/2020 9:45	3.5	0.1	0.03	0.05	0.00	N/A	<3m	<3m	N/A
18	9/2/2020 11:15	24.75	0.28	0.01	0.18	0.01	N/A	<3m	<3m	N/A
19	9/10/2020 16:30	3.25	0.48	0.15	0.39	0.02	N/A	<3m	<3m	N/A
20	9/30/2020 2:00	8.25	0.63	0.08	0.29	0.03	N/A	<3m	<3m	N/A
21	10/2/2020 14:45	0.5	0.02	0.04	0.02	0.02	N/A	<3m	<3m	N/A
22	10/7/2020 17:00	0.25	0.04	0.16	0.04	0.04	N/A	<3m	<3m	N/A
23	10/13/2020 4:45	15.75	1.41	0.09	0.34	0.34	N/A	<3m	<3m	N/A
24	10/16/2020 12:15	19.75	1.92	0.10	0.28	0.28	N/A	<3m	<3m	N/A
25	10/21/2020 5:30	2.5	0.03	0.01	0.34	0.34	N/A	<3m	<3m	N/A
26	10/28/2020 3:45	12.75	0.31	0.02	0.08	0.08	N/A	<3m	<3m	N/A
27	10/29/2020 10:00	20.75	1.15	0.06	0.17	0.17	N/A	<3m	<3m	N/A
28	10/31/2020 9:45	1.75	0.08	0.05	0.00	0	N/A	<3m	<3m	N/A
29	11/1/2020 15:15	7	0.59	0.08	0.25	0.00	N/A	<3m	<3m	N/A
30	11/12/2020 0:15	0.25	0.01	0.04	0.01	0.00	N/A	<3m	<3m	N/A
31	11/13/2020 1:45	16.25	0.31	0.02	0.07	0.01	N/A	<3m	<3m	N/A
32	11/15/2020 20:30	5.75	0.42	0.07	0.26	0.02	N/A	<3m	<3m	N/A
33	11/23/2020 4:15	8.75	1.65	0.19	0.39	0.07	N/A	<3m	<3m	N/A
34	11/25/2020 20:15	18.75	0.32	0.02	0.11	0.01	N/A	<3m	<3m	N/A
35	11/30/2020 12:00	16.75	2.34	0.14	0.30	0.06	N/A	<3m	<3m	N/A
36	12/5/2020 3:00	19.5	2.13	0.11	0.23	0.09	N/A	<3m	3-6m	N/A

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval [1]		
								1-hr	24-hr	48-hr
37	12/12/2020 12:30	10	0.47	0.05	0.15	0.02	N/A	<3m	<3m	N/A
38	12/14/2020 9:00	7.75	0.05	0.01	0.01	0.00	N/A	<3m	<3m	N/A
39	12/18/2020 15:15	0.25	0.01	0.04	0.01	0.00	N/A	<3m	<3m	N/A
40	12/19/2020 10:30	3.5	0.10	0.03	0.32	0.00	N/A	<3m	<3m	N/A
41	12/20/2020 15:30	0.25	0.01	0.04	0.01	0.00	N/A	<3m	<3m	N/A
42	12/21/2020 9:15	0.75	0.03	0.04	0.03	0.00	N/A	<3m	<3m	N/A
43	12/25/2020 2:45	16.25	1.87	0.12	0.32	0.08	N/A	<3m	3m	N/A
44	12/31/2020 4:30	1.75	0.10	0.06	0.08	0.00	N/A	<3m	<3m	N/A

(1) Recurrence intervals given in ranges of less than 3 months (<3m), 3-months, (3m), 3-6 months (3-6m), 6 months (6m), 6 months-1 year (6m-1yr), 1 year (1yr), 1 year to 2 year (1yr-2yr), 2 year (2yr) or the nearest year.

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Rain Gauge 2: Ward Street

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval [(1)]		
								1-hr	24-hr	48-hr
1	7/1/2020 6:15	0.25	0.01	0.04	0.01	0.00	N/A	<3m	<3m	N/A
2	7/5/2020 21:15	1.5	0.19	0.13	0.17	0.01	N/A	<3m	<3m	N/A
3	7/10/2020 17:00	6.25	0.11	0.02	0.10	0.00	N/A	<3m	<3m	N/A
4	7/13/2020 13:15	0.25	0.19	0.76	0.19	0.01	N/A	<3m	<3m	N/A
5	7/14/2020 9:45	0.5	0.11	0.22	0.11	0.01	N/A	<3m	<3m	N/A
6	7/15/2020 4:00	1	0.03	0.03	0.03	0.01	N/A	<3m	<3m	N/A
7	7/17/2020 5:15	2	0.15	0.08	0.10	0.01	N/A	<3m	<3m	N/A
8	7/22/2020 5:30	17	0.42	0.02	0.33	0.02	N/A	<3m	<3m	N/A
9	7/23/2020 15:30	0.75	0.49	0.65	0.49	0.04	N/A	<3m	<3m	N/A
10	7/31/2020 8:30	0.25	0.69	2.76	0.69	0.03	N/A	<3m	<3m	N/A
11	8/2/2020 16:15	0.25	0.03	0.12	0.03	0.00	N/A	<3m	<3m	N/A
12	8/4/2020 15:30	1.25	0.19	0.15	0.17	0.01	N/A	<3m	<3m	N/A
13	8/16/2020 18:00	5.25	0.22	0.04	0.11	0.01	N/A	<3m	<3m	N/A
14	8/18/2020 1:15	1.25	0.07	0.06	0.06	0.00	N/A	<3m	<3m	N/A
15	8/19/2020 17:45	0.25	0.03	0.12	0.03	0.00	N/A	<3m	<3m	N/A
16	8/23/2020 15:45	4	0.62	0.16	0.50	0.03	N/A	<3m	<3m	N/A
17	8/27/2020 12:30	2.25	0.25	0.11	0.20	0.01	N/A	<3m	<3m	N/A
18	8/29/2020 9:30	2.5	0.07	0.03	0.04	0.00	N/A	<3m	<3m	N/A
19	9/2/2020 11:00	25.25	0.25	0.01	0.12	0.01	0.01	<3m	<3m	N/A
20	9/10/2020 13:45	6	0.32	0.05	0.15	0.01	N/A	<3m	<3m	N/A
21	9/30/2020 1:45	8.25	0.98	0.12	0.47	0.04	N/A	<3m	<3m	N/A
22	10/7/2020 16:45	0.5	0.17	0.34	0.17	0.01	N/A	<3m	<3m	N/A
23	10/13/2020 4:30	17.5	1.69	0.10	0.41	0.07	N/A	<3m	<3m	N/A
24	10/16/2020 12:00	20	1.94	0.10	0.30	0.08	N/A	<3m	3m	N/A
25	10/20/2020 9:00	0.25	0.19	0.76	0.19	0.01	N/A	<3m	<3m	N/A
26	10/21/2020 4:30	0.25	0.01	0.04	0.01	0.01	N/A	<3m	<3m	N/A
27	10/28/2020 3:45	0.25	0.01	0.04	0.01	0.00	N/A	<3m	<3m	N/A
28	10/29/2020 8:15	22.75	0.17	0.01	0.03	0.01	N/A	<3m	<3m	N/A
29	10/31/2020 10:00	0.25	0.01	0.04	0.00	0.00	N/A	<3m	<3m	N/A
30	11/1/2020 15:15	7.25	0.63	0.09	0.23	0.00	N/A	<3m	<3m	N/A
31	11/11/2020 23:30	0.25	0.01	0.04	0.01	0.00	N/A	<3m	<3m	N/A
32	11/13/2020 0:15	17.5	0.34	0.02	0.08	0.01	N/A	<3m	<3m	N/A
33	11/15/2020 20:45	4.5	0.51	0.11	0.34	0.02	N/A	<3m	<3m	N/A
34	11/23/2020 4:00	9	1.80	0.20	0.44	0.08	N/A	<3m	3m	N/A
35	11/25/2020 20:15	17.5	0.27	0.02	0.08	0.01	N/A	<3m	<3m	N/A
36	11/30/2020 11:45	26	1.77	0.07	0.23	0.04	0.02	<3m	<3m	N/A
37	12/4/2020 22:45	23	2.01	0.09	0.25	0.08	N/A	<3m	3m	N/A
38	12/12/2020 12:30	7.5	0.45	0.06	0.16	0.02	N/A	<3m	<3m	N/A

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
39	12/14/2020 9:45	7.25	0.04	0.01	0.01	0.00	N/A	<3m	<3m	N/A
40	12/16/2020 23:30	39.25	0.59	0.02	0.11	0.02	0.01	<3m	<3m	N/A
41	12/19/2020 10:15	4	0.09	0.02	0.04	0.00	N/A	<3m	<3m	N/A
42	12/20/2020 10:45	6.75	0.19	0.03	0.04	0.01	N/A	<3m	<3m	N/A
43	12/25/2020 2:45	15.75	1.63	0.10	0.30	0.07	N/A	<3m	<3m	N/A
44	12/31/2020 4:30	2	0.11	0.06	0.09	0.00	N/A	<3m	<3m	N/A

(1) Recurrence intervals given in ranges of less than 3 months (<3m), 3-months, (3m), 3-6 months (3-6m), 6 months (6m), 6 months-1 year (6m-1yr), 1 year (1yr), 1 year to 2 year (1yr-2yr), 2 year (2yr) or the nearest year.

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Rain Gauge 3: Columbus Park

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval [1]		
								1-hr	24-hr	48-hr
1	7/1/2020 6:00	0.25	0.01	0.04	0.01	0.00	N/A	<3m	<3m	N/A
2	7/5/2020 21:30	1	0.14	0.14	0.14	0.01	N/A	<3m	<3m	N/A
3	7/10/2020 23:30	0.25	0.01	0.04	0.01	0.00	N/A	<3m	<3m	N/A
4	7/13/2020 13:00	0.5	0.15	0.30	0.15	0.01	N/A	<3m	<3m	N/A
5	7/14/2020 10:00	18.75	0.18	0.01	0.10	0.01	N/A	<3m	<3m	N/A
6	7/17/2020 5:30	1.75	0.16	0.09	0.11	0.01	N/A	<3m	<3m	N/A
7	7/22/2020 5:30	17.25	0.35	0.02	0.23	0.01	N/A	<3m	<3m	N/A
8	7/23/2020 15:45	0.5	0.72	1.44	0.72	0.04	N/A	6m	<3m	N/A
9	7/31/2020 9:45	0.5	0.37	0.74	0.00	0.00	N/A	<3m	<3m	N/A
10	8/2/2020 16:15	0.75	0.04	0.05	0.04	0.00	N/A	<3m	<3m	N/A
11	8/4/2020 16:15	0.5	0.35	0.70	0.35	0.01	N/A	<3m	<3m	N/A
12	8/16/2020 17:45	10	0.31	0.03	0.11	0.01	N/A	<3m	<3m	N/A
13	8/18/2020 0:45	1.75	0.17	0.10	0.14	0.01	N/A	<3m	<3m	N/A
14	8/19/2020 17:45	0.5	0.04	0.08	0.04	0.00	N/A	<3m	<3m	N/A
15	8/23/2020 16:00	4	0.82	0.21	0.70	0.03	N/A	6m	<3m	N/A
16	8/27/2020 12:30	1.5	0.23	0.15	0.19	0.01	N/A	<3m	<3m	N/A
17	8/29/2020 9:45	2	0.05	0.03	0.04	0.00	N/A	<3m	<3m	N/A
18	9/2/2020 11:00	19.5	0.23	0.01	0.11	0.01	N/A	<3m	<3m	N/A
19	9/10/2020 16:00	4	0.26	0.07	0.19	0.01	N/A	<3m	<3m	N/A
20	9/28/2020 13:15	0.5	0.03	0.06	0.03	0.00	N/A	<3m	<3m	N/A
21	9/30/2020 1:30	8.5	0.61	0.07	0.32	0.03	N/A	<3m	<3m	N/A
22	10/2/2020 14:45	0.5	0.03	0.06	0.03	0.00	N/A	<3m	<3m	N/A
23	10/7/2020 17:00	0.25	0.06	0.24	0.06	0.00	N/A	<3m	<3m	N/A
24	10/13/2020 4:15	18	1.68	0.09	0.31	0.07	N/A	<3m	<3m	N/A
25	10/16/2020 12:30	19.5	2.11	0.11	0.31	0.09	N/A	<3m	3-6m	N/A
26	10/28/2020 2:45	14	0.31	0.02	0.10	0.01	N/A	<3m	<3m	N/A
27	11/1/2020 15:15	7.25	0.62	0.09	0.22	0.00	N/A	<3m	<3m	N/A
28	11/11/2020 23:30	0.25	0.01	0.04	0.01	0.00	N/A	<3m	<3m	N/A
29	11/13/2020 1:15	17.5	0.31	0.02	0.09	0.01	N/A	<3m	<3m	N/A
30	11/15/2020 21:45	3.75	0.31	0.08	0.20	0.01	N/A	<3m	<3m	N/A
31	11/23/2020 4:00	9	1.76	0.20	0.50	0.07	N/A	<3m	<3m	N/A
32	11/25/2020 20:00	21	0.28	0.01	0.09	0.01	N/A	<3m	<3m	N/A
33	11/30/2020 11:45	14.75	0.93	0.06	0.18	0.03	N/A	<3m	<3m	N/A
34	12/4/2020 22:00	23	1.98	0.09	0.30	0.08	N/A	<3m	3m	N/A
35	12/12/2020 12:15	6.5	0.53	0.08	0.23	0.02	N/A	<3m	<3m	N/A
36	12/14/2020 9:00	3.5	0.04	0.01	0.02	0.00	N/A	<3m	<3m	N/A
37	12/16/2020 22:45	15.75	0.51	0.03	0.12	0.02	N/A	<3m	<3m	N/A
38	12/19/2020 11:45	29.25	0.26	0.01	0.05	0.01	0.01	<3m	<3m	N/A

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
39	12/25/2020 2:45	15.75	1.37	0.09	0.41	0.06	N/A	<3m	<3m	N/A
40	12/31/2020 4:45	1.75	0.10	0.06	0.08	0.00	N/A	<3m	<3m	N/A

(1) Recurrence intervals given in ranges of less than 3 months (<3m), 3-months, (3m), 3-6 months (3-6m), 6 months (6m), 6 months-1 year (6m-1yr), 1 year (1yr), 1 year to 2 year (1yr-2yr), 2 year (2yr) or the nearest year.

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Rain Gauge 4: Charlestown

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval [1]		
								1-hr	24-hr	48-hr
1	7/1/2020 4:45	5.25	0.08	0.02	0.04	0.00	N/A	<3m	<3m	N/A
2	7/5/2020 21:30	1.25	0.15	0.12	0.12	0.01	N/A	<3m	<3m	N/A
3	7/13/2020 13:15	0.75	0.08	0.11	0.08	0.00	N/A	<3m	<3m	N/A
4	7/14/2020 10:00	21.5	0.36	0.02	0.24	0.02	N/A	<3m	<3m	N/A
5	7/17/2020 5:15	3.75	0.13	0.03	0.08	0.01	N/A	<3m	<3m	N/A
6	7/22/2020 5:45	0.5	0.03	0.06	0.03	0.00	N/A	<3m	<3m	N/A
7	7/22/2020 19:45	3.25	0.36	0.11	0.29	0.02	N/A	<3m	<3m	N/A
8	7/23/2020 16:00	0.75	0.52	0.69	0.52	0.04	N/A	<3m	<3m	N/A
9	8/2/2020 16:30	0.5	0.02	0.04	0.02	0.00	N/A	<3m	<3m	N/A
10	8/4/2020 16:30	3.25	0.23	0.07	0.22	0.01	N/A	<3m	<3m	N/A
11	8/16/2020 18:45	4.75	0.15	0.03	0.07	0.01	N/A	<3m	<3m	N/A
12	8/17/2020 23:30	3.25	0.06	0.02	0.05	0.00	N/A	<3m	<3m	N/A
13	8/19/2020 15:00	3.25	0.09	0.03	0.08	0.00	N/A	<3m	<3m	N/A
14	8/23/2020 16:00	4	0.84	0.21	0.73	0.04	N/A	6m	<3m	N/A
15	8/27/2020 12:45	1.75	0.17	0.10	0.14	0.01	N/A	<3m	<3m	N/A
16	8/29/2020 10:00	2.25	0.07	0.03	0.04	0.00	N/A	<3m	<3m	N/A
17	9/2/2020 11:15	3.5	0.25	0.07	0.17	0.01	N/A	<3m	<3m	N/A
18	9/10/2020 16:15	3.75	0.31	0.08	0.17	0.01	N/A	<3m	<3m	N/A
19	9/28/2020 13:45	0.25	0.01	0.04	0.01	0.00	N/A	<3m	<3m	N/A
20	9/30/2020 1:45	8.5	0.75	0.09	0.34	0.03	N/A	<3m	<3m	N/A
21	10/7/2020 17:00	0.5	0.06	0.12	0.06	0.00	N/A	<3m	<3m	N/A
22	10/13/2020 4:45	17.25	1.64	0.10	0.31	0.07	N/A	<3m	<3m	N/A
23	10/16/2020 12:15	19.75	2.15	0.11	0.30	0.09	N/A	<3m	3-6m	N/A
24	10/21/2020 4:45	4.25	0.07	0.02	0.02	0.00	N/A	<3m	<3m	N/A
25	10/28/2020 3:45	13	0.27	0.02	0.06	0.01	N/A	<3m	<3m	N/A
26	10/29/2020 10:15	20.75	1.17	0.06	0.16	0.05	N/A	<3m	<3m	N/A
27	10/31/2020 10:00	1.75	0.3	0.17	0.00	0.00	N/A	<3m	<3m	N/A
28	11/1/2020 14:45	7.75	0.64	0.08	0.21	0.00	N/A	<3m	<3m	N/A
29	11/13/2020 1:30	16.25	0.30	0.02	0.07	0.01	N/A	<3m	<3m	N/A
30	11/15/2020 20:30	12.25	0.51	0.04	0.34	0.02	N/A	<3m	<3m	N/A
31	11/23/2020 4:00	9	1.70	0.19	0.39	0.07	N/A	<3m	<3m	N/A
32	11/26/2020 2:45	10	0.24	0.02	0.08	0.01	N/A	<3m	<3m	N/A
33	11/27/2020 8:30	0.25	0.01	0.04	0.01	0.01	N/A	<3m	<3m	N/A
34	11/30/2020 11:45	14.75	1.39	0.09	0.25	0.04	N/A	<3m	<3m	N/A
35	12/5/2020 2:45	20.25	2.27	0.11	0.31	0.09	N/A	<3m	3-6m	N/A
36	12/12/2020 12:30	6.25	0.52	0.08	0.20	0.02	N/A	<3m	<3m	N/A
37	12/14/2020 9:00	7.75	0.05	0.01	0.02	0.00	N/A	<3m	<3m	N/A
38	12/20/2020 14:30	5.5	0.13	0.02	0.04	0.01	N/A	<3m	<3m	N/A

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
39	12/21/2020 8:45	24.5	0.34	0.01	0.04	0.01	0.01	<3m	<3m	N/A
40	12/25/2020 2:45	16	1.64	0.10	0.44	0.07	N/A	<3m	<3m	N/A
41	12/31/2020 4:45	1.75	0.11	0.06	0.09	0.00	N/A	<3m	<3m	N/A

(1) Recurrence intervals given in ranges of less than 3 months (<3m), 3-months, (3m), 3-6 months (3-6m), 6 months (6m), 6 months-1 year (6m-1yr), 1 year (1yr), 1 year to 2 year (1yr-2yr), 2 year (2yr) or the nearest year.

Rain Gauge 5: Chelsea Creek

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
1	7/1/2020 6:00	3.75	0.09	0.02	0.06	0.00	N/A	<3m	<3m	N/A
2	7/5/2020 21:15	1.25	0.08	0.06	0.07	0.00	N/A	<3m	<3m	N/A
3	7/13/2020 13:00	0.75	0.07	0.09	0.07	0.00	N/A	<3m	<3m	N/A
4	7/14/2020 9:45	18.25	1.1	0.06	0.90	0.05	N/A	1y	<3m	N/A
5	7/17/2020 5:00	3.75	0.15	0.04	0.10	0.01	N/A	<3m	<3m	N/A
6	7/23/2020 15:45	0.25	0.01	0.04	0.01	0.00	N/A	<3m	<3m	N/A
7	8/2/2020 16:30	0.5	0.04	0.08	0.04	0.00	N/A	<3m	<3m	N/A
8	8/4/2020 16:15	0.75	0.32	0.43	0.32	0.01	N/A	<3m	<3m	N/A
9	8/16/2020 18:30	7.75	0.16	0.02	0.07	0.01	N/A	<3m	<3m	N/A
10	8/18/2020 1:45	0.75	0.05	0.07	0.05	0.00	N/A	<3m	<3m	N/A
11	8/19/2020 14:45	3	0.1	0.03	0.09	0.00	N/A	<3m	<3m	N/A
12	8/22/2020 10:30	0.5	0.15	0.30	0.15	0.01	N/A	<3m	<3m	N/A
13	8/23/2020 15:45	4	0.97	0.24	0.93	0.04	N/A	1-2y	<3m	N/A
14	8/27/2020 12:30	1.75	0.17	0.10	0.15	0.01	N/A	<3m	<3m	N/A
15	8/29/2020 9:30	2.75	0.07	0.03	0.03	0.00	N/A	<3m	<3m	N/A
16	9/2/2020 11:00	14	0.28	0.02	0.18	0.01	N/A	<3m	<3m	N/A
17	9/10/2020 16:00	3.75	0.33	0.09	0.17	0.01	N/A	<3m	<3m	N/A
18	9/28/2020 13:30	0.25	0.01	0.04	0.01	0.00	N/A	<3m	<3m	N/A
19	9/30/2020 1:45	8.25	0.76	0.09	0.34	0.03	N/A	<3m	<3m	N/A
20	10/7/2020 16:45	0.5	0.04	0.08	0.04	0.00	N/A	<3m	<3m	N/A
21	10/13/2020 4:45	17	1.53	0.09	0.30	0.06	N/A	<3m	<3m	N/A
22	10/16/2020 12:00	20	2.2	0.11	0.32	0.09	N/A	<3m	3-6m	N/A
23	10/20/2020 6:00	0.25	0.02	0.08	0.02	0.00	N/A	<3m	<3m	N/A
24	10/21/2020 5:30	2.25	0.03	0.01	0.02	0.00	N/A	<3m	<3m	N/A
25	10/27/2020 22:15	23.75	0.06	0.00	0.01	0.00	N/A	<3m	<3m	N/A
26	10/29/2020 11:15	22.25	0.19	0.01	0.02	0.01	N/A	<3m	<3m	N/A
27	10/31/2020 9:30	7	0.05	0.01	0.00	0.00	N/A	<3m	<3m	N/A
28	11/1/2020 14:45	7.75	0.64	0.08	0.21	0.00	N/A	<3m	<3m	N/A
29	11/13/2020 1:30	16.25	0.30	0.02	0.07	0.01	N/A	<3m	<3m	N/A
30	11/15/2020 20:30	12.25	0.51	0.04	0.34	0.02	N/A	<3m	<3m	N/A
31	11/23/2020 4:00	9	1.70	0.19	0.39	0.07	N/A	<3m	<3m	N/A
32	11/26/2020 2:45	10	0.24	0.02	0.08	0.01	N/A	<3m	<3m	N/A
33	11/27/2020 8:30	0.25	0.01	0.04	0.01	0.01	N/A	<3m	<3m	N/A
34	11/30/2020 11:45	14.75	1.39	0.09	0.25	0.04	N/A	<3m	<3m	N/A
35	12/4/2020 11:30	0.25	0.02	0.08	0.02	0.00	N/A	<3m	<3m	N/A
36	12/5/2020 3:00	18.5	2.10	0.11	0.32	0.09	N/A	<3m	3-6m	N/A
37	12/12/2020 12:30	6.25	0.45	0.07	0.18	0.02	N/A	<3m	<3m	N/A
38	12/14/2020 7:15	9.25	0.05	0.01	0.01	0.00	N/A	<3m	<3m	N/A

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval [1]		
								1-hr	24-hr	48-hr
39	12/17/2020 3:30	0.25	0.01	0.04	0.01	0.00	N/A	<3m	<3m	N/A
40	12/19/2020 15:30	0.25	0.01	0.04	0.01	0.00	N/A	<3m	<3m	N/A
41	12/20/2020 12:45	25	0.34	0.01	0.05	0.01	0.01	<3m	<3m	N/A
42	12/25/2020 3:00	20.5	1.45	0.07	0.42	0.06	N/A	<3m	<3m	N/A
43	12/31/2020 4:45	1.75	0.11	0.06	0.09	0.00	N/A	<3m	<3m	N/A

(1) Recurrence intervals given in ranges of less than 3 months (<3m), 3-months, (3m), 3-6 months (3-6m), 6 months (6m), 6 months-1 year (6m-1yr), 1 year (1yr), 1 year to 2 year (1yr-2yr), 2 year (2yr) or the nearest year.

AECOM Imagine it. Delivered.

Rain Gauge 6: Dorchester-Adams

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval [(1)]		
								1-hr	24-hr	48-hr
1	7/5/2020 21:30	7.25	0.29	0.04	0.27	0.01	N/A	<3m	<3m	N/A
2	7/10/2020 14:30	9.75	0.20	0.02	0.10	0.01	N/A	<3m	<3m	N/A
3	7/13/2020 13:15	0.5	0.12	0.24	0.12	0.01	N/A	<3m	<3m	N/A
4	7/14/2020 10:15	0.25	0.01	0.04	0.01	0.01	N/A	<3m	<3m	N/A
5	7/15/2020 4:15	1.25	0.03	0.02	0.02	0.00	N/A	<3m	<3m	N/A
6	7/17/2020 5:15	2	0.26	0.13	0.21	0.01	N/A	<3m	<3m	N/A
7	7/22/2020 5:45	2.5	0.07	0.03	0.04	0.00	N/A	<3m	<3m	N/A
8	7/22/2020 20:30	2.25	0.18	0.08	0.16	0.01	N/A	<3m	<3m	N/A
9	7/23/2020 16:00	0.5	0.44	0.88	0.44	0.03	N/A	<3m	<3m	N/A
10	8/2/2020 16:15	0.75	0.03	0.04	0.03	0.00	N/A	<3m	<3m	N/A
11	8/4/2020 15:45	1.25	0.23	0.18	0.20	0.01	N/A	<3m	<3m	N/A
12	8/16/2020 17:45	9	0.29	0.03	0.08	0.01	N/A	<3m	<3m	N/A
13	8/18/2020 0:45	2	0.15	0.08	0.11	0.01	N/A	<3m	<3m	N/A
14	8/19/2020 15:00	3.5	0.08	0.02	0.06	0.00	N/A	<3m	<3m	N/A
15	8/22/2020 14:00	0.25	0.02	0.08	0.02	0.00	N/A	<3m	<3m	N/A
16	8/23/2020 16:15	4	0.67	0.17	0.48	0.03	N/A	<3m	<3m	N/A
17	8/27/2020 12:45	2	0.27	0.14	0.23	0.01	N/A	<3m	<3m	N/A
18	8/29/2020 10:00	2	0.06	0.03	0.04	0.00	N/A	<3m	<3m	N/A
19	9/2/2020 11:00	17.75	0.27	0.02	0.13	0.01	N/A	<3m	<3m	N/A
20	9/10/2020 14:00	7.75	0.38	0.05	0.27	0.02	N/A	<3m	<3m	N/A
21	9/30/2020 1:45	8.5	1.14	0.13	0.54	0.05	N/A	3m	<3m	N/A
22	10/7/2020 17:00	0.5	0.11	0.22	0.11	0.00	N/A	<3m	<3m	N/A
23	10/13/2020 4:30	17.75	1.76	0.10	0.41	0.07	N/A	<3m	<3m	N/A
24	10/16/2020 12:15	19.75	2.02	0.10	0.31	0.08	N/A	<3m	3m	N/A
25	10/21/2020 4:45	3.75	0.08	0.02	0.03	0.00	N/A	<3m	<3m	N/A
26	10/28/2020 1:30	15	0.32	0.02	0.09	0.01	N/A	<3m	<3m	N/A
27	10/29/2020 10:00	21	1.24	0.06	0.16	0.05	N/A	<3m	<3m	N/A
28	10/31/2020 11:15	1.75	0.42	0.24	0.00	0.00	N/A	<3m	<3m	N/A
29	11/1/2020 15:15	7.25	0.63	0.09	0.23	0.00	N/A	<3m	<3m	N/A
30	11/11/2020 23:15	1.5	0.02	0.01	0.01	0.00	N/A	<3m	<3m	N/A
31	11/13/2020 1:45	16.75	0.37	0.02	0.11	0.02	N/A	<3m	<3m	N/A
32	11/15/2020 21:00	4.5	0.55	0.12	0.34	0.02	N/A	<3m	<3m	N/A
33	11/23/2020 4:15	8.75	1.92	0.22	0.56	0.08	N/A	3m	3m	N/A
34	11/25/2020 20:30	17.25	0.29	0.02	0.08	0.01	N/A	<3m	<3m	N/A
35	11/27/2020 4:15	0.25	0.01	0.04	0.01	0.01	N/A	<3m	<3m	N/A
36	11/30/2020 12:00	16	2.04	0.13	0.32	0.05	N/A	<3m	<3m	N/A
37	12/4/2020 20:30	28.25	2.15	0.08	0.28	0.09	0.04	<3m	3-6m	N/A
38	12/12/2020 12:15	7.5	0.44	0.06	0.17	0.02	N/A	<3m	<3m	N/A

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval [1]		
								1-hr	24-hr	48-hr
39	12/14/2020 9:00	7.5	0.09	0.01	0.02	0.00	N/A	<3m	<3m	N/A
40	12/19/2020 10:00	3.5	0.10	0.03	0.06	0.00	N/A	<3m	<3m	N/A
41	12/20/2020 16:15	1.5	0.03	0.02	0.02	0.00	N/A	<3m	<3m	N/A
42	12/25/2020 2:45	15.75	2.06	0.13	0.64	0.09	N/A	3-6m	3-6m	N/A
43	12/31/2020 4:45	2	0.13	0.07	0.10	0.01	N/A	<3m	<3m	N/A

(1) Recurrence intervals given in ranges of less than 3 months (<3m), 3-months, (3m), 3-6 months (3-6m), 6 months (6m), 6 months-1 year (6m-1yr), 1 year (1yr), 1 year to 2 year (1yr-2yr), 2 year (2yr) or the nearest year.

Rain Gauge 7: Dorchester-Talbot

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
1	7/5/2020 21:30	7.25	0.07	0.01	0.27	0.01	N/A	<3m	<3m	N/A
2	7/10/2020 14:30	9.75	0.05	0.01	0.10	0.01	N/A	<3m	<3m	N/A
3	7/13/2020 13:15	0.5	0.03	0.06	0.12	0.01	N/A	<3m	<3m	N/A
4	7/14/2020 10:15	0.25	0.00	0.01	0.01	0.01	N/A	<3m	<3m	N/A
5	7/15/2020 4:15	1.25	0.01	0.01	0.02	0.00	N/A	<3m	<3m	N/A
6	7/17/2020 5:15	2	0.07	0.03	0.21	0.01	N/A	<3m	<3m	N/A
7	7/22/2020 5:45	2.5	0.02	0.01	0.04	0.00	N/A	<3m	<3m	N/A
8	7/22/2020 20:30	2.25	0.05	0.02	0.16	0.01	N/A	<3m	<3m	N/A
9	7/23/2020 16:00	0.5	0.11	0.22	0.44	0.03	N/A	<3m	<3m	N/A
10	8/2/2020 16:15	0.75	0.03	0.04	0.03	0.00	N/A	<3m	<3m	N/A
11	8/4/2020 15:45	1.25	0.23	0.18	0.20	0.01	N/A	<3m	<3m	N/A
12	8/16/2020 17:45	9	0.29	0.03	0.08	0.01	N/A	<3m	<3m	N/A
13	8/18/2020 0:45	2	0.15	0.08	0.11	0.01	N/A	<3m	<3m	N/A
14	8/19/2020 15:00	3.5	0.08	0.02	0.06	0.00	N/A	<3m	<3m	N/A
15	8/22/2020 14:00	0.25	0.02	0.08	0.02	0.00	N/A	<3m	<3m	N/A
16	8/23/2020 16:15	4	0.67	0.17	0.48	0.03	N/A	<3m	<3m	N/A
17	8/27/2020 12:45	2	0.27	0.14	0.23	0.01	N/A	<3m	<3m	N/A
18	8/29/2020 10:00	2	0.06	0.03	0.04	0.00	N/A	<3m	<3m	N/A
19	9/2/2020 11:00	17.75	0.27	0.02	0.13	0.01	N/A	<3m	<3m	N/A
20	9/10/2020 14:00	7.75	0.38	0.05	0.27	0.02	N/A	<3m	<3m	N/A
21	9/30/2020 1:45	8.5	1.14	0.13	0.54	0.05	N/A	3m	<3m	N/A
22	10/7/2020 17:00	0.5	0.11	0.22	0.11	0.00	N/A	<3m	<3m	N/A
23	10/13/2020 4:30	17.75	1.76	0.10	0.41	0.07	N/A	<3m	<3m	N/A
24	10/16/2020 12:15	19.75	2.02	0.10	0.31	0.08	N/A	<3m	3m	N/A
25	10/21/2020 4:45	3.75	0.08	0.02	0.03	0.00	N/A	<3m	<3m	N/A
26	10/28/2020 1:30	15	0.32	0.02	0.09	0.01	N/A	<3m	<3m	N/A
27	10/29/2020 10:00	21	1.24	0.06	0.16	0.05	N/A	<3m	<3m	N/A
28	10/31/2020 11:15	1.75	0.42	0.24	0.00	0.00	N/A	<3m	<3m	N/A
29	11/1/2020 15:15	7.25	0.63	0.09	0.23	0.00	N/A	<3m	<3m	N/A
30	11/11/2020 23:15	1.5	0.02	0.01	0.01	0.00	N/A	<3m	<3m	N/A
31	11/13/2020 1:45	16.75	0.37	0.02	0.11	0.02	N/A	<3m	<3m	N/A
32	11/15/2020 21:00	4.5	0.55	0.12	0.34	0.02	N/A	<3m	<3m	N/A
33	11/23/2020 4:15	8.75	1.92	0.22	0.56	0.08	N/A	3m	3m	N/A
34	11/25/2020 20:30	17.25	0.29	0.02	0.08	0.01	N/A	<3m	<3m	N/A
35	11/27/2020 4:15	0.25	0.01	0.04	0.01	0.01	N/A	<3m	<3m	N/A
36	11/30/2020 12:00	16	2.04	0.13	0.32	0.05	N/A	<3m	<3m	N/A
37	12/4/2020 20:30	28.25	2.15	0.08	0.28	0.09	0.04	<3m	3-6m	N/A
38	12/12/2020 12:15	7.5	0.44	0.06	0.17	0.02	N/A	<3m	<3m	N/A

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
39	12/14/2020 9:00	7.5	0.09	0.01	0.02	0.00	N/A	<3m	<3m	N/A
40	12/19/2020 10:00	3.5	0.10	0.03	0.06	0.00	N/A	<3m	<3m	N/A
41	12/20/2020 16:15	1.5	0.03	0.02	0.02	0.00	N/A	<3m	<3m	N/A
42	12/25/2020 2:45	15.75	2.06	0.13	0.64	0.09	N/A	3-6m	3-6m	N/A
43	12/31/2020 4:45	2	0.13	0.07	0.10	0.01	N/A	<3m	<3m	N/A

(1) Recurrence intervals given in ranges of less than 3 months (<3m), 3-months, (3m), 3-6 months (3-6m), 6 months (6m), 6 months-1 year (6m-1yr), 1 year (1yr), 1 year to 2 year (1yr-2yr), 2 year (2yr) or the nearest year.

Rain Gauge 8: East Boston

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval [1]		
								1-hr	24-hr	48-hr
1	7/1/2020 6:15	3.75	0.11	0.03	0.06	0.00	N/A	<3m	<3m	N/A
2	7/5/2020 21:30	1.25	0.11	0.09	0.09	0.00	N/A	<3m	<3m	N/A
3	7/13/2020 13:15	0.75	0.05	0.07	0.05	0.00	N/A	<3m	<3m	N/A
4	7/14/2020 10:15	18	0.57	0.03	0.39	0.02	N/A	<3m	<3m	N/A
5	7/17/2020 5:15	3.75	0.14	0.04	0.10	0.01	N/A	<3m	<3m	N/A
6	7/22/2020 6:00	1.25	0.03	0.02	0.02	0.00	N/A	<3m	<3m	N/A
7	7/22/2020 19:45	3.25	0.4	0.12	0.33	0.02	N/A	<3m	<3m	N/A
8	7/23/2020 16:00	0.75	0.49	0.65	0.49	0.04	N/A	<3m	<3m	N/A
9	8/2/2020 16:30	0.5	0.04	0.08	0.04	0.00	N/A	<3m	<3m	N/A
10	8/4/2020 16:15	0.75	0.32	0.43	0.32	0.01	N/A	<3m	<3m	N/A
11	8/16/2020 18:45	8	0.18	0.02	0.08	0.01	N/A	<3m	<3m	N/A
12	8/18/2020 1:30	1.25	0.06	0.05	0.05	0.00	N/A	<3m	<3m	N/A
13	8/19/2020 15:00	3.5	0.08	0.02	0.07	0.00	N/A	<3m	<3m	N/A
14	8/22/2020 10:45	0.5	0.04	0.08	0.04	0.00	N/A	<3m	<3m	N/A
15	8/23/2020 16:00	4	0.97	0.24	0.91	0.04	N/A	1y	<3m	N/A
16	8/27/2020 12:45	2	0.17	0.09	0.15	0.01	N/A	<3m	<3m	N/A
17	8/29/2020 10:00	2.25	0.06	0.03	0.03	0.00	N/A	<3m	<3m	N/A
18	9/2/2020 11:15	3.5	0.25	0.07	0.17	0.01	N/A	<3m	<3m	N/A
19	9/10/2020 16:15	3.75	0.31	0.08	0.17	0.01	N/A	<3m	<3m	N/A
20	9/28/2020 13:45	0.25	0.01	0.04	0.01	0.00	N/A	<3m	<3m	N/A
21	9/30/2020 1:45	8.5	0.75	0.09	0.34	0.03	N/A	<3m	<3m	N/A
22	10/7/2020 17:00	0.5	0.06	0.12	0.06	0.00	N/A	<3m	<3m	N/A
23	10/13/2020 4:45	17.25	1.64	0.10	0.31	0.07	N/A	<3m	<3m	N/A
24	10/16/2020 12:15	19.75	2.15	0.11	0.30	0.09	N/A	<3m	3-6m	N/A
25	10/21/2020 4:45	4.25	0.07	0.02	0.02	0.00	N/A	<3m	<3m	N/A
26	10/28/2020 3:45	13	0.27	0.02	0.06	0.01	N/A	<3m	<3m	N/A
27	10/29/2020 10:15	20.75	1.17	0.06	0.16	0.05	N/A	<3m	<3m	N/A
28	10/31/2020 10:00	1.75	0.3	0.17	0.00	0.00	N/A	<3m	<3m	N/A
29	11/1/2020 14:45	7.75	0.64	0.08	0.21	0.00	N/A	<3m	<3m	N/A
30	11/13/2020 1:30	16.25	0.30	0.02	0.07	0.01	N/A	<3m	<3m	N/A
31	11/15/2020 20:30	12.25	0.51	0.04	0.34	0.02	N/A	<3m	<3m	N/A
32	11/23/2020 4:00	9	1.70	0.19	0.39	0.07	N/A	<3m	<3m	N/A
33	11/26/2020 2:45	10	0.24	0.02	0.08	0.01	N/A	<3m	<3m	N/A
34	11/27/2020 8:30	0.25	0.01	0.04	0.01	0.01	N/A	<3m	<3m	N/A
35	11/30/2020 11:45	14.75	1.39	0.09	0.25	0.04	N/A	<3m	<3m	N/A
36	12/5/2020 2:45	20.25	2.27	0.11	0.31	0.09	N/A	<3m	3-6m	N/A
37	12/12/2020 12:30	6.25	0.52	0.08	0.20	0.02	N/A	<3m	<3m	N/A
38	12/14/2020 9:00	7.75	0.05	0.01	0.02	0.00	N/A	<3m	<3m	N/A

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
39	12/20/2020 14:30	5.5	0.13	0.02	0.04	0.01	N/A	<3m	<3m	N/A
40	12/21/2020 8:45	24.5	0.34	0.01	0.04	0.01	0.01	<3m	<3m	N/A
41	12/25/2020 2:45	16	1.64	0.10	0.44	0.07	N/A	<3m	<3m	N/A
42	12/31/2020 4:45	1.75	0.11	0.06	0.09	0.00	N/A	<3m	<3m	N/A

(1) Recurrence intervals given in ranges of less than 3 months (<3m), 3-months, (3m), 3-6 months (3-6m), 6 months (6m), 6 months-1 year (6m-1yr), 1 year (1yr), 1 year to 2 year (1yr-2yr), 2 year (2yr) or the nearest year.

Rain Gauge 9: Hanscom AFB

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
1	7/1/2020 11:00	0.25	0.01	0.04	0.01	0.00	N/A	<3m	<3m	N/A
2	7/5/2020 21:30	15.25	0.11	0.01	0.06	0.00	N/A	<3m	<3m	N/A
3	7/17/2020 4:15	4	0.15	0.04	0.09	0.01	N/A	<3m	<3m	N/A
4	7/22/2020 5:15	16.75	0.38	0.02	0.24	0.02	N/A	<3m	<3m	N/A
5	7/23/2020 15:00	0.75	0.61	0.81	0.61	0.04	N/A	3-6m	<3m	N/A
6	8/2/2020 16:30	0.75	0.02	0.03	0.02	0.00	N/A	<3m	<3m	N/A
7	8/4/2020 15:45	1.25	0.18	0.14	0.17	0.01	N/A	<3m	<3m	N/A
8	8/16/2020 18:15	5.5	0.19	0.03	0.08	0.01	N/A	<3m	<3m	N/A
9	8/17/2020 22:45	4	0.07	0.02	0.05	0.00	N/A	<3m	<3m	N/A
10	8/19/2020 14:45	3.5	0.06	0.02	0.04	0.00	N/A	<3m	<3m	N/A
11	8/23/2020 16:00	4	0.54	0.14	0.46	0.02	N/A	<3m	<3m	N/A
12	8/27/2020 12:45	1.25	0.21	0.17	0.18	0.01	N/A	<3m	<3m	N/A
13	8/29/2020 9:45	3.5	0.1	0.03	0.05	0.00	N/A	<3m	<3m	N/A
14	9/2/2020 11:00	12.5	0.24	0.02	0.12	0.01	N/A	<3m	<3m	N/A
15	9/10/2020 16:15	2	0.72	0.36	0.56	0.03	N/A	3m	<3m	N/A
16	9/30/2020 1:45	12	0.32	0.03	0.08	0.01	N/A	<3m	<3m	N/A
17	10/13/2020 7:15	15.25	2.08	0.14	0.44	0.09	N/A	<3m	3-6m	N/A
18	10/16/2020 13:15	18.5	1.96	0.11	0.32	0.08	N/A	<3m	3m	N/A
19	10/28/2020 6:30	9.5	0.08	0.01	0.04	0.00	N/A	<3m	<3m	N/A
20	10/30/2020 10:30	0.25	0.04	0.16	0.04	0.00	N/A	<3m	<3m	N/A
21	11/1/2020 14:45	7.5	0.64	0.09	0.26	0.00	N/A	<3m	<3m	N/A
22	11/13/2020 8:45	7	0.14	0.02	0.06	0.01	N/A	<3m	<3m	N/A
23	11/15/2020 21:30	4	0.36	0.09	0.25	0.02	N/A	<3m	<3m	N/A
24	11/23/2020 4:15	8.75	1.77	0.20	0.43	0.07	N/A	<3m	3m	N/A
25	11/26/2020 8:30	4.75	0.26	0.05	0.13	0.01	N/A	<3m	<3m	N/A
26	11/30/2020 12:00	14.25	2.08	0.15	0.34	0.05	N/A	<3m	<3m	N/A
27	12/5/2020 3:45	17.5	2.03	0.12	0.22	0.08	N/A	<3m	3m	N/A
28	12/12/2020 12:45	5.75	0.44	0.08	0.14	0.02	N/A	<3m	<3m	N/A
29	12/17/2020 0:15	10	0.55	0.06	0.14	0.02	N/A	<3m	<3m	N/A
30	12/25/2020 2:45	16	2.20	0.14	0.28	0.09	N/A	<3m	3-6m	N/A
31	12/31/2020 5:15	0.5	0.08	0.16	0.08	0.00	N/A	<3m	<3m	N/A

(1) Recurrence intervals given in ranges of less than 3 months (<3m), 3-months, (3m), 3-6 months (3-6m), 6 months (6m), 6 months-1 year (6m-1yr), 1 year (1yr), 1 year to 2 year (1yr-2yr), 2 year (2yr) or the nearest year.

Rain Gauge 10: Hyde Park

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval [1]		
								1-hr	24-hr	48-hr
1	7/1/2020 10:45	0.5	0.12	0.24	0.12	0.00	N/A	<3m	<3m	N/A
2	7/5/2020 21:30	1.25	0.42	0.34	0.37	0.02	N/A	<3m	<3m	N/A
3	7/10/2020 16:00	7.25	0.04	0.01	0.03	0.00	N/A	<3m	<3m	N/A
4	7/13/2020 12:45	0.75	0.28	0.37	0.28	0.01	N/A	<3m	<3m	N/A
5	7/14/2020 9:45	0.75	0.03	0.04	0.03	0.01	N/A	<3m	<3m	N/A
6	7/15/2020 4:30	0.5	0.02	0.04	0.02	0.00	N/A	<3m	<3m	N/A
7	7/17/2020 6:00	1.25	0.27	0.22	0.22	0.01	N/A	<3m	<3m	N/A
8	7/22/2020 5:45	2.25	0.06	0.03	0.04	0.00	N/A	<3m	<3m	N/A
9	7/22/2020 21:15	1.75	0.21	0.12	0.19	0.01	N/A	<3m	<3m	N/A
10	7/23/2020 16:00	1.25	0.34	0.27	0.33	0.02	N/A	<3m	<3m	N/A
11	8/2/2020 16:15	0.5	0.03	0.06	0.03	0.00	N/A	<3m	<3m	N/A
12	8/4/2020 16:00	0.75	0.17	0.23	0.17	0.01	N/A	<3m	<3m	N/A
13	8/16/2020 13:15	14.25	0.28	0.02	0.10	0.01	N/A	<3m	<3m	N/A
14	8/17/2020 22:15	4.5	0.13	0.03	0.11	0.01	N/A	<3m	<3m	N/A
15	8/19/2020 17:45	7.75	0.12	0.02	0.11	0.01	N/A	<3m	<3m	N/A
16	8/22/2020 11:15	3.5	0.31	0.09	0.27	0.01	N/A	<3m	<3m	N/A
17	8/23/2020 16:30	4.5	2.26	0.50	1.58	0.09	N/A	1-2y	3-6m	N/A
18	8/27/2020 12:45	2	0.44	0.22	0.39	0.02	N/A	<3m	<3m	N/A
19	8/29/2020 10:45	1.25	0.06	0.05	0.05	0.00	N/A	<3m	<3m	N/A
20	9/2/2020 10:45	26.75	0.21	0.01	0.08	0.01	0.00	<3m	<3m	N/A
21	9/10/2020 18:45	2.5	0.21	0.08	0.15	0.01	N/A	<3m	<3m	N/A
22	9/28/2020 14:30	0.25	0.01	0.04	0.01	0.00	N/A	<3m	<3m	N/A
23	9/30/2020 1:30	8.75	1.3	0.15	0.59	0.05	N/A	3m	<3m	N/A
24	10/2/2020 15:00	0.75	0.03	0.04	0.03	0.00	N/A	<3m	<3m	N/A
25	10/7/2020 17:00	0.5	0.14	0.28	0.14	0.01	N/A	<3m	<3m	N/A
26	10/13/2020 3:15	19	1.7	0.09	0.45	0.07	N/A	<3m	<3m	N/A
27	10/16/2020 12:45	19	2.24	0.12	0.33	0.09	N/A	<3m	3-6m	N/A
28	10/21/2020 4:45	3.75	0.05	0.01	0.02	0.00	N/A	<3m	<3m	N/A
29	10/28/2020 5:30	11.5	0.31	0.03	0.07	0.01	N/A	<3m	<3m	N/A
30	10/29/2020 8:45	22.25	1.43	0.06	0.16	0.06	N/A	<3m	<3m	N/A
31	10/31/2020 8:15	2.75	0.44	0.16	0.00	0.00	N/A	<3m	<3m	N/A
32	11/1/2020 14:45	7.75	0.73	0.09	0.25	0.00	N/A	<3m	<3m	N/A
33	11/11/2020 22:45	5.25	0.05	0.01	0.03	0.00	N/A	<3m	<3m	N/A
34	11/13/2020 0:15	19	0.34	0.02	0.07	0.01	N/A	<3m	<3m	N/A
35	11/15/2020 20:15	5.25	0.62	0.12	0.37	0.03	N/A	<3m	<3m	N/A
36	11/23/2020 4:00	9	1.78	0.20	0.49	0.07	N/A	<3m	3m	N/A
37	11/25/2020 19:30	21.25	0.36	0.02	0.11	0.02	N/A	<3m	<3m	N/A
38	11/27/2020 23:30	0.25	0.01	0.04	0.01	0.00	N/A	<3m	<3m	N/A

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
39	11/30/2020 11:45	16.25	2.21	0.14	0.34	0.06	N/A	<3m	<3m	N/A
40	12/4/2020 20:15	27	2.5	0.09	0.36	0.10	0.05	<3m	6m-1yr	N/A
41	12/12/2020 12:15	6	0.43	0.07	0.15	0.02	N/A	<3m	<3m	N/A
42	12/14/2020 8:45	7.75	0.11	0.01	0.03	0.00	N/A	<3m	<3m	N/A
43	12/18/2020 14:45	1	0.05	0.05	0.05	0.00	N/A	<3m	<3m	N/A
44	12/19/2020 11:30	1.25	0.12	0.10	0.10	0.01	N/A	<3m	<3m	N/A
45	12/20/2020 16:00	2	0.03	0.02	0.02	0.00	N/A	<3m	<3m	N/A
46	12/25/2020 2:30	16	1.94	0.12	0.33	0.08	N/A	<3m	3m	N/A
47	12/31/2020 4:30	2.25	0.16	0.07	0.11	0.01	N/A	<3m	<3m	N/A

(1) Recurrence intervals given in ranges of less than 3 months (<3m), 3-months, (3m), 3-6 months (3-6m), 6 months (6m), 6 months-1 year (6m-1yr), 1 year (1yr), 1 year to 2 year (1yr-2yr), 2 year (2yr) or the nearest year.

Rain Gauge 11: Lexington Farm

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
1	7/1/2020 11:00	0.25	0.01	0.04	0.01	0.00	N/A	<3m	<3m	N/A
2	7/5/2020 21:30	15.25	0.11	0.01	0.06	0.00	N/A	<3m	<3m	N/A
3	7/17/2020 4:15	4	0.15	0.04	0.09	0.01	N/A	<3m	<3m	N/A
4	7/22/2020 5:15	16.75	0.38	0.02	0.24	0.02	N/A	<3m	<3m	N/A
5	7/23/2020 15:00	0.75	0.61	0.81	0.61	0.04	N/A	3-6m	<3m	N/A
6	8/2/2020 17:15	1	0.12	0.12	0.12	0.01	N/A	<3m	<3m	N/A
7	8/4/2020 15:45	1	0.18	0.18	0.18	0.01	N/A	<3m	<3m	N/A
8	8/16/2020 19:00	4	0.18	0.05	0.09	0.01	N/A	<3m	<3m	N/A
9	8/17/2020 22:30	4	0.06	0.02	0.04	0.00	N/A	<3m	<3m	N/A
10	8/19/2020 17:45	0.25	0.01	0.04	0.01	0.00	N/A	<3m	<3m	N/A
11	8/22/2020 10:45	0.25	0.01	0.04	0.01	0.00	N/A	<3m	<3m	N/A
12	8/23/2020 15:45	4	0.8	0.20	0.74	0.03	N/A	6m-1yr	<3m	N/A
13	8/27/2020 12:30	1.5	0.16	0.11	0.13	0.01	N/A	<3m	<3m	N/A
14	8/29/2020 9:30	9	0.16	0.02	0.09	0.01	N/A	<3m	<3m	N/A
15	9/2/2020 11:15	24.75	0.28	0.01	0.18	0.01	0.01	<3m	<3m	N/A
16	9/10/2020 16:30	3.25	0.48	0.15	0.39	0.02	N/A	<3m	<3m	N/A
17	9/30/2020 2:00	8.25	0.63	0.08	0.29	0.03	N/A	<3m	<3m	N/A
18	10/2/2020 14:45	0.5	0.02	0.04	0.02	0.00	N/A	<3m	<3m	N/A
19	10/7/2020 16:45	0.25	0.04	0.16	0.04	0.00	N/A	<3m	<3m	N/A
20	10/13/2020 4:45	15.5	1.4	0.09	0.26	0.06	N/A	<3m	<3m	N/A
21	10/16/2020 12:00	20.5	1.76	0.09	0.29	0.07	N/A	<3m	<3m	N/A
22	10/21/2020 5:00	3.5	0.03	0.01	0.01	0.00	N/A	<3m	<3m	N/A
23	10/28/2020 2:45	15	0.26	0.02	0.05	0.01	N/A	<3m	<3m	N/A
24	10/29/2020 10:15	27.5	1.11	0.04	0.16	0.04	0.03	<3m	<3m	N/A
25	11/1/2020 15:15	7	0.59	0.08	0.25	0.00	N/A	<3m	<3m	N/A
26	11/13/2020 8:45	7	0.14	0.02	0.06	0.01	N/A	<3m	<3m	N/A
27	11/15/2020 21:30	4	0.36	0.09	0.25	0.02	N/A	<3m	<3m	N/A
28	11/23/2020 4:15	8.75	1.77	0.20	0.43	0.07	N/A	<3m	3m	N/A
29	11/26/2020 8:30	4.75	0.26	0.05	0.13	0.01	N/A	<3m	<3m	N/A
30	11/30/2020 12:00	14.25	2.08	0.15	0.34	0.05	N/A	<3m	<3m	N/A
31	12/5/2020 3:45	17.5	2.03	0.12	0.22	0.08	N/A	<3m	3m	N/A
32	12/12/2020 12:45	5.75	0.44	0.08	0.14	0.02	N/A	<3m	<3m	N/A
33	12/17/2020 0:15	10	0.55	0.06	0.14	0.02	N/A	<3m	<3m	N/A
34	12/25/2020 3:00	15.75	1.86	0.12	0.32	0.08	N/A	<3m	3m	N/A
35	12/31/2020 5:00	1.5	0.11	0.07	0.09	0.00	N/A	<3m	<3m	N/A

(1) Recurrence intervals given in ranges of less than 3 months (<3m), 3-months, (3m), 3-6 months (3-6m), 6 months (6m), 6 months-1 year (6m-1yr), 1 year (1yr), 1 year to 2 year (1yr-2yr), 2 year (2yr) or the nearest year.

Rain Gauge 12: Longwood

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
1	7/1/2020 6:15	0.25	0.01	0.04	0.01	0.00	N/A	<3m	<3m	N/A
2	7/5/2020 21:15	1.5	0.19	0.13	0.17	0.01	N/A	<3m	<3m	N/A
3	7/10/2020 17:00	6.25	0.11	0.02	0.10	0.00	N/A	<3m	<3m	N/A
4	7/13/2020 13:15	0.25	0.19	0.76	0.19	0.01	N/A	<3m	<3m	N/A
5	7/14/2020 9:45	0.5	0.11	0.22	0.11	0.01	N/A	<3m	<3m	N/A
6	7/15/2020 4:00	1	0.03	0.03	0.03	0.01	N/A	<3m	<3m	N/A
7	7/17/2020 5:15	2	0.15	0.08	0.10	0.01	N/A	<3m	<3m	N/A
8	7/22/2020 5:30	17	0.42	0.02	0.33	0.02	N/A	<3m	<3m	N/A
9	7/23/2020 15:30	0.75	0.49	0.65	0.49	0.04	N/A	<3m	<3m	N/A
10	7/31/2020 8:30	0.25	0.69	2.76	0.00	0.00	N/A	<3m	<3m	N/A
11	8/2/2020 16:15	0.25	0.03	0.12	0.03	0.00	N/A	<3m	<3m	N/A
12	8/4/2020 15:30	1.25	0.19	0.15	0.17	0.01	N/A	<3m	<3m	N/A
13	8/16/2020 18:00	5.25	0.22	0.04	0.11	0.01	N/A	<3m	<3m	N/A
14	8/18/2020 1:15	1.25	0.07	0.06	0.06	0.00	N/A	<3m	<3m	N/A
15	8/19/2020 17:45	0.25	0.03	0.12	0.03	0.00	N/A	<3m	<3m	N/A
16	8/23/2020 15:45	4	0.62	0.16	0.50	0.03	N/A	<3m	<3m	N/A
17	8/27/2020 12:30	2.25	0.25	0.11	0.20	0.01	N/A	<3m	<3m	N/A
18	8/29/2020 9:30	2.5	0.07	0.03	0.04	0.00	N/A	<3m	<3m	N/A
19	9/2/2020 11:00	25.25	0.25	0.01	0.12	0.01	0.01	<3m	<3m	N/A
20	9/10/2020 13:45	6	0.32	0.05	0.15	0.01	N/A	<3m	<3m	N/A
21	9/30/2020 1:45	8.25	0.98	0.12	0.47	0.04	N/A	<3m	<3m	N/A
22	10/7/2020 16:45	0.5	0.17	0.34	0.17	0.01	N/A	<3m	<3m	N/A
23	10/13/2020 4:30	17.5	1.69	0.10	0.41	0.07	N/A	<3m	<3m	N/A
24	10/16/2020 12:00	20	1.94	0.10	0.30	0.08	N/A	<3m	3m	N/A
25	10/20/2020 9:00	0.25	0.19	0.76	0.19	0.01	N/A	<3m	<3m	N/A
26	10/21/2020 4:30	0.25	0.01	0.04	0.01	0.01	N/A	<3m	<3m	N/A
27	10/28/2020 3:45	0.25	0.01	0.04	0.01	0.00	N/A	<3m	<3m	N/A
28	10/29/2020 8:15	22.75	0.17	0.01	0.03	0.01	N/A	<3m	<3m	N/A
29	10/31/2020 10:00	0.25	0.01	0.04	0.00	0.00	N/A	<3m	<3m	N/A
30	11/1/2020 15:15	22	0.73	0.03	0.23	0.03	N/A	<3m	<3m	N/A
31	11/11/2020 23:30	0.25	0.01	0.04	0.01	0.00	N/A	<3m	<3m	N/A
32	11/13/2020 0:15	17.5	0.34	0.02	0.08	0.01	N/A	<3m	<3m	N/A
33	11/15/2020 20:45	4.5	0.51	0.11	0.34	0.02	N/A	<3m	<3m	N/A
34	11/23/2020 4:00	9	1.80	0.20	0.44	0.08	N/A	<3m	3m	N/A
35	11/25/2020 20:15	17.5	0.27	0.02	0.08	0.01	N/A	<3m	<3m	N/A
36	11/30/2020 11:45	26	1.77	0.07	0.23	0.04	0.02	<3m	<3m	N/A
37	12/4/2020 22:45	23	2.01	0.09	0.25	0.08	N/A	<3m	3m	N/A
38	12/12/2020 12:30	7.5	0.45	0.06	0.16	0.02	N/A	<3m	<3m	N/A

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval [1]		
								1-hr	24-hr	48-hr
39	12/14/2020 9:45	7.25	0.04	0.01	0.01	0.00	N/A	<3m	<3m	N/A
40	12/16/2020 23:30	39.25	0.59	0.02	0.11	0.02	0.01	<3m	<3m	N/A
41	12/19/2020 10:15	4	0.09	0.02	0.04	0.00	N/A	<3m	<3m	N/A
42	12/20/2020 10:45	6.75	0.19	0.03	0.04	0.01	N/A	<3m	<3m	N/A
43	12/25/2020 2:45	15.75	1.63	0.10	0.30	0.07	N/A	<3m	<3m	N/A
44	12/31/2020 4:30	2	0.11	0.06	0.09	0.00	N/A	<3m	<3m	N/A

(1) Recurrence intervals given in ranges of less than 3 months (<3m), 3-months, (3m), 3-6 months (3-6m), 6 months (6m), 6 months-1 year (6m-1yr), 1 year (1yr), 1 year to 2 year (1yr-2yr), 2 year (2yr) or the nearest year.

Rain Gauge 13: Hayes Pump Station

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
1	7/5/2020 21:15	1.25	0.07	0.06	0.06	0.00	N/A	<3m	<3m	N/A
2	7/13/2020 13:45	27	0.48	0.02	0.17	0.02	0.01	<3m	<3m	N/A
3	7/17/2020 4:45	1.5	0.15	0.10	0.13	0.01	N/A	<3m	<3m	N/A
4	7/22/2020 6:45	16.25	0.61	0.04	0.32	0.03	N/A	<3m	<3m	N/A
5	7/23/2020 12:30	3.75	0.08	0.02	0.07	0.03	N/A	<3m	<3m	N/A
6	8/2/2020 15:15	2.75	0.16	0.06	0.10	0.01	N/A	<3m	<3m	N/A
7	8/4/2020 16:00	1	0.23	0.23	0.23	0.01	N/A	<3m	<3m	N/A
8	8/16/2020 20:15	3	0.05	0.02	0.02	0.00	N/A	<3m	<3m	N/A
9	8/18/2020 0:30	2	0.08	0.04	0.07	0.00	N/A	<3m	<3m	N/A
10	8/19/2020 17:00	0.25	0.01	0.04	0.01	0.00	N/A	<3m	<3m	N/A
11	8/22/2020 10:15	0.5	0.09	0.18	0.09	0.00	N/A	<3m	<3m	N/A
12	8/23/2020 15:30	2	0.65	0.33	0.64	0.03	N/A	3-6m	<3m	N/A
13	8/27/2020 12:15	2	0.15	0.08	0.11	0.01	N/A	<3m	<3m	N/A
14	8/29/2020 10:15	4.5	0.27	0.06	0.17	0.01	N/A	<3m	<3m	N/A
15	9/2/2020 11:15	5.25	0.21	0.04	0.12	0.01	N/A	<3m	<3m	N/A
16	9/3/2020 10:00	2.5	0.02	0.01	0.01	0.01	N/A	<3m	<3m	N/A
17	9/10/2020 15:00	3.75	0.93	0.25	0.72	0.04	N/A	6m	<3m	N/A
18	9/30/2020 2:00	8	0.47	0.06	0.20	0.02	N/A	<3m	<3m	N/A
19	10/7/2020 16:45	0.5	0.04	0.08	0.04	0.00	N/A	<3m	<3m	N/A
20	10/13/2020 5:00	15.25	1.48	0.10	0.26	0.06	N/A	<3m	<3m	N/A
21	10/16/2020 13:15	19.25	1.45	0.08	0.26	0.06	N/A	<3m	<3m	N/A
22	10/28/2020 7:30	8.5	0.15	0.02	0.04	0.01	N/A	<3m	<3m	N/A
23	10/29/2020 11:00	28	1	0.04	0.14	0.04	0.02	<3m	<3m	N/A
24	10/31/2020 10:30	2	0.3	0.15	0.00	0.00	N/A	<3m	<3m	N/A
25	11/1/2020 15:00	7.25	0.66	0.09	0.25	0.00	N/A	<3m	<3m	N/A
26	11/13/2020 8:15	10	0.14	0.01	0.06	0.01	N/A	<3m	<3m	N/A
27	11/14/2020 8:45	0.25	0.01	0.04	0.01	0.01	N/A	<3m	<3m	N/A
28	11/15/2020 21:45	3.5	0.39	0.11	0.31	0.02	N/A	<3m	<3m	N/A
29	11/23/2020 4:15	8.5	1.69	0.20	0.42	0.07	N/A	<3m	<3m	N/A
30	11/26/2020 3:00	11.75	0.35	0.03	0.14	0.01	N/A	<3m	<3m	N/A
31	11/30/2020 11:45	15.25	1.83	0.12	0.24	0.05	N/A	<3m	<3m	N/A
32	12/5/2020 4:00	35.75	1.78	0.05	0.20	0.07	0.04	<3m	<3m	N/A
33	12/7/2020 12:30	0.25	0.01	0.04	0.01	0.00	N/A	<3m	<3m	N/A
34	12/12/2020 12:45	10	0.48	0.05	0.16	0.02	N/A	<3m	<3m	N/A
35	12/14/2020 9:15	0.5	0.02	0.04	0.02	0.00	N/A	<3m	<3m	N/A
36	12/19/2020 12:45	3.5	0.05	0.01	0.03	0.00	N/A	<3m	<3m	N/A
37	12/20/2020 11:30	9.25	0.09	0.01	0.03	0.00	N/A	<3m	<3m	N/A

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
38	12/21/2020 10:30	11.25	0.14	0.01	0.03	0.01	N/A	<3m	<3m	N/A
39	12/22/2020 10:15	3.5	0.14	0.04	0.08	0.01	N/A	<3m	<3m	N/A
40	12/25/2020 2:45	15.75	1.55	0.10	0.28	0.06	N/A	<3m	<3m	N/A
41	12/31/2020 4:45	2	0.10	0.05	0.07	0.00	N/A	<3m	<3m	N/A

(1) Recurrence intervals given in ranges of less than 3 months (<3m), 3-months, (3m), 3-6 months (3-6m), 6 months (6m), 6 months-1 year (6m-1yr), 1 year (1yr), 1 year to 2 year (1yr-2yr), 2 year (2yr) or the nearest year.

Rain Gauge 14: Roslindale

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval [1]		
								1-hr	24-hr	48-hr
1	7/1/2020 11:30	0.25	0.12	0.48	0.12	0.00	N/A	<3m	<3m	N/A
2	7/5/2020 21:30	3.25	0.31	0.10	0.22	0.01	N/A	<3m	<3m	N/A
3	7/10/2020 16:00	7.5	0.06	0.01	0.03	0.00	N/A	<3m	<3m	N/A
4	7/13/2020 13:00	0.5	0.18	0.36	0.18	0.01	N/A	<3m	<3m	N/A
5	7/15/2020 4:15	0.75	0.02	0.03	0.02	0.00	N/A	<3m	<3m	N/A
6	7/17/2020 5:45	1.5	0.29	0.19	0.26	0.01	N/A	<3m	<3m	N/A
7	7/22/2020 5:45	2.5	0.07	0.03	0.05	0.00	N/A	<3m	<3m	N/A
8	7/22/2020 21:00	6	0.15	0.03	0.12	0.01	N/A	<3m	<3m	N/A
9	7/23/2020 15:45	1.25	0.27	0.22	0.26	0.02	N/A	<3m	<3m	N/A
10	8/2/2020 16:15	0.75	0.03	0.04	0.03	0.00	N/A	<3m	<3m	N/A
11	8/4/2020 15:45	1.25	0.17	0.14	0.16	0.01	N/A	<3m	<3m	N/A
12	8/16/2020 17:30	13.5	0.35	0.03	0.09	0.01	N/A	<3m	<3m	N/A
13	8/18/2020 1:00	2	0.16	0.08	0.13	0.01	N/A	<3m	<3m	N/A
14	8/19/2020 14:45	12.75	0.07	0.01	0.05	0.00	N/A	<3m	<3m	N/A
15	8/22/2020 11:15	3.5	0.38	0.11	0.36	0.02	N/A	<3m	<3m	N/A
16	8/23/2020 16:30	4	1.08	0.27	0.78	0.05	N/A	6m-1yr	<3m	N/A
17	8/27/2020 12:45	2.5	0.32	0.13	0.28	0.01	N/A	<3m	<3m	N/A
18	8/29/2020 10:00	2.25	0.07	0.03	0.05	0.00	N/A	<3m	<3m	N/A
19	9/2/2020 10:45	27.5	0.37	0.01	0.11	0.01	0.01	<3m	<3m	N/A
20	9/10/2020 14:00	9.25	0.33	0.04	0.19	0.01	N/A	<3m	<3m	N/A
21	9/30/2020 1:30	8.5	1.1	0.13	0.50	0.05	N/A	<3m	<3m	N/A
22	10/2/2020 14:45	0.25	0.01	0.04	0.01	0.00	N/A	<3m	<3m	N/A
23	10/7/2020 16:15	1	0.1	0.10	0.10	0.00	N/A	<3m	<3m	N/A
24	10/13/2020 4:00	17.75	1.62	0.09	0.41	0.07	N/A	<3m	<3m	N/A
25	10/16/2020 12:00	19.75	2.2	0.11	0.35	0.09	N/A	<3m	3-6m	N/A
26	10/21/2020 4:45	3.75	0.06	0.02	0.02	0.00	N/A	<3m	<3m	N/A
27	10/28/2020 4:45	11.75	0.32	0.03	0.09	0.01	N/A	<3m	<3m	N/A
28	10/29/2020 9:30	21.25	1.41	0.07	0.17	0.06	N/A	<3m	<3m	N/A
29	10/31/2020 10:45	2.5	0.49	0.20	0.00	0.00	N/A	<3m	<3m	N/A
30	11/1/2020 15:15	7.5	0.74	0.10	0.28	0.00	N/A	<3m	<3m	N/A
31	11/11/2020 22:45	1.5	0.03	0.02	0.02	0.00	N/A	<3m	<3m	N/A
32	11/13/2020 0:15	26.75	0.40	0.01	0.10	0.02	0.01	<3m	<3m	N/A
33	11/15/2020 20:45	4.75	0.58	0.12	0.36	0.02	N/A	<3m	<3m	N/A
34	11/23/2020 4:15	9.25	1.77	0.19	0.39	0.07	N/A	<3m	3m	N/A
35	11/25/2020 20:00	20.75	0.36	0.02	0.09	0.02	N/A	<3m	<3m	N/A
36	11/28/2020 16:00	0.5	0.03	0.06	0.03	0.00	N/A	<3m	<3m	N/A
37	11/30/2020 11:45	15.5	2.23	0.14	0.29	0.06	N/A	<3m	<3m	N/A
38	12/4/2020 20:15	27.75	2.47	0.09	0.36	0.10	0.05	<3m	6m	N/A

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
39	12/12/2020 12:15	7.75	0.50	0.06	0.17	0.02	N/A	<3m	<3m	N/A
40	12/14/2020 9:00	8.75	0.10	0.01	0.02	0.00	N/A	<3m	<3m	N/A
41	12/18/2020 14:45	0.5	0.02	0.04	0.02	0.00	N/A	<3m	<3m	N/A
42	12/19/2020 9:30	5.5	0.10	0.02	0.09	0.01	N/A	<3m	<3m	N/A
43	12/20/2020 15:30	3	0.07	0.02	0.05	0.00	N/A	<3m	<3m	N/A
44	12/21/2020 9:30	25	0.15	0.01	0.04	0.01	N/A	<3m	<3m	N/A
45	12/25/2020 2:30	16	2.00	0.13	0.35	0.08	N/A	<3m	3m	N/A
46	12/31/2020 4:30	2.75	0.15	0.05	0.10	0.01	N/A	<3m	<3m	N/A

(1) Recurrence intervals given in ranges of less than 3 months (<3m), 3-months, (3m), 3-6 months (3-6m), 6 months (6m), 6 months-1 year (6m-1yr), 1 year (1yr), 1 year to 2 year (1yr-2yr), 2 year (2yr) or the nearest year.

Rain Gauge 15: Roxbury

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval [1]		
								1-hr	24-hr	48-hr
1	7/5/2020 21:30	7.25	0.29	0.04	0.27	0.01	N/A	<3m	<3m	N/A
2	7/10/2020 14:30	9.75	0.2	0.02	0.10	0.01	N/A	<3m	<3m	N/A
3	7/13/2020 13:15	0.5	0.12	0.24	0.12	0.01	N/A	<3m	<3m	N/A
4	7/14/2020 10:15	0.25	0.01	0.04	0.01	0.01	N/A	<3m	<3m	N/A
5	7/15/2020 4:15	1.25	0.03	0.02	0.02	0.00	N/A	<3m	<3m	N/A
6	7/17/2020 5:15	2	0.26	0.13	0.21	0.01	N/A	<3m	<3m	N/A
7	7/22/2020 5:45	2.5	0.07	0.03	0.04	0.00	N/A	<3m	<3m	N/A
8	7/22/2020 20:30	2.25	0.18	0.08	0.16	0.01	N/A	<3m	<3m	N/A
9	7/23/2020 16:00	0.5	0.44	0.88	0.44	0.03	N/A	<3m	<3m	N/A
10	8/2/2020 16:15	0.75	0.03	0.04	0.03	0.00	N/A	<3m	<3m	N/A
11	8/4/2020 15:45	1.25	0.23	0.18	0.20	0.01	N/A	<3m	<3m	N/A
12	8/16/2020 17:45	9	0.29	0.03	0.08	0.01	N/A	<3m	<3m	N/A
13	8/18/2020 0:45	2	0.15	0.08	0.11	0.01	N/A	<3m	<3m	N/A
14	8/19/2020 15:00	3.5	0.08	0.02	0.06	0.00	N/A	<3m	<3m	N/A
15	8/22/2020 14:00	0.25	0.02	0.08	0.02	0.00	N/A	<3m	<3m	N/A
16	8/23/2020 16:15	4	0.67	0.17	0.48	0.03	N/A	<3m	<3m	N/A
17	8/27/2020 12:45	2	0.27	0.14	0.23	0.01	N/A	<3m	<3m	N/A
18	8/29/2020 10:00	2	0.06	0.03	0.04	0.00	N/A	<3m	<3m	N/A
19	9/2/2020 11:00	17.75	0.27	0.02	0.13	0.01	N/A	<3m	<3m	N/A
20	9/10/2020 14:00	7.75	0.38	0.05	0.27	0.02	N/A	<3m	<3m	N/A
21	9/30/2020 1:45	8.5	1.14	0.13	0.54	0.05	N/A	3m	<3m	N/A
22	10/7/2020 17:00	0.5	0.11	0.22	0.11	0.00	N/A	<3m	<3m	N/A
23	10/13/2020 4:30	17.75	1.76	0.10	0.41	0.07	N/A	<3m	<3m	N/A
24	10/16/2020 12:15	19.75	2.02	0.10	0.31	0.08	N/A	<3m	3m	N/A
25	10/21/2020 4:45	3.75	0.08	0.02	0.03	0.00	N/A	<3m	<3m	N/A
26	10/28/2020 1:30	15	0.32	0.02	0.09	0.01	N/A	<3m	<3m	N/A
27	10/29/2020 10:00	21	1.24	0.06	0.16	0.05	N/A	<3m	<3m	N/A
28	10/31/2020 11:15	1.75	0.42	0.24	0.00	0.00	N/A	<3m	<3m	N/A
29	11/1/2020 15:15	7.25	0.63	0.09	0.23	0.00	N/A	<3m	<3m	N/A
30	11/11/2020 23:15	1.5	0.02	0.01	0.01	0.00	N/A	<3m	<3m	N/A
31	11/13/2020 1:45	16.75	0.37	0.02	0.11	0.02	N/A	<3m	<3m	N/A
32	11/15/2020 21:00	4.5	0.55	0.12	0.34	0.02	N/A	<3m	<3m	N/A
33	11/23/2020 4:15	8.75	1.92	0.22	0.56	0.08	N/A	3m	3m	N/A
34	11/25/2020 20:30	17.25	0.29	0.02	0.08	0.01	N/A	<3m	<3m	N/A
35	11/27/2020 4:15	0.25	0.01	0.04	0.01	0.01	N/A	<3m	<3m	N/A
36	11/30/2020 12:00	16	2.04	0.13	0.32	0.05	N/A	<3m	<3m	N/A
37	12/4/2020 22:00	24.75	2.14	0.09	0.29	0.09	0.04	<3m	3-6m	N/A
38	12/12/2020 12:30	7.75	0.47	0.06	0.17	0.02	N/A	<3m	<3m	N/A

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval [1]		
								1-hr	24-hr	48-hr
39	12/14/2020 9:00	7.5	0.07	0.01	0.02	0.00	N/A	<3m	<3m	N/A
40	12/18/2020 15:00	0.25	0.01	0.04	0.01	0.00	N/A	<3m	<3m	N/A
41	12/20/2020 12:45	6	0.13	0.02	0.05	0.01	N/A	<3m	<3m	N/A
42	12/21/2020 9:45	25.25	0.24	0.01	0.04	0.01	0.01	<3m	<3m	N/A
43	12/25/2020 2:45	15.75	1.82	0.12	0.33	0.08	N/A	<3m	3m	N/A
44	12/31/2020 4:30	2.25	0.13	0.06	0.09	0.01	N/A	<3m	<3m	N/A

(1) Recurrence intervals given in ranges of less than 3 months (<3m), 3-months, (3m), 3-6 months (3-6m), 6 months (6m), 6 months-1 year (6m-1yr), 1 year (1yr), 1 year to 2 year (1yr-2yr), 2 year (2yr) or the nearest year.

Rain Gauge 16: Somerville

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval [1]		
								1-hr	24-hr	48-hr
1	7/1/2020 3:15	3	0.03	0.01	0.01	0.00	N/A	<3m	<3m	N/A
2	7/5/2020 21:15	1.25	0.11	0.09	0.03	0.00	N/A	<3m	<3m	N/A
3	7/13/2020 13:00	2.75	0.27	0.10	0.24	0.01	N/A	<3m	<3m	N/A
4	7/14/2020 9:45	7.25	0.33	0.05	0.24	0.01	N/A	<3m	<3m	N/A
5	7/17/2020 5:00	2.25	0.16	0.07	0.04	0.01	N/A	<3m	<3m	N/A
6	7/22/2020 5:45	16.75	0.46	0.03	0.26	0.02	N/A	<3m	<3m	N/A
7	7/23/2020 15:30	0.75	0.49	0.65	0.38	0.04	N/A	<3m	<3m	N/A
8	8/2/2020 17:15	1	0.12	0.12	0.07	0.01	N/A	<3m	<3m	N/A
9	8/4/2020 15:45	1	0.18	0.18	0.09	0.01	N/A	<3m	<3m	N/A
10	8/16/2020 19:00	4	0.18	0.05	0.03	0.01	N/A	<3m	<3m	N/A
11	8/17/2020 22:30	4	0.06	0.02	0.02	0.00	N/A	<3m	<3m	N/A
12	8/19/2020 17:45	0.25	0.01	0.04	0.01	0.00	N/A	<3m	<3m	N/A
13	8/22/2020 10:45	0.25	0.01	0.04	0.01	0.00	N/A	<3m	<3m	N/A
14	8/23/2020 15:45	4	0.8	0.20	0.50	0.03	N/A	<3m	<3m	N/A
15	8/27/2020 12:30	1.5	0.16	0.11	0.06	0.01	N/A	<3m	<3m	N/A
16	8/29/2020 9:30	9	0.16	0.02	0.05	0.00	N/A	<3m	<3m	N/A
17	9/2/2020 11:00	5.25	0.29	0.06	0.10	0.01	N/A	<3m	<3m	N/A
18	9/3/2020 11:15	0.25	0.01	0.04	0.01	0.01	N/A	<3m	<3m	N/A
19	9/10/2020 16:00	4.25	0.29	0.07	0.10	0.01	N/A	<3m	<3m	N/A
20	9/30/2020 1:45	8.25	0.83	0.10	0.22	0.03	N/A	<3m	<3m	N/A
21	10/2/2020 14:45	0.5	0.02	0.04	0.01	0.00	N/A	<3m	<3m	N/A
22	10/7/2020 16:45	0.25	0.04	0.16	0.04	0.00	N/A	<3m	<3m	N/A
23	10/13/2020 4:45	15.5	1.4	0.09	0.16	0.06	N/A	<3m	<3m	N/A
24	10/16/2020 12:00	20.5	1.76	0.09	0.10	0.07	N/A	<3m	<3m	N/A
25	10/21/2020 5:00	3.5	0.03	0.01	0.01	0.00	N/A	<3m	<3m	N/A
26	10/28/2020 2:45	15	0.26	0.02	0.02	0.01	N/A	<3m	<3m	N/A
27	10/29/2020 10:15	27.5	1.11	0.04	0.05	0.04	0.03	<3m	<3m	N/A
28	11/1/2020 14:45	7.5	0.64	0.09	0.08	0.00	N/A	<3m	<3m	N/A
29	11/2/2020 11:45	0.25	0.01	0.04	0.01	0.03	N/A	<3m	<3m	N/A
30	11/13/2020 0:00	17.75	0.26	0.01	0.02	0.01	N/A	<3m	<3m	N/A
31	11/15/2020 20:30	4.75	0.40	0.08	0.13	0.02	N/A	<3m	<3m	N/A
32	11/23/2020 4:15	8.75	1.66	0.19	0.17	0.07	N/A	<3m	<3m	N/A
33	11/26/2020 3:00	10.75	0.27	0.03	0.04	0.01	N/A	<3m	<3m	N/A
34	11/30/2020 11:30	10.75	0.87	0.08	0.08	0.04	N/A	<3m	<3m	N/A
35	12/4/2020 11:30	0.25	0.02	0.08	0.02	0.00	N/A	<3m	<3m	N/A
36	12/5/2020 3:00	18.5	2.10	0.11	0.10	0.09	N/A	<3m	3-6m	N/A
37	12/12/2020 12:30	7.75	0.43	0.06	0.05	0.02	N/A	<3m	<3m	N/A
38	12/14/2020 9:00	3.5	0.03	0.01	0.01	0.00	N/A	<3m	<3m	N/A

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
39	12/17/2020 1:00	10.25	0.16	0.02	0.01	0.01	N/A	<3m	<3m	N/A
40	12/20/2020 16:00	1.25	0.03	0.02	0.01	0.00	N/A	<3m	<3m	N/A
41	12/25/2020 2:45	15.75	1.70	0.11	0.11	0.07	N/A	<3m	<3m	N/A
42	12/31/2020 4:45	1.75	0.10	0.06	0.03	0.00	N/A	<3m	<3m	N/A

(1) Recurrence intervals given in ranges of less than 3 months (<3m), 3-months, (3m), 3-6 months (3-6m), 6 months (6m), 6 months-1 year (6m-1yr), 1 year (1yr), 1 year to 2 year (1yr-2yr), 2 year (2yr) or the nearest year.

Rain Gauge 17: Spot Pond

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval [(1)]		
								1-hr	24-hr	48-hr
1	7/1/2020 3:15	3	0.03	0.01	0.02	0.00	N/A	<3m	<3m	N/A
2	7/5/2020 21:15	1.25	0.11	0.09	0.10	0.00	N/A	<3m	<3m	N/A
3	7/13/2020 13:00	2.75	0.27	0.10	0.26	0.01	N/A	<3m	<3m	N/A
4	7/14/2020 9:45	7.25	0.33	0.05	0.27	0.01	N/A	<3m	<3m	N/A
5	7/17/2020 5:00	2.25	0.16	0.07	0.10	0.01	N/A	<3m	<3m	N/A
6	7/22/2020 5:45	16.75	0.46	0.03	0.34	0.02	N/A	<3m	<3m	N/A
7	7/23/2020 15:30	0.75	0.49	0.65	0.49	0.04	N/A	<3m	<3m	N/A
8	8/2/2020 17:15	1	0.12	0.12	0.12	0.01	N/A	<3m	<3m	N/A
9	8/4/2020 15:45	1	0.18	0.18	0.18	0.01	N/A	<3m	<3m	N/A
10	8/16/2020 19:00	4	0.18	0.05	0.09	0.01	N/A	<3m	<3m	N/A
11	8/17/2020 22:30	4	0.06	0.02	0.04	0.00	N/A	<3m	<3m	N/A
12	8/19/2020 17:45	0.25	0.01	0.04	0.01	0.00	N/A	<3m	<3m	N/A
13	8/22/2020 10:45	0.25	0.01	0.04	0.01	0.00	N/A	<3m	<3m	N/A
14	8/23/2020 15:45	4	0.8	0.20	0.74	0.03	N/A	6m-1yr	<3m	N/A
15	8/27/2020 12:30	1.5	0.16	0.11	0.13	0.01	N/A	<3m	<3m	N/A
16	8/29/2020 9:30	9	0.16	0.02	0.09	0.01	N/A	<3m	<3m	N/A
17	9/2/2020 11:00	5.25	0.29	0.06	0.21	0.01	N/A	<3m	<3m	N/A
18	9/3/2020 11:15	0.25	0.01	0.04	0.01	0.01	N/A	<3m	<3m	N/A
19	9/10/2020 16:00	4.25	0.29	0.07	0.23	0.01	N/A	<3m	<3m	N/A
20	9/30/2020 1:45	8.25	0.83	0.10	0.38	0.03	N/A	<3m	<3m	N/A
21	10/2/2020 14:45	0.5	0.02	0.04	0.02	0.00	N/A	<3m	<3m	N/A
22	10/7/2020 16:45	0.25	0.04	0.16	0.04	0.00	N/A	<3m	<3m	N/A
23	10/13/2020 4:45	15.5	1.4	0.09	0.26	0.06	N/A	<3m	<3m	N/A
24	10/16/2020 12:00	20.5	1.76	0.09	0.29	0.07	N/A	<3m	<3m	N/A
25	10/21/2020 5:00	3.5	0.03	0.01	0.01	0.00	N/A	<3m	<3m	N/A
26	10/28/2020 2:45	15	0.26	0.02	0.05	0.01	N/A	<3m	<3m	N/A
27	10/29/2020 10:15	27.5	1.11	0.04	0.16	0.04	0.03	<3m	<3m	N/A
28	11/1/2020 14:45	7.5	0.64	0.09	0.26	0.00	N/A	<3m	<3m	N/A
29	11/2/2020 11:45	0.25	0.01	0.04	0.01	0.03	N/A	<3m	<3m	N/A
30	11/13/2020 0:00	17.75	0.26	0.01	0.07	0.01	N/A	<3m	<3m	N/A
31	11/15/2020 20:30	4.75	0.40	0.08	0.26	0.02	N/A	<3m	<3m	N/A
32	11/23/2020 4:15	8.75	1.66	0.19	0.45	0.07	N/A	<3m	<3m	N/A
33	11/26/2020 3:00	10.75	0.27	0.03	0.10	0.01	N/A	<3m	<3m	N/A
34	11/30/2020 11:30	10.75	0.87	0.08	0.19	0.04	N/A	<3m	<3m	N/A
35	12/4/2020 11:30	0.25	0.02	0.08	0.02	0.00	N/A	<3m	<3m	N/A
36	12/5/2020 3:00	18.5	2.10	0.11	0.32	0.09	N/A	<3m	3-6m	N/A
37	12/12/2020 12:30	7.75	0.43	0.06	0.13	0.02	N/A	<3m	<3m	N/A
38	12/14/2020 9:00	3.5	0.03	0.01	0.02	0.00	N/A	<3m	<3m	N/A

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
39	12/17/2020 1:00	10.25	0.16	0.02	0.04	0.01	N/A	<3m	<3m	N/A
40	12/20/2020 16:00	1.25	0.03	0.02	0.02	0.00	N/A	<3m	<3m	N/A
41	12/25/2020 2:45	15.75	1.70	0.11	0.37	0.07	N/A	<3m	<3m	N/A
42	12/31/2020 4:45	1.75	0.10	0.06	0.08	0.00	N/A	<3m	<3m	N/A

(1) Recurrence intervals given in ranges of less than 3 months (<3m), 3-months, (3m), 3-6 months (3-6m), 6 months (6m), 6 months-1 year (6m-1yr), 1 year (1yr), 1 year to 2 year (1yr-2yr), 2 year (2yr) or the nearest year.

AECOM Imagine it. Delivered.

Rain Gauge 18: Union Park

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
1	7/1/2020 6:00	5.25	0.15	0.03	0.14	0.00	N/A	<3m	<3m	N/A
2	7/5/2020 21:45	1.5	0.13	0.09	0.12	0.01	N/A	<3m	<3m	N/A
3	7/10/2020 22:30	1	0.02	0.02	0.02	0.00	N/A	<3m	<3m	N/A
4	7/13/2020 13:30	0.25	0.11	0.44	0.11	0.00	N/A	<3m	<3m	N/A
5	7/14/2020 10:15	18.5	0.09	0.00	0.04	0.01	N/A	<3m	<3m	N/A
6	7/17/2020 5:15	2.25	0.14	0.06	0.09	0.01	N/A	<3m	<3m	N/A
7	7/22/2020 5:45	17	0.28	0.02	0.18	0.01	N/A	<3m	<3m	N/A
8	7/23/2020 16:00	0.5	0.56	1.12	0.56	0.03	N/A	3m	<3m	N/A
9	8/2/2020 16:15	0.5	0.04	0.08	0.04	0.00	N/A	<3m	<3m	N/A
10	8/4/2020 15:45	1.25	0.24	0.19	0.23	0.01	N/A	<3m	<3m	N/A
11	8/16/2020 18:00	9.25	0.26	0.03	0.08	0.01	N/A	<3m	<3m	N/A
12	8/18/2020 1:30	1.25	0.1	0.08	0.09	0.01	N/A	<3m	<3m	N/A
13	8/19/2020 17:45	0.75	0.03	0.04	0.03	0.00	N/A	<3m	<3m	N/A
14	8/23/2020 16:00	4	0.7	0.18	0.61	0.03	N/A	3-6m	<3m	N/A
15	8/27/2020 12:45	1.25	0.22	0.18	0.19	0.01	N/A	<3m	<3m	N/A
16	8/29/2020 9:45	2.25	0.06	0.03	0.04	0.00	N/A	<3m	<3m	N/A
17	9/2/2020 11:00	25.75	0.22	0.01	0.18	0.01	0.01	<3m	<3m	N/A
18	9/10/2020 16:00	4	0.22	0.06	0.00	0.02	N/A	<3m	<3m	N/A
19	9/30/2020 1:45	9	0.97	0.11	0.05	0.02	N/A	<3m	<3m	N/A
20	10/7/2020 17:00	0.5	0.15	0.30	0.15	0.01	N/A	<3m	<3m	N/A
21	10/13/2020 4:30	18	1.67	0.09	0.32	0.07	N/A	<3m	<3m	N/A
22	10/16/2020 12:15	20	1.93	0.10	0.29	0.08	N/A	<3m	3m	N/A
23	10/21/2020 4:45	3.75	0.08	0.02	0.03	0.00	N/A	<3m	<3m	N/A
24	10/28/2020 2:45	14	0.31	0.02	0.10	0.01	N/A	<3m	<3m	N/A
25	10/29/2020 10:00	21	1.2	0.06	0.16	0.05	N/A	<3m	<3m	N/A
26	10/31/2020 10:15	1.75	0.39	0.22	0.00	0.00	N/A	<3m	<3m	N/A
27	11/1/2020 15:15	7.25	0.62	0.09	0.22	0.00	N/A	<3m	<3m	N/A
28	11/11/2020 23:45	0.25	0.01	0.04	0.01	0.00	N/A	<3m	<3m	N/A
29	11/13/2020 0:15	18.75	0.33	0.02	0.08	0.01	N/A	<3m	<3m	N/A
30	11/15/2020 21:15	4.25	0.53	0.12	0.34	0.02	N/A	<3m	<3m	N/A
31	11/23/2020 4:15	8.75	1.70	0.19	0.48	0.07	N/A	<3m	<3m	N/A
32	11/25/2020 20:15	17.75	0.27	0.02	0.07	0.01	N/A	<3m	<3m	N/A
33	11/30/2020 12:00	14.5	1.65	0.11	0.30	0.04	N/A	<3m	<3m	N/A
34	12/4/2020 22:00	24.5	2.07	0.08	0.30	0.09	0.04	<3m	3-6m	N/A
35	12/12/2020 12:30	6	0.49	0.08	0.19	0.02	N/A	<3m	<3m	N/A
36	12/14/2020 9:00	8	0.07	0.01	0.02	0.00	N/A	<3m	<3m	N/A
37	12/18/2020 14:30	0.75	0.02	0.03	0.02	0.00	N/A	<3m	<3m	N/A
38	12/19/2020 14:45	0.25	0.01	0.04	0.01	0.00	N/A	<3m	<3m	N/A

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
39	12/20/2020 10:30	28.75	0.42	0.01	0.05	0.02	0.01	<3m	<3m	N/A
40	12/25/2020 2:45	15.75	1.74	0.11	0.46	0.07	N/A	<3m	<3m	N/A
41	12/31/2020 4:30	2	0.12	0.06	0.09	0.01	N/A	<3m	<3m	N/A

(1) Recurrence intervals given in ranges of less than 3 months (<3m), 3-months, (3m), 3-6 months (3-6m), 6 months (6m), 6 months-1 year (6m-1yr), 1 year (1yr), 1 year to 2 year (1yr-2yr), 2 year (2yr) or the nearest year.

Rain Gauge 19: USGS Fresh Pond

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval [1]		
								1-hr	24-hr	48-hr
1	7/1/2020 11:00	0.25	0.01	0.04	0.01	0.00	N/A	<3m	<3m	N/A
2	7/5/2020 21:30	15.25	0.11	0.01	0.06	0.00	N/A	<3m	<3m	N/A
3	7/17/2020 4:15	4	0.15	0.04	0.01	0.01	N/A	<3m	<3m	N/A
4	7/22/2020 5:15	16.75	0.38	0.02	0.24	0.02	N/A	<3m	<3m	N/A
5	7/23/2020 15:00	0.75	0.61	0.81	0.00	0.04	N/A	<3m	<3m	N/A
6	8/4/2020 15:45	1.25	0.18	0.14	0.17	0.01	N/A	<3m	<3m	N/A
7	8/16/2020 18:15	5.5	0.19	0.03	0.08	0.01	N/A	<3m	<3m	N/A
8	8/17/2020 22:45	4	0.07	0.02	0.05	0.00	N/A	<3m	<3m	N/A
9	8/19/2020 14:45	3.5	0.06	0.02	0.04	0.00	N/A	<3m	<3m	N/A
10	8/23/2020 16:00	4	0.54	0.14	0.46	0.02	N/A	<3m	<3m	N/A
11	8/27/2020 12:45	1.25	0.21	0.17	0.18	0.01	N/A	<3m	<3m	N/A
12	8/29/2020 9:45	3.5	0.1	0.03	0.05	0.00	N/A	<3m	<3m	N/A
13	9/2/2020 11:15	24.75	0.28	0.01	0.12	0.01	0.00	<3m	<3m	N/A
14	9/10/2020 16:30	3.25	0.48	0.15	0.12	0.01	N/A	<3m	<3m	N/A
15	9/30/2020 2:00	8.25	0.63	0.08	0.43	0.04	N/A	<3m	<3m	N/A
16	10/2/2020 14:45	0.5	0.02	0.04	0.02	0.00	N/A	<3m	<3m	N/A
17	10/7/2020 17:00	0.25	0.04	0.16	0.04	0.00	N/A	<3m	<3m	N/A
18	10/13/2020 4:45	15.75	1.41	0.09	0.34	0.06	N/A	<3m	<3m	N/A
19	10/16/2020 12:15	19.75	1.92	0.10	0.28	0.08	N/A	<3m	3m	N/A
20	10/21/2020 5:30	2.5	0.03	0.01	0.01	0.00	N/A	<3m	<3m	N/A
21	10/28/2020 3:45	12.75	0.31	0.02	0.08	0.01	N/A	<3m	<3m	N/A
22	10/29/2020 10:00	20.75	1.15	0.06	0.16	0.03	N/A	<3m	<3m	N/A
23	10/31/2020 9:45	1.75	0.08	0.05	0.00	0.00	N/A	<3m	<3m	N/A
24	11/1/2020 15:15	7	0.59	0.08	0.25	0.00	N/A	<3m	<3m	N/A
25	11/13/2020 8:45	7	0.14	0.02	0.06	0.01	N/A	<3m	<3m	N/A
26	11/15/2020 21:30	4	0.36	0.09	0.25	0.02	N/A	<3m	<3m	N/A
27	11/23/2020 4:15	8.75	1.77	0.20	0.43	0.07	N/A	<3m	3m	N/A
28	11/26/2020 8:30	4.75	0.26	0.05	0.13	0.01	N/A	<3m	<3m	N/A
29	11/30/2020 12:00	14.25	2.08	0.15	0.34	0.05	N/A	<3m	<3m	N/A
30	12/5/2020 3:45	17.5	2.03	0.12	0.22	0.08	N/A	<3m	3m	N/A
31	12/12/2020 12:45	5.75	0.44	0.08	0.14	0.02	N/A	<3m	<3m	N/A
32	12/17/2020 0:15	10	0.55	0.06	0.14	0.02	N/A	<3m	<3m	N/A
33	12/25/2020 3:00	15.75	1.86	0.12	0.32	0.08	N/A	<3m	3m	N/A
34	12/31/2020 5:00	1.5	0.11	0.07	0.00	0.00	N/A	<3m	<3m	N/A

(1) Recurrence intervals given in ranges of less than 3 months (<3m), 3-months, (3m), 3-6 months (3-6m), 6 months (6m), 6 months-1 year (6m-1yr), 1 year (1yr), 1 year to 2 year (1yr-2yr), 2 year (2yr) or the nearest year.

Rain Gauge 20: Waltham Farm

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
1	7/1/2020 11:00	0.25	0.01	0.04	0.01	0.00	N/A	<3m	<3m	N/A
2	7/5/2020 21:30	15.25	0.11	0.01	0.06	0.00	N/A	<3m	<3m	N/A
3	7/17/2020 4:15	4	0.15	0.04	0.09	0.01	N/A	<3m	<3m	N/A
4	7/22/2020 5:15	16.75	0.38	0.02	0.24	0.02	N/A	<3m	<3m	N/A
5	7/23/2020 15:00	0.75	0.61	0.81	0.61	0.04	N/A	3-6m	<3m	N/A
6	8/2/2020 16:30	0.75	0.02	0.03	0.02	0.00	N/A	<3m	<3m	N/A
7	8/4/2020 15:45	1.25	0.18	0.14	0.17	0.01	N/A	<3m	<3m	N/A
8	8/16/2020 18:15	5.5	0.19	0.03	0.08	0.01	N/A	<3m	<3m	N/A
9	8/17/2020 22:45	4	0.07	0.02	0.05	0.00	N/A	<3m	<3m	N/A
10	8/19/2020 14:45	3.5	0.06	0.02	0.04	0.00	N/A	<3m	<3m	N/A
11	8/23/2020 16:00	4	0.54	0.14	0.46	0.02	N/A	<3m	<3m	N/A
12	8/27/2020 12:45	1.25	0.21	0.17	0.18	0.01	N/A	<3m	<3m	N/A
13	8/29/2020 9:45	3.5	0.1	0.03	0.05	0.00	N/A	<3m	<3m	N/A
14	9/2/2020 11:15	24.75	0.28	0.01	0.18	0.01	0.01	<3m	<3m	N/A
15	9/10/2020 16:30	3.25	0.48	0.15	0.39	0.02	N/A	<3m	<3m	N/A
16	9/30/2020 2:00	8.25	0.63	0.08	0.29	0.03	N/A	<3m	<3m	N/A
17	10/2/2020 14:45	0.5	0.02	0.04	0.02	0.00	N/A	<3m	<3m	N/A
18	10/7/2020 17:00	0.25	0.04	0.16	0.04	0.00	N/A	<3m	<3m	N/A
19	10/13/2020 4:45	15.75	1.41	0.09	0.34	0.06	N/A	<3m	<3m	N/A
20	10/16/2020 12:15	19.75	1.92	0.10	0.28	0.08	N/A	<3m	3m	N/A
21	10/21/2020 5:30	2.5	0.03	0.01	0.01	0.00	N/A	<3m	<3m	N/A
22	10/28/2020 3:45	12.75	0.31	0.02	0.08	0.01	N/A	<3m	<3m	N/A
23	10/29/2020 10:00	20.75	1.15	0.06	0.17	0.05	N/A	<3m	<3m	N/A
24	10/31/2020 9:45	1.75	0.08	0.05	0.00	0.00	N/A	<3m	<3m	N/A
25	11/1/2020 15:15	7	0.59	0.08	0.25	0.00	N/A	<3m	<3m	N/A
26	11/13/2020 8:45	7	0.14	0.02	0.06	0.01	N/A	<3m	<3m	N/A
27	11/15/2020 21:30	4	0.36	0.09	0.25	0.02	N/A	<3m	<3m	N/A
28	11/23/2020 4:15	8.75	1.77	0.20	0.43	0.07	N/A	<3m	3m	N/A
29	11/26/2020 8:30	4.75	0.26	0.05	0.13	0.01	N/A	<3m	<3m	N/A
30	11/30/2020 12:00	14.25	2.08	0.15	0.34	0.05	N/A	<3m	<3m	N/A
31	12/5/2020 3:45	17.5	2.03	0.12	0.22	0.08	N/A	<3m	3m	N/A
32	12/12/2020 12:45	5.75	0.44	0.08	0.14	0.02	N/A	<3m	<3m	N/A
33	12/17/2020 0:15	10	0.55	0.06	0.14	0.02	N/A	<3m	<3m	N/A
34	12/25/2020 3:00	15.75	1.86	0.12	0.32	0.08	N/A	<3m	3m	N/A
35	12/31/2020 5:00	1.5	0.11	0.07	0.09	0.00	N/A	<3m	<3m	N/A

(1) Recurrence intervals given in ranges of less than 3 months (<3m), 3-months, (3m), 3-6 months (3-6m), 6 months (6m), 6 months-1 year (6m-1yr), 1 year (1yr), 1 year to 2 year (1yr-2yr), 2 year (2yr) or the nearest year.

Appendix C Rainfall Hyetographs

All hyetographs are plotted using 15-minute peak intensities.

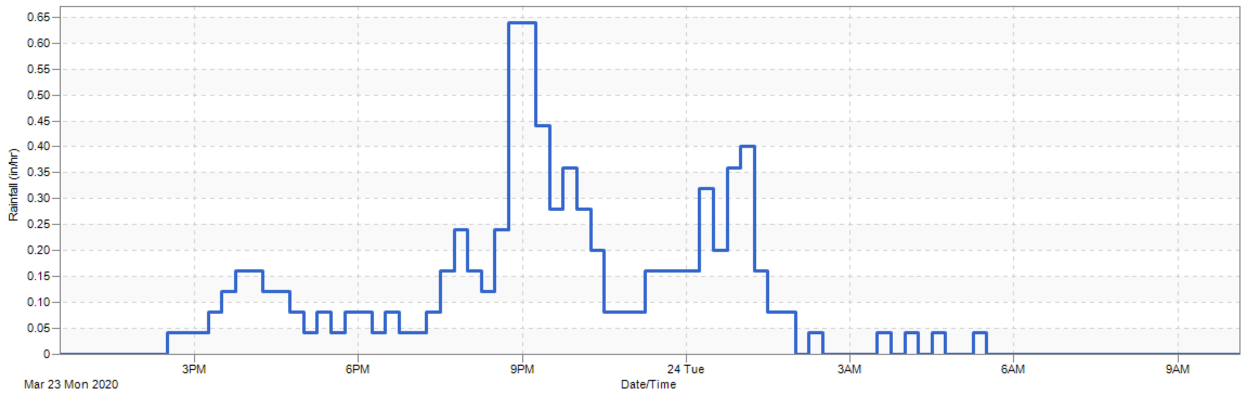

Figure 1. Ward Street March 23, 2020

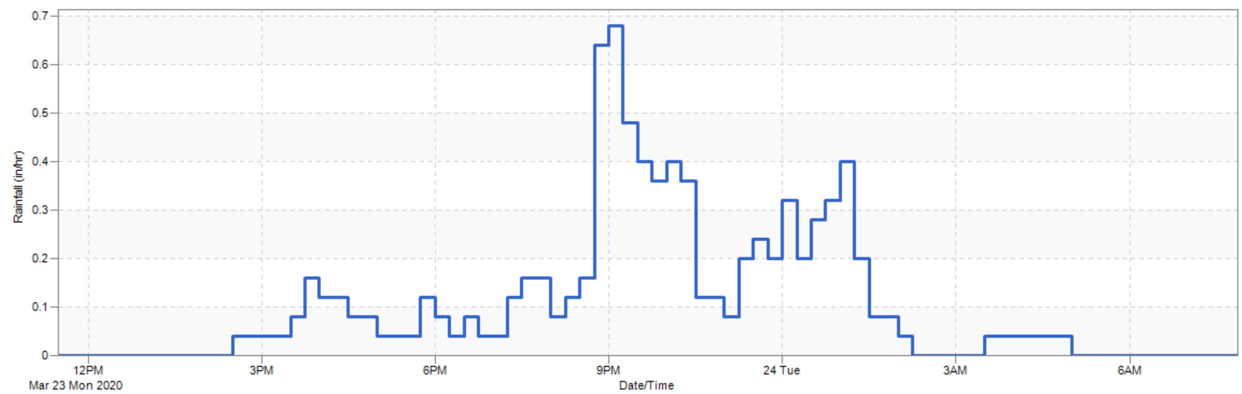

Figure 2. Columbus Park March 23, 2020

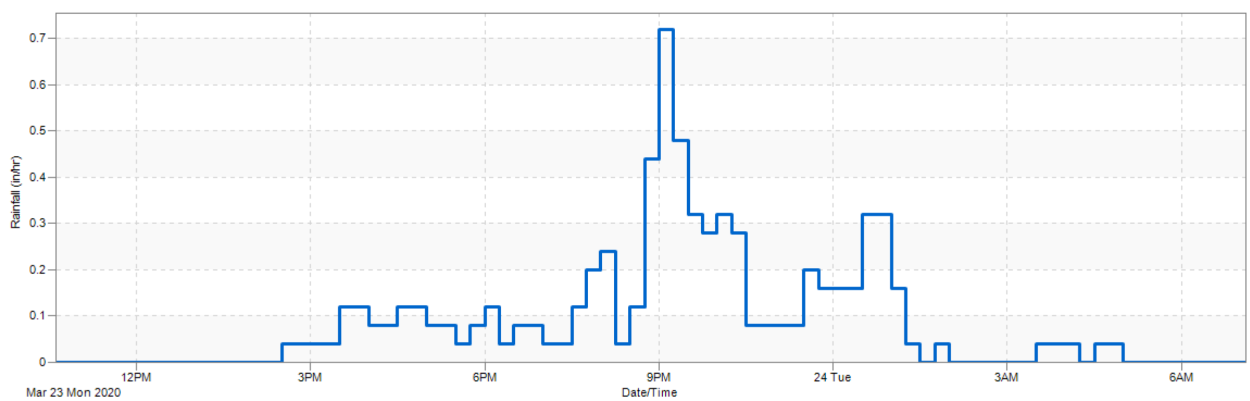

Figure 3. Chelsea Creek March 23, 2020

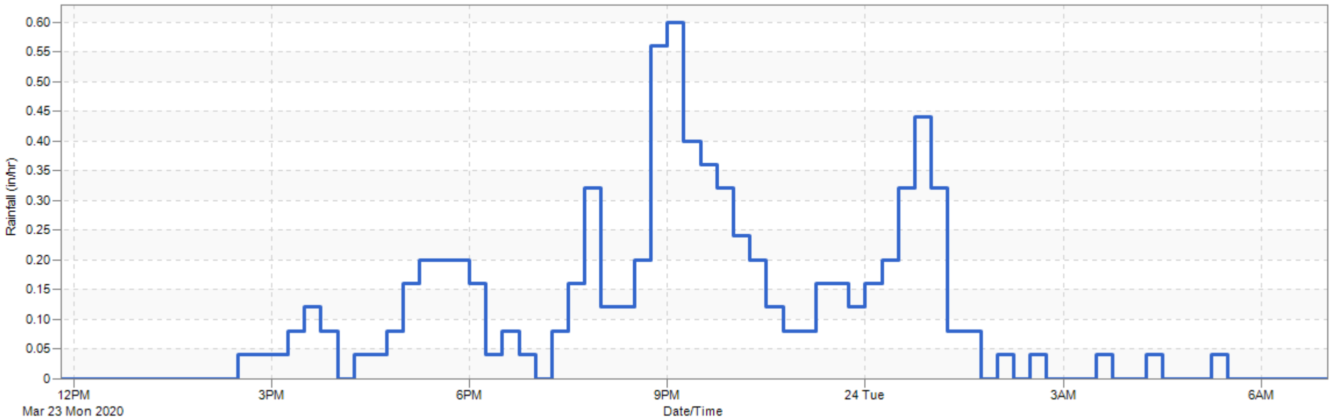

Figure 4. USGS Fresh Pond March 23, 2020

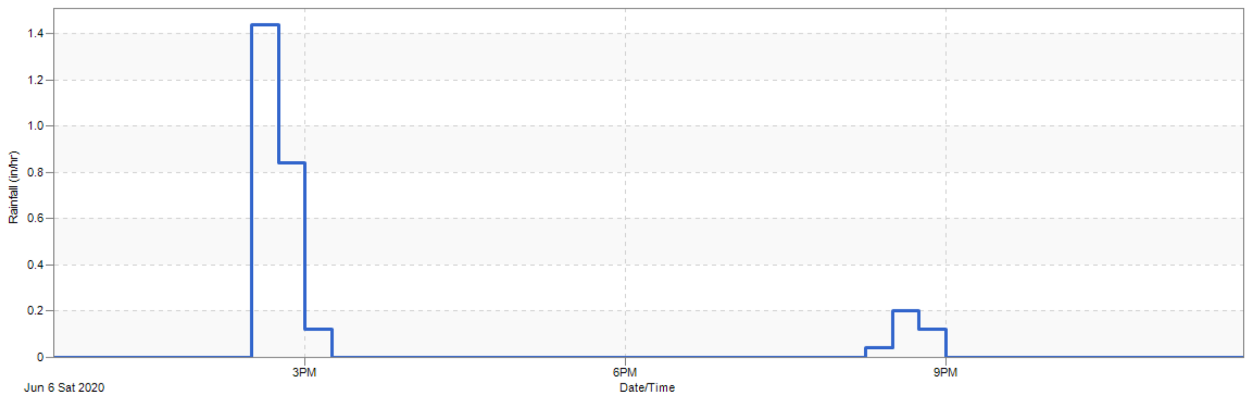

Figure 5. Ward Street June 6, 2020

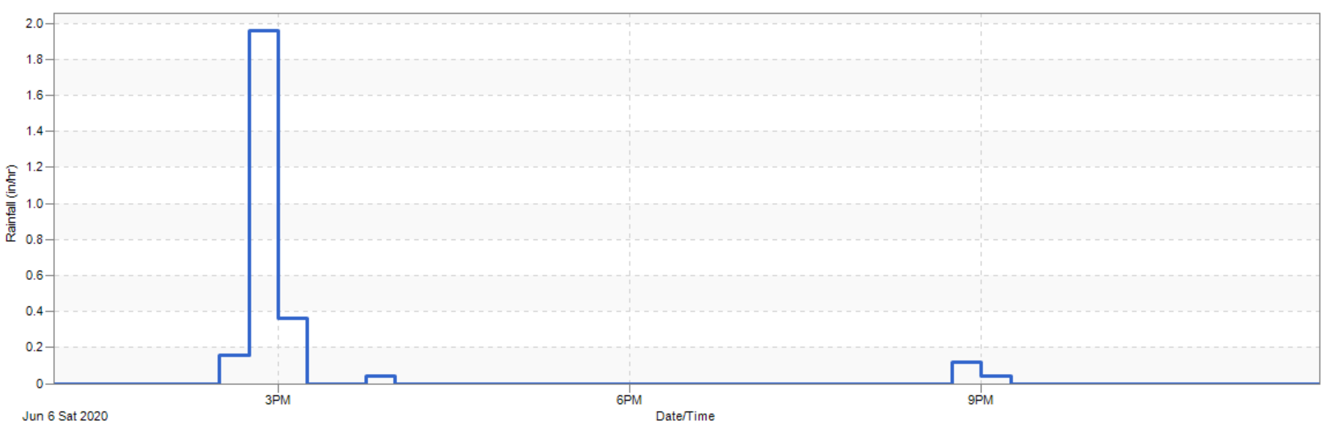

Figure 6. Columbus Park June 6, 2020

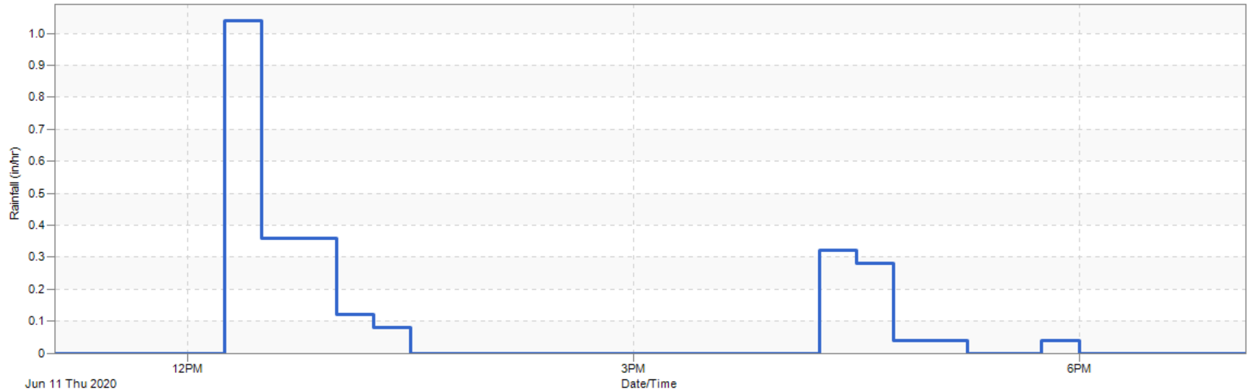

Figure 7. Ward Street June 11, 2020

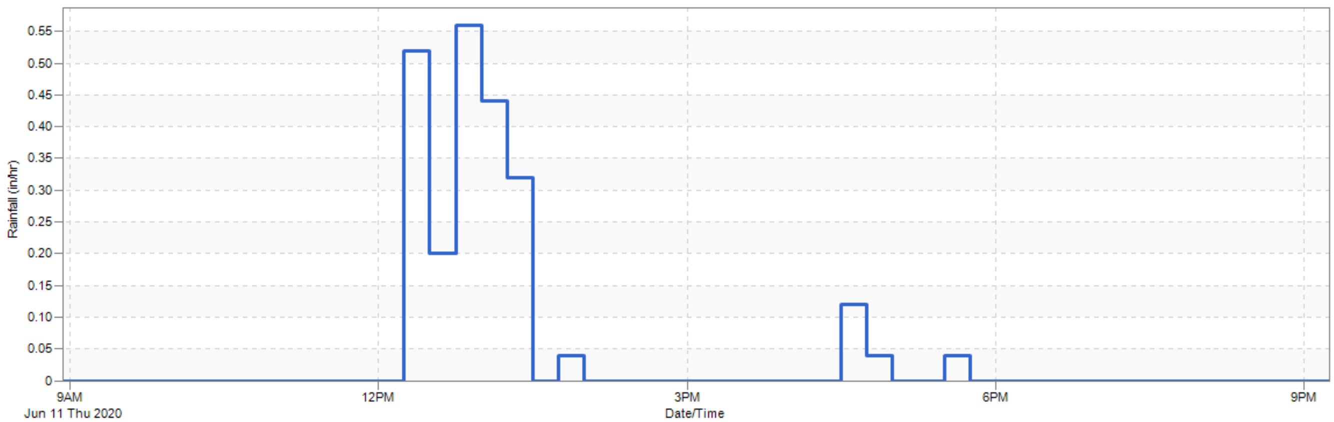

Figure 8. Columbus Park June 11, 2020

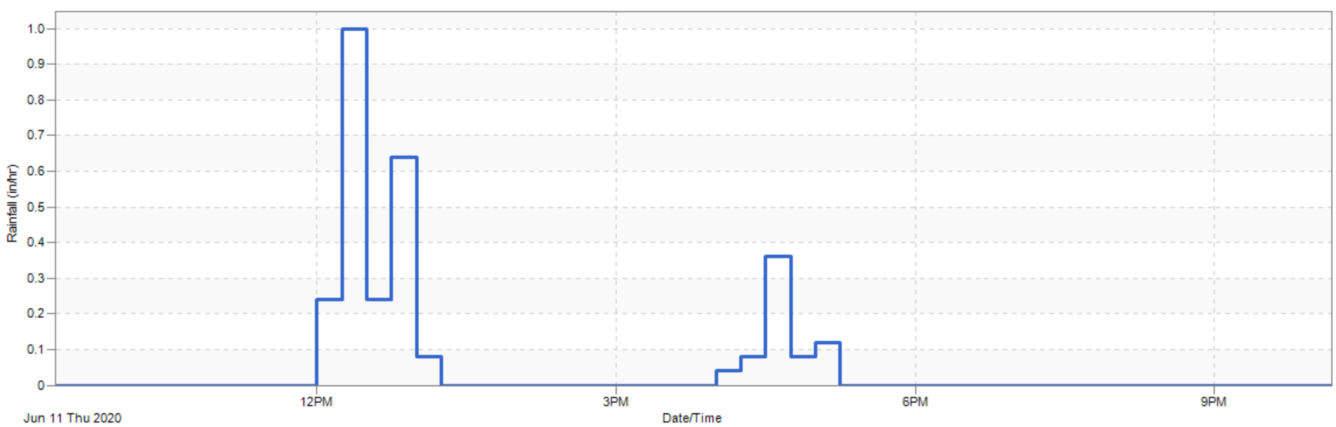

Figure 9. USGS Fresh Pond June 11, 2020

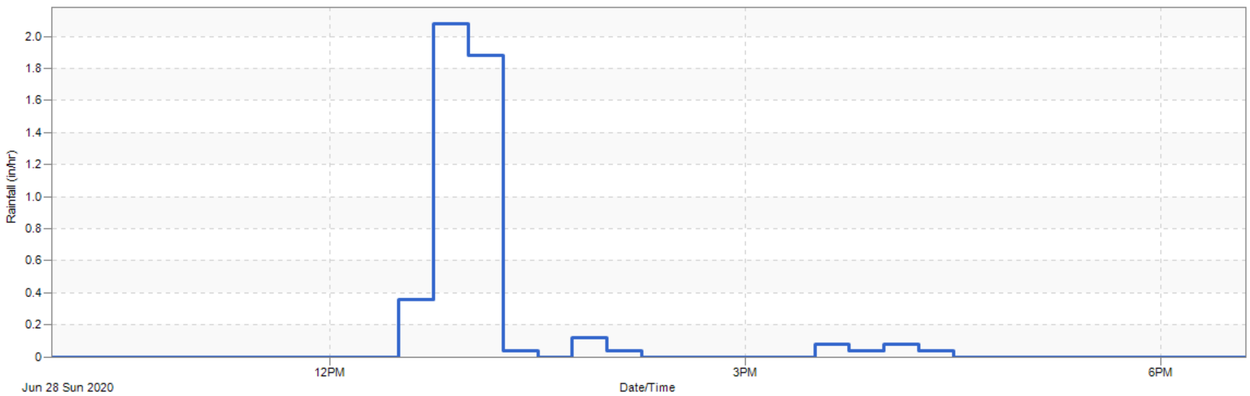

Figure 10. Ward Street June 28, 2020

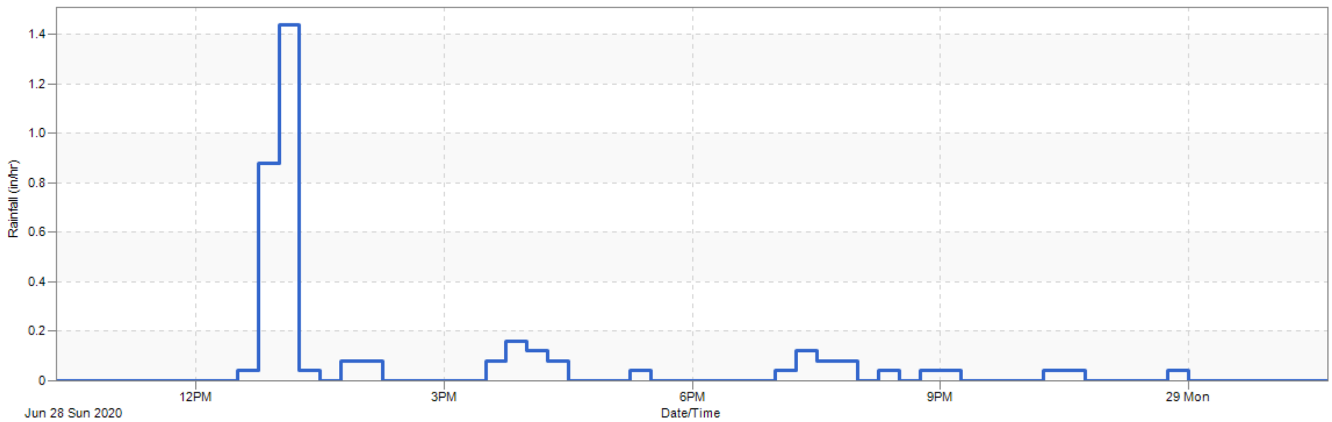

Figure 11. Columbus Park June 28, 2020

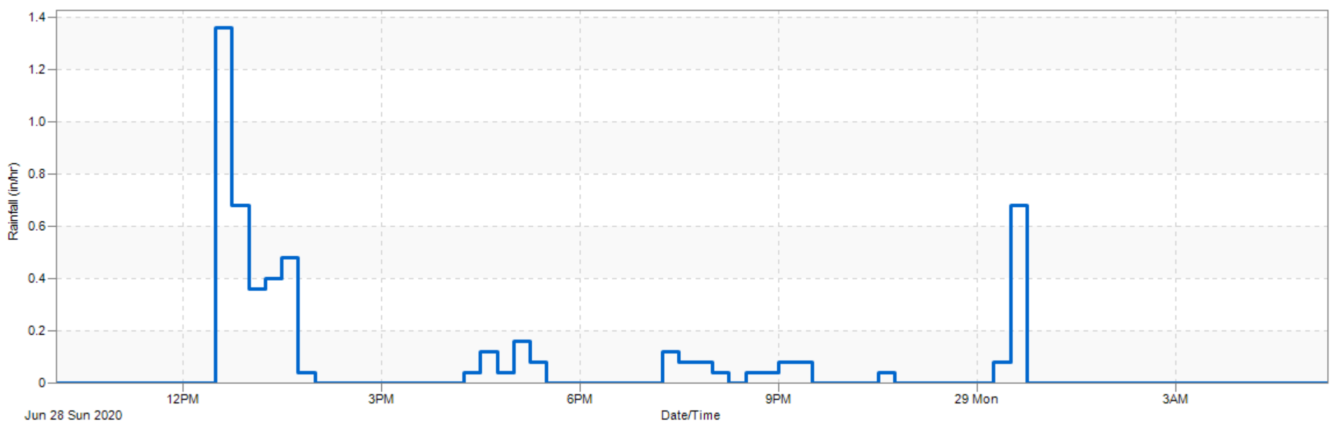

Figure 12. Chelsea Creek June 28, 2020

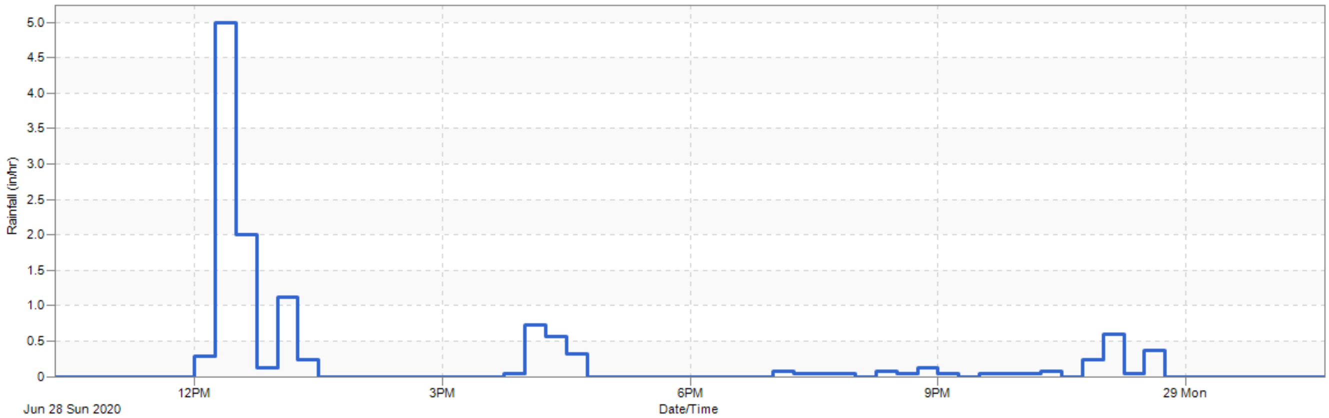

Figure 13. USGS Fresh Pond June 28, 2020

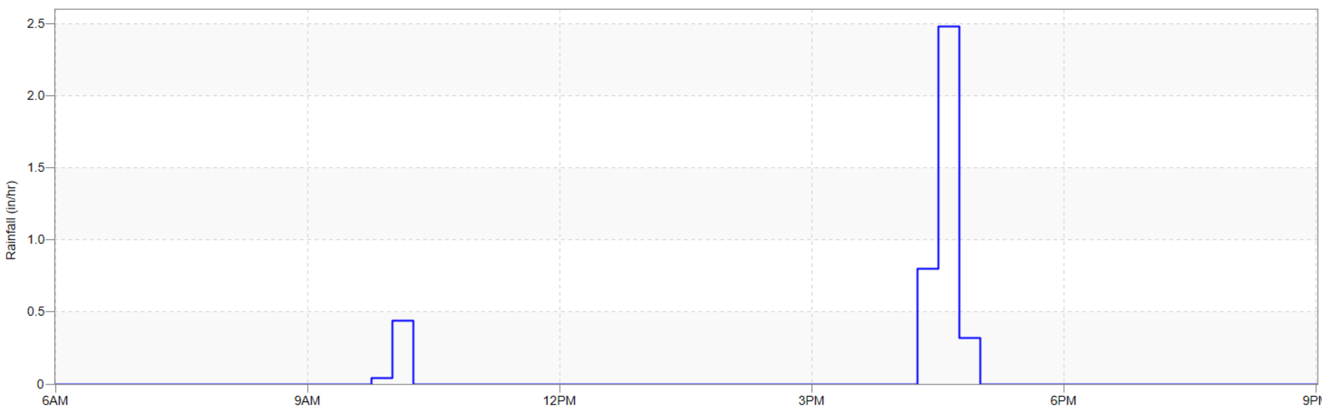

Figure 14. Chelsea Creek July 14, 2020

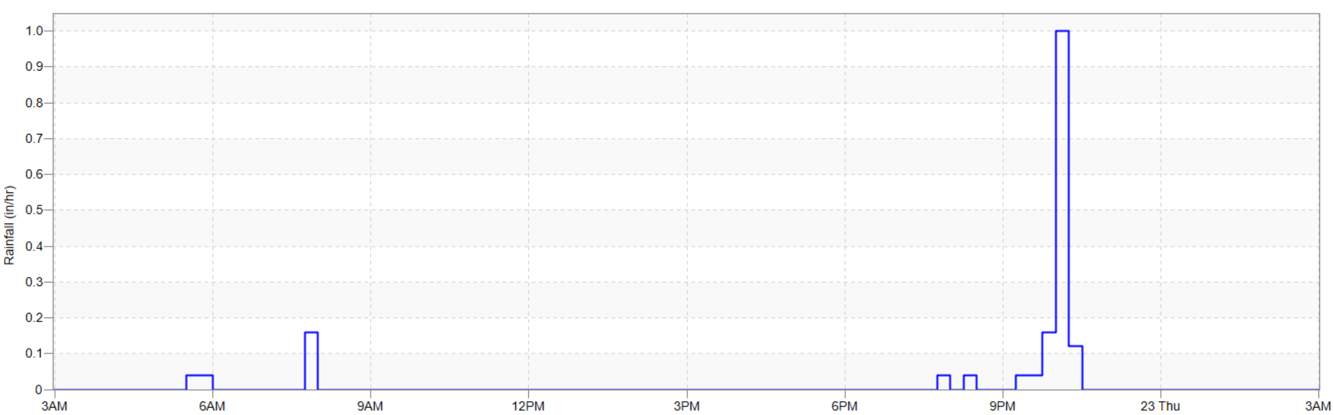

Figure 15. Ward Street July 23, 2020

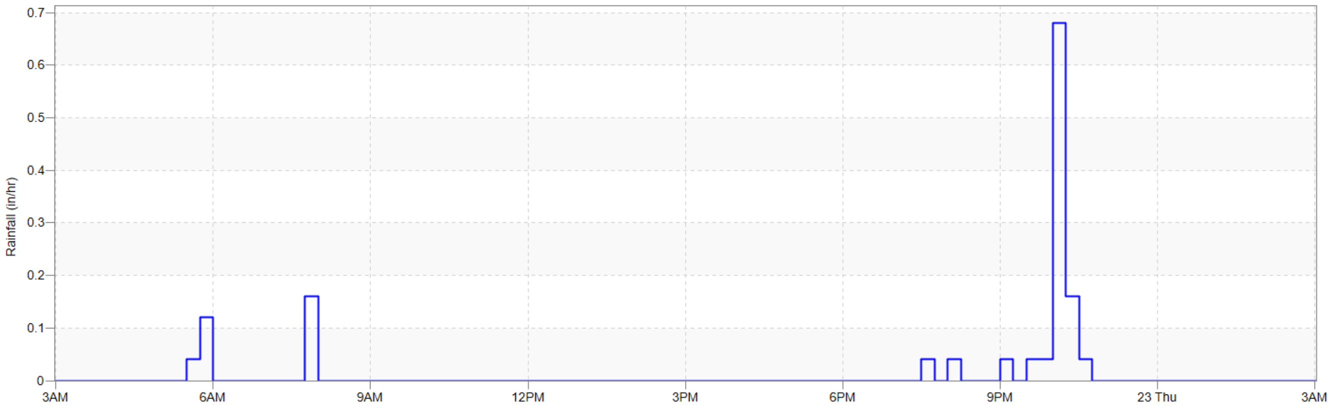

Figure 16. Columbus Park July 23, 2020

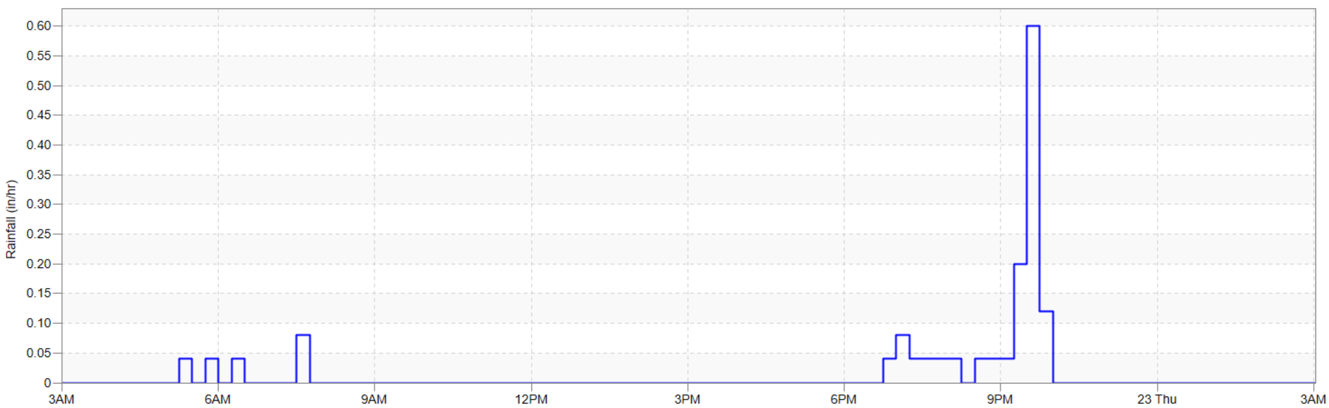

Figure 17. Fresh Pond July 23, 2020

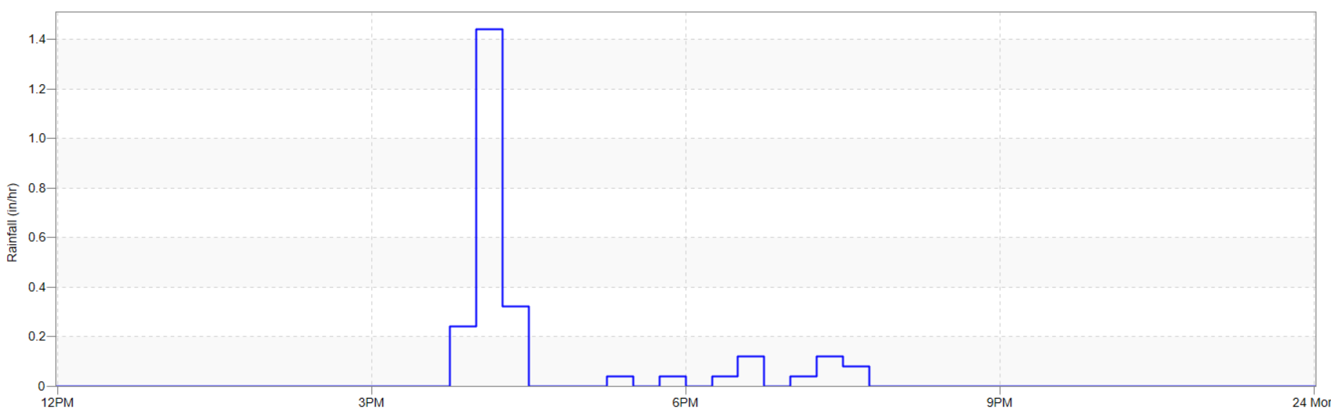

Figure 18. Ward Street August 23, 2020

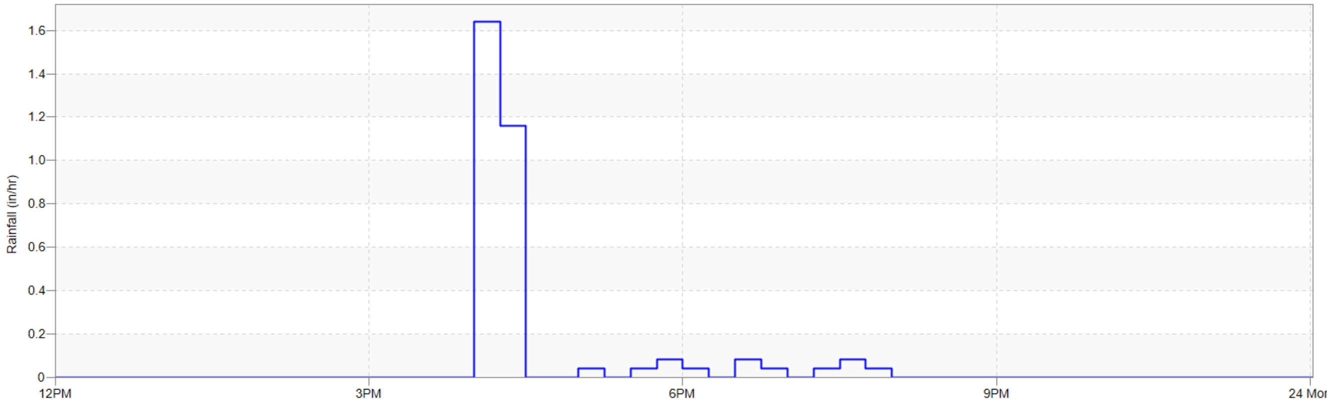

Figure 19. Columbus Park August 23, 2020

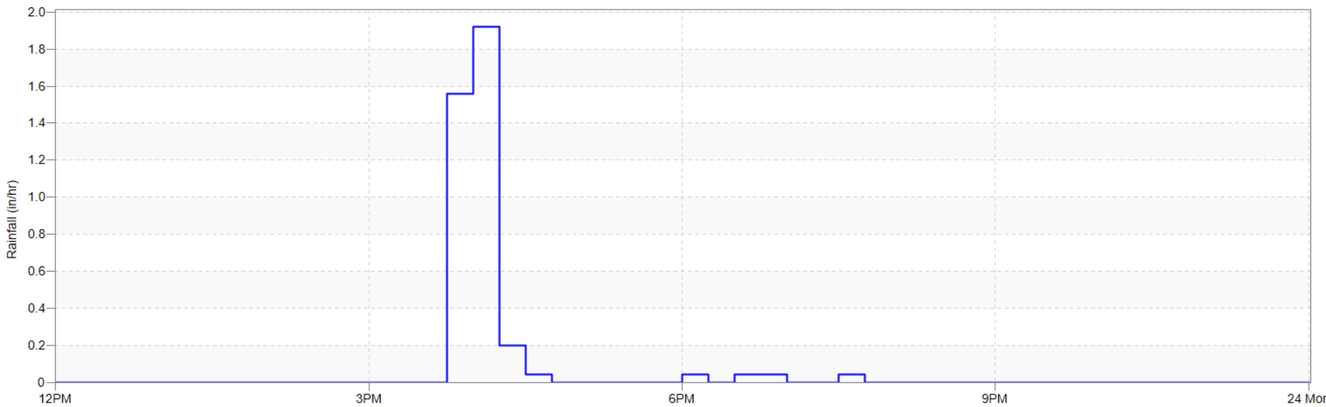

Figure 20. Chelsea Creek August 23, 2020

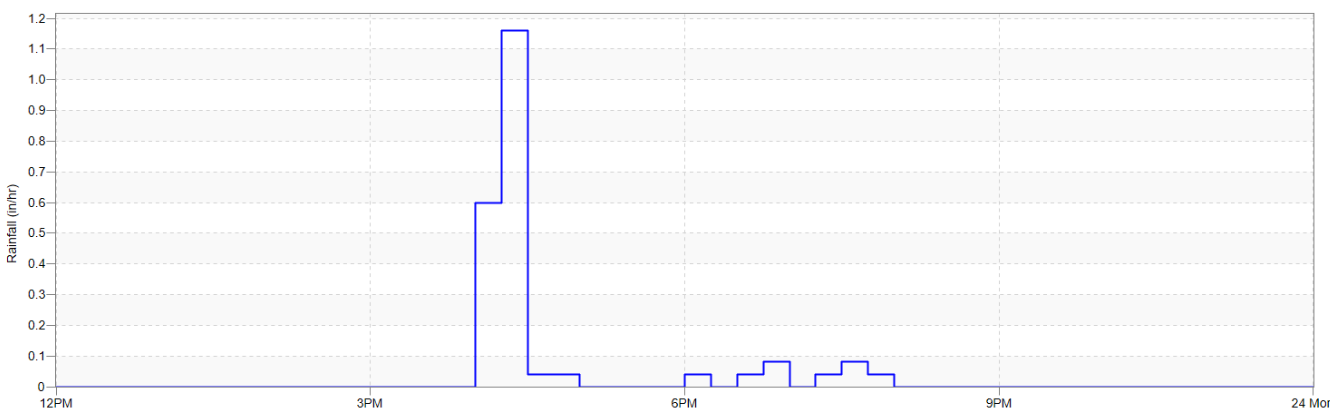

Figure 21. Fresh Pond August 23, 2020

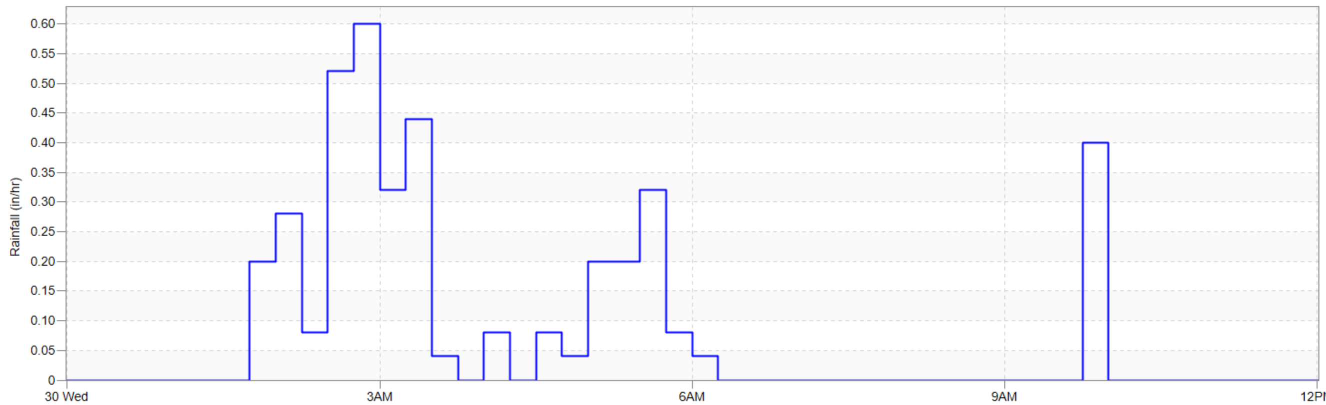

Figure 22. Ward Street September 30, 2020

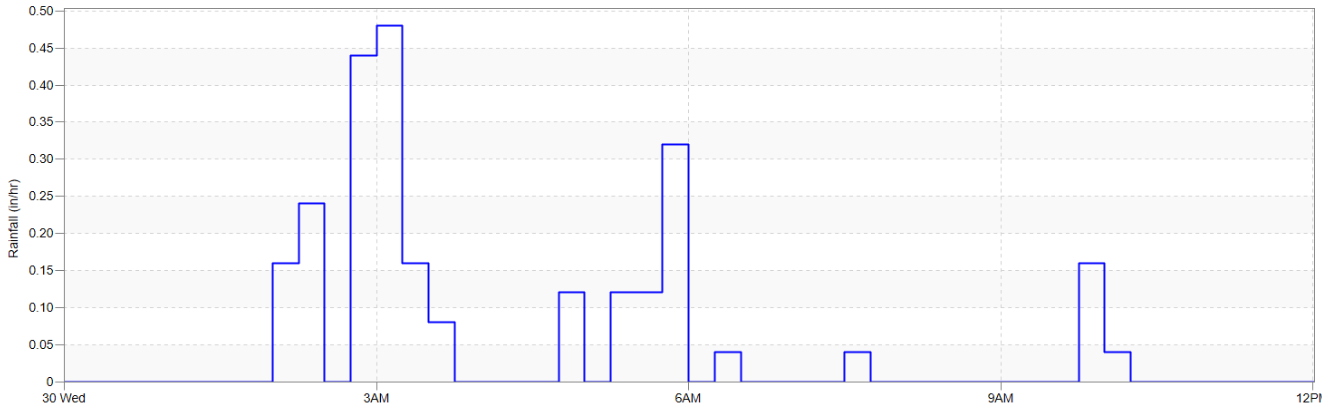

Figure 23. Fresh Pond September 30, 2020

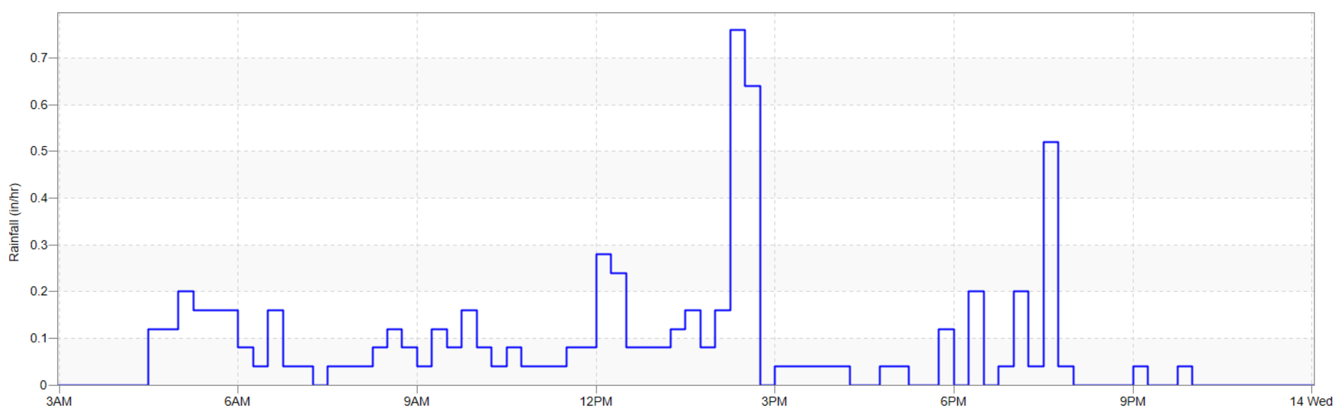

Figure 24. Ward Street October 13, 2020

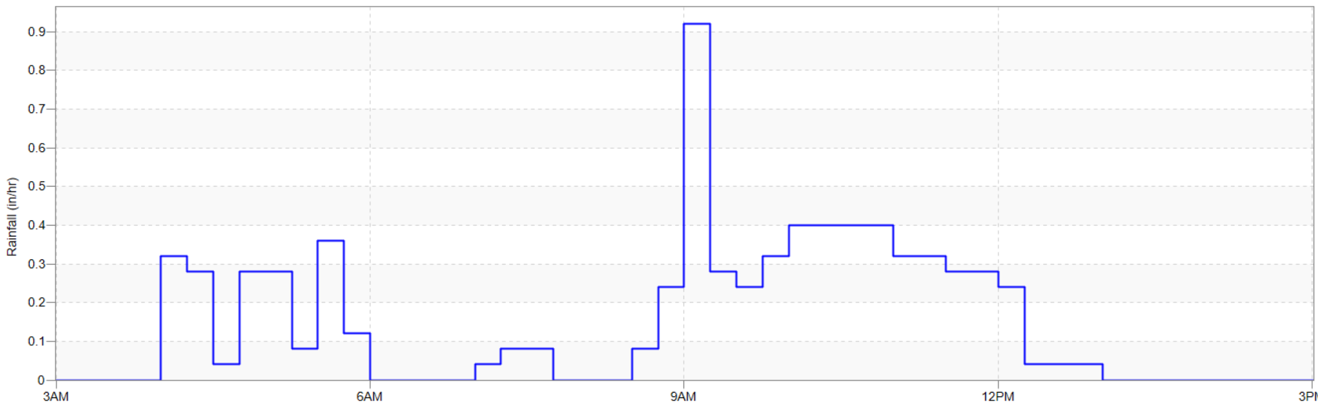

Figure 25. Ward Street November 23, 2020

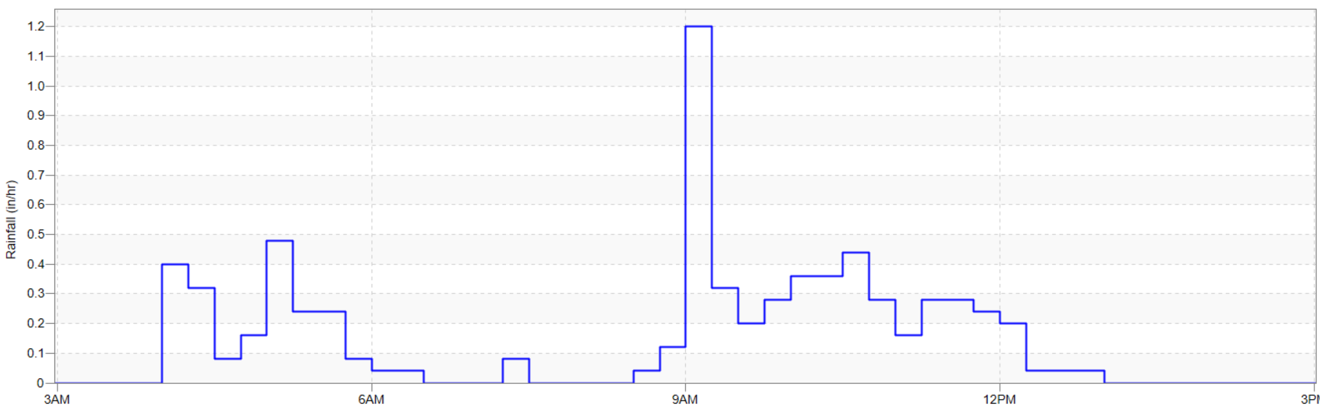

Figure 26. Columbus Park November 23, 2020

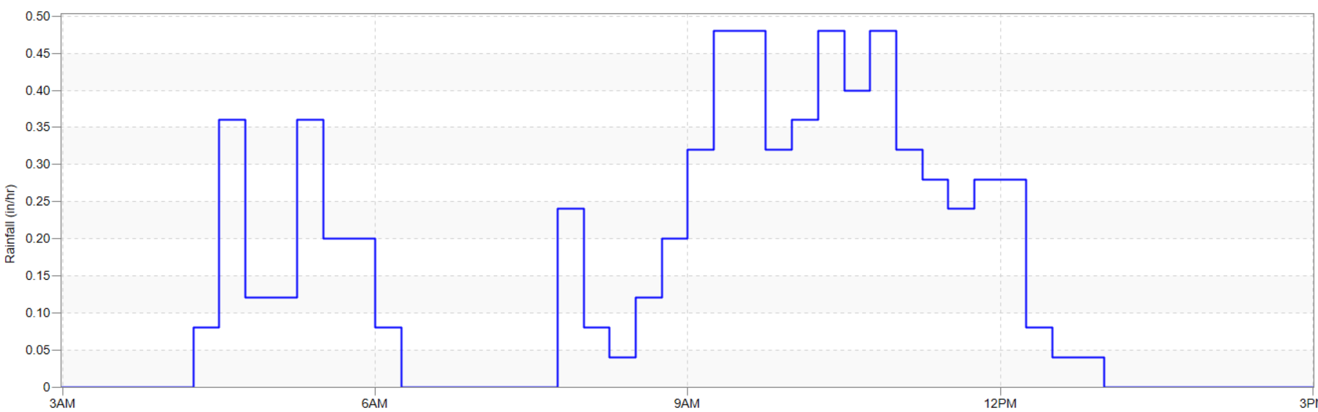

Figure 27. Fresh Pond November 23, 2020

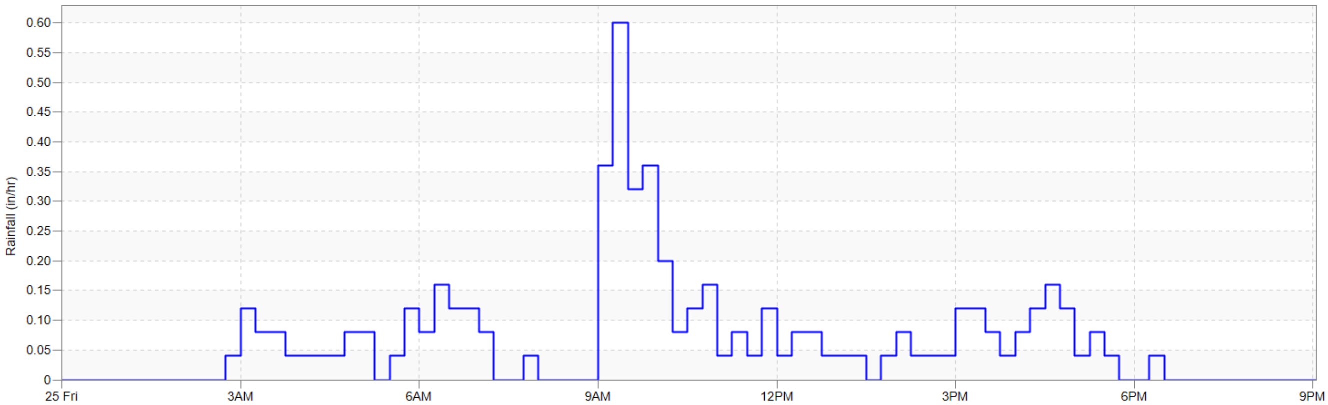

Figure 28. Columbus Park December 25, 2020

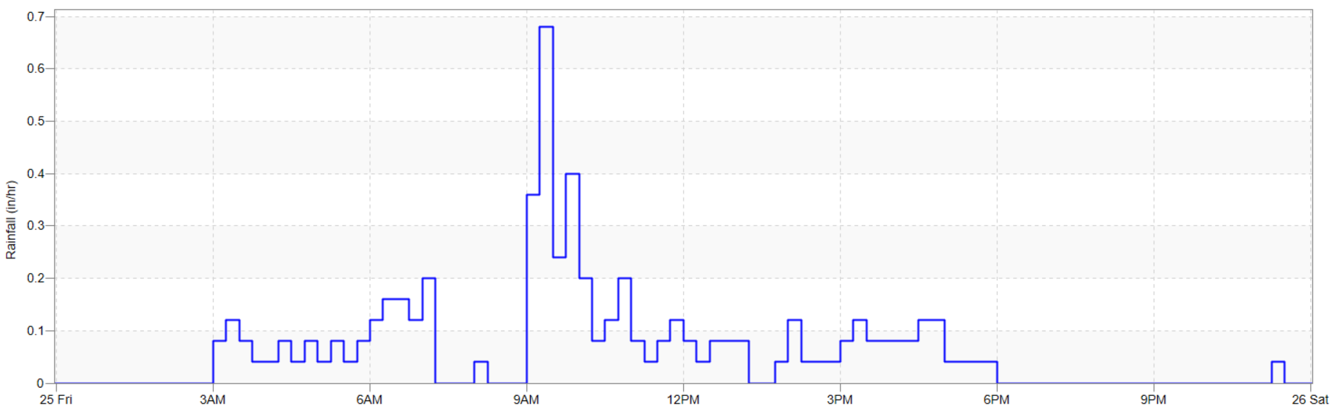

Figure 29. Chelsea Creek December 25, 2020