Task 4: Semiannual CSO Discharge Report No. 5
January 1, 2020 – June 30, 2020

CSO Post Construction Monitoring and
Performance Assessment
MWRA Contract No. 7572

October 30, 2020

Project number: 60559027

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Definitions

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. Introduction

1.1 Purpose and Scope of the Semiannual CSO Discharge Report

On November 8, 2017, the Massachusetts Water Resources Authority (MWRA) commenced a multi-year study to measure the performance of its $912.5 million long-term combined sewer overflow ("CSO") control plan (the "Long-Term Control Plan" or "LTCP"). This is the fifth 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	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;
- Collection of extensive rainfall data and overflow related data (field measurements) at remaining CSO regulators;

[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.

- Upgrade and improvement of the calibration of MWRA's hydraulic model of the wastewater system using inspection information and overflow 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 is due to the Court in just over one year, MWRA highlights in this fifth progress report the potential for specific outfall locations to achieve - or not to achieve - the LTCP activation and volume goals. MWRA notes here, as it described in Semiannual Report No. 4 sections 2.1 and 4.1, 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 Exhibit A to the Second CSO Stipulation.

- Locations already achieving or that MWRA (based on currently available data) can reasonably anticipate will achieve activation and volume goals are identified in Table 1-2 on page 4.

- Locations previously characterized as inconsistent with volume and/or activation goals but which are within reasonable metering and modeling margins of error (BOS057, BOS060, BOS064 and MWR023) are presented in Table 1-2 as consistent with those goals.

- There are locations where additional evaluations and work are underway or planned but it is simply too soon to forecast whether and how the activation and volume goals can be achieved. These locations are identified in Table 1-2 as not likely to achieve the goals based on results of investigations to date.

1.2 Progress of CSO Post-Construction Monitoring and Performance Assessment

The following information provides a summary of MWRA work progress since the submission of the last semiannual progress report on April 30, 2020. More information on each of these items is provided in subsequent chapters of this report.

1.2.1 Updated Interim System Performance Assessment and Comparison with LTCP Levels of Control

With 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) an interim assessment of the existing system's Typical Year CSO performance relative to the LTCP's activation and volume goals by outfall and receiving water segment. An updated interim assessment of Typical Year performance, for mid-2020 system conditions, is presented in Table 1-2 below and in Chapter 6 of this report.

Updates to MWRA's hydraulic model from "2019 System Conditions" to "Mid-2020 System Conditions" are described in Section 4.3. The sources of model updates to mid-2020 system conditions included new information from MWRA or community wastewater system inspections; additional data from temporary flow meters; operation, maintenance or capital improvements made to the MWRA or community wastewater systems; and other model adjustments to improve the characterization or simulation of hydrologic or hydraulic conditions.

A comparison of the Typical Year results from the 2019 System Conditions and Mid-2020 System Conditions models are presented in Chapter 6, and specifically Table 6-1. At most discharge locations, Typical Year activation and volume predictions did not change or changed very little from 2019 to Mid-2020 conditions. At several locations, Typical Year activation and/or volume changed more significantly, as presented and described in Section 4.3 and in Table 6-1.

As noted above, Table 1-2 includes MWRA's forecast of what is reasonable to expect, based on currently available data, at the conclusion of the performance assessment in December 2021. Table 1-2 identifies, by a single asterisk, locations where short-term or longer-term CSO mitigation measures are being evaluated, some of which are in accordance with conditions in the CSO water quality standards variances for the Lower Charles River/Charles Basin and the Alewife Brook/Upper Mystic River.

Table 1-2 identifies locations where achievement of the LTCP activation and volume goals can be reasonably expected based on investigations conducted to date and site-specific projects proposed or underway. It should be noted that at locations where it is not yet reasonable to forecast whether activation and/or volume goals will be met, water quality goals may still be achieved. The receiving water quality models described in Chapter 3 will better inform whether CSO or non-CSO sources should be pursued to realize any additional water quality improvement in the variance waters. At some locations, CSO solutions to attain LTCP goals may yield minimal water quality improvement. MWRA's ongoing efforts also support the eventual development of a use attainability analyses as a means to evaluate the appropriateness of current state water quality standards in the event that identified minimal CSO contributions have limited water quality impact, non-CSO pollution sources are the dominant contributors to water quality impairment, and further CSO control would not improve water quality.

1.2.2 Site-Specific Overflow Activity Investigations

MWRA, in coordination with the CSO communities, 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 closer to the LTCP goals. MWRA and the CSO communities have made substantial progress in evaluating the feasibility and CSO reduction benefit of mitigation measures at many of these locations, and have completed or are implementing improvements at some locations. Table 1-3, on page 7 lists these locations, candidate mitigation measures, and a summary of progress made, though some of these efforts may not be completed by December 2021. More information on the progress of these evaluations is presented in Chapter 2.

Table 1-2. Typical Year Performance: Baseline 1992, Current (Mid-2020) and LTCP (1 of 3)

Outfall likely to achieve LTCP activation and volume goals
Outfall likely not to achieve LTCP activation and/or volume goal
Model prediction is greater than LTCP value.

Outfall	1992 SYSTEM CONDITIONS [1]		Mid-2020 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	0.49	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	16	2.17	5	1.61
CAM401B			4	0.53	7	2.15
SOM001A*	10	11.93	8	4.51	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**		**7.71**		**7.29**
UPPER MYSTIC RIVER						
SOM007A/MWR205A*	9	7.61	6	4.91	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**		**4.91**		**3.48**
MYSTIC/CHELSEA CONFLUENCE						
MWR205 (Somerville Marginal Facility)*	33	120.37	30	101.74	39	60.58
BOS013*	36	4.40	8	0.37	4	0.54
BOS014*	20	4.91	8	1.44	0	0.00
BOS015	76	2.76	Closed	N/A	Closed	N/A
BOS017*	49	7.16	6	0.32	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	7	1.01	3	0.32
CHE008*	35	22.35	11	3.81	0	0.00
TOTAL		**185.96**		**108.69**		**61.72**

Table 1-2. Typical Year Performance: Baseline 1992, Current (Mid-2020) and LTCP (2 of 3)

Outfall	1992 SYSTEM CONDITIONS [1]		Mid-2020 SYSTEM CONDITIONS		LONG TERM CONTROL PLAN [2]	
	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)
UPPER INNER HARBOR						
BOS009*	34	3.60	10	0.70	5	0.59
BOS010*	48	11.83	7	0.77	4	0.72
BOS012*	41	7.90	13	1.34	5	0.72
BOS019	107	4.48	1	0.09	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	1.43	1	0.43
BOS058	17	0.29	Closed	N/A	Closed	N/A
BOS060**	64	2.90	2	0.17	0	0.00
MWR203 (Prison Point Facility)	28	261.85	17	242.90	17	243.00
TOTAL		**307.56**		**247.39**		**246.04**
LOWER INNER HARBOR						
BOS003*	28	18.09	9	6.13	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**		6.19		**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	4	0.98	1	0.01
BOS064**	14	0.99	1	0.02	0	0.00
BOS065*	11	3.08	3	0.91	1	0.06
BOS068	4	0.62	0	0.00	0	0.00
BOS070	4	281.62				
BOS070/DBC*			7	5.90	3	2.19
MWR215 (Union Park Facility)			10	26.65	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**		**34.45**		**73.89**
RESERVED CHANNEL						
BOS076	65	65.94	2	0.21	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**		**0.21**		**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**

Table 1-2. Typical Year Performance: Baseline 1992, 2019, Current (Mid-2020) and LTCP (3 of 3)

Outfall	1992 SYSTEM CONDITIONS (1)		Mid-2020 SYSTEM CONDITIONS		LONG TERM CONTROL PLAN (2)	
	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)
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	8	0.73	3	0.84
CAM007**	1	0.81	2	0.42	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**		**1.15**		**0.88**
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	1.93	0	0.00
MWR019*	2	1.32	2	0.56	0	0.00
MWR020*	2	0.64	2	0.31	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	4	12.64	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**		**15.58**		**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**		**384**		**381**
Total Untreated		**759**		**42**		**23**
GRAND TOTAL		**1457**		**426**		**404**

* See Table 1-3 for site-specific investigations or projects underway.

**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.

(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.

Table 1-3. Site-Specific Investigations and Progress (1 of 2)

Outfall likely to achieve LTCP activation and volume goals
Outfall likely not to achieve LTCP activation and/or volume goal

<table>
<tr><th>Outfall</th><th colspan="4">Progress Summary (see Chapter 2 for more information)</th></tr>
<tr><td colspan="5">East Boston</td></tr>
<tr><td>Mystic Chelsea Confluence
BOS013
BOS014
Upper Inner Harbor
BOS009
BOS010
BOS012
Lower Inner Harbor
BOS003</td><td colspan="2">BWSC is implementing sewer separation in parts of East Boston. Contract 1 is complete, Contract 2 is in construction and will be complete in 2021, and Contract 3 is in design with start of construction in May 2021. MWRA modeling shows that contracts 1 and 2 will result in attainment or near attainment of activation and volume goals at BOS010, BOS012, and BOS013. MWRA modeling shows that Contract 3, scheduled for completion in November 2022, will reduce the total Typical Year discharge volume to below the total LTCP volume from all East Boston outfalls.</td><td colspan="2">Next steps: MWRA and BWSC will continue to evaluate regulator adjustments including weir raising and or connection relief to further reduce CSO discharge frequencies and volumes at BOS003 and BOS014 toward LTCP goals.</td></tr>
<tr><td colspan="5">Cottage Farm CSO Facility</td></tr>
<tr><td>Lower Charles River
MWR201</td><td colspan="4">On August 14, 2020, the City of Cambridge completed its Partial Sewer Separation improvements that reduce separate stormwater inflow to sewer systems upstream of the Cottage Farm Facility. Prior to completion, MWRA performed preliminary modeling of the improvements, which showed attainment of the LTCP’s 2 activations in the Typical Year and a reduction in treated discharge volume to 8.75 million gallons, compared to the LTCP goal of 6.3 MG. With the improvements now in place, Cambridge and MWRA are collecting meter data on stormwater flow discharging to the Charles River Basin and the remaining stormwater flow entering the sewer system. Data from a large storm that causes Cottage Farm activation will allow a more accurate modeling assessment of the benefits of the Partial Sewer Separation improvements on Cottage Farm’s treated discharges. This outfall is also subject to CSO optimization evaluations, pursuant to the Charles River CSO variance.</td></tr>
<tr><td colspan="5">Somerville-Marginal CSO Facility</td></tr>
<tr><td>Mystic-Chelsea Confluence
MWR205
Upper Mystic River Basin
SOM007A/MWR205A</td><td>MWRA has completed investigations into the causes of tidal inflow leaking through the MWR205 outfall tide gate and is now preparing construction documents to replace the tide gate. MWRA modeling shows that replacement of the tide gate will provide a slight benefit to SOM007A/ MWR205A discharges.</td><td>In looking for modifications to facility operations that might lower CSO discharges, MWRA determined that closing the facility gates earlier, when influent flow level towards the end of a storm drops to el.106.5 MWRA datum instead of 105.5, would reduce the treated volume in the Typical Year by 2.7 MG. This operational modification has been adopted, and has been incorporated into the Mid-2020 Conditions model.</td><td>MWRA has begun an evaluation of the benefits and feasibility of increasing the 18” diameter dry weather connection to MWRA’s Somerville Medford Branch Sewer immediately upstream of the CSO facility (a condition of the Alewife Brook/Upper Mystic River Variance). Initial modeling by MWRA shows that increasing the connection to 24” diameter can reduce Typical Year treated discharges at MWR205 and SOM007A/ MWR205A towards LTCP levels, but that without hydraulic controls on the connection, increased CSOs at other locations are predicted, including the Prison Point facility. The impact of increasing the connection size on other systems and CSOs requires further investigation.</td><td>MWRA has also begun an evaluation of the benefits and feasibility of removing separate stormwater flows that enter the sewer system immediately upstream of the CSO facility (a condition of the Alewife Brook/Upper Mystic River Variance). Recent field investigation by City of Somerville and MWRA concluded that the 72” MassDOT storm drain connection cannot be redirected, due to upstream combined sewer connections. Somerville and MWRA are investigating upstream separate stormwater areas that may be redirected, including a 19-acre separated area in the Ten Hills neighborhood. MWRA is conducting water quality sampling and flow measurement of the Ten Hills flow.</td></tr>
</table>

Table 1-3. Site-Specific Investigations and Progress (2 of 2)

<table>
<tr><th>Outfall</th><th colspan="3">Progress Summary (see Chapter 2 for more information)</th></tr>
<tr><td colspan="4">Outfall BOS070 (Fort Point Channel)</td></tr>
<tr><td>BOS070/DBC</td><td colspan="3">In March 2020, BWSC completed <u>extensive sediment cleaning</u> in its South Boston Interceptor-North Branch and tributary sewers. and removed a maintenance weir that had contributed to sediment deposition. MWRA had added the weir and sediment to its hydraulic model to be able to calibrate the model predicted overflows at the several regulators associated with Outfall BOS070 against overflow measurements in 2018. With information BWSC provided on the results of its cleaning contract, MWRA adjusted the model for this area and recalibrated the adjusted model to overflow measurements collected after March 2020. Updated Typical Year model results show no or a minor reduction in CSO activation and/or volume at most of the regulators. Discharges at RE070/10-5 were reduced from 2 activations and 0.11 MG to 1 activation and 0.04 MG in the Typical Year. Of the nine regulators, three continue to contribute to higher overflow activity exceeding the LTCP goals: RE070/8-3, RE070/9-4 and RE070/7-2.

Next steps: At these regulators, BWSC and MWRA will evaluate <u>regulator adjustments, such as raising overflow weirs</u>. MWRA will also evaluate the CSO benefits of BWSC's plan to separate sewers in a 400-acre area in this part of South Boston over the next seven years. BWSC's modeling shows significant CSO reduction at some of the BOS070/DBC regulators with this sewer separation. BWSC plans to award the first of several planned construction contracts in Spring 2021.</td></tr>
<tr><td colspan="4">Alewife Brook</td></tr>
<tr><td>CAM401A
SOM001A</td><td>MWRA has made progress with the <u>evaluation of the potential CSO benefits of modifying the pump operation strategy at the Alewife Brook Pumping Station</u> (a condition of the Alewife Brook/Upper Mystic River Variance). MWRA has completed a review of record information on pump performance, a field test on the one dry weather pump, and an analysis of the theoretical lowest allowable wet well operating level. A preliminary Typical Year model run simulating this low wet well level operation showed only minor CSO reduction at some regulators, and no or negligible benefit at CAM401A and SOM001A.</td><td>During 2018 inspections and metering, the City of Cambridge and MWRA observed standing water in the dry weather connection (Sherman St. sewer) downstream of the CAM401A regulator. Cambridge confirmed high sediment levels in the Sherman St. sewer and other downstream pipes and issued a contract for <u>sediment cleaning and inspections</u> that Cambridge expects will be complete this fall. MWRA has made preliminary model runs of the planned sediment removal, which predict that activation and volume goals at CAM401A will be met with completion of the contract. However, the benefit of this sediment removal requires confirmation.</td><td>MWRA's next steps include the <u>evaluation of CSO system optimization measures</u>, which is required by the Alewife Brook/Upper Mystic River Variance to commence by December 2020. Evaluations will consider 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.</td></tr>
<tr><td colspan="4">Chelsea Outfalls/Chelsea Creek</td></tr>
<tr><td>CHE004</td><td colspan="3">The City of Chelsea and MWRA each previously modeled the potential benefits and impacts of <u>raising the overflow weir</u> at the outfall's sole regulator, RE-041. The results from both models showed that raising the weir by 1.5 feet could reduce Typical Year CSO activations and volume to the LTCP levels without causing impacts either to the upstream Chelsea sewer system or the downstream MWRA interceptor system. The City has contracted for design and construction services to raise the weir by 1.5 feet, and expects the work will be completed this fall. Post-construction data from permanent overflow meters operated by the City at this regulator will support verification of CSO control benefits, including whether the LTCP goals are attained.</td></tr>
<tr><td>CHE008</td><td colspan="3">The City of Chelsea and MWRA previously determined that the 30-inch dry weather connection from regulator RE-081 to the MWRA interceptor system causes significant head loss and restriction of flow. MWRA has completed an analysis of the connection's hydraulic conditions. MWRA is evaluating connection relief alternatives, including interim improvements to reduce headloss in the existing connection. MWRA recently trimmed the protrusion of the 30-inch pipe in the regulator structure, which had impeded flow entering the connection. In addition, MWRA is also evaluating the feasibility of replacing or relieving the 30-inch connection.</td></tr>
<tr><td colspan="4">Other Outfalls and Regulators</td></tr>
<tr><td>Mystic/Chelsea Confluence</td><td colspan="3"></td></tr>
<tr><td>BOS017</td><td colspan="3">BWSC recently completed an extensive inspection of the outfall, the regulator, and upstream systems. BWSC and MWRA are making adjustments to their hydraulic models with the inspection results prior to confirming model calibration at BOS017 and then evaluating CSO optimization measures, including raising the overflow weir. BWSC is also pursuing repairs to a leaky tide gate at BOS017 that was previously identified.</td></tr>
<tr><td>Fort Point Channel</td><td colspan="3"></td></tr>
<tr><td>BOS062</td><td colspan="3" rowspan="2">BWSC is conducting inspections of these regulator systems and, with MWRA support, will evaluate CSO optimization measures, including raising overflow weirs.</td></tr>
<tr><td>BOS065</td></tr>
<tr><td>Charles River</td><td colspan="2" rowspan="5">MWRA will commence an evaluation of CSO system optimization measures at all regulators tributary to the Charles River by December 2020, in accordance with a condition in the Lower Charles River/Charles Basin CSO Variance.</td><td rowspan="5">Cambridge plans to inspect the CAM005 system to verify the presence and condition of possible obstructions in the City's connection to the MWRA interceptor, which MWRA had previously identified.</td></tr>
<tr><td>CAM005</td></tr>
<tr><td>MWR018</td></tr>
<tr><td>MWR019</td></tr>
<tr><td>MWR020</td></tr>
</table>

1.2.3 Water Quality Assessment Approaches and Receiving Water Quality Model

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 (also see Section 1.4 "Massachusetts Water Quality Standards and CSO Variances"). 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 3 of this report describes MWRA's progress with development of the receiving water quality models.

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. MWRA plans to issue the Final Receiving Water Quality Model Development and Calibration Report in November 2020. MWRA will then use the calibrated models to perform the Water Quality Assessments, and will issue first draft reports to DEP and EPA in April 2021.

1.2.4 Data Collection and Analyses

In the period January 1, 2020 through June 30, 2020, MWRA continued to collect and analyze rainfall data from the 20 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. Most of these 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 January 1, 2020 through June 30, 2020 are presented in Appendices C and D. The rainfall characteristics support a comparison of the collection period storms to the Typical Year (see Section 5.1) and the validation of measured CSO discharges (Section 5.2 and Appendix A). In addition, rainfall data are input to the calibrated model to produce storm-by-storm model-predicted CSO discharges (Section 5.3).

Comparisons of storms January 1, 2020 through June 30, 2020, to half of the storms in the Typical Year are shown in Table 1-4, The comparison shows that rainfall in the first half of 2020 had almost the same number of storms approximated in half of the Typical year, however, the period had three inches less of total rainfall depth and the rainfall was distributed differently among the categories of rainfall event size.

Table 1-4. Comparison of Rainfall January 1, 2020 through June 30, 2020 and Half 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-Jun, 2020	20.3	46	21	8	12	4	1	3
Half Typical Year	23.4	47	25	7	8	4	3	5

Section 5.2 of this report presents a summary of the CSO metering program and the meter results for the period January 1, 2020 through June 30, 2020. In this period, MWRA continued to employ CSO metering technology at 36 potentially active CSO regulators.[2] Temporary meters at the 36 CSO regulators remained in place and operational through June 30, 2020, when the temporary metering program came to an end. Temporary meters were then removed at most of these locations.

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 ahead of expected 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, start and stop times, public health warnings, 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 8 untreated and 5 treated MWRA CSO outfalls.

MWRA will continue to collect, analyze and use data from these meters, along with data from permanent meters at CSO treatment facilities and in MWRA's interceptor system. The CSO communities (Boston Water and Sewer Commission 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 with the predictions of its Mid-2020 System Conditions model for all storms in the period January 1, 2020 through June 30, 2020 and at all CSO regulators where MWRA meter data were available. The comparison (Table 5-8) shows closeness of the metered and modeled discharges at all locations, with the greatest differences at the locations shown in Table 1-5.

The total volume of discharge (all outfalls) predicted by the Mid-2020 System Conditions model for storms in the first half of 2020 is 87.27 million gallons. The same model predicts 213 million gallons discharge in half of the Typical Year. In comparing first half of 2020 to a half Typical Year, Table 1-4 shows general closeness of the number of storms, depth of rainfall and rainfall characteristics. The significantly lower model-predicted CSO volume for first half 2020 compared to half Typical Year underscores the significant effect of larger and more intense storms on CSO discharges, where the first half of 2020 saw fewer storms of greater than 2.0 inches rainfall and fewer storms of greater than 0.4 in./hr. peak intensity than the half Typical Year.

Table 1-5. Notable Differences between Metered and Modeled CSO Discharges, Jan 1-Jun 30, 2020

Location	Meter	Model	Comment
Union Park CSO Facility	3 activations 3.94 MG	2 activations 6.46 MG	The one metered activation that the model missed only lasted 27 minutes with a volume of 0.3 MG. For the other two metered activations, the model overpredicted the volumes. These differences are believed to be due to spatial variation in rainfall.
CAM005	4 activations 0.1 MG	1 activation 0.27 MG	Meters are operated by the MWRA and the City of Cambridge at this location. Conditions within the complex regulator structure have made it difficult to correlate the MWRA meter with meters operated by the City of Cambridge. The City of Cambridge's meter showed two activations (March 23 and June 28, 2020). The March 23 activation had a volume of 0.001 MG. The model predicted the activation on June 28, 2020. The model-predicted volume for the June 28, 2020 storm was likely affected by the high degree of spatial variation in rainfall exhibited by that storm. Work continues to resolve differences between the MWRA and City of Cambridge meters.
Cottage Farm CSO Facility	1 activation 4.03 MG	1 activation 0.15 MG	The one activation registered by both the meter and the model occurred for the June 28, 2020 storm. This storm exhibited a high degree of spatial variation in rainfall which is believed to have contributed to the differences in measured versus modeled overflow volume.

[2] 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. 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.

1.2.5 Conclusions and Next Steps

This report presents an updated interim system performance assessment, i.e., Typical Year model results for Mid-2020 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 1-2), MWRA concludes from the model results that LTCP volume and activation goals are achieved at 25 locations, and MWRA expects through ongoing investigations and projects that the goals will be achieved at an additional 4 locations. At 17 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 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, the City of Chelsea's ongoing effort to raise the overflow weir at Outfall CHE004, and BWSC's sewer separation contracts in East Boston and South Boston. The City of Somerville's ongoing construction of a major new storm drain through Union Square 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.

Lastly, the development of receiving water models to assess the impact of CSOs on water quality in the Charles River and Alewife Brook/Mystic River is on-going. The models will also provide information about impacts of stormwater and boundary conditions. Specifically, the models will predict resulting *Enterococcus* and *E. coli* counts during the 3-month and 1-year storms as well as the Typical Year. MWRA will begin reviewing early results of the receiving water modeling in February 2021 and, at that point, MWRA and its partners will have a firmer understanding of CSO versus non-CSO impacts to water quality.

2. Site Specific Overflow Activity Investigations

This section contains information on ongoing site specific overflow activity investigations. This section describes the continuation of investigations discussed in Section 5 of Semiannual Report No. 4. The primary tool for these site specific overflow activity investigations is the MWRA's hydraulic model which is further discussed in Chapter 4.

2.1 Addressing Higher Activations and Volumes

MWRA, in consultation with BWSC, Cambridge, Chelsea and Somerville, has been studying the locations where the current model predicts higher Typical Year activations and/or volume compared with the LTCP. Efforts are underway to assess measures that may improve CSO performance. For example, MWRA has and will continue perform model investigations to assess whether CSO performance will improve with ongoing maintenance activities (e.g., sediment removal) and planned changes to the collection system (e.g., sewer separation and partial sewer separation projects). In advance of submitting the December 2021 final report on the performance assessment, MWRA has already or intends to implement additional system adjustments (potentially, weir changes, flow shifting, modifications to facility operations, etc.) aimed at improving CSO performance. More information on general investigation approaches can be found in Semiannual Progress Report No. 3, October 31, 2019.

Areas currently being investigated are detailed in the sections to follow and include: East Boston (Inner Harbor and Chelsea Creek), Somerville Marginal CSO Facility Discharges (Upper Mystic River and Mystic/Chelsea Confluence), the Cottage Farm Facility (Lower Charles River), Outfall BOS070 (Fort Point Channel), the Alewife Brook Pumping Station (Alewife Brook), the Chelsea Creek Outfalls and Outfall BOS017 (Mystic/Chelsea Confluence).

2.2 Overflow Activity Investigations by Sub-System

The following sections provide an update on progress completed in investigating overflow activity for most sub-systems where the LTCP level of control is exceeded.

2.2.1 East Boston Outfalls

2.2.1.1 BWSC Sewer Separation

BWSC is currently implementing a three-contract sewer separation program (Figure 2-1, on the following page) covering approximately 111 acres in East Boston. Contract 1 separates certain areas tributary to outfalls BOS013 and BOS012; Contract 2 separates certain areas tributary to outfalls BOS010 and BOS005; and Contract 3 separates 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%.

Construction of Contract 1 is substantially complete, with remaining work limited to downspout disconnections at 11 remaining houses. Contract 2 construction is underway, and is approximately 40% complete. The completed streets include: Bennington, Saratoga, Meridian, and Princeton Streets. The remaining streets in the contract include: Decatur, London, Liverpool, Sumner, and Webster Streets and is scheduled to be completed by May 2021. Construction of Contract 3 is scheduled to begin in April 2021 with an estimated completion date of November 2022.

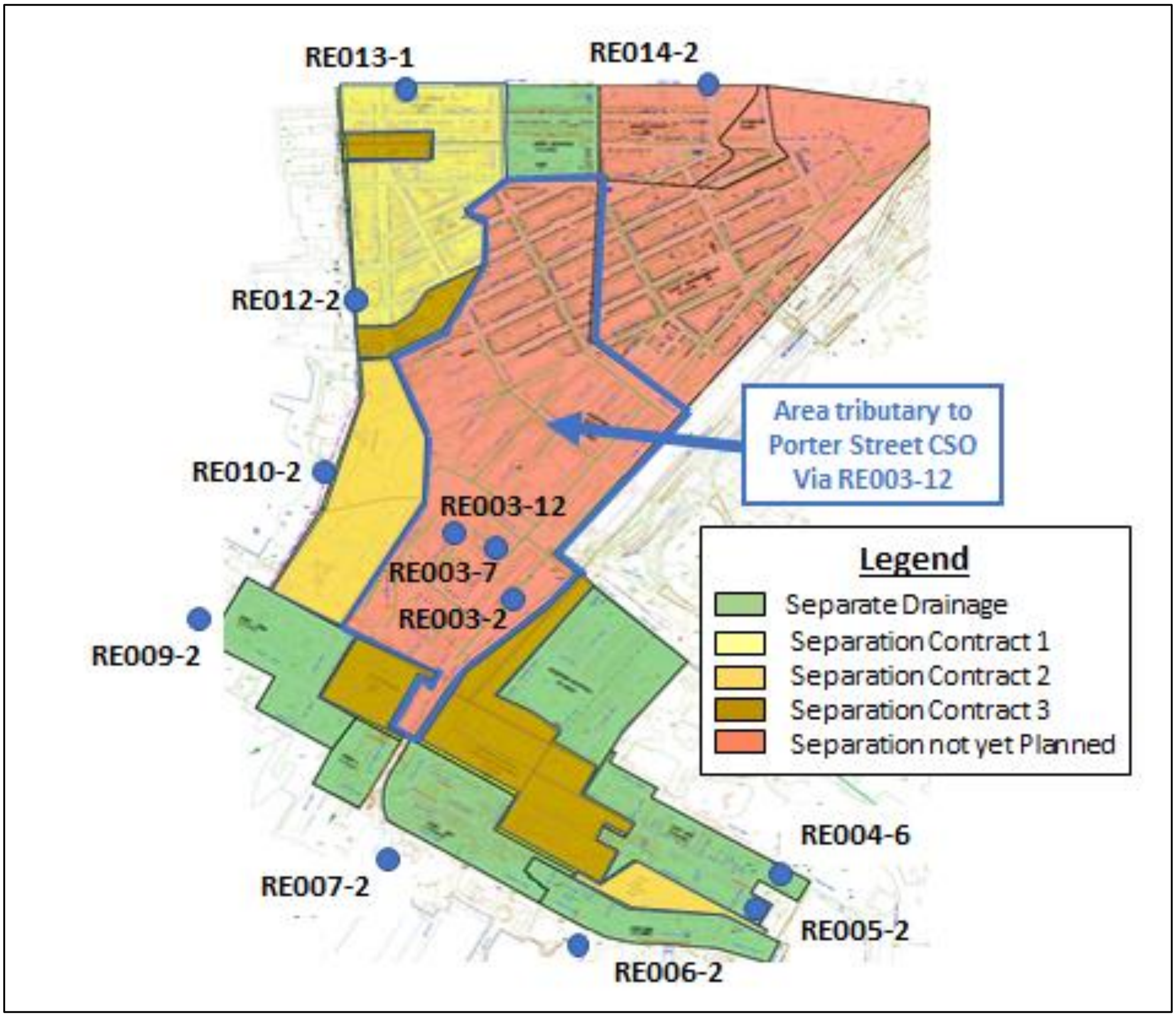


Figure 2-1. East Boston Sewer Separation

A hydraulic assessment was completed utilizing the MWRA's model, to estimate the benefits of these sewer separation projects in reducing CSO further towards the LTCP levels of control in East Boston. The combined sewer subcatchments in the MWRA model to be separated were identified by comparing the BWSC sewer separation figures and tables, the BWSC model, and the calibrated MWRA model. The work supporting the assessment included correlation of the sewer separation areas in the three BWSC contracts to subcatchments in MWRA's model; reconfiguration of certain MWRA model subcatchments to match the BWSC work areas; and adjustments to the calibration of MWRA's East Boston model where subcatchment changes affected the allocation of flow inputs to MWRA's system. As noted above, BWSC estimated that the sewer separation projects would reduce inflow into the sewer system from the separated systems by up to 85%. Table 2-1 on the following page shows the LTCP goals along with the predicted CSO activation frequency and volume for the Typical Year with mid-2020 system conditions (no sewer separation), and sewer separation with 85% inflow removal. Shaded values are higher than the LTCP goals, while values that are not shaded meet the LTCP goals.

Table 2-1. Typical Year Model Results with Contracts 1, 2 and 3 Sewer Separation

Outfall	Regulator	Mid-2020 System Conditions (1)		85% Sewer Separation Contracts 1 & 2 (1)		85% Sewer Separation Contracts 1, 2 & 3 (1)		Long Term Control Plan	
		Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)
Mystic/Chelsea Confluence									
BOS013	RE013-1	8	0.37	6	0.17	6	0.17	4	0.54
BOS014	RE014-2	8	1.44	8	1.44	8	1.42	0	0
Upper Inner Harbor									
BOS009	RE009-2	10	0.70	10	0.70	5	0.16	5	0.59
BOS010	RE010-2	7	0.77	5	0.35	5	0.34	4	0.72
BOS012	RE012-2	13	1.34	0	0	0	0	5	0.72
Lower Inner Harbor									
BOS003 (2)	RE003-2	1	0.02	1	0.01	0	0	4	2.87
	RE003-7	8	1.71	8	1.65	2	0.17		
	RE003-12	9	4.4	9	4.03	9	3.85		
BOS004	RE004-6	2	0.06	0	0	0	0	5	1.84
BOS005	RE005-1	0	0	0	0	0	0	1	0.01
Total (3)		**13 (Max.)**	**11.19**	**10 (Max.)**	**8.34**	**9 (Max.)**	**6.1**	**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.

Potential CSO Reduction

The results of the model simulations as presented in Table 2-1 are summarized in the following bullets:

- LTCP activation and volume goals are attained at outfalls BOS004 and BOS005. While the LTCP called for outfalls BOS006 and BOS007 to remain active, BWSC closed these two outfalls more than a decade ago. Sewer separation contracts 1 and 2 are predicted to reduce Typical Year activations and volume at outfall BOS012 to well below the LTCP goals. These two contracts are also predicted to reduce Typical Year activations at outfalls BOS010 and BOS013 to just shy of the LTCP goals. With completion of Contract 3 in November 2022, the model predicts LTCP activation and volume goals will also be attained at outfall BOS009. The three separation contracts are not predicted to significantly affect activations and volumes at outfall BOS014, both of which exceed the LTCP goals. This result was expected because the separation areas are not directly tributary to BOS014. At outfall BOS003, the model predicts that activations and volumes at one of the three regulators, RE003-12, contribute to the outfall's discharges exceeding the LTCP goals. This result was expected because the area tributary to RE003-12 is not included in the three separation contracts, as indicated in Figure 2-1.

- While the remaining activations and volumes at outfalls BOS003 and BOS014 are predicted to continue to exceed their LTCP goals following completion of the three sewer separation contracts, the total volume discharged from all East Boston outfalls is predicted to be less than the sum of their LTCP volume goals.

To assess the sensitivity of performance to the level of inflow removal achieved, Typical Year model runs were conducted for 75% inflow removal. In general, the differences in predicted performance between the 75% and 85% inflow removal runs were small, indicating that Typical Year system performance was not very sensitive to variations in inflow removal performance within that range. This adds a level of confidence that the estimated benefits could be achieved with the three BWSC construction contracts.

2.2.1.2 Evaluation of System Modifications

Evaluation of the predicted performance of BWSC's three sewer separation contracts in East Boston using the MWRA's collection system model shows that the sewer separation work 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.

The next step in the evaluation will be to assess if 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. MWRA has installed a temporary meter on the Condor Street interceptor (Figure 2-2) to measure flows and flow depth. 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), will be used to confirm the modeled representation of capacity in the interceptors. If available capacity is confirmed, alternatives to send additional wet weather flows to the interceptors will be evaluated as a means to further improve the performance of the East Boston outfalls.

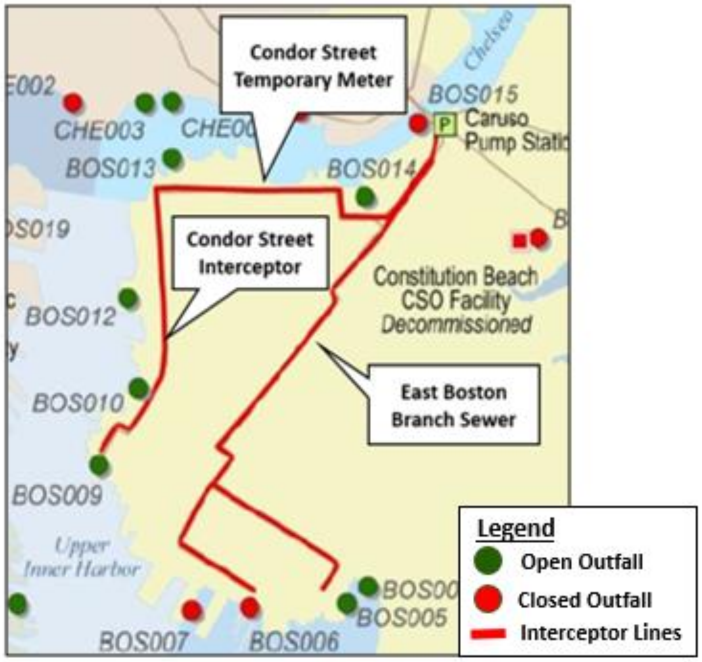


Figure 2-2. Condor Street Temporary Meter

2.2.2 Somerville Marginal CSO Facility Discharges

2.2.2.1 Purpose, Scope and Schedule of Evaluation

Outfall MWR205A/SOM007A is the only CSO outfall discharging to the Upper Mystic River (see Figure 2-3, on the following page). It discharges treated CSO from MWRA's Somerville-Marginal CSO Facility, and separate stormwater that enters the outfall downstream of the Somerville Marginal Facility (the Somerville Marginal Conduit). Outfall MWR205/SOM007A discharges to the Mystic River Basin upstream of Amelia Earhart Dam only when the primary discharge to the tidal portion of the Mystic River at Outfall MWR205 is limited by rising tide.

Mid-2020 conditions Typical Year model results indicated that the frequency and volume of discharges at outfall MWR205A/SOM007A exceed the LTCP levels of control. The frequency and volume of discharges are directly related to the timing of the Somerville Marginal Facility's activation with respect to tide, and the volume of stormwater that drains directly to the Somerville Marginal Conduit downstream of the facility. Reducing discharges at this outfall will primarily involve lowering the frequency and volume of discharges from the Somerville Marginal Facility.

Outfall MWR205 is located in tidal waters 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 (see Figure 2-3).

Mid-2020 conditions Typical Year model results showed that the 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.

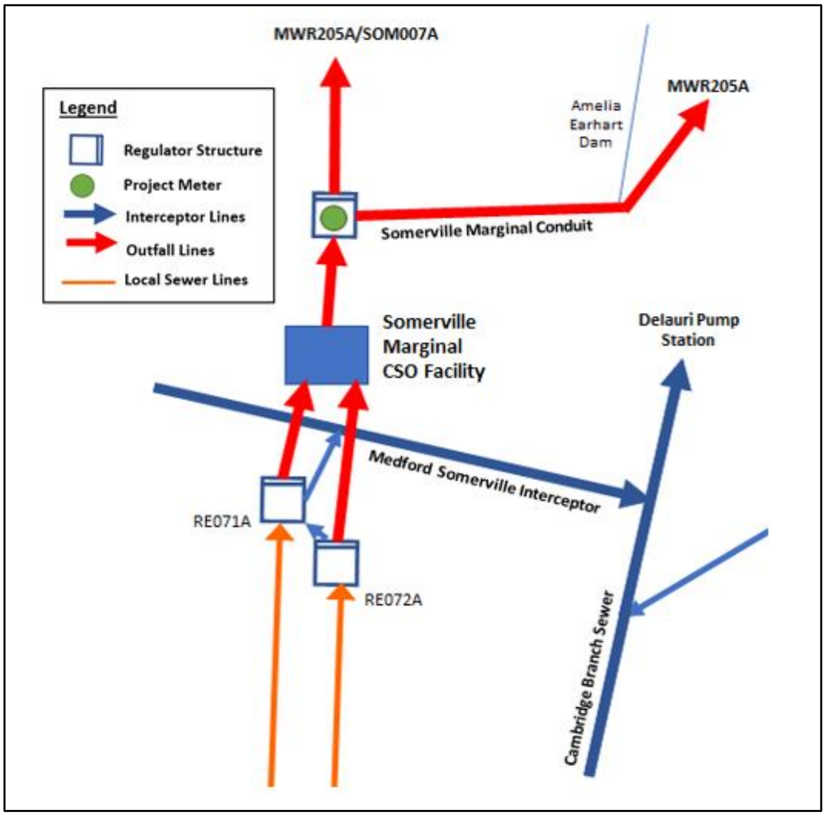


Figure 2-3. Schematic of Somerville Marginal Facility, MWR205A/SOM007A and MWR205A

MWRA has also investigated the impacts on CSO discharges at outfalls MWR205 and MWR205A/SOM007A due to a leaking tide gate discovered at the end of Outfall MWR205, as well as changes to the operation of the influent gates at the Somerville Marginal Facility. These two opportunities would be considered short term improvements, and are discussed further below.

In accordance with a condition in the Alewife Brook/Upper Mystic River CSO Variance, MWRA will commence, by December 2020, evaluations of specific projects that may reduce overflows to the Somerville Marginal Facility and discharges from outfalls MWR205 and MWR205A/SOM007A. These evaluations include 1) the benefit and feasibility of removing MassDOT I-93 stormwater flows that enter the combined sewer system immediately upstream of the Somerville-Marginal Facility and redirecting the stormwater downstream of the Facility, and 2) the benefit and feasibility of increasing the capacity of the connection to the Somerville-Medford Branch Sewer. Well before the December 2020 required start date, MWRA has already begun preliminary evaluations of the possible benefit of these alternatives.

2.2.2.2 Short Term Improvements

As noted above, MWRA identified two opportunities for potential short-term improvements to reduce discharges at outfalls MWR205 and MWR205A/SOM007A: modifications to the operation of the Somerville Marginal Facility influent gates, and repair of a leaking tide gate at outfall MWR205. These opportunities are discussed below.

Somerville Marginal Facility Influent Gate Operation

MWRA investigated the benefits of adjusting the operation of the Somerville Marginal Facility influent gates. The gates were originally set to close at the end of a storm when the upstream water surface elevation reached 105.5 ft. The model was used to evaluate the potential benefits of raising the elevation at which the gates closed to maximize in system storage and minimize flow into the facility. After several iterations, it was found that closing the gates at elevation 106.5 maximized in system storage without causing negative impacts upstream. The MWRA's model was used to estimate the benefits of adjusting the gate operation in reducing CSO at outfall MWR205 and MWR205A/SOM007A. At the time this evaluation was conducted, MWRA used the 2019 conditions model for the assessment. Table 2-2 on the following page shows the LTCP goals along with the predicted CSO activation frequency and volume for the Typical Year with 2019 system conditions with the gates closing at elevation 105.5 ft., and 2019 system conditions with gates closing at elevation 106.5 ft. Raising the elevation at which the gates closed at the end of a storm was predicted to decrease the annual volume at outfall MWR205 from 109.6 to 106.9 MG. The predicted volume at outfall MWRA205A/SOM007A was predicted to increase slightly (0.05 MG), which is attributed to the margin of error expected in a hydraulic model of this type. The activation frequencies at outfalls MWR205 and MWR205A/SOM007A were not predicted to change. As a result of these findings, MWRA implemented the change in operating procedure for the Somerville Marginal Facility influent gates, and that change has been incorporated into the final mid-2020 conditions model configuration.

Table 2-2 Comparison of Alternative Influent Gate Operation for 2019 Conditions Typical Year

Outfall	2019 System Conditions With Gate Close at el. 105.5 (1)		2019 System Conditions with Gate Close at 106.5 (1)		Long Term Control Plan	
	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)
Upper Mystic River						
MWR205A/SOM007A	6	4.95	6	5.00	3	3.48
Mystic/Chelsea Confluence						
MWR205 (Somerville Marginal Facility)	39	109.63	39	106.90	39	60.58

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

Repair of Tide Gate at Outfall MWR205

MWRA also used the hydraulic model to assess the impact of a leaking tide gate at the end of Outfall MWR205. The leaking tide gate is allowing water to enter the outfall, which could potentially reduce available storage in the outfall pipe during periods of higher tide. The MWRA's model was used to estimate the benefits of repairing the leaking tide gate in reducing CSO at outfalls MWR205 and SOM007A/MWR205. Table 2-3 shows the LTCP goals along with the predicted CSO activation frequency and volume for the Typical Year with mid-2020 system conditions for the baseline condition and with the tide gate repaired. As indicated in Table 2-3, repairing the tide gate was not predicted to change the activation frequency at outfall MWR205 or MWR205A/SOM007A, but was predicted to slightly decrease the discharge volume in the Typical Year. This finding showed that the leaking tide gate was having a minor impact on CSO discharges at MWR205A/SOM007A, and that the benefit of repairing the tide gate would currently be minimal. Notwithstanding this finding, MWRA performed a detailed inspection and assessment of the gate's condition and recently commenced design services to replace the tide gate.

Table 2-3. Comparison of Mid-2020 Typical Year Results to Mid-2020 Typical Year Results with Tide Gate Repaired

Outfall	Mid-2020 System Conditions (1)		Mid-2020 System Conditions With Tide Gate Repaired (1)		Long Term Control Plan	
	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)
Upper Mystic River						
SOM007A/MWR205A	6	4.91	6	4.57	3	3.48
Mystic/Chelsea Confluence						
MWR205 (Somerville Marginal Facility)	30	101.74	30	101.28	39	60.58

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

2.2.2.3 Initial Investigations in Support of CSO Variance Evaluations

In accordance with a condition in the Alewife Brook/Upper Mystic River CSO Variance, MWRA has been conducting investigations into specific projects that may reduce overflows to the Somerville Marginal

Facility and discharges from outfalls MWR205 and MWR205A/SOM007A. Two alternatives for which investigations have been initiated include: increasing the size of the connection to the Somerville-Medford Branch Sewer, and diverting stormwater that is currently tributary to the Somerville Marginal Facility.

Increasing the Connection to the Somerville-Medford Branch Sewer

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 Facility (see Figure 2-3). 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. Table 2-4 shows the LTCP goals along with the predicted CSO activation frequency and volume for the Typical Year with mid-2020 system conditions for the baseline condition and with the size of the connection increased to 24 inches (with the tide gate repaired). As indicated in Table 2-4, increasing the size of the connection to the Somerville-Medford Branch Sewer and repairing the tide gate was predicted to reduce the annual activations at outfall MWR205 from 30 to 20, and reduce the volume from 102 to 62.8 MG. At outfall MWR205A/SOM007A, this alternative was predicted to reduce the activation frequency from 6 to 3, and the volume from 4.9 to 3.0 MG. Therefore, with this alternative, outfall MWR205A/SOM007A would meet the LTCP goals for activations and volume. Outfall MWR205 would be well below the LTCP goal for activation, and the volume would be just over the target.

However, Table 2-4 also indicates that as a result of increasing the dry weather flow connection, the treated volume at Prison Point is predicted to increase by about 11 MG, and the treated volume at Cottage Farm is predicted to increase by about 1.4 MG. These predicted increases are due to the hydraulic connectivity between these facilities and the interceptor network downstream of the Somerville-Medford Branch Sewer.

These model results indicate that increasing the capacity of the connection to the Somerville-Medford Branch Sewer shows promise in terms of progress to move closer to the LTCP goals for outfalls MWR205 and MWR205A/SOM007A, although the resulting increases in treated discharge at Prison Point and Cottage Farm will need to be considered. Next steps will include investigating the potential downstream hydraulic impacts of increasing the capacity of the connection to the Somerville-Medford Branch Sewer, and assessing whether the connection could be optimized to minimize the impacts at Prison Point and Cottage Farm. It is likely that some means of flow control will be required for the connection to limit peak flows in larger storm events, and it remains to be evaluated the impact that a flow control devise would have on the larger storms in a Typical Year. Construction feasibility, impacts and costs will also need to be assessed.

Table 2-4. Comparison of Mid-2020 Typical Year Results to Mid-2020 Typical Year Results with Connection Increased to 24-inches and Repaired Tide Gate

Outfall	Mid-2020 System Conditions (1)		Mid-2020 System Conditions With DWF Connection Increased to 24 inches and TG Repaired (1)		Long Term Control Plan	
	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)
Upper Mystic River						
SOM007A/MWR205A	6	4.91	3	3.03	3	3.48
Mystic/Chelsea Confluence						
MWR205 (Somerville Marginal Facility)	30	102	20	62.81	39	60.58
Upper Inner Harbor						
MWR 203 (Prison Point)	17	243	17	254	17	243
Lower Charles River						
MWR201 (Cottage Farm)	4	12.6	4	14.0	2	6.3

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

Diverting Stormwater Upstream of the Somerville Marginal Facility

Evaluations were initiated to assess the benefit and feasibility of removing MassDOT I-93 stormwater flows that enter the combined sewer system through a 72-inch pipe connection immediately upstream of the Somerville Marginal Facility and redirecting this stormwater downstream of the Facility. It was initially thought that only separate storm drainage was tributary to the 72-inch pipe, so diverting the flow in that pipe around the facility could potentially reduce activations and treated volume discharged from the facility. However, initial investigations determined that a City of Somerville sanitary sewer is connected to the 72-inch pipe, precluding the wholesale redirection of the 72-inch pipe flow downstream of the CSO facility. MWRA then looked for separate stormwater flows coming into the 72-inch pipe that may be feasible to redirect. MWRA, with Somerville's assistance, is currently investigating the feasibility of relocating separate stormwater from the Ten Hills area that is tributary to the 72-inch MassDOT pipe. MWRA is conducting water quality sampling of the Ten Hills flow, and is collecting data from a flow meter it installed in September 2020 to better quantify the stormwater from this area.

2.2.3 Cottage Farm CSO Facility Discharges

2.2.3.1 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. 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 Street and Waverly Streets (refer to Figure 2-4, on the following page). At Pacific and Albany Street, 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 Street, an 18-inch connection that entered a short section of 12-inch combined sewer originally conveyed stormwater to the North Charles Relief Sewer. Refer to Semiannual Report No. 4 Section 5.4 for additional information regarding the partial sewer separation project.

The partial separation work included the following:

- At Pacific and Albany Streets, the existing 10-inch connection to the North Charles Relief Sewer North Branch was sealed off, and a new 6-inch connection with a backflow preventer was constructed between the Pacific Street storm drain and an 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, and a weir gate was installed on the new Talbot Street storm drain outfall, and the new outfall was put in service.
- During the first half of 2020, the conditions at Pacific and Albany streets varied among having just the existing 10-inch connection open, both the 10-inch and new 6-inch connection open for a short period during which no Cottage Farm CSO Facility activations occurred, and just the 6-inch connection open. For the purposes of modeling the 2020 mid-year conditions presented in Section 6.1, it was assumed that just the existing 10-inch connection was open. At Talbot and Waverly Streets, the new outfall was not yet activated, and the 6-inch orifice was not yet installed. As mentioned above, the partial sewer separation project was fully in place in mid-August 2020.

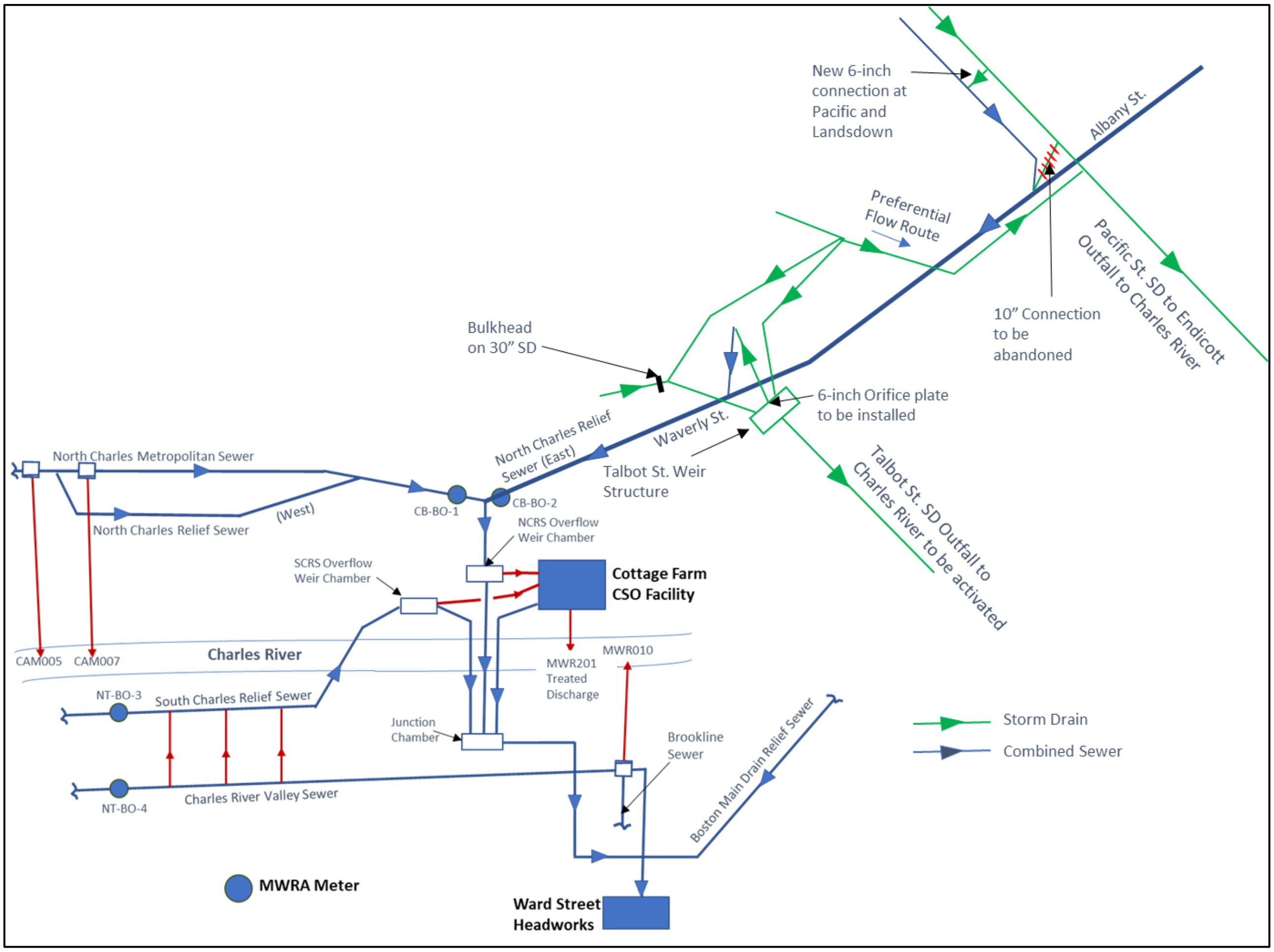


Figure 2-4. Schematic of Cambridge Partial Sewer Separation Work

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 allow Cambridge to meet phosphorus discharge limits for the Charles River[3], 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.

2.2.3.2 Preliminary Performance Assessment

MWRA completed a preliminary hydraulic assessment, utilizing the MWRA's model, to estimate the benefits of the partial sewer separation project in reducing CSO to move closer to LTCP levels of control at the Cottage Farm CSO Facility. The evaluation is considered preliminary at this time because the project components were not fully activated until August 14, 2020, and flow metering data are not yet available to confirm the model predictions of performance. Once the meter data are available, the model-predicted performance will be checked against the measured flow data.

For the purposes of this preliminary assessment, 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 determine stormwater flows tributary to MWRA's interceptor from these connections before and after the restricted connections were installed and to determine stormwater flow discharging to the Charles River Using these meters, the upstream hydrology was adjusted to better match the meter data, and the model

[3] 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.

was run for the Typical Year. The model was then updated to reflect the new 6-inch connections and the new stormwater outfall at Talbot Street and run for the Typical Year.

Table 2-5 shows the LTCP goals along with the predicted CSO activation frequency and volume for the Typical Year at Cottage Farm with 2019 system conditions before the upstream hydrology adjustments, with the upstream hydrology adjustments, and with the 6-inch connections and Talbot Street outfall activated.

Table 2-5. Preliminary Typical Year Model Results of Cambridge Partial Sewer Separation at Cottage Farm

Outfall	Baseline before Upstream Hydrology Calibration		Baseline with Upstream Hydrology Calibration		With 6-in. Connections and Talbot St. OF Activated		Long Term CSO Control Plan	
	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)
Cottage Farm	4	12.01	4	10.98	2	8.75	2	6.3

As indicated in Table 2-5, reducing the connections to 6-inches and activating the Talbot street outfall was predicted to reduce the activation frequency at Cottage Farm to a level that meets the LTCP goal of 2 activations. The volume discharged from Cottage Farm was predicted to be reduced, but is still predicted to be greater than the LTCP goal. The partial separation project was not predicted to significantly affect the other CSOs upstream of Cottage Farm (CAM005 and CAM007).

Table 2-6 presents the predicted activation frequency and volume for the Typical Year 2019 system conditions at the Endicott Street and Talbot Street stormwater outfalls.

Table 2-6. Preliminary Typical Year Model Results of Cambridge Partial Sewer Separation at Endicott Street and Talbot Street Stormwater Outfalls

Stormwater Outfall	Baseline with Upstream Hydrology Calibration		With 6-in. Connections and Talbot St. OF Activated	
	Activation Frequency	Stormwater Volume (MG)	Activation Frequency	Stormwater Volume (MG)
Endicott Street Outfall	30	21.88	35	34.96
Talbot Street Outfall	N/A (1)	N/A	24	7.17

(1) N/A = Not applicable. Talbot Street outfall was not activated under baseline conditions

As indicated in Table 2-6, with the 6-inch connections and the Talbot Street stormwater outfall activated, the total volume and frequency of separate stormwater discharges to the Charles River were predicted to increase (as expected). The increase in stormwater discharge would correlate to a similar reduction in wet weather flow diverted to the North Charles Relief Sewer North Branch. Table 2-6 also indicates that the Endicott Street tributary area was the more significant contributor of stormwater to the interceptor system as compared to the Talbot Street system. With the 6-inch connections in place and Talbot Street outfall activated, the stormwater volume discharged at Endicott Street increased by about 13 MG, while the stormwater volume discharged at the new Talbot Street outfall was about 7.2 MG. Given that the Typical Year has 47 storm events, not all storms result in a stormwater discharge to the Charles River.

2.2.4 Outfall BOS070 (Fort Point Channel)

2.2.4.1 South Boston System Sediment Cleaning

BWSC recently conducted 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, a temporary maintenance weir inadvertently left in the South Boston Interceptor-North Branch was also discovered and removed. The locations of the maintenance weir that was removed and the tributary systems where sediment was removed are shown schematically in Figure 2-5. The cleaning operation included approximately 12,000 linear feet of sewer ranging in size from 10 inches diameter to 57x66 inches, from which approximately 250 tons of sediment were removed. BWSC completed the cleaning program in March 2020.

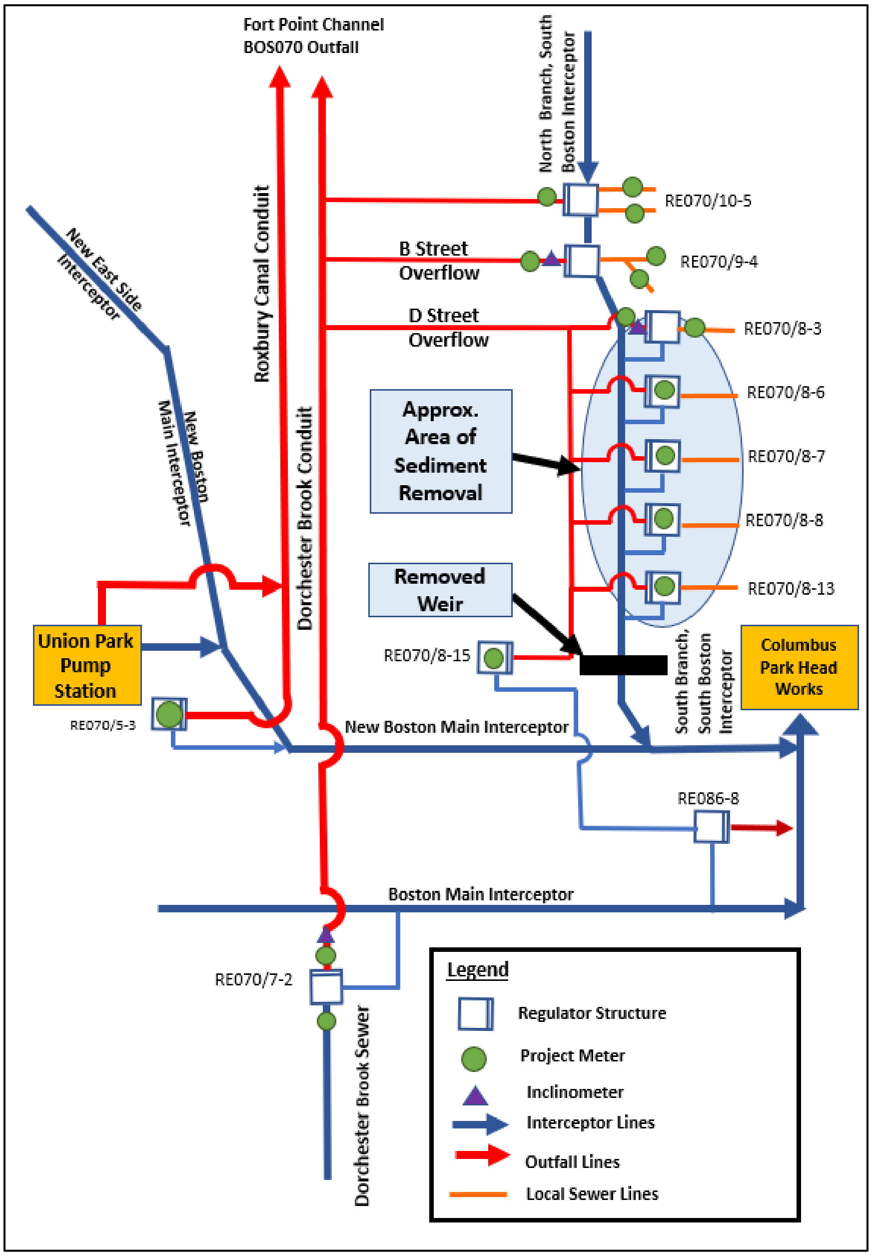


Figure 2-5. Schematic of South Boston Interceptor System, Showing Location of Removed Maintenance Weir and Approximate Location of Sediment Removal

2.2.4.2 Sediment Cleaning Effect on CSOs to BOS070 Dorchester Brook Conduit

MWRA completed a preliminary hydraulic assessment utilizing the MWRA's 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, before the sediment and maintenance weir were removed and was recalibrated using data collected at these meters after March 2020 when the sediment and weir were removed. The flow meters were installed as part of the Post Construction Monitoring program, and their locations are indicated on Figure 2-5.

Table 2-7 on the following page 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.

As indicated in Table 2-7, removing the sediment in this area is predicted to reduce the CSO discharge volume slightly at regulators RE070/8-3, RE070/9-4 and RE070/10-5. However, discharge volume increased slightly at regulator RE070/7-2. The reductions at regulators RE070/8-3, RE070/9-4 and RE070/10-5 are attributable to the increased conveyance capacity in the South Boston Interceptor North Branch (SBI-NB) as a result of the removal of the sediment and maintenance weir. The increase in flow in the SBI-NB would result in an increase in flow conveyed to Columbus Park Headworks via the New Boston Main Interceptor. This in turn would affect flows in the Boston Main Interceptor, which likely caused the slight increase at regulator RE070/7-2. The number of activations at the BOS070/DBC regulators did not change except for a reduction from 2 activations to 1 activation at regulator RE070/10-5.

Table 2-7. Typical Year Model Results before and after Sediment and Weir Removal

Outfall	Regulator	2019 System Conditions (without Sediment/ Maintenance Weir Removal in BOS070 Area)		Mid-2020 System Conditions (with Sediment/ Maintenance Weir Removal in BOS070 Area)		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.

2.2.4.3 BOS070 Conclusion/Next Steps

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 will continue to investigate opportunities to reduce CSO activation frequency and discharge at the BOS070/DBC regulators. At these regulators, BWSC and MWRA will evaluate regulator adjustments, such as raising overflow weirs. In addition, MWRA will evaluate the CSO benefits of BWSC's planned multi-year sewer separation project that involves approximately 400 acres of area tributary to the BOS070 system. BWSC plans to commence the first of several construction contracts in the spring of 2021.

2.2.5 Progress towards Alewife Brook Pumping Station Evaluation

2.2.5.1 Background

The Alewife Brook Pump Station (ABPS) receives flow from four upstream MWRA sewers: Alewife Brook Conduit, Alewife Brook Sewer, Belmont Branch Sewer, and Lexington Branch Sewer. Flow is lifted and discharged downstream to the North Metropolitan Trunk Sewer and North Metropolitan Relief Sewer, continuing by gravity to the Chelsea Creek Headworks. The tributary area includes portions of Arlington, Belmont, Cambridge, Somerville and Medford. A schematic of the Alewife Brook system is presented in Figure 2-6, on the following page.

In 2019, as part of the ABPS Rehabilitation project, three new wet weather pumps were installed with individual capacities greater than the previously installed pumps. These increased capacities allowed for the use of two wet weather pumps in parallel while a third wet weather pump served as a stand-by.

Additionally, the facility has a dry weather pump to control the wet well level during normal, non-storm operating conditions. This pump is also operated during wet weather to provide additional wet weather pumping capacity. The dry weather pump was not replaced as part of the 2019 upgrade because it was installed in 2008 and continues to operate as intended. A dry weather pump test was conducted as part of this evaluation which confirmed the pump was still operating at the capacity expected.

In accordance with a condition in the Alewife Brook/Upper Mystic River CSO Variance, MWRA is to evaluate operational optimization of the rehabilitated Alewife Brook pump station. Although preliminary evaluations and progress is provided below, the study will produce a Technical Memorandum to be completed by April 2021. The study is specifically evaluating if modifications to the ABPS operating control strategy could reduce or eliminate upstream CSO. The investigation of alternative pump operation strategies is focused on pump sequencing, on-off level setpoints, and pump speed versus wet well elevation settings.

The scope of work for this evaluation includes:

- Field testing of the dry weather pump to assess capacity and operation at a lower wet well level.
- Evaluating new operating level and pumping strategies to potentially reduce or eliminate upstream CSOs without negatively impacting 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 indicates such changes would result in CSO reduction benefits. Preparing a final Alewife Brook PS Optimization Report documenting the modeling and field testing performed and the predicted and observed results.

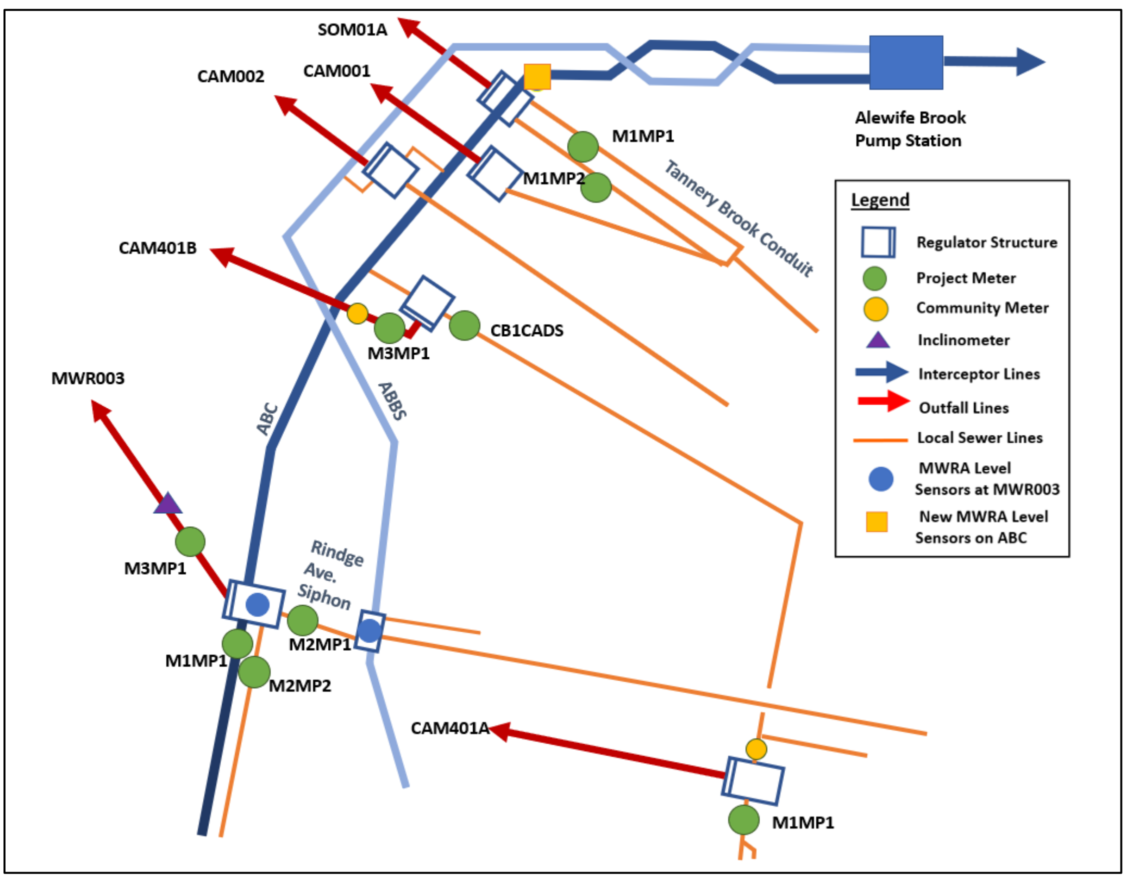


Figure 2-6. Schematic of Alewife Brook System

The MWRA's collection system model was needed to assess the potential benefits of any operational changes at ABPS in terms of annual CSO reductions. While this model was originally calibrated to 2018 meter data, a number of changed conditions or issues were identified subsequent to the 2018 calibration that required the Alewife system calibration to be updated. These changes included:

- Physical changes constructed at the regulators associated with outfalls CAM002 and SOM001A
- The availability of data from a meter located in the Alewife Brook Conduit that would allow for refinement of the calibration of the interceptor depth
- Discovery of a model connectivity issue downstream of the regulator associated with outfall CAM401A

These changes and their impacts on the predicted annual CSO activation frequencies and volumes in the Alewife Brook system are described in the subsection below. The results of the pump station operations evaluation are then presented, followed by an evaluation of the impact of sediment removal downstream of outfall CAM401A. The results of the field testing of the dry weather pump at ABPS are presented, then the section concludes with a description of further optimization evaluations to be conducted.

2.2.5.2. Alewife Brook System Revisions

The system changes, new information, and model configuration revisions that drove the need to re-calibrate the model of the Alewife Brook system are described below.

Outfall SOM001A/CAM002 Physical Changes

During 2019, system modifications were made to the regulators associated with outfalls SOM001A and CAM002. At SOM001A, the modifications included the removal of a structure that had been built over the dry weather flow connection, and the removal of the orifice plate that was used to restrict the dry weather flow connection. Metering data from 2019 and 2020 were used to adjust the model at SOM001A to account for the removal of the structure in the manhole and the orifice plate. Adjustments to the model's hydrology tributary to Tannery Brook were made to improve the model's ability to predict influent flows to SOM001A, and the orifice coefficient at SOM001A was adjusted based on comparison of the metered and modeled system responses.

At outfall CAM002, the weir elevation was modified in 2019 and a plate was removed which opened a connection between the influent line to CAM002 and the MWRA downstream interceptor (Alewife Brook Conduit).The model was revised to reflect the new weir elevation, and the model output was compared to 2019 and 2020 meter data. As a result of the new meter data in the Alewife Brook Conduit indicating the model was over predicting influent flows to the Alewife Brook Pump Station, other metered tributary areas to the Alewife Brook Conduit were re-evaluated and adjusted as necessary.

Interceptor Meter Data

Data from a meter located on the Alewife Brook Conduit just downstream of outfall SOM001A became available in 2019. The location of this meter is shown by the orange box in Figure 2-6 above. The data from this meter identified that the hydraulic grade line in the interceptor was over-predicted by the model during large storms. In conjunction with the changes at SOM001a and CAM002, further adjustments were made to improve the model's ability to predict the hydraulic grade line in the interceptor using the newly available metering data as well as data from existing temporary and permanent meters for 2019 and 2020.

Outfall CAM401A

Investigation by the City of Cambridge has been ongoing into the approximately 16 inches of standing water located downstream of CAM401A. With the objective of understanding how the removal of the standing water would impact the anticipated CSO activation frequency and volume at CAM401A, this location was further assessed. It is assumed that the standing water is attributed to sediment, as the City of Cambridge has been actively removing sediment from the pipes downstream of the regulator. Therefore, as part of the model assessment in the Alewife sub-system, 16 inches of sediment was added downstream of the regulator to match the observed standing water (previously a weir had been used in the model to replicate the standing water). As part of these efforts, the connectivity at CAM401A was revised to match field conditions, and the model was updated using 2019 and 2020 metering data. This connectivity adjustment, in conjunction with the changes to improve the model's ability to predict the hydraulic grade line (HGL) in the Alewife Brook Conduit, impacted model predictions at CAM401A, CAM401B and MWR003, resulting in an improved comparisons between model predicted and metered CSO activations.

With the update and recalibration of the Alewife system, the model was run for the mid-2020 conditions, and compared to the previous configuration (2019 System Conditions) and the LTCP goals. Table 2-8 presents the results of this comparison. As indicated in Table 2-8, the updated model resulted in reductions in predicted CSO volumes at outfalls MWR003, CAM401A, and CAM401B, while the volume at SOM001A was predicted to increase. Overall, the changes resulted in a net reduction in CSO volume of 1.83 MG. However, as indicated by the shaded cells in Table 2-8, the activations and volumes at CAM401A and SOM001A, and the total volume to Alewife Brook, are still predicted to exceed the LTCP goals.

Table 2-8. Comparison of Alewife 2019 and mid-2020 Typical Year System Conditions

Outfall	2019 System Conditions		Mid-2020 System Conditions		Long Term Control Plan	
	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)
CAM001	1	0.02	1	0.02	5	0.19
CAM002	0	0.00	0	0.00	4	0.69
MWR003	3	1.60	3	0.49	5	0.98
CAM401A	10	3.59	16	2.17	5	1.61
CAM401B	5	0.73	4	0.53	7	2.15
SOM001A	6	3.60	8	4.51	3	1.67
TOTAL	**10 (max.)**	**9.54**	**16 (max.)**	**7.71**	**7 (max.)**	**7.29**

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

2.2.5.3. Progress and Potential for CSO Reduction

Initial activities to assess opportunities for further CSO reduction focused on modifying the operation of the ABPS, and sediment removal at CAM401A. These activities are described below.

ABPS Operations

The primary control for operation of the ABPS pumps is the ABPS wet well level, located upstream on the suction side of the pumps. The operational strategy for the pumps uses this wet well level to set the pump speeds and to control the pump on-off set points and sequencing. Initial options for modifying the pump control strategies considered options to turn on the pumps at lower wet well levels, ramp the pumps up to full speed faster, and to stay on longer, thus being more aggressive than the existing pump control strategy. Additional options to be evaluated will focus on controlling the pumps to maintain a constant, lower wet well elevation.

Pump station data including drawings, pump vibration and performance test reports, and historical SCADA data were reviewed to help set operational constraints and limits when defining alternative strategies. Information collected from SCADA data, pump tests, and correspondence with MWRA staff was used to define the wet-weather pump flow capacity and performance. Minimum pump submergence calculations were performed to determine the theoretical lowest wet well level that would allow for continuous safe and efficient pump operation (i.e., to avoid severe cavitation or air entrainment).

These same data sources were used to characterize dry weather pump performance. The information, however, was later revised to include results from the dry weather pump field test performed on July 13th, 2020, as discussed in Section 2.2.5.4.

MWRA's hydraulic model, updated and re-calibrated as described above, is being used to evaluate several potential alternative pump control strategies for the Typical Year conditions. Each potential alternative will be evaluated in terms of CSO activation frequency/volume for the six outfalls tributary to the Alewife Brook and compared to the LTCP goals. The alternatives will also be evaluated in terms of feasibility and pump station longevity. The predicted performance of one example pump strategy based on the first approach described above (turn on the pumps at lower wet well levels, ramp the pumps up to full speed faster, and to stay on longer) in comparison to the current operating strategy is presented in Table 2-9.

Table 2-9. Comparison of Alternative ABPS Operating Strategy to Baseline and LTCP Goals

Outfall	Regulator	Typical Year Rainfall Under mid-2020 System Conditions: Baseline Operating Strategy		Typical Year Rainfall Under mid-2020 System Conditions: Alternative Operating Strategy		Long Term Control Plan	
		Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)
CAM001	RE-011	1	0.02	1	0.02	5	0.19
CAM002	RE-021	0	0.00	0	0.00	4	0.69
MWR003	RE-031	3	0.49	2	0.40	5	0.98
CAM401A	RE-401	16	2.17	16	2.16	5	1.61
CAM401B	RE-401B	4	0.53	3	0.46	7	2.15
SOM001A	RE-01A	8	4.51	8	4.42	3	1.67
Total		**16 (Max)**	**7.71**	**16 (Max)**	**7.44**	**7 (Max)**	**7.29**

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

As indicated in Table 2-9, the more aggressive operating strategy was predicted to result in small improvements in the volume of CSOs to Alewife Brook, and reductions of one activation at each of two outfalls (MWR003 and CAM401B).

CAM401A Sediment Removal

The updated/re-calibrated model was used for a preliminary assessment of the potential benefits of removing the sediment at CAM401A. Table 2-10 on the following page presents a comparison of conditions with the sediment simulated as removed, versus the baseline condition with the sediment in place, and the LTCP goals. As indicated in Table 2-10, removal of the sediment at CAM401A is predicted to substantially reduce the activation frequency and volume at CAM401A. That reduction is accompanied by slight increases in predicted volume at MWR003, CAM401B and SOM001A, likely due to the increase in flow into the interceptor from CAM401A. The activations and volume at SOM001A are still predicted to exceed the LTCP goals, but the activations and volumes at all of the other Alewife outfalls are predicted to achieve or improve upon the LTCP goals. The total volume to Alewife Brook is predicted to be less than the LTCP goal, while the maximum activation frequency misses by one activation (8 vs 7). These results, however, have to be considered preliminary until Cambridge completes their sediment removal program and can confirm that the standing water downstream of CAM401A has been substantially reduced or eliminated. If the standing water still remains after completion of the sediment removal, then some other factor must be affecting the hydraulics downstream of CAM401A, and the results of the sediment removal run will have to be re-assessed.

2.2.5.4. Field Testing

A pump test for the dry weather pump was performed and completed on Monday, July 13th, 2020, with two goals:

1. Develop pump curves based on the field performance of the pump and compare its field performance to its factory performance.
2. Assess the minimum wet well operating level below which the pump may experience physical phenomenon that could reduce its performance and/or cause damage to the pump.

Results of the first test indicated that the pump's field performance closely matched, yet slightly underperformed, the factory performance. The field performance data showed a slightly reduced pumped flow capacity compared to the factory performance data for a given pump head data point. However, given the variability of field conditions compared to factory test conditions, it was concluded that the field test confirmed the current understanding of the pump capacity. Results of the second test suggest that the dry weather pump can operate at 100% speed down to a wet well level of at least 92 feet, a level much lower than the current operational controls OFF level of 96.67 feet.

Table 2-10. Preliminary Evaluation of CAM401A Sediment Removal

Outfall	Regulator	Typical Year Rainfall Under 2020 System Conditions				Long Term Control Plan	
		Baseline		CAM401A Sediment Removed			
		Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)
CAM001	RE-011	1	0.02	1	0.02	5	0.19
CAM002	RE-021	0	0.00	0	0.00	4	0.69
MWR003	RE-031	3	0.49	3	0.69	5	0.98
CAM401A	RE-401	16	2.17	5	0.68	5	1.61
CAM401B	RE-401B	4	0.53	4	0.56	7	2.15
SOM001A	RE-01A	8	4.51	8	4.56	3	1.67
Total		**16 (Max)**	**7.71**	**8 (Max)**	**6.51**	**7 (Max)**	**7.29**

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

Field testing of the wet weather pumps has been completed and the results are being evaluated.

2.2.5.5 Alewife Brook CSO Optimization Evaluations

In accordance with a condition in the Alewife Brook/Upper Mystic River CSO Variance, by December 2020 MWRA will begin the evaluation of system optimization measures to determine if CSO discharges to the Alewife Brook can be further improved. These evaluations will include the following:

- **LTCP attainment evaluations for SOM001A:** Up to three optimization alternatives will be developed to help achieve the LTCP goals for SOM001A. The potential alternatives are expected to include weir adjustments and modifications to the regulator structure to get more flow into the downstream interceptor. Alternatives will be modeled using the MWRA's hydraulic model using the Typical Year as well as design storm(s).
- **CSO Variance related system optimization:** Site investigations will be conducted, and optimization alternatives will be developed to further reduce CSO activations and volumes beyond the LTCP goals along the Alewife, if feasible. The potential alternatives will be modeled using the MWRA's hydraulic model using the Typical Year as well as design storm(s). Concept sketches, conceptual site plans, and permitting consideration will be developed for the system optimization alternatives.

2.2.6 Other Outfall Activity Investigations

This section presents a summary of investigations conducted at outfalls CHE004 and CHE008, which discharge to the Mystic/Chelsea confluence.

2.2.6.1 CHE004 Weir Raising

As shown in Table 1-2 above, outfall CHE004 is 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 RE-041, which overflows to outfall CHE004. The combined sewershed tributary to outfall CHE004 is approximately 87 acres. The area is serviced by a single 72-inch diameter, circular brick trunk combined sewer pipe. Dry and wet weather flows from this combined sewershed are conveyed into Chelsea's 30-inch Chelsea Trunk Sewer. The Chelsea Trunk Sewer ties into the MWRA's North Metropolitan Relief Sewer which ultimately conveys flow to the Chelsea Creek Headworks (Figure 2-7, on the following page).

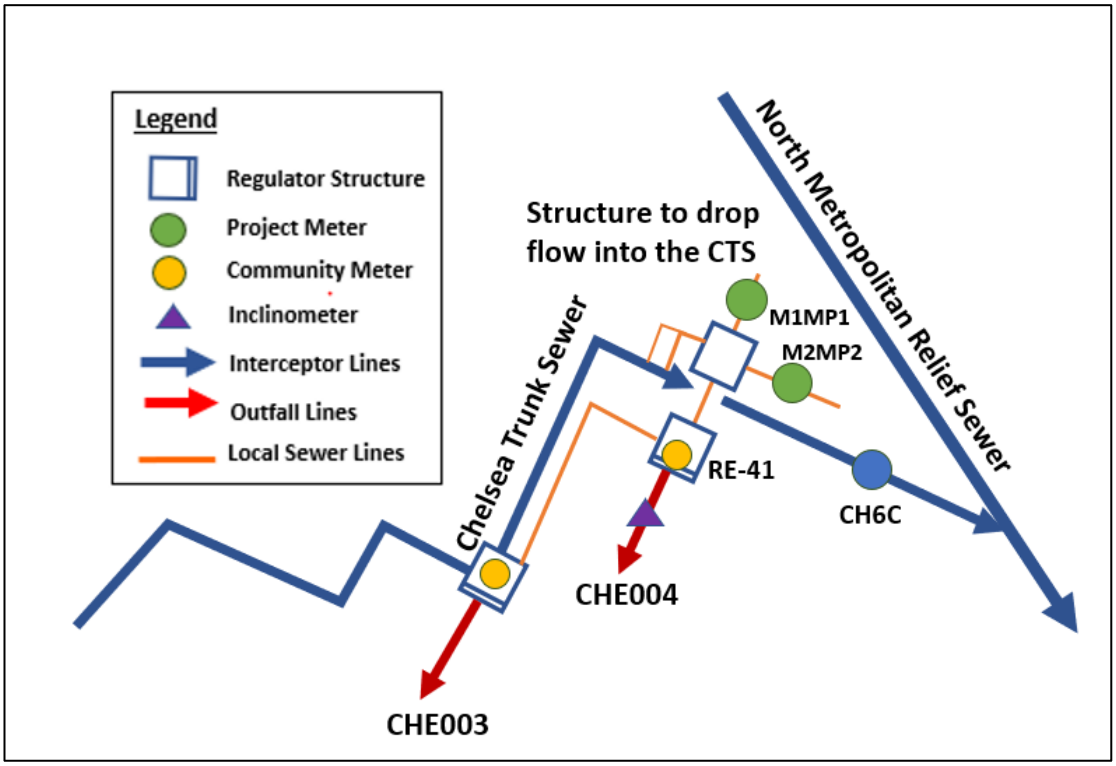


Figure 2-7. Schematic of CHE004 Model Configuration

The initial evaluations of alternatives to raise the weir at regulator RE-41 were based on the 2019 conditions Typical Year model. The impacts of raising the weir by 1.0 feet and 1.5 feet on predicted annual activation frequency and volume for the 2019 System Conditions Typical Year are presented in Table 2-11. As indicated in Table 2-11, raising the weir by 1.5 feet at regulator RE-041 is predicted to bring the activation frequency and volume into compliance with the LTCP goals for outfall CHE004. The impact of raising the weir at regulator RE-41 by 1.5 feet was then evaluated for the 5-year and 10-year, 24-hour storms, to check for potential adverse upstream impacts during large events. Table 2-12 presents the results of this evaluation. As indicated in Table 2-12, the peak hydraulic grade line in the regulator was predicted to increase by 0.23 feet in the 5-year, 24-hour storm, and by 0.36 feet in the 10-year, 24-hour storm.

Table 2-11. Evaluation of Raising Weir at Regulator RE-041 (CHE004)

Outfall	Regulator	2019 System Conditions Weir Elevation 108.33 ft.		2019 System Conditions Weir Elevation raised 1.0 ft. to 109.33		Mid-2020 System Conditions Weir Elevation raised 1.5 ft. to 109.83		Long Term Control Plan	
		Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)
CHE004	RE-041	7	1.01	6	0.50	3	0.30	3	0.32

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

Table 2-12. Peak Hydraulic Grade Line Impacts of Raising Weir at Regulator RE-041 (CHE004)

System Condition	CHE004 Weir Elevation (ft.)	Peak HGL (ft.) at CHE004 Regulator	
		5-Year Design Storm	10-Year Design Storm
2019 System Conditions	108.33	112.72	114.30
2019 System Conditions w/Raising CHE004 Weir by 1.5 ft.	109.83	112.95	114.66

Conclusions/Next Steps

The City of Chelsea has added the raising of the weir at regulator RE-41 by 1.5 feet into an existing construction contract with the City. The City of Chelsea will continue to review the design and construction submittals and will provide inspections during the construction, which is expected to take place this fall.

2.2.6.2 Outfall CHE008 Hydraulic Evaluations

As shown in Section 6 below, 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.

In order to match meter data for this outfall, the headloss in the dry weather flow connection between regulator RE-081 and the MWRA's interceptor had to be increased higher than would be expected based on the diameter and pipe material of the dry weather flow connection. Field inspection of this connection showed no visible signs of obstruction in the dry weather flow connection, but the dry weather flow connection pipe was observed to protrude out from the wall of the regulator, at an angle facing away from the direction of the influent flow to the regulator, and was offset from the invert of the regulator. Given these observations and the high measured headloss across the dry weather flow connection, the hydraulics of regulator RE-081 were investigated in an attempt to understand the cause of the high observed headloss, and to identify potential solutions to improve performance at this regulator.

Figure 2-8 shows an image of the dry weather flow connection pipe protruding at an angle into regulator RE-081. This image was taken from regulator RE-081 in dry weather, looking in the direction of flow towards the interceptor connection. The relatively smooth walls of the cement-lined ductile iron pipe suggest that pipe roughness would not significantly contribute to head loss in the dry weather flow connection, nor is there evidence of a flow obstruction.

Figure 2-8. View of 30-inch Dry Weather Flow Pipe Protruding into Regulator RE-081

Figure 2-9, on the following page, shows a cross section view of regulator RE-081, the 30-inch dry weather flow connection, and the structure where the dry weather flow drops into the MWRA's interceptor system. Also shown on the cross section are the locations of three flow meters, and the measured peak hydraulic grade lines from four storms that occurred in 2019. The meter data show that for these storms, the hydraulic grade line in regulator RE-081 was above the crown of the dry weather flow connection, but the pipe was only partially full at the downstream end. These observations indicate that the dry weather flow connection was behaving as an inlet-controlled culvert. Specifically, conditions at the inlet to the pipe were limiting the peak flow that could pass through the pipe.

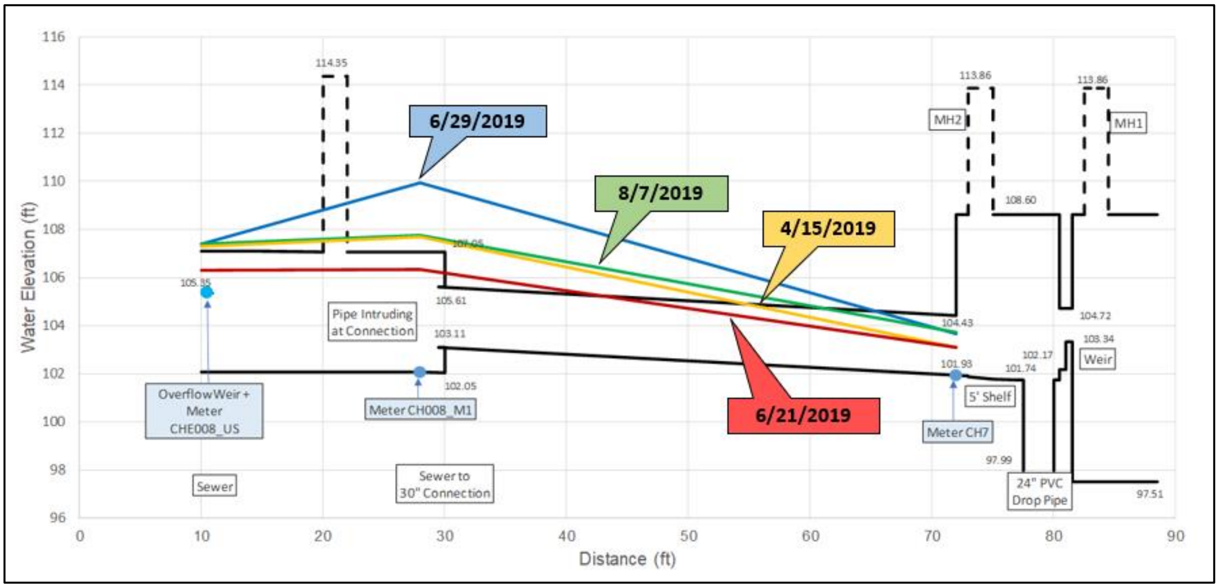


Figure 2-9. Cross Section View of Regulator RE-081 and Connection to Interceptor

The Federal Highway Administration has published equations describing the hydraulics and head losses associated with various configurations of inlet-controlled culverts. Using these equations, it was possible to replicate the observed head losses through the dry weather flow connection, and to infer the benefits of options to improve the hydraulics.

MWRA is currently in the process of translating these equations into their InfoWorks collection system model, so that the benefits of potential solutions can be quantified in terms of Typical Year performance. However, based in the initial findings described above, MWRA has moved forward with the following activities:

- MWRA recently performed field work to cut away a portion of the protrusion of the 30-inch pipe into the regulator structure, with the expected benefit of reducing head loss and increasing flow into the connection, as shown in Figure 2-10.
- MWRA to monitor the City's and its own flow meters to assess the benefit of the removal of the protrusion.
- MWRA is evaluating engineering alternatives to relieve the dry weather flow connection, i.e. providing more hydraulic capacity to move flow into the MWRA's interceptor, including the feasibility of replacing or relieving the 30-inch connection.

Figure 2-10. View of 30-inch Dry Weather Flow Pipe with Removed Protrusion at Regulator RE-081

3. Receiving Water Quality Models: Charles River Basin and Alewife Brook/Upper Mystic River

Water quality models of the Charles River and Alewife Brook/Upper Mystic River have been developed to support the water quality assessments for those waterbodies. The goals of the water quality modeling and assessment and the specific water quality issues to be addressed by the models are to:

- Assess the relative impact of CSO 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.

The first step in this process was to develop and calibrate the water quality models for the Charles River and Alewife Brook/Upper Mystic River. The calibration process involved comparing model-predicted *Enterococcus and E. coli* counts at specific locations in the receiving waters with concentrations measured at those locations during specific storm events and dry weather periods. MWRA submitted a draft Water Quality Model Development and Calibration Report to MADEP and USEPA on September 8, 2020, for their review and comments. MWRA plans to issue the Final Water Quality Model Development and Calibration Report in November. Use of the model to conduct the water quality assessment activities will then commence following submittal of the final report. The sections below summarize the work that went into the development and calibration of the water quality models, followed by a preview of how the model will be used to support the anticipated water quality assessment activities.

3.1 Description of the Water Quality Models

The water quality models and the area covered by each are as follows:

- The Charles River model is being implemented with the Delft3D software in two-dimensional mode. The model extends from the New Charles River Dam and Locks to the Watertown Dam (see Figure 3-1, on the following page).
- The Alewife Brook/Upper Mystic River model is being implemented with the one-dimensional InfoWorks ICM software. The model extends from the Amelia Earhart Dam to the Lower Mystic Lake outlet and it includes the entirety of Alewife Brook (see Figure 3-1).

The models will calculate time-varying bacterial count distributions within the modeled extents of the Charles River and Alewife Brook/Upper Mystic River as a function of rainfall hyetographs (rainfall as a function of time). As an intermediate step, the rainfall data will be input to other models to assess the CSO, stormwater, and stream boundary flowrates as a function of time. The bacterial counts in CSOs, stormwater and at upstream boundaries assigned to these flowrates will be derived from sampling and measurements, and may be adjusted if necessary during model calibration.

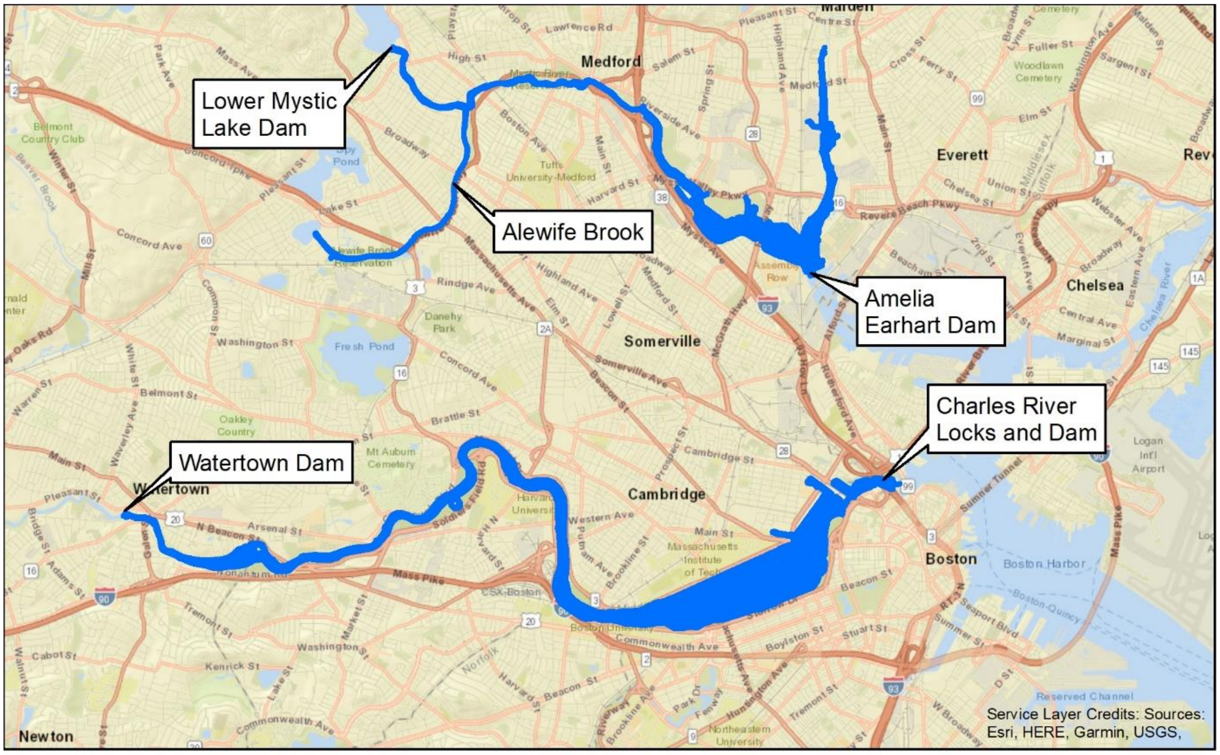


Figure 3-1. Extent of the Charles River and Alewife Brook/Upper Mystic River Models

3.2 Data to Support Model Development

The monitoring data that were used to support development of the CSO and stormwater flows and water quality (*Enterococcus* and *E. coli* counts), as well as the boundary conditions for the water quality models of the Charles River and Alewife Brook/Upper Mystic River are summarized in Table 3-1 on the following page, and described in more detail in the subsections below.

3.2.1 Untreated CSOs

Untreated CSO sampling and analysis for *Enterococcus* and *E. coli* was conducted on influent flow to the Cottage Farm and Prison Point CSO Facilities, and at CSO outfalls CAM401A and SOM001A which discharge to Alewife Brook. As indicated in Table 3-2 on the following page, the measured bacterial counts at Cottage Farm were substantially higher than the counts at the other locations. This difference was attributed to differences in the relative proportions of sanitary sewage and stormwater in the combined sewage. The combined sewage tributary to Cottage Farm had a much higher proportion of sanitary flow, due to the flows tributary to the facility from the upstream separately-sewered communities along the Charles River Valley Sewer and South Charles Relief Sewer. In contrast, the flow tributary to Prison Point, for example, was primarily separate stormwater from the Old Stony Brook system.

Given these distinct measured differences in bacteria counts, which could be tied to differences in the sanitary and stormwater fractions in the influent combined sewage, it did not seem appropriate to assign a single, average value of bacteria count to untreated CSO. Rather, it would be more appropriate to compute time-varying CSO counts based on the relative fraction of stormwater and sanitary flow in the CSO. The “sanitary fraction” of combined sewage is a parameter that can be calculated by the collection system model by tagging the sanitary inputs to the system with a tracer. By assigning bacterial counts to the sanitary and stormwater fractions, the model could then compute the resulting concentration of the sanitary/stormwater mix, based on a mass-balance equation. The initial bacteria counts applied to the stormwater fractions were based on measured data, and the concentrations of the sanitary fractions were then adjusted based on trial-and-error until the computed CSO counts matched the measured counts in the sampled CSO. The resulting sanitary fraction counts were then checked for reasonableness against dry weather flow sampling data from the MWRA’s North System at Deer Island.

Table 3-1. Model Data Sources

Parameter	Charles River	Alewife Brook/Upper Mystic
Bathymetry	MIT surveys (2015-17)	FEMA measurements (2003)
Upstream Boundary Flow	Waltham USGS Gauge	InfoWorks ICM Mystic River Basin Model
Upstream Boundary Quality	Calibrated buildup/washoff model	MWRA receiving water quality monitoring (2017-2018)
CSO Flows	MWRA collection system hydraulic/hydrologic model (2019)	
Untreated CSO Quality	Cottage Farm and Prison Point CSO Facility influent bacteria monitoring data (2017-19)	MWRA bacteria monitoring at outfalls CAM401A and SOM001A (2019)
Treated CSO Quality	Cottage Farm effluent bacteria monitoring data (2018 to 2019)	Somerville Marginal CSO Facility effluent bacteria monitoring data (2018)
Stormwater Flows	BWSC Drain model USGS Charles River Stormwater Model Cambridge Stormwater Model	InfoWorks ICM Mystic River Basin Model
Stormwater Quality	BWSC stormwater model (2012-16) USGS stormwater quality Monitoring Data (1999-2000)	MWRA stormwater monitoring in Medford and Arlington (2019) Cambridge and Somerville Monitoring (2019-2020)
Bacterial Die-off Rates	Literature and previous modeling	Literature and previous modeling

Table 3-2. Untreated CSO Bacterial Data

Location		***Enterococcus*** **MPN/100 mL**	***E. coli*** **MPN/100 mL**
Cottage Farm CSO Facility Influent	Number of Measurements	31	
	Number of Storms	7	
	Arithmetic Average of all samples	**206,000**	**1,306,000**
Prison Point CSO Facility Influent	Number of Measurements	16	
	Number of Storms	8	
	Arithmetic Average of all samples	**52,000**	**175,000**
CAM401A	Number of Measurements	8	
	Number of Storms	2	
	Arithmetic Average of all samples	**36,838**	**55,838**
SOM001A	Number of Measurements	4	
	Number of Storms	2	
	Arithmetic Average of all samples	**22,050**	**64,775**

Figure 3-2, on the following page, presents a schematic of how this approach works, and Figure 3-3, also located on the following page, shows an example of the measured versus predicted bacterial counts at the Cottage Farm and Prison Point influents using this approach. As indicated in Figure 3-3, this approach reproduced the observed variations in bacterial counts at the two facilities.

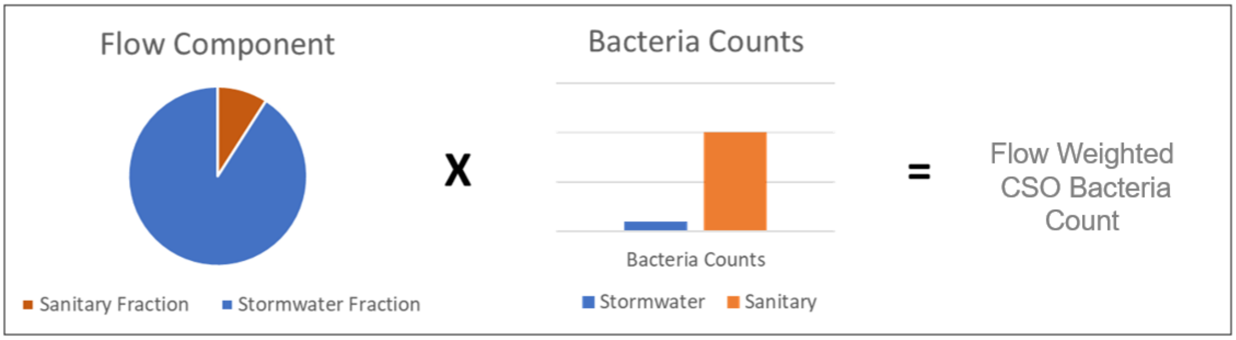


Figure 3-2. Sanitary Fraction Approach to Computing CSO Bacteria Counts

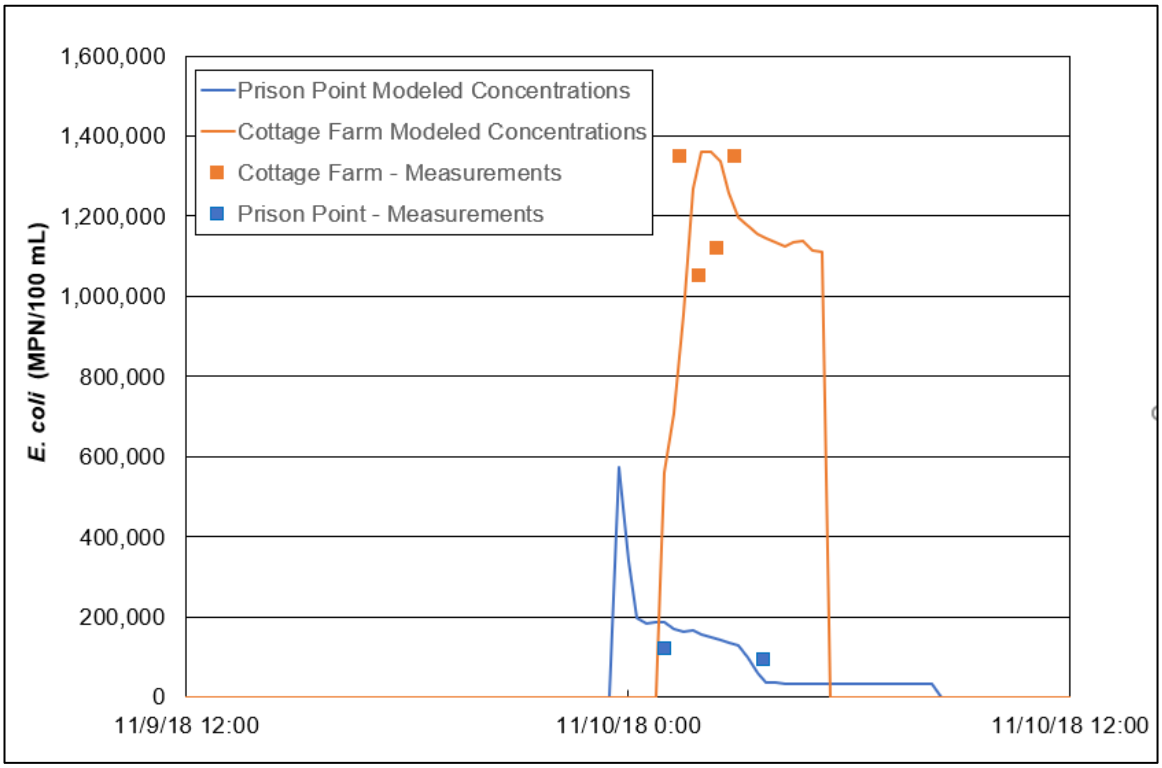


Figure 3-3. Measured and Calculated *E. Coli* Counts at Cottage Farm and Prison Point

The initial values of bacteria counts for the sanitary and stormwater fractions used for the computation of CSO counts for the Charles River and Alewife Brook/Upper Mystic River are presented in Table 3-3 on the following page. As indicated in Table 3-3, the values used for the stormwater components and the *Enterococcus* counts for the sanitary component were the same for the Charles River and Alewife Brook/Upper Mystic River models, but the *E. coli* counts for the sanitary component differed. It is not unusual to specify differing counts in the sanitary fraction for different hydraulic systems within a municipality. This has been the case for modeling of CSO concentrations using the sanitary fraction method in San Francisco and New York City.

For the water quality model calibrations, time-varying sanitary fractions were calculated by the collection system model at each of the CSOs discharging to the respective receiving waters. By applying the sanitary and stormwater bacteria counts shown in Table 3-3, *Enterococcus* and *E. coli* bacterial counts were determined for the CSO flows, and the resulting loads were applied to the receiving water quality models. The applied sanitary and stormwater bacteria counts were then adjusted within reasonable bounds to better match measured in-stream counts as part of the calibration process as described further below.

Table 3-3. Initial Bacterial Counts Used for Sanitary and Stormwater Components of Untreated CSO

Model	Component	*Enterococcus* MPN/100 mL	*E. coli* MPN/100 mL	Source
Charles River	Sanitary	1,000,000	7,000,000	Trial-and-error to match measured CSO concentrations; values are consistent with range of measurements of influent dry weather flow for North System at Deer Island
	Stormwater	5,500	13,400	Average of stormwater samples (see Table 3-5)
Alewife Brook/Upper Mystic River	Sanitary	1,000,000	2,500,000	Trial-and-error to match measured CSO concentrations; values are consistent with range of measurements of influent dry weather flow for North System at Deer Island
	Stormwater	5,500	13,400	Average of stormwater samples (see Table 3-5)

3.2.2 Treated CSOs

For treated CSOs from the Cottage Farm and Somerville Marginal CSO Facilities, average bacterial counts from sampling of the treated from those facilities were calculated and applied to the water quality models. These values are summarized in Table 3-4.

Table 3-4. Bacterial Counts of Treated CSO Discharges

CSO Treatment Facility	*Enterococcus* (MPN/100 mL)	*E. coli* (MPN/100 mL)
Cottage Farm	212	394
Somerville Marginal	17	18

3.2.3 Stormwater

Stormwater bacterial counts were assessed through sampling conducted in 2019 and 2020 in Cambridge (4 locations), Medford (3 locations), Arlington (2 locations) and Somerville (5 locations). These locations are shown in Figures 3-4 and 3-5, on the following page. The results of the sampling are shown in Table 3-5 on pages 40 and 41.

Potential correlations of the stormwater bacterial counts with storm characteristics and catchment land use were explored, to see whether it would be appropriate to apply different stormwater counts to different land use characteristics or storm characteristics. Correlations evaluated included storm depth, number of prior dry days, catchment area, percent undeveloped land, undeveloped area, percent residential, and residential area. No correlation was observed and, hence, average values were used, with the potential for adjustments during the calibration process.

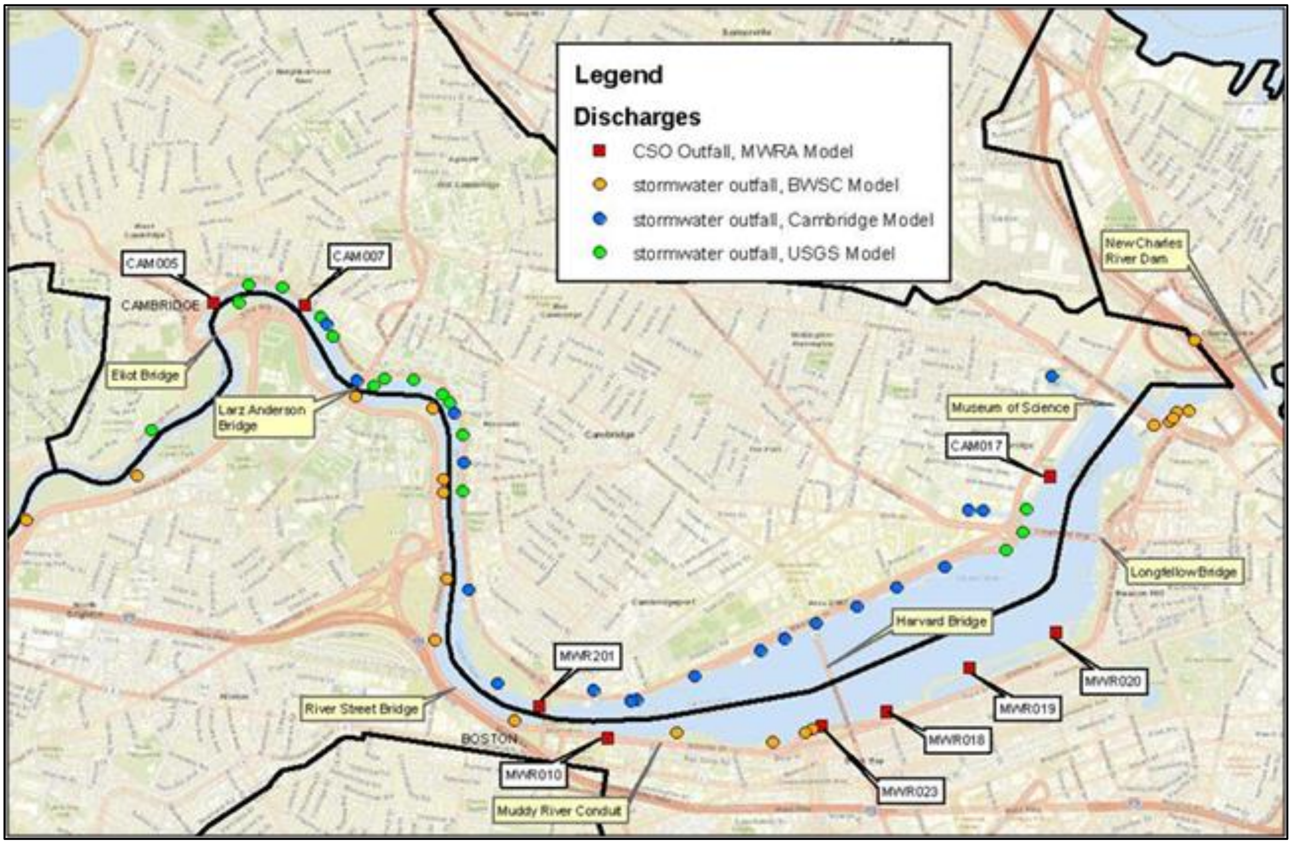


Figure 3-4. Stormwater Monitoring Stations for the Charles River

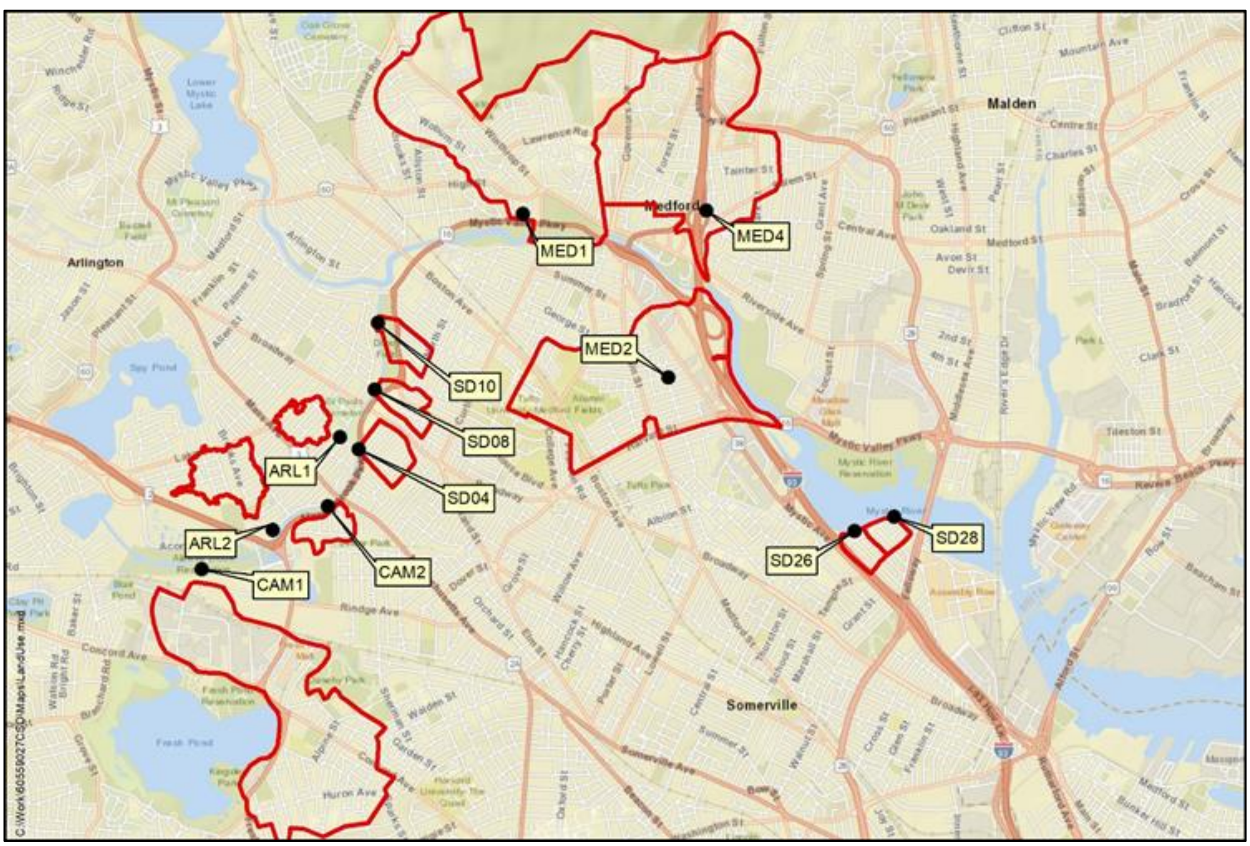


Figure 3-5. Stormwater Monitoring Stations for Alewife Brook/Upper Mystic River

3.3 Model Calibration Data and Approach

As described above, the calibration process involves comparing model-predicted *Enterococcus* and *E. coli* counts at specific locations in the receiving waters with concentrations measured at those locations during specific storm events and dry weather periods. Certain model parameters can then be adjusted within reasonable ranges to improve the match between the modeled and the measured values. This section describes the in-stream sampling data used to compare against model predictions, the specific model parameters that could be adjusted during calibration, and the metrics used to assess how well the model is calibrated.

3.3.1 Calibration Data

For the two water quality models, MWRA's extensive in-stream water quality monitoring data were used as the basis for comparing to model results during the calibration process are. These data included the results of water quality sampling and analysis at 17 stations in the Charles River and 17 stations in the Alewife Brook/Upper Mystic River.

During the period used for calibration, MWRA sampled the receiving water segments in two-week rotating blocks. Weekend sampling during and after storm events was added for the Charles River and Mystic River in 2017. At each station, near-surface water samples were collected and for deeper stations near-bottom samples were also collected. The samples were tested for several water quality parameters including *Enterococcus* and *E. coli*.

Model calibration was conducted with in-stream monitoring data collected in 2018 during 14 rounds of wet weather sampling in the Charles River, and 10 rounds of sampling in the Alewife Brook/Upper Mystic River for totals of 1,082 samples in the Charles River and 1,057 samples in the Alewife Brook/Upper Mystic River. The 2018 sampling data provided a sufficient range of data to conduct the calibration.

3.3.2 Calibration Parameters

The model parameters that were considered for adjustment during the calibration process were:

- *E. coli* and *Enterococcus* die-off rates
- Stormwater and CSO bacterial counts

While these parameters were subject to adjustments during calibration, the adjustments were strongly constrained by literature values (for the die-off rates) and monitoring data (for the stormwater and CSO bacterial counts). Most of the data input to the models were either measured data or data resulting from other models, such as the MWRA collection system model, that were separately calibrated.

Stream bottom roughness, simulated by Manning's equation, and diffusion coefficients are also parameters that are amenable to adjustments during calibration; however, these parameters have a limited impact on the water quality and were not changed from literature and previous modeling values during calibration.

Table 3-5. 2019-2020 Stormwater Sampling Bacterial Results (Page 1 of 2)

Storm Data												
Date	10/7/2019	10/27/2019	11/18/2019	11/24/2019	12/13/2019	5/8/2020						
Depth (in) [(1)]	0.16	1.43	0.24	1.51	1.41	0.41						
Duration (hr)	2.5	10.5	6	17	17.25	14.25						
Peak 15-minute Intensity (in/hr)	0.16	0.56	0.12	0.6	0.24	0.07						
Prior Dry Days	2	3	5	1	2.2	7						
***Enterococcus* (MPN/100 mL)**												
	Average by Storm [(2)]						**By Station [(3)]**		**By Town [(4)]**		**All Data [(5)]**	
							Average	**Standard Deviation**	**Average**	**Standard Deviation**	**Average**	**Standard Deviation**
ARL1	9,195	25,150	4,723	10,605			10,599	9,790	8,406	8,020	5,477	20,933
ARL2	3,723	4,423		8,223			5,614	3,805				
CAM1	918	960		4,678	1,130		1,922	1,817	2,832	2,887		
CAM2	1,154	370		4,412	990		1,716	2,354				
CAM3	7,116	2,938		4,772	9,180		6,002	3,259				
CAM4	1,508	1,364		1,656	2,232		1,690	1,034				
MED1	7,135	4,418	1,200	1,030			3,503	3,398	9,762	31,221		
MED2	4,125	4,375	3,556	2,080			3,454	2,415				
MED4	78,250	4,468	9,574	3,380			21,980	63,429				
SD04						1,265	1,265	239	811	694		
SD08						360	360	202				
SD10						1,768	1,768	498				
SD26						100	100	0				
SD28						660	660	383				

Table 3-5. 2019-2020 Stormwater Sampling Bacterial Results (Page 2 of 2)

Date	10/7/2019	10/27/2019	11/18/2019	11/24/2019	12/13/2019	5/8/2020						
Depth (in) (1)	0.16	1.43	0.24	1.51	1.41	0.41						
Duration (hr)	2.5	10.5	6	17	17.25	14.25						
Peak 15-minute Intensity (in/hr)	0.16	0.56	0.12	0.6	0.24	0.07						
Prior Dry Days	2	3	5	1	2.2	7						
***E. coli* (MPN/100 mL)**												
	Average by Storm (2)						**By Station (3)**		**By Town (4)**		**All Data (5)**	
							Average	**Standard Deviation**	**Average**	**Standard Deviation**	**Average**	**Standard Deviation**
ARL1	14,030	28,895	8,015	2,910			11,258	14,964	19,358	32,994	13,395	29,046
ARL2	2,670	4,600		74,980			29,666	45,966				
CAM1	1,760	24,940		5,640	504		8,211	26,515	11,361	31,953		
CAM2	402	175		700	512		441	393				
CAM3	46,200	3,610		4,480	15,580		17,468	18,511				
CAM4	640	2,750		9,346	64,560		19,324	54,383				
MED1	3,800	3,148	10,578	625			4,456	7,187	14,625	23,995		
MED2	8,210	6,928	9,848	2,000			6,655	6,573				
MED4	27,518	27,915	49,454	22,114			32,198	34,230				
SD04						2,650	2,650	551	10,687	23,942		
SD08						358	358	246				
SD10						47,200	47,200	34,388				
SD26						100	100	0				
SD28						1,110	1,110	658				

Notes:
1. From Somerville Marginal rain gauge.
2. Average of individual wet weather samples taken during the storm.
3. Average and standard deviation of all wet weather samples taken for each station for all storms sampled.
4. Average and standard deviation of all wet weather samples taken at all stations in the community for all storms sampled.
5. Average and standard deviation of all wet weather samples taken.

3.3.3 Calibration Metrics

The first evaluation of calibration fit was visual, by assessing graphical comparisons of model predictions with measurements. This approach is commonly called the Weight-of-Evidence approach. For the current modeling, the main element of the Weight-of-Evidence approach was the general shape of the bacterial count versus time curves, including peaks and lows. A caveat is that the measurements are few (for example daily, at discrete monitoring stations and at different times during the day), and thus do not provide a complete depiction of the bacterial count variations with time. Because of the rapid variation of bacterial counts versus time at the beginning of an event, large differences between model and measured values can result from a slight shift of the timing of the modeled versus the measured values. For this reason, it was important to calibrate over a number of storms so that the general comparison of the model versus measured values could be assessed.

Quantitative measures of model to measurement comparison are desirable to impartially establish that one set of calibration parameters is better than another. One such quantitative metric is the Wilmott "Index of Agreement" (IA) defined as follows[4]:

$$IA = 1 - \frac{\sum_{i=1}^{n} \left|P_i - O_i\right|^2}{\sum_{i=1}^{n} \left(\left|P_i - \overline{O}\right| + \left|O_i - \overline{O}\right|\right)^2}$$

where *P* and *O* are the predicted and observed time series respectively and $\overline{O}$ is the time-average of the observed time series, i is an index refering to individual measurements (and corresponding predictions) and n is the total number of measurements. IA varies between 0 and 1, with 1 showing perfect agreement between the model output and the observed time series. Overall values of IA were computed from model output at all stations from each calibration run.

3.4 Charles River Model Calibration

3.4.1 Hydrologic Model

Calibrated stormwater models developed by the USGS, BWSC and Cambridge were used to develop stormwater flows as a function of time and rainfall for input into the Charles River model, and the MWRA collection system model was used to develop CSO flows as a function of time and rainfall.

3.4.2 Boundary Conditions

The Charles River model has two external boundaries: one at the upstream end at the Watertown Dam, and one at the downstream end at the New Charles River Locks and Dam. The modeled representation of the conditions at these boundaries are described below.

Upstream Boundary. At the upstream end of the model the Watertown Dam), stream flow and water quality needed to be specified as a function of time. During wet weather events, flows and pollutant concentrations at the Watertown Dam increase due to upstream runoff and non-point sources. As documented in previous studies and in the MWRA stream monitoring, the increases in flow and pollutant concentration are substantial, and have considerable impact on water quality downstream of the dam. Therefore, the accuracy of the upstream boundary condition was important.

Flows at the Watertown Dam could be estimated from measurements at the USGS gauge at Waltham (No. 01104500), located upstream of the dam, with adjustments based on the distance between the gauge and the dam[5]. For bacterial data, *Enterococcus* and *E. coli* data were available in the Watertown Dam area for the calibration periods but these data were not sufficiently frequent to be used for the model boundary condition. Therefore, a model based on the buildup/washoff formulation was used to estimate the bacterial counts at the Watertown Dam based on measured flows in the river at the USGS gauge.

Downstream Boundary. Water level versus time needed to be specified at the downstream end of the model. At the New Charles River Locks and Dam, water is discharged at low tide and pumped out of the

[4] Willmott, C.J. 1981. On the Validation of Models. Physical Geography.
[5] USGS. 2002b. Zariello, P.J. and Barlow, L.K. Measured and Simulated Runoff to the Lower Charles River, Massachusetts, October 1999 – September 2000. Water Resources Investigations Report 024129.

basin in anticipation of wet weather events, with the goal of maintaining a stable water level. Water surface elevation measurements are conducted at a USGS gauge just upstream of the dam. For the model, the water levels measured at the New Charles River Dam USGS gauge were specified as the downstream boundary condition. The model indicated that the water level fluctuations at the dam, however small, propagated up to Watertown Dam, with some attenuation.

3.4.3 Dry Weather Calibration

The in-stream monitoring showed elevated bacterial counts in the Charles River during dry weather. Previous modeling indicated that some of the dry weather bacterial counts were due to the effects of previous discharges, which could last for several days. Dry weather sources, for example illicit sanitary connections to storm drains, can also contribute to dry weather bacterial counts in the river. The stormwater models used to specify stormwater inflows to the river included dry weather flows, and bacterial counts were assigned to those dry weather flows to simulate dry weather bacterial loading sources.

Through a process of trial-and-error, the dry weather counts measured at Stations 012 at the Watertown Dam and 001, about one mile downstream of the dam (45 MPN/100 mL for *Enterococcus* and 134 MPN/100 mL for *E. coli*) were found to result in satisfactory match of the predicted in-river counts to the measured counts in dry weather.

3.4.4 Wet Weather Calibration

The wet weather calibration was primarily conducted for *Enterococcus*, with corresponding parameter values applied to *E. coli*. Many different model simulations were conducted with different combinations of parameters including primarily the bacterial counts in stormwater and die-off rates. The parameters that were found to yield in-stream bacterial counts close to the measurements are summarized in Table 3-6 on the following page. Table 3-7 also located on the following page presents the model-computed sanitary fractions, and the flow-weighted *Enterococcus* and *E. coli* counts in the CSOs discharging to the Charles River for the calibration period (2018). The flow-weighted counts for each CSO location were computed as:

$$C_{fw} = \sum_{i=1}^{n} CiQi / \sum_{i=1}^{n} Qi$$

where C_{fw} is the flow-weighted count of *Enterococcus* or *E. coli*, C_i is the model-calculated *Enterococcus* or *E. coli* count in the overflow at each timestep where an overflow occurred, Q_i is the model-calculated overflow rate at each timestep where an overflow occurred, and n is the total number of model timesteps when an overflow occurred.

An example of a model-to-measurement comparison plot is shown in Figure 3-6 on page 45. The Water Quality Model Development and Calibration report contains many more similar figures.

Table 3-6. Selected Charles River Model Parameters

	Stormwater Count (MPN/100 mL)	Base Flow Count (MPN/100 mL)	CSO Sanitary Fraction Count (MPN/100 mL)	CSO non-Sanitary Fraction Count (MPN/100 mL)	Die-off Rate (Day-1)
Enterococcus	10,000	45	1,000,000	6,700	0.8
E. coli	14,000	134	7,000,000	14,000	0.8

Table 3-7. Predicted Sanitary Fractions and Flow-weighted Counts for 2018

Location	Sanitary Fraction (%)	Flow-weighted Counts (MPN/100 mL)	
		Enterococcus	***E. coli***
CAM005	0.02%	10,190	15,341
CAM007	1.76%	27,428	136,985
MWR010	0.00%	10,000	14,000
MWR023	0.03%	7,547	12,571
MWR018	0.63%	16,258	58,163
MWR019	0.51%	15,072	49,789
MWR020	0.47%	14,606	46,500
CAM017	0.07%	10,666	18,700
Cottage Farm Influent	16.62%	174,517	1,174,924
Prison Point Influent	2.78%	37,566	208,524
Cottage Farm Effluent MWR201	N/A[1]	212	394

(1) For outfall MWR201, the flow-weighted counts reflect the treated discharge concentrations from the Cottage Farm CSO Facility. The sanitary fraction method was not applied to the treated discharge. Counts applied to the treated discharge were based on the average values of measured counts sampled from facility effluent in 2018-2019.

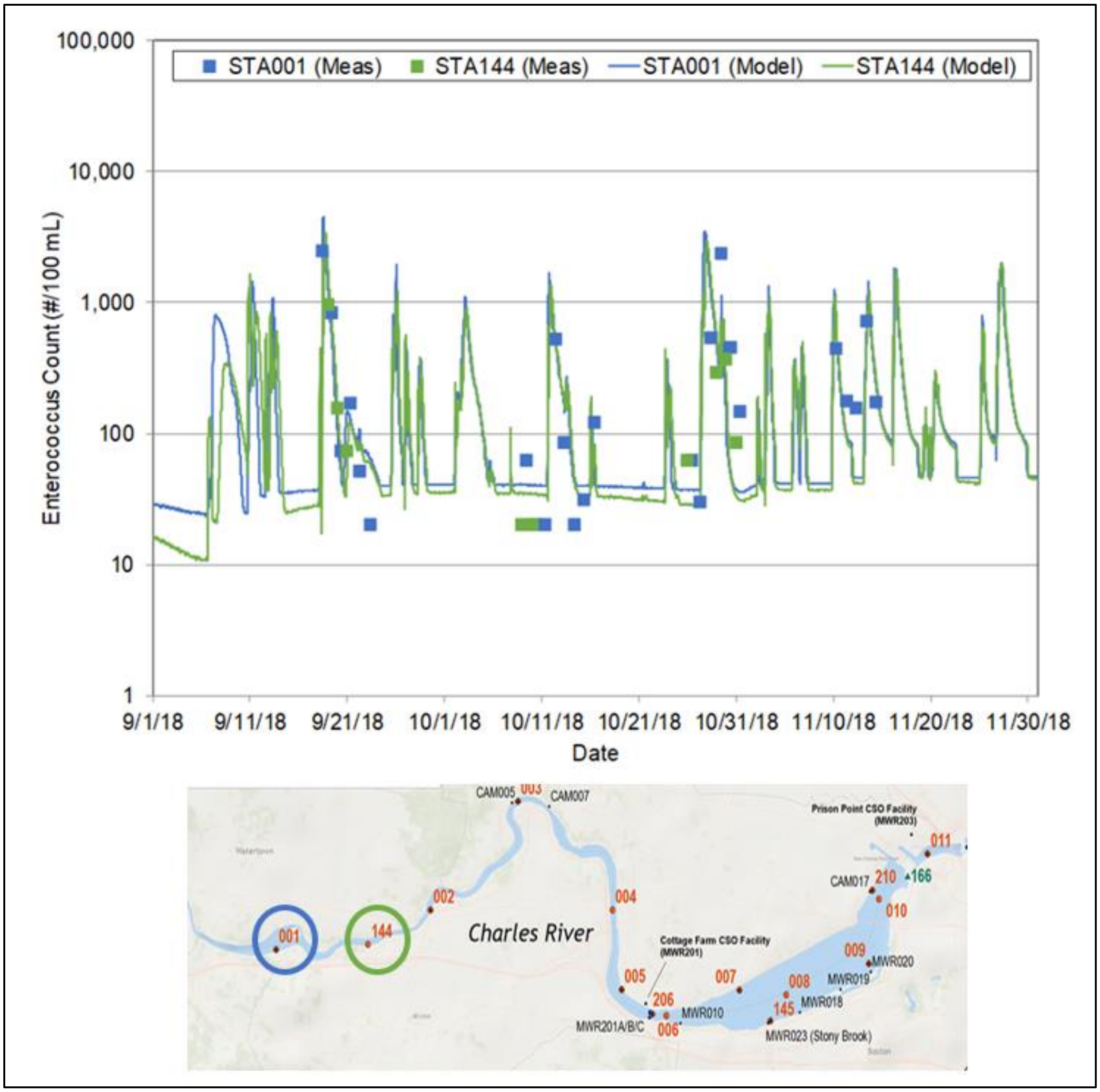


Figure 3-6. Graph with Measured and Calculated *Enterococcus* at Stations 001 and 144 for September through November 2018 with die off rate of 0.8 day^{-1} and Map with Locations of Sampling Sites

3.5 Alewife Brook/Upper Mystic River Model Calibration

3.5.1 Hydrologic Model

The Alewife Brook/Upper Mystic River model was based on a model developed for FEMA and converted to InfoWorks by the City of Cambridge. The FEMA model, however, focused on larger storms with up to a 100-year return period. For this project, flow predictions throughout the year were needed, driven by rainfall and groundwater influences. Therefore, the model hydrology was replaced by the SWMM RUNOFF hydrology, with groundwater routines that simulated the infiltration of stormwater into the ground and the groundwater discharge to the stream. The parameters governing runoff and groundwater infiltration and discharge were calibrated to flows measured at the USGS Alewife Brook Gauge. An example of measured to model flows in Alewife Brook at the USGS Alewife Brook Gauge is shown in Figure 3-7, on the following page.

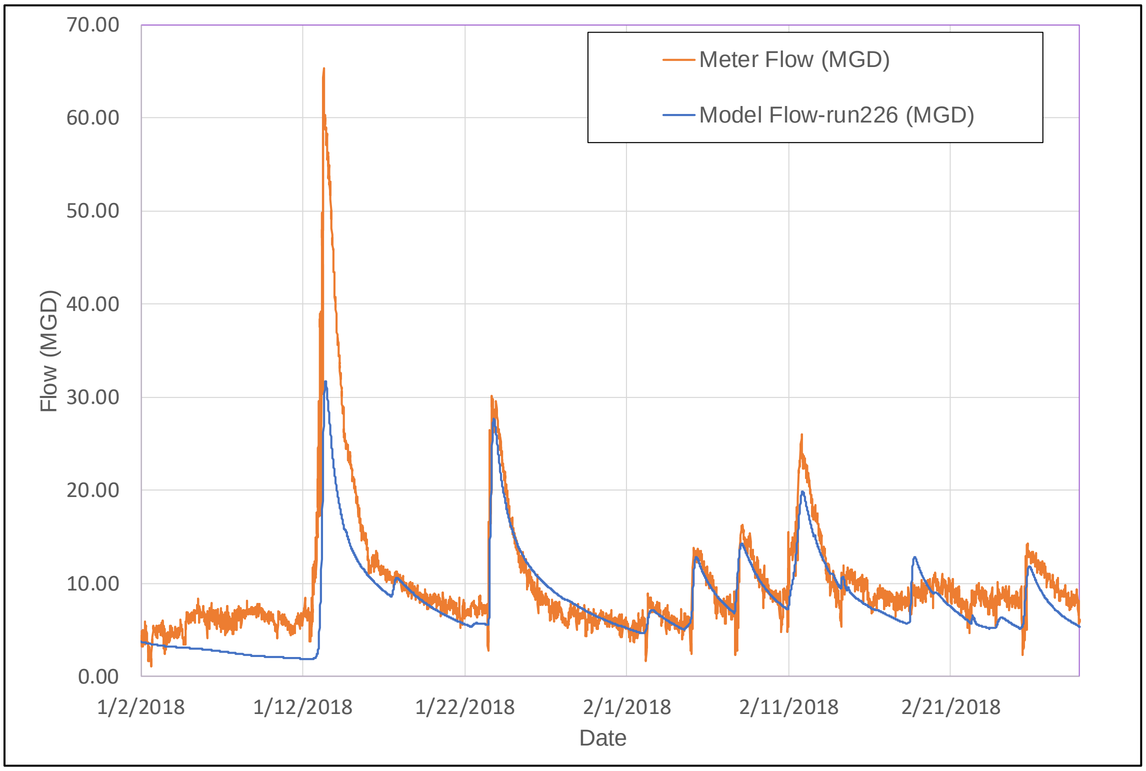


Figure 3-7. Measured and Calculated Flows at the Alewife Brook River Gauge for Jan-Feb, 2018

3.5.2 Boundary Conditions

The Alewife Brook/Upper Mystic River model has three upstream boundaries and one downstream boundary. The upstream boundaries are at the upstream ends of Alewife Brook and the Malden River, and at the outlet of the Lower Mystic Lake into the Mystic River. The downstream boundary is at the Amelia Earhart Dam. The modeled representation of the conditions at these boundaries are described below.

Upstream Boundaries. Stream flow at the boundary at the outlet of the Lower Mystic Lake was specified based on the original version of the watershed model, which covered the entire watershed extending beyond the Upper and Lower Mystic Lakes. Water quality was simulated by specifying base flow and stormwater flow bacterial counts in the sub-catchments just downstream of the lake.

The flows at the boundaries at the upstream ends of Alewife Brook and the Malden River were generated directly from the tributary sub-catchments in the InfoWorks model, with bacteria counts assigned to baseflow (dry weather) and runoff flows during wet weather.

Downstream Boundary. Measured water levels at the USGS gauge just upstream of the Amelia Earhart Dam were specified for the downstream boundary.

3.5.3 Dry Weather Calibration

Bacterial counts were specified in the groundwater discharge to the stream. Following an iterative process, values corresponding to dry weather counts of 45 MPN/100 mL for *Enterococcus* and 134 MPN/100 mL for *E. coli* were found to closely replicate measured counts in the receiving waters.

3.5.4 Wet Weather Calibration

The values of the parameters that were used for calibration are listed in Table 3-8 on the following page. Table 3-9 also on the following page presents the model-computed sanitary fractions, and the flow-weighted *Enterococcus* and *E. coli* counts in the CSOs discharging to the Alewife Brook/Upper Mystic River for the calibration period (2018). An example of model to measurement comparison is shown in Figure 3-8, on page 48.

Table 3-8. Selected Model Parameters

	Stormwater Count (MPN/100 mL)	Soil Store Inflow Count (MPN/100 mL)	CSO Sanitary Fraction Count (MPN/100 mL)	CSO non-Sanitary Fraction Count (MPN/100 mL)	Die-off Rate (Day-1)
Enterococcus	6,700	45	1,000,000	6,700	0.8
E. coli	25,000	134	2,500,000	14,000	0.8

Table 3-9. Predicted Sanitary Fractions and Flow-weighted Counts for 2018

Location	Sanitary Fraction (%)	Flow-weighted Counts (MPN/100 mL)	
		Enterococcus	***E. coli***
MWR003	1.23%	18,953	44,666
CAM401B	2.95%	36,033	87,413
CAM401A	2.01%	26,693	64,038
CAM002	0.39%	10,560	23,660
CAM001	7.60%	82,226	203,024
SOM001A	3.34%	39,870	97,016
SOM007A (1)	N/A	17	18

(1) For outfall SOM007A, the flow-weighted counts reflect the treated discharge concentrations from the Somerville Marginal CSO Facility. The sanitary fraction method was not applied to the treated discharge. Counts applied to the treated discharge were based on the average values of measured counts sampled from facility effluent in 2018.

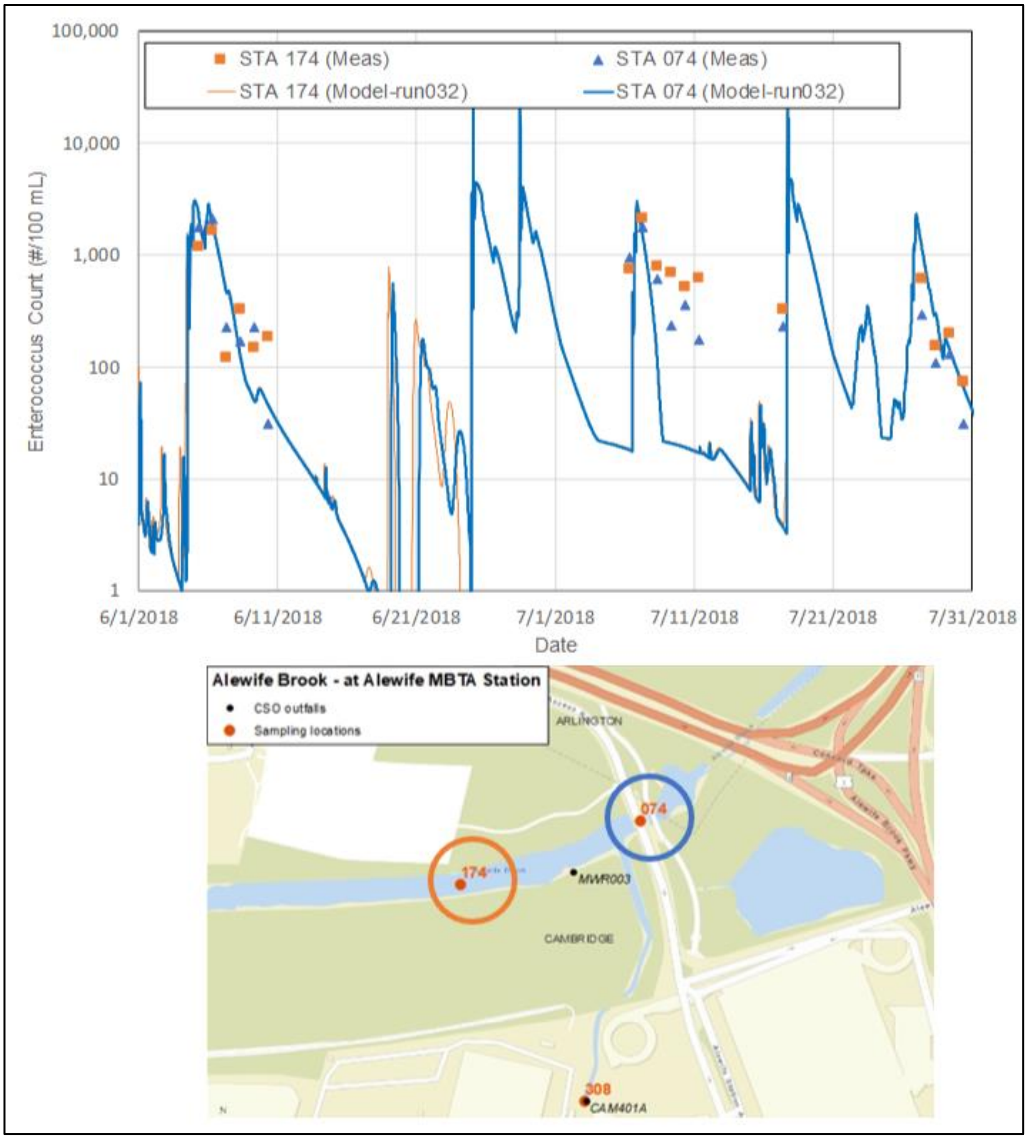


Figure 3-8. Graph with Measured and Calculated Enterococcus at Stations 074 and 174 for June and July 2018 with die off rate of 0.8 day^{-1} and Map with Locations of Sampling Sites

3.6 Water Quality Assessment

The water quality models will be used to develop an assessment of the effects of wet weather sources on present-day water quality in the Charles River and Alewife Brook/Upper Mystic River and compare these effects to the water quality impacts expected after completion of the LTCP. Simulations will be conducted with loadings from CSOs, stormwater and upstream boundaries for *Enterococcus* and *E. coli*. Because the transport equation is linear, results with loadings from different sources are additive. Thus, it will be possible to separate the effects of CSOs, stormwater, and boundary conditions. In addition, model runs will be conducted with varied bacterial loadings to assess the sensitivity of findings to variations in loading concentrations.

For example, model runs will be conducted to determine the number of hours per year that WQ standards are exceeded anywhere in the model domain for conditions including:

- Typical Year storms, CSO + SW + boundary source included
- Typical Year storms, CSO sources only
- Typical Year storms, SW + boundary sources only

Results will be presented in terms of contour plots of bacterial counts (for the Charles River) and plots of bacterial counts as a function of distance (for Upper Mystic River/Alewife Brook) for various times as well as tables of bacterial water quality standards exceedance durations for the different sources and conditions.

The results of the assesment will be presented in a Water Quality Assessment report.

3.7 Alternatives Simulations

After the water quality assessment is complete, the models will be used to evaluate a range of bacterial loading reduction scenarios. Alternatives to be evaluated may include the following:

- Scenarios with bacterial concentrations from non-CSO sources set to: i) zero, ii) 50% of the water quality standard and iii) 100% of the water quality standard.
- Scenarios applying a range of statistically-derived CSO and/or stormwater bacteria concentrations based on sampling data (e.g., median, 25th percentile, 75th percentile).
- Additional scenarios reflecting further CSO reduction opportunities.

Each of the simulations will be conducted for the Typical Year. The results and analysis of the alternatives will be presented in the Alternatives Simulation Report.

The results of the MWRA's CSO Post Construction Monitoring and Performance Assessment program will be presented in the Post Construction Compliance Monitoring Report.

3.8 Schedule

Table 3-10 presents the schedule for submittal of reports related to the water quality evaluations.

Table 3-10. Schedule for Water Quality Assessment and Alternatives Simulations

Report	Date
Model Development and Calibration Technical Memorandum	November 2020
Water Quality Assessment Report	September 2021
Alternatives Simulations Report	December 2021

4. Hydraulic Modeling

4.1 Description, Purpose and Use of the Hydraulic Model

The MWRA's hydraulic model is the primary tool used to evaluate the performance of the MWRA system 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 MWRA's 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. The extent of the MWRA north system model is shown in Figure 4-1. 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 wastewater collection system is continuously improving, and as a result the model is constantly being updated with known changes to the physical configuration of the system. From the spring of 2018 to early 2020, efforts were taken to upgrade and calibrate MWRA's 2017 system conditions model with recent inspection information and meter data, to replicate observed wet weather responses and predict CSO activations. Subsequent to the 2018 calibration, additional modifications have been made to the model based on new information and changes have been informed by continued metering throughout the system.

Figure 4-1. MWRA InfoWorks ICM North System Model

4.2 Model Calibration and Factors Affecting Model Results

Model calibration is the process of adjusting the model so that the model predictions more closely replicate the observations. The model is run using a set of input data, and the modeled and metered responses are compared. Using the measurements and model predictions, model parameters are then adjusted so that the model more closely replicates the observed response. An abbreviated summary of the model calibration and verification efforts is provided as follows. A more comprehensive description of the model calibration efforts and factors affecting the model calibration performance where provided in Semiannual Progress Report No. 4 (link).

As part of the calibration efforts, a limited number of model parameters were adjusted based on observed measurements, including time of concentration parameters, infiltration coefficients, in-pipe sediment depth, percentage of impervious area, and pipe roughness coefficients. These changes were made to the model where physical observations of the system and/or metering data suggested that the changes were necessary to reflect the physical state and hydraulic conditions of the sewer system. In assessing the integrity of the calibration, important comparisons include total flow volumes, peak flows, and the shape of the hydrographs for system flows and CSO discharges. At locations where measured and modeled responses were not rectified by standard calibration adjustments, additional investigations were conducted. In some cases, these investigations found missing elements, such as secondary pipes, interconnections, upstream (in-system) weirs, or other phenomena that had impacts on upstream or downstream hydraulics. These were added to the model as appropriate.

The 2018-2020 calibration efforts included thousands of model iterations to bring the model predictions and the observations closer together. According to the 1999 EPA CSO Guidance for Monitoring and Modeling, an adequate number of storm events (usually 5 to 10) should be monitored and used in model calibration. However, significant rainfall occurred in the April 15, 2018 through September 30, 2018 metering period, with approximately 50 storm events. The model simulated all storm events in the monitoring period, and calibration efforts focused on more than 20 storms in the 2018, increasing the rigor and difficulty of the calibration by providing a variety of storm events with varying rainfall depths, intensities, and durations.

The model calibration followed a multiple-step process, outlined below:

1. Identify the calibration period.
2. Collect and review the data necessary for model calibration.
3. Update the modeled physical configuration at the regulators based on site inspections, record drawings, manhole rim measurements, manhole rim to sewer invert measurements, and other pertinent and available information.
4. Calibrate the dry weather and wet weather flows at the regulator influent meters.
5. Calibrate the overflow meters to achieve a reasonably close match to the observed CSO activations.

While the 5-step calibration process outlined above shows a linear procedure, the calibration was an iterative process. For example, calibrating an overflow meter in Step 5 could result in impacts on regulators that are hydraulically related, requiring re-calibration of an influent meter. An additional field investigation resulting from the inability to reconcile differences between the modeled and observed responses could result in further updates to the physical configuration of the system in the model. Actions taken to calibrate to the overflow meters in Step 5 sometimes resulted in reverting to Steps 2 and 3 of the calibration process.

Once the model was calibrated, it was checked against meter data from a separate verification period, which covered the period from October 1 to November 30, 2018.

The model calibration to the 2018 metering data was substantially complete in the fourth quarter of 2019. However, comparison of model predictions to measurements in the verification period suggested that additional improvements to the calibration were warranted at some regulators. Detailed assessments of the differences between the modeled and metered activations were conducted at ten locations where the comparison suggested that additional calibration refinement efforts could potentially improve the model's ability to predict the meter-observed CSO activations during the 2018 and 2019 metering periods. Metering data from January 1-June 30, 2020 has also informed subsequent adjustments to the model.

For 2018, 2019, and the first six months of 2020, metered and modeled CSO activation frequencies and CSO discharge volumes were compared. In general, the model was able to replicate the storm responses for the majority of storm events in the calibration and subsequent verification periods. However, it is not possible to closely match all of the modeled and metered activations for every meter and storm event, nor was an exact match an expected outcome from the calibration process. Factors affecting the match between modeled and metered activations and volumes include the following:

- **Rainfall data quality and spatial variation**
  Spatial variation of rainfall can cause discrepancies between metered and modeled CSO discharges. Rainfall input to the model is derived from 20 rain gauges distributed throughout the project area, with each rain gauge representing approximately 7.5 square miles of model tributary area. The actual area associated with each rain gauge varies based on the distances and positions of the adjacent rain gauges. Therefore, localized rainfall variations are imperfectly captured. This is particularly relevant for thunderstorms, which can have localized bursts that may not be captured by a gauge. Similarly, a localized downburst may be captured by a gauge, but the rain may not have fallen on a portion of the tributary area assigned to that gauge. The accuracy of the recorded rainfall at each gauge can also be affected by factors such as wind, freezing temperatures, and frequency of maintenance.

- **Unknown transient conditions in the collection system**
  The MWRA model is a simplification of a complex and dynamic system. While CSO inspections and subsequent field investigations identified many previously unknown conditions in the MWRA system affecting the hydraulics of regulators, additional unknown transient conditions may exist. New interconnections, changes in groundwater/seasonal variation, and leaking tide gates are all other examples of unknown transient conditions that could impact the comparison of modeled and metered activations.

- **Accuracy of metering data.**
  Each CSO regulator has a unique flow metering configuration designed to estimate CSO activations or confirm that the regulator is not active. However, regulators are inherently complicated structures with unique hydraulic conditions and are sometimes difficult to meter. Turbulence present in these structures can interfere with recorded measurements. Additionally, sedimentation in a pipe can impact volume calculations. Metering is also susceptible to fouling, creating false positive activations as well as missing activations due to meter failure. The measurements to which model predictions are compared are subject to a certain level of uncertainty, particularly measurements of overflow volumes. Overflow volumes are estimated using several methods depending on the CSO configuration. The longevity of the metering program has increased confidence in characterizing overflow activations, with the ability to generate scattergraphs (presented in Appendix A) that portray the rainfall intensity and depth that correlates to a CSO activation at each regulator.

- **Modeled approximations of hydraulic conditions in pipes and structures**
  The model represents the main parameters that affect CSO activation and volume in mechanistic fashion, i.e., by simulating the relevant phenomena based on basic, well established equations. Flows in the interceptors, community combined and separate sewers, and regulators is modeled using the Saint Venant equations, which are very accurate provided the system is correctly specified. Conduit dimensions and invert elevations have been field-verified in relevant locations, as well as sediment depths. However, many regulators and other structures are often less than ideally configured, which can lead to simulation discrepancies. Certain complex hydraulic structures may be represented in a more simplified fashion in InfoWorks ICM. Additionally, the hydrologic conditions which control the flow inputs to the model are simulated in detail. However, the catchments are inevitably large and all the parameters that affect runoff are not individually specified. The model flows are calibrated at numerous connection points and are generally within +/- 15% of the measurements.

4.3 Model Updates/Adjustments to Mid-2020 System Conditions

The MWRA wastewater collection system is continuously being modified and maintained to improve performance, and as a result the model is constantly being updated with known changes to the physical configuration of the system. Following calibration and 2019 modifications, the model was updated to more accurately represent the system conditions as of June 30, 2020. This version of the model is referred to as the "Mid-2020 System Conditions Model". These conditions included the following modifications from the 2019 version of the model:

- **Alewife Brook Pump Station:** Expanding on the current 2019 version of the ABPS, the wet weather pumps were separated into individual pump elements and real time controls (RTC) were added for each pump (two wet weather pumps and one dry weather pump). Each pump's RTC is programmed to control the pump's on-off logic. Although the pump station housed centrifugal pumps the pumps are modeled as screw pumps, allowing for explicit definition of pump performance, defined using a head versus discharge table. Each wet weather pump's performance is defined to have a maximum pumped flowrate of 37.5 MGD at 100% speed and maximum pumped flowrate of 22.5 MGD at 60% speed. The dry weather pump's performance is defined based on the field and SCADA data taken during the July 14, 2020 pump test. At 100% speed the dry weather pump will produce a pumped flowrate between 15.5 MGD and 16.4 MGD, depending on wet well level. At 60% speed the dry weather pump will produce a pumped flowrate of 4 MGD.
- **Alewife Brook Hydraulic System Evaluation:** As part of the Task 8, Alewife Brook Evaluations and System Optimization efforts, additional investigation was conducted into the regulators discharging to the Alewife Brook. These efforts identified that the hydraulic grade line in the interceptor was over predicted by the model, and adjustments were made to improve the model's ability to predict the hydraulic grade line in the interceptor. Additionally, the connectivity at CAM401A was revised to match field conditions. Metering data from 2019 and 2020 were also used to adjust the calibration at SOM001A resulting from the removal of cap over the drop connection from the regulator to the MWRA interceptor and removal of the temporary orifice plate that was installed in this drop connection to restrict flows until other CSO control measures were completed upstream. Additional model adjustments were made to CAM002 resulting from the modification to the weir elevation in 2019.
- **Somerville Marginal:** The modeled RTC controlling the Somerville Marginal CSO Facility influent gates was updated to reflect a change in operational procedure implemented by MWRA, where at the end of a storm the influent gates are now closed at El. 106.5 ft MDC during normal operation, compared to the previous level of 105.5 MDC.
- **BOS070:** In March of 2020, BWSC completed the removal of a maintenance weir and sediment in the South Boston Interceptor-North Branch. Post removal meter data was used to recalibrate the model to the conditions with the maintenance weir and sediment removed.
- **BOS013, RE0013-1:** As part of the review of the subcatchment areas for BWSC's three East Boston sewer separation contracts, one of the subcatchments tributary to regulator RE013-1 had to be moved in the model from one of the influent pipes to another to account for its actual location and point of entry into the model. Since this change affected the metered flows into the regulator, the influent flows were recalibrated. The recalibration slightly improved the previous match between metered and modeled flows at this location.
- **CSO Facility gate operation data:** As part of the 2018 model calibration, the control logic in the model was adjusted to reflect actual gate operation based on data from the MWRA's SCADA system. MWRA also provided gate operation data for storm events during the 2019 and 2020 monitoring period, and the model was updated to include these data as well.

This Mid-2020 System Conditions Model includes the updates made to the 2017 version as part of the calibration efforts in 2018, as well as the changes for the 2019 system conditions. The Mid-2020 System Conditions Model was used for model simulations of the storms occurring in 2020.

5. Data Collection and CSO Discharge

5.1 Rainfall and Rainfall Analysis

Rainfall is a driving factor in the analysis of CSOs, as the occurrence of overflows within the MWRA combined sewer system is dependent on rainfall intensity and/or depth. This section presents the rainfall data measured during the period of January 1 through June 30, 2020. It also describes the analysis of the rainfall data to characterize the return period of each storm event and a comparison of measured rainfall for the first half 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 20 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
BWSC008	Longwood Medical	BWSC	SP	Spot Pond	Project
BWSC005	Hyde Park	BWSC	WF	Waltham Farm	Project

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. Table 5-2, on page 57, identifies the two closest rain gauges to each of the 20 rain gauges used. Replacement of suspect data was recorded in Table 5-3, on page 57. Rainfall data used for the analysis are provided in Appendix B.

Intensity-Duration-Frequency (IDF) analysis was used to characterize the return periods of the storm events in the January 1 through June 30, 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.

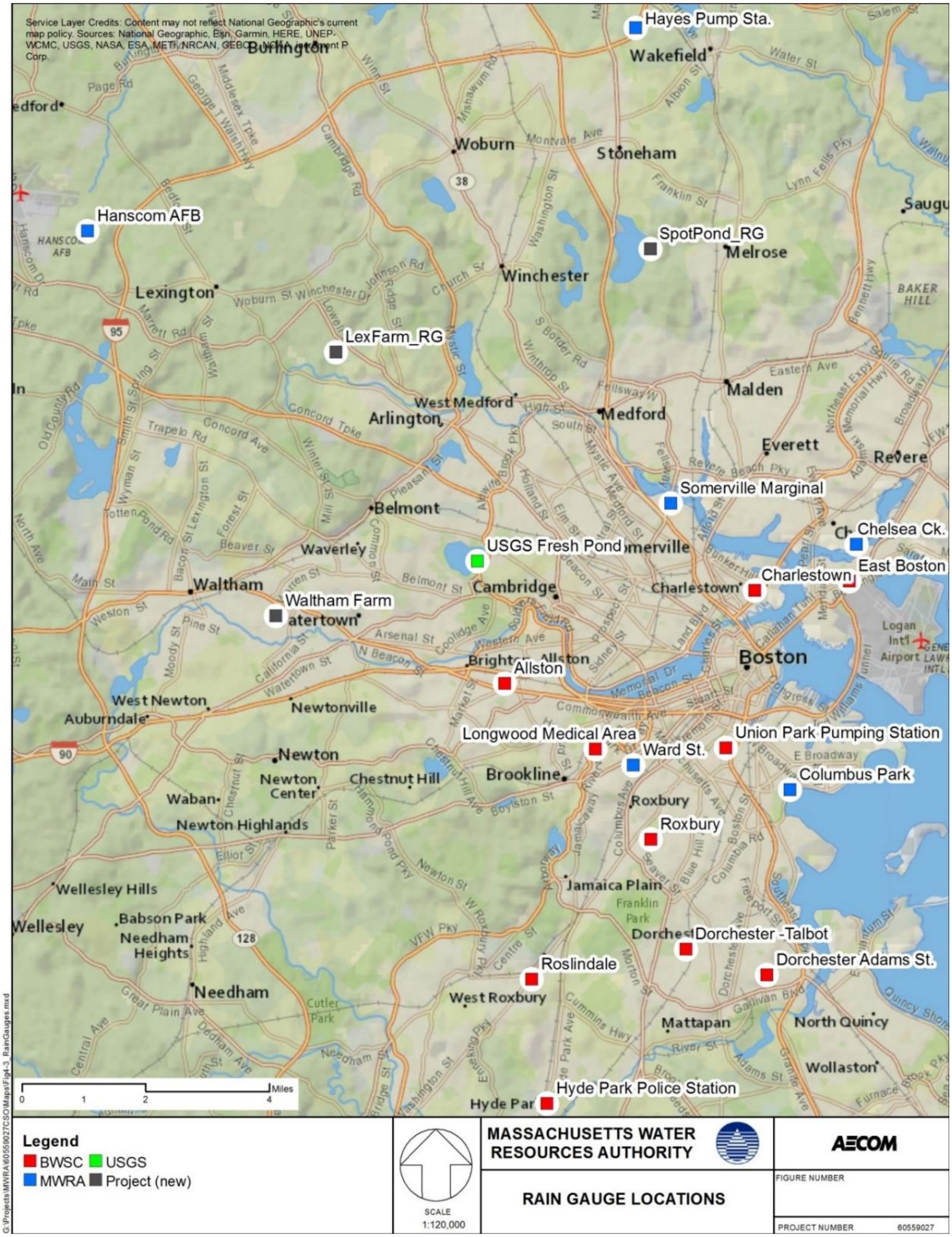


Figure 5-1. Rain Gauge Location Plan

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, January - June 2020 (Page 1 of 2)

Rain Gauge	Replacement Data Start Time	Replacement Data End Time	Replacement Rain Gauge
Columbus Park (BO-DI-2)	January 1, 2020 0:00	January 10, 2020 6:45	BO-DI-1
Union Park Pump Station	January 1, 2020 0:00	January 31, 2020 23:45	BO-DI-1
	February 1, 2020 0:00	March 31, 2020 23:59	BO-DI-2
Dorchester Adams	January 1, 2020 0:00	March 31, 2020 23:59	BO-DI-1
	April 1, 2020 0:00	May 31, 2020 23:45	Dorchester Talbot
	June 1, 2020 0:00	June 30, 2020 23:45	Roxbury
Dorchester Talbot	January 1, 2020 0:00	March 31, 2020 23:59	BO-DI-1
	June 1, 2020 0:00	June 30, 2020 23:45	Roxbury
Charlestown	February 1, 2020 0:00	April 30, 2020 23:45	East Boston
Longwood Medical Area	June 12, 2020 5:45	June 30, 2020 23:45	BO-DI-1
Chelsea Creek (CH-BO-1)	March 1, 2020 0:00	March 31, 2020 23:59	East Boston
USGS Fresh Pond	January 1, 2020 0:00	May 31, 2020 23:45	Allston

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

Rain Gauge	Replacement Data Start Time	Replacement Data End Time	Replacement Rain Gauge
Columbus Park (BO-DI-2)	January 1, 2020 0:00	January 10, 2020 6:45	BO-DI-1
Union Park Pump Station	January 1, 2020 0:00	January 31, 2020 23:45	BO-DI-1
	February 1, 2020 0:00	March 31, 2020 23:59	BO-DI-2
Dorchester Adams	January 1, 2020 0:00	March 31, 2020 23:59	BO-DI-1
	April 1, 2020 0:00	May 31, 2020 23:45	Dorchester Talbot
	June 1, 2020 0:00	June 30, 2020 23:45	Roxbury
Dorchester Talbot	January 1, 2020 0:00	March 31, 2020 23:59	BO-DI-1
	June 1, 2020 0:00	June 30, 2020 23:45	Roxbury
Charlestown	February 1, 2020 0:00	April 30, 2020 23:45	East Boston
Longwood Medical Area	June 12, 2020 5:45	June 30, 2020 23:45	BO-DI-1
Chelsea Creek (CH-BO-1)	March 1, 2020 0:00	March 31, 2020 23:59	East Boston
USGS Fresh Pond	January 1, 2020 0:00	May 31, 2020 23:45	Allston
Hanscom AFB (HF-1C)	January 1, 2020 0:00	April 30, 2020 23:45	Allston
	May 1, 2020 0:00	June 30, 2020 23:45	Lexington Farm
Lexington Farm	January 1, 2020 0:00	April 30, 2020 23:45	Allston
Hayes Pump Sta. (RG-WF-1)	January 1, 2020 0:00	January 13, 2020 11:30	Allston
Roxbury	January 2, 2020 19:45	March 31, 2020 23:59	BO-DI-1
Spot Pond	January 1, 2020 0:00	April 30, 2020 23:45	Somerville
Waltham Farm	January 1, 2020 0:00	April 30, 2020 23:45	Allston

5.1.2 Monitored Storms and Comparison of Storms to the Typical Year

For the period of January 1 through June 30, 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 on the following pages presents the summary of storm events for Ward Street Headworks for the period January to June 2020. These data show that 45 storm events occurred in the 6-month period January to June 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. One storm event had a 1-hour recurrence interval of 3 months (June 6, 2020). The largest storm event based on the 1-hour recurrence interval was on June 28, 2020, with a 2-year recurrence interval. Two storms (March 23 and June 28) had 24-hour recurrence intervals of 3 months. Tables summarizing the storm events from January to June 2020 for the other rain gauges are provided in Appendix C.

Table 5-4. Summary of Storm Events at Ward Street Headworks Rain Gauge (BO-DI-1) for January to June 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	1/4/2020 10:30	22.5	0.28	0.01	0.05	0.01	0.01	<3m	<3m	N/A
2	1/8/2020 1:30	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
3	1/12/2020 4:00	6.5	0.06	0.01	0.04	0.00	0.00	<3m	<3m	N/A
4	1/16/2020 3:30	5.75	0.08	0.01	0.04	0.00	0.00	<3m	<3m	N/A
5	1/18/2020 18:30	16.75	0.3	0.02	0.09	0.01	0.01	<3m	<3m	N/A
6	1/25/2020 17:30	4.75	0.63	0.13	0.21	0.03	0.01	<3m	<3m	N/A
7	2/5/2020 1:45	4	0.04	0.01	0.02	0.00	0.00	<3m	<3m	N/A
8	2/6/2020 2:45	35	0.8	0.02	0.15	0.02	0.02	<3m	<3m	N/A
9	2/10/2020 4:30	10	0.15	0.02	0.08	0.01	0.00	<3m	<3m	N/A
10	2/11/2020 5:15	14.25	0.17	0.01	0.07	0.01	0.01	<3m	<3m	N/A
11	2/13/2020 1:15	13.5	0.55	0.04	0.16	0.02	0.01	<3m	<3m	N/A
12	2/18/2020 15:00	7.25	0.46	0.06	0.10	0.02	0.01	<3m	<3m	N/A
13	2/25/2020 20:45	6.25	0.42	0.07	0.11	0.02	0.01	<3m	<3m	N/A
14	2/27/2020 1:15	8	0.84	0.11	0.25	0.04	0.03	<3m	<3m	N/A
15	3/3/2020 19:45	6.5	0.04	0.01	0.02	0.00	0.00	<3m	<3m	N/A
16	3/13/2020 1:00	14	0.35	0.03	0.12	0.01	0.01	<3m	<3m	N/A
17	3/17/2020 8:15	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
18	3/19/2020 4:30	26.5	0.68	0.03	0.17	0.03	0.01	<3m	<3m	N/A
19	3/23/2020 14:30	15	2.00	0.13	0.50	0.08	0.04	<3m	3m	N/A
20	3/28/2020 20:15	26.75	0.97	0.04	0.15	0.04	0.02	<3m	<3m	N/A
21	3/30/2020 14:00	5.5	0.1	0.02	0	0.00	0.00	<3m	<3m	N/A
22	4/2/2020 13:30	37.25	1.31	0.04	0.18	0.04	0.03	<3m	<3m	N/A
23	4/8/2020 5:15	3.25	0.06	0.02	0.24	0.00	0.00	<3m	<3m	N/A
24	4/9/2020 10:00	8.5	0.65	0.08	0.24	0.03	0.01	<3m	<3m	N/A
25	4/10/2020 15:15	0.5	0.02	0.04	0.03	0.01	0.01	<3m	<3m	N/A
26	4/13/2020 4:30	15.25	0.89	0.06	0.24	0.03	0.02	<3m	<3m	N/A
27	4/18/2020 0:00	9	0.72	0.08	0.15	0.02	0.01	<3m	<3m	N/A
28	4/21/2020 15:15	2.75	0.41	0.15	0.24	0.02	0.01	<3m	<3m	N/A
29	4/24/2020 3:45	11.75	0.2	0.02	0.04	0.01	0.00	<3m	<3m	N/A
30	4/26/2020 13:45	32.25	0.85	0.03	0.08	0.03	0.02	<3m	<3m	N/A
31	4/30/2020 10:00	0.25	0.01	0.04	0	0.00	0.00	<3m	<3m	N/A
32	5/1/2020 2:15	24.5	0.9	0.04	0.29	0.04	0.00	<3m	<3m	N/A
33	5/6/2020 23:00	4	0.02	0.01	0.01	0.00	0.00	<3m	<3m	N/A
34	5/8/2020 18:00	14.5	0.39	0.03	0.07	0.02	0.01	<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
35	5/11/2020 16:15	4.75	0.36	0.08	0.26	0.02	0.01	<3m	<3m	N/A
36	5/15/2020 1:15	1.75	0.05	0.03	0.04	0.00	0.00	<3m	<3m	N/A
37	5/15/2020 20:00	5	0.7	0.14	0.40	0.03	0.02	<3m	<3m	N/A
38	5/30/2020 2:15	1	0.2	0.20	0	0.00	0.00	<3m	<3m	N/A
39	6/2/2020 18:30	0.5	0.02	0.04	0.02	0.00	0.00	<3m	<3m	N/A
40	6/5/2020 3:45	2.5	0.12	0.05	0.11	0.01	0.00	<3m	<3m	N/A
41	6/6/2020 14:30	6.5	0.69	0.11	0.6	0.03	0.02	3m	<3m	N/A
42	6/11/2020 12:15	5.75	0.67	0.12	0.47	0.03	0.01	<3m	<3m	N/A
43	6/24/2020 18:30	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
44	6/27/2020 15:15	0.5	0.02	0.04	0.02	0.00	0.00	<3m	<3m	N/A
45	6/28/2020 12:30	48.5	2.04	0.04	1.09	0.08	0.04	2yr	3m	3m

(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 June 30, 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 June 30, 2020, and the number of storms by depth identified. These values were then compared to the values from the Typical Year. Table 5-5 on the following page presents this comparison. As indicated in Table 5-5, during the first half of 2020, rain gauges measured an average of 46 storms with total rainfall volume of 20.3 inches, compared with 47 storms and 23.4 inches in half of the Typical Year. Storm frequencies for the 0.25 to 0.5-inch and 1.0 to 2.0-inch ranges were similar to half the Typical Year, while the numbers of storms in the less than 0.25-inch and greater than 2-inch ranges were less than half the Typical Year. There were more storm events in the 0.5 to 1.0 inch range in the first half of 2020 as compared to half the Typical Year. These observations suggest that more medium-volume storms and fewer large-volume and small-volume storms occurred during January to June 2020 than in half of the Typical Year.

Storms with greater than two 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 greater than two inches of total rainfall in the Typical Year (Table 5-6, page 62). Experience has shown that large storms often account for a disproportionate volume of CSO. Table 5-6 indicates that two storm events (March 23, 2020 and June 28, 2020) had rainfall depths observed at Ward Street, Columbus Park and/or Chelsea Creek greater than two inches. No storm events with rainfall depths greater than two inches were recorded at the USGS Fresh Pond gauge.

In the first half 2020 monitoring period, the largest storm in terms of total rainfall at the Ward Street, Columbus Park or Chelsea Creek gauges (June 28, 2020) would have been the sixth-largest in the full Typical Year. However, the peak intensity of the June 28, 2020 storm at Ward Street and Chelsea Creek was higher than any of the >2-inch storms in the Typical Year.

Table 5-5. Frequency of Events within Selected Ranges of Total Rainfall for January-June, 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
Half Typical Year	23.4	47	25	7	8	4	3
January- June 2020 Metering Data							
Average of 20 Rain Gauges							
Average	20.3	46	21	8	12	4	1
MWRA Rain Gauges							
Ward Street	20.25	45	20	8	14	1	2
Columbus Park	19.39	45	22	6	13	3	1
Chelsea Creek	16.67	49	27	8	12	1	1
Hanscom Air	19.92	46	21	9	12	4	0
Hayes PS	18.21	43	19	6	15	3	0
BWSC Rain Gauges							
Allston	19.23	45	20	9	13	3	0
Charlestown	18.64	44	19	9	11	5	0
Dorchester-Adams	20.46	43	17	9	12	4	1
Dorchester-Talbot	21.46	42	15	10	11	5	0
Hyde Park	25.22	52	24	9	14	2	3
East Boston	19.43	44	20	8	12	4	0
Longwood	20.81	47	22	8	14	2	1
Roslindale	23.36	48	22	9	10	5	2
Roxbury	20.97	44	18	9	12	4	0
Union Park	20.47	43	19	7	12	4	1
USGS Rain Gauge							
Fresh Pond	19.28	45	20	8	14	3	0
Project Gauges							
Lexington Farm	20.93	47	23	6	12	6	0
Spot Pond	20.29	49	25	8	9	7	0
Somerville	17.79	50	27	8	13	1	1
Waltham Farm	22.43	46	20	11	9	4	2

Table 5-6. Comparison of Storms Between January 1 and June 30, 2020 and Typical Year with Greater than Two 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-June 2020 Metering Data						
Ward Street	6/28/2020 12:30	48.5	2.04	0.04	1.09	3m
Columbus Park	3/23/2020 14:30	23.25	2.15	0.09	0.55	3m-6m
Chelsea Creek	6/28/2020 12:30	48.25	2.11	0.04	0.7	3m
Fresh Pond (USGS)	No Storm Event > 2 inches					

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, page 63). For this period Fresh Pond (USGS) did not record storms with this intensity. 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 first half 2020 monitoring period had four storm events with intensities greater than 0.40 inches per 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 on the following page, with the remaining hyetographs in Appendix D.

Comparisons of the first half 2020 monitoring period to half the Typical Year suggest that 2020 is tracking to be similar to the Typical Year rainfall. The following is a summary of the rainfall comparison of January to June 2020 to half the Typical Year:

- Half the Typical Year has 47 storm events, while the first half of 2020 averaged 46 storm events (Table 5-5).
- The total average rainfall depth for first half 2020 (20.2 inches) was similar to but slightly less than half the Typical Year (23.4 inches) (Table 5-5).
- First half 2020 had more storm events with depths between 0.5 to 1.0 inches than half the Typical Year. First half 2020 had an average of 12 storm events with depths between 0.5 and 1.0 inches while the Typical Year had 8 such storm events (Table 5-5).
- The first half 2020 storm events had a slightly higher average frequency of events with depths 0.25 to 0.5 inches than half the Typical Year. First half 2020 had an average of 8 storms in that depth range while the Typical Year had 7 storm events (Table 5-5).

- The first half 2020 had fewer storm events with a total rainfall depth greater than 2 inches than half the Typical year. However, the storm events with depths greater than 2 inches in the first half of 2020 tended to have shorter durations and higher intensities than storms in the same size range in the Typical Year (Table 5-6).

Table 5-7. Comparison of Storms with Peak Intensities Greater than 0.40 inches/hour Between January 1 and June 30, 2020 versus the Full Typical Year

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-June 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
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
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
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

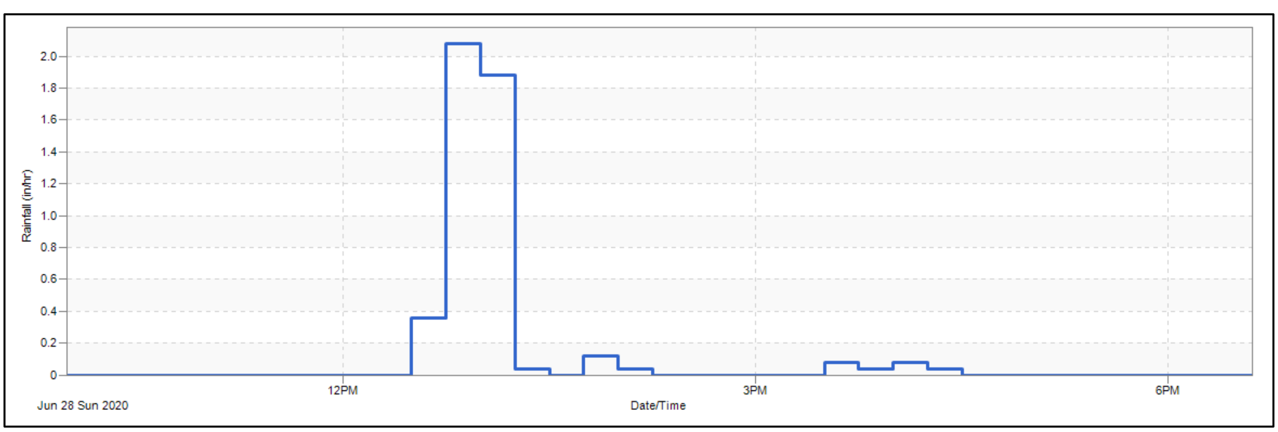


Figure 5-2. Hyetograph from the Ward Street Headworks Gauge for June 28, 2020

5.2. Metering of CSO Discharges

Each CSO regulator was configured with a unique flow metering configuration designed to estimate CSO activations or confirm that the regulator was not active. Meter configurations were intended to quantify the CSO activation frequency, duration, and volumes at most locations, as well as calibrate MWRA's hydraulic model. Additional information on the CSO Metering Plan can be found in Section 3 of Semiannual Report No. 2.

A variety of methods were used for the assessment of metered CSO discharges. Not all of the methods were applicable to each of the meter configurations, but the intent was to use available information to assess the accuracy and reasonableness of the measured CSO activations. Depending on the particular meter configuration, the review of meter data may have included the following methods:

- Direct measurement of meter data
- Comparison with other meters
- Analysis of influent meter scattergraphs of flow and depth to assess how well the influent meters conformed to hydraulic theory
- Comparison of influent meter volume with rainfall to assess how well the volumes correlated with rainfall
- Field inspection of level only meter configurations to check for evidence of CSO discharges
- Correlation of CSO activation with rainfall depth and intensity using scattergraphs. Updated scattergraphs which include the activation and non-activation events from April 15, 2018 to June 30, 2020 are provided in Appendix A
- Calculation of CSO discharge volume using alternate methods
- Evaluation of reasonableness of meter data

When the meter data indicated that an activation occurred, the duration of the overflow was identified and, in locations where possible, the CSO volume was calculated. The method of calculating the CSO volume depended on the meter configuration.

In locations where the necessary depth and velocity sensors were installed, measurements were used to calculate flowrate and total volume of CSO activations. CSO flowrate was calculated by using one of three methods: Continuity, Continuity by subtraction, or a weir equation. The Continuity (Qc) method used the cross-sectional area of the pipe in flow (estimated by depth measurement) multiplied by the velocity measurement to estimate the flow. The Continuity by subtraction (Qs) method used the flow difference from two separate pipes (i.e. influent and DWF connection) as calculated by depth and velocity measurements. The Weir (Qw) method used a depth measurement over a weir structure and an appropriate weir equation. In each case, CSO volume was computed by integrating CSO flowrate over time.

In locations where CSO flowrates and volumes could not be measured by depth/velocity sensors in the outfall, an attempt was made to estimate the overflow volume using other means such as Continuity by subtraction or a weir equation as described above or using Manning's Equation or the Scattergraph method. Alternative methods were used at regulator RE057-6 for outfall BOS057 (weir equation) and regulator RE060-7 for outfall BOS060 (scattergraph method).

In locations where the continuity methods or alternative methods could not be used, the overflow was reported as duration only. At these locations, volumes were not calculated using alternate means for a number of reasons:

- Use of the weir equation assumes a free discharge condition. Therefore, the presence of backwater from conditions such as high tide may prevent use of this method.

- At some locations CSO volumes were not able to be verified and were thus considered inconsistent. This occurred at regulators RE401A (CAM401A), RE011 (CAM001), RE021 (CAM002), CAM005, and CAM017.

The total CSO volume from the upstream BOS046/MWR023 regulators that can overflow to BSWC Stony Brook Conduit is proportioned between outfalls MWR023 and BOS046 for reporting purposes during periods when Boston Gatehouse No. 1 is open. However, Boston Gatehouse No. 1 was not reported to be opened during the first six months of the 2020 monitoring period, and any overflow from the upstream regulators would be reported as being conveyed to the MWR023 outfall as long as the gates at Boston Gatehouse No. 1 were not overtopped. It should also be noted that the total metered volume indicated for outfall MWR023 would not include volume that may have discharged from upstream regulators that were level-only sites, where volumes could not be estimated based on available data.

5.3 Metered and Modeled CSO Discharge Estimates January through June 2020

MWRA's recently calibrated model, updated to the mid-2020 system conditions, was used to simulate the storm events from January 1, 2020 to June 30, 2020. The comparison of metered and modeled CSO discharges from January 1, 2020 to June 30, 2020 is presented in Table 5-8. The model was able to replicate the storm responses for the majority of storm events in the 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 June 28, 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.

Table 5-8. Summary of January 1-June 30, 2020 Modeled and Metered CSO Discharges (1 of 2)

Outfall	Regulator	Level Only	Meter Removed 3/1/19[(1)]	January 1 – June 30, 2020			
				Meter		Model	
				Activation Frequency	Volume (MG) [(2)]	Activation Frequency	Volume (MG)
Alewife Brook							
CAM001	RE-011	Y		0	0.00	1	0.02
CAM002	RE-021			0	0.00	0	0.00
MWR003	RE-031			0	0.00	1	0.29
CAM401A	RE-401			6	N/A	4	0.65
CAM401B	RE-401B			0	0.00	1	0.20
SOM001A	RE-01A			0	0.00	1	0.98
Upper Mystic River							
SOM007A/MWR205A		Y		3	N/A	1	3.82
Mystic/Chelsea Confluence							
MWR205 (Somerville Marginal Facility)				12	21.57	16	26.80
BOS013	RE013-1		Y	-	-	3	0.04
BOS014	RE014-2		Y	-	-	4	0.05
BOS017	RE017-3		Y	-	-	2	0.01
CHE003	RE-031	Y		0	0.00	0	0.00
CHE004	RE-041			2	0.43	3	0.14
CHE008	RE-081			11	0.32	6	0.62
Upper Inner Harbor							
BOS009	RE009-2		Y	-	-	11	0.07
BOS010	RE010-2		Y	-	-	2	0.08
BOS012	RE012-2		Y	-	-	6	0.31
BOS019	RE019-2	Y		0	0.00	0	0.00
BOS057	RE057-6			0	0.00	1	0.01
BOS060	RE060-7			1	0.00 [(3)]	0	0.00
	RE060-20			0	0.00	0	0.00
MWR203 (Prison Point)				4	49.18	3	43.82
Lower Inner Harbor							
BOS003	RE003-2		Y	-	-	0	0.00
	RE003-7		Y	-	-	2	0.23
	RE003-12			3	0.64	2	0.67
BOS004	RE004-6		Y	-	-	2	0.00
BOS005	RE005-1	Y	Y	-	-	0	0.00
Fort Point Channel							
BOS062	RE062-4		Y	-	-	4	0.08
BOS064	RE064-4		Y	-	-	0	0.00
	RE064-5	Y	Y	-	-	2	0.02
BOS065	RE065-2	Y		2	N/A	2	0.00
BOS068	RE068-1A	Y	Y	-	-	0	0.00
BOS070/DBC	RE070/8-3			2	0.44	3	0.34
	RE070/8-6	Y		0	0.00	0	0.00
	RE070/8-7	Y		2	N/A	2	0.04
	RE070/8-8	Y		0	0.00	0	0.00
	RE070/8-13	Y		0	0.00	0	0.00
	RE070/8-15	Y		3	N/A	0	0.00

Table 5-8. Summary of January 1-June 30, 2020 Modeled and Metered CSO Discharges (2 of 2)

Outfall	Regulator	Level Only	Meter Removed 3/1/19[(1)]	January 1 – June 30, 2020			
				Meter		Model	
				Activation Frequency	Volume (MG) [(2)]	Activation Frequency	Volume (MG)
Fort Point Channel (cont.)							
BOS070/DBC *(cont.)*	RE070/9-4			4	0.32	3	0.32
	RE070/10-5			0	0.00	0	0.00
	RE070/7-2			9[(4)]	0.40	12	0.02
MWR215 (Union Park)				3	3.94	2	6.46
BOS070/RCC	RE070/5-3	Y	Y	-	-	1	0.05
BOS073	RE073-4			0	0.00	0	0.00
Reserved Channel							
BOS076	RE076/2-3			0	0.00	0	0.00
	RE076/4-3			0	0.00	0	0.00
BOS078	RE078-1 RE078-2		Y	-	-	0	0.00
BOS079	RE079-3	Y	Y	-	-	0	0.00
BOS080	RE080-2B	Y	Y	-	-	0	0.00
Upper Charles							
CAM005	RE-051			4	0.10	1	0.27
CAM007	RE-071			0	0.00	1	0.68
Lower Charles							
CAM017	CAM017			0	0.00	0	0.00
MWR010	RE036-9	Y		0	0.00	0	0.00
	RE037	Y		0	0.00	0	0.00
MWR018		Y		0	0.00	0	0.00
MWR019		Y		0	0.00	0	0.00
MWR020		Y		0	0.00	0	0.00
MWR201 (Cottage Farm)				1	4.03	1	0.15
MWR023	RE046-19	Y		0	0.00	0	0.00
	RE046-30			0	0.00	0	0.00
	RE046-50	Y		0	0.00	0	0.00
	RE046-54	Y		0	0.00	0	0.00
	RE046-55	Y		0	0.00	0	0.00
	RE046-62A	Y		0	0.00	0	0.00
	RE046-90	Y		1	N/A	0	0.00
	RE046-100			1	0.00 [(3)]	1	0.01
	RE046-105			0	0.00	1	0.02
	RE046-381	Y		0	0.00	0	0.00
	RE046-192	Y		0	0.00	0	0.00
Back Bay Fens							
BOS046 [(5)]	Boston Gatehouse #1			-	-	0	0.00
GRAND TOTAL					-		87.27

(1) For locations indicated with a "Y" in the meter removed column, the meter was removed on March 1, 2019 and therefore no metered results are presented.

(2) Flow volumes are estimates based on information available. Direct measurements in the outfall pipe, weir equation, scattergraphs and other methods were used to estimate volumes. Where activations occurred and volume is reported as 0.00 MG, volumes were less than 0.01 MG. In locations where these methods were not applicable (N/A), such as the sites with level-only sensors, no volume was approximated.

(3) A metered volume less than 0.005 MG was recorded.

(4) Meter malfunctioned on June 28, 2020.

(5) Boston Gatehouse 1 is primarily a stormwater discharge but may contain CSO if the upstream regulators overflow. The upstream regulators are monitored directly. The gatehouse is normally closed but may be opened for flood mitigation. Flow can discharge at the Gatehouse if either the gate is opened or if water overtops the gate. Based on model tracer studies, when a discharge occurs during model simulations at BOS046 it was estimated that 25% of the CSO from the upstream regulators discharges at the MWR023 outfall (Charles River) and 75% discharges at BOS046 (Back Bay Fens). The model at BOS046 did not predict any CSO discharging from Fens Gatehouse #1.

5.4 CSO Metering and Modeling after June 2020

As of July 1, 2020, with the model calibration efforts complete and a substantial post-calibration metering period available to compare modeled and metered CSO discharges, the temporary project meters were removed. In some locations MWRA has converted temporary project meters to permanent meters. The locations of these new permanent meters are listed in Table 5-9.

Table 5-9. Temporary Project Meters Converted to Permanent Meters

Outfall	Meter Name
SOM007A/MWR205A	SOM007A_LEV
MWR003	RE031
MWR010	RE037
	RE036-9
MWR023	RE046-19
	RE046-30
	RE046-100
	RE046-105
	RE046-381

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

6.1 Typical Year Results from 2019 to Mid-2020

Table 6-1 provides a comparison of the 2019 and mid-2020 system conditions. Where system conditions or the model configuration changed between 2019 and mid- 2020 conditions, a brief description of the change is provided.

Table 6-1. Typical Year Performance: Comparison of 2019 and Mid-2020 System Conditions (1 of 3)

Outfall	2019 SYSTEM CONDITIONS		Mid-2020 SYSTEM CONDITIONS		Description of System/Model Change
	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	
ALEWIFE BROOK					
CAM001	1	0.02	1	0.02	
CAM002	0	0.00	0	0.00	
MWR003	3	1.60	3	0.49	Model of the Alewife Brook System was updated based on new meter data for the HGL in the ABC, and reconfiguring CAM401A. The model was also updated to include physical changes to the system constructed at SOM001A and CAM002. *See section 2.2.5.2*
CAM004	Closed	N/A	Closed	N/A	
CAM400	Closed	N/A	Closed	N/A	
CAM401A	10	3.59	16	2.17	See description for MWR003.
CAM401B	5	0.73	4	0.53	
SOM001A	6	3.60	8	4.51	
SOM001	Closed	N/A	Closed	N/A	
SOM002	Closed	N/A	Closed	N/A	
SOM002A	Closed	N/A	Closed	N/A	
SOM003	Closed	N/A	Closed	N/A	
SOM004	Closed	N/A	Closed	N/A	
TOTAL		**9.54**		7.71	
UPPER MYSTIC RIVER					
SOM007A/MWR205A	6	4.95	6	4.91	
SOM006[(4)]	Closed	N/A	Closed	N/A	
SOM007	Closed	N/A	Closed	N/A	
TOTAL		**4.95**		**4.91**	
MYSTIC/CHELSEA CONFLUENCE					
MWR205 (Somerville Marginal Facility)	39	109.63	30	101.74	Model was updated to reflect change implemented to gate operation. *See section 2.2.2*
BOS013	10	0.74	8	0.37	Model was updated with new information from East Boston Sewer Separation program. *See section 2.2.1*
BOS014	8	1.45	8	1.44	
BOS015	Closed	N/A	Closed	N/A	
BOS017	6	0.32	6	0.32	
CHE002	Closed	N/A	Closed	N/A	
CHE003	0	0	0	0.00	
CHE004	7	1.01	7	1.01	
CHE008	11	3.81	11	3.81	
TOTAL		**116.96**		**108.69**	

Table 6-1. Typical Year Performance: Comparison of 2019 and Mid-2020 System Conditions (2 of 3)

Outfall	2019 SYSTEM CONDITIONS		Mid-2020 SYSTEM CONDITIONS		Description of System/Model Change
	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	
UPPER INNER HARBOR					
BOS009	10	0.70	10	0.70	
BOS010	7	0.77	7	0.77	
BOS012	13	1.34	13	1.34	
BOS019	1	0.09	1	0.09	
BOS050	Closed	N/A	Closed	N/A	
BOS052	Closed	N/A	Closed	N/A	
BOS057	2	1.37	2	1.43	Model was updated to incorporate BOS070 sediment and maintenance weir removal. *See section 2.2.4*
BOS058	Closed	N/A	Closed	N/A	
BOS060	2	0.17	2	0.17	
MWR203 (Prison Point)	17	241.71	17	242.90	
TOTAL		**246.15**		**247.39**	
LOWER INNER HARBOR					
BOS003	9	6.13	9	6.13	
BOS004	2	0.06	2	0.06	
BOS005	0	0.00	0	0.00	
BOS006	Closed	N/A	Closed	N/A	
BOS007	Closed	N/A	Closed	N/A	
TOTAL		**6.19**		**6.19**	
CONSTITUTION BEACH					
MWR207	Closed	N/A	Closed	N/A	
TOTAL		**N/A**		**N/A**	
FORT POINT CHANNEL					
BOS062	4	0.97	4	0.98	
BOS064	0	0.00	1	0.02	Model was updated to incorporate BOS070 sediment removal. *See section 2.2.4*
BOS065	3	0.71	3	0.91	
BOS068	0	0.00	0	0.00	
BOS070					
BOS070/DBC	7	6.21	7	5.90	See comment for BOS064/065
MWR215 (Union Park)	10	26.66	10	26.65	
BOS070/RCC	0	0.00	0	0.00	
BOS072	Closed	N/A	Closed	N/A	
BOS073	0	0.00	0	0.00	
TOTAL		**34.55**		**34.45**	
RESERVED CHANNEL					
BOS076	2	0.22	2	0.21	
BOS078	0	0.00	0	0.00	
BOS079	0	0.00	0	0.00	
BOS080	0	0.00	0	0.00	
TOTAL		**0.22**		**0.21**	
NORTHERN DORCHESTER BAY					
BOS081	0 / 25 year	N/A	0 / 25 year	N/A	
BOS082	0 / 25 year	N/A	0 / 25 year	N/A	
BOS083	Closed	N/A	0 / 25 year	N/A	
BOS084	0 / 25 year	N/A	0 / 25 year	N/A	
BOS085	0 / 25 year	N/A	0 / 25 year	N/A	
BOS086	0 / 25 year	N/A	0 / 25 year	N/A	
BOS087	Closed	N/A	Closed	N/A	
TOTAL		**0.00**		**0.00**	

Table 6-1. Typical Year Performance: Comparison of 2019 and Mid-2020 System Conditions (3 of 3)

Outfall	2019 SYSTEM CONDITIONS		Mid-2020 SYSTEM CONDITIONS		Description of System/Model Change
	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	
SOUTHERN DORCHESTER BAY					
BOS088	Closed	N/A	Closed	N/A	
BOS089 (Fox Pt.)	Closed	N/A	Closed	N/A	
BOS090 (Commercial Pt.)	Closed	N/A	Closed	N/A	
TOTAL		**0.00**		**0.00**	
UPPER CHARLES					
BOS032	Closed	N/A	Closed	N/A	
BOS033	Closed	N/A	Closed	N/A	
CAM005	8	0.73	8	0.73	
CAM007	1	0.82	2	0.42	Small change may be attributed to model's numerical solution
CAM009	Closed	N/A	Closed	N/A	
CAM011	Closed	N/A	Closed	N/A	
TOTAL		**1.55**		**1.15**	
LOWER CHARLES					
BOS028	Closed	N/A	Closed	N/A	
BOS042	Closed	N/A	Closed	N/A	
BOS049	Closed	N/A	Closed	N/A	
CAM017	0	0.00	0	0.00	
MWR010	0	0.00	0	0.00	
MWR018	2	1.92	2	1.93	
MWR019	2	0.56	2	0.56	
MWR020	2	0.32	2	0.31	
MWR021	Closed	N/A	Closed	N/A	
MWR022	Closed	N/A	Closed	N/A	
MWR201 (Cottage Farm)	4	12.36	4	12.64	
MWR023	1	0.14	1	0.14	
SOM010	Closed	N/A	Closed	N/A	
TOTAL		**15.30**		**15.58**	
NEPONSET RIVER					
BOS093	Closed	N/A	Closed	N/A	
BOS095	Closed	N/A	Closed	N/A	
TOTAL		**0.00**		**0.00**	
BACK BAY FENS					
BOS046	0	0.00	0	0.00	
TOTAL		**0.00**		**0.00**	
Total Treated		**390**		**384**	
Total Untreated		**40**		**42**	
GRAND TOTAL		**430**		**426**	

(1) Grey shading indicates locations where system conditions or the model configuration changed between 2019 and mid-2020 conditions, a brief description of the change is provided.

6.2 Updated System Performance for Mid-2020 System Conditions

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.

MWRA used the mid-2020 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 6-2 on the following page along with the LTCP Typical Year levels of control and the system conditions in 1992 when MWRA commenced planning for the LTCP. In Table 6-2, Mid-2020 System Conditions activations or volumes that exceed the LTCP goals are shaded in grey.

6.3 Closed CSO Outfalls

Table 6-2 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 6-2 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 6-2 shows that 35 of the 84 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.

6.4 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.

Table 6-2. Typical Year Performance: Baseline 1992, Current (Mid-2020) and LTCP (1 of 3)

Outfall	1992 SYSTEM CONDITIONS [1]		Mid-2020 SYSTEM CONDITIONS[2]		LONG TERM CONTROL PLAN [3]	
	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	0.49	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	16	2.17	5	1.61
CAM401B			4	0.53	7	2.15
SOM001A	10	11.93	8	4.51	3	1.67
SOM001	0	0.00	Closed	N/A	Closed	N/A
SOM002	0	0.00	Closed	N/A	N/I [4]	N/I [4]
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**		**7.71**		**7.29**
UPPER MYSTIC RIVER						
SOM007A/MWR205A	9	7.61	6	4.91	3	3.48
SOM006	0	0.00	Closed	N/A	N/I [4]	N/I [4]
SOM007	3	0.06	Closed	N/A	Closed	N/A
TOTAL		**7.67**		**4.91**		**3.48**
MYSTIC/CHELSEA CONFLUENCE						
MWR205 (Somerville Marginal Facility)	33	120.37	30	101.74	39	60.58
BOS013	36	4.40	8	0.37	4	0.54
BOS014	20	4.91	8	1.44	0	0.00
BOS015	76	2.76	Closed	N/A	Closed	N/A
BOS017	49	7.16	6	0.32	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	7	1.01	3	0.32
CHE008	35	22.35	11	3.81	0	0.00
TOTAL		**185.96**		**108.69**		**61.72**
UPPER INNER HARBOR						
BOS009	34	3.60	10	0.70	5	0.59
BOS010	48	11.83	7	0.77	4	0.72
BOS012	41	7.90	13	1.34	5	0.72
BOS019	107	4.48	1	0.09	2	0.58
BOS050	No Data			Closed	N/A	N/A
BOS052	0	0.00	Closed	N/A	Closed	N/A
BOS057	33	14.71	2	1.43	1	0.43
BOS058	17	0.29	Closed	N/A	Closed	N/A
BOS060	64	2.90	2	0.17	0	0.00
MWR203 (Prison Point)	28	261.85	17	242.90	17	243.00
TOTAL		**307.56**		**247.39**		**246.04**

Table 6-2. Typical Year Performance: Baseline 1992, Current (Mid-2020) and LTCP (2 of 3)

Outfall	1992 SYSTEM CONDITIONS [1]		Mid-2020 SYSTEM CONDITIONS [2]		LONG TERM CONTROL PLAN [3]	
	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)
LOWER INNER HARBOR						
BOS003	28	18.09	9	6.13	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**		6.19		**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	4	0.98	1	0.01
BOS064	14	0.99	1	0.02	0	0.00
BOS065	11	3.08	3	0.91	1	0.06
BOS068	4	0.62	0	0.00	0	0.00
BOS070	4	281.62				
BOS070/DBC			7	5.90	3	2.19
MWR215 (Union Park)			10	26.65	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**		**34.45**		**73.89**
RESERVED CHANNEL						
BOS076	65	65.94	2	0.21	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**		**0.21**		**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**

Table 6-2. Typical Year Performance: Baseline 1992, Current (Mid-2020) and LTCP (3 of 3)

Outfall	1992 SYSTEM CONDITIONS (1)		Mid-2020 SYSTEM CONDITIONS(2)		LONG TERM CONTROL PLAN (3)	
	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)
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	8	0.73	3	0.84
CAM007	1	0.81	2	0.42	1	0.03
CAM009	19	0.19	Closed	N/A	2	0.01
CAM011	1	0.07	Closed	N/A	0	0.00
TOTAL		**46.06**		**1.15**		**0.88**
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	1.93	0	0.00
MWR019	2	1.32	2	0.56	0	0.00
MWR020	2	0.64	2	0.31	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)	18	214.10	4	12.64	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**		**15.58**		**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**		**384**		**381**
Total Untreated		**759**		**42**		**23**
GRAND TOTAL		**1457**		**426**		**404**

(1) 1992 System Conditions include completion of Deer Island Fast-Track Improvements, upgrades to headworks, and new Caruso and DeLauri pumping stations.
(2) Grey shading indicates model prediction is greater than LTCP value.
(3) 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").
(4) N/I: Outfall was closed by prior to 2006 and is not included in Exhibit B to the Second CSO Stipulation.

6.5 Updated CSO Typical Year Performance at Remaining CSO Outfalls

As indicated in Table 6-2, the Typical Year CSO performance based on mid-2020 System Conditions indicate substantial improvements over 1992 conditions as a result of implementing the MWRA's LTCP, as well as other actions taken by MWRA and the CSO communities to further control CSOs. A similar version of this table was previously presented in Semiannual Report No. 4 based on 2019 system conditions. As noted in Section 4.3, 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 2019 and mid-2020 system conditions. More details on the changes are provided in Section 4 above.

7. Progress Toward the Sixth Semiannual Report

MWRA plans to issue the next semiannual report (Semiannual CSO Discharge Report No. 6) in April 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 (Lower Charles River/Charles Basin and Alewife Brook/Upper Mystic River) through September 2020.

- Use of receiving water quality models of the Charles River and the Alewife Brook/Upper Mystic River to:
    - Assess the relative impact of CSO 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.

- Recommendation of further short-term and long-term CSO mitigation measures from site-specific evaluations

Appendix A Meter Data Scattergraphs

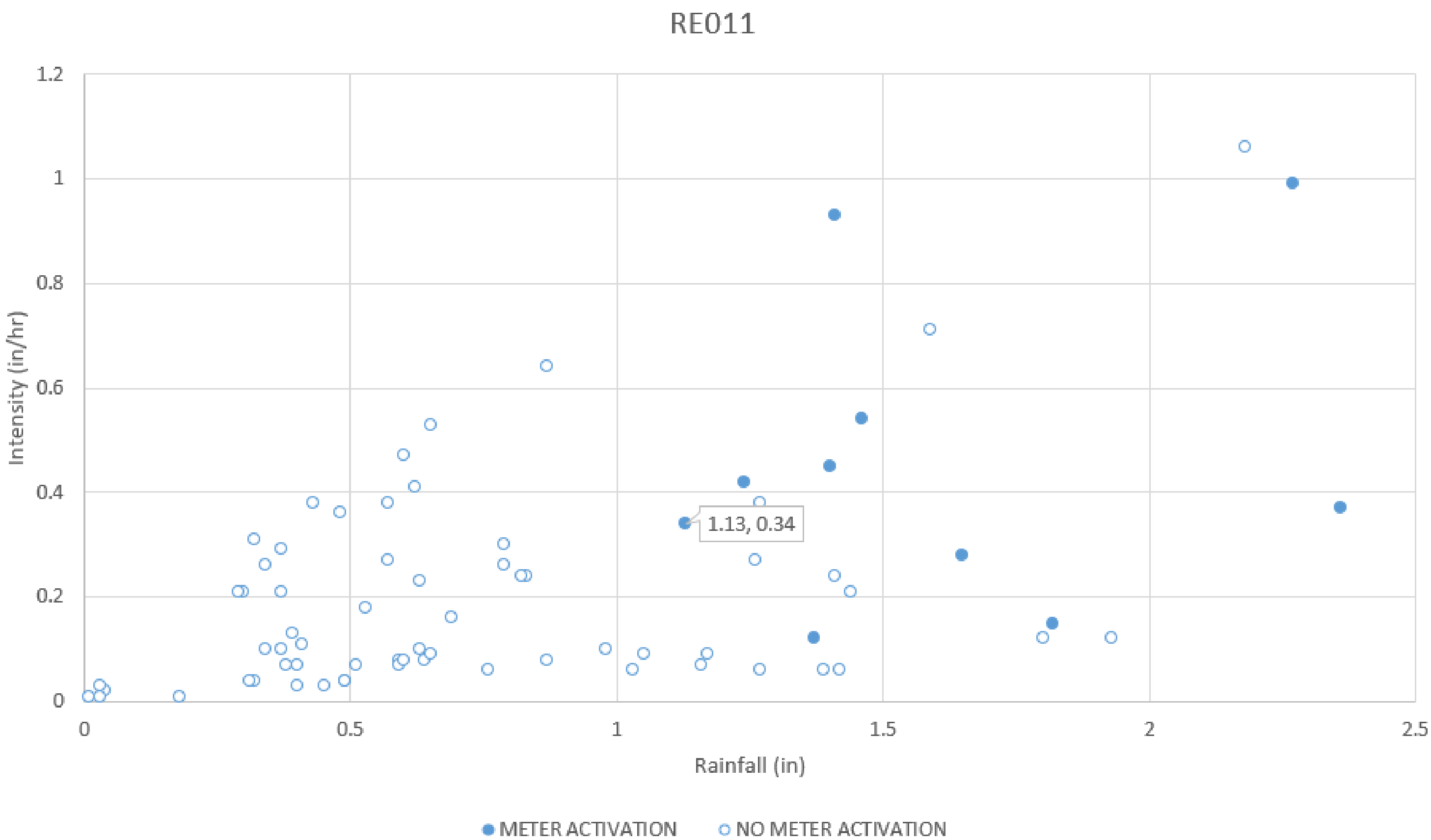
Contents

The scattergraphs cover the period of April 15, 2018 to June 30, 2020. In locations where the meter was removed on March 1, 2019 the scattergraphs cover the period of April 15, 2018 to February 28, 2019.

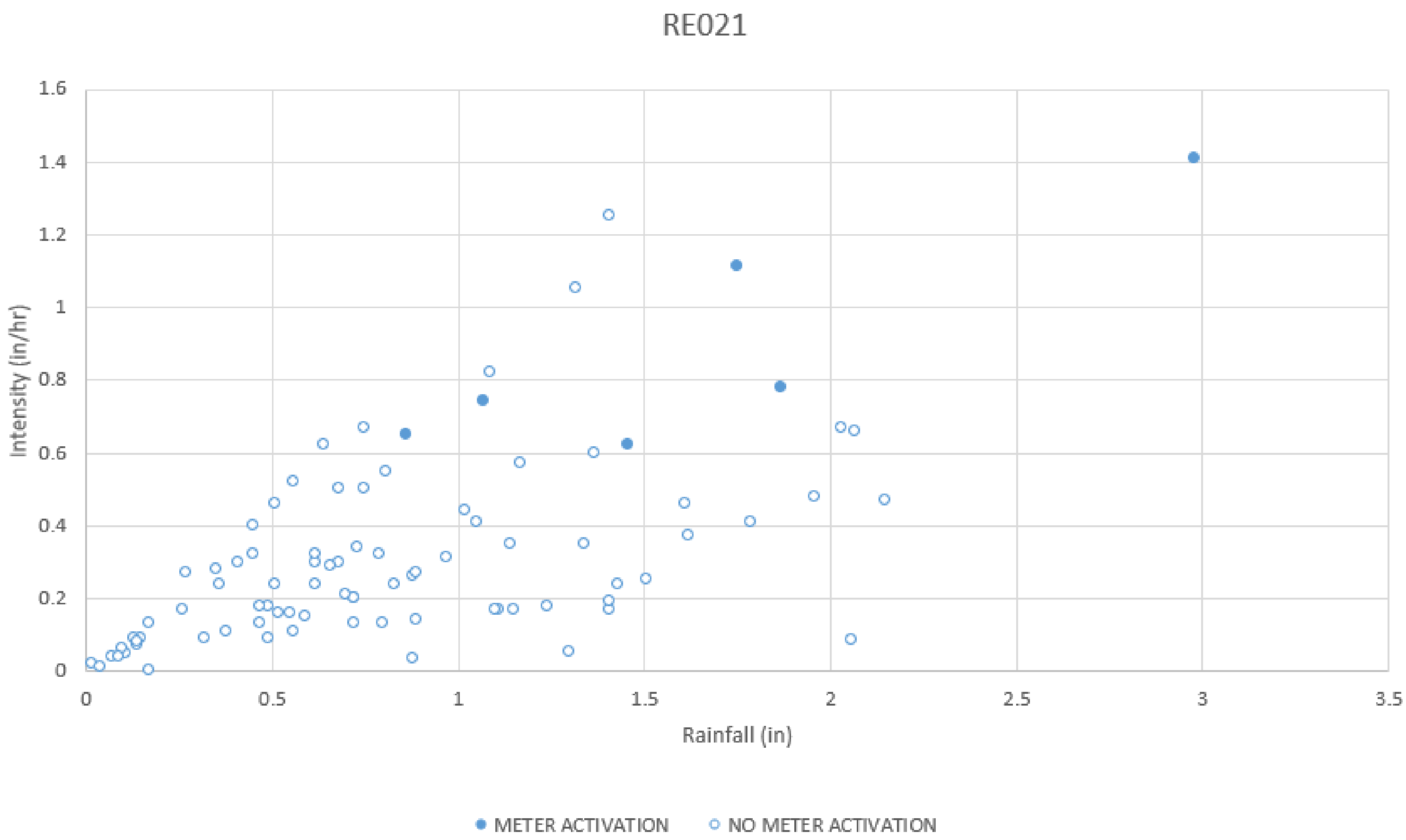
Alewife Brook

CAM001	RE-011
CAM002	RE-021
MWR003	RE-031
CAM401A	RE-401
CAM401B	RE-401B
SOM001A	RE-01A

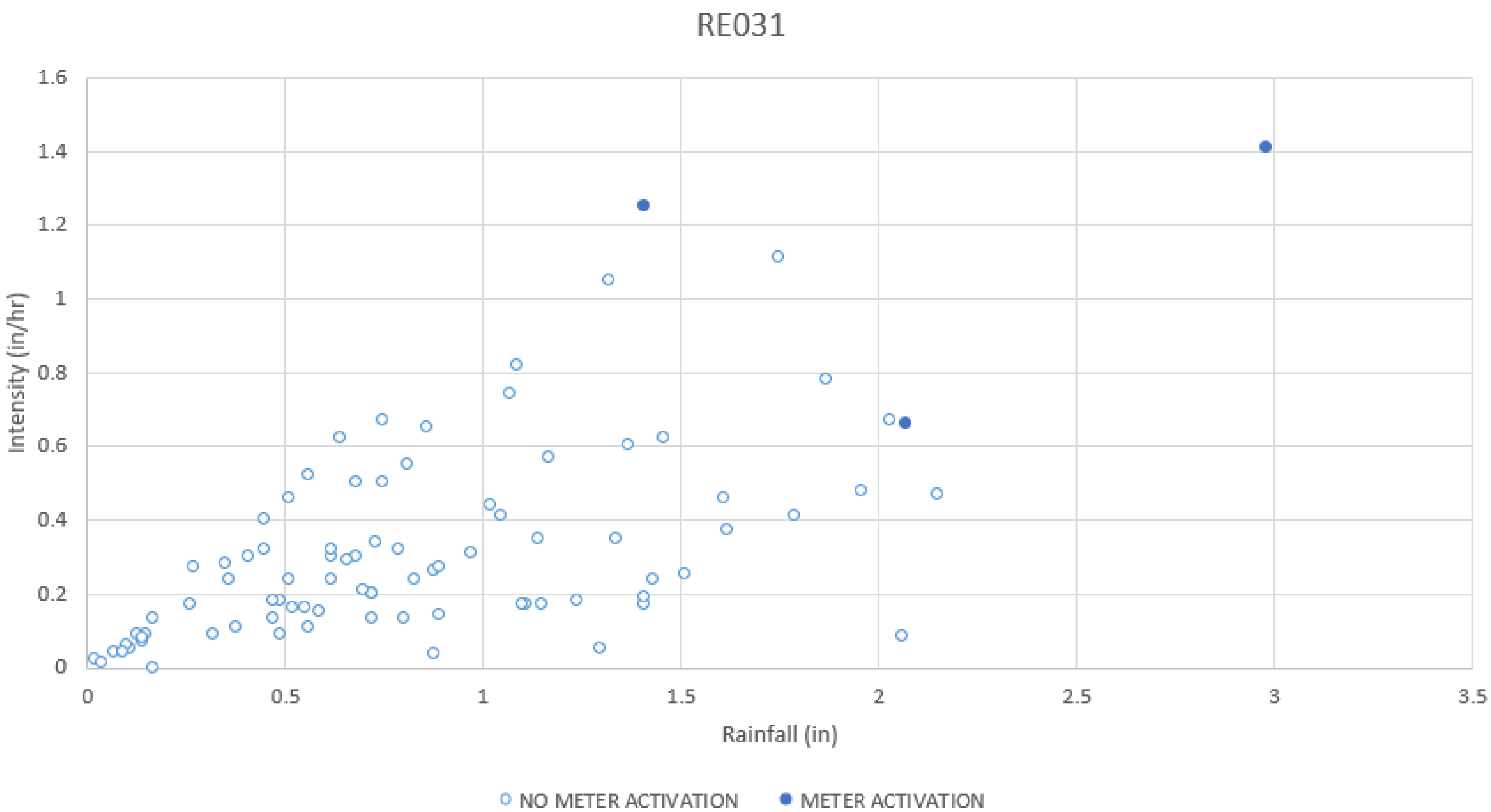
Outfall: CAM001
Regulator: RE011
Related Rain Gauge: 16



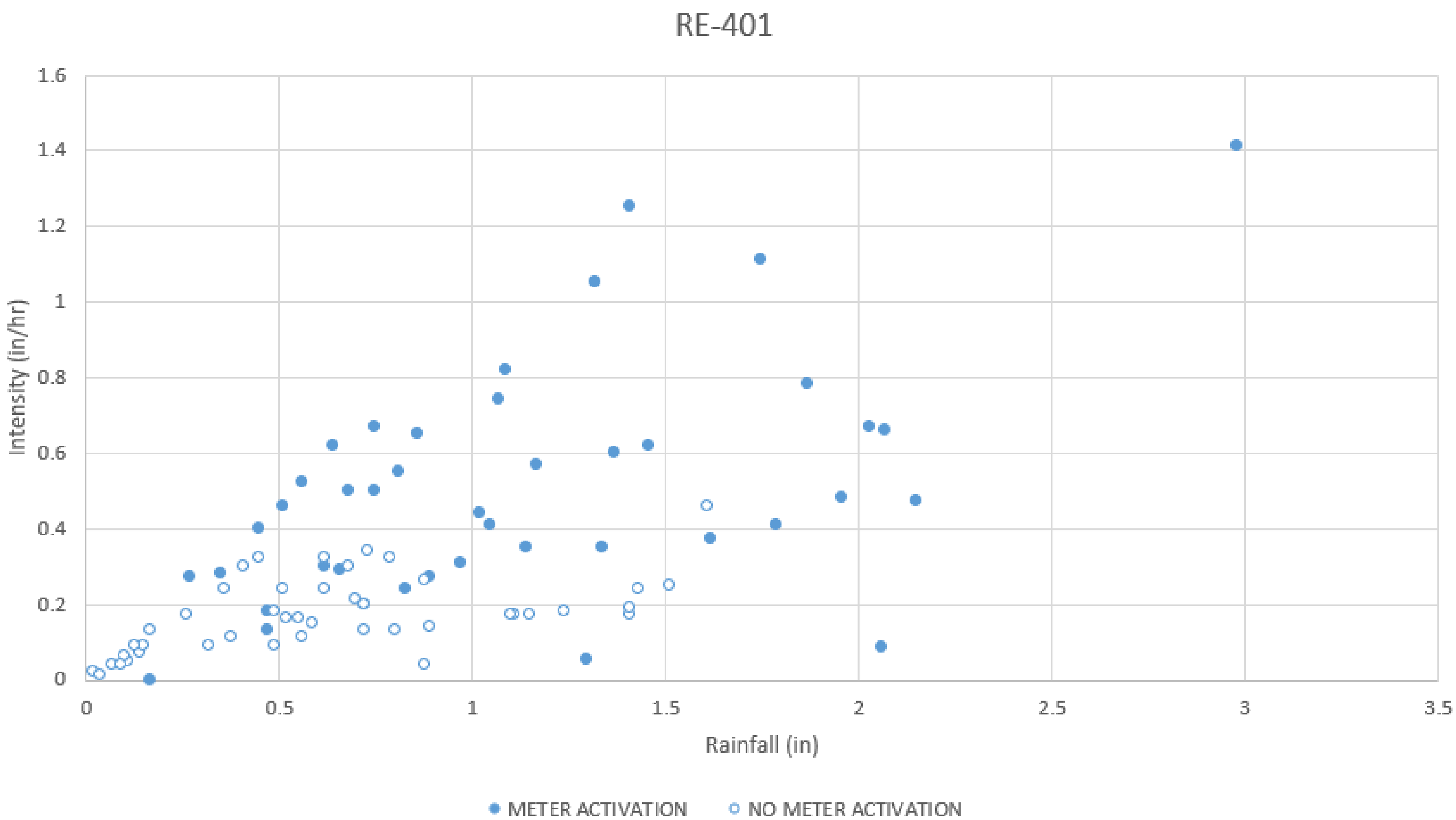
Outfall:CAM002
Regulator: RE021
Related Rain Gauge: 19



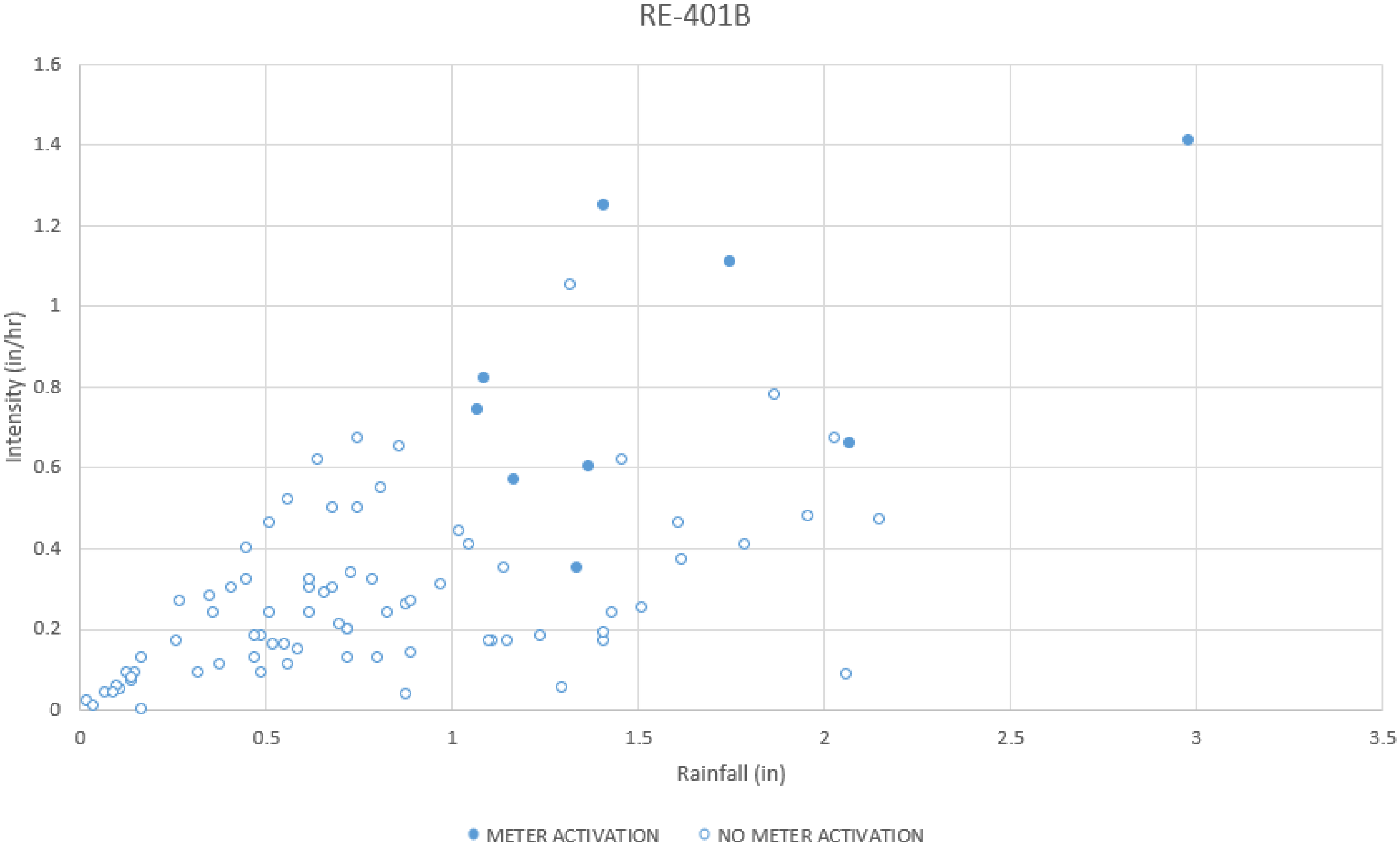
Outfall:MWR003
Regulator: RE031
Related Rain Gauge: 19



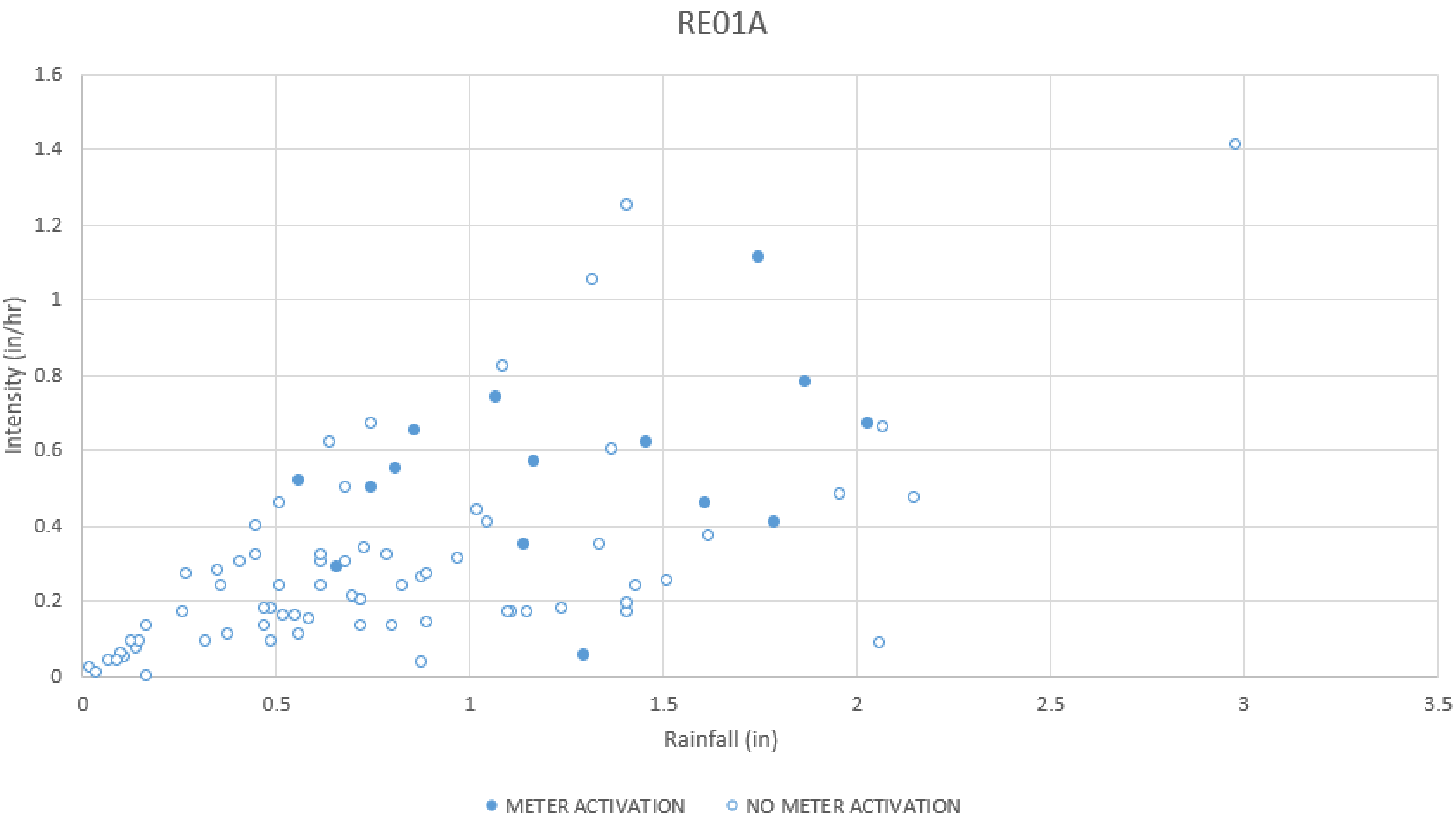
Outfall:CAM401a
Regulator: RE401
Related Rain Gauge: 19



Outfall:CAM401B
Regulator: RE401B
Related Rain Gauge: 19



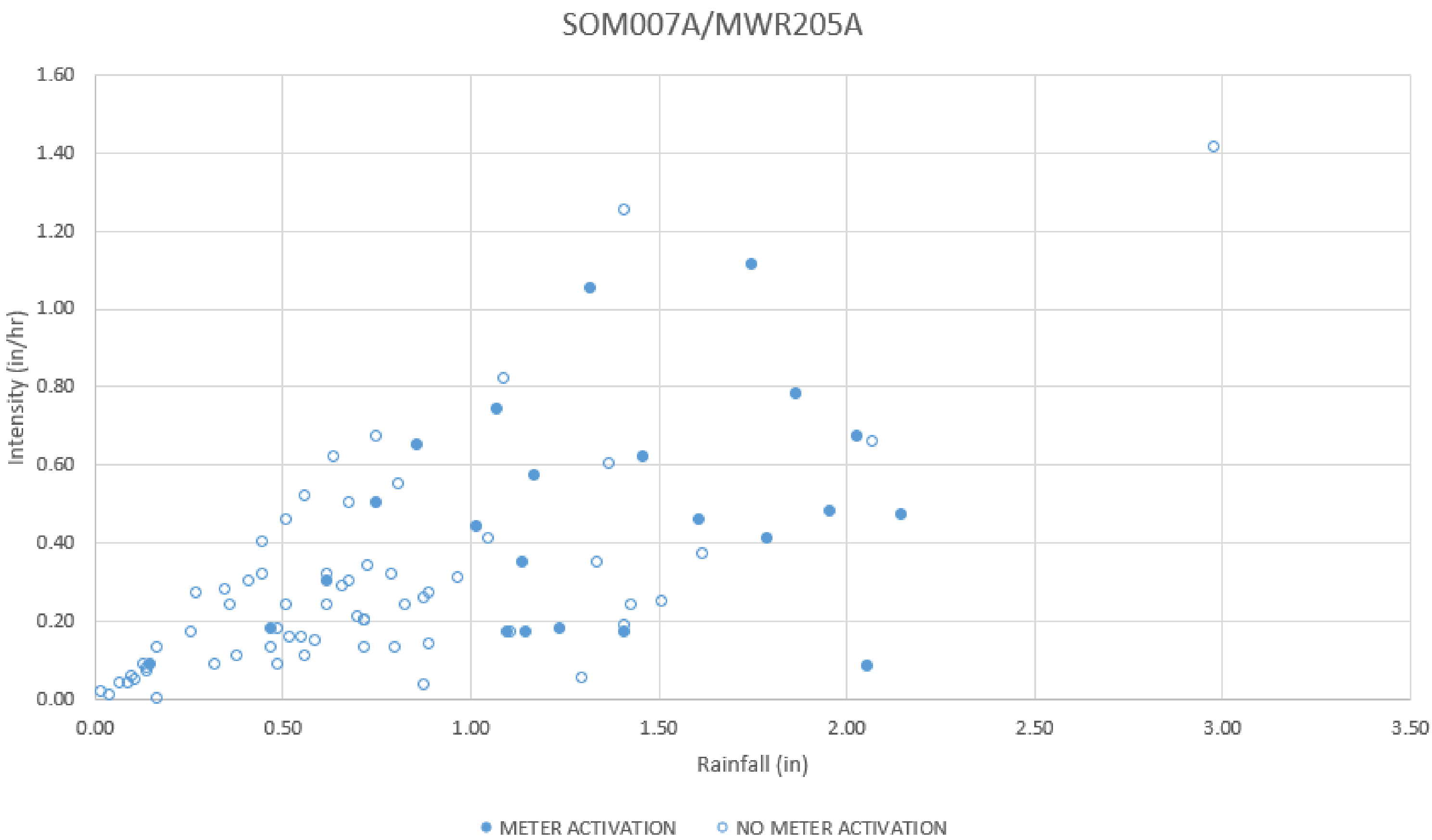
Outfall:SOM001A
Regulator: RE01A
Related Rain Gauge: 19



Upper Mystic River

SOM007/MWR205A

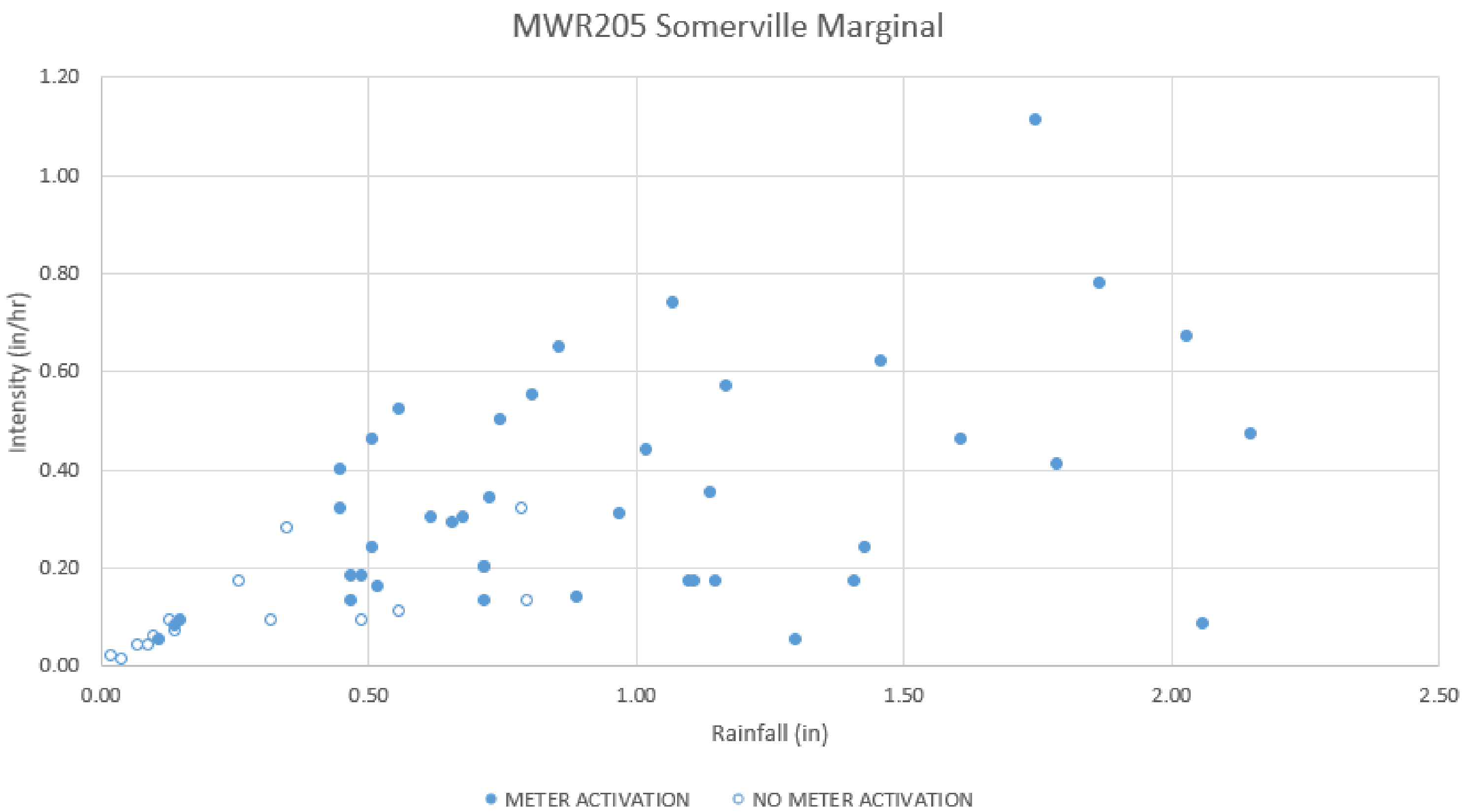
Outfall:SOM007A/MWR205A
Related Rain Gauge: 19



Mystic/Chelsea Confluence

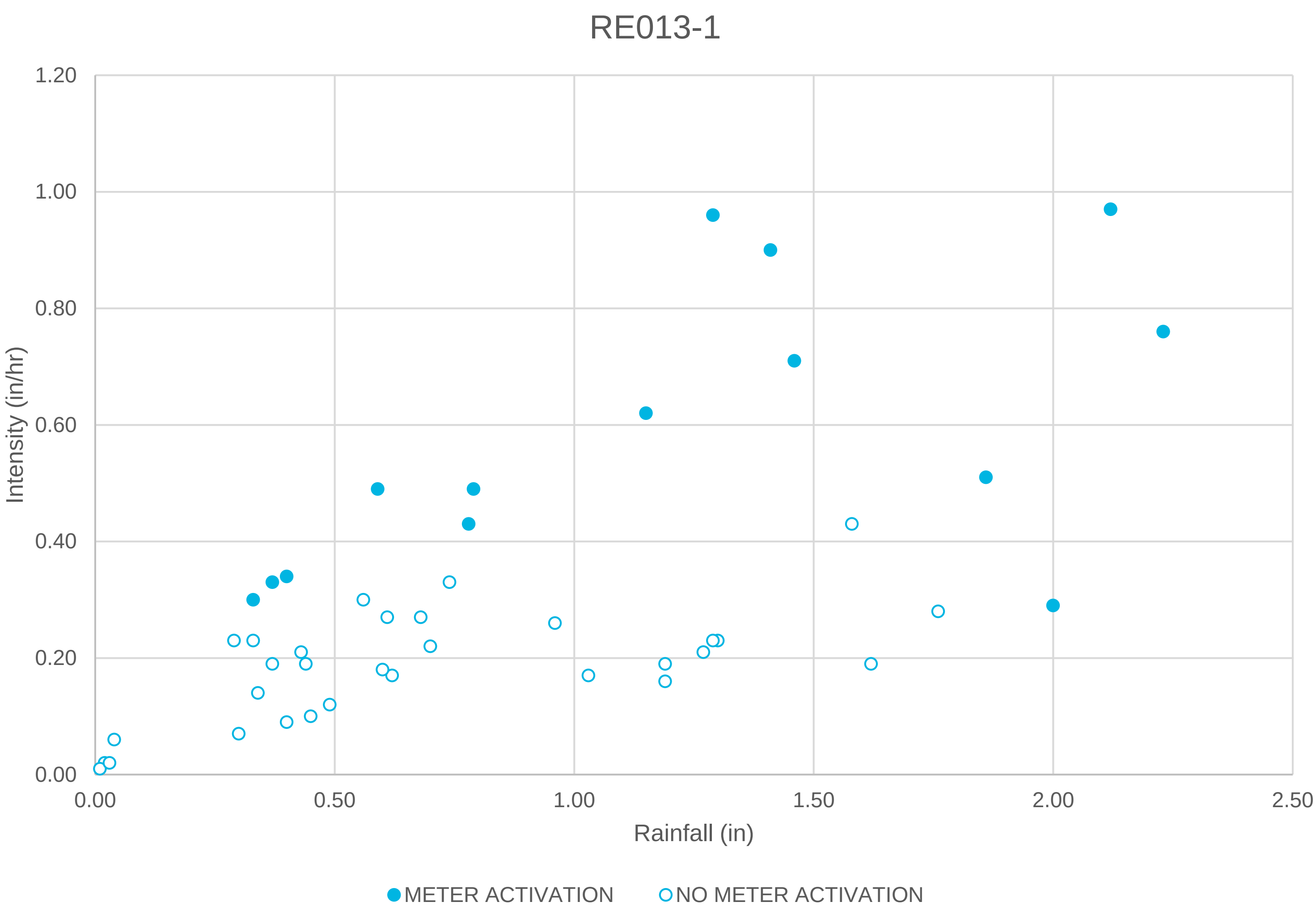
MWR205 (Somerville Marginal Facility)	
BOS013	RE013-1
BOS014	RE014-2
BOS017	RE017-3
CHE003	RE-031
CHE004	RE-041
CHE008	RE-081

Outfall:MWR205 (Somerville Marginal)
Related Rain Gauge: 19



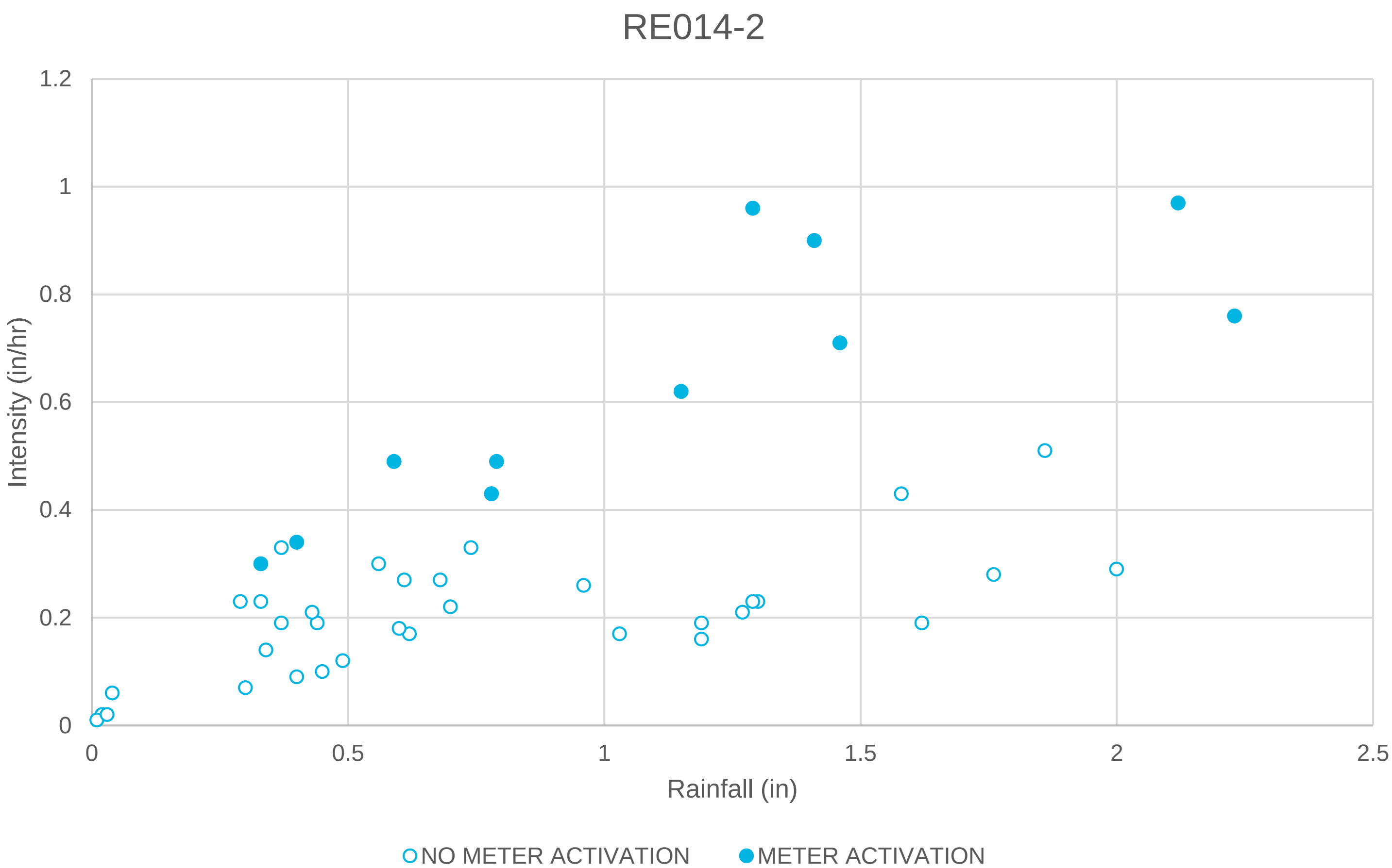
Meter activation represents an activation in which flow was discharged out of Somerville Marginal.

Outfall: BOS013
Regulator: RE013-1
Related Rain Gauge: 8



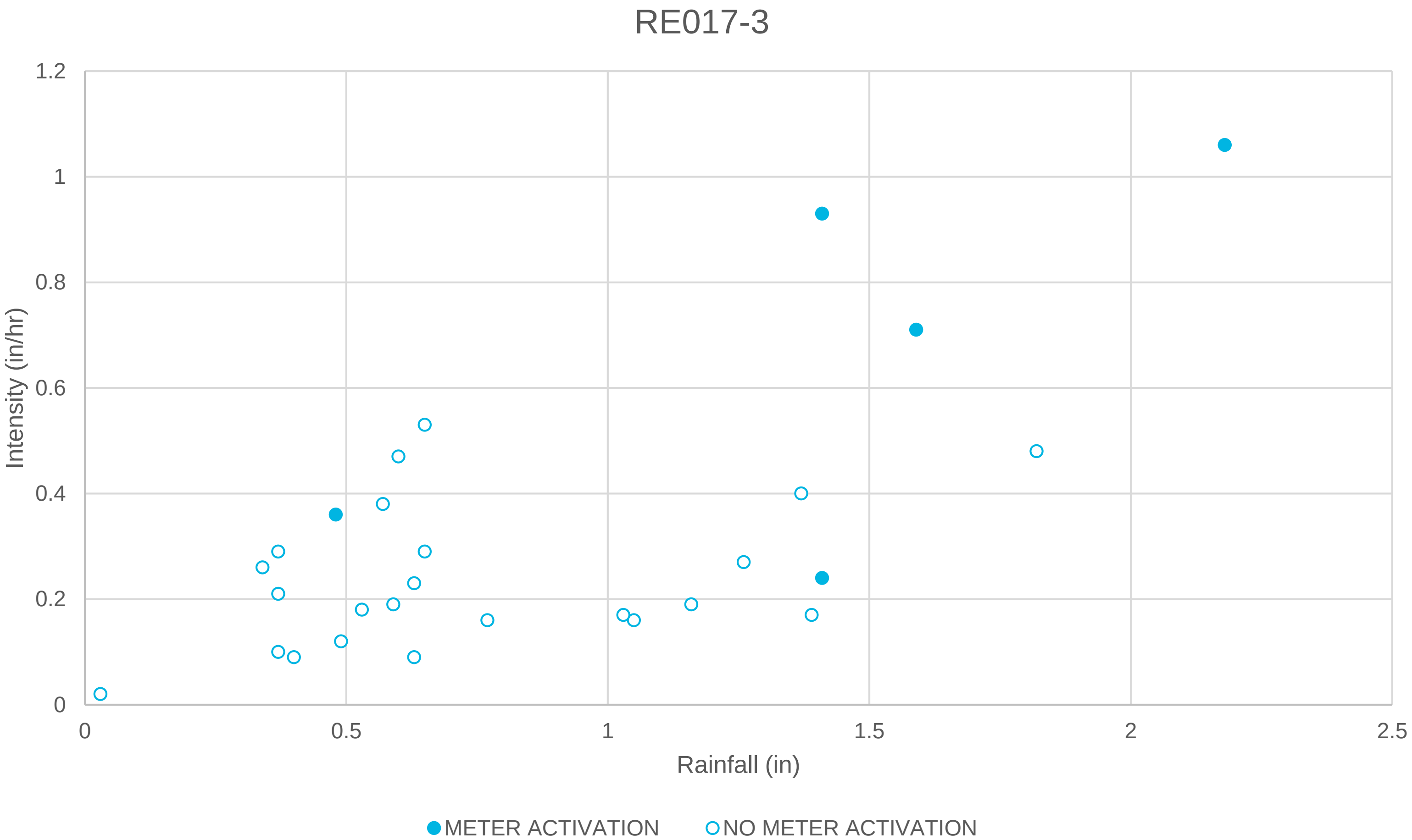
Meter was removed as of March 1, 2019. No activations were assessed following March 1, 2019.

Outfall: BOS014
Regulator: RE014-2
Related Rain Gauge: 8



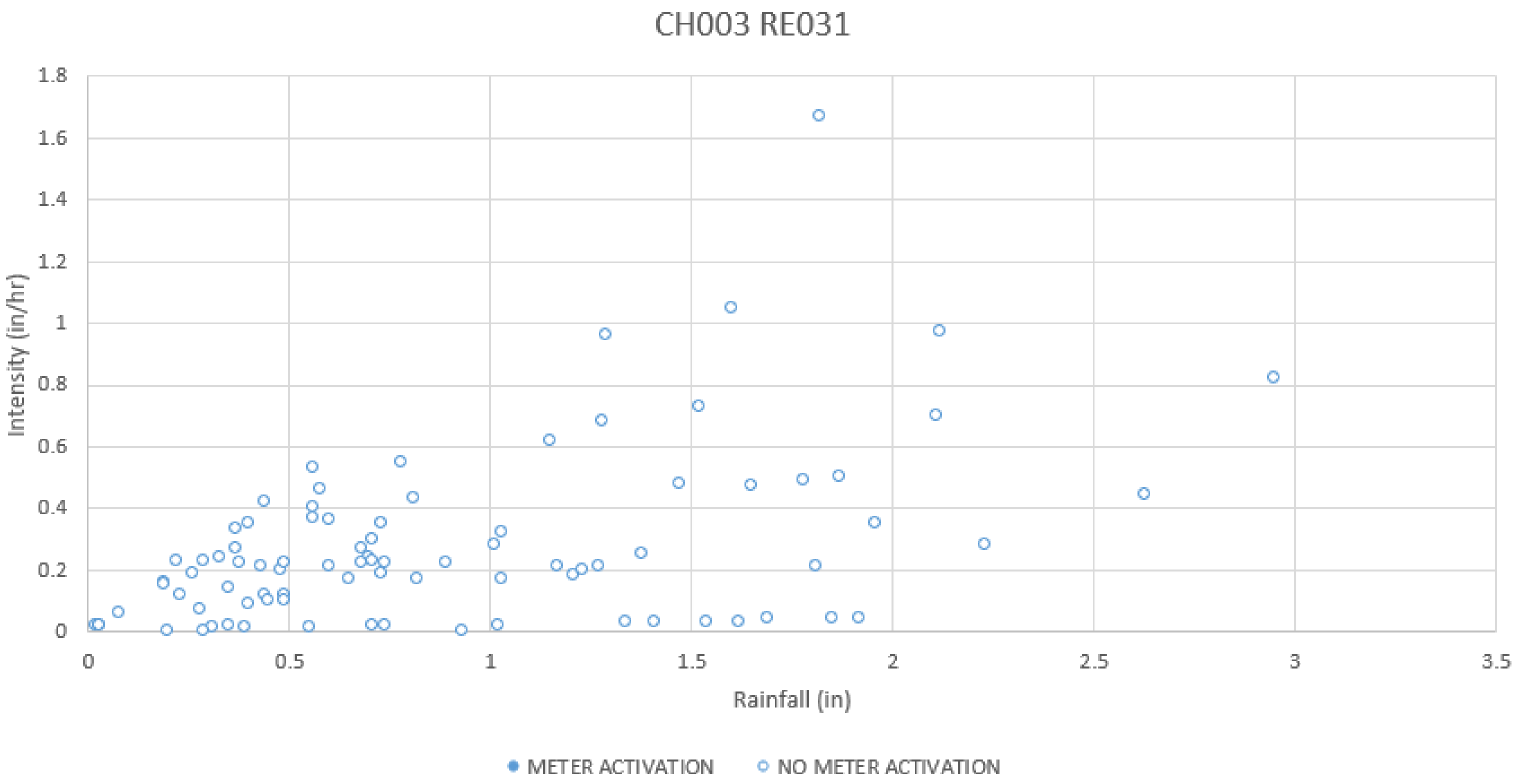
Meter was removed as of March 1, 2019. No activations were assessed following March 1, 2019.

Outfall: BOS017
Regulator: RE017-3
Related Rain Gauge: 4

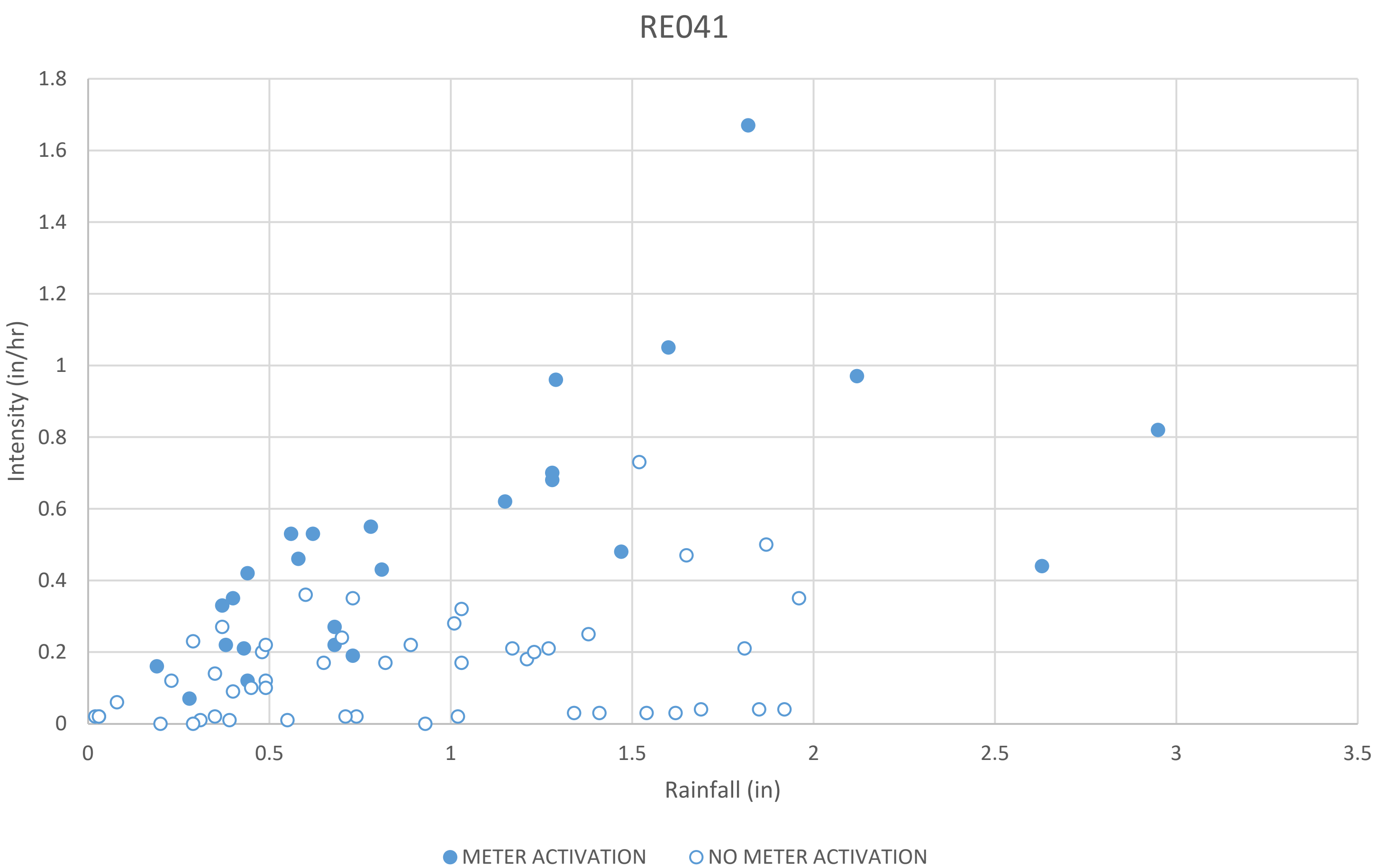


Does not include activations from April 15-July 18. After July 18 an inclinometer was added providing increased confidence in CSO activations
Meter was removed as of March 1, 2019. No activations were assessed following March 1, 2019.

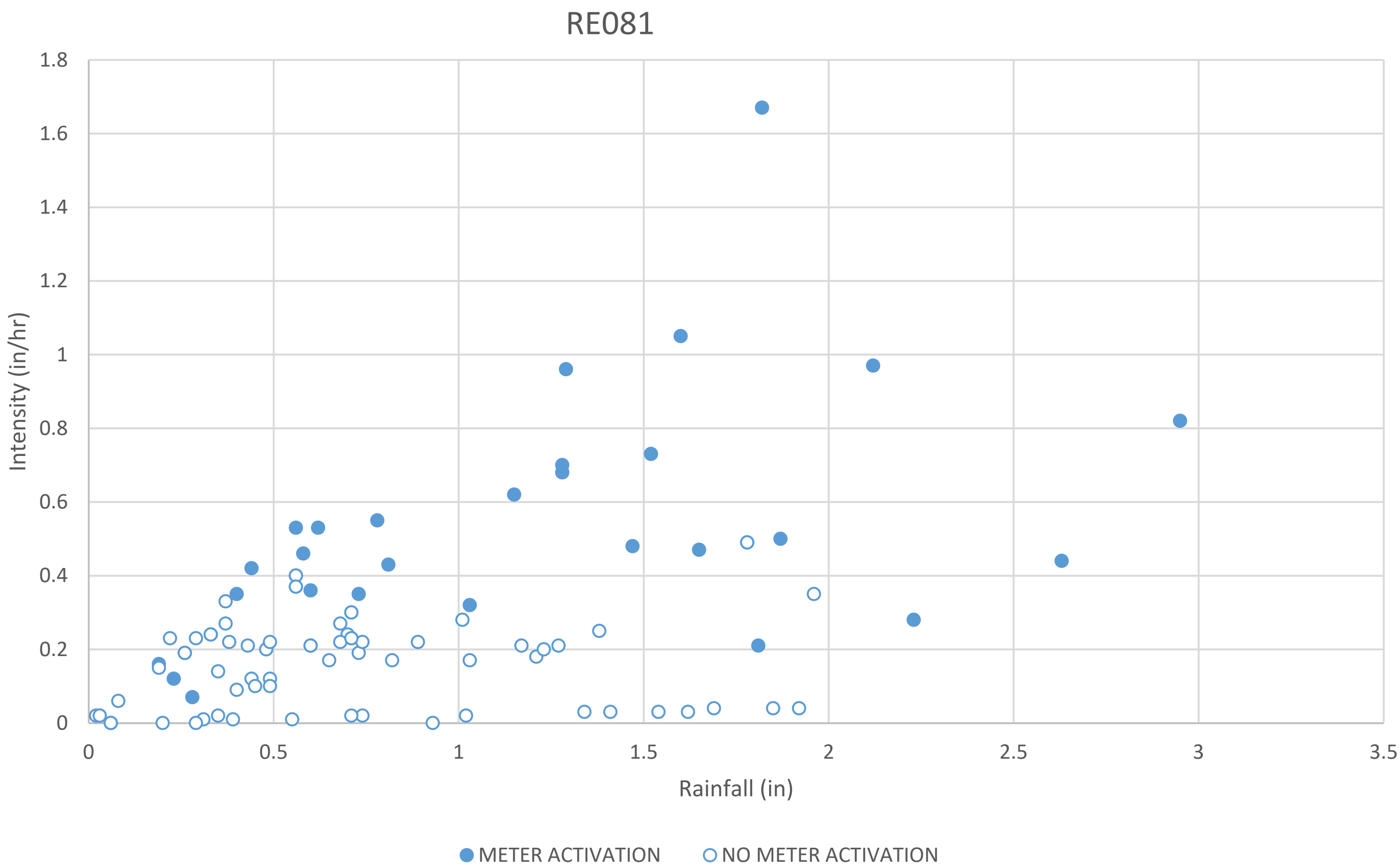
Outfall: CHE003
Regulator: RE031
Related Rain Gauge: 5



Outfall: CHE004
Regulator: RE041
Related Rain Gauge: 5



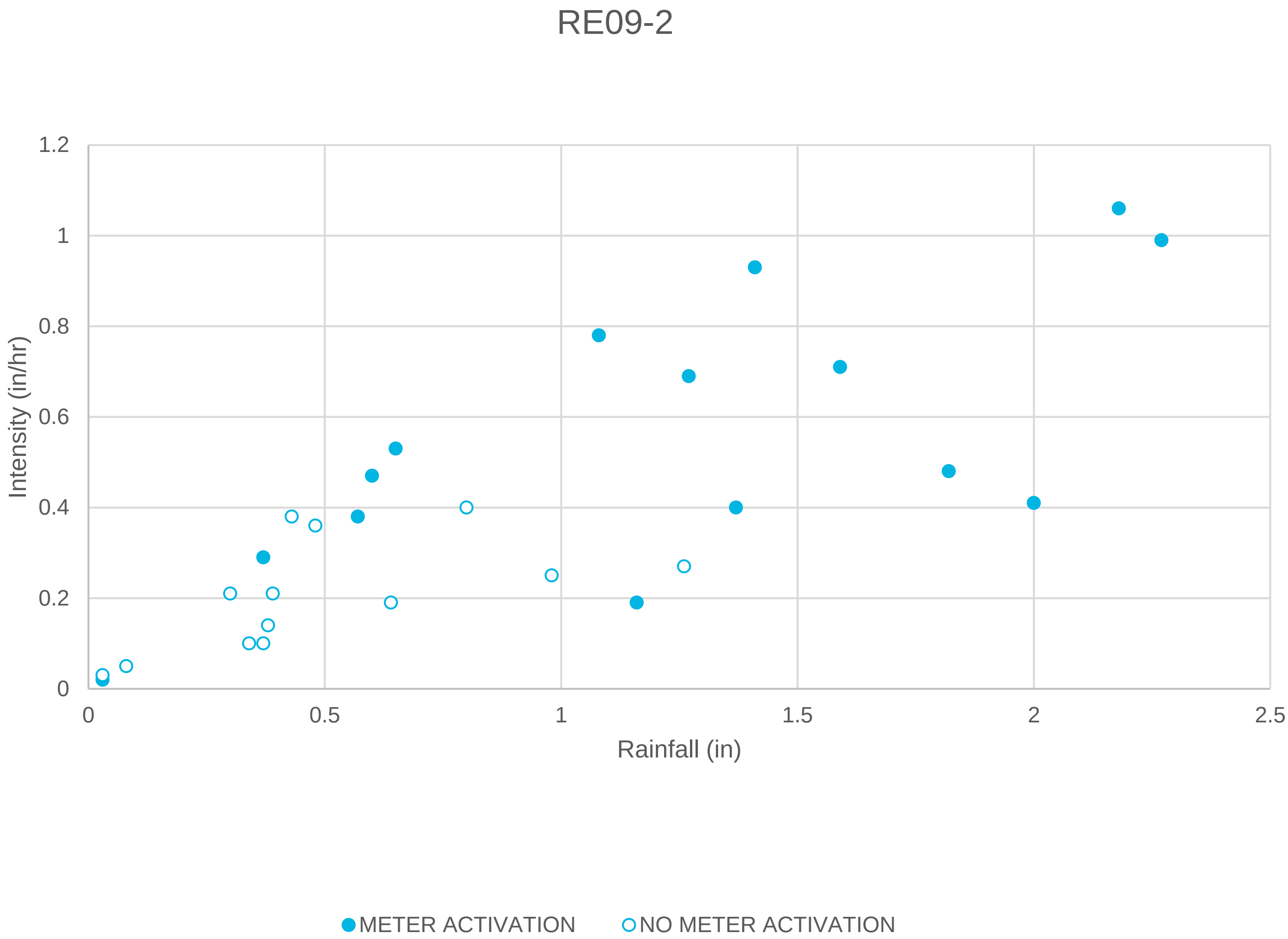
Outfall: CHE008
Regulator: RE081
Related Rain Gauge: 5



Upper Inner Harbor

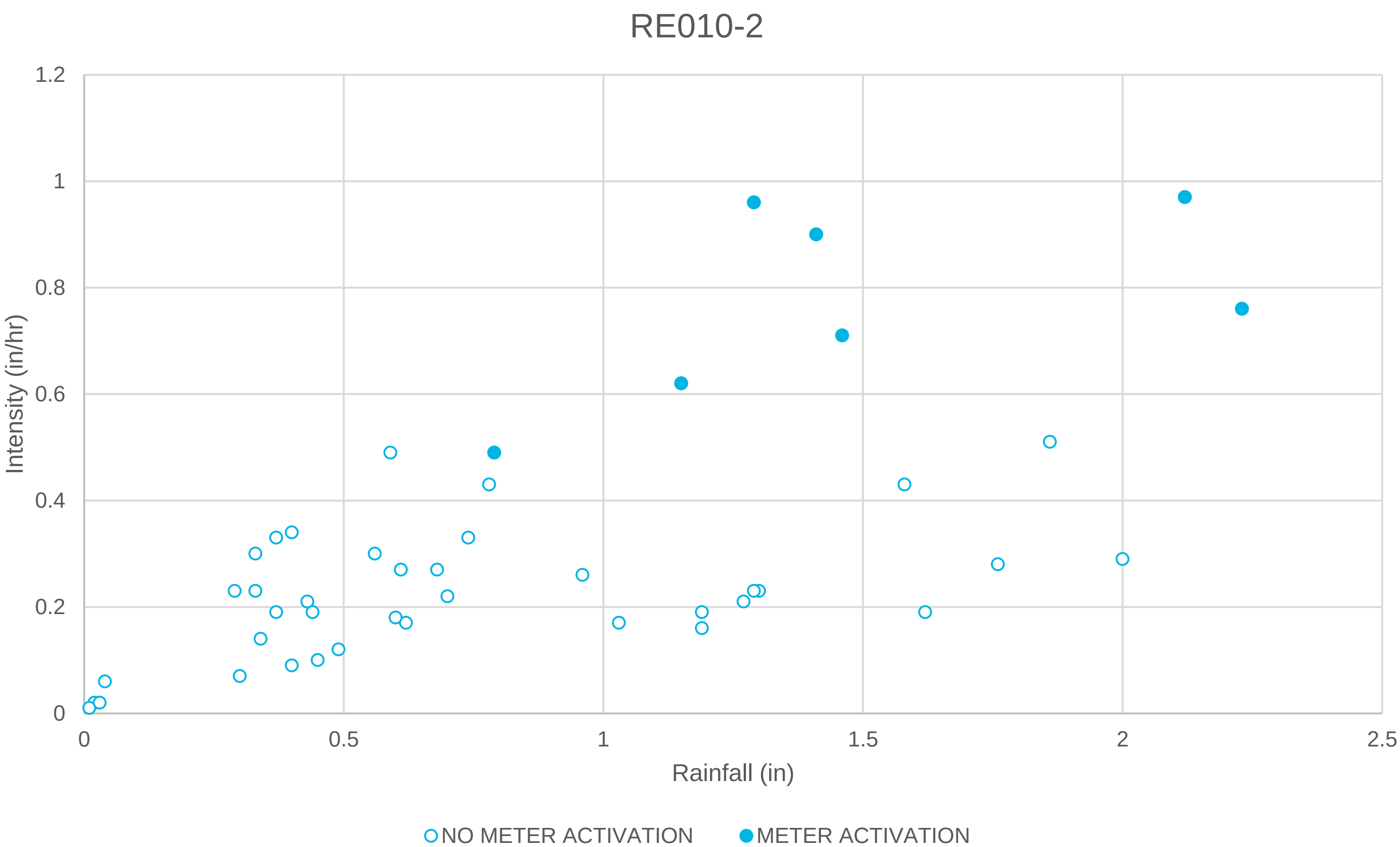
<table>
<tr><td>BOS009</td><td>RE009-2</td></tr>
<tr><td>BOS010</td><td>RE010-2</td></tr>
<tr><td>BOS012</td><td>RE012-2</td></tr>
<tr><td>BOS019</td><td>RE019-2</td></tr>
<tr><td>BOS057</td><td>RE057-6</td></tr>
<tr><td rowspan="2">BOS060</td><td>RE060-7</td></tr>
<tr><td>RE060-20</td></tr>
<tr><td colspan="2">MWR203 (Prison Point)</td></tr>
</table>

Outfall: BOS09
Regulator: RE09-2
Related Rain Gauge: 4



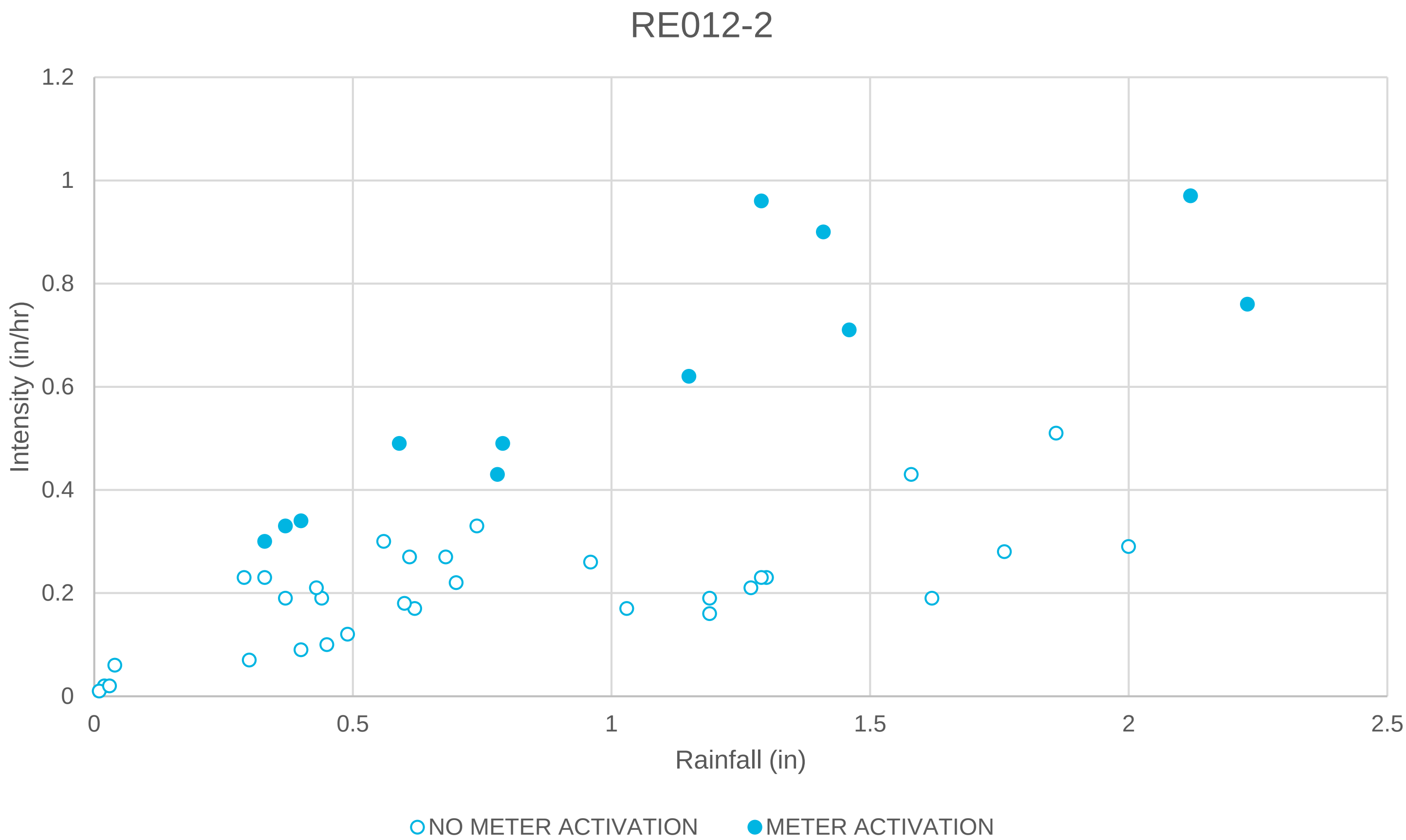
Meter was removed as of March 1, 2019. No activations were assessed following March 1, 2019.

Outfall: BOS010
Regulator: RE010-2
Related Rain Gauge: 8



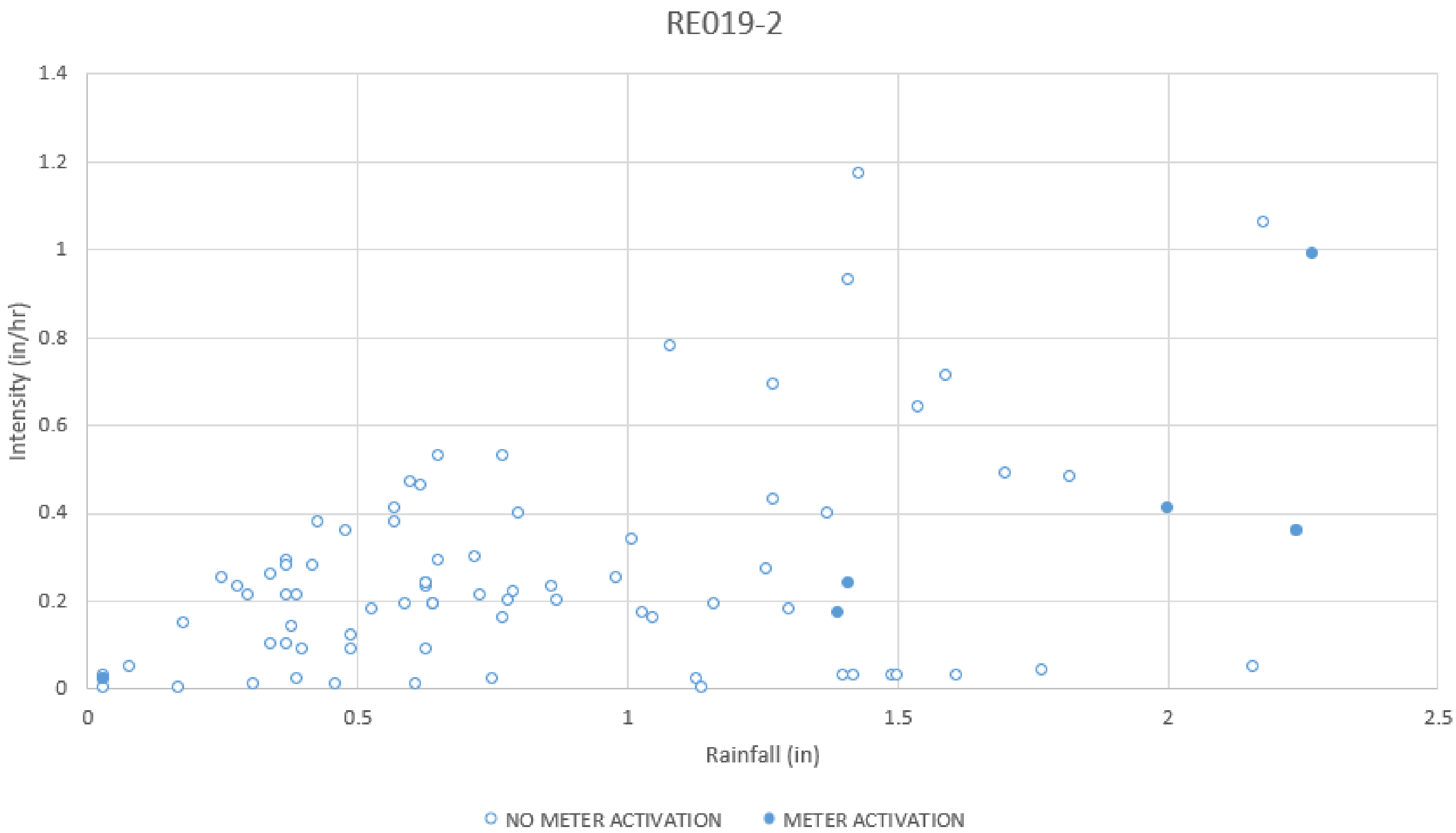
Meter was removed as of March 1, 2019. No activations were assessed following March 1, 2019.

Outfall: BOS012
Regulator: RE012-2
Related Rain Gauge: 8

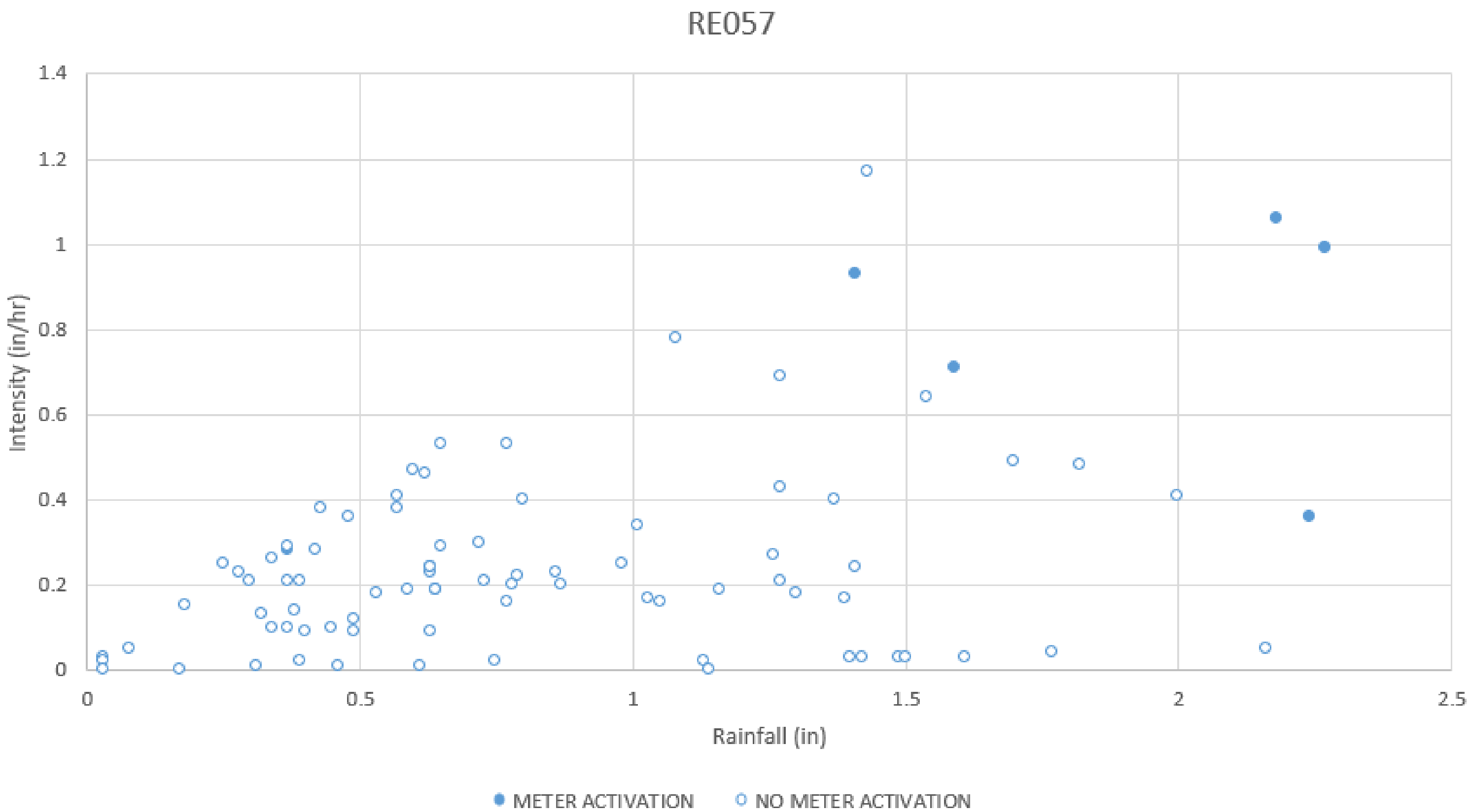


Meter was removed as of March 1, 2019. No activations were assessed following March 1, 2019.

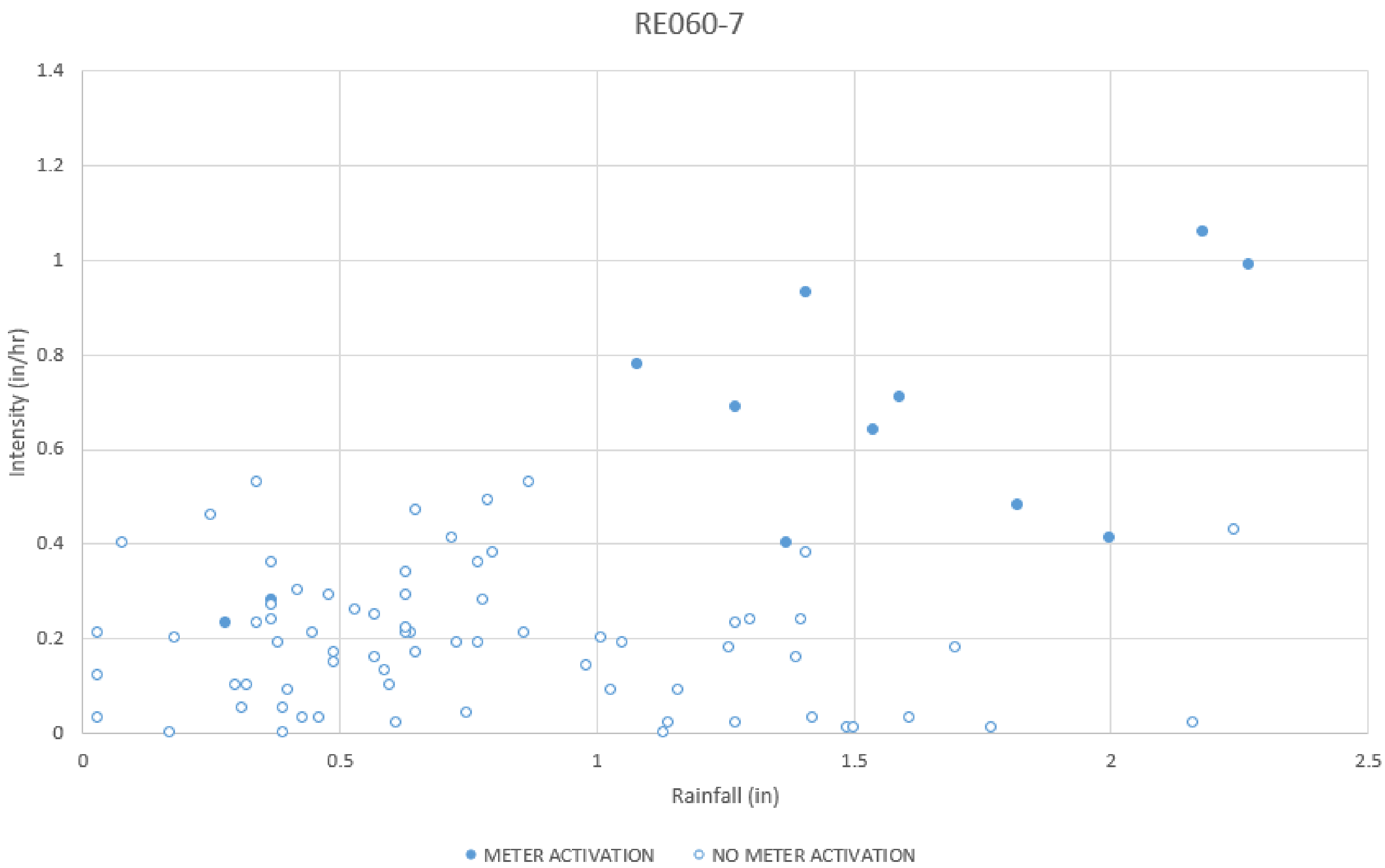
Outfall: BOS019
Regulator: RE019-2
Related Rain Gauge: 4



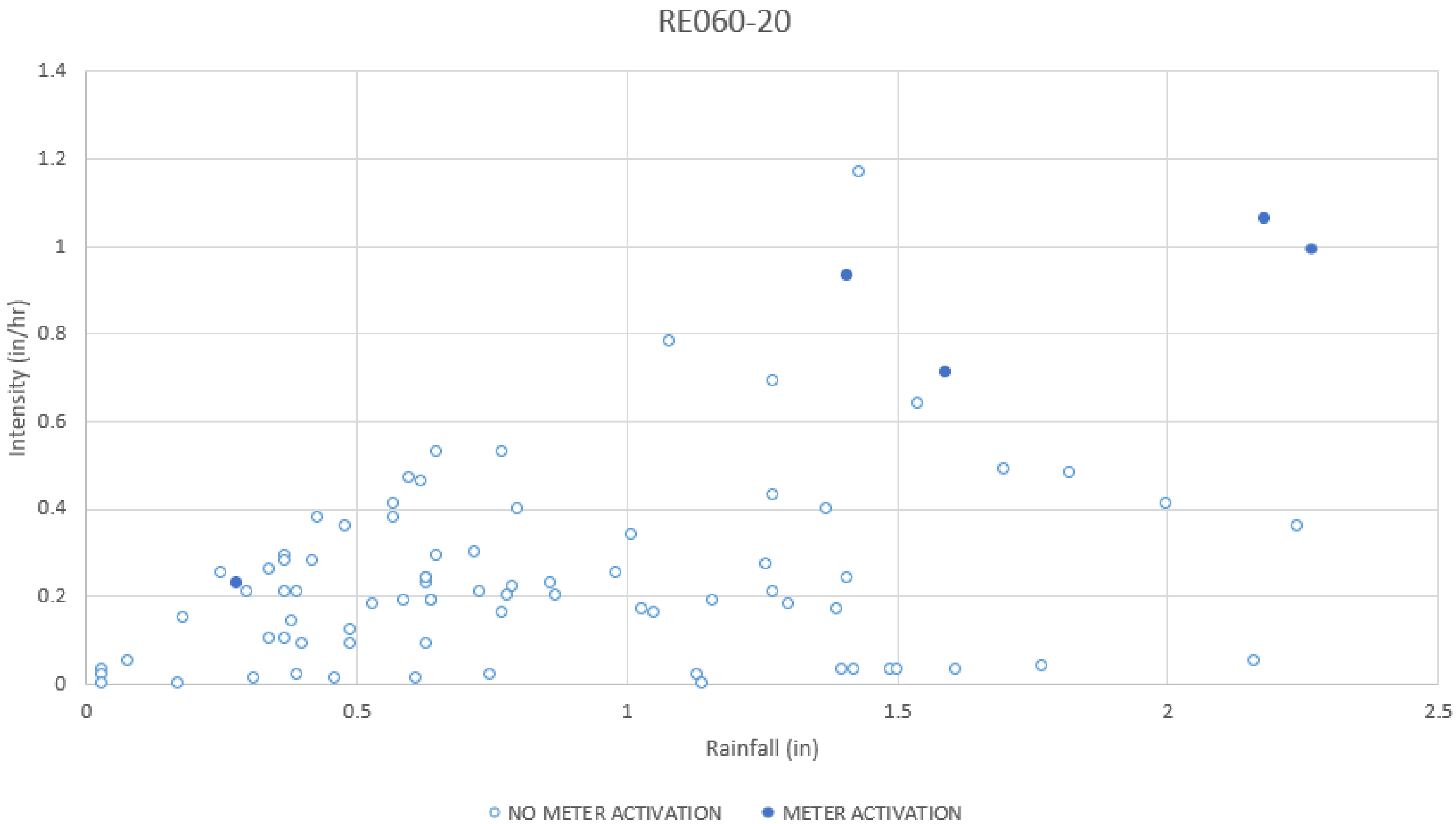
Outfall: BOS057
Regulator: RE057
Related Rain Gauge: 4



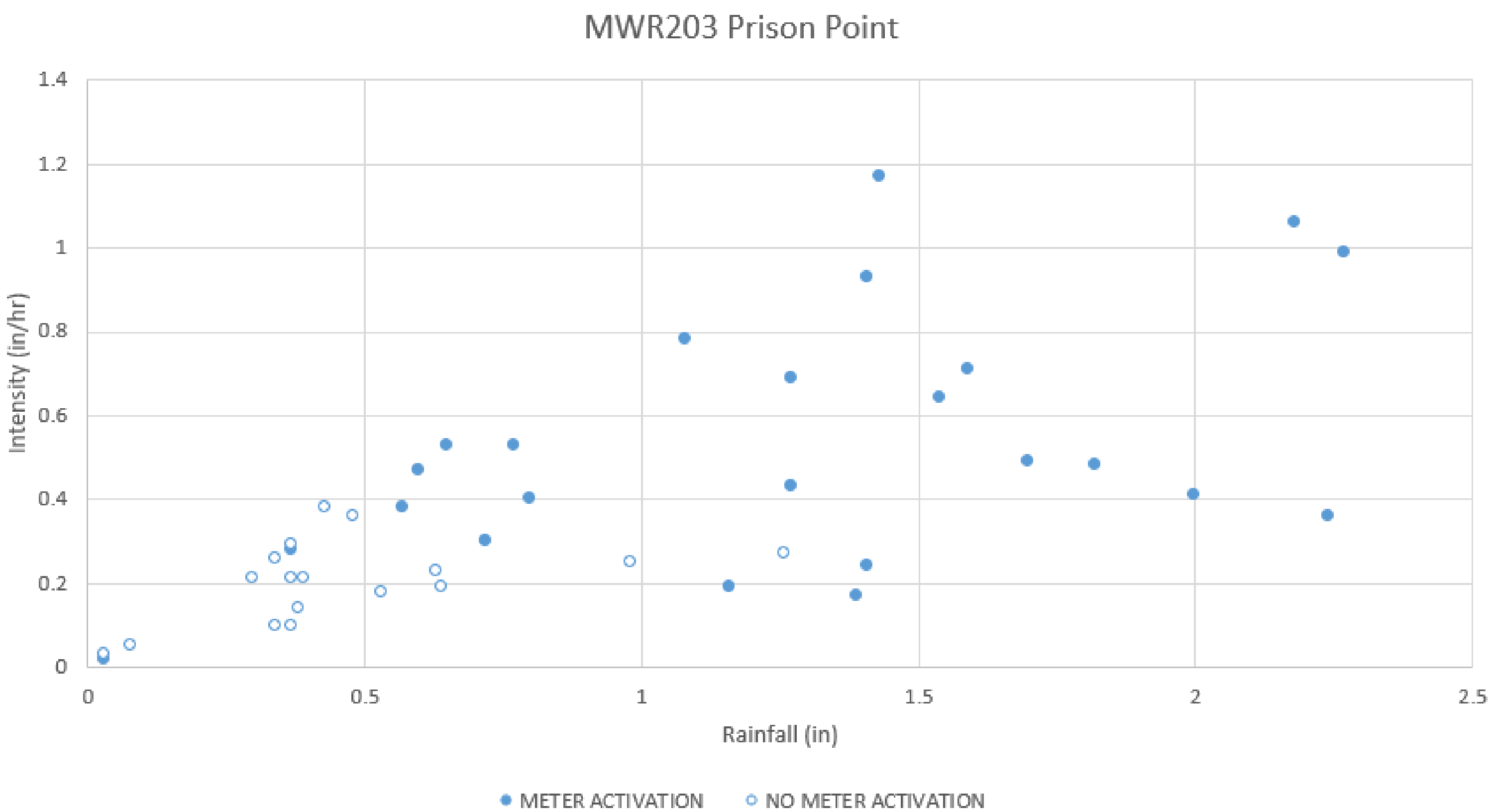
Outfall: BOS060
Regulator: RE060-7
Related Rain Gauge: 4



Outfall: BOS060
Regulator: RE060-20
Related Rain Gauge: 4



Outfall: MWR203
Regulator: Prison Point
Related Rain Gauge: 4

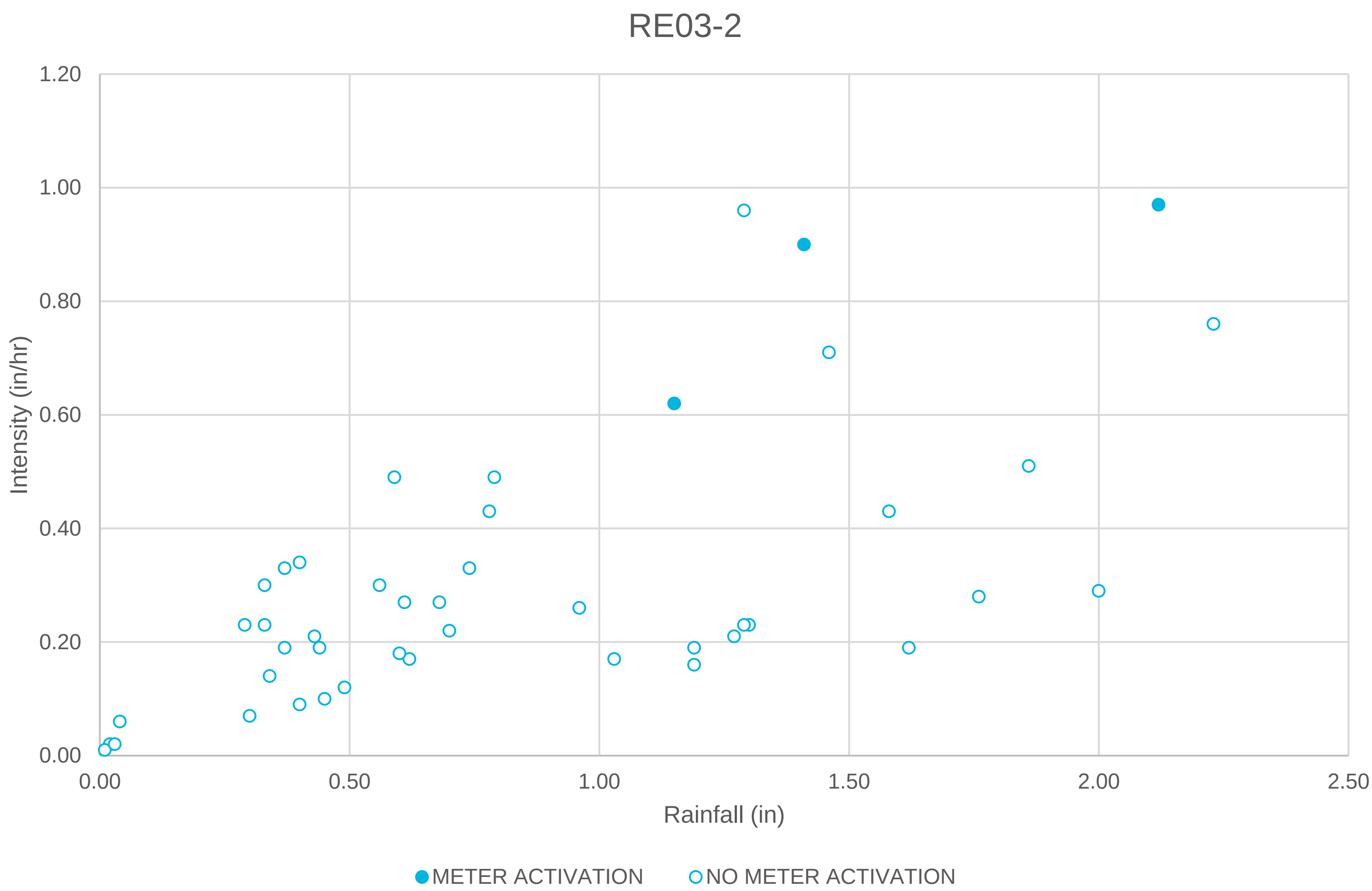


Meter activation represents an activation in which flow was discharged out of Prison Point.

Lower Inner Harbor

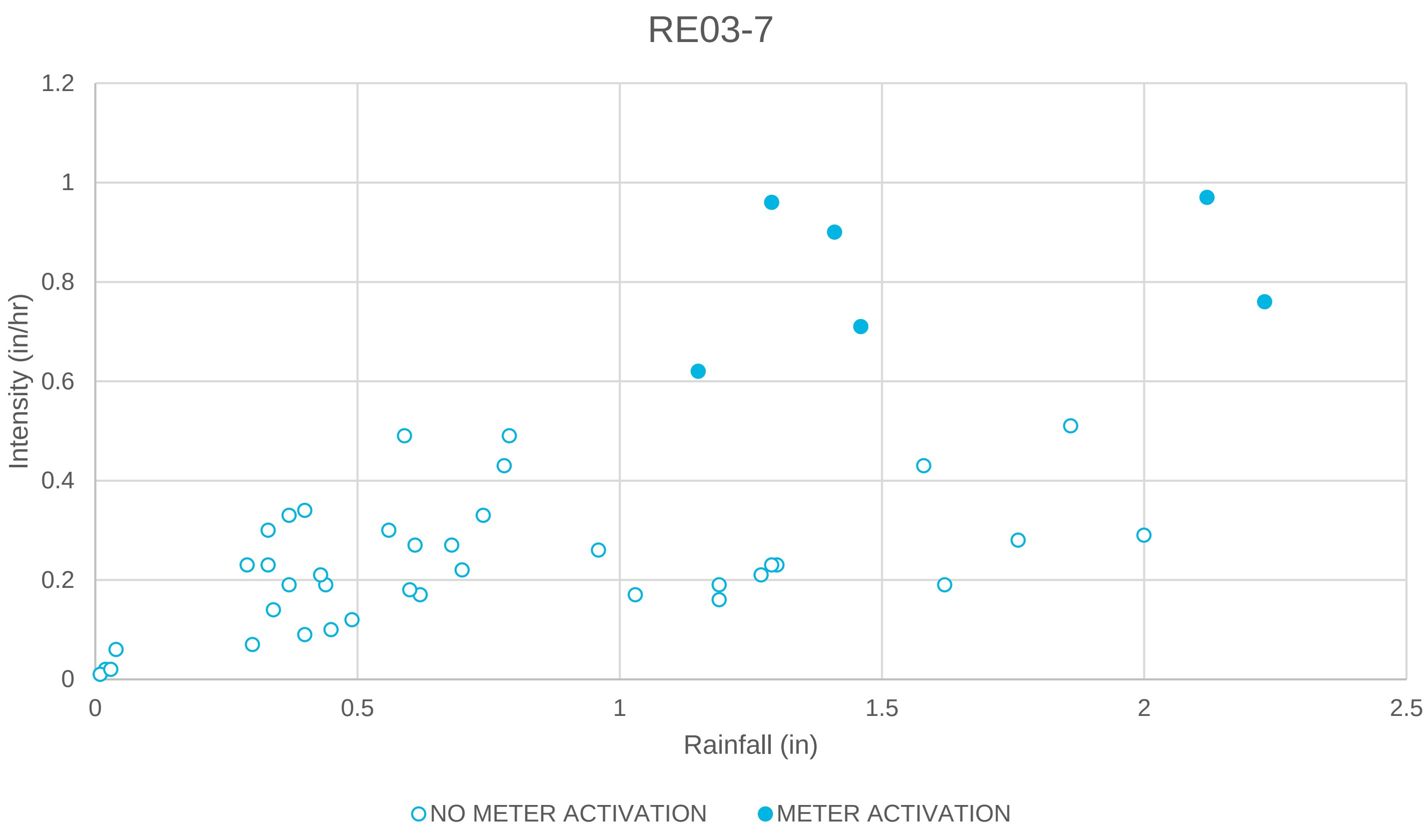
BOS003	RE003-2
	RE003-7
	RE003-12
BOS004	RE004-6
BOS005	RE005-1

Outfall: BOS003
Regulator: RE03-2
Related Rain Gauge: 8



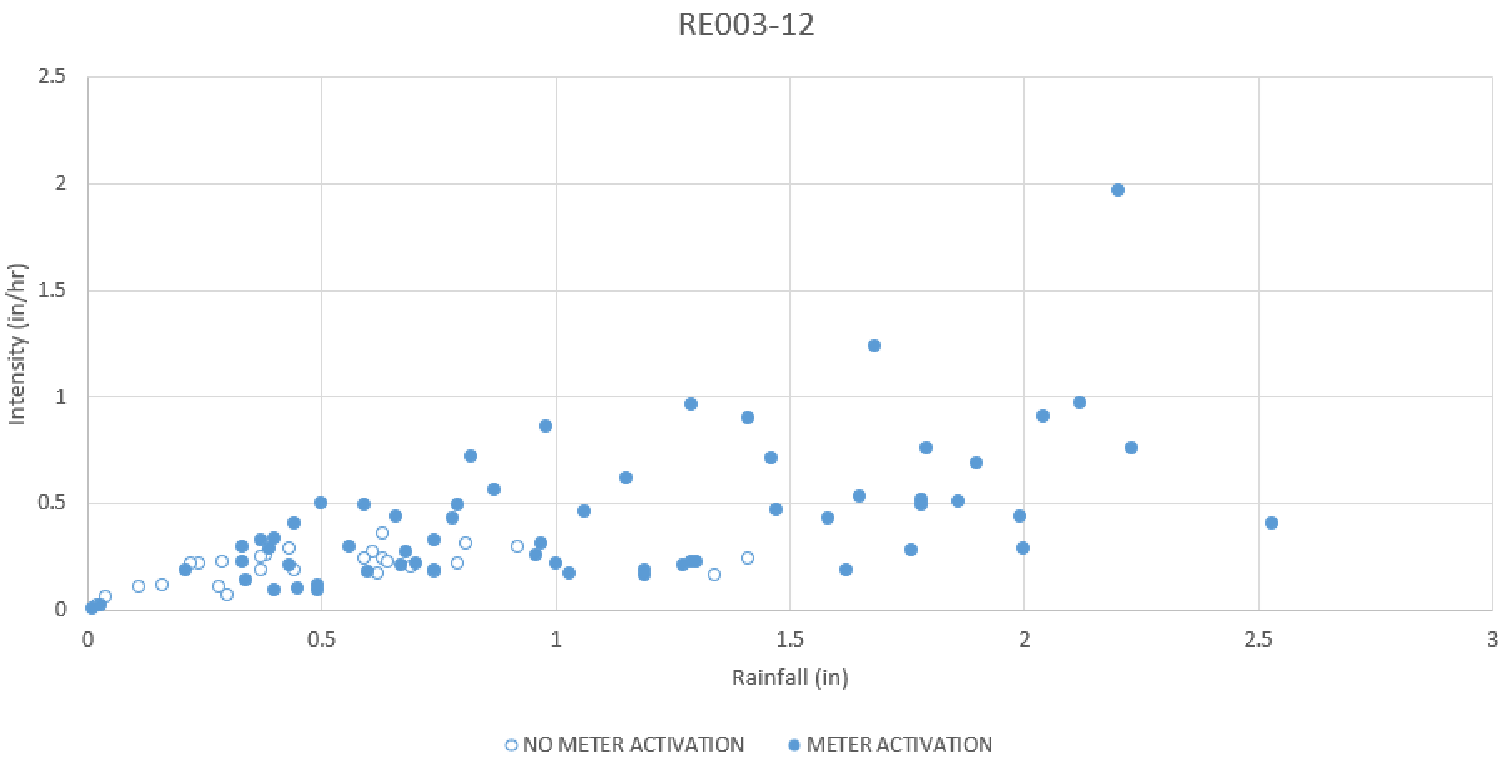
Meter was removed as of March 1, 2019. No activations were assessed following March 1, 2019.

Outfall: BOS003
Regulator: RE03-7
Related Rain Gauge: 8

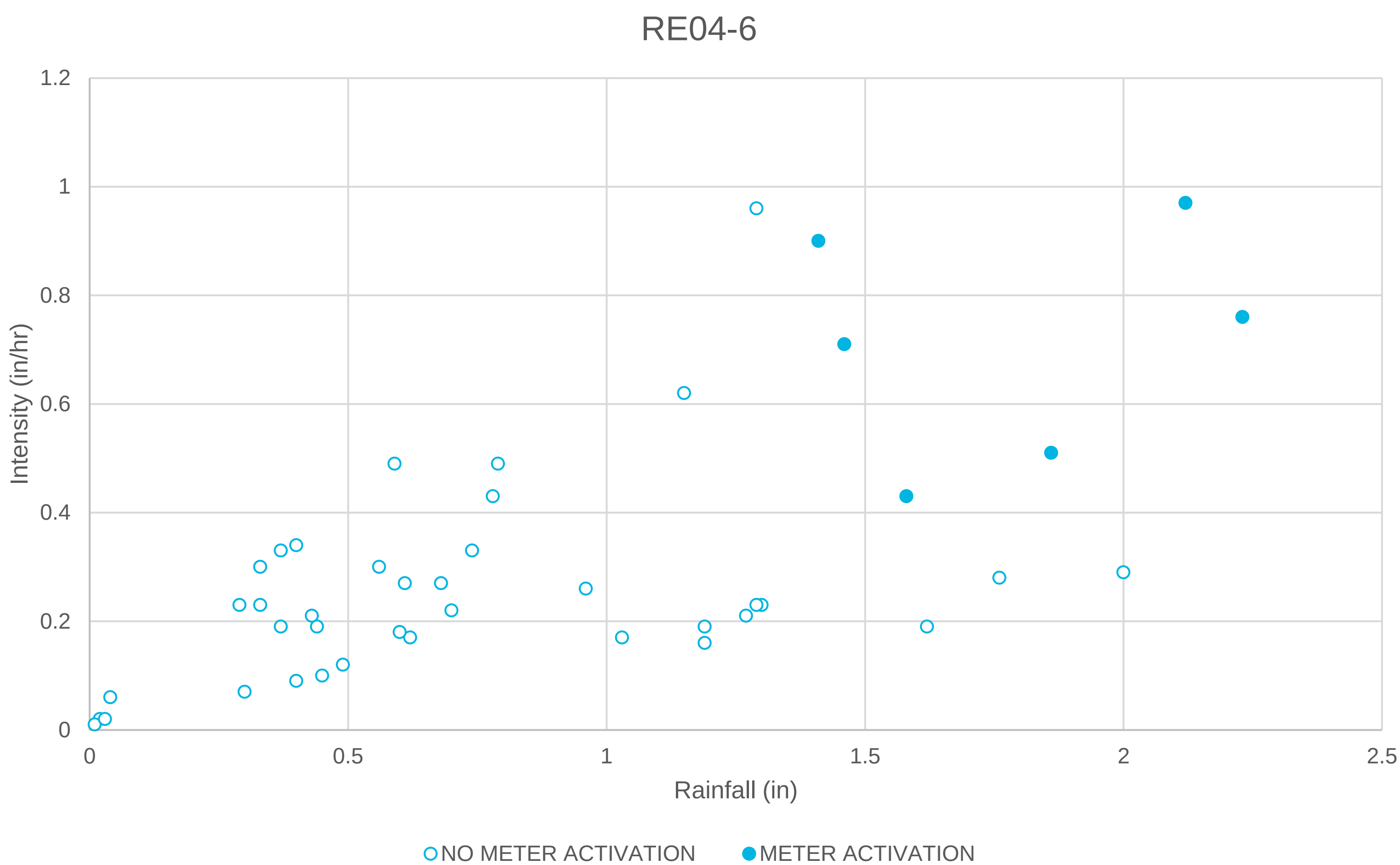


Meter was removed as of March 1, 2019. No activations were assessed following March 1, 2019.

Outfall: BOS003
Regulator: RE03-12
Related Rain Gauge: 8

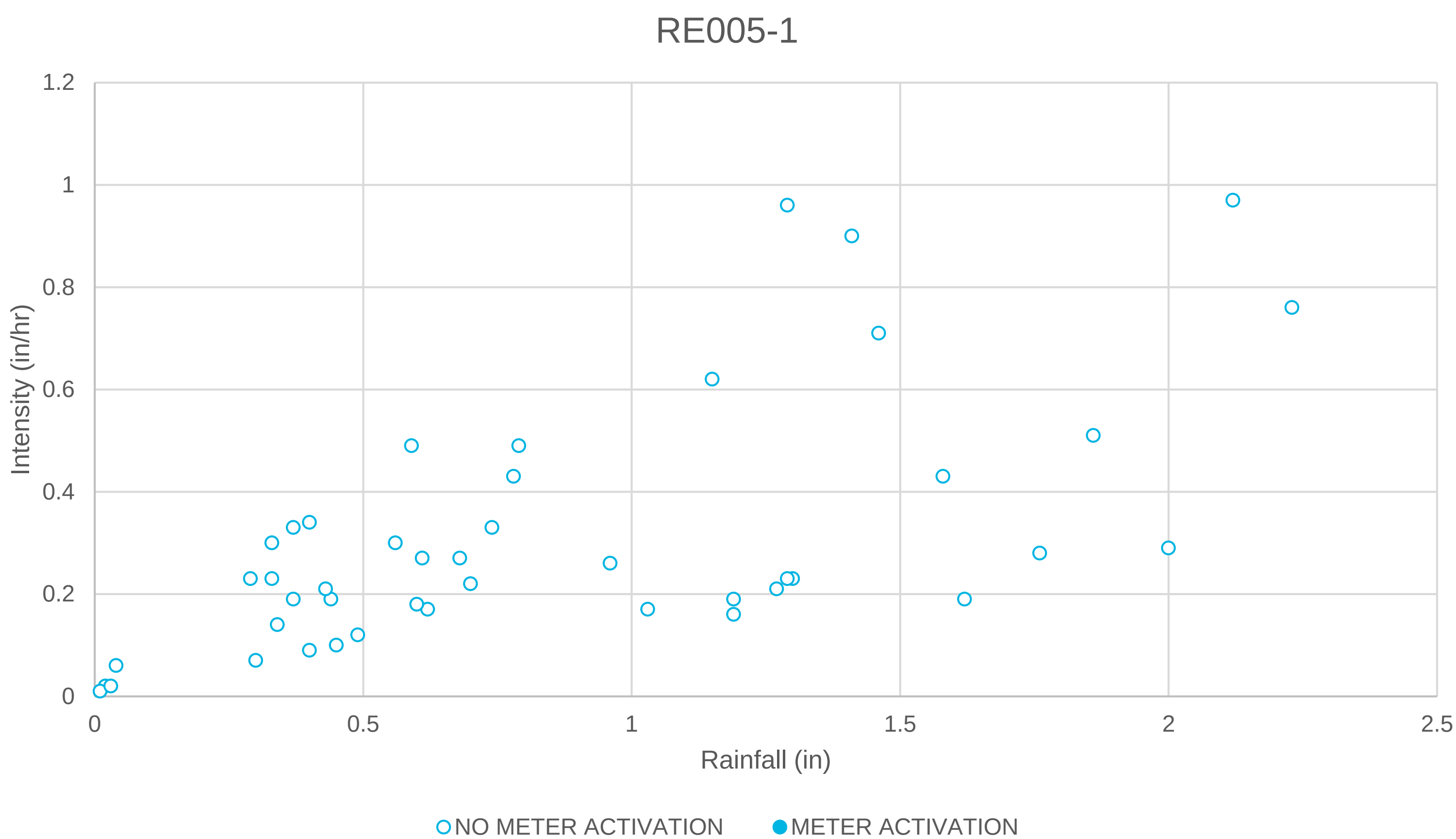


Outfall: BOS004
Regulator: RE04-6
Related Rain Gauge: 8



Meter was removed as of March 1, 2019. No activations were assessed following March 1, 2019.

Outfall: BOS005
Regulator: RE05-1
Related Rain Gauge: 8

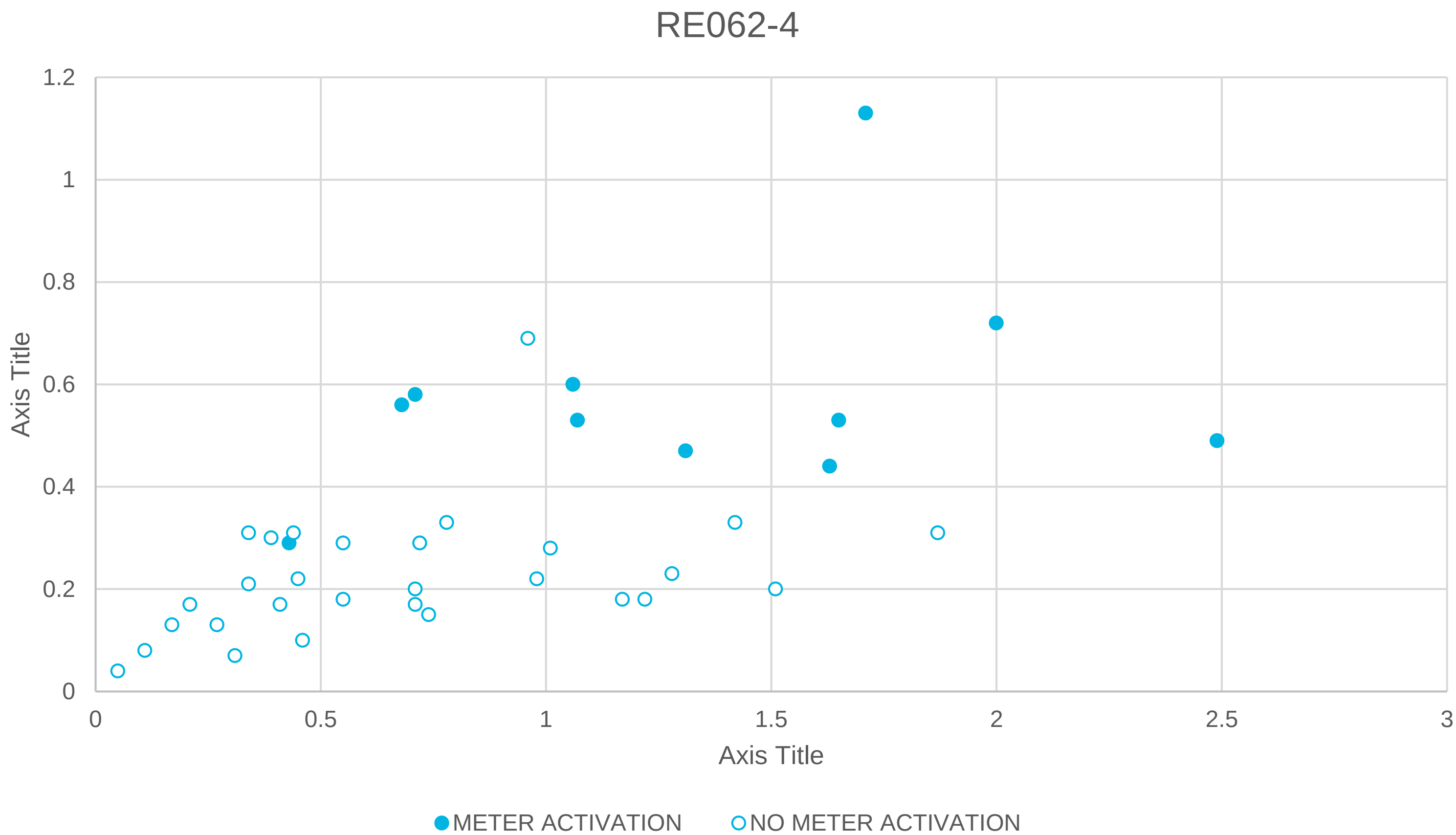


Meter was removed as of March 1, 2019. No activations were assessed following March 1, 2019.

Fort Point Channel

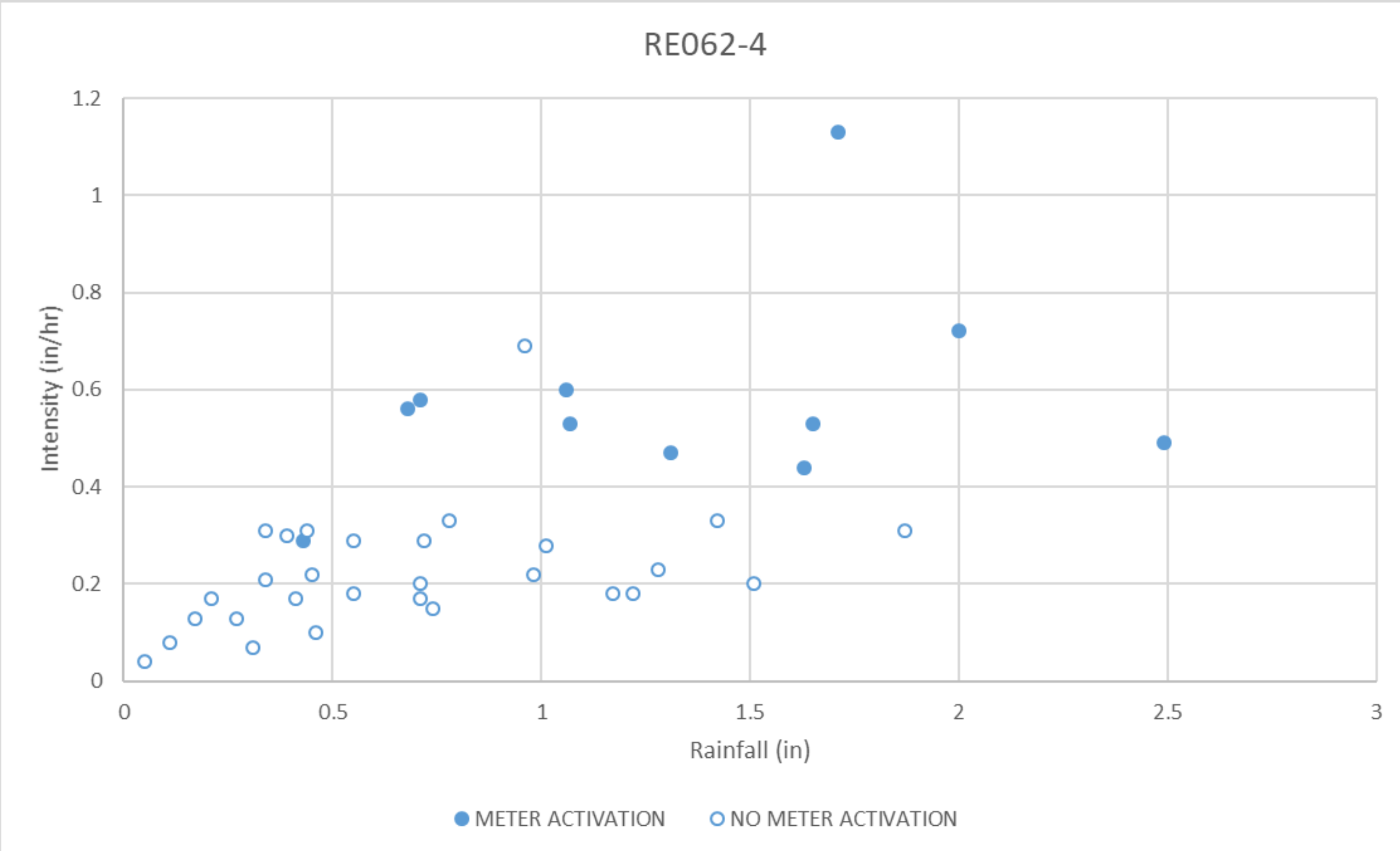
BOS062	RE062-4
BOS064	RE064-4
	RE064-5
BOS065	RE065-2
BOS068	RE068-1A
BOS070/DBC	RE070/8-3
	RE070/8-6
	RE070/8-7
	RE070/8-8
	RE070/8-13
	RE070/8-15
	RE070/9-4
	RE070/10-5
	RE070/7-2
MWR215 (Union Park)	
BOS070/RCC	RE070/5-3
BOS073	RE073-4

Outfall:BOS062
Regulator: RE62-4
Related Rain Gauge: 18



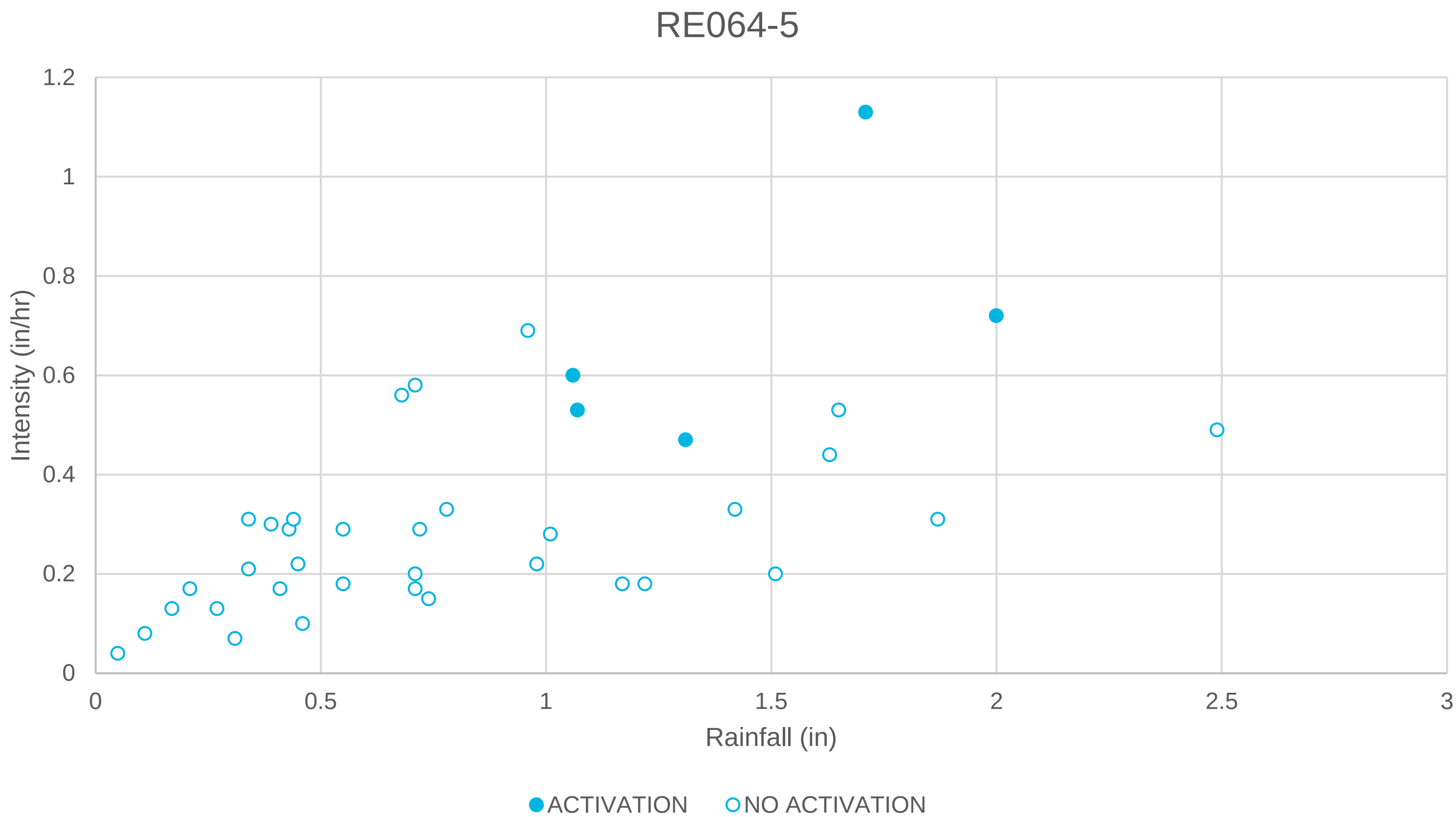
Meter was removed as of March 1, 2019. No activations were assessed following March 1, 2019.

Outfall:BOS064
Regulator: RE64-4
Related Rain Gauge: 18



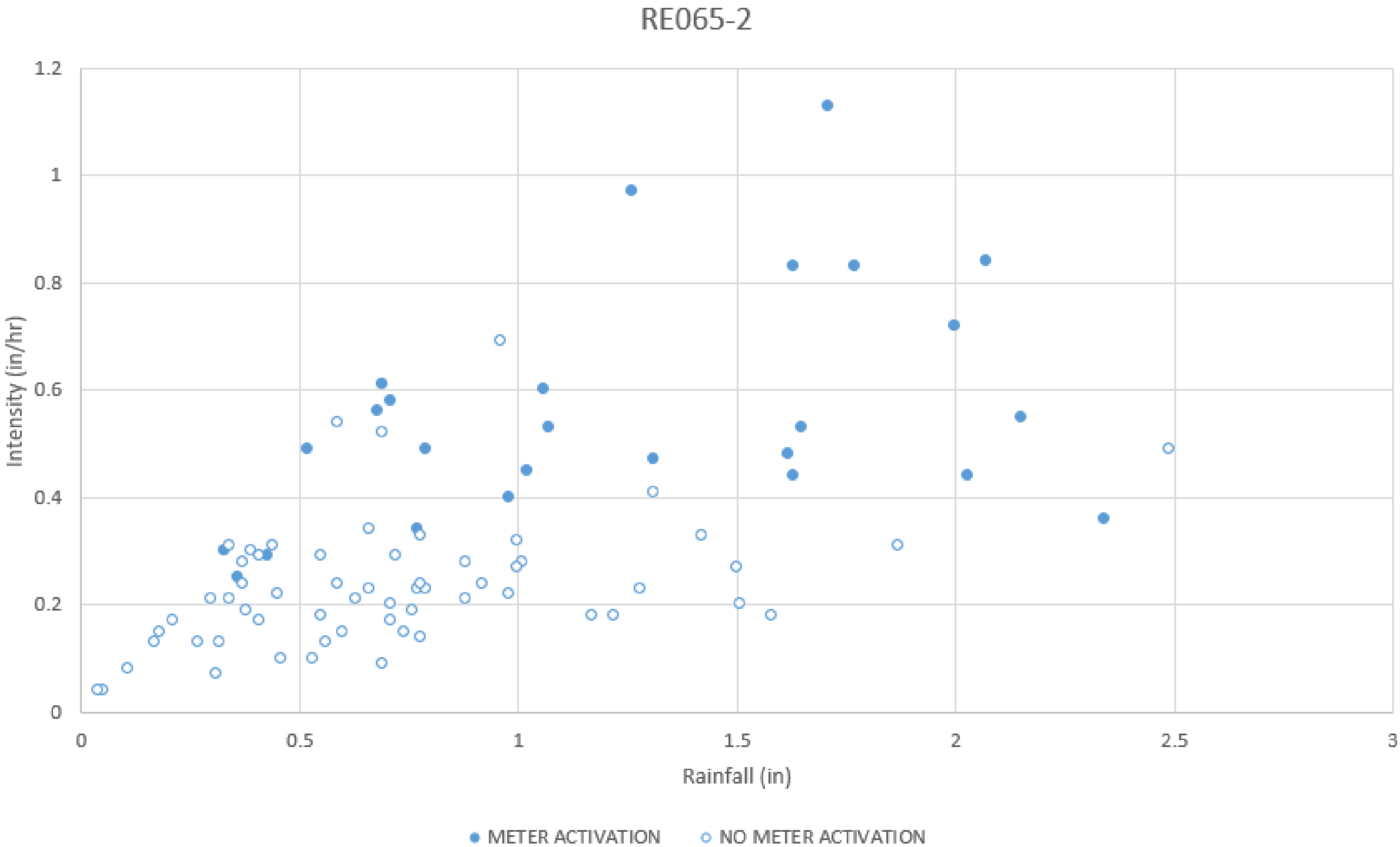
Meter was removed as of March 1, 2019. No activations were assessed following March 1, 2019.

Outfall:BOS064
Regulator: RE64-5
Related Rain Gauge: 18

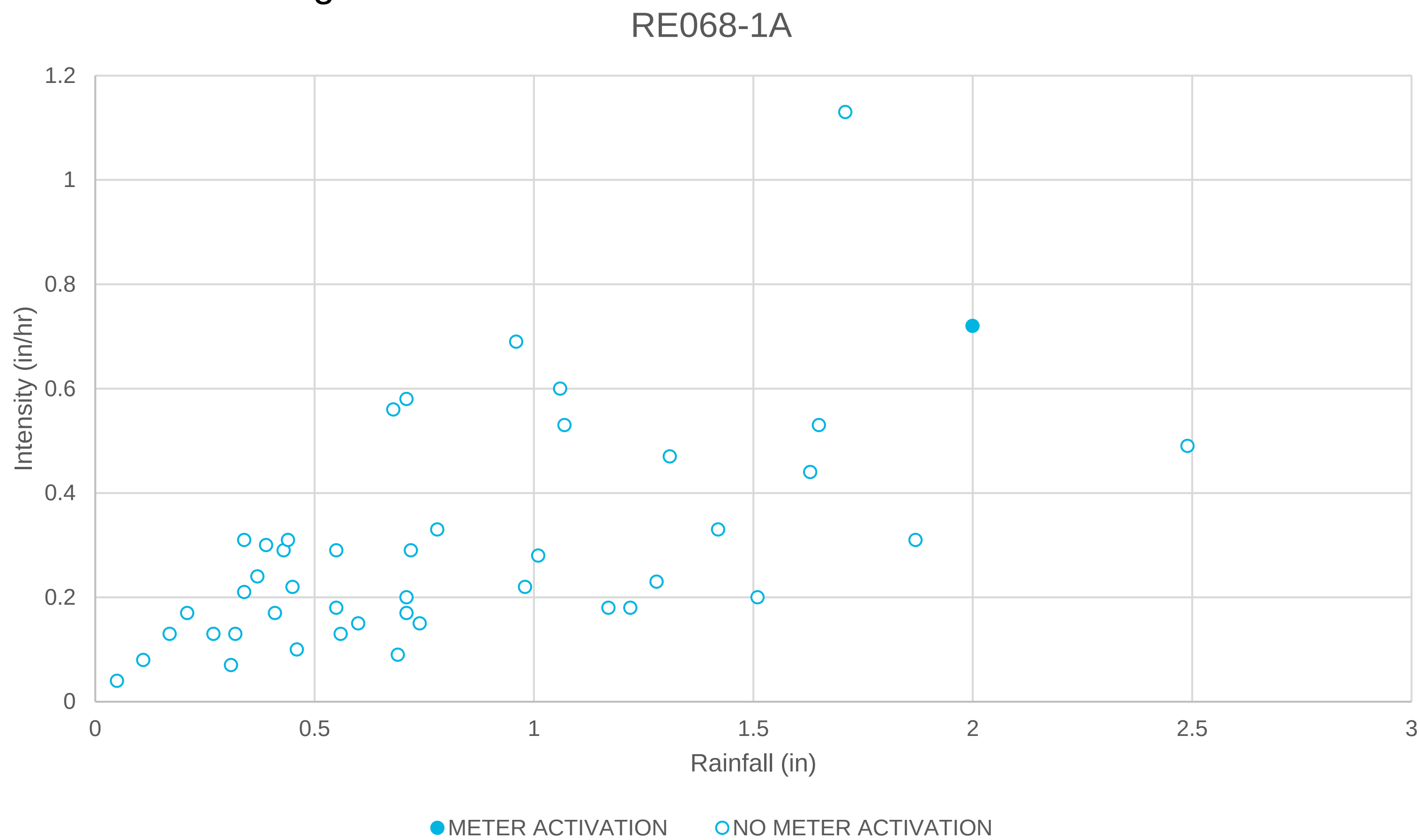


Meter was removed as of March 1, 2019. No activations were assessed following March 1, 2019.

Outfall:BOS065
Regulator: RE65-2
Related Rain Gauge: 18

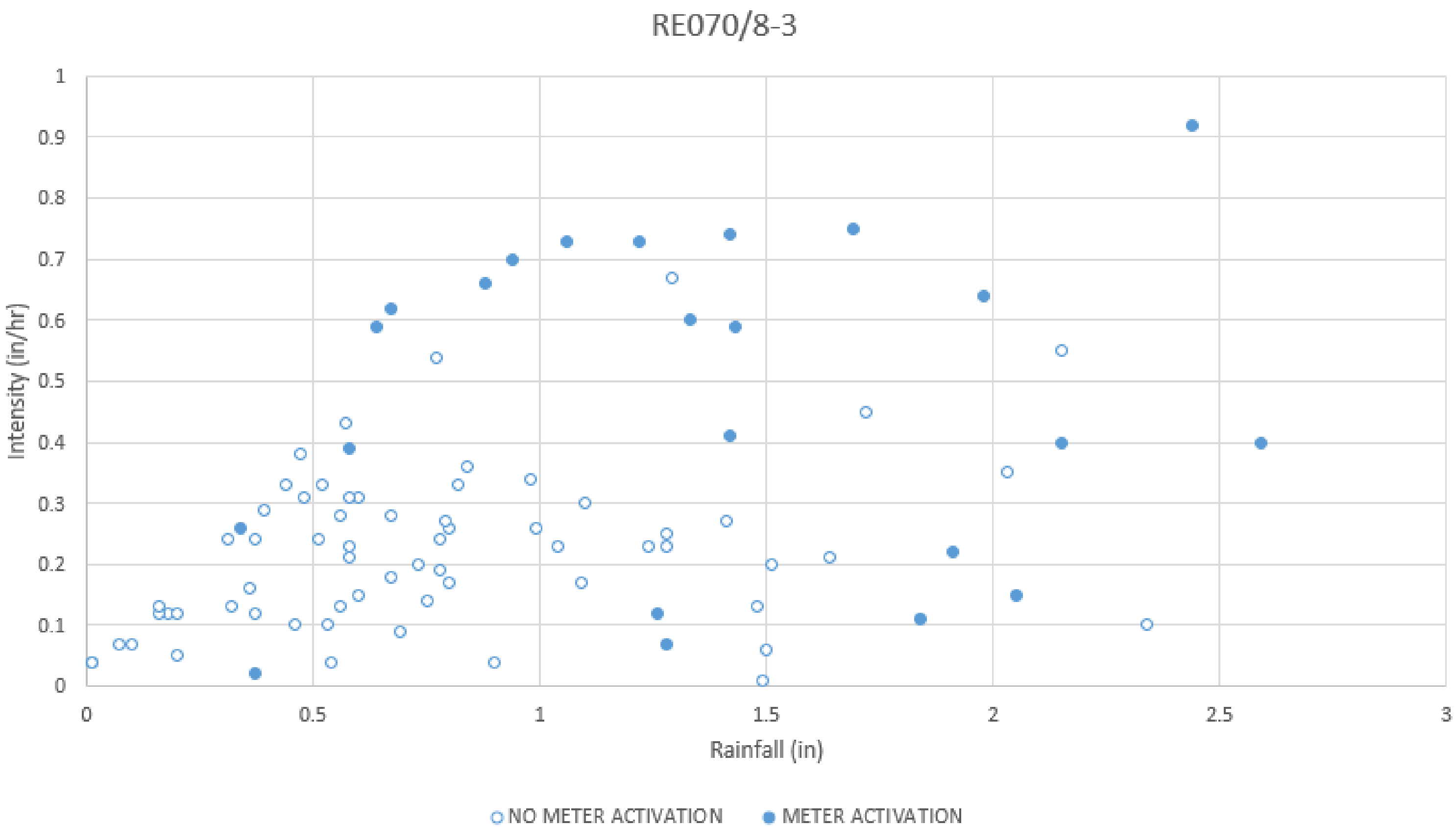


Outfall:BOS068
Regulator: RE68-1A
Related Rain Gauge: 18

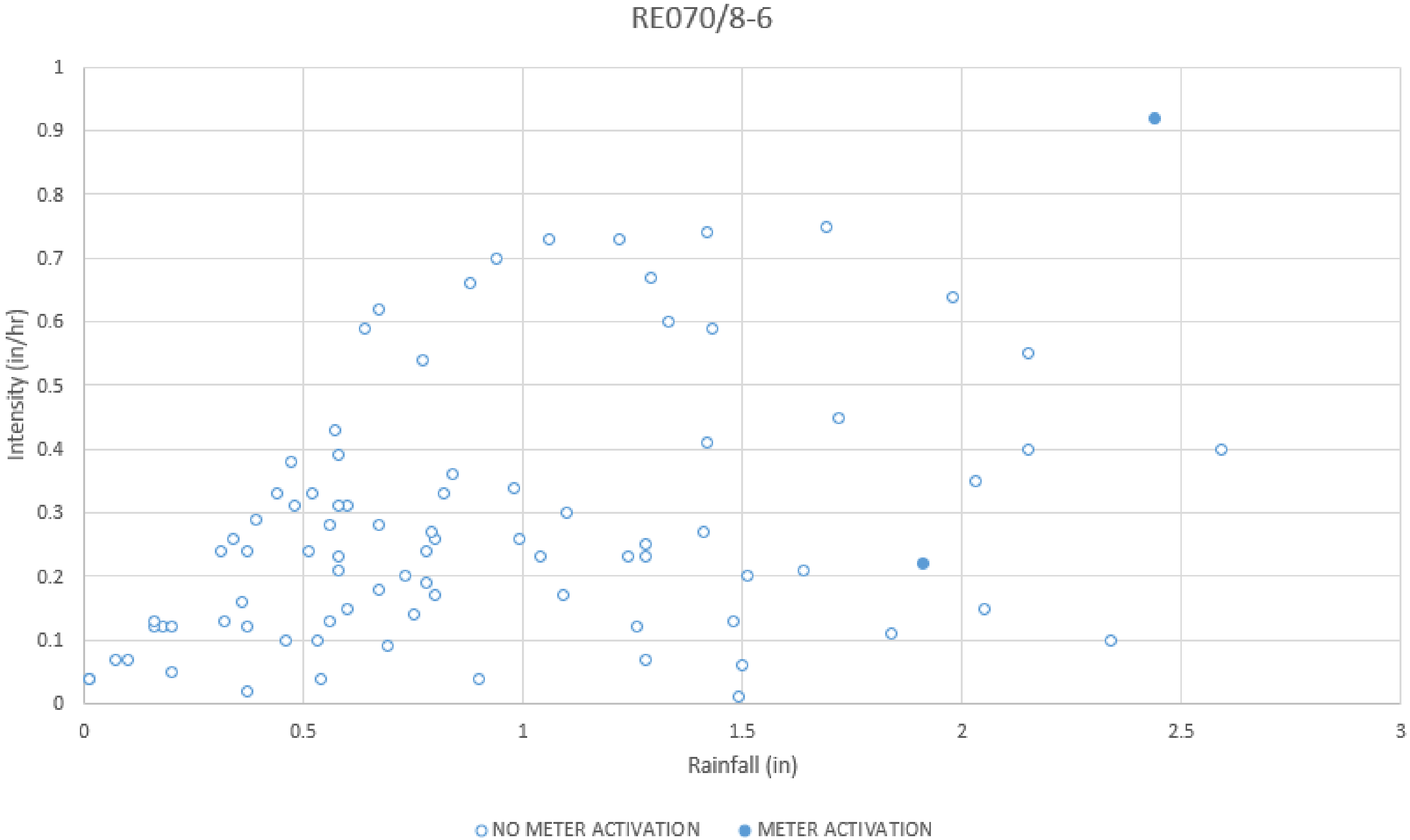


Meter was removed as of March 1, 2019. No activations were assessed following March 1, 2019.

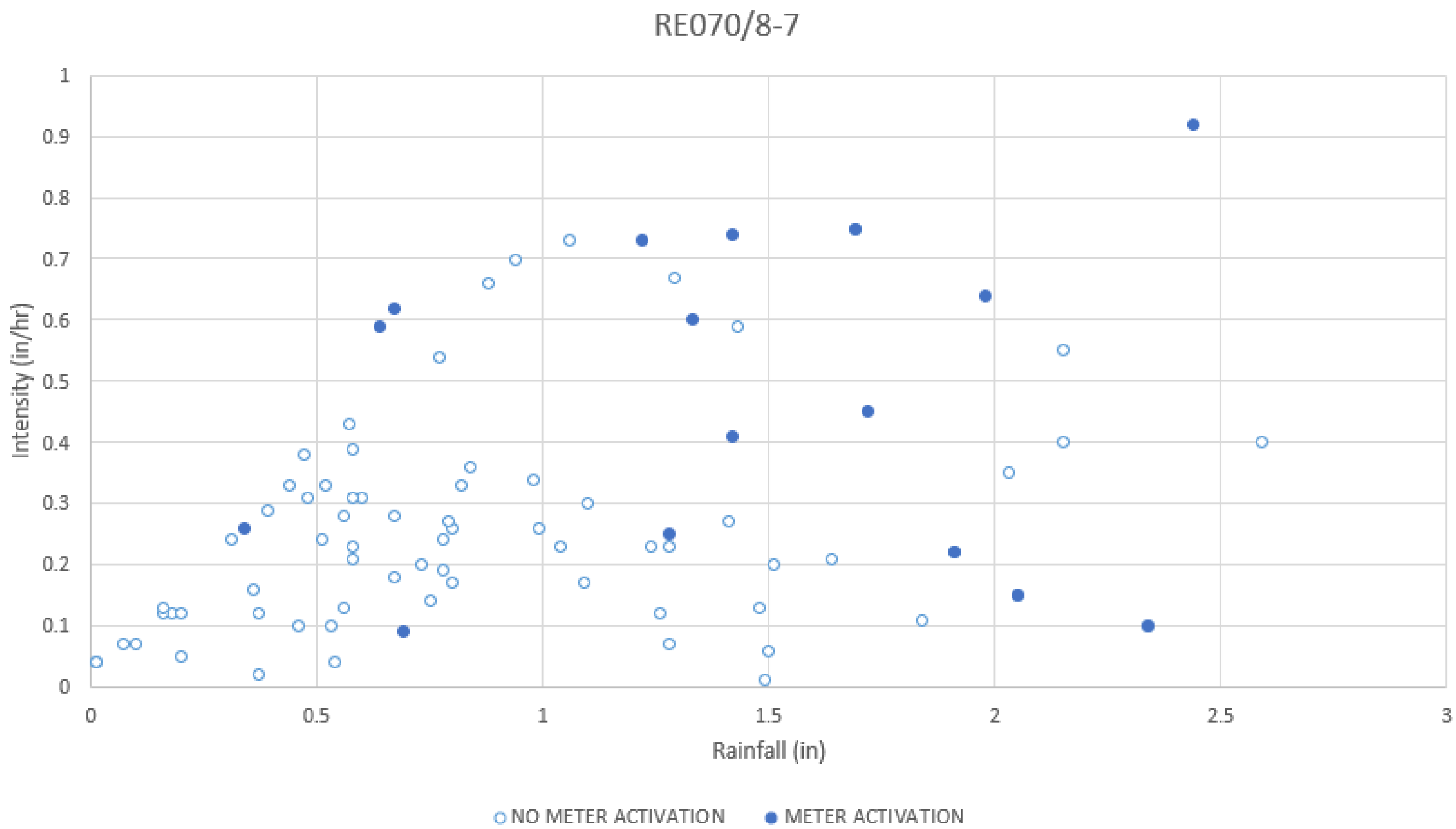
Outfall:BOS70/DBC
Regulator: RE070/8-3
Related Rain Gauge: 3



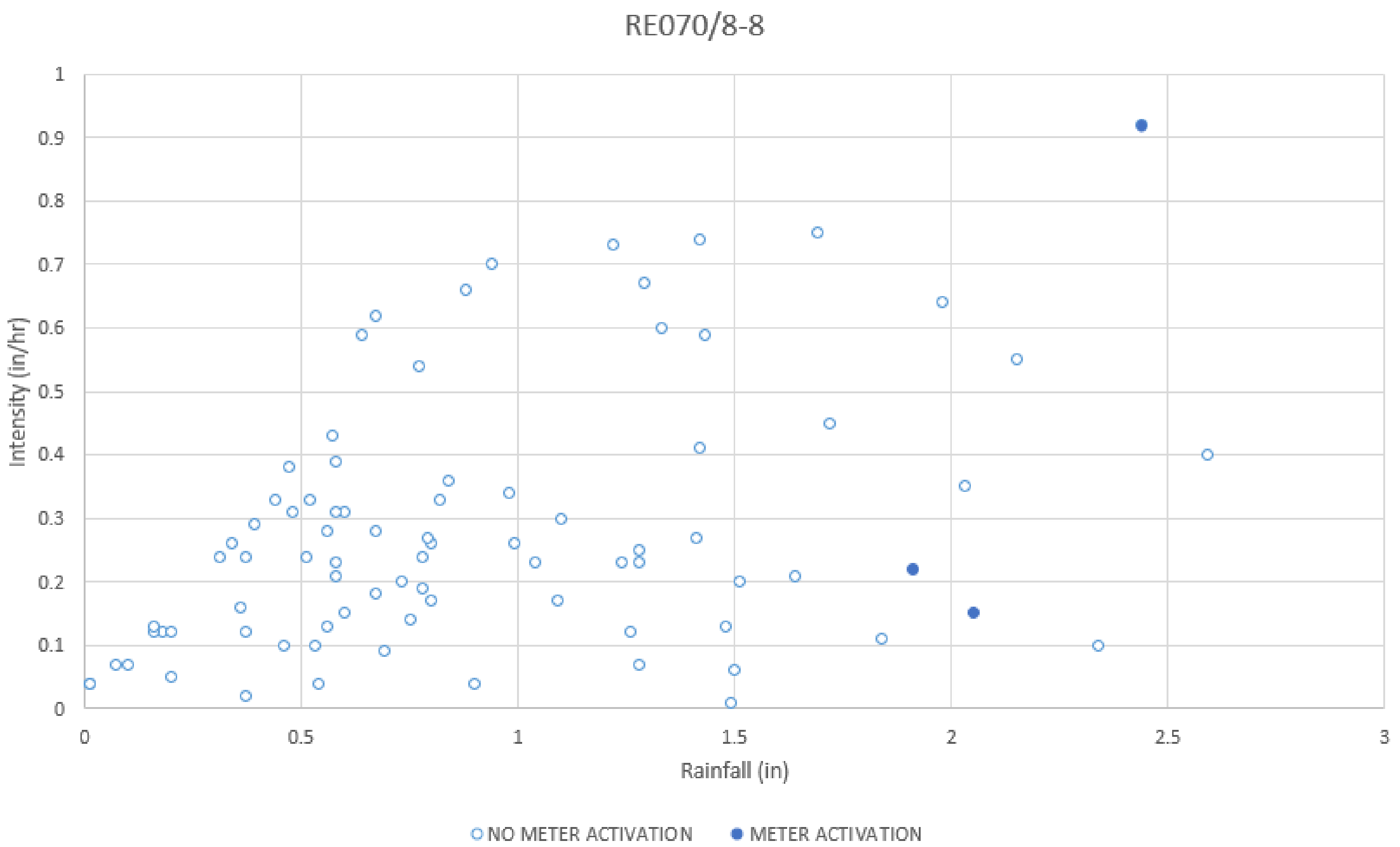
Outfall:BOS70/DBC
Regulator: RE070/8-6
Related Rain Gauge: 3



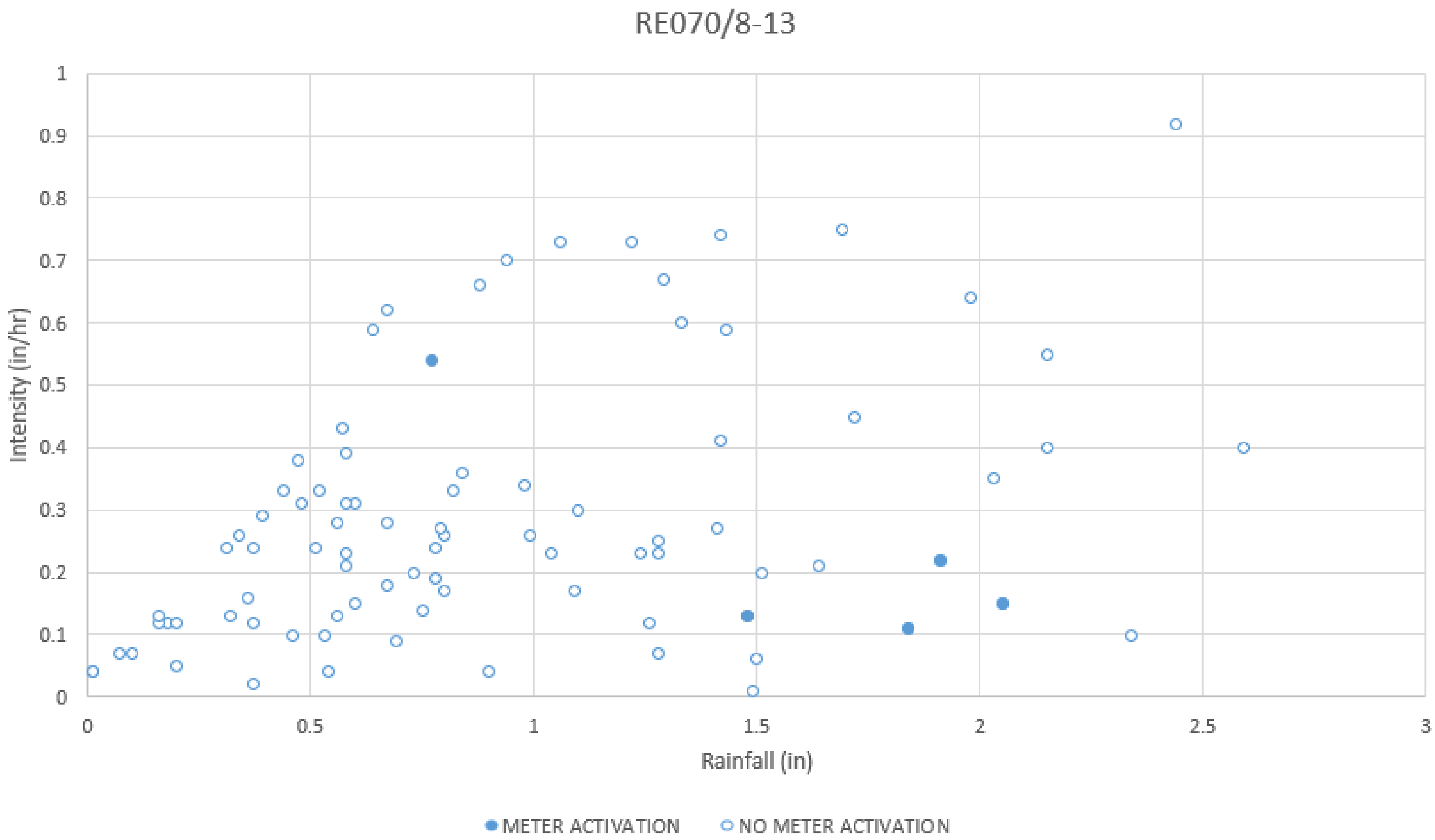
Outfall:BOS70/DBC
Regulator: RE070/8-7
Related Rain Gauge: 3



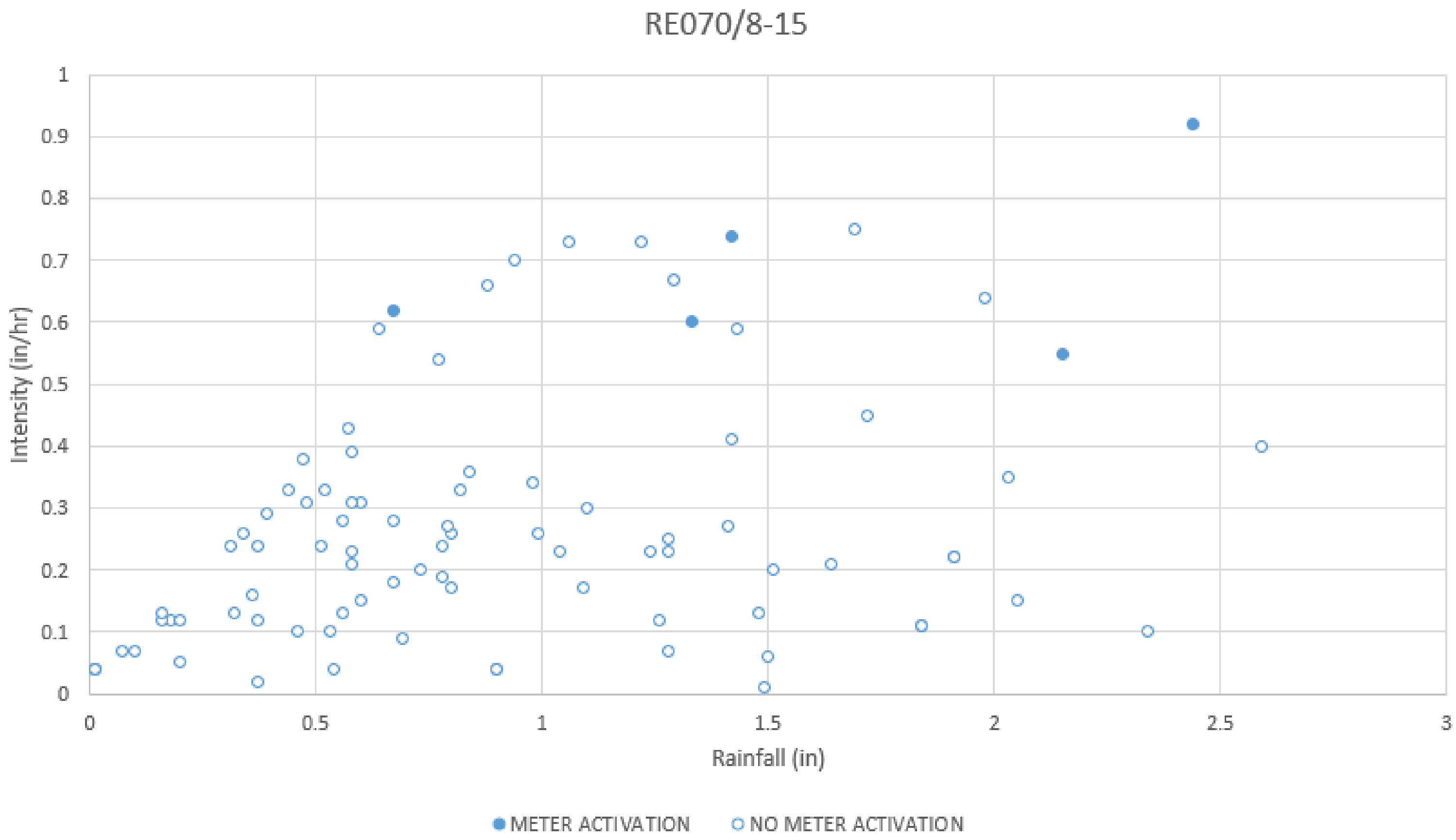
Outfall:BOS70/DBC
Regulator: RE070/8-8
Related Rain Gauge: 3



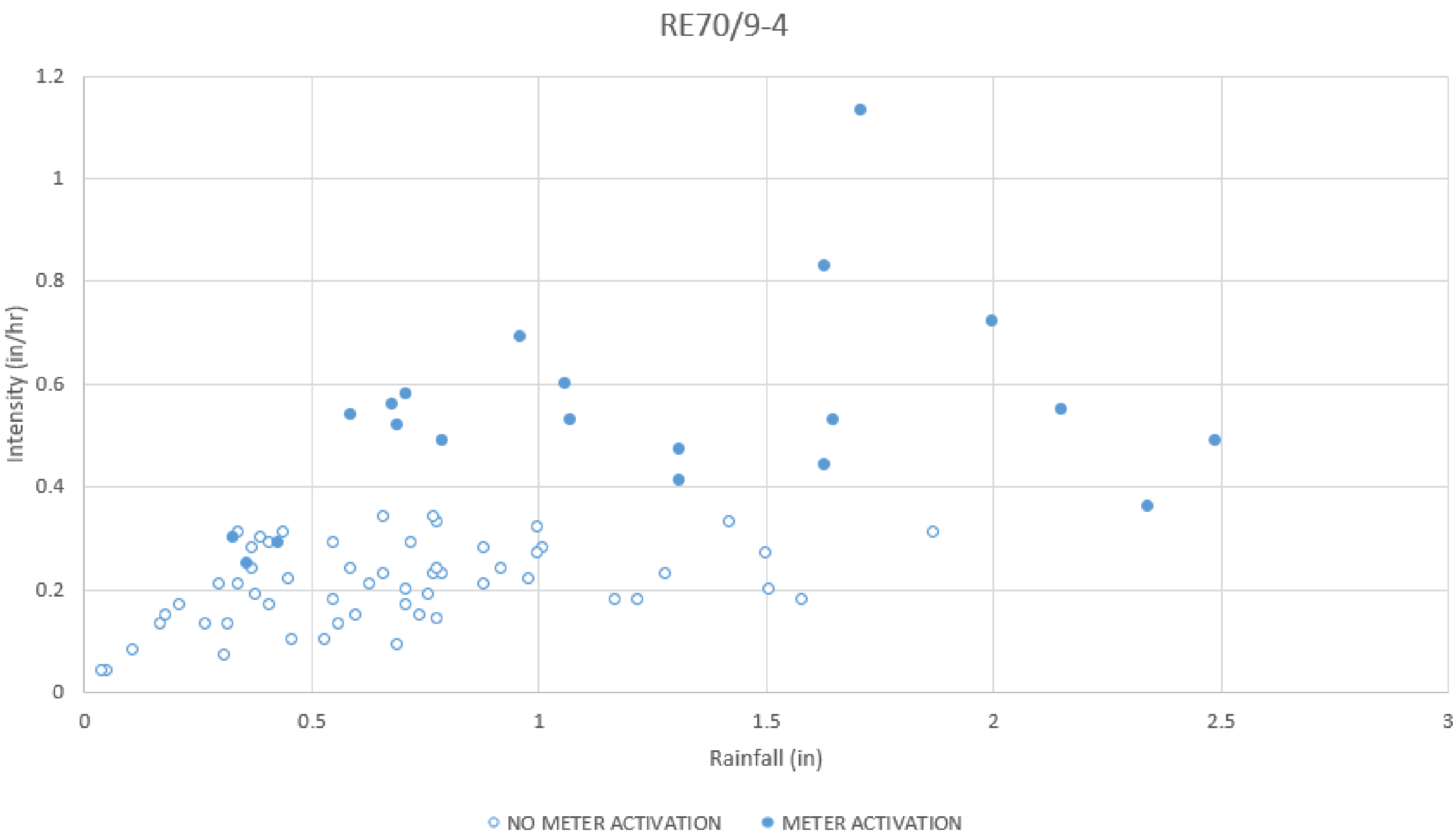
Outfall:BOS70/DBC
Regulator: RE070/8-13
Related Rain Gauge: 3



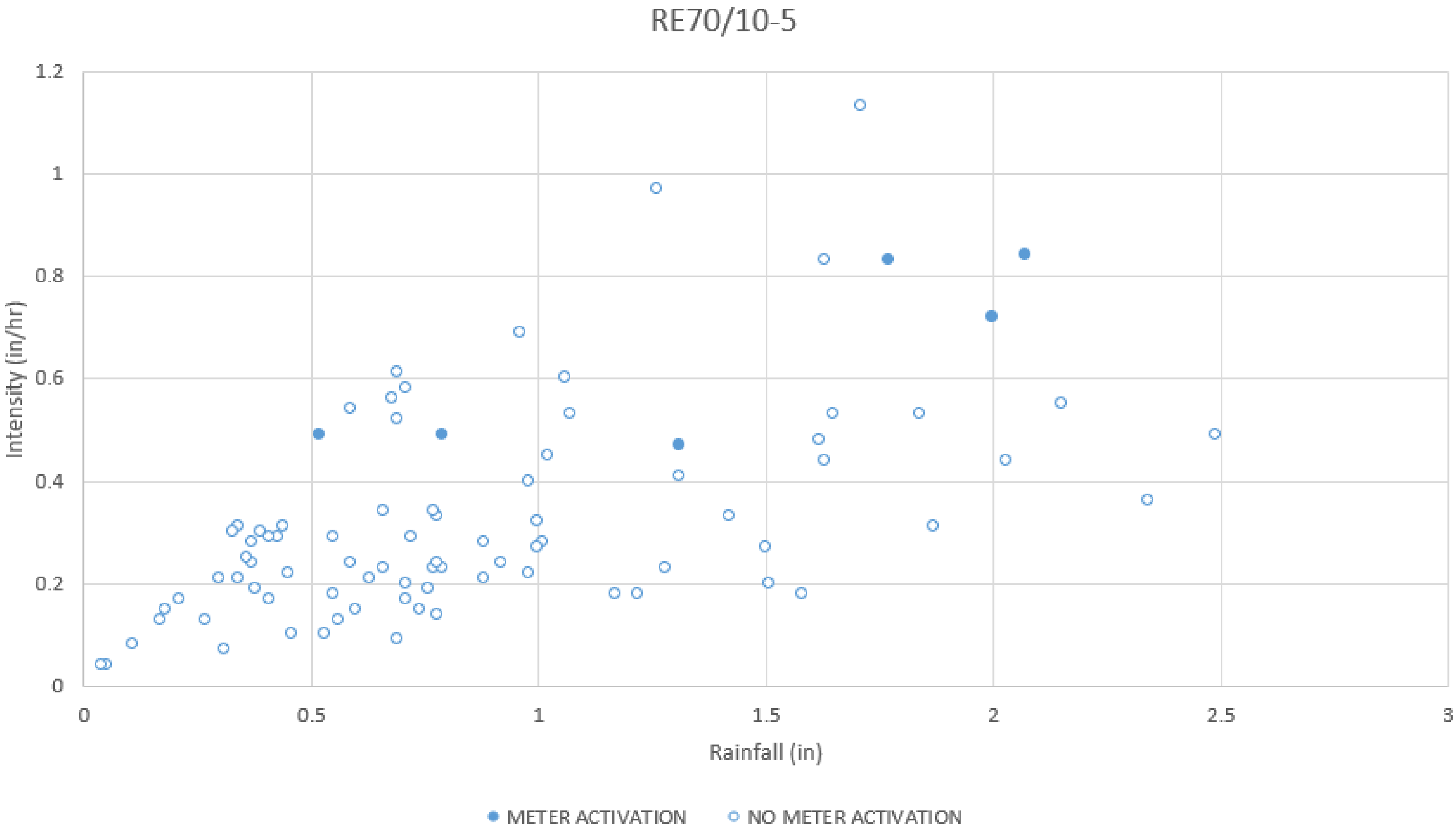
Outfall:BOS70/DBC
Regulator: RE070/8-15
Related Rain Gauge: 3



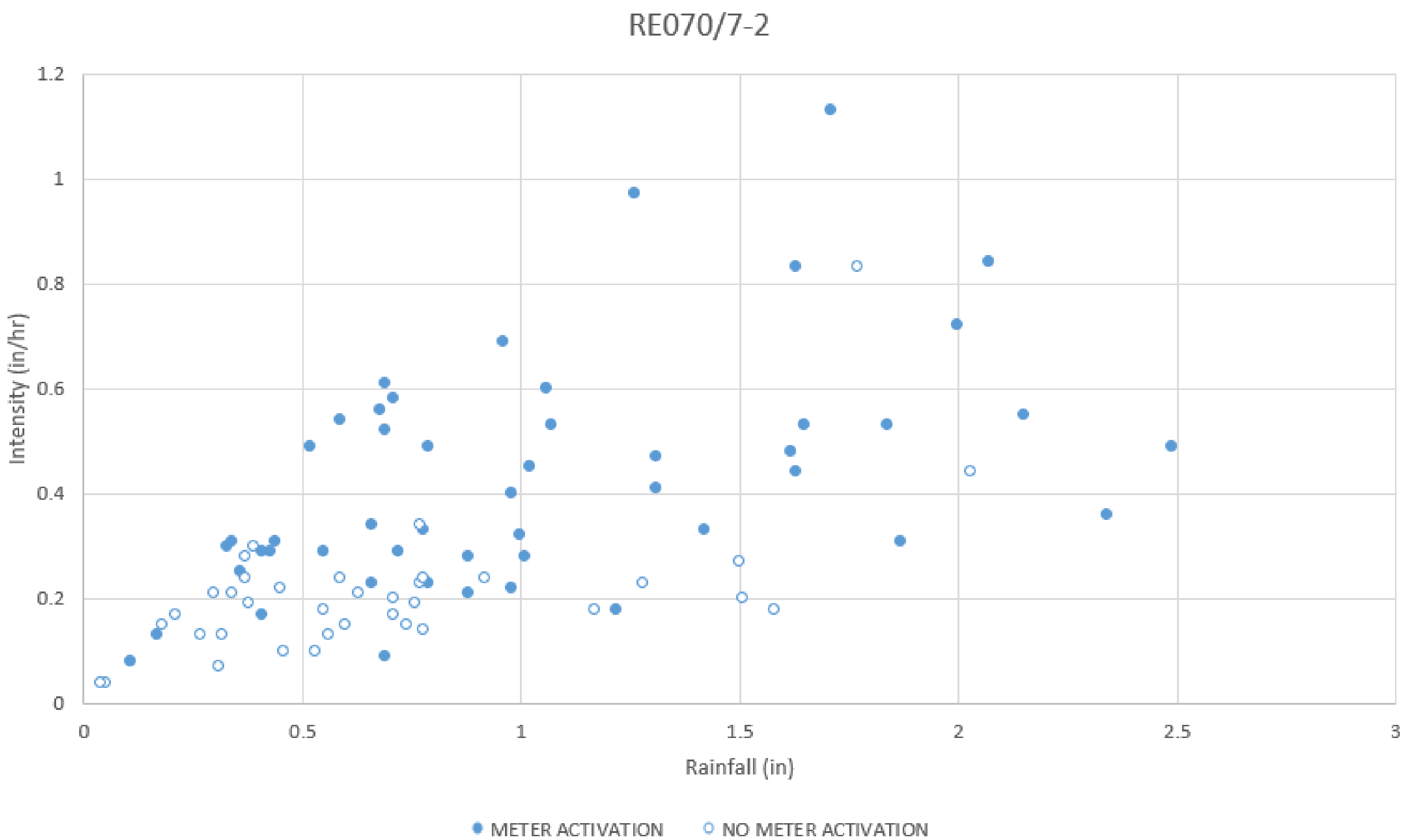
Outfall:BOS070/DBC
Regulator: RE70/9-4
Related Rain Gauge: 18



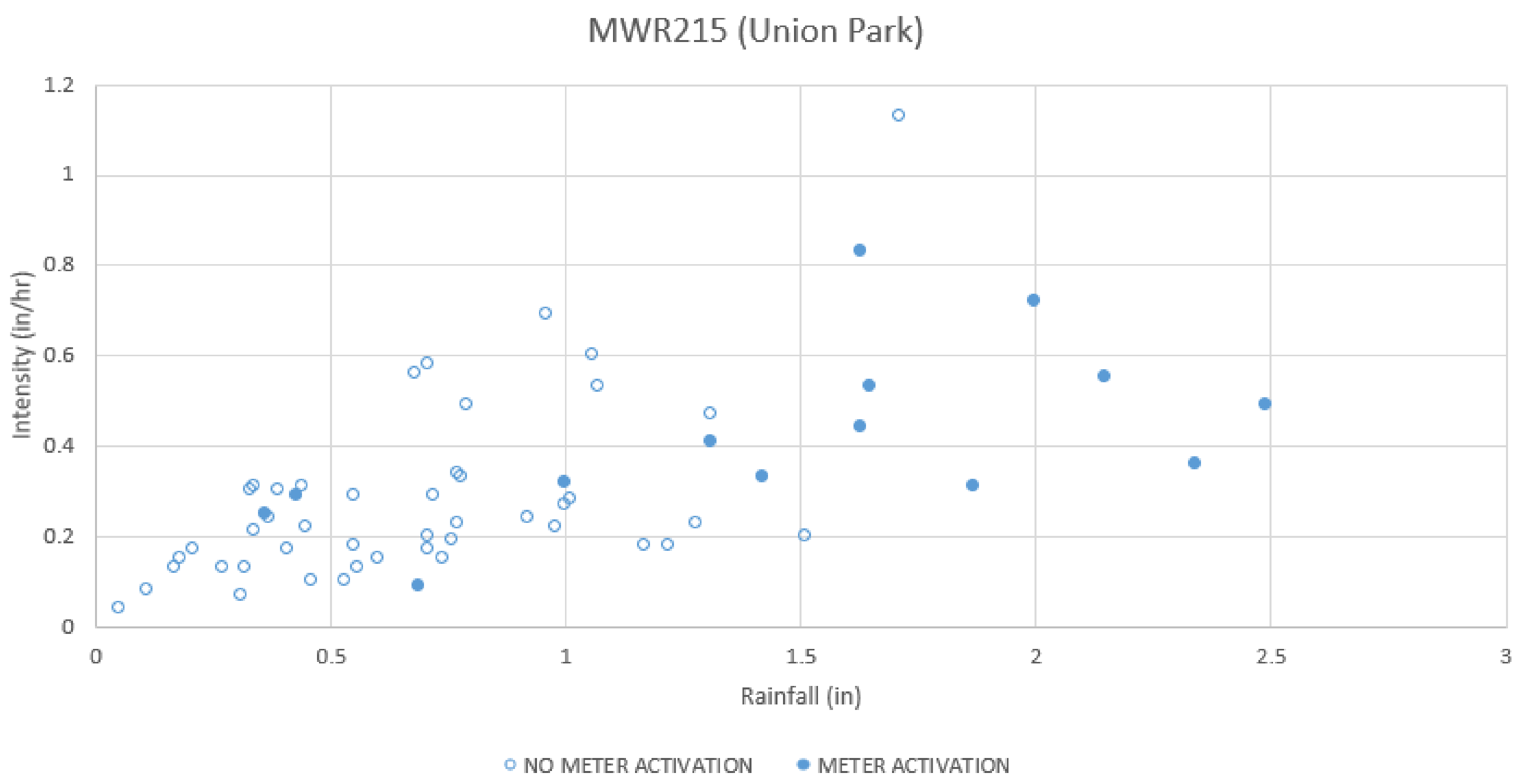
Outfall:BOS070/DBC
Regulator: RE70/10-5
Related Rain Gauge: 18



Outfall:BOS070/DBC
Regulator: RE70/7-2
Related Rain Gauge: 18

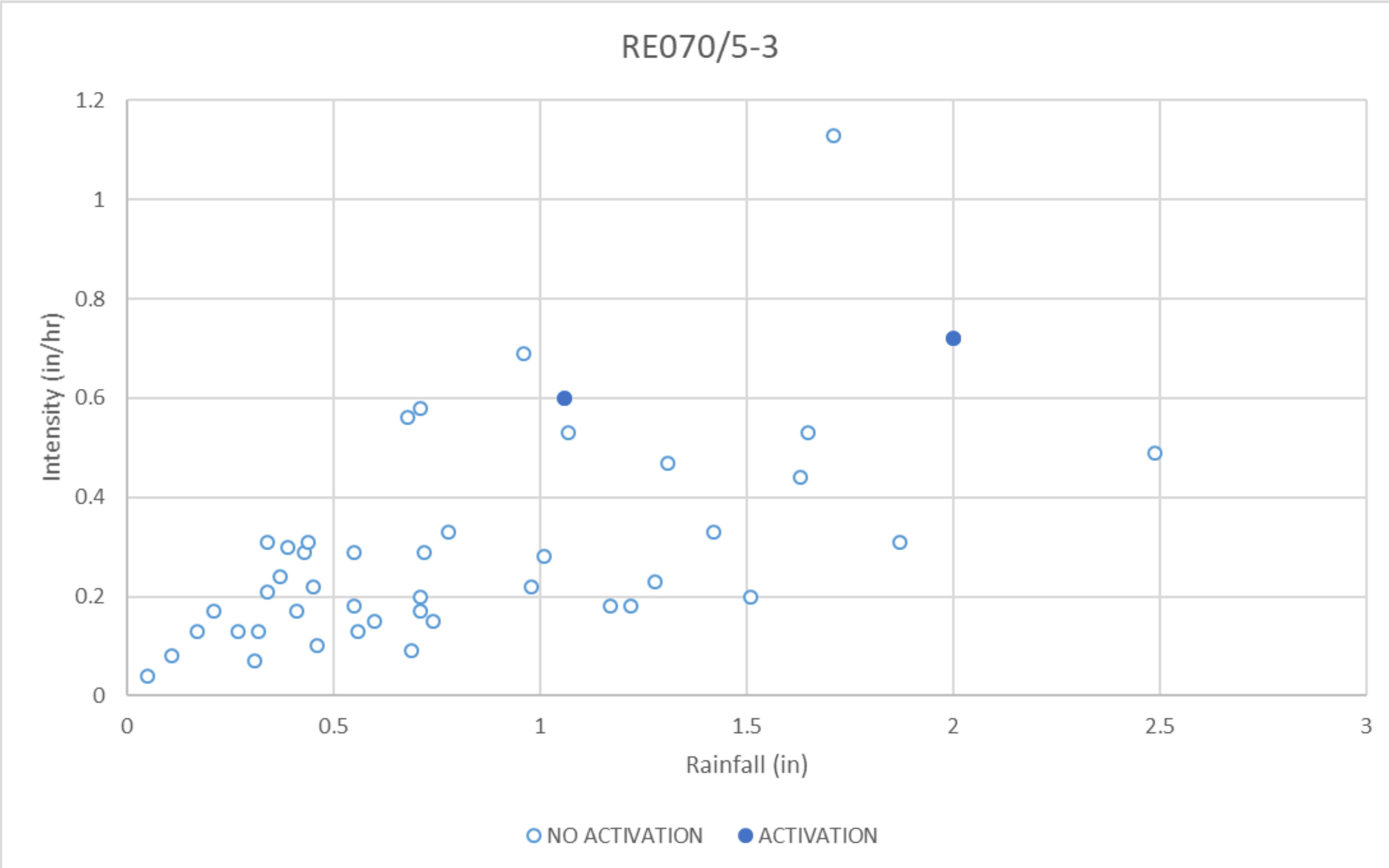


Outfall:MWR215 (Union Park)
Regulator: N/A
Related Rain Gauge: 18



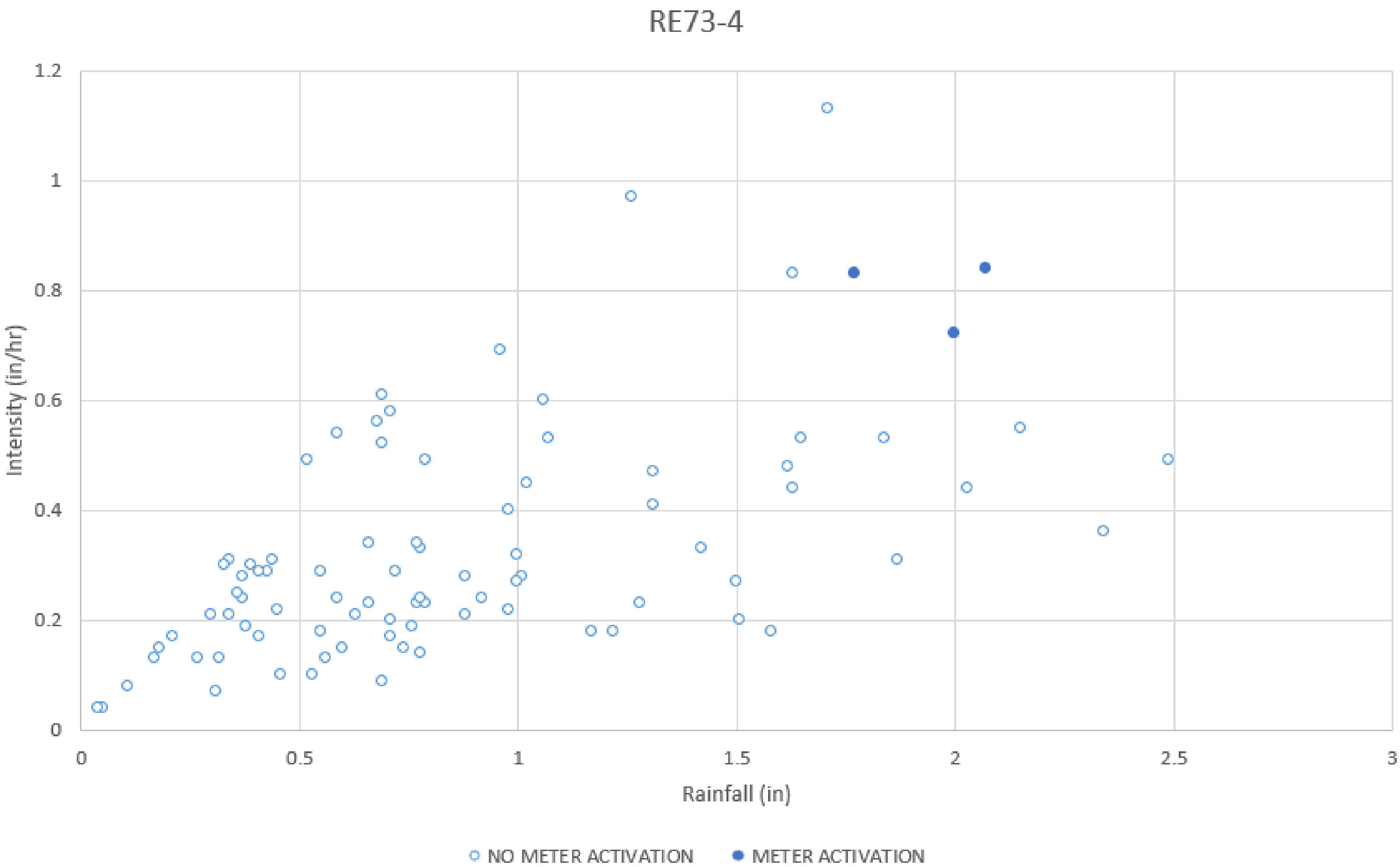
Meter activation represents an activation in which flow was discharged out of Union Park.

Outfall:BOS070/RRCC
Regulator: RE70/5-3
Related Rain Gauge: 18



Meter was removed as of March 1, 2019. No activations were assessed following March 1, 2019.

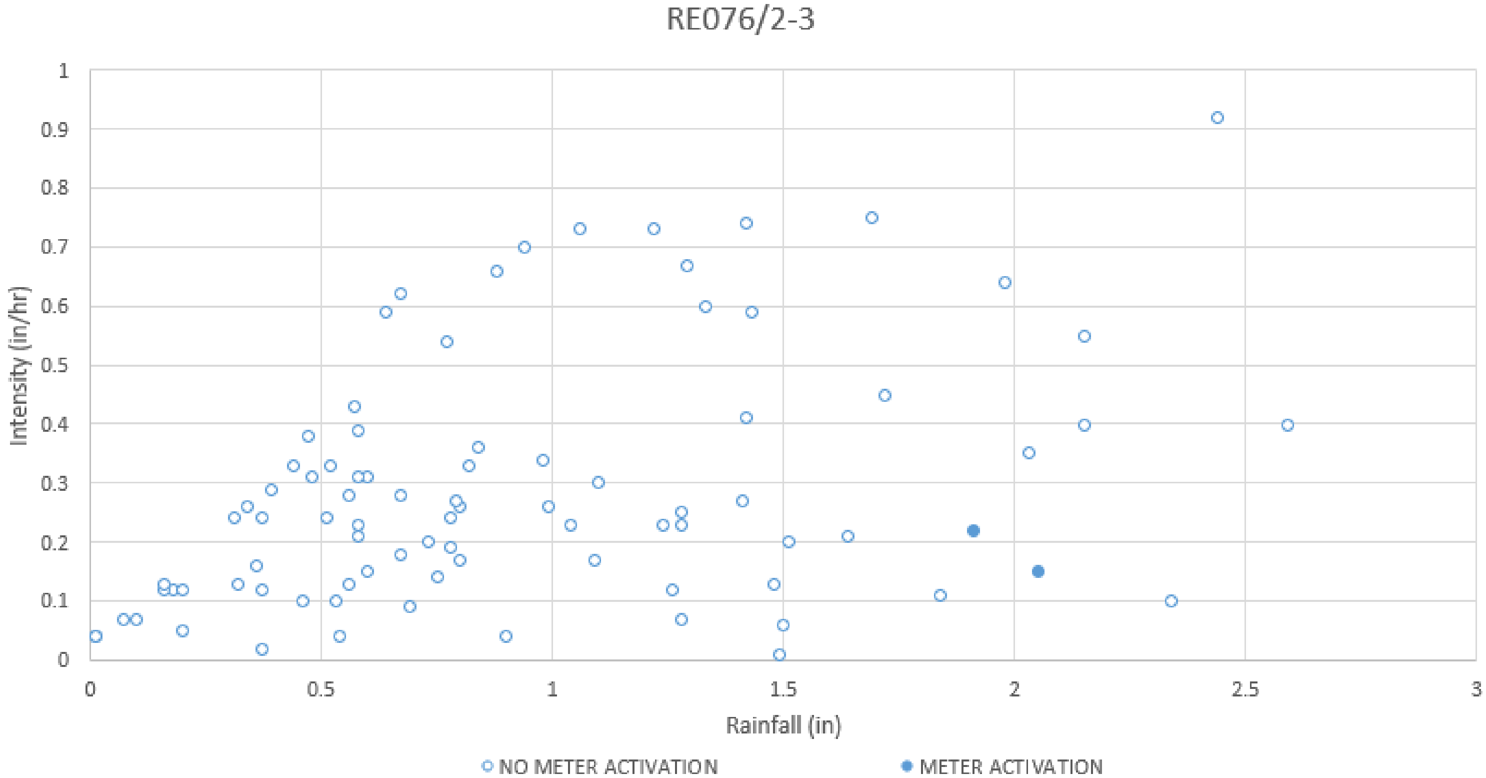
Outfall:BOS073
Regulator: RE073-4
Related Rain Gauge: 18



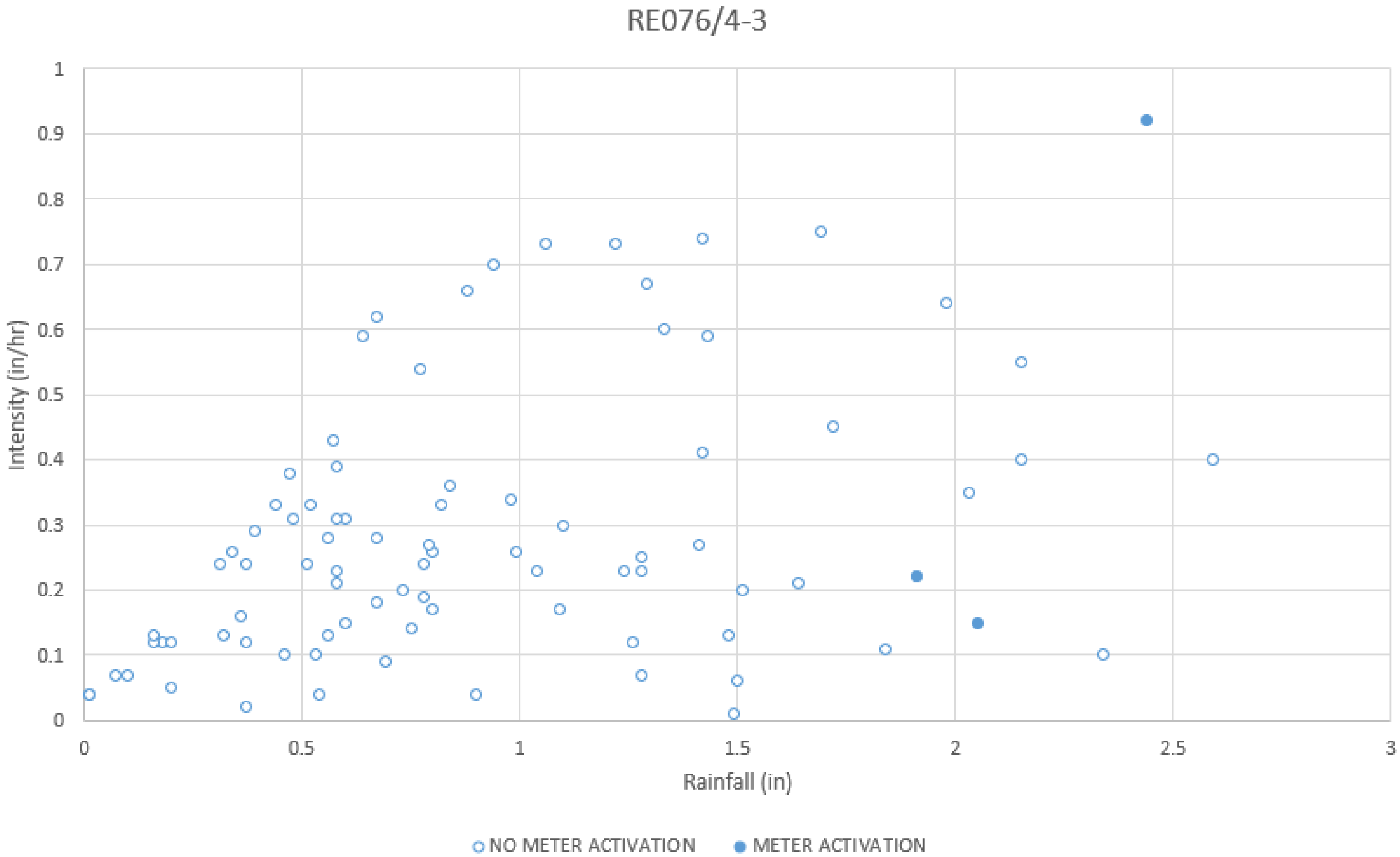
Reserved Channel

BOS076	RE076/2-3
	RE076/4-3
BOS078	RE078-1 RE078-2
BOS079	RE079-3
BOS080	RE080-2B

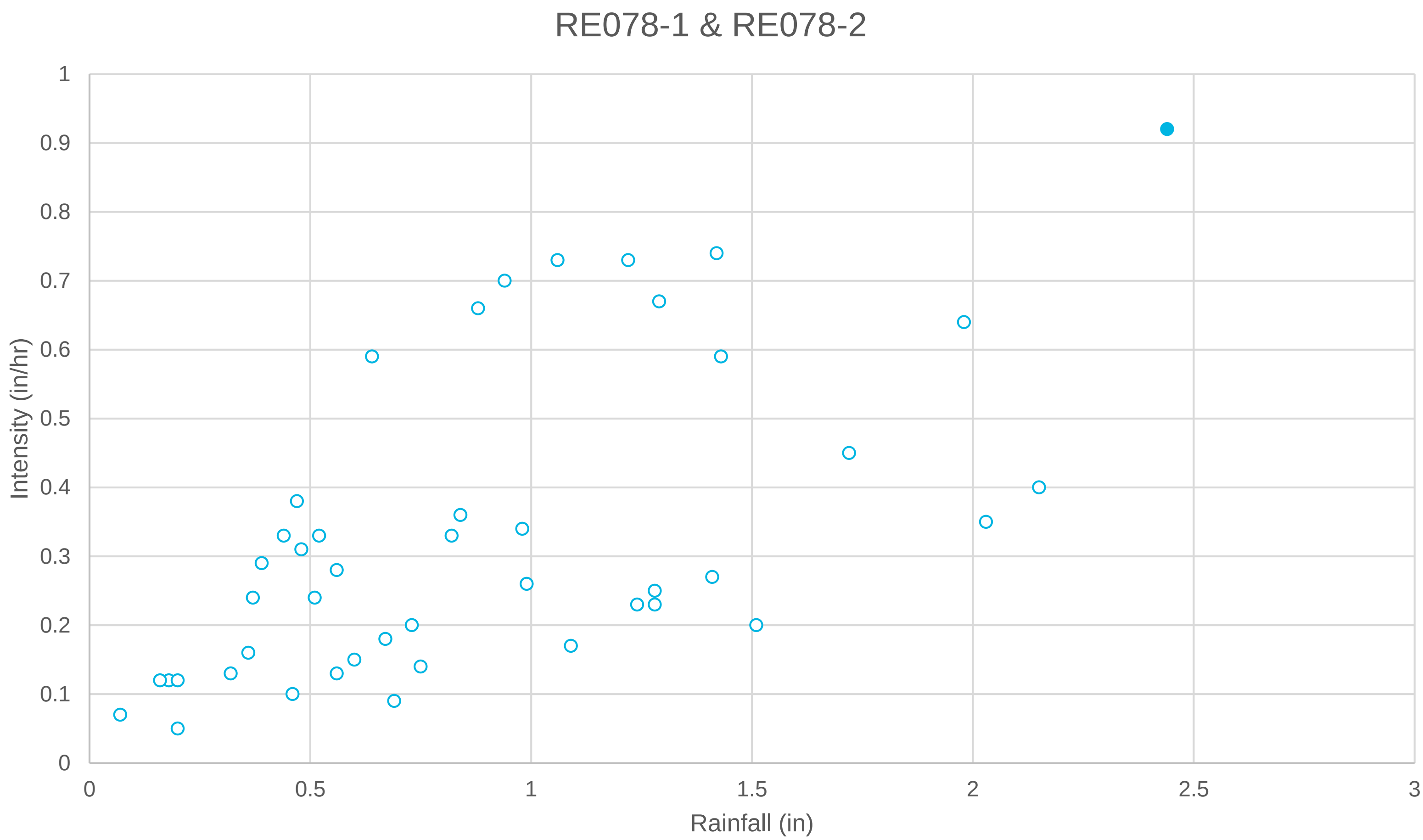
Outfall: BOS076
Regulator: RE076/2-3
Related Rain Gauge: 3



Outfall: BOS076
Regulator: RE076/4-3
Related Rain Gauge: 3

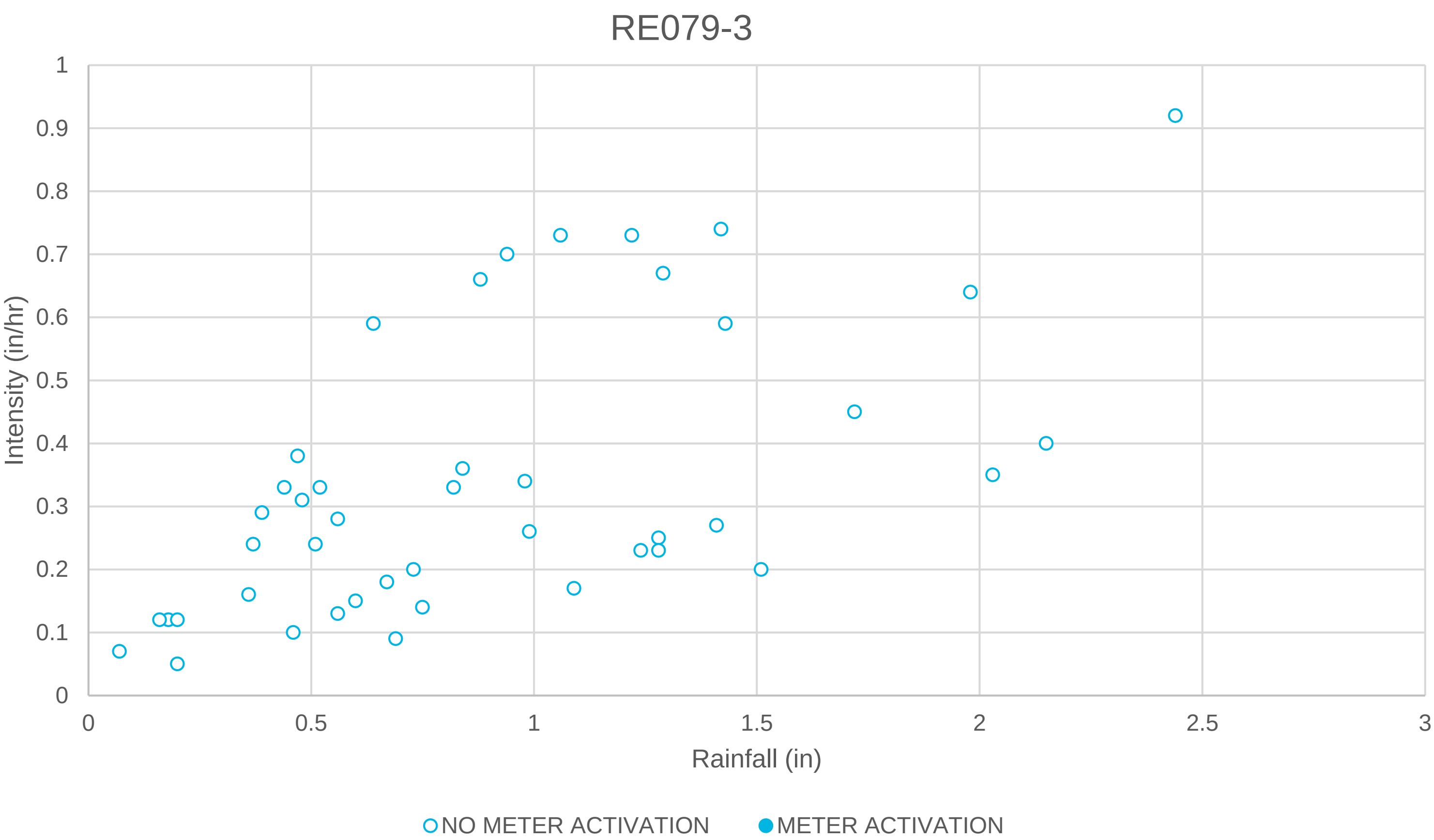


Outfall: BOS078
Regulator: RE078-1 & RE078-2
Related Rain Gauge: 3



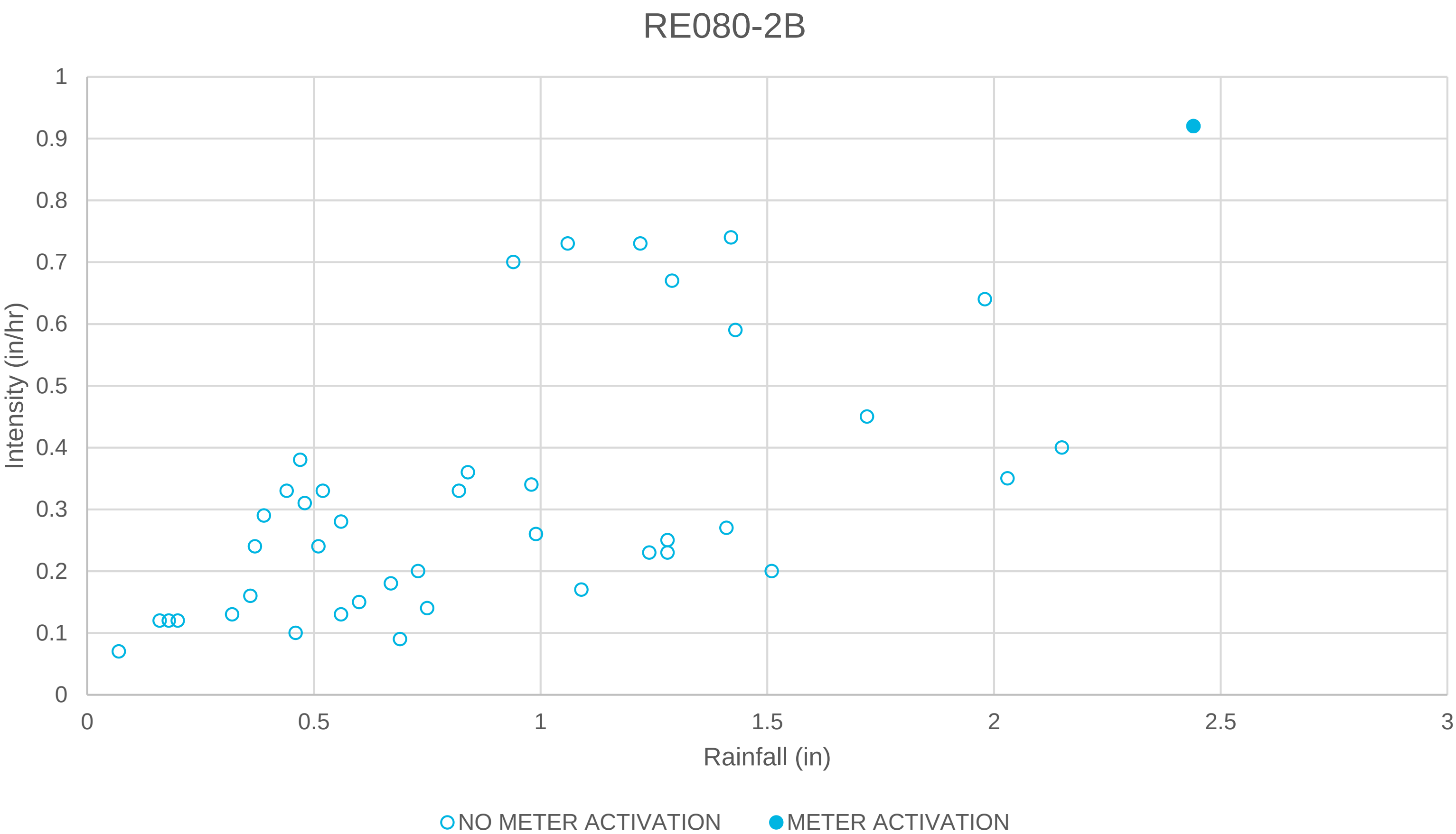
Meter was removed as of March 1, 2019. No activations were assessed following March 1, 2019.

Outfall: BOS079
Regulator: RE079-3
Related Rain Gauge: 3



Meter was removed as of March 1, 2019. No activations were assessed following March 1, 2019.

Outfall: BOS080
Regulator: RE080-2B
Related Rain Gauge: 3

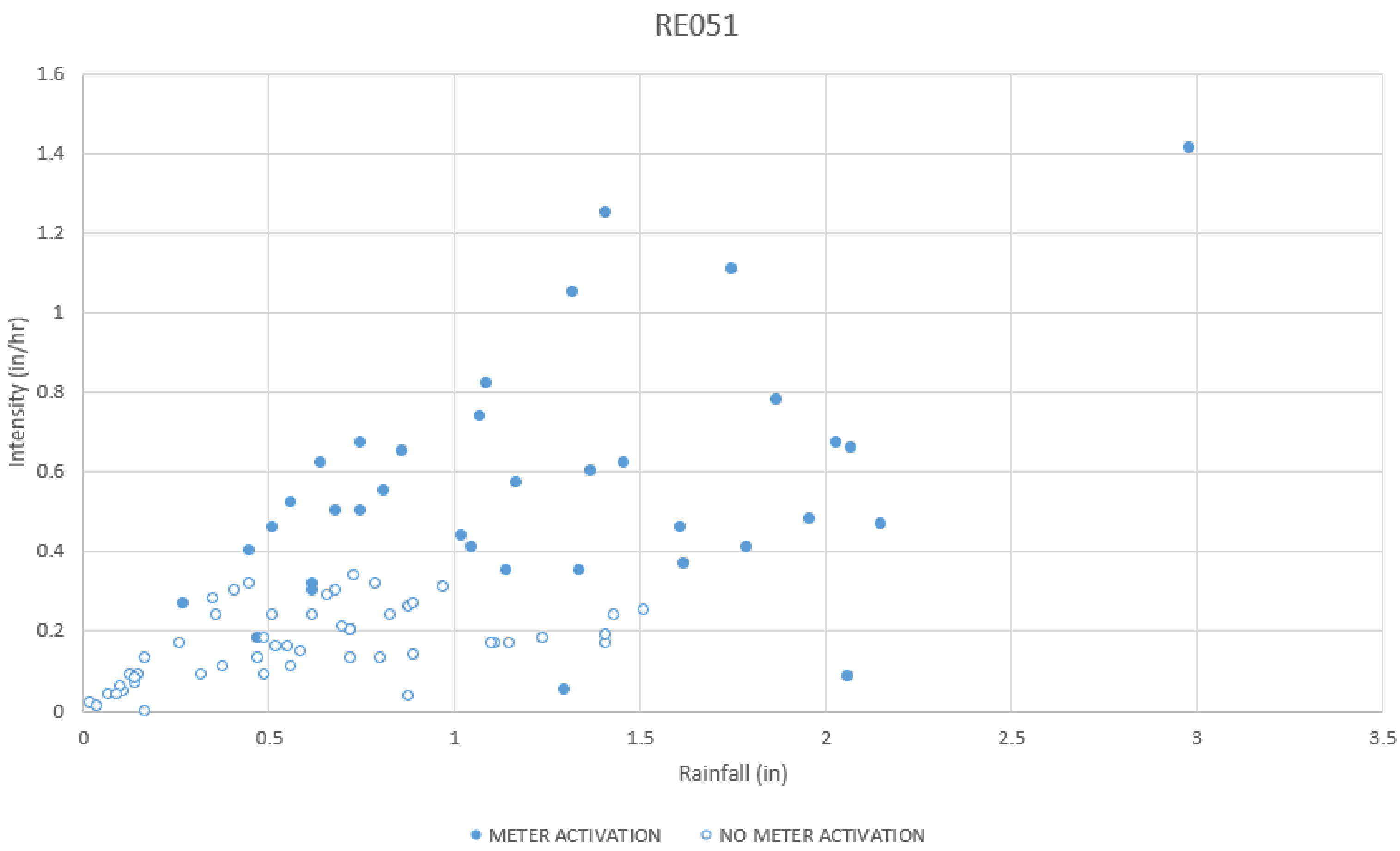


Meter was removed as of March 1, 2019. No activations were assessed following March 1, 2019.

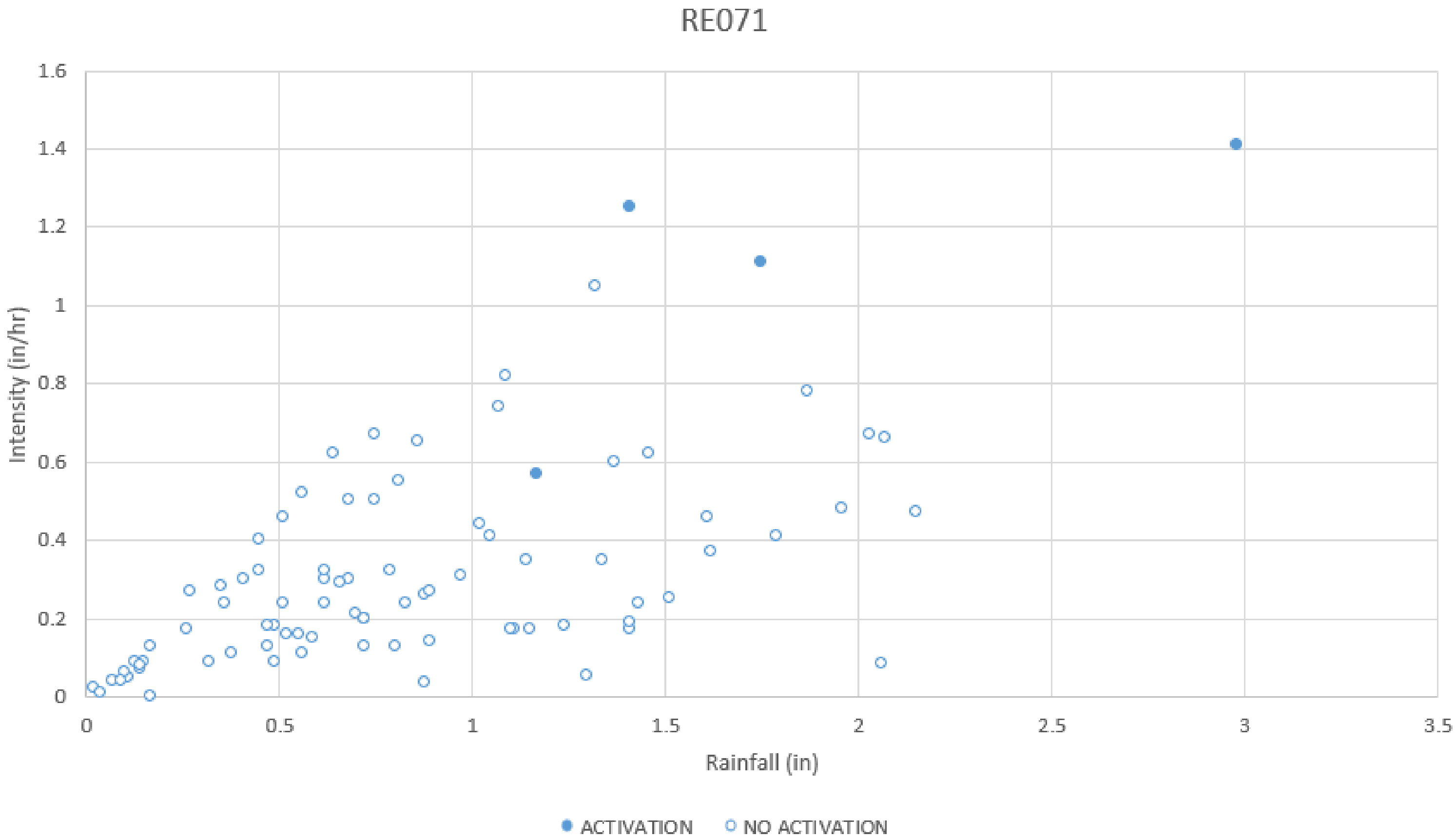
Upper Charles

CAM005	RE-051
CAM007	RE-071

Outfall:CAM005
Regulator: RE051
Related Rain Gauge: 19



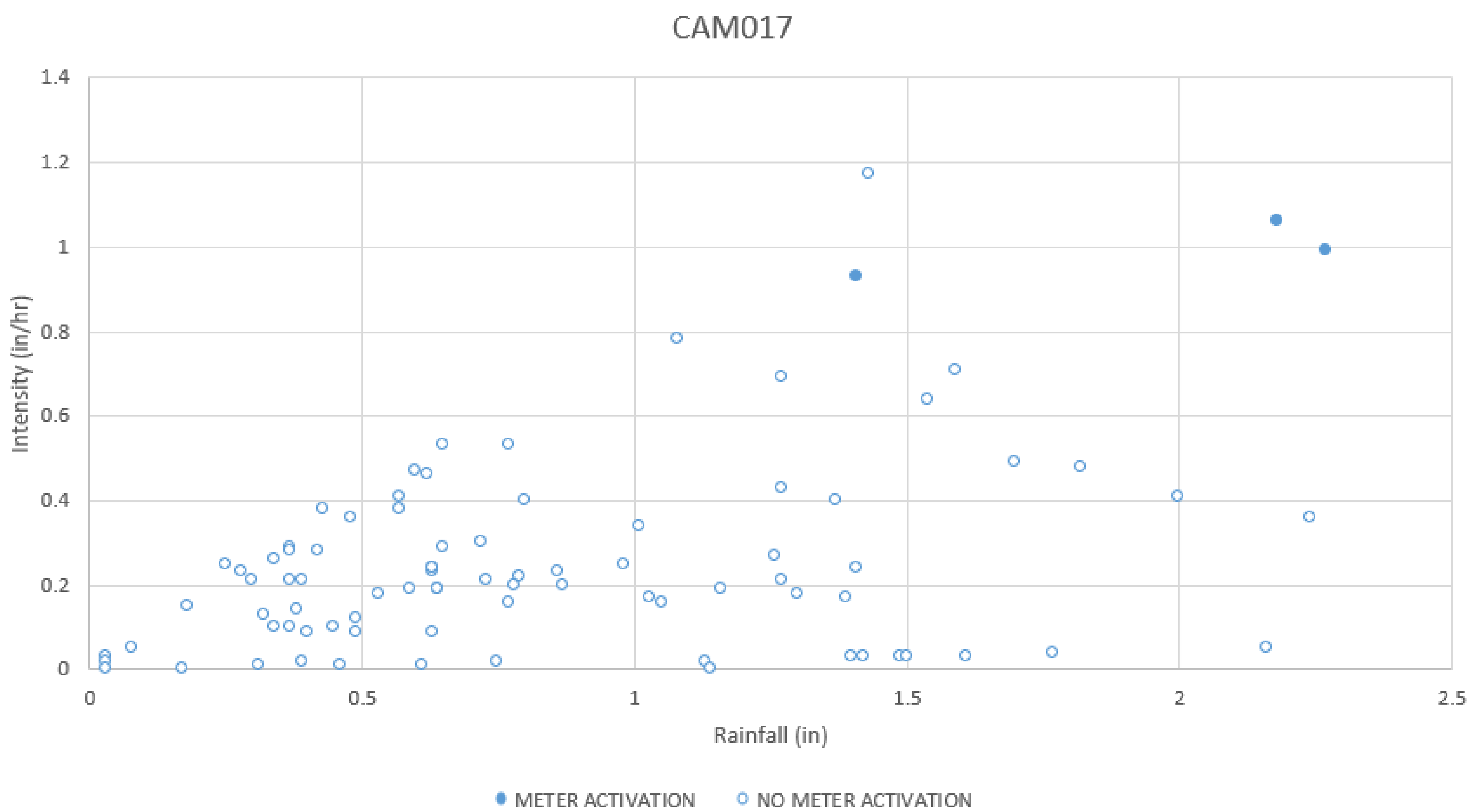
Outfall:CAM007
Regulator: RE071
Related Rain Gauge: 19



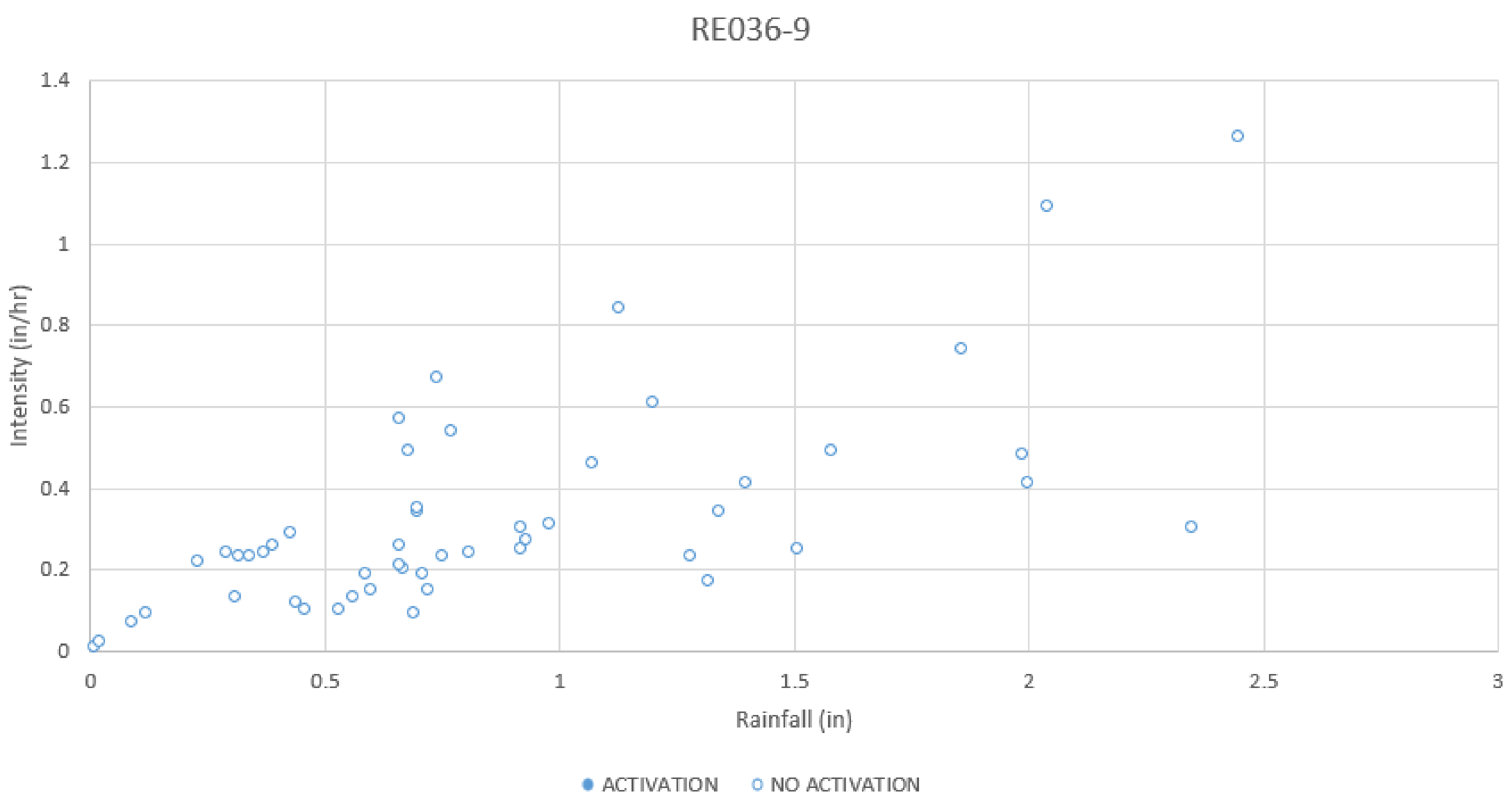
Lower Charles

CAM017	CAM017
MWR010	RE036-9
	RE037
MWR201	Cottage Farm
MWR023	RE046-19
	RE046-30
	RE046-50
	RE046-54
	RE046-55
	RE046-62A
	RE046-90
	RE046-100
	RE046-105
	RE046-381
	RE046-192

Outfall: CAM017
Regulator: CAM017
Related Rain Gauge: 4

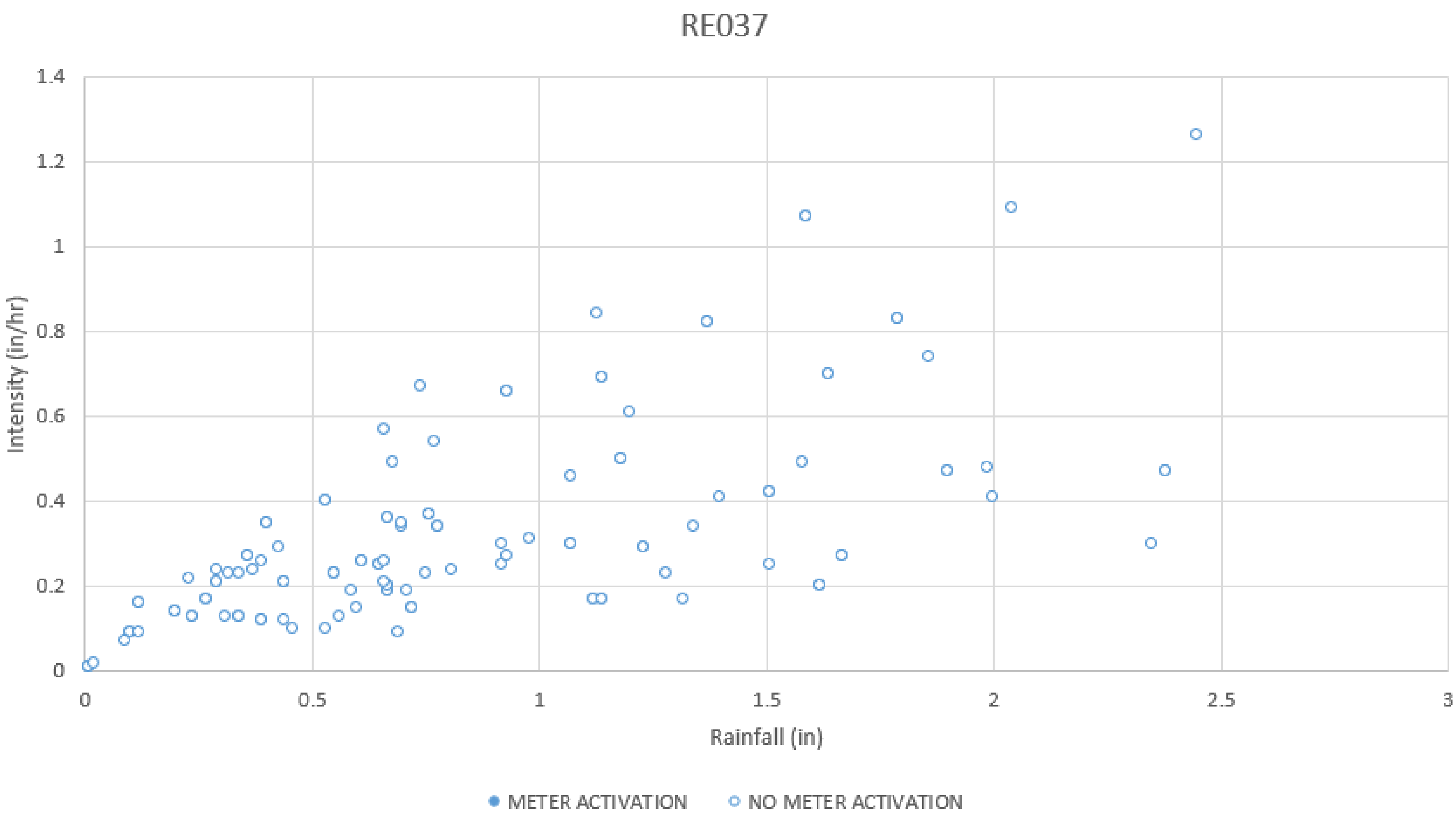


Outfall: MWR010
Regulator: RE036-9
Related Rain Gauge: 12

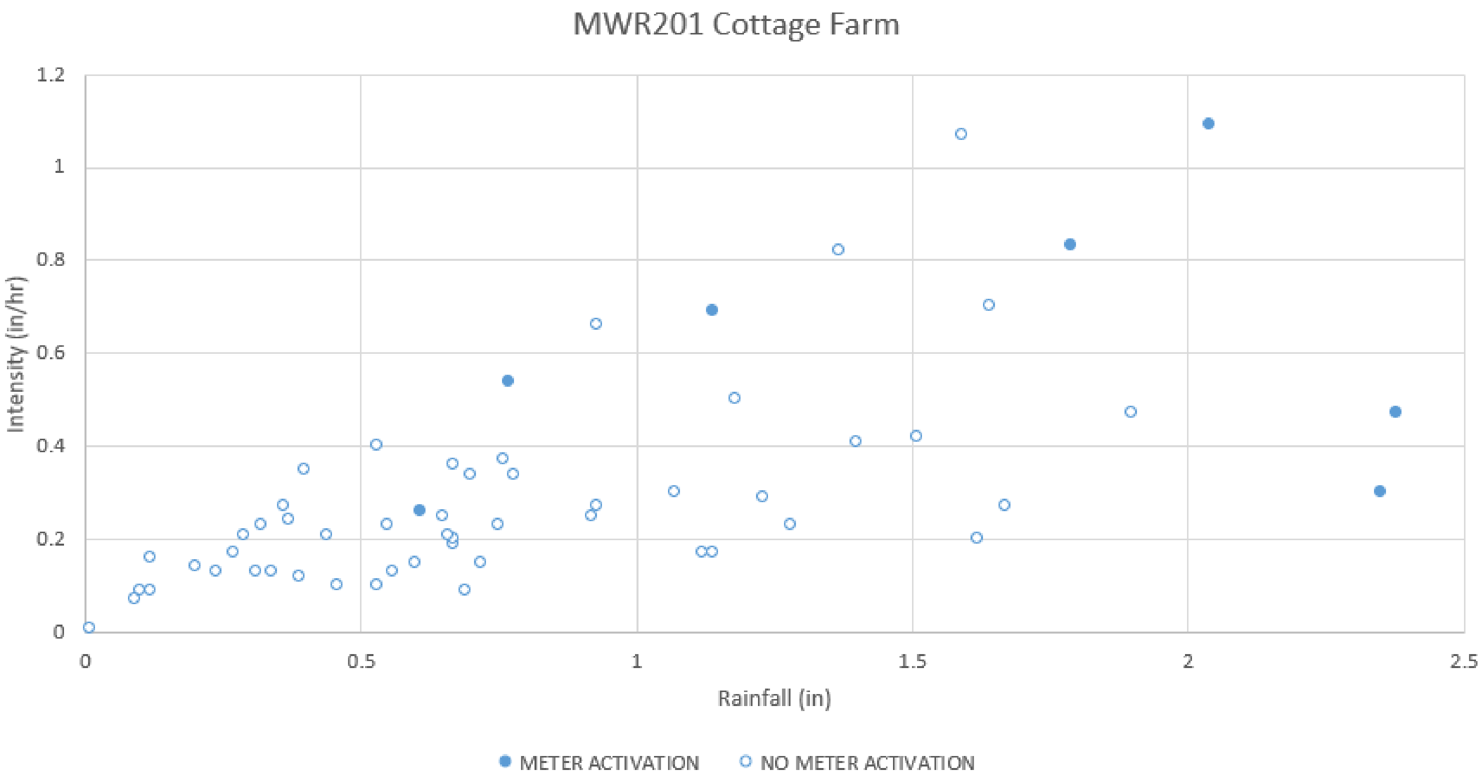


Metering data not available until December, 2018

Outfall: MWR010
Regulator: RE037
Related Rain Gauge: 12

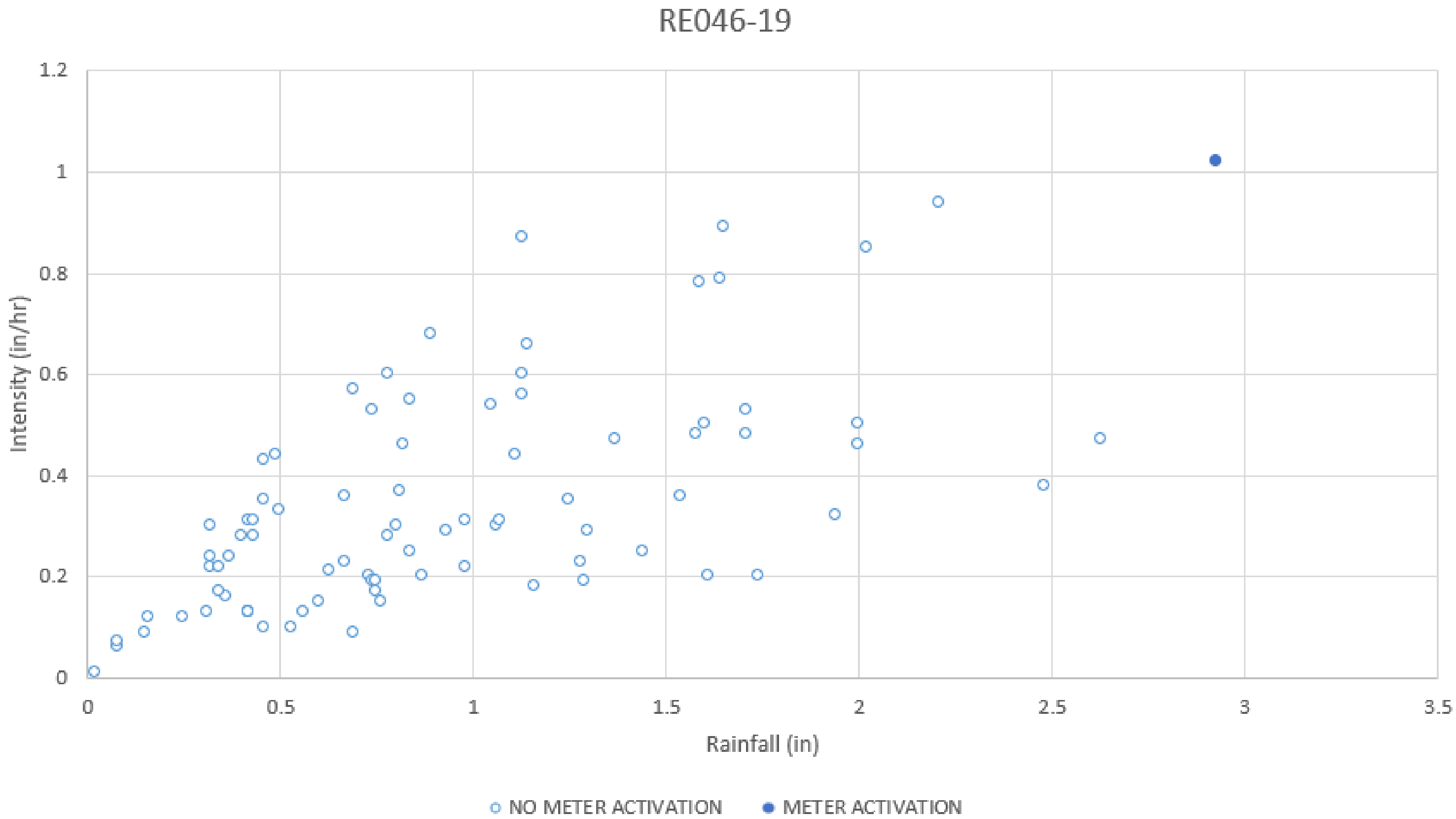


Outfall: MWR201 (Cottage Farm)
Regulator: RE042
Related Rain Gauge: 12

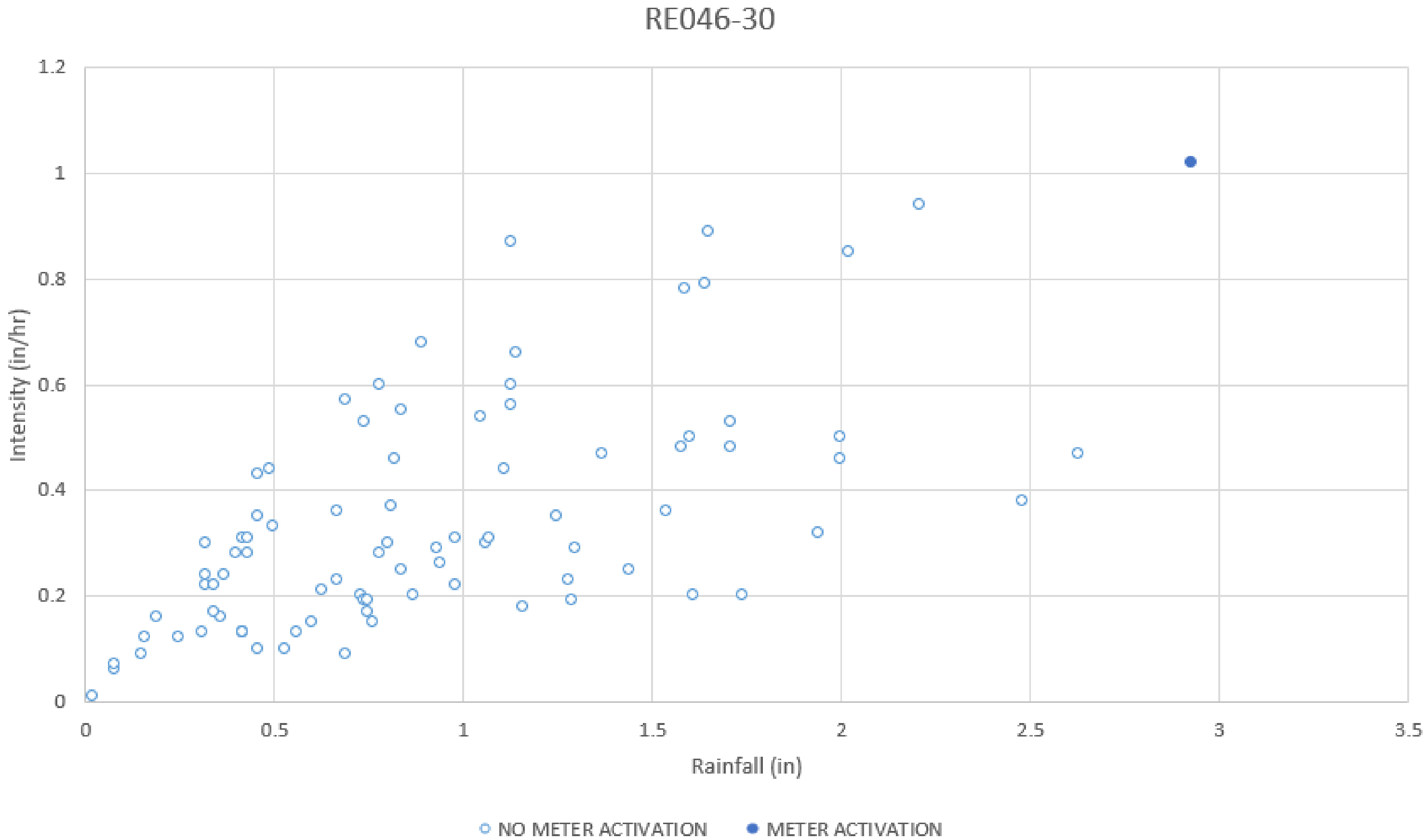


Meter activation represents an activation in which flow was discharged out of Cottage Farm

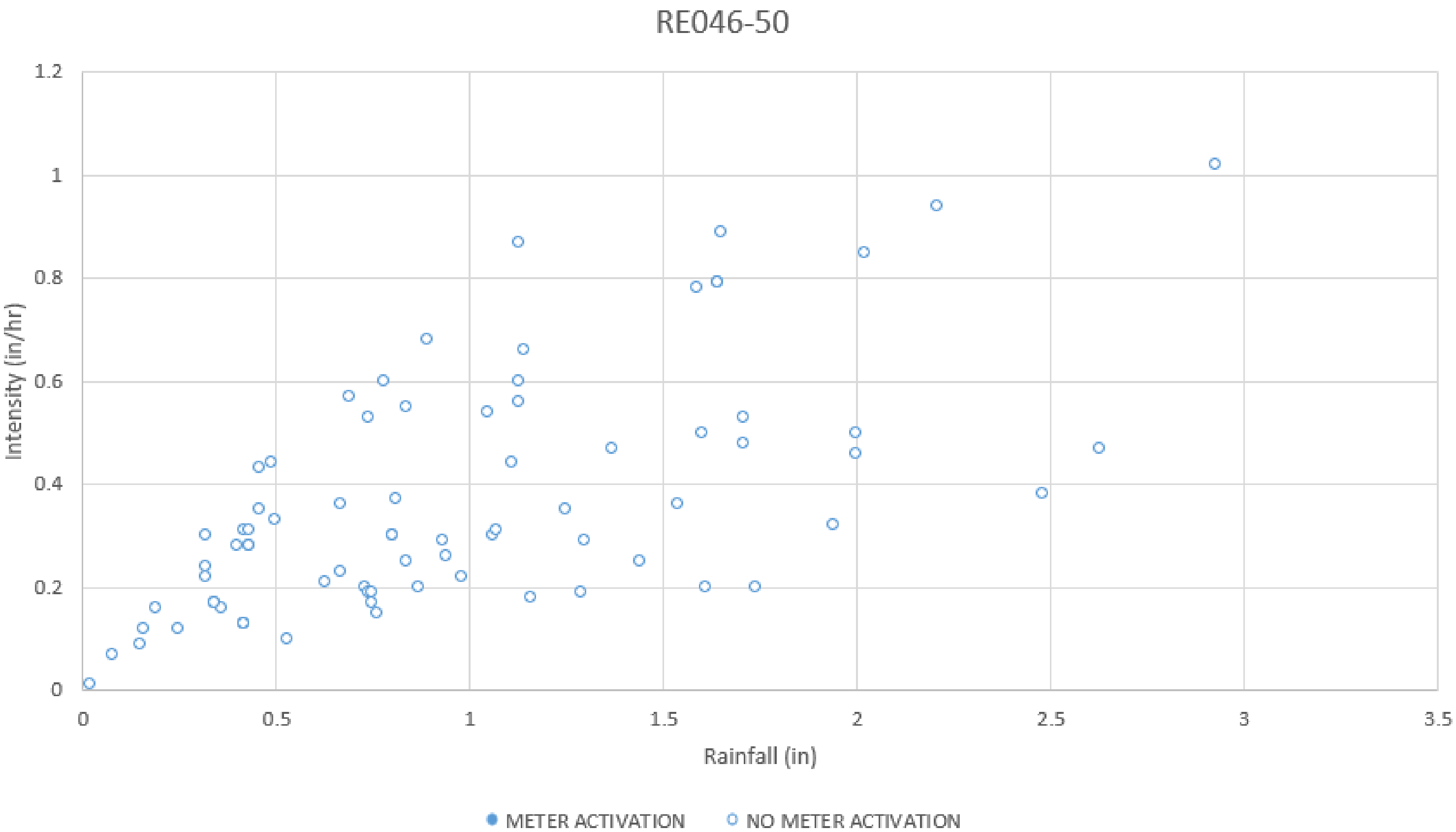
Outfall: MWR023
Regulator: RE046-19
Related Rain Gauge: 15



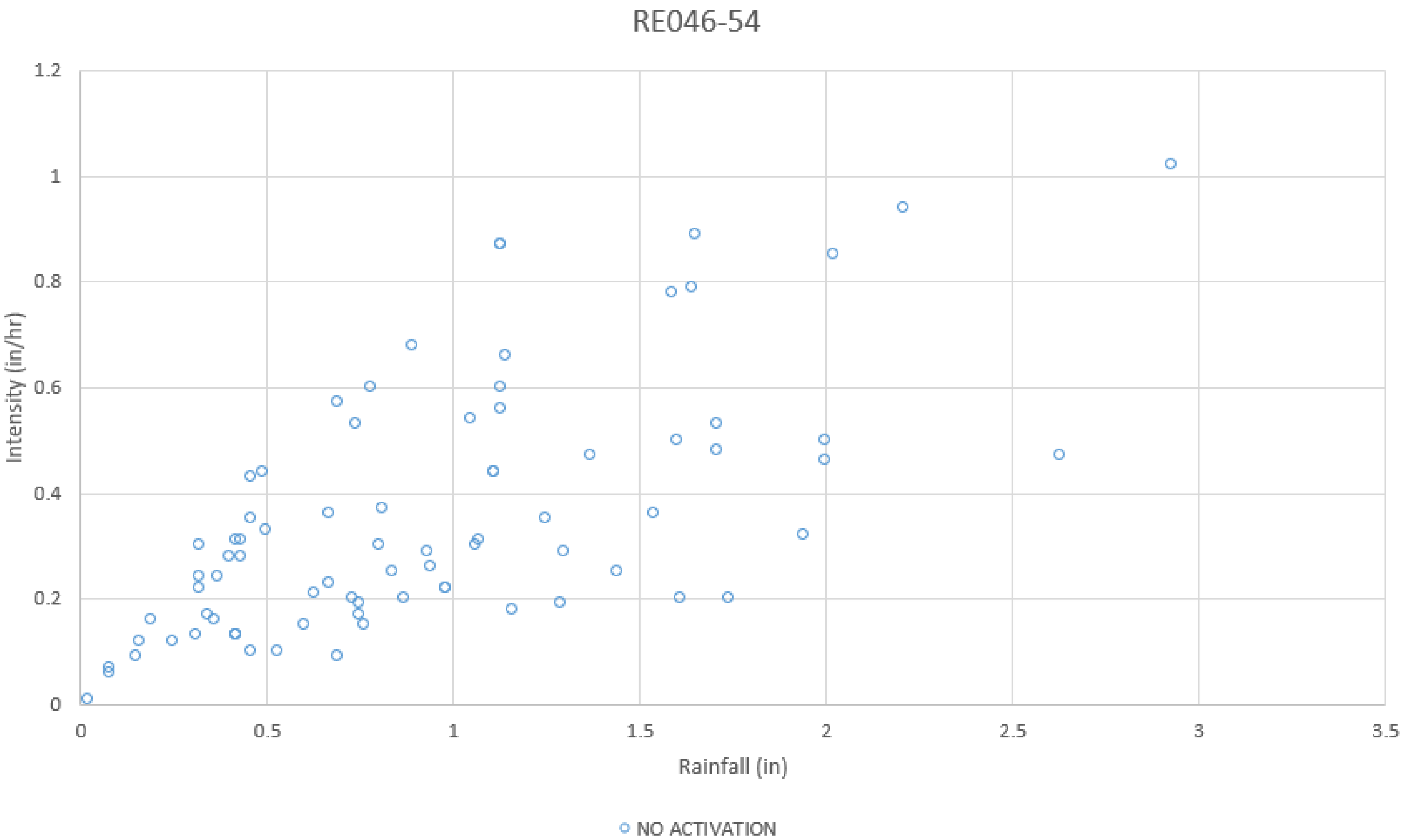
Outfall: MWR023
Regulator: RE046-30
Related Rain Gauge: 15



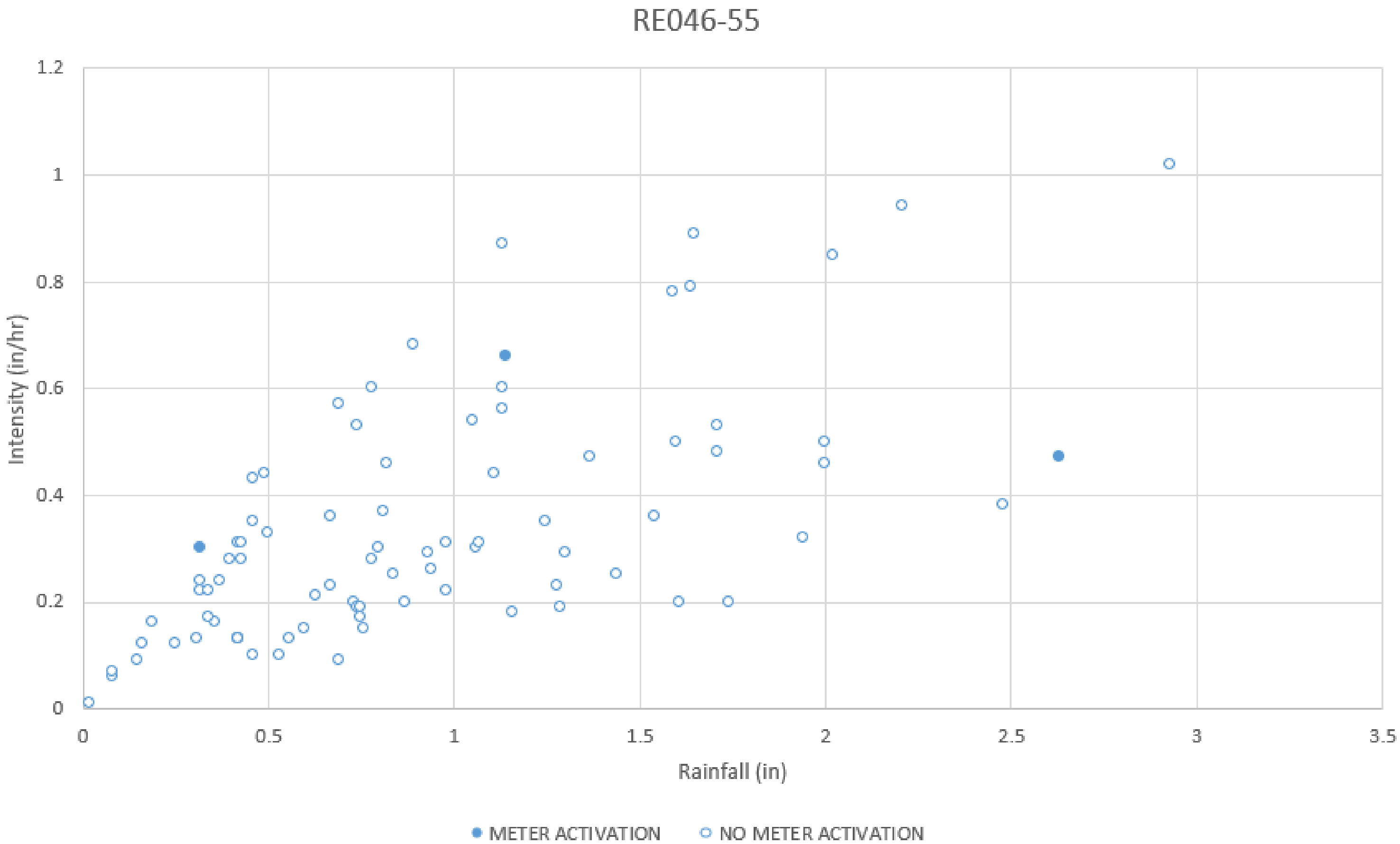
Outfall: MWR023
Regulator: RE046-50
Related Rain Gauge: 15



Outfall: MWR023
Regulator: RE046-54
Related Rain Gauge: 15

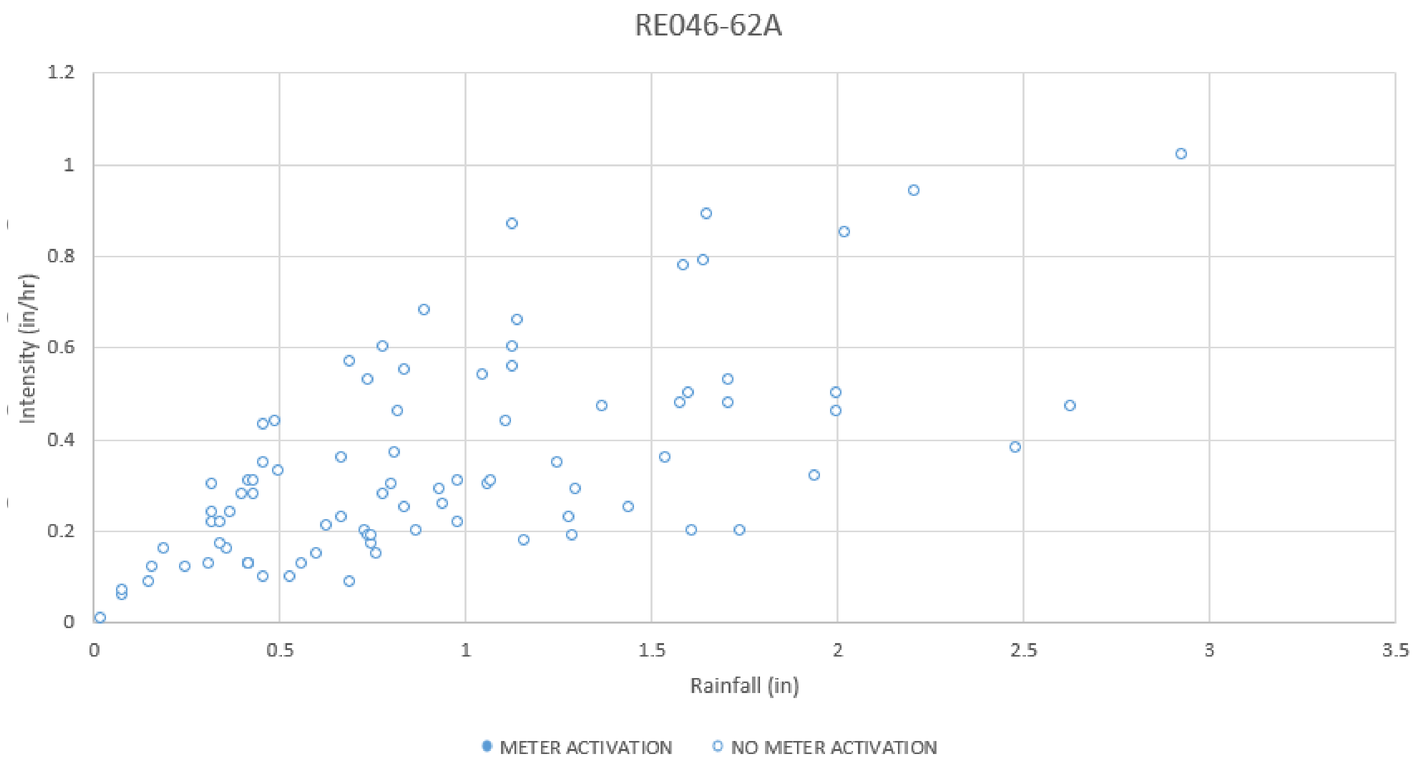


Outfall: MWR023
Regulator: RE046-55
Related Rain Gauge: 15

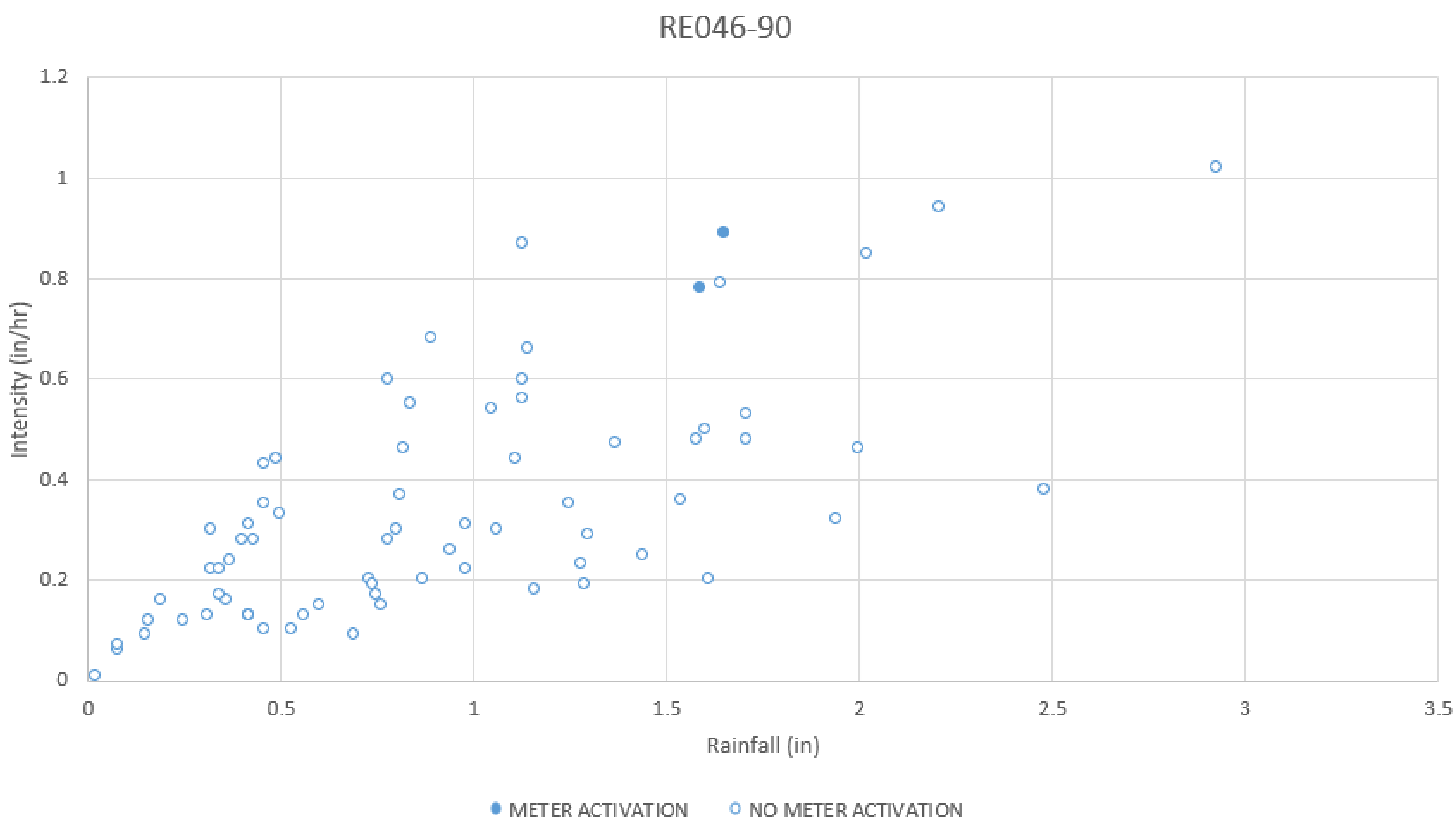


Blockage may have contributed to some activations prior to June 21, 2018.

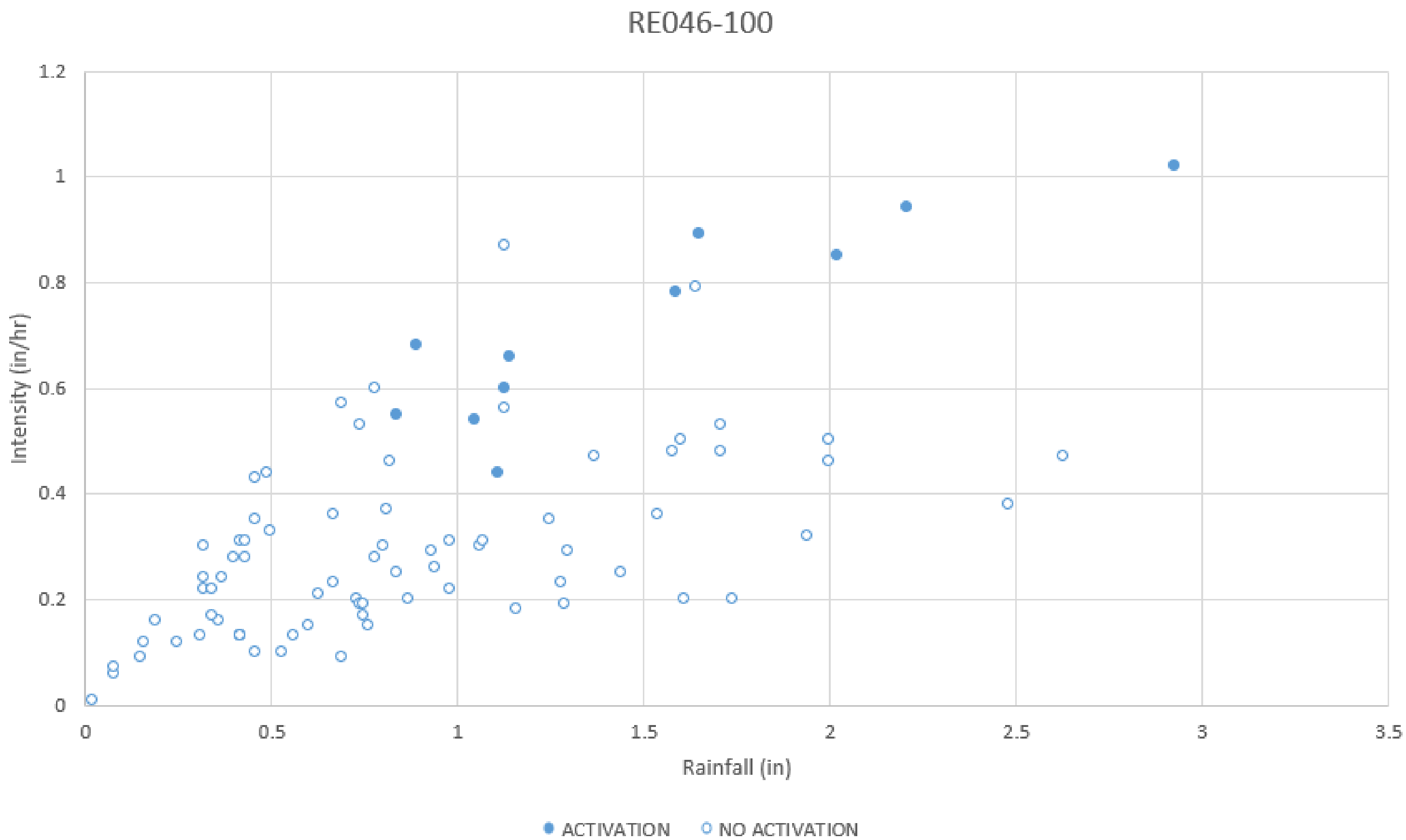
Outfall: MWR023
Regulator: RE046-62A
Related Rain Gauge: 15



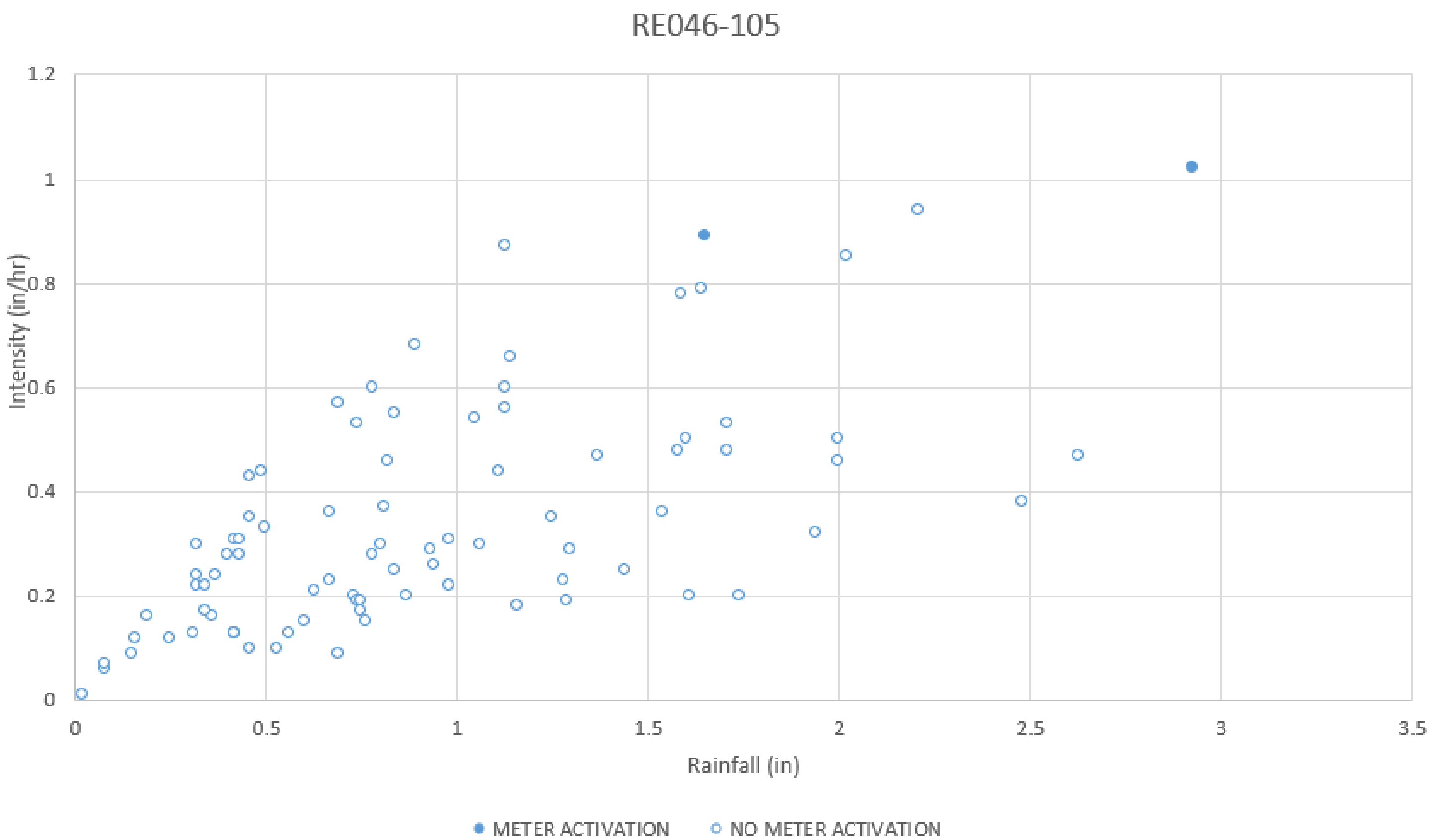
Outfall: MWR023
Regulator: RE046-90
Related Rain Gauge: 15



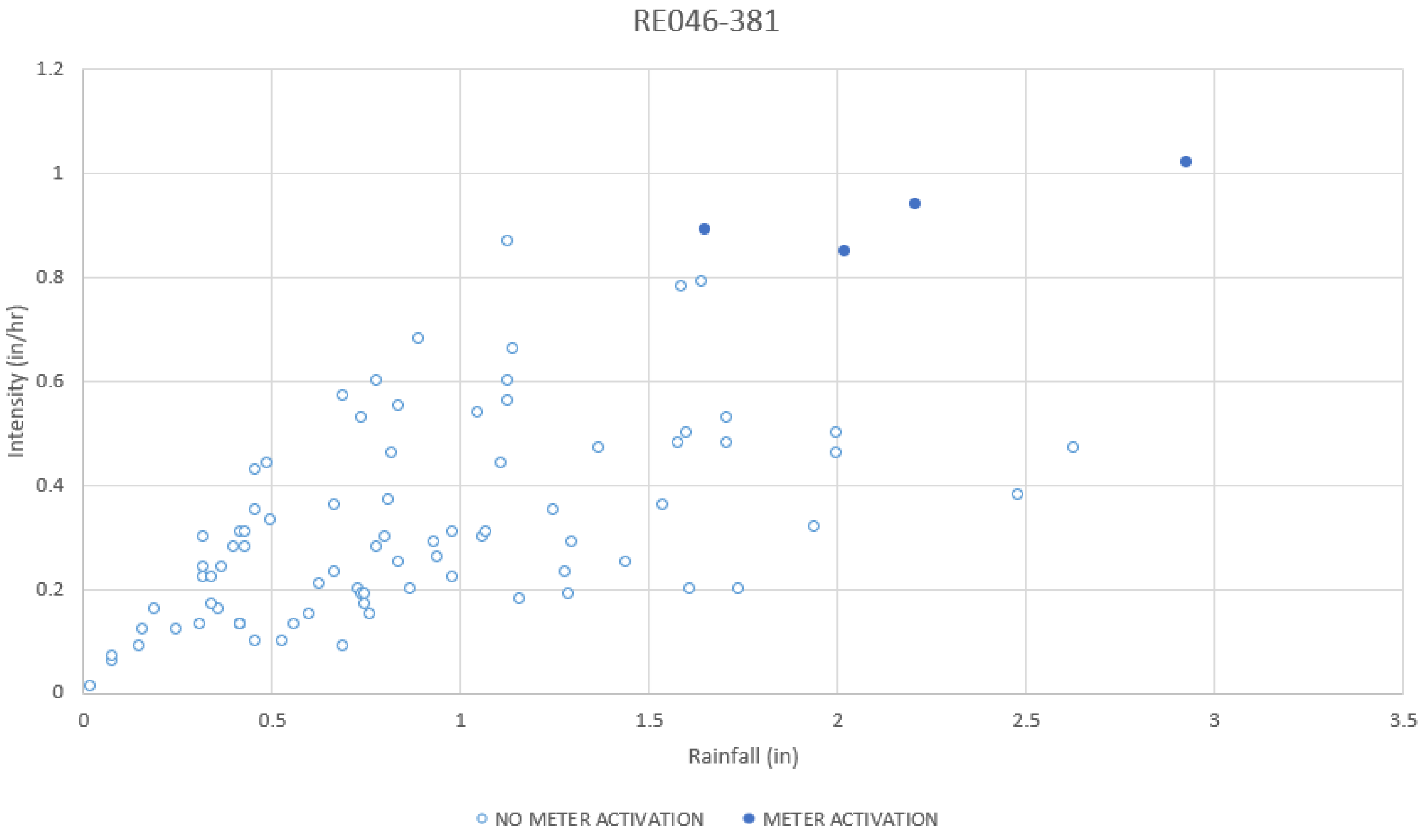
Outfall: MWR023
Regulator: RE046-100
Related Rain Gauge: 15



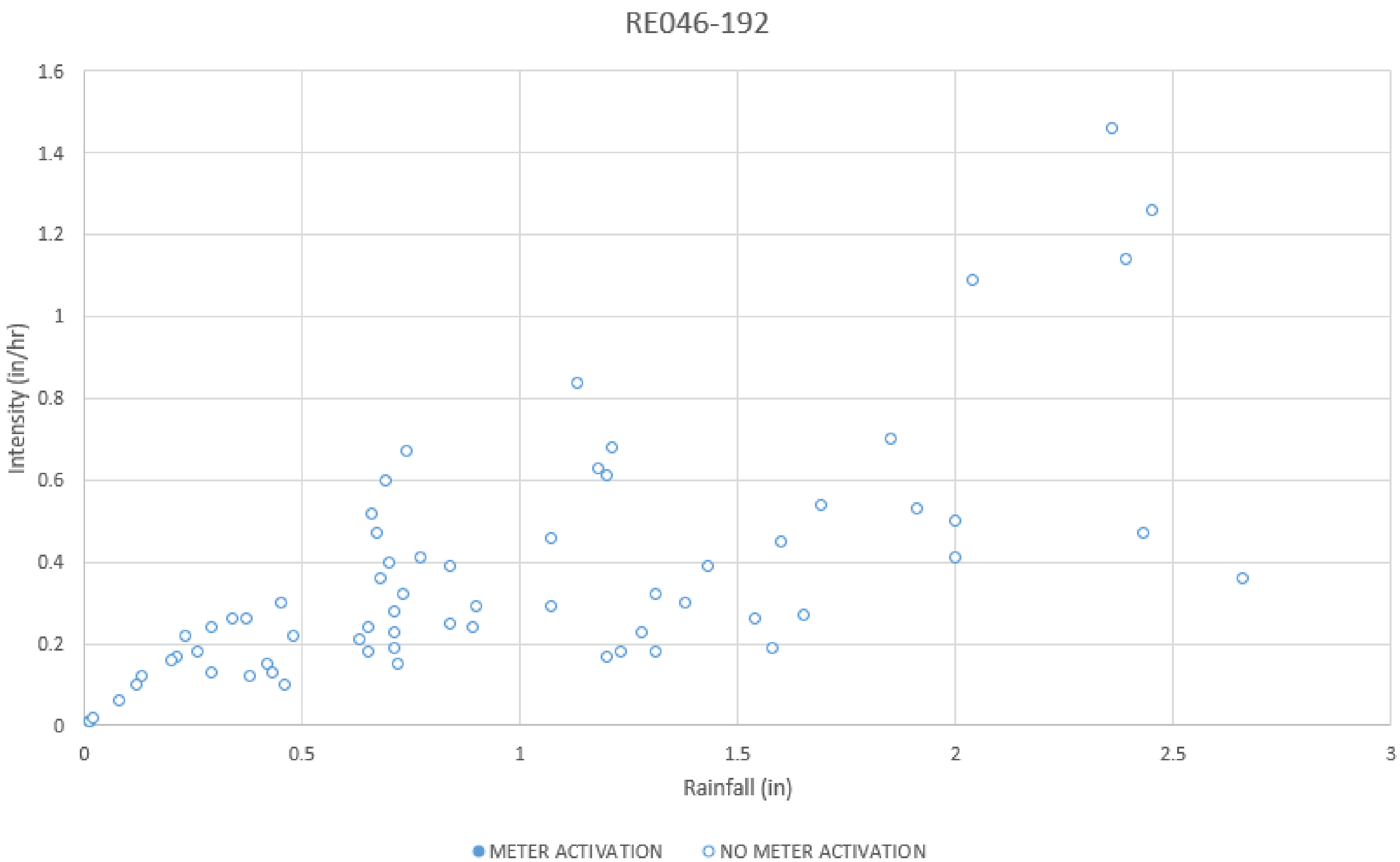
Outfall: MWR023
Regulator: RE046-105
Related Rain Gauge: 15



Outfall: MWR023
Regulator: RE046-381
Related Rain Gauge: 15



Outfall: MWR023
Regulator: RE046-192
Related Rain Gauge: 2



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

Appendix C 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	1/4/2020 10:30	18.25	0.25	0.01	0.05	0.01	0.01	<3m	<3m	N/A
2	1/12/2020 4:00	5.5	0.06	0.01	0.03	0.00	0.00	<3m	<3m	N/A
3	1/14/2020 21:15	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
4	1/16/2020 3:30	6	0.11	0.02	0.04	0.00	0.00	<3m	<3m	N/A
5	1/19/2020 9:30	3.5	0.32	0.09	0.24	0.01	0.01	<3m	<3m	N/A
6	1/25/2020 17:30	5.75	0.55	0.10	0.16	0.02	0.01	<3m	<3m	N/A
7	2/5/2020 1:30	4	0.05	0.01	0.02	0.00	0.00	<3m	<3m	N/A
8	2/6/2020 7:15	32.25	0.86	0.03	0	0.02	0.02	<3m	<3m	N/A
9	2/10/2020 3:45	8.25	0.16	0.02	0.08	0.01	0.00	<3m	<3m	N/A
10	2/11/2020 5:00	11.25	0.15	0.01	0.07	0.01	0.01	<3m	<3m	N/A
11	2/13/2020 1:00	13.25	0.55	0.04	0.17	0.02	0.01	<3m	<3m	N/A
12	2/18/2020 12:30	9.75	0.45	0.05	0.1	0.02	0.01	<3m	<3m	N/A
13	2/25/2020 20:30	6.75	0.35	0.05	0.11	0.01	0.01	<3m	<3m	N/A
14	2/27/2020 1:30	7.75	0.88	0.11	0.26	0.04	0.03	<3m	<3m	N/A
15	3/3/2020 19:15	6.75	0.04	0.01	0.02	0.00	0.00	<3m	<3m	N/A
16	3/13/2020 1:00	15.25	0.45	0.03	0.11	0.02	0.01	<3m	<3m	N/A
17	3/17/2020 7:30	0.25	0.01	0.04	0	0.00	0.00	<3m	<3m	N/A
18	3/19/2020 4:15	26.5	0.66	0.02	0.16	0.03	0.01	<3m	<3m	N/A
19	3/23/2020 14:30	15	1.96	0.13	0.48	0.08	0.04	<3m	3m	N/A
20	3/28/2020 20:00	26.75	0.86	0.03	0.12	0.03	0.02	<3m	<3m	N/A
21	3/30/2020 16:45	10.25	0.11	0.01	0	0.00	0.00	<3m	<3m	N/A
22	4/2/2020 14:30	36.5	1.24	0.03	0.18	0.04	0.03	<3m	<3m	N/A
23	4/8/2020 5:15	2.75	0.06	0.02	0.24	0.00	0.00	<3m	<3m	N/A
24	4/9/2020 9:45	8.5	0.62	0.07	0.24	0.03	0.01	<3m	<3m	N/A
25	4/10/2020 15:15	0.5	0.03	0.06	0.03	0.01	0.01	<3m	<3m	N/A
26	4/13/2020 4:15	15.25	0.83	0.05	0.24	0.03	0.02	<3m	<3m	N/A
27	4/18/2020 0:00	11.5	0.7	0.06	0.21	0.03	0.01	<3m	<3m	N/A
28	4/21/2020 15:00	3	0.36	0.12	0.24	0.02	0.01	<3m	<3m	N/A
29	4/24/2020 3:30	11.5	0.19	0.02	0.04	0.01	0.00	<3m	<3m	N/A
30	4/26/2020 13:15	33.25	0.9	0.03	0.08	0.03	0.02	<3m	<3m	N/A
31	4/30/2020 8:30	0.25	0.01	0.04	0	0.00	0.00	<3m	<3m	N/A
32	5/1/2020 1:00	24.5	0.89	0.04	0.27	0.04	0.00	<3m	<3m	N/A
33	5/7/2020 1:00	0.25	0.01	0.04	0.32	0.00	0.00	<3m	<3m	N/A
34	5/8/2020 18:00	14.75	0.38	0.03	0.06	0.02	0.01	<3m	<3m	N/A
35	5/11/2020 16:00	5	0.3	0.06	0.21	0.01	0.01	<3m	<3m	N/A
36	5/15/2020 1:15	1	0.04	0.04	0.04	0.00	0.00	<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
37	5/15/2020 20:00	5	0.62	0.12	0.32	0.03	0.01	<3m	<3m	N/A
38	5/30/2020 2:45	0.5	0.13	0.26	0	0.00	0.00	<3m	<3m	N/A
39	6/2/2020 18:30	0.5	0.03	0.06	0.03	0.00	0.00	<3m	<3m	N/A
40	6/5/2020 3:45	0.75	0.23	0.31	0.23	0.01	0.00	<3m	<3m	N/A
41	6/6/2020 14:30	6.75	0.27	0.04	0.17	0.01	0.01	<3m	<3m	N/A
42	6/11/2020 12:00	6	0.64	0.11	0.46	0.03	0.01	<3m	<3m	N/A
43	6/24/2020 17:30	0.25	0.05	0.20	0	0.00	0.00	<3m	<3m	N/A
44	6/27/2020 14:30	1.25	0.03	0.02	0.02	0.00	0.00	<3m	<3m	N/A
45	6/28/2020 12:15	49.75	1.83	0.04	1.09	0.07	0.04	1-2yr	<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 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	1/4/2020 10:30	22.5	0.28	0.01	0.05	0.01	0.01	<3m	<3m	N/A
2	1/8/2020 1:30	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
3	1/12/2020 4:00	6.5	0.06	0.01	0.04	0.00	0.00	<3m	<3m	N/A
4	1/16/2020 3:30	5.75	0.08	0.01	0.04	0.00	0.00	<3m	<3m	N/A
5	1/18/2020 18:30	16.75	0.3	0.02	0.09	0.01	0.01	<3m	<3m	N/A
6	1/25/2020 17:30	4.75	0.63	0.13	0.21	0.03	0.01	<3m	<3m	N/A
7	2/5/2020 1:45	4	0.04	0.01	0.02	0.00	0.00	<3m	<3m	N/A
8	2/6/2020 2:45	35	0.8	0.02	0.15	0.02	0.02	<3m	<3m	N/A
9	2/10/2020 4:30	10	0.15	0.02	0.08	0.01	0.00	<3m	<3m	N/A
10	2/11/2020 5:15	14.25	0.17	0.01	0.07	0.01	0.01	<3m	<3m	N/A
11	2/13/2020 1:15	13.5	0.55	0.04	0.16	0.02	0.01	<3m	<3m	N/A
12	2/18/2020 15:00	7.25	0.46	0.06	0.10	0.02	0.01	<3m	<3m	N/A
13	2/25/2020 20:45	6.25	0.42	0.07	0.11	0.02	0.01	<3m	<3m	N/A
14	2/27/2020 1:15	8	0.84	0.11	0.25	0.04	0.03	<3m	<3m	N/A
15	3/3/2020 19:45	6.5	0.04	0.01	0.02	0.00	0.00	<3m	<3m	N/A
16	3/13/2020 1:00	14	0.35	0.03	0.12	0.01	0.01	<3m	<3m	N/A
17	3/17/2020 8:15	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
18	3/19/2020 4:30	26.5	0.68	0.03	0.17	0.03	0.01	<3m	<3m	N/A
19	3/23/2020 14:30	15	2.00	0.13	0.50	0.08	0.04	<3m	3m	N/A
20	3/28/2020 20:15	26.75	0.97	0.04	0.15	0.04	0.02	<3m	<3m	N/A
21	3/30/2020 14:00	5.5	0.1	0.02	0	0.00	0.00	<3m	<3m	N/A
22	4/2/2020 13:30	37.25	1.31	0.04	0.18	0.04	0.03	<3m	<3m	N/A
23	4/8/2020 5:15	3.25	0.06	0.02	0.24	0.00	0.00	<3m	<3m	N/A
24	4/9/2020 10:00	8.5	0.65	0.08	0.24	0.03	0.01	<3m	<3m	N/A
25	4/10/2020 15:15	0.5	0.02	0.04	0.03	0.01	0.01	<3m	<3m	N/A
26	4/13/2020 4:30	15.25	0.89	0.06	0.24	0.03	0.02	<3m	<3m	N/A
27	4/18/2020 0:00	9	0.72	0.08	0.15	0.02	0.01	<3m	<3m	N/A
28	4/21/2020 15:15	2.75	0.41	0.15	0.24	0.02	0.01	<3m	<3m	N/A
29	4/24/2020 3:45	11.75	0.2	0.02	0.04	0.01	0.00	<3m	<3m	N/A
30	4/26/2020 13:45	32.25	0.85	0.03	0.08	0.03	0.02	<3m	<3m	N/A
31	4/30/2020 10:00	0.25	0.01	0.04	0	0.00	0.00	<3m	<3m	N/A
32	5/1/2020 2:15	24.5	0.9	0.04	0.29	0.04	0.00	<3m	<3m	N/A
33	5/6/2020 23:00	4	0.02	0.01	0.01	0.00	0.00	<3m	<3m	N/A
34	5/8/2020 18:00	14.5	0.39	0.03	0.07	0.02	0.01	<3m	<3m	N/A
35	5/11/2020 16:15	4.75	0.36	0.08	0.26	0.02	0.01	<3m	<3m	N/A
36	5/15/2020 1:15	1.75	0.05	0.03	0.04	0.00	0.00	<3m	<3m	N/A
37	5/15/2020 20:00	5	0.7	0.14	0.40	0.03	0.02	<3m	<3m	N/A
38	5/30/2020 2:15	1	0.2	0.20	0	0.00	0.00	<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	6/2/2020 18:30	0.5	0.02	0.04	0.02	0.00	0.00	<3m	<3m	N/A
40	6/5/2020 3:45	2.5	0.12	0.05	0.11	0.01	0.00	<3m	<3m	N/A
41	6/6/2020 14:30	6.5	0.69	0.11	0.60	0.03	0.02	3m	<3m	N/A
42	6/11/2020 12:15	5.75	0.67	0.12	0.47	0.03	0.01	<3m	<3m	N/A
43	6/24/2020 18:30	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
44	6/27/2020 15:15	0.5	0.02	0.04	0.02	0.00	0.00	<3m	<3m	N/A
45	6/28/2020 12:30	48.5	2.04	0.04	1.09	0.08	0.04	1-2yr	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	1/4/2020 10:30	22.5	0.28	0.01	0.05	0.01	0.01	<3m	<3m	N/A
2	1/8/2020 1:30	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
3	1/12/2020 4:00	1	0.04	0.04	0.04	0.00	0.00	<3m	<3m	N/A
4	1/13/2020 9:00	9.25	0.02	0.00	0.01	0.00	0.00	<3m	<3m	N/A
5	1/16/2020 3:30	8.25	0.1	0.01	0.04	0.00	0.00	<3m	<3m	N/A
6	1/19/2020 9:30	2.75	0.29	0.11	0.20	0.01	0.01	<3m	<3m	N/A
7	1/25/2020 17:30	4.75	0.58	0.12	0.23	0.02	0.01	<3m	<3m	N/A
8	2/5/2020 1:30	4.5	0.06	0.01	0.03	0.00	0.00	<3m	<3m	N/A
9	2/6/2020 4:15	34.25	0.93	0.03	0.14	0.02	0.02	<3m	<3m	N/A
10	2/10/2020 5:15	9.25	0.13	0.01	0.07	0.01	0.00	<3m	<3m	N/A
11	2/11/2020 5:00	11.75	0.19	0.02	0.07	0.01	0.01	<3m	<3m	N/A
12	2/13/2020 1:00	14	0.59	0.04	0.16	0.02	0.01	<3m	<3m	N/A
13	2/18/2020 15:00	7	0.44	0.06	0.10	0.02	0.01	<3m	<3m	N/A
14	2/25/2020 20:45	6.25	0.47	0.08	0.16	0.02	0.01	<3m	<3m	N/A
15	2/27/2020 0:15	16.25	0.78	0.05	0.24	0.03	0.03	<3m	<3m	N/A
16	3/3/2020 19:00	7.5	0.04	0.01	0.02	0.00	0.00	<3m	<3m	N/A
17	3/13/2020 0:45	10.75	0.21	0.02	0.09	0.01	0.00	<3m	<3m	N/A
18	3/17/2020 8:00	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
19	3/19/2020 4:30	24.25	0.68	0.03	0.20	0.03	0.01	<3m	<3m	N/A
20	3/23/2020 14:30	23.25	2.15	0.09	0.55	0.09	0.04	3m	3-6m	N/A
21	3/28/2020 20:15	26.75	0.88	0.03	0.21	0.03	0.02	<3m	<3m	N/A
22	3/30/2020 14:30	11.25	0.12	0.01	0	0.00	0.00	<3m	<3m	N/A
23	4/2/2020 14:30	36.5	1.64	0.04	0.21	0.06	0.03	<3m	<3m	N/A
24	4/8/2020 5:15	2.75	0.06	0.02	0.03	0.00	0.00	<3m	<3m	N/A
25	4/9/2020 9:45	8.5	0.58	0.07	0.21	0.02	0.01	<3m	<3m	N/A
26	4/10/2020 15:15	0.5	0	0.00	0	0.01	0.01	<3m	<3m	N/A
27	4/13/2020 4:15	15.25	0.6	0.04	0.31	0.03	0.01	<3m	<3m	N/A
28	4/18/2020 0:00	11.5	0.78	0.07	0.19	0.03	0.02	<3m	<3m	N/A
29	4/21/2020 15:00	3	0.31	0.10	0.24	0.01	0.01	<3m	<3m	N/A
30	4/24/2020 3:30	11.5	0.23	0.02	0.06	0.01	0.01	<3m	<3m	N/A
31	4/26/2020 13:15	33.25	1.32	0.04	0.12	0.04	0.03	<3m	<3m	N/A
32	4/30/2020 8:30	0.25	0	0.00	0	0.00	0.00	<3m	<3m	N/A
33	5/1/2020 2:00	23.25	0.79	0.03	0.27	0.03	0.00	<3m	<3m	N/A
34	5/8/2020 18:00	14.25	0.41	0.03	0.07	0.02	0.01	<3m	<3m	N/A
35	5/11/2020 16:15	4.75	0.22	0.05	0.15	0.01	0.00	<3m	<3m	N/A
36	5/15/2020 1:15	2.5	0.06	0.02	0.04	0.00	0.00	<3m	<3m	N/A
37	5/15/2020 20:00	5.5	0.58	0.11	0.31	0.03	0.01	<3m	<3m	N/A
38	5/30/2020 2:15	1.5	0.08	0.05	0	0.00	0.00	<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	6/2/2020 18:45	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
40	6/5/2020 3:45	0.75	0.08	0.11	0.08	0.00	0.00	<3m	<3m	N/A
41	6/6/2020 14:30	6.75	0.67	0.10	0.62	0.03	0.02	3-6m	<3m	N/A
42	6/11/2020 12:15	5.5	0.57	0.10	0.43	0.02	0.01	<3m	<3m	N/A
43	6/24/2020 18:30	0.5	0.04	0.08	0.04	0.00	0.00	<3m	<3m	N/A
44	6/27/2020 14:30	1	0.03	0.03	0.03	0.00	0.00	<3m	<3m	N/A
45	6/28/2020 12:30	48.5	1.33	0.03	0.60	0.04	0.03	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 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	1/4/2020 11:45	17.5	0.27	0.02	0.05	0.01	0.01	<3m	<3m	N/A
2	1/12/2020 4:00	5.5	0.07	0.01	0.04	0.00	0.00	<3m	<3m	N/A
3	1/13/2020 9:30	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
4	1/16/2020 3:30	6	0.12	0.02	0.05	0.01	0.00	<3m	<3m	N/A
5	1/19/2020 9:00	3	0.27	0.09	0.22	0.01	0.01	<3m	<3m	N/A
6	1/25/2020 17:30	5	0.63	0.13	0.24	0.03	0.01	<3m	<3m	N/A
7	2/1/2020 4:15	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
8	2/5/2020 2:15	3.5	0.05	0.01	0.02	0.00	0.00	<3m	<3m	N/A
9	2/6/2020 6:15	31.25	0.87	0.03	0.14	0.02	0.02	<3m	<3m	N/A
10	2/10/2020 3:45	10.75	0.15	0.01	0.06	0.01	0.00	<3m	<3m	N/A
11	2/11/2020 6:00	13.5	0.16	0.01	0.07	0.01	0.01	<3m	<3m	N/A
12	2/13/2020 1:15	13.25	0.56	0.04	0.18	0.02	0.01	<3m	<3m	N/A
13	2/18/2020 14:45	7	0.48	0.07	0.1	0.02	0.01	<3m	<3m	N/A
14	2/25/2020 20:45	6.25	0.32	0.05	0.09	0.01	0.01	<3m	<3m	N/A
15	2/27/2020 0:30	8.75	0.79	0.09	0.22	0.03	0.02	<3m	<3m	N/A
16	3/3/2020 19:45	6.5	0.04	0.01	0.02	0.00	0.00	<3m	<3m	N/A
17	3/13/2020 0:45	15.5	0.3	0.02	0.1	0.01	0.01	<3m	<3m	N/A
18	3/17/2020 7:30	1	0.02	0.02	0.02	0.00	0.00	<3m	<3m	N/A
19	3/19/2020 4:30	24.75	0.58	0.02	0.16	0.03	0.01	<3m	<3m	N/A
20	3/23/2020 14:30	15	1.7	0.11	0.49	0.07	0.04	<3m	3m	N/A
21	3/28/2020 20:15	32.25	0.86	0.03	0.17	0.04	0.02	<3m	<3m	N/A
22	3/30/2020 17:00	6.5	0.1	0.02	0	0.00	0.00	<3m	<3m	N/A
23	4/2/2020 1:45	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
24	4/2/2020 14:30	36.5	1.3	0.04	0.18	0.05	0.03	<3m	<3m	N/A
25	4/8/2020 5:00	3.75	0.11	0.03	0.04	0.00	0.00	<3m	<3m	N/A
26	4/9/2020 9:45	8.75	0.63	0.07	0.24	0.03	0.02	<3m	<3m	N/A
27	4/10/2020 15:15	1.75	0.04	0.02	0.03	0.01	0.01	<3m	<3m	N/A
28	4/13/2020 4:30	15.25	1.01	0.07	0.34	0.04	0.02	<3m	<3m	N/A
29	4/18/2020 0:00	13.75	0.78	0.06	0.2	0.03	0.02	<3m	<3m	N/A
30	4/21/2020 15:15	2.75	0.42	0.15	0.28	0.02	0.01	<3m	<3m	N/A
31	4/24/2020 3:45	12	0.26	0.02	0.05	0.01	0.01	<3m	<3m	N/A
32	4/26/2020 14:00	33.75	1.13	0.03	0.09	0.04	0.02	<3m	<3m	N/A
33	5/1/2020 2:00	6.5	0.72	0.11	0.3	0.00	0.00	<3m	<3m	N/A
34	5/1/2020 23:15	1.75	0.04	0.02	0.03	0.04	0.00	<3m	<3m	N/A
35	5/8/2020 18:00	14.5	0.41	0.03	0.07	0.02	0.01	<3m	<3m	N/A
36	5/11/2020 16:15	6.25	0.22	0.04	0.25	0.01	0.01	<3m	<3m	N/A
37	5/15/2020 1:15	1.25	0.04	0.03	0.04	0.00	0.00	<3m	<3m	N/A
38	5/15/2020 20:00	5	0.57	0.11	0.41	0.03	0.02	<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	5/30/2020 2:45	0.5	0.06	0.12	0	0.00	0.00	<3m	<3m	N/A
40	6/2/2020 18:30	0.25	0.02	0.08	0.02	0.00	0.00	<3m	<3m	N/A
41	6/5/2020 4:00	0.75	0.25	0.33	0.25	0.01	0.01	<3m	<3m	N/A
42	6/6/2020 14:30	6.75	0.1	0.01	0.06	0.00	0.01	<3m	<3m	N/A
43	6/11/2020 12:15	5.75	0.62	0.11	0.46	0.03	0.01	<3m	<3m	N/A
44	6/28/2020 12:15	48.5	1.54	0.03	0.64	0.05	0.03	3-6m	<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	1/4/2020 11:45	17.5	0.27	0.02	0.05	0.01	0.01	<3m	<3m	N/A
2	1/12/2020 4:00	5.5	0.05	0.01	0.03	0.00	0.00	<3m	<3m	N/A
3	1/13/2020 17:30	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
4	1/16/2020 3:45	5.75	0.1	0.02	0.05	0.00	0.00	<3m	<3m	N/A
5	1/19/2020 9:30	2	0.16	0.08	0.12	0.01	0.00	<3m	<3m	N/A
6	1/25/2020 17:30	4.75	0.49	0.10	0.22	0.02	0.01	<3m	<3m	N/A
7	2/1/2020 1:00	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
8	2/5/2020 2:15	3.25	0.05	0.02	0.02	0.00	0.00	<3m	<3m	N/A
9	2/6/2020 6:00	33.5	0.59	0.02	0.13	0.02	0.01	<3m	<3m	N/A
10	2/10/2020 4:45	9.75	0.1	0.01	0.04	0.00	0.00	<3m	<3m	N/A
11	2/11/2020 5:00	11.5	0.15	0.01	0.08	0.01	0.01	<3m	<3m	N/A
12	2/13/2020 1:00	13.5	0.52	0.04	0.14	0.02	0.01	<3m	<3m	N/A
13	2/18/2020 14:45	13.25	0.48	0.04	0.11	0.02	0.01	<3m	<3m	N/A
14	2/25/2020 20:45	6.5	0.32	0.05	0.10	0.01	0.01	<3m	<3m	N/A
15	2/27/2020 3:00	9	0.74	0.08	0.22	0.03	0.02	<3m	<3m	N/A
16	3/3/2020 19:15	7	0.04	0.01	0.02	0.00	0.00	<3m	<3m	N/A
17	3/13/2020 1:00	15.5	0.27	0.02	0.10	0.01	0.01	<3m	<3m	N/A
18	3/17/2020 7:30	1	0.02	0.02	0.02	0.00	0.00	<3m	<3m	N/A
19	3/19/2020 4:30	23.5	0.62	0.03	0.16	0.03	0.01	<3m	<3m	N/A
20	3/23/2020 14:30	14.5	1.78	0.12	0.49	0.07	0.04	<3m	3m	N/A
21	3/28/2020 20:15	26.75	0.91	0.03	0.17	0.04	0.02	<3m	<3m	N/A
22	3/30/2020 13:45	9.75	0.13	0.01	0	0.00	0.00	<3m	<3m	N/A
23	4/8/2020 5:15	2.75	0.07	0.03	0.04	0.00	0.00	<3m	<3m	N/A
24	4/9/2020 10:00	8.5	0.6	0.07	0.21	0.03	0.01	<3m	<3m	N/A
25	4/10/2020 15:15	1.75	0.04	0.02	0.03	0.01	0.01	<3m	<3m	N/A
26	4/13/2020 4:45	24	0.71	0.03	0.23	0.03	0.01	<3m	<3m	N/A
27	4/18/2020 0:00	13.75	0.65	0.05	0.17	0.03	0.01	<3m	<3m	N/A
28	4/21/2020 15:45	2.25	0.33	0.15	0.24	0.01	0.01	<3m	<3m	N/A
29	4/22/2020 6:00	0.25	0.01	0.04	0.01	0.01	0.01	<3m	<3m	N/A
30	4/24/2020 3:45	11.5	0.19	0.02	0.05	0.01	0.00	<3m	<3m	N/A
31	4/26/2020 13:30	34.75	0.95	0.03	0.09	0.03	0.02	<3m	<3m	N/A
32	5/1/2020 2:15	6.25	0.71	0.11	0.30	0.00	0.00	<3m	<3m	N/A
33	5/1/2020 23:15	2	0.05	0.03	0.02	0.03	0.00	<3m	<3m	N/A
34	5/8/2020 18:00	14.25	0.41	0.03	0.07	0.02	0.01	<3m	<3m	N/A
35	5/11/2020 16:15	13.5	0.22	0.02	0.23	0.01	0.01	<3m	<3m	N/A
36	5/15/2020 1:30	1.75	0.04	0.02	0.04	0.00	0.00	<3m	<3m	N/A
37	5/15/2020 20:00	4.75	0.56	0.12	0.40	0.03	0.01	<3m	<3m	N/A
38	5/30/2020 2:45	0.75	0.06	0.08	0	0.00	0.00	<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	6/2/2020 18:30	0.75	0.03	0.04	0.03	0.00	0.00	<3m	<3m	N/A
40	6/4/2020 7:00	0.25	0.02	0.08	0.02	0.00	0.00	<3m	<3m	N/A
41	6/5/2020 4:00	4	0.26	0.07	0.19	0.01	0.01	<3m	<3m	N/A
42	6/6/2020 14:30	6.75	0.08	0.01	0.05	0.00	0.01	<3m	<3m	N/A
43	6/11/2020 12:15	5.5	0.56	0.10	0.37	0.02	0.01	<3m	<3m	N/A
44	6/12/2020 6:00	2.5	0.06	0.02	0.03	0.03	0.01	<3m	<3m	N/A
45	6/15/2020 7:00	0.25	0.03	0.12	0.03	0.00	0.00	<3m	<3m	N/A
46	6/18/2020 6:30	0.25	0.04	0.16	0.04	0.00	0.00	<3m	<3m	N/A
47	6/24/2020 8:15	0.25	0.06	0.24	0.06	0.00	0.00	<3m	<3m	N/A
48	6/25/2020 6:00	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
49	6/28/2020 12:30	48.25	2.11	0.04	0.70	0.08	0.04	6m	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 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	1/4/2020 10:30	22.5	0.28	0.01	0.05	0.01	0.01	<3m	<3m	N/A
2	1/8/2020 1:30	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
3	1/12/2020 4:00	6.5	0.06	0.01	0.04	0.00	0.00	<3m	<3m	N/A
4	1/16/2020 3:30	5.75	0.08	0.01	0.04	0.00	0.00	<3m	<3m	N/A
5	1/18/2020 18:30	16.75	0.3	0.02	0.09	0.01	0.01	<3m	<3m	N/A
6	1/25/2020 17:30	4.75	0.63	0.13	0.21	0.03	0.01	<3m	<3m	N/A
7	2/1/2020 1:00	0.25	0	0.00	0	0.00	0.00	<3m	<3m	N/A
8	2/5/2020 2:15	3.25	0.02	0.01	0.02	0.00	0.00	<3m	<3m	N/A
9	2/6/2020 6:00	33.5	0.55	0.02	0.15	0.02	0.02	<3m	<3m	N/A
10	2/10/2020 4:45	9.75	0.14	0.01	0.08	0.01	0.00	<3m	<3m	N/A
11	2/11/2020 5:00	11.5	0.16	0.01	0.07	0.01	0.01	<3m	<3m	N/A
12	2/13/2020 1:00	13.5	0.54	0.04	0.16	0.02	0.01	<3m	<3m	N/A
13	2/18/2020 14:45	13.25	0.46	0.03	0.1	0.02	0.01	<3m	<3m	N/A
14	2/25/2020 20:45	6.5	0.42	0.06	0.11	0.02	0.01	<3m	<3m	N/A
15	2/27/2020 3:00	9	0.81	0.09	0.25	0.04	0.03	<3m	<3m	N/A
16	3/3/2020 19:45	6.5	0.04	0.01	0.02	0.00	0.00	<3m	<3m	N/A
17	3/13/2020 1:00	14	0.35	0.03	0.12	0.01	0.01	<3m	<3m	N/A
18	3/17/2020 8:15	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
19	3/19/2020 4:30	26.5	0.68	0.03	0.17	0.03	0.01	<3m	<3m	N/A
20	3/23/2020 14:30	15	2	0.13	0.5	0.08	0.04	<3m	3m	N/A
21	3/28/2020 20:15	26.75	0.97	0.04	0.15	0.04	0.02	<3m	<3m	N/A
22	3/30/2020 14:00	5.5	0.1	0.02	0	0.00	0.00	<3m	<3m	N/A
23	4/2/2020 1:00	49.25	1.84	0.04	0.19	0.06	0.04	<3m	<3m	N/A
24	4/8/2020 4:15	4.25	0.06	0.01	0.02	0.00	0.00	<3m	<3m	N/A
25	4/9/2020 8:45	8.75	0.68	0.08	0.22	0.03	0.02	<3m	<3m	N/A
26	4/10/2020 14:30	2.25	0.02	0.01	0.01	0.01	0.01	<3m	<3m	N/A
27	4/13/2020 3:15	15.75	1.24	0.08	0.45	0.05	0.03	<3m	<3m	N/A
28	4/17/2020 22:45	13.5	0.8	0.06	0.2	0.03	0.02	<3m	<3m	N/A
29	4/21/2020 14:15	2.75	0.41	0.15	0.29	0.02	0.01	<3m	<3m	N/A
30	4/24/2020 2:30	11.75	0.26	0.02	0.05	0.01	0.01	<3m	<3m	N/A
31	4/26/2020 12:15	33.75	1.19	0.04	0.13	0.04	0.02	<3m	<3m	N/A
32	5/1/2020 0:30	24	0.78	0.03	0.29	0.04	0.00	<3m	<3m	N/A
33	5/8/2020 16:30	15.75	0.41	0.03	0.08	0.02	0.01	<3m	<3m	N/A
34	5/11/2020 15:15	4.5	0.2	0.04	0.2	0.01	0.01	<3m	<3m	N/A
35	5/15/2020 0:15	1.75	0.03	0.02	0.05	0.00	0.00	<3m	<3m	N/A
36	5/15/2020 19:15	5.25	0.55	0.10	0.31	0.04	0.02	<3m	<3m	N/A
37	6/2/2020 18:45	8.25	0.02	0.00	0.01	0.00	0.00	<3m	<3m	N/A
38	6/5/2020 3:45	1.75	0.06	0.03	0.05	0.00	0.00	<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	6/6/2020 14:45	6.5	0.74	0.11	0.53	0.03	0.02	3m	<3m	N/A
40	6/11/2020 12:15	5.5	0.69	0.13	0.57	0.03	0.01	3m	<3m	N/A
41	6/24/2020 18:15	8	0.25	0.03	0.24	0.01	0.01	<3m	<3m	N/A
42	6/27/2020 14:30	1	0.03	0.03	0.03	0.00	0.00	<3m	<3m	N/A
43	6/28/2020 12:45	48.5	1.59	0.03	0.78	0.06	0.03	6m-1yr	<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	1/4/2020 10:30	22.5	0.28	0.01	0.05	0.01	0.01	<3m	<3m	N/A
2	1/8/2020 1:30	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
3	1/12/2020 4:00	6.5	0.06	0.01	0.04	0.00	0.00	<3m	<3m	N/A
4	1/16/2020 3:30	5.75	0.08	0.01	0.04	0.00	0.00	<3m	<3m	N/A
5	1/18/2020 18:30	16.75	0.3	0.02	0.09	0.01	0.01	<3m	<3m	N/A
6	1/25/2020 17:30	4.75	0.63	0.13	0.21	0.03	0.01	<3m	<3m	N/A
7	2/5/2020 1:45	4	0.04	0.01	0.02	0.00	0.00	<3m	<3m	N/A
8	2/6/2020 2:45	35	0.8	0.02	0.15	0.02	0.02	<3m	<3m	N/A
9	2/10/2020 4:30	10	0.15	0.02	0.08	0.01	0.00	<3m	<3m	N/A
10	2/11/2020 5:15	14.25	0.17	0.01	0.07	0.01	0.01	<3m	<3m	N/A
11	2/13/2020 1:15	13.5	0.55	0.04	0.16	0.02	0.01	<3m	<3m	N/A
12	2/18/2020 15:00	7.25	0.46	0.06	0.1	0.02	0.01	<3m	<3m	N/A
13	2/25/2020 20:45	6.25	0.42	0.07	0.11	0.02	0.01	<3m	<3m	N/A
14	2/27/2020 1:15	8	0.84	0.11	0.25	0.04	0.03	<3m	<3m	N/A
15	3/3/2020 19:45	6.5	0.04	0.01	0.02	0.00	0.00	<3m	<3m	N/A
16	3/13/2020 1:00	14	0.35	0.03	0.12	0.01	0.01	<3m	<3m	N/A
17	3/17/2020 8:15	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
18	3/19/2020 4:30	26.5	0.68	0.03	0.17	0.03	0.01	<3m	<3m	N/A
19	3/23/2020 14:30	15	2	0.13	0.5	0.08	0.04	<3m	3m	N/A
20	3/28/2020 20:15	26.75	0.97	0.04	0.15	0.04	0.02	<3m	<3m	N/A
21	3/30/2020 14:00	5.5	0.1	0.02	0	0.00	0.00	<3m	<3m	N/A
22	4/2/2020 1:00	49.25	1.84	0.04	0.19	0.06	0.04	<3m	<3m	N/A
23	4/8/2020 4:15	4.25	0.06	0.01	0.02	0.00	0.00	<3m	<3m	N/A
24	4/9/2020 8:45	8.75	0.68	0.08	0.22	0.03	0.02	<3m	<3m	N/A
25	4/10/2020 14:30	2.25	0.02	0.01	0.01	0.01	0.01	<3m	<3m	N/A
26	4/13/2020 3:15	15.75	1.24	0.08	0.45	0.05	0.03	<3m	<3m	N/A
27	4/17/2020 22:45	13.5	0.8	0.06	0.2	0.03	0.02	<3m	<3m	N/A
28	4/21/2020 14:15	2.75	0.41	0.15	0.29	0.02	0.01	<3m	<3m	N/A
29	4/24/2020 2:30	11.75	0.26	0.02	0.05	0.01	0.01	<3m	<3m	N/A
30	4/26/2020 12:15	33.75	1.19	0.04	0.13	0.04	0.02	<3m	<3m	N/A
31	5/1/2020 0:30	24	1.04	0.04	0.29	0.04	0.00	<3m	<3m	N/A
32	5/8/2020 16:30	15.75	0.47	0.03	0.08	0.02	0.01	<3m	<3m	N/A
33	5/11/2020 15:15	4.5	0.28	0.06	0.2	0.01	0.01	<3m	<3m	N/A
34	5/15/2020 0:15	1.75	0.06	0.03	0.05	0.00	0.00	<3m	<3m	N/A
35	5/15/2020 19:15	5.25	0.79	0.15	0.31	0.04	0.02	<3m	<3m	N/A
36	6/2/2020 18:45	8.25	0.02	0.00	0.01	0.00	0.00	<3m	<3m	N/A
37	6/5/2020 3:45	1.75	0.06	0.03	0.05	0.00	0.00	<3m	<3m	N/A
38	6/6/2020 14:45	6.5	0.74	0.11	0.53	0.03	0.02	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	6/11/2020 12:15	5.5	0.69	0.13	0.57	0.03	0.01	3m	<3m	N/A
40	6/24/2020 18:15	8	0.25	0.03	0.24	0.01	0.01	<3m	<3m	N/A
41	6/27/2020 14:30	1	0.03	0.03	0.03	0.00	0.00	<3m	<3m	N/A
42	6/28/2020 12:45	48.5	1.59	0.03	0.78	0.06	0.03	6m-1yr	<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	1/4/2020 11:45	17.5	0.27	0.02	0.05	0.01	0.01	<3m	<3m	N/A
2	1/12/2020 4:00	5.5	0.07	0.01	0.04	0.00	0.00	<3m	<3m	N/A
3	1/13/2020 9:30	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
4	1/16/2020 3:30	6	0.12	0.02	0.05	0.01	0.00	<3m	<3m	N/A
5	1/19/2020 9:00	3	0.27	0.09	0.22	0.01	0.01	<3m	<3m	N/A
6	1/25/2020 17:30	5	0.63	0.13	0.24	0.03	0.01	<3m	<3m	N/A
7	2/1/2020 4:15	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
8	2/5/2020 2:15	3.5	0.05	0.01	0.02	0.00	0.00	<3m	<3m	N/A
9	2/6/2020 6:15	31.25	0.87	0.03	0.14	0.02	0.02	<3m	<3m	N/A
10	2/10/2020 3:45	10.75	0.15	0.01	0.06	0.01	0.00	<3m	<3m	N/A
11	2/11/2020 6:00	13.5	0.16	0.01	0.07	0.01	0.01	<3m	<3m	N/A
12	2/13/2020 1:15	13.25	0.56	0.04	0.18	0.02	0.01	<3m	<3m	N/A
13	2/18/2020 14:45	7	0.48	0.07	0.1	0.02	0.01	<3m	<3m	N/A
14	2/25/2020 20:45	6.25	0.32	0.05	0.09	0.01	0.01	<3m	<3m	N/A
15	2/27/2020 0:30	8.75	0.79	0.09	0.22	0.03	0.02	<3m	<3m	N/A
16	3/3/2020 19:15	7	0.04	0.01	0.02	0.00	0.00	<3m	<3m	N/A
17	3/13/2020 1:00	15.5	0.27	0.02	0.1	0.01	0.01	<3m	<3m	N/A
18	3/17/2020 7:30	1	0.02	0.02	0.02	0.00	0.00	<3m	<3m	N/A
19	3/19/2020 4:30	23.5	0.62	0.03	0.16	0.03	0.01	<3m	<3m	N/A
20	3/23/2020 14:30	14.5	1.78	0.12	0.49	0.07	0.04	<3m	3m	N/A
21	3/28/2020 20:15	26.75	0.91	0.03	0.17	0.04	0.02	<3m	<3m	N/A
22	3/30/2020 13:45	9.75	0.13	0.01	0	0.00	0.00	<3m	<3m	N/A
23	4/2/2020 1:45	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
24	4/2/2020 14:30	35.25	1.34	0.04	0.16	0.05	0.03	<3m	<3m	N/A
25	4/8/2020 5:00	3.75	0.08	0.02	0.04	0.00	0.00	<3m	<3m	N/A
26	4/9/2020 10:00	8.5	0.64	0.08	0.23	0.03	0.02	<3m	<3m	N/A
27	4/10/2020 15:15	1.75	0.05	0.03	0.03	0.01	0.01	<3m	<3m	N/A
28	4/13/2020 4:30	15.25	0.92	0.06	0.3	0.04	0.02	<3m	<3m	N/A
29	4/18/2020 0:15	11.25	0.74	0.07	0.18	0.03	0.02	<3m	<3m	N/A
30	4/21/2020 15:30	2.5	0.38	0.15	0.26	0.02	0.01	<3m	<3m	N/A
31	4/24/2020 3:45	12	0.23	0.02	0.06	0.01	0.00	<3m	<3m	N/A
32	4/26/2020 14:00	33.75	1.21	0.04	0.11	0.04	0.03	<3m	<3m	N/A
33	5/1/2020 2:00	6.75	0.81	0.12	0.31	0.00	0.00	<3m	<3m	N/A
34	5/1/2020 23:15	0.75	0.02	0.03	0.02	0.03	0.00	<3m	<3m	N/A
35	5/8/2020 18:00	14.25	0.41	0.03	0.07	0.02	0.01	<3m	<3m	N/A
36	5/11/2020 16:15	5	0.37	0.07	0.25	0.02	0.01	<3m	<3m	N/A
37	5/15/2020 1:15	1.25	0.05	0.04	0.04	0.00	0.00	<3m	<3m	N/A
38	5/15/2020 20:00	4.75	0.63	0.13	0.36	0.03	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	5/30/2020 2:30	1	0.22	0.22	0	0.00	0.00	<3m	<3m	N/A
40	6/2/2020 18:30	0.5	0.03	0.06	0.03	0.00	0.00	<3m	<3m	N/A
41	6/5/2020 4:00	0.5	0.11	0.22	0.11	0.00	0.00	<3m	<3m	N/A
42	6/6/2020 14:30	6.75	0.09	0.01	0.05	0.00	0.00	<3m	<3m	N/A
43	6/11/2020 12:15	5.25	0.66	0.13	0.44	0.03	0.01	<3m	<3m	N/A
44	6/28/2020 12:30	48.25	1.9	0.04	0.69	0.07	0.04	6m	<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	1/4/2020 10:30	18.25	0.25	0.01	0.05	0.01	0.01	<3m	<3m	N/A
2	1/12/2020 4:00	5.5	0.06	0.01	0.03	0.00	0.00	<3m	<3m	N/A
3	1/14/2020 21:15	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
4	1/16/2020 3:30	6	0.11	0.02	0.04	0.00	0.00	<3m	<3m	N/A
5	1/19/2020 9:30	3.5	0.32	0.09	0.24	0.01	0.01	<3m	<3m	N/A
6	1/25/2020 17:30	5.75	0.55	0.10	0.16	0.02	0.01	<3m	<3m	N/A
7	2/5/2020 1:30	4	0.05	0.01	0.02	0.00	0.00	<3m	<3m	N/A
8	2/6/2020 7:15	32.25	0.86	0.03	0.14	0.02	0.02	<3m	<3m	N/A
9	2/10/2020 3:45	8.25	0.16	0.02	0.08	0.01	0.00	<3m	<3m	N/A
10	2/11/2020 5:00	11.25	0.15	0.01	0.07	0.01	0.01	<3m	<3m	N/A
11	2/13/2020 1:00	13.25	0.55	0.04	0.17	0.02	0.01	<3m	<3m	N/A
12	2/18/2020 12:30	9.75	0.45	0.05	0.1	0.02	0.01	<3m	<3m	N/A
13	2/25/2020 20:30	6.75	0.35	0.05	0.11	0.01	0.01	<3m	<3m	N/A
14	2/27/2020 1:30	7.75	0.88	0.11	0.26	0.04	0.03	<3m	<3m	N/A
15	3/3/2020 19:15	6.75	0.04	0.01	0.02	0.00	0.00	<3m	<3m	N/A
16	3/13/2020 1:00	15.25	0.45	0.03	0.11	0.02	0.01	<3m	<3m	N/A
17	3/17/2020 7:30	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
18	3/19/2020 4:15	26.5	0.66	0.02	0.16	0.03	0.01	<3m	<3m	N/A
19	3/23/2020 14:30	15	1.96	0.13	0.48	0.08	0.04	<3m	3m	N/A
20	3/28/2020 20:00	26.75	0.86	0.03	0.12	0.03	0.02	<3m	<3m	N/A
21	3/30/2020 16:45	10.25	0.11	0.01	0	0.00	0.00	<3m	<3m	N/A
22	4/2/2020 14:30	36.5	1.24	0.03	0.18	0.04	0.03	<3m	<3m	N/A
23	4/8/2020 5:15	2.75	0.06	0.02	0.03	0.00	0.00	<3m	<3m	N/A
24	4/9/2020 9:45	8.5	0.62	0.07	0.24	0.03	0.01	<3m	<3m	N/A
25	4/10/2020 15:15	0.5	0.03	0.06	0.03	0.01	0.01	<3m	<3m	N/A
26	4/13/2020 4:15	15.25	0.83	0.05	0.24	0.03	0.02	<3m	<3m	N/A
27	4/18/2020 0:00	11.5	0.7	0.06	0.21	0.03	0.01	<3m	<3m	N/A
28	4/21/2020 15:00	3	0.36	0.12	0.24	0.02	0.01	<3m	<3m	N/A
29	4/24/2020 3:30	11.5	0.19	0.02	0.04	0.01	0.00	<3m	<3m	N/A
30	4/26/2020 13:15	33.25	0.9	0.03	0.08	0.03	0.02	<3m	<3m	N/A
31	4/30/2020 8:30	0.25	0.01	0.04	0	0.00	0.00	<3m	<3m	N/A
32	5/1/2020 1:15	23.75	1.1	0.05	0.25	0.05	0.00	<3m	<3m	N/A
33	5/4/2020 3:45	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
34	5/7/2020 1:00	3.75	0.02	0.01	0.01	0.00	0.00	<3m	<3m	N/A
35	5/8/2020 18:15	14.5	0.43	0.03	0.07	0.02	0.01	<3m	<3m	N/A
36	5/11/2020 15:30	8.25	0.5	0.06	0.31	0.02	0.01	<3m	<3m	N/A
37	5/15/2020 1:30	1.5	0.05	0.03	0.04	0.00	0.00	<3m	<3m	N/A
38	5/15/2020 19:45	5.25	0.73	0.14	0.51	0.03	0.02	<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	5/30/2020 2:15	1	0.09	0.09	0	0.00	0.00	<3m	<3m	N/A
40	6/2/2020 18:30	0.25	0.02	0.08	0.02	0.00	0.00	<3m	<3m	N/A
41	6/5/2020 4:00	0.75	0.24	0.32	0.24	0.01	0.01	<3m	<3m	N/A
42	6/6/2020 14:15	6.75	0.07	0.01	0.04	0.00	0.01	<3m	<3m	N/A
43	6/11/2020 12:00	5.5	0.48	0.09	0.38	0.02	0.01	<3m	<3m	N/A
44	6/21/2020 15:30	1	0.38	0.38	0.38	0.02	0.01	<3m	<3m	N/A
45	6/24/2020 14:00	12.25	0.24	0.02	0.17	0.01	0.01	<3m	<3m	N/A
46	6/28/2020 12:30	44.5	1.78	0.04	1	0.07	0.04	1-2yr	<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 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	1/4/2020 10:15	18.5	0.31	0.02	0.05	0.01	0.01	<3m	<3m	N/A
2	1/8/2020 0:30	1.5	0.03	0.02	0.02	0.00	0.00	<3m	<3m	N/A
3	1/12/2020 4:00	5.25	0.07	0.01	0.05	0.00	0.00	<3m	<3m	N/A
4	1/14/2020 20:00	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
5	1/16/2020 3:00	6.5	0.11	0.02	0.05	0.00	0.00	<3m	<3m	N/A
6	1/19/2020 9:15	2.25	0.32	0.14	0.2	0.01	0.01	<3m	<3m	N/A
7	1/25/2020 17:15	4.75	0.51	0.11	0.21	0.02	0.01	<3m	<3m	N/A
8	2/1/2020 0:45	7	0.02	0.00	0.01	0.00	0.00	<3m	<3m	N/A
9	2/5/2020 1:00	4.75	0.09	0.02	0.03	0.00	0.00	<3m	<3m	N/A
10	2/6/2020 2:15	35.25	0.89	0.03	0.12	0.02	0.02	<3m	<3m	N/A
11	2/10/2020 4:00	8.5	0.19	0.02	0.09	0.01	0.00	<3m	<3m	N/A
12	2/11/2020 4:00	17.5	0.25	0.01	0.06	0.01	0.01	<3m	<3m	N/A
13	2/13/2020 0:45	13.5	0.63	0.05	0.16	0.03	0.02	<3m	<3m	N/A
14	2/18/2020 15:00	6.5	0.42	0.06	0.1	0.02	0.01	<3m	<3m	N/A
15	2/25/2020 20:15	9.25	0.35	0.04	0.11	0.01	0.01	<3m	<3m	N/A
16	2/26/2020 22:30	10.5	0.76	0.07	0.23	0.03	0.02	<3m	<3m	N/A
17	3/3/2020 18:45	7.5	0.1	0.01	0.04	0.00	0.00	<3m	<3m	N/A
18	3/13/2020 0:30	16	0.28	0.02	0.05	0.01	0.01	<3m	<3m	N/A
19	3/17/2020 6:45	8	0.04	0.01	0.02	0.00	0.00	<3m	<3m	N/A
20	3/19/2020 4:15	27.5	0.7	0.03	0.17	0.03	0.01	<3m	<3m	N/A
21	3/23/2020 14:15	15	2.34	0.16	0.47	0.10	0.05	<3m	6m	N/A
22	3/25/2020 9:30	0.25	0.01	0.04	0.01	0.00	0.05	<3m	<3m	N/A
23	3/28/2020 19:45	31	0.99	0.03	0.28	0.04	0.02	<3m	<3m	N/A
24	3/30/2020 14:45	11	0.19	0.02	0	0.00	0.00	<3m	<3m	N/A
25	4/2/2020 2:00	49.5	2.35	0.05	0.24	0.08	0.05	<3m	3m	N/A
26	4/8/2020 5:00	3.5	0.05	0.01	0.03	0.00	0.00	<3m	<3m	N/A
27	4/9/2020 9:30	8.75	0.59	0.07	0.18	0.02	0.01	<3m	<3m	N/A
28	4/10/2020 15:30	2.5	0.03	0.01	0.02	0.00	0.01	<3m	<3m	N/A
29	4/13/2020 4:00	15.75	1.37	0.09	0.43	0.06	0.03	<3m	<3m	N/A
30	4/15/2020 5:45	0.25	0.01	0.04	0.01	0.00	0.03	<3m	<3m	N/A
31	4/17/2020 23:45	15.5	0.8	0.05	0.17	0.03	0.02	<3m	<3m	N/A
32	4/21/2020 11:15	6.5	0.41	0.06	0.28	0.02	0.01	<3m	<3m	N/A
33	4/24/2020 3:15	12.25	0.29	0.02	0.06	0.01	0.01	<3m	<3m	N/A
34	4/26/2020 13:15	33.75	1.37	0.04	0.11	0.05	0.03	<3m	<3m	N/A
35	4/30/2020 8:30	0.25	0.01	0.04	0	0.00	0.00	<3m	<3m	N/A
36	5/1/2020 1:00	23	0.99	0.04	0.28	0.04	0.00	<3m	<3m	N/A
37	5/7/2020 4:30	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
38	5/8/2020 17:30	15.5	0.5	0.03	0.08	0.02	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	5/11/2020 12:30	8.5	0.27	0.03	0.17	0.01	0.01	<3m	<3m	N/A
40	5/15/2020 1:00	2	0.06	0.03	0.05	0.00	0.00	<3m	<3m	N/A
41	5/15/2020 20:00	5.25	0.8	0.15	0.36	0.04	0.02	<3m	<3m	N/A
42	5/23/2020 5:00	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
43	5/29/2020 3:00	0.25	0.02	0.08	0.02	0.00	0.00	<3m	<3m	N/A
44	5/30/2020 2:00	1.25	0.14	0.11	0	0.00	0.00	<3m	<3m	N/A
45	6/2/2020 19:00	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
46	6/5/2020 3:30	1.75	0.15	0.09	0.14	0.01	0.00	<3m	<3m	N/A
47	6/6/2020 14:45	6.5	0.88	0.14	0.48	0.04	0.02	<3m	<3m	N/A
48	6/11/2020 12:15	5.5	0.63	0.11	0.51	0.03	0.01	<3m	<3m	N/A
49	6/21/2020 15:30	1	0.2	0.20	0.2	0.01	0.00	<3m	<3m	N/A
50	6/27/2020 14:45	1.25	0.04	0.03	0.03	0.00	0.00	<3m	<3m	N/A
51	6/28/2020 13:30	7.5	3.01	0.40	1.46	0.13	0.06	4yr	1-2yr	N/A
52	6/29/2020 10:30	27	0.61	0.02	0.49	0.15	0.08	<3m	3yr	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	1/4/2020 9:00	18.25	0.25	0.01	0.05	0.01	0.01	<3m	<3m	N/A
2	1/12/2020 2:30	5.5	0.06	0.01	0.03	0.00	0.00	<3m	<3m	N/A
3	1/14/2020 19:45	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
4	1/16/2020 2:00	6	0.11	0.02	0.04	0.00	0.00	<3m	<3m	N/A
5	1/19/2020 8:00	3.5	0.32	0.09	0.24	0.01	0.01	<3m	<3m	N/A
6	1/25/2020 16:00	5.75	0.55	0.10	0.16	0.02	0.01	<3m	<3m	N/A
7	2/1/2020 8:45	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
8	2/5/2020 1:30	3.5	0.06	0.02	0.03	0.00	0.00	<3m	<3m	N/A
9	2/6/2020 7:15	34.25	1.08	0.03	0.12	0.03	0.02	<3m	<3m	N/A
10	2/10/2020 3:45	8.5	0.23	0.03	0.08	0.01	0.00	<3m	<3m	N/A
11	2/11/2020 5:00	20.75	0.16	0.01	0.07	0.01	0.01	<3m	<3m	N/A
12	2/13/2020 1:00	13.5	0.71	0.05	0.13	0.03	0.02	<3m	<3m	N/A
13	2/18/2020 12:15	9.75	0.52	0.05	0.12	0.02	0.01	<3m	<3m	N/A
14	2/25/2020 20:30	14	0.15	0.01	0.05	0.01	0.01	<3m	<3m	N/A
15	2/27/2020 1:30	7.75	0.88	0.11	0.26	0.04	0.03	<3m	<3m	N/A
16	3/3/2020 19:00	7.25	0.05	0.01	0.02	0.00	0.00	<3m	<3m	N/A
17	3/13/2020 1:00	15.25	0.51	0.03	0.14	0.02	0.01	<3m	<3m	N/A
18	3/17/2020 7:30	1.75	0.04	0.02	0.03	0.00	0.00	<3m	<3m	N/A
19	3/19/2020 4:15	28.25	0.73	0.03	0.16	0.03	0.02	<3m	<3m	N/A
20	3/23/2020 14:45	13.75	1.81	0.13	0.39	0.08	0.04	<3m	3m	N/A
21	3/28/2020 20:00	30	0.79	0.03	0.12	0.03	0.02	<3m	<3m	N/A
22	3/30/2020 14:45	12.25	0.15	0.01	0	0.00	0.00	<3m	<3m	N/A
23	4/2/2020 13:30	36.75	1.31	0.04	0.15	0.05	0.03	<3m	<3m	N/A
24	4/8/2020 5:00	4	0.1	0.03	0.04	0.00	0.00	<3m	<3m	N/A
25	4/9/2020 9:45	9	0.77	0.09	0.2	0.03	0.02	<3m	<3m	N/A
26	4/10/2020 15:15	0.25	0.02	0.08	0.02	0.01	0.02	<3m	<3m	N/A
27	4/13/2020 4:15	15.5	0.87	0.06	0.14	0.04	0.02	<3m	<3m	N/A
28	4/18/2020 0:00	17	0.65	0.04	0.22	0.03	0.01	<3m	<3m	N/A
29	4/21/2020 15:00	3	0.43	0.14	0.26	0.02	0.01	<3m	<3m	N/A
30	4/24/2020 3:30	11.5	0.18	0.02	0.05	0.01	0.00	<3m	<3m	N/A
31	4/26/2020 13:15	34.75	1.27	0.04	0.14	0.04	0.03	<3m	<3m	N/A
32	4/30/2020 8:30	0.25	0.01	0.04	0	0.00	0.00	<3m	<3m	N/A
33	5/1/2020 1:15	23.75	1.1	0.05	0.25	0.05	0.00	<3m	<3m	N/A
34	5/4/2020 3:45	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
35	5/7/2020 1:00	3.75	0.02	0.01	0.01	0.00	0.00	<3m	<3m	N/A
36	5/8/2020 18:15	14.5	0.43	0.03	0.07	0.02	0.01	<3m	<3m	N/A
37	5/11/2020 15:30	8.25	0.5	0.06	0.31	0.02	0.01	<3m	<3m	N/A
38	5/15/2020 1:30	1.5	0.05	0.03	0.04	0.00	0.00	<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	5/15/2020 19:45	5.25	0.73	0.14	0.51	0.03	0.02	<3m	<3m	N/A
40	5/30/2020 2:15	1	0.09	0.09	0	0.00	0.00	<3m	<3m	N/A
41	6/2/2020 18:30	0.25	0.02	0.08	0.02	0.00	0.00	<3m	<3m	N/A
42	6/5/2020 4:00	0.75	0.24	0.32	0.24	0.01	0.01	<3m	<3m	N/A
43	6/6/2020 14:15	6.75	0.07	0.01	0.04	0.00	0.01	<3m	<3m	N/A
44	6/11/2020 12:00	5.5	0.48	0.09	0.38	0.02	0.01	<3m	<3m	N/A
45	6/21/2020 15:30	1	0.38	0.38	0.38	0.02	0.01	<3m	<3m	N/A
46	6/24/2020 14:00	12.25	0.24	0.02	0.17	0.01	0.01	<3m	<3m	N/A
47	6/28/2020 12:30	44.5	1.78	0.04	1.00	0.07	0.04	1-2yr	<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 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	1/4/2020 10:30	18.5	0.27	0.01	0.05	0.01	0.01	<3m	<3m	N/A
2	1/8/2020 1:00	0.75	0.02	0.03	0.02	0.00	0.00	<3m	<3m	N/A
3	1/12/2020 4:00	5.5	0.06	0.01	0.05	0.00	0.00	<3m	<3m	N/A
4	1/13/2020 9:00	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
5	1/14/2020 20:45	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
6	1/16/2020 3:30	6	0.1	0.02	0.04	0.00	0.00	<3m	<3m	N/A
7	1/19/2020 9:45	2.75	0.27	0.10	0.2	0.01	0.01	<3m	<3m	N/A
8	1/25/2020 17:30	5	0.59	0.12	0.19	0.02	0.01	<3m	<3m	N/A
9	2/5/2020 1:30	4.25	0.05	0.01	0.02	0.00	0.00	<3m	<3m	N/A
10	2/6/2020 7:00	32.5	0.87	0.03	0.18	0.02	0.02	<3m	<3m	N/A
11	2/10/2020 3:45	10.75	0.2	0.02	0.08	0.01	0.00	<3m	<3m	N/A
12	2/11/2020 5:00	14.25	0.16	0.01	0.07	0.01	0.01	<3m	<3m	N/A
13	2/13/2020 1:00	13.5	0.57	0.04	0.17	0.02	0.01	<3m	<3m	N/A
14	2/18/2020 12:30	9.5	0.47	0.05	0.1	0.02	0.01	<3m	<3m	N/A
15	2/25/2020 20:30	6.75	0.42	0.06	0.1	0.02	0.01	<3m	<3m	N/A
16	2/27/2020 1:30	7.5	0.81	0.11	0.24	0.03	0.03	<3m	<3m	N/A
17	3/3/2020 19:00	7.25	0.06	0.01	0.03	0.00	0.00	<3m	<3m	N/A
18	3/13/2020 1:00	15.25	0.4	0.03	0.11	0.02	0.01	<3m	<3m	N/A
19	3/17/2020 7:15	6.5	0.03	0.00	0.02	0.00	0.00	<3m	<3m	N/A
20	3/19/2020 4:30	26.5	0.7	0.03	0.17	0.03	0.01	<3m	<3m	N/A
21	3/23/2020 14:15	14.75	1.99	0.13	0.48	0.08	0.04	<3m	3m	N/A
22	3/28/2020 20:00	27	0.99	0.04	0.14	0.04	0.02	<3m	<3m	N/A
23	3/30/2020 16:45	6.25	0.11	0.02	0	0.00	0.00	<3m	<3m	N/A
24	4/2/2020 13:45	37	1.32	0.04	0.17	0.05	0.03	<3m	<3m	N/A
25	4/8/2020 5:00	3.5	0.07	0.02	0.03	0.00	0.00	<3m	<3m	N/A
26	4/9/2020 9:45	8.5	0.66	0.08	0.26	0.03	0.02	<3m	<3m	N/A
27	4/10/2020 15:15	0.5	0.03	0.06	0.03	0.01	0.01	<3m	<3m	N/A
28	4/13/2020 4:15	15.5	0.98	0.06	0.31	0.04	0.02	<3m	<3m	N/A
29	4/17/2020 23:45	9.25	0.74	0.08	0.16	0.03	0.02	<3m	<3m	N/A
30	4/21/2020 15:00	2.75	0.39	0.14	0.26	0.02	0.01	<3m	<3m	N/A
31	4/24/2020 3:30	11.75	0.22	0.02	0.05	0.01	0.00	<3m	<3m	N/A
32	4/26/2020 13:30	33	0.91	0.03	0.1	0.03	0.02	<3m	<3m	N/A
33	4/30/2020 9:45	0.25	0.01	0.04	0	0.00	0.00	<3m	<3m	N/A
34	5/1/2020 1:30	23.5	0.92	0.04	0.3	0.04	0.00	<3m	<3m	N/A
35	5/6/2020 20:45	4.5	0.06	0.01	0.05	0.00	0.00	<3m	<3m	N/A
36	5/8/2020 17:45	15	0.42	0.03	0.07	0.02	0.01	<3m	<3m	N/A
37	5/11/2020 16:15	4.5	0.34	0.08	0.23	0.01	0.01	<3m	<3m	N/A
38	5/15/2020 1:15	1.25	0.05	0.04	0.04	0.00	0.00	<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	5/15/2020 20:00	5	0.7	0.14	0.35	0.03	0.02	<3m	<3m	N/A
40	5/30/2020 2:15	1	0.24	0.24	0	0.00	0.00	<3m	<3m	N/A
41	6/2/2020 18:30	0.25	0.02	0.08	0.02	0.00	0.00	<3m	<3m	N/A
42	6/5/2020 3:45	0.75	0.16	0.21	0.16	0.01	0.00	<3m	<3m	N/A
43	6/6/2020 14:15	6.75	0.66	0.10	0.57	0.03	0.02	3m	<3m	N/A
44	6/11/2020 12:15	5.75	0.68	0.12	0.49	0.03	0.01	<3m	<3m	N/A
45	6/24/2020 18:30	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
46	6/27/2020 15:15	0.5	0.02	0.04	0.02	0.00	0.00	<3m	<3m	N/A
47	6/28/2020 12:30	48.5	2.04	0.04	1.09	0.08	0.04	1-2yr	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	1/4/2020 10:30	18.25	0.25	0.01	0.05	0.01	0.01	<3m	<3m	N/A
2	1/12/2020 4:00	5.5	0.06	0.01	0.03	0.00	0.00	<3m	<3m	N/A
3	1/16/2020 3:00	6.75	0.21	0.03	0.06	0.01	0.00	<3m	<3m	N/A
4	1/19/2020 9:45	3.25	0.4	0.12	0.31	0.02	0.01	<3m	<3m	N/A
5	1/25/2020 17:45	5.75	0.7	0.12	0.24	0.03	0.01	<3m	<3m	N/A
6	2/5/2020 2:00	3.75	0.04	0.01	0.01	0.00	0.00	<3m	<3m	N/A
7	2/6/2020 9:30	30.5	0.85	0.03	0.15	0.03	0.02	<3m	<3m	N/A
8	2/10/2020 4:00	8.5	0.16	0.02	0.06	0.01	0.00	<3m	<3m	N/A
9	2/11/2020 9:45	6	0.09	0.02	0.07	0.00	0.01	<3m	<3m	N/A
10	2/13/2020 1:15	14	0.6	0.04	0.12	0.03	0.01	<3m	<3m	N/A
11	2/18/2020 12:30	9.75	0.53	0.05	0.12	0.02	0.01	<3m	<3m	N/A
12	2/25/2020 21:15	2.5	0.04	0.02	0.02	0.00	0.00	<3m	<3m	N/A
13	2/27/2020 0:30	8.75	1.15	0.13	0.36	0.05	0.02	<3m	<3m	N/A
14	3/3/2020 19:30	6.75	0.02	0.00	0.01	0.00	0.00	<3m	<3m	N/A
15	3/13/2020 1:30	10	0.55	0.06	0.18	0.02	0.01	<3m	<3m	N/A
16	3/17/2020 7:45	1.25	0.02	0.02	0.01	0.00	0.00	<3m	<3m	N/A
17	3/19/2020 4:45	26.25	0.66	0.03	0.13	0.03	0.01	<3m	<3m	N/A
18	3/23/2020 14:45	14	1.49	0.11	0.49	0.06	0.03	<3m	<3m	N/A
19	3/28/2020 21:30	30.25	0.84	0.03	0.12	0.03	0.02	<3m	<3m	N/A
20	3/30/2020 16:00	12.5	0.17	0.01	0	0.00	0.00	<3m	<3m	N/A
21	4/2/2020 14:45	39.5	0.96	0.02	0.12	0.04	0.02	<3m	<3m	N/A
22	4/8/2020 5:00	4.75	0.11	0.02	0.04	0.00	0.00	<3m	<3m	N/A
23	4/9/2020 10:00	15.75	0.83	0.05	0.22	0.03	0.02	<3m	<3m	N/A
24	4/13/2020 4:30	14.75	0.69	0.05	0.17	0.03	0.01	<3m	<3m	N/A
25	4/18/2020 0:45	14.75	0.54	0.04	0.21	0.02	0.01	<3m	<3m	N/A
26	4/21/2020 16:00	2	0.3	0.15	0.2	0.01	0.01	<3m	<3m	N/A
27	4/24/2020 4:30	10.25	0.05	0.00	0.02	0.00	0.00	<3m	<3m	N/A
28	4/26/2020 14:45	40	0.97	0.02	0.09	0.03	0.02	<3m	<3m	N/A
29	5/1/2020 3:15	6.25	0.88	0.14	0.3	0.00	0.00	<3m	<3m	N/A
30	5/1/2020 23:00	0.5	0.03	0.06	0.03	0.00	0.00	<3m	<3m	N/A
31	5/8/2020 18:30	13.5	0.35	0.03	0.07	0.01	0.01	<3m	<3m	N/A
32	5/11/2020 12:15	9.25	0.52	0.06	0.31	0.02	0.01	<3m	<3m	N/A
33	5/15/2020 1:45	0.5	0.02	0.04	0.02	0.00	0.00	<3m	<3m	N/A
34	5/15/2020 19:45	5.75	0.59	0.10	0.37	0.03	0.01	<3m	<3m	N/A
35	5/30/2020 2:30	0.75	0.08	0.11	0	0.00	0.00	<3m	<3m	N/A
36	6/2/2020 18:15	0.5	0.02	0.04	0.02	0.00	0.00	<3m	<3m	N/A
37	6/3/2020 19:00	0.5	0.26	0.52	0.26	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
38	6/5/2020 4:15	0.5	0.07	0.14	0.07	0.00	0.01	<3m	<3m	N/A
39	6/6/2020 14:00	6.75	0.03	0.00	0.02	0.00	0.00	<3m	<3m	N/A
40	6/11/2020 12:15	5.25	0.39	0.07	0.34	0.02	0.01	<3m	<3m	N/A
41	6/24/2020 13:45	3.75	0.21	0.06	0.16	0.01	0.00	<3m	<3m	N/A
42	6/28/2020 12:00	32.75	1.47	0.04	0.7	0.05	0.03	6m	<3m	N/A
43	6/30/2020 22:30	0.25	0.01	0.04	0.01	0.00	0.02	<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 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	1/1/2020 11:00	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
2	1/4/2020 10:15	19	0.33	0.02	0.05	0.01	0.01	<3m	<3m	N/A
3	1/8/2020 8:45	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
4	1/12/2020 4:00	1.5	0.07	0.05	0.06	0.00	0.00	<3m	<3m	N/A
5	1/13/2020 9:15	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
6	1/16/2020 3:00	6.5	0.14	0.02	0.06	0.01	0.00	<3m	<3m	N/A
7	1/19/2020 9:15	4	0.38	0.10	0.25	0.02	0.01	<3m	<3m	N/A
8	1/25/2020 17:30	4.75	0.58	0.12	0.24	0.02	0.01	<3m	<3m	N/A
9	2/1/2020 0:45	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
10	2/5/2020 1:00	5	0.09	0.02	0.03	0.00	0.00	<3m	<3m	N/A
11	2/6/2020 7:15	30.25	0.94	0.03	0.14	0.03	0.02	<3m	<3m	N/A
12	2/10/2020 3:45	8.25	0.19	0.02	0.08	0.01	0.00	<3m	<3m	N/A
13	2/11/2020 4:30	18	0.24	0.01	0.05	0.01	0.01	<3m	<3m	N/A
14	2/13/2020 1:00	14.25	0.64	0.04	0.17	0.03	0.02	<3m	<3m	N/A
15	2/18/2020 15:00	9.75	0.46	0.05	0.1	0.02	0.01	<3m	<3m	N/A
16	2/25/2020 20:15	6.75	0.39	0.06	0.12	0.02	0.01	<3m	<3m	N/A
17	2/26/2020 22:15	10.75	0.84	0.08	0.25	0.04	0.03	<3m	<3m	N/A
18	3/3/2020 18:45	7.25	0.08	0.01	0.03	0.00	0.00	<3m	<3m	N/A
19	3/13/2020 0:30	12.5	0.34	0.03	0.08	0.01	0.01	<3m	<3m	N/A
20	3/17/2020 7:45	6.5	0.03	0.00	0.02	0.00	0.00	<3m	<3m	N/A
21	3/19/2020 4:15	27.5	0.75	0.03	0.2	0.03	0.02	<3m	<3m	N/A
22	3/23/2020 14:30	14.75	2.3	0.16	0.5	0.10	0.05	<3m	3-6m	N/A
23	3/28/2020 20:00	52.25	1.22	0.02	0.23	0.04	0.02	<3m	<3m	N/A
24	4/2/2020 1:00	59	2.2	0.04	0.23	0.07	0.05	<3m	3m	N/A
25	4/8/2020 5:00	4.25	0.06	0.01	0.02	0.00	0.00	<3m	<3m	N/A
26	4/9/2020 9:45	8.5	0.72	0.08	0.24	0.03	0.02	<3m	<3m	N/A
27	4/10/2020 15:30	2.25	0.04	0.02	0.02	0.01	0.02	<3m	<3m	N/A
28	4/13/2020 4:00	15.75	1.31	0.08	0.39	0.05	0.03	<3m	<3m	N/A
29	4/17/2020 23:45	14.5	0.81	0.06	0.24	0.03	0.02	<3m	<3m	N/A
30	4/21/2020 15:00	5	0.47	0.09	0.34	0.02	0.01	<3m	<3m	N/A
31	4/24/2020 3:15	12	0.28	0.02	0.06	0.01	0.01	<3m	<3m	N/A
32	4/26/2020 13:30	34.25	1.29	0.04	0.12	0.04	0.03	<3m	<3m	N/A
33	4/30/2020 8:45	0.25	0.01	0.04	0	0.00	0.00	<3m	<3m	N/A
34	5/1/2020 1:15	23.5	1.18	0.05	0.31	0.05	0.00	<3m	<3m	N/A
35	5/7/2020 2:15	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
36	5/8/2020 17:45	15.25	0.49	0.03	0.09	0.02	0.01	<3m	<3m	N/A
37	5/11/2020 16:00	6	0.34	0.06	0.25	0.01	0.01	<3m	<3m	N/A
38	5/15/2020 1:00	1.25	0.06	0.05	0.05	0.00	0.00	<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	5/15/2020 20:00	5.25	0.81	0.15	0.31	0.04	0.02	<3m	<3m	N/A
40	5/29/2020 3:00	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
41	5/30/2020 2:00	2.5	0.11	0.04	0	0.00	0.00	<3m	<3m	N/A
42	6/2/2020 18:45	8.25	0.04	0.00	0.03	0.00	0.00	<3m	<3m	N/A
43	6/5/2020 3:45	3.75	0.06	0.02	0.05	0.00	0.00	<3m	<3m	N/A
44	6/6/2020 14:45	6.5	0.9	0.14	0.5	0.04	0.02	<3m	<3m	N/A
45	6/11/2020 12:15	5.75	0.74	0.13	0.57	0.03	0.02	3m	<3m	N/A
46	6/21/2020 16:00	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
47	6/27/2020 14:30	1.25	0.04	0.03	0.03	0.00	0.00	<3m	<3m	N/A
48	6/28/2020 12:45	49	1.32	0.03	0.55	0.05	0.03	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	1/4/2020 10:30	22.5	0.28	0.01	0.05	0.01	0.01	<3m	<3m	N/A
2	1/8/2020 1:30	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
3	1/12/2020 4:00	6.5	0.06	0.01	0.04	0.00	0.00	<3m	<3m	N/A
4	1/16/2020 3:30	5.75	0.08	0.01	0.04	0.00	0.00	<3m	<3m	N/A
5	1/18/2020 18:30	16.75	0.3	0.02	0.09	0.01	0.01	<3m	<3m	N/A
6	1/25/2020 17:30	4.75	0.63	0.13	0.21	0.03	0.01	<3m	<3m	N/A
7	2/5/2020 1:45	4	0.04	0.01	0.02	0.00	0.00	<3m	<3m	N/A
8	2/6/2020 2:45	35	0.8	0.02	0.15	0.02	0.02	<3m	<3m	N/A
9	2/10/2020 4:30	10	0.15	0.02	0.08	0.01	0.00	<3m	<3m	N/A
10	2/11/2020 5:15	14.25	0.17	0.01	0.07	0.01	0.01	<3m	<3m	N/A
11	2/13/2020 1:15	13.5	0.55	0.04	0.16	0.02	0.01	<3m	<3m	N/A
12	2/18/2020 15:00	7.25	0.46	0.06	0.1	0.02	0.01	<3m	<3m	N/A
13	2/25/2020 20:45	6.25	0.42	0.07	0.11	0.02	0.01	<3m	<3m	N/A
14	2/27/2020 1:15	8	0.84	0.11	0.25	0.04	0.03	<3m	<3m	N/A
15	3/3/2020 19:45	6.5	0.04	0.01	0.02	0.00	0.00	<3m	<3m	N/A
16	3/13/2020 1:00	14	0.35	0.03	0.12	0.01	0.01	<3m	<3m	N/A
17	3/17/2020 8:15	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
18	3/19/2020 4:30	26.5	0.68	0.03	0.17	0.03	0.01	<3m	<3m	N/A
19	3/23/2020 14:30	15	2	0.13	0.5	0.08	0.04	<3m	3m	N/A
20	3/28/2020 20:15	26.75	0.97	0.04	0.15	0.04	0.02	<3m	<3m	N/A
21	3/30/2020 14:00	5.5	0.1	0.02	0	0.00	0.00	<3m	<3m	N/A
22	4/2/2020 12:30	38.25	1.74	0.05	0.2	0.06	0.04	<3m	<3m	N/A
23	4/8/2020 5:15	3	0.05	0.02	0.02	0.00	0.00	<3m	<3m	N/A
24	4/9/2020 9:30	8.75	0.67	0.08	0.23	0.03	0.02	<3m	<3m	N/A
25	4/10/2020 15:15	2.5	0.03	0.01	0.02	0.01	0.01	<3m	<3m	N/A
26	4/13/2020 4:00	15.75	1.07	0.07	0.31	0.04	0.02	<3m	<3m	N/A
27	4/18/2020 0:00	15.25	0.75	0.05	0.19	0.03	0.02	<3m	<3m	N/A
28	4/21/2020 15:15	2.75	0.43	0.16	0.31	0.02	0.01	<3m	<3m	N/A
29	4/24/2020 3:30	12.25	0.24	0.02	0.06	0.01	0.01	<3m	<3m	N/A
30	4/26/2020 13:45	33	1.17	0.04	0.12	0.04	0.02	<3m	<3m	N/A
31	5/1/2020 1:30	23.75	0.93	0.04	0.29	0.04	0.00	<3m	<3m	N/A
32	5/7/2020 2:45	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
33	5/8/2020 17:45	15	0.43	0.03	0.07	0.02	0.01	<3m	<3m	N/A
34	5/11/2020 16:15	4.5	0.32	0.07	0.24	0.01	0.01	<3m	<3m	N/A
35	5/15/2020 1:15	1.75	0.05	0.03	0.04	0.00	0.00	<3m	<3m	N/A
36	5/15/2020 20:00	5.25	0.67	0.13	0.36	0.03	0.02	<3m	<3m	N/A
37	5/30/2020 2:15	2	0.09	0.05	0	0.00	0.00	<3m	<3m	N/A
38	6/2/2020 18:45	8.25	0.02	0.00	0.01	0.00	0.00	<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	6/5/2020 3:45	1.75	0.06	0.03	0.05	0.00	0.00	<3m	<3m	N/A
40	6/6/2020 14:45	6.5	0.74	0.11	0.53	0.03	0.02	3m	<3m	N/A
41	6/11/2020 12:15	5.5	0.69	0.13	0.57	0.03	0.01	3m	<3m	N/A
42	6/24/2020 18:15	8	0.25	0.03	0.24	0.01	0.01	<3m	<3m	N/A
43	6/27/2020 14:30	1	0.03	0.03	0.03	0.00	0.00	<3m	<3m	N/A
44	6/28/2020 12:45	48.5	1.59	0.03	0.78	0.06	0.03	6m-1yr	<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	1/4/2020 11:45	17	0.22	0.01	0.02	0.01	0.00	<3m	<3m	N/A
2	1/12/2020 4:00	1	0.04	0.04	0.02	0.00	0.00	<3m	<3m	N/A
3	1/13/2020 9:45	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
4	1/16/2020 2:45	6.75	0.13	0.02	0.02	0.01	0.00	<3m	<3m	N/A
5	1/19/2020 9:00	4.5	0.44	0.10	0.09	0.02	0.01	<3m	<3m	N/A
6	1/25/2020 17:30	8.25	0.6	0.07	0.08	0.03	0.01	<3m	<3m	N/A
7	2/1/2020 1:30	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
8	2/5/2020 2:15	3.25	0.05	0.02	0.01	0.00	0.00	<3m	<3m	N/A
9	2/6/2020 6:00	37.25	0.62	0.02	0.07	0.02	0.01	<3m	<3m	N/A
10	2/10/2020 4:30	7.25	0.12	0.02	0.02	0.01	0.00	<3m	<3m	N/A
11	2/11/2020 4:00	15.25	0.15	0.01	0.03	0.01	0.01	<3m	<3m	N/A
12	2/13/2020 1:15	14	0.59	0.04	0.04	0.02	0.01	<3m	<3m	N/A
13	2/18/2020 12:30	9.25	0.45	0.05	0.1	0.02	0.01	<3m	<3m	N/A
14	2/25/2020 20:45	6.5	0.24	0.04	0.11	0.01	0.01	<3m	<3m	N/A
15	2/27/2020 3:00	6.25	0.79	0.13	0.26	0.04	0.03	<3m	<3m	N/A
16	3/3/2020 19:00	7.25	0.04	0.01	0.01	0.00	0.00	<3m	<3m	N/A
17	3/13/2020 1:15	15.5	0.38	0.02	0.04	0.02	0.01	<3m	<3m	N/A
18	3/17/2020 7:30	0.75	0.02	0.03	0.01	0.00	0.00	<3m	<3m	N/A
19	3/19/2020 4:30	11.5	0.47	0.04	0.04	0.02	0.01	<3m	<3m	N/A
20	3/20/2020 4:00	4	0.03	0.01	0.01	0.02	0.01	<3m	<3m	N/A
21	3/23/2020 14:30	15.25	1.61	0.11	0.16	0.07	0.03	<3m	<3m	N/A
22	3/28/2020 20:00	26.75	0.66	0.02	0.07	0.03	0.01	<3m	<3m	N/A
23	3/30/2020 17:00	2.5	0.09	0.04	0	0.00	0.00	<3m	<3m	N/A
24	4/2/2020 2:15	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
25	4/2/2020 14:45	34.75	0.83	0.02	0.04	0.03	0.02	<3m	<3m	N/A
26	4/8/2020 5:00	3.5	0.07	0.02	0.01	0.00	0.00	<3m	<3m	N/A
27	4/9/2020 10:00	9	0.63	0.07	0.11	0.03	0.01	<3m	<3m	N/A
28	4/10/2020 15:15	1.75	0.03	0.02	0.01	0.01	0.01	<3m	<3m	N/A
29	4/13/2020 4:45	15	0.71	0.05	0.1	0.03	0.01	<3m	<3m	N/A
30	4/15/2020 3:30	0.25	0.01	0.04	0.01	0.00	0.02	<3m	<3m	N/A
31	4/18/2020 0:00	11	0.59	0.05	0.07	0.02	0.01	<3m	<3m	N/A
32	4/21/2020 15:30	2.5	0.39	0.16	0.24	0.02	0.01	<3m	<3m	N/A
33	4/24/2020 3:30	11.5	0.17	0.01	0.04	0.01	0.00	<3m	<3m	N/A
34	4/26/2020 13:30	33	0.65	0.02	0.08	0.03	0.02	<3m	<3m	N/A
35	4/30/2020 8:45	0.25	0.01	0.04	0	0.00	0.00	<3m	<3m	N/A
36	5/1/2020 3:00	5.75	0.82	0.14	0.09	0.00	0.00	<3m	<3m	N/A
37	5/1/2020 23:15	1.5	0.04	0.03	0.02	0.04	0.00	<3m	<3m	N/A
38	5/7/2020 1:45	0.25	0.01	0.04	0.01	0.00	0.00	<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	5/8/2020 18:00	14.75	0.39	0.03	0.02	0.02	0.01	<3m	<3m	N/A
40	5/11/2020 16:00	8	0.48	0.06	0.14	0.02	0.01	<3m	<3m	N/A
41	5/15/2020 1:15	1.75	0.05	0.03	0.01	0.00	0.00	<3m	<3m	N/A
42	5/15/2020 19:45	5	0.65	0.13	0.28	0.03	0.01	<3m	<3m	N/A
43	5/30/2020 2:45	0.5	0.07	0.14	0	0.00	0.00	<3m	<3m	N/A
44	6/2/2020 18:30	0.25	0.03	0.12	0.03	0.00	0.00	<3m	<3m	N/A
45	6/5/2020 4:00	2.25	0.31	0.14	0.26	0.01	0.01	<3m	<3m	N/A
46	6/6/2020 14:45	6.5	0.05	0.01	0.01	0.00	0.01	<3m	<3m	N/A
47	6/11/2020 12:15	5.75	0.77	0.13	0.35	0.03	0.02	<3m	<3m	N/A
48	6/24/2020 17:45	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
49	6/28/2020 12:00	33.25	2.21	0.07	0.46	0.09	0.05	<3m	3-6m	N/A
50	6/30/2020 12:00	0.75	0.04	0.05	0.02	0.01	0.05	<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	1/4/2020 11:45	18.5	0.29	0.02	0.05	0.01	0.01	<3m	<3m	N/A
2	1/12/2020 4:00	6.5	0.08	0.01	0.06	0.00	0.00	<3m	<3m	N/A
3	1/13/2020 9:45	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
4	1/15/2020 4:30	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
5	1/16/2020 2:45	7	0.19	0.03	0.07	0.01	0.00	<3m	<3m	N/A
6	1/19/2020 9:00	4.5	0.45	0.10	0.28	0.02	0.01	<3m	<3m	N/A
7	1/25/2020 17:30	13.75	0.67	0.05	0.19	0.03	0.01	<3m	<3m	N/A
8	2/1/2020 1:30	7.5	0.02	0.00	0.01	0.00	0.00	<3m	<3m	N/A
9	2/5/2020 2:15	3	0.05	0.02	0.02	0.00	0.00	<3m	<3m	N/A
10	2/6/2020 6:00	37.25	1.05	0.03	0.14	0.03	0.02	<3m	<3m	N/A
11	2/10/2020 4:00	9	0.18	0.02	0.09	0.01	0.00	<3m	<3m	N/A
12	2/11/2020 4:00	15.25	0.15	0.01	0.06	0.01	0.01	<3m	<3m	N/A
13	2/13/2020 1:15	14	0.69	0.05	0.12	0.03	0.02	<3m	<3m	N/A
14	2/14/2020 6:00	0.25	0.01	0.04	0.01	0.02	0.01	<3m	<3m	N/A
15	2/18/2020 12:30	9.25	0.48	0.05	0.11	0.02	0.01	<3m	<3m	N/A
16	2/25/2020 20:45	7.25	0.21	0.03	0.06	0.01	0.00	<3m	<3m	N/A
17	2/26/2020 23:30	10.75	1.06	0.10	0.28	0.04	0.03	<3m	<3m	N/A
18	3/3/2020 19:00	7.25	0.05	0.01	0.02	0.00	0.00	<3m	<3m	N/A
19	3/13/2020 1:15	15.5	0.49	0.03	0.12	0.02	0.01	<3m	<3m	N/A
20	3/17/2020 7:30	0.75	0.03	0.04	0.03	0.00	0.00	<3m	<3m	N/A
21	3/19/2020 4:30	26.5	0.7	0.03	0.13	0.03	0.01	<3m	<3m	N/A
22	3/23/2020 14:30	15.25	1.71	0.11	0.41	0.07	0.04	<3m	<3m	N/A
23	3/28/2020 20:00	53.25	1.07	0.02	0.12	0.03	0.02	<3m	<3m	N/A
24	4/2/2020 2:15	48	1.25	0.03	0.14	0.05	0.03	<3m	<3m	N/A
25	4/8/2020 5:00	4.75	0.11	0.02	0.04	0.00	0.00	<3m	<3m	N/A
26	4/9/2020 10:00	8.75	0.71	0.08	0.17	0.03	0.02	<3m	<3m	N/A
27	4/10/2020 15:00	2	0.04	0.02	0.03	0.01	0.02	<3m	<3m	N/A
28	4/13/2020 4:45	15.25	0.89	0.06	0.26	0.04	0.02	<3m	<3m	N/A
29	4/15/2020 3:30	0.25	0.01	0.04	0.01	0.00	0.02	<3m	<3m	N/A
30	4/18/2020 0:00	15	0.63	0.04	0.22	0.03	0.01	<3m	<3m	N/A
31	4/21/2020 15:30	2.5	0.35	0.14	0.24	0.01	0.01	<3m	<3m	N/A
32	4/24/2020 3:30	12.25	0.2	0.02	0.05	0.01	0.00	<3m	<3m	N/A
33	4/26/2020 13:30	33.5	1.39	0.04	0.11	0.05	0.03	<3m	<3m	N/A
34	4/30/2020 8:45	0.25	0.01	0.04	0	0.00	0.00	<3m	<3m	N/A
35	5/1/2020 1:45	22	0.99	0.05	0.31	0.00	0.00	<3m	<3m	N/A
36	5/4/2020 4:00	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
37	5/7/2020 1:15	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
38	5/8/2020 18:15	15.5	0.4	0.03	0.07	0.02	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	5/11/2020 12:30	8.75	0.46	0.05	0.28	0.02	0.01	<3m	<3m	N/A
40	5/15/2020 1:15	2	0.07	0.04	0.05	0.00	0.00	<3m	<3m	N/A
41	5/15/2020 20:00	5	0.54	0.11	0.35	0.03	0.01	<3m	<3m	N/A
42	5/30/2020 2:45	0.5	0.03	0.06	0	0.00	0.00	<3m	<3m	N/A
43	6/2/2020 18:15	0.75	0.05	0.07	0.05	0.00	0.00	<3m	<3m	N/A
44	6/3/2020 19:15	0.5	0.09	0.18	0.09	0.00	0.00	<3m	<3m	N/A
45	6/5/2020 4:00	0.75	0.41	0.55	0.41	0.02	0.01	<3m	<3m	N/A
46	6/6/2020 20:30	0.5	0.02	0.04	0.02	0.00	0.01	<3m	<3m	N/A
47	6/11/2020 12:15	5.25	0.55	0.10	0.44	0.02	0.01	<3m	<3m	N/A
48	6/24/2020 12:45	6.75	0.03	0.00	0.01	0.00	0.00	<3m	<3m	N/A
49	6/28/2020 12:00	58.75	1.39	0.02	0.43	0.05	0.03	<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 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	1/4/2020 10:30	22.5	0.28	0.01	0.05	0.01	0.01	<3m	<3m	N/A
2	1/8/2020 1:30	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
3	1/12/2020 4:00	6.5	0.06	0.01	0.04	0.00	0.00	<3m	<3m	N/A
4	1/16/2020 3:30	5.75	0.08	0.01	0.04	0.00	0.00	<3m	<3m	N/A
5	1/18/2020 18:30	16.75	0.3	0.02	0.09	0.01	0.01	<3m	<3m	N/A
6	1/25/2020 17:30	4.75	0.63	0.13	0.21	0.03	0.01	<3m	<3m	N/A
7	2/5/2020 1:30	4.5	0.06	0.01	0.03	0.00	0.00	<3m	<3m	N/A
8	2/6/2020 4:15	34.25	0.93	0.03	0.14	0.02	0.02	<3m	<3m	N/A
9	2/10/2020 5:15	9.25	0.13	0.01	0.07	0.01	0.00	<3m	<3m	N/A
10	2/11/2020 5:00	11.75	0.19	0.02	0.07	0.01	0.01	<3m	<3m	N/A
11	2/13/2020 1:00	14	0.59	0.04	0.16	0.02	0.01	<3m	<3m	N/A
12	2/18/2020 15:00	7	0.44	0.06	0.1	0.02	0.01	<3m	<3m	N/A
13	2/25/2020 20:45	6.25	0.47	0.08	0.16	0.02	0.01	<3m	<3m	N/A
14	2/27/2020 0:15	16.25	0.78	0.05	0.24	0.03	0.03	<3m	<3m	N/A
15	3/3/2020 19:00	7.5	0.04	0.01	0.02	0.00	0.00	<3m	<3m	N/A
16	3/13/2020 0:45	10.75	0.21	0.02	0.09	0.01	0.00	<3m	<3m	N/A
17	3/17/2020 8:00	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
18	3/19/2020 4:30	24.25	0.68	0.03	0.2	0.03	0.01	<3m	<3m	N/A
19	3/23/2020 14:30	23.25	2.15	0.09	0.55	0.09	0.04	3m	3-6m	N/A
20	3/28/2020 20:15	26.75	0.88	0.03	0.21	0.03	0.02	<3m	<3m	N/A
21	3/30/2020 14:30	11.25	0.12	0.01	0	0.00	0.00	<3m	<3m	N/A
22	4/2/2020 15:15	36.5	1.58	0.04	0.18	0.06	0.03	<3m	<3m	N/A
23	4/8/2020 6:15	2.75	0.06	0.02	0.03	0.00	0.00	<3m	<3m	N/A
24	4/9/2020 10:45	8.75	0.66	0.08	0.23	0.03	0.02	<3m	<3m	N/A
25	4/10/2020 17:00	0.5	0.02	0.04	0.02	0.00	0.01	<3m	<3m	N/A
26	4/13/2020 5:30	15.25	1	0.07	0.32	0.04	0.02	<3m	<3m	N/A
27	4/18/2020 1:00	15.25	0.78	0.05	0.14	0.03	0.02	<3m	<3m	N/A
28	4/21/2020 16:15	2.75	0.41	0.15	0.29	0.02	0.01	<3m	<3m	N/A
29	4/24/2020 4:30	12.25	0.22	0.02	0.05	0.01	0.00	<3m	<3m	N/A
30	4/26/2020 14:45	33.25	1.19	0.04	0.12	0.04	0.02	<3m	<3m	N/A
31	5/1/2020 2:45	23	0.88	0.04	0.28	0.04	0.00	<3m	<3m	N/A
32	5/8/2020 18:45	15	0.41	0.03	0.07	0.02	0.01	<3m	<3m	N/A
33	5/11/2020 17:15	6.25	0.3	0.05	0.21	0.01	0.01	<3m	<3m	N/A
34	5/15/2020 2:15	1.5	0.05	0.03	0.04	0.00	0.00	<3m	<3m	N/A
35	5/15/2020 21:00	4.75	0.66	0.14	0.34	0.03	0.01	<3m	<3m	N/A
36	5/30/2020 2:15	1	0.14	0.14	0	0.00	0.00	<3m	<3m	N/A
37	6/2/2020 18:30	8.25	0.03	0.00	0.02	0.00	0.00	<3m	<3m	N/A
38	6/5/2020 3:45	0.75	0.07	0.09	0.07	0.00	0.00	<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	6/6/2020 14:30	6.75	0.59	0.09	0.54	0.02	0.01	3m	<3m	N/A
40	6/11/2020 12:15	5.75	0.69	0.12	0.52	0.03	0.01	<3m	<3m	N/A
41	6/24/2020 18:30	0.5	0.04	0.08	0.04	0.00	0.00	<3m	<3m	N/A
42	6/27/2020 14:45	0.75	0.02	0.03	0.02	0.00	0.00	<3m	<3m	N/A
43	6/28/2020 12:30	48.5	1.63	0.03	0.83	0.06	0.03	6m-1yr	<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	1/4/2020 10:30	18.25	0.25	0.01	0.05	0.01	0.01	<3m	<3m	N/A
2	1/12/2020 4:00	5.5	0.06	0.01	0.03	0.00	0.00	<3m	<3m	N/A
3	1/14/2020 21:15	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
4	1/16/2020 3:30	6	0.11	0.02	0.04	0.00	0.00	<3m	<3m	N/A
5	1/19/2020 9:30	3.5	0.32	0.09	0.24	0.01	0.01	<3m	<3m	N/A
6	1/25/2020 17:30	5.75	0.55	0.10	0.16	0.02	0.01	<3m	<3m	N/A
7	2/5/2020 1:30	4	0.05	0.01	0.02	0.00	0.00	<3m	<3m	N/A
8	2/6/2020 7:15	32.25	0.86	0.03	0.14	0.02	0.02	<3m	<3m	N/A
9	2/10/2020 3:45	8.25	0.16	0.02	0.08	0.01	0.00	<3m	<3m	N/A
10	2/11/2020 5:00	11.25	0.15	0.01	0.07	0.01	0.01	<3m	<3m	N/A
11	2/13/2020 1:00	13.25	0.55	0.04	0.17	0.02	0.01	<3m	<3m	N/A
12	2/18/2020 12:30	9.75	0.45	0.05	0.10	0.02	0.01	<3m	<3m	N/A
13	2/25/2020 20:30	6.75	0.35	0.05	0.11	0.01	0.01	<3m	<3m	N/A
14	2/27/2020 1:30	7.75	0.88	0.11	0.26	0.04	0.03	<3m	<3m	N/A
15	3/3/2020 19:15	6.75	0.04	0.01	0.02	0.00	0.00	<3m	<3m	N/A
16	3/13/2020 1:00	15.25	0.45	0.03	0.11	0.02	0.01	<3m	<3m	N/A
17	3/17/2020 7:30	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
18	3/19/2020 4:15	26.5	0.66	0.02	0.16	0.03	0.01	<3m	<3m	N/A
19	3/23/2020 14:30	15	1.96	0.13	0.48	0.08	0.04	<3m	3m	N/A
20	3/28/2020 20:00	26.75	0.86	0.03	0.12	0.03	0.02	<3m	<3m	N/A
21	3/30/2020 16:45	10.25	0.11	0.01	0	0.00	0.00	<3m	<3m	N/A
22	4/2/2020 14:30	36.5	1.24	0.03	0.18	0.04	0.03	<3m	<3m	N/A
23	4/8/2020 5:15	2.75	0.06	0.02	0.03	0.00	0.00	<3m	<3m	N/A
24	4/9/2020 9:45	8.5	0.62	0.07	0.24	0.03	0.01	<3m	<3m	N/A
25	4/10/2020 15:15	0.5	0.03	0.06	0.03	0.01	0.01	<3m	<3m	N/A
26	4/13/2020 4:15	15.25	0.83	0.05	0.24	0.03	0.02	<3m	<3m	N/A
27	4/18/2020 0:00	11.5	0.7	0.06	0.21	0.03	0.01	<3m	<3m	N/A
28	4/21/2020 15:00	3	0.36	0.12	0.24	0.02	0.01	<3m	<3m	N/A
29	4/24/2020 3:30	11.5	0.19	0.02	0.04	0.01	0.00	<3m	<3m	N/A
30	4/26/2020 13:15	33.25	0.9	0.03	0.08	0.03	0.02	<3m	<3m	N/A
31	4/30/2020 8:30	0.25	0.01	0.04	0	0.00	0.00	<3m	<3m	N/A
32	5/1/2020 1:00	24.5	0.89	0.04	0.27	0.04	0.00	<3m	<3m	N/A
33	5/7/2020 1:00	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
34	5/8/2020 18:00	14.75	0.38	0.03	0.06	0.02	0.01	<3m	<3m	N/A
35	5/11/2020 16:00	5	0.3	0.06	0.21	0.01	0.01	<3m	<3m	N/A
36	5/15/2020 1:15	1	0.04	0.04	0.04	0.00	0.00	<3m	<3m	N/A
37	5/15/2020 20:00	5	0.62	0.12	0.32	0.03	0.01	<3m	<3m	N/A
38	5/30/2020 2:45	0.5	0.13	0.26	0	0.00	0.00	<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	6/2/2020 18:45	8.25	0.04	0.00	0.03	0.00	0.00	<3m	<3m	N/A
40	6/5/2020 4:00	0.75	0.17	0.23	0	0.00	0.00	<3m	<3m	N/A
41	6/6/2020 14:45	6.75	0.11	0.02	0.05	0.00	0.00	<3m	<3m	N/A
42	6/11/2020 12:15	22.75	0.68	0.03	0.50	0.03	0.01	<3m	<3m	N/A
43	6/27/2020 15:15	0.5	0.02	0.04	0	0.00	0.00	<3m	<3m	N/A
44	6/28/2020 12:15	29.25	1.32	0.05	1.05	0.05	0.03	1yr	<3m	N/A
45	6/30/2020 9:45	10.5	0.79	0.08	0.31	0.03	0.03	<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	1/4/2020 10:30	18.25	0.25	0.01	0.05	0.01	0.01	<3m	<3m	N/A
2	1/12/2020 4:00	5.5	0.06	0.01	0.03	0.00	0.00	<3m	<3m	N/A
3	1/14/2020 21:15	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
4	1/16/2020 3:30	6	0.11	0.02	0.04	0.00	0.00	<3m	<3m	N/A
5	1/19/2020 9:30	3.5	0.32	0.09	0.24	0.01	0.01	<3m	<3m	N/A
6	1/25/2020 17:30	5.75	0.55	0.10	0.16	0.02	0.01	<3m	<3m	N/A
7	2/1/2020 8:45	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
8	2/5/2020 1:30	4	0.06	0.02	0.02	0.00	0.00	<3m	<3m	N/A
9	2/6/2020 7:15	32.25	1.18	0.04	0.14	0.04	0.02	<3m	<3m	N/A
10	2/10/2020 3:45	8.75	0.25	0.03	0.12	0.01	0.01	<3m	<3m	N/A
11	2/11/2020 4:00	12	0.18	0.02	0.07	0.01	0.01	<3m	<3m	N/A
12	2/13/2020 1:00	13.5	0.65	0.05	0.11	0.03	0.02	<3m	<3m	N/A
13	2/18/2020 12:30	13.25	0.49	0.04	0.11	0.02	0.01	<3m	<3m	N/A
14	2/25/2020 20:30	6.5	0.28	0.04	0.11	0.01	0.01	<3m	<3m	N/A
15	2/27/2020 0:45	8.5	0.81	0.10	0.23	0.03	0.02	<3m	<3m	N/A
16	3/3/2020 19:15	7	0.06	0.01	0.04	0.00	0.00	<3m	<3m	N/A
17	3/13/2020 1:00	15.25	0.45	0.03	0.12	0.02	0.01	<3m	<3m	N/A
18	3/17/2020 7:45	0.75	0.03	0.04	0.03	0.00	0.00	<3m	<3m	N/A
19	3/19/2020 4:15	27.75	0.73	0.03	0.18	0.03	0.02	<3m	<3m	N/A
20	3/23/2020 14:30	14.25	2.08	0.15	0.46	0.09	0.04	<3m	3-6m	N/A
21	3/25/2020 18:15	0.25	0.01	0.04	0.01	0.00	0.04	<3m	<3m	N/A
22	3/28/2020 20:00	30.75	0.9	0.03	0.13	0.03	0.02	<3m	<3m	N/A
23	3/30/2020 16:45	10.25	0.12	0.01	0	0.00	0.00	<3m	<3m	N/A
24	4/2/2020 4:30	51.5	1.46	0.03	0.16	0.05	0.03	<3m	<3m	N/A
25	4/8/2020 5:15	3.5	0.07	0.02	0.03	0.00	0.00	<3m	<3m	N/A
26	4/12/2020 13:00	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
27	4/13/2020 4:00	15.75	0.95	0.06	0.27	0.04	0.02	<3m	<3m	N/A
28	4/18/2020 0:00	15	0.76	0.05	0.21	0.03	0.02	<3m	<3m	N/A
29	4/21/2020 15:00	5	0.47	0.09	0.32	0.02	0.01	<3m	<3m	N/A
30	4/24/2020 3:30	11.75	0.25	0.02	0.05	0.01	0.01	<3m	<3m	N/A
31	4/26/2020 13:15	34	1.23	0.04	0.13	0.04	0.03	<3m	<3m	N/A
32	4/30/2020 7:45	2.75	0.04	0.01	0	0.00	0.00	<3m	<3m	N/A
33	5/1/2020 1:00	23	1.07	0.05	0.25	0.04	0.00	<3m	<3m	N/A
34	5/7/2020 1:00	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
35	5/8/2020 18:00	15	0.42	0.03	0.07	0.02	0.01	<3m	<3m	N/A
36	5/11/2020 12:30	9.75	0.38	0.04	0.28	0.02	0.01	<3m	<3m	N/A
37	5/15/2020 1:00	2	0.06	0.03	0.05	0.00	0.00	<3m	<3m	N/A
38	5/15/2020 20:00	4.75	0.67	0.14	0.47	0.03	0.02	<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	5/30/2020 2:15	1	0.04	0.04	0	0.00	0.00	<3m	<3m	N/A
40	6/2/2020 18:30	10	0.04	0.00	0.03	0.00	0.00	<3m	<3m	N/A
41	6/5/2020 3:45	1.25	0.34	0.27	0.33	0.01	0.01	<3m	<3m	N/A
42	6/6/2020 14:30	6.75	0.22	0.03	0.13	0.01	0.01	<3m	<3m	N/A
43	6/11/2020 12:00	5.25	0.72	0.14	0.53	0.03	0.02	3m	<3m	N/A
44	6/24/2020 13:45	0.75	0.21	0.28	0.21	0.01	0.00	<3m	<3m	N/A
45	6/27/2020 14:45	1	0.03	0.03	0.03	0.00	0.00	<3m	<3m	N/A
46	6/28/2020 12:00	49.5	3.39	0.07	2.06	0.14	0.07	20yr	2yr	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 D Rainfall Hyetographs

All hyetographs are plotted using 15-minute peak intensities.

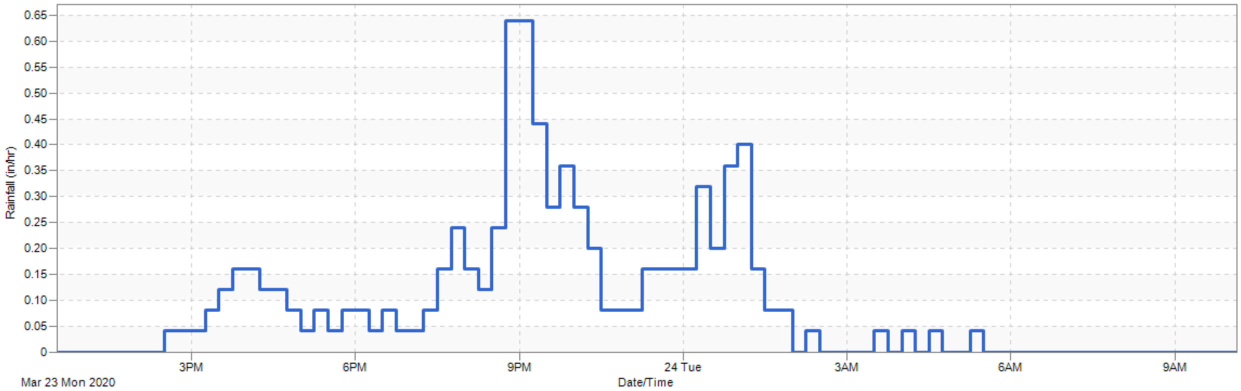

Figure 1. Ward Street March 23, 2020

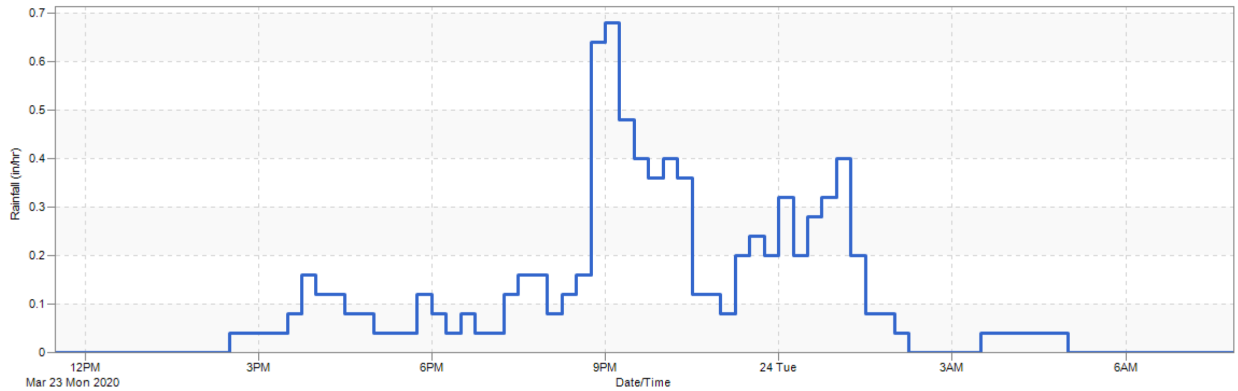

Figure 2. Columbus Park March 23, 2020

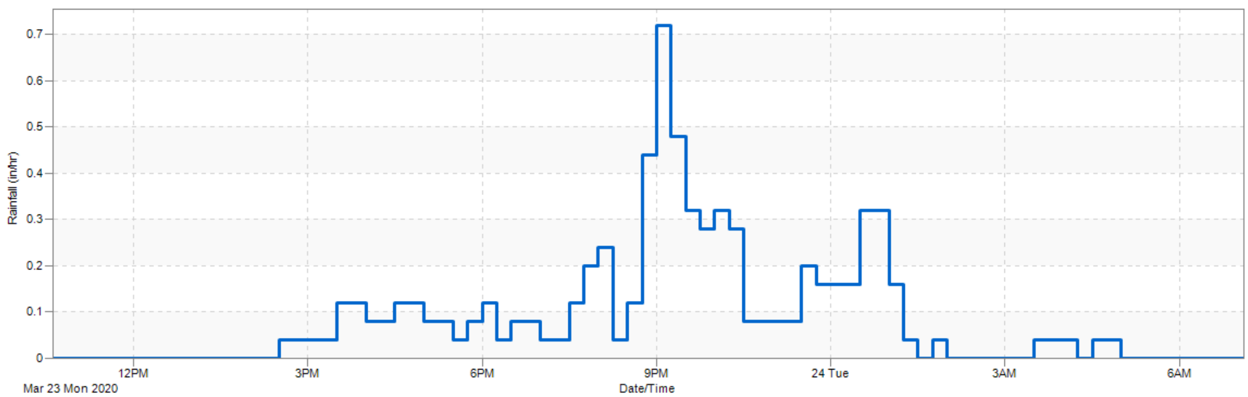

Figure 3. Chelsea Creek March 23, 2020

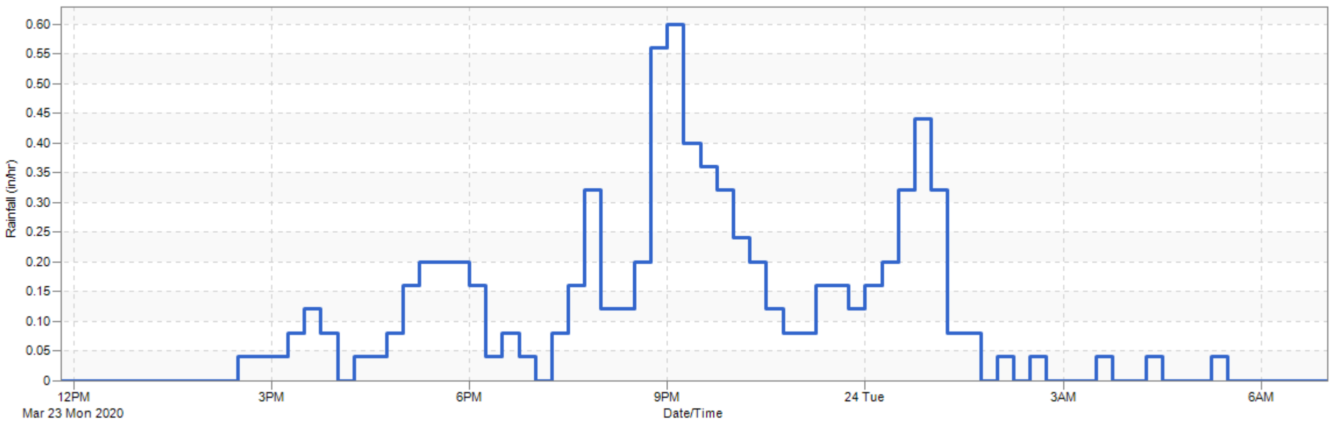

Figure 4. USGS Fresh Pond March 23, 2020

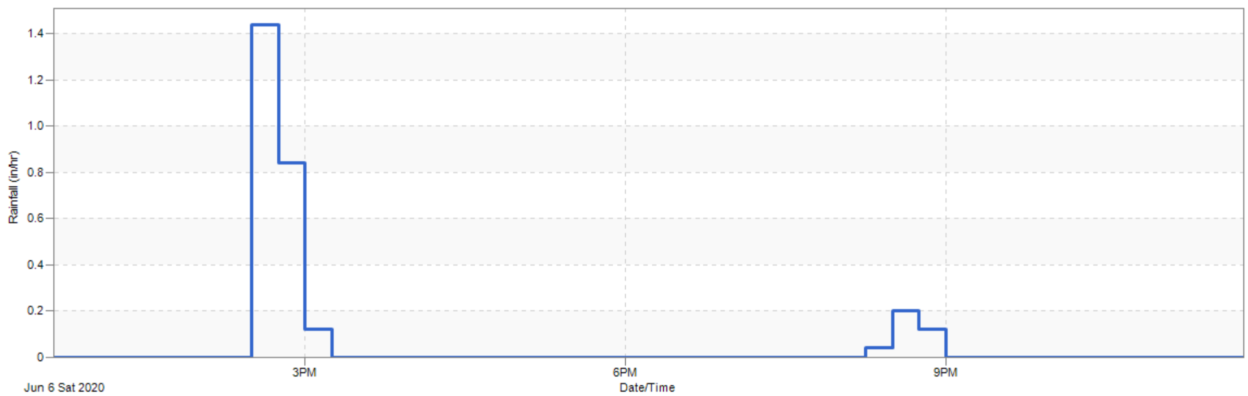

Figure 5. Ward Street June 6, 2020

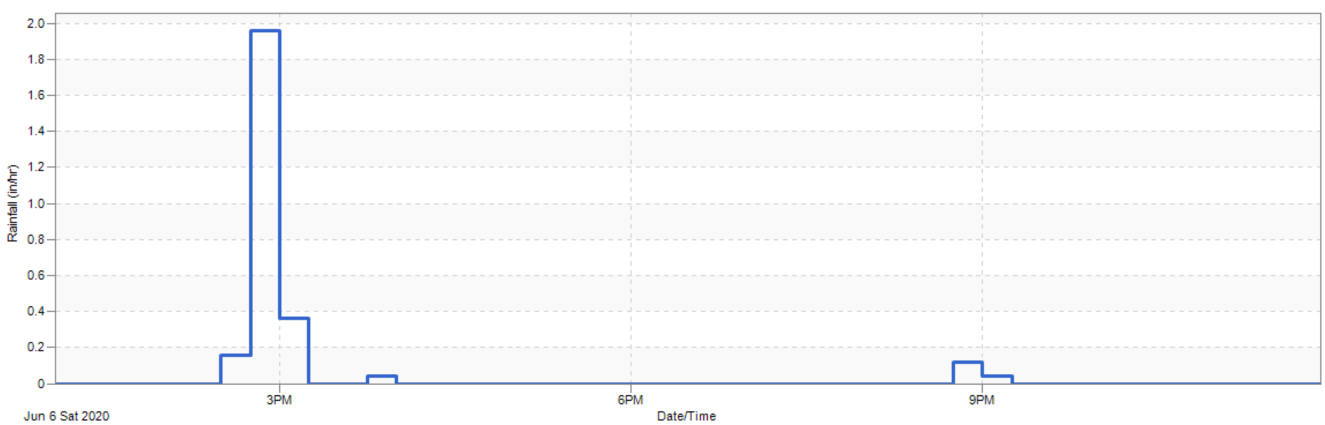

Figure 6. Columbus Park June 6, 2020

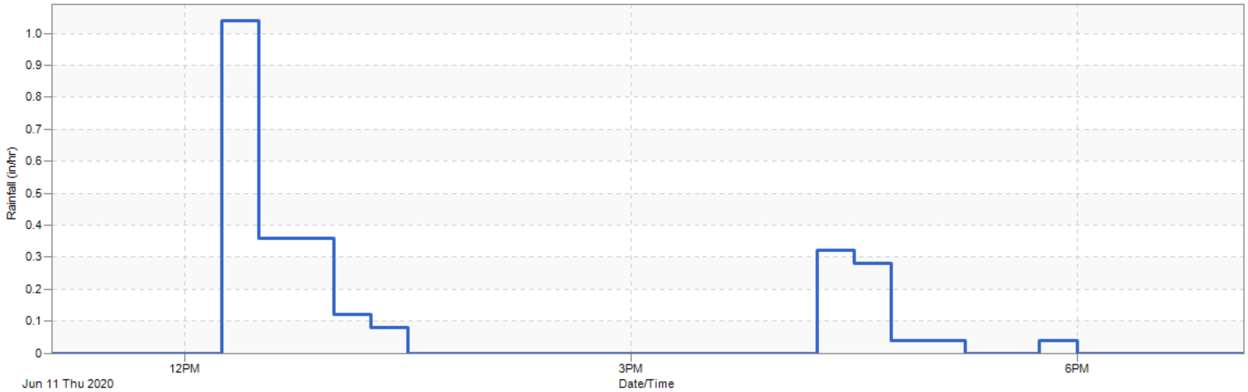

Figure 7. Ward Street June 11, 2020

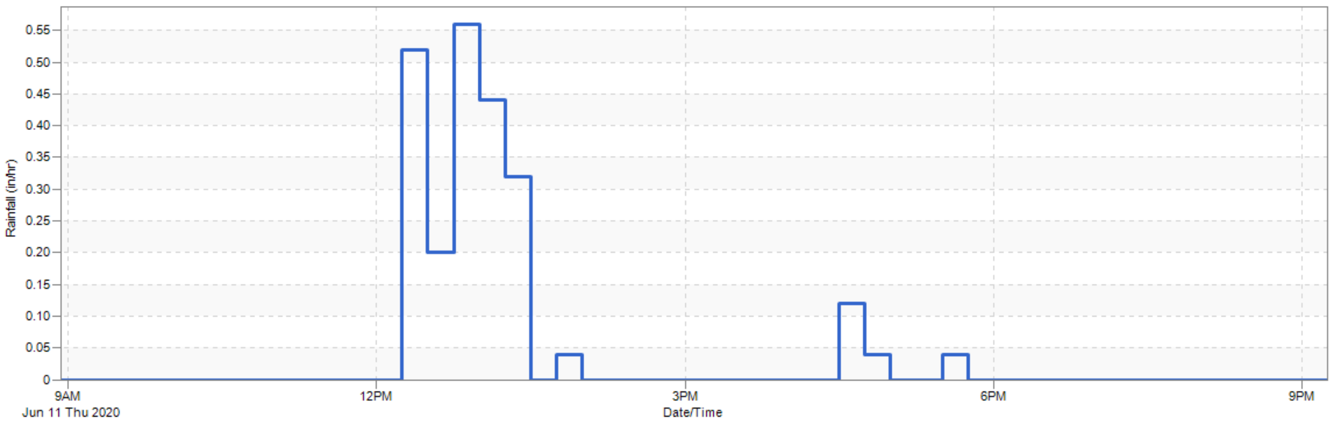

Figure 8. Columbus Park June 11, 2020

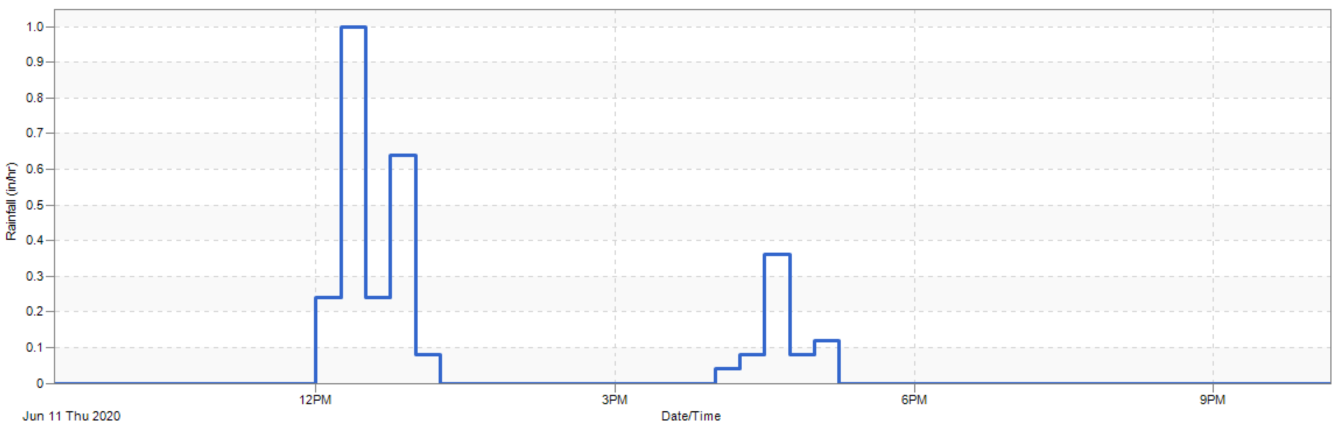

Figure 9. USGS Fresh Pond June 11, 2020

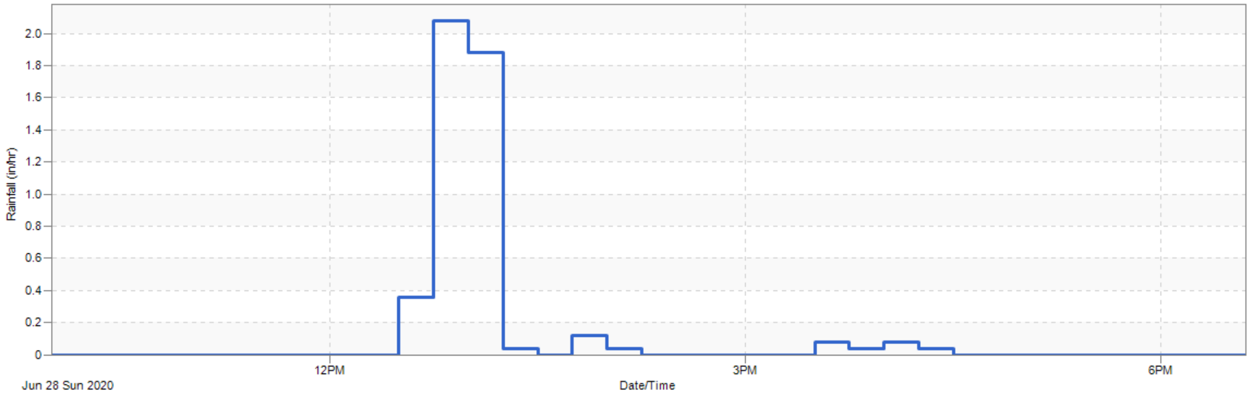

Figure 10. Ward Street June 28, 2020

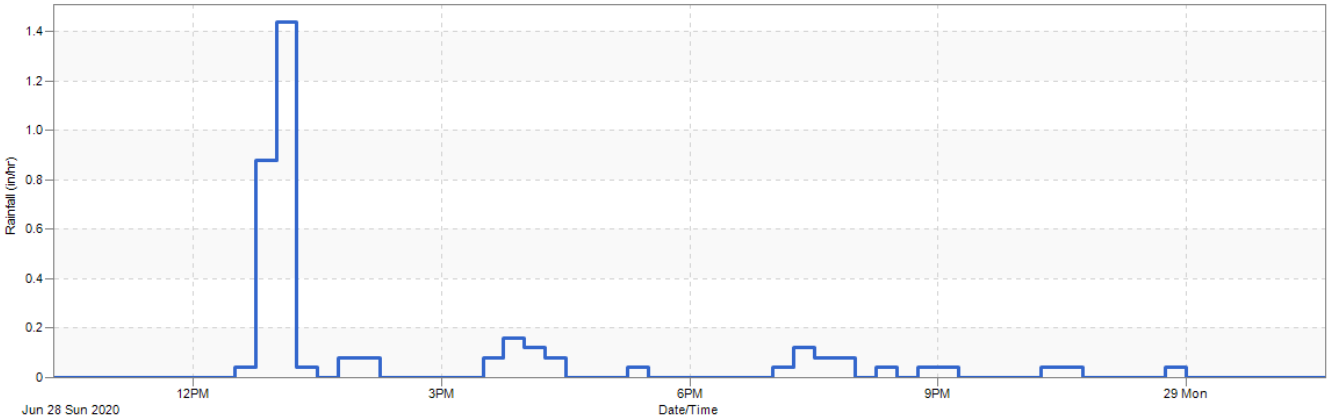

Figure 11. Columbus Park June 28, 2020

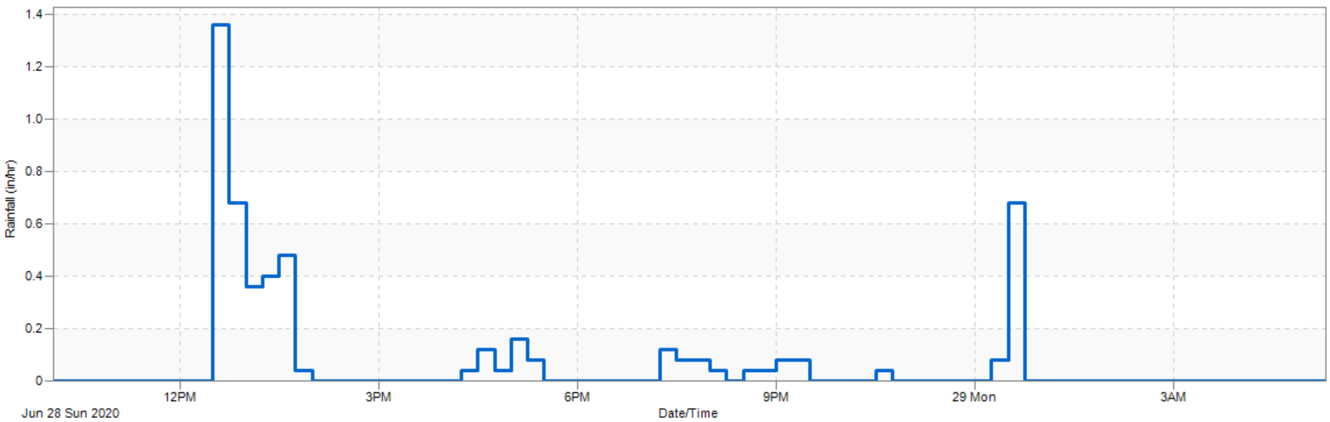

Figure 12. Chelsea Creek June 28, 2020

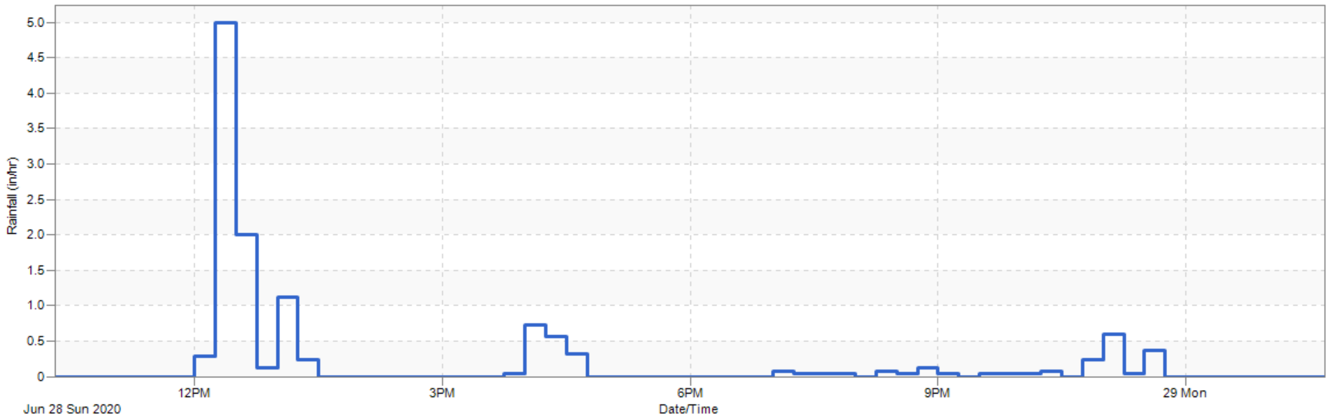

Figure 13. USGS Fresh Pond June 28, 2020