UNITED STATES DISTRICT COURT
for the
DISTRICT OF MASSACHUSETTS

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| UNITED STATES OF AMERICA,<br><br>Plaintiff,<br><br>v.<br><br>METROPOLITAN DISTRICT COMMISSION, et al.,<br><br>Defendants. | CIVIL ACTION<br>No. 85-0489-RGS |
| CONSERVATION LAW FOUNDATION OF NEW ENGLAND, INC.,<br><br>Plaintiff,<br><br>v.<br><br>METROPOLITAN DISTRICT COMMISSION,<br><br>Defendants. | CIVIL ACTION<br>No. 83-1614-RGS |

MWRA BIANNUAL COMPLIANCE AND
PROGRESS REPORT AS OF DECEMBER 17, 2018

The Massachusetts Water Resources Authority (the "Authority") submits the following biannual compliance report for the period from June 16, 2018, to December 17, 2018, and supplementary compliance information in accordance with the Court's order of December 23, 1985, and subsequent orders of the Court.

I. Schedule Seven.

There were no scheduled activities for the past six-month period on the Court's Schedule Seven.

A. Progress Report.

1. Combined Sewer Overflow Program.

a. Three-Year Performance Assessment of Long-Term CSO Control Plan.

On November 30, 2018, the Authority submitted the first of five planned semiannual progress reports on the three-year CSO performance assessment of its $910 million approved Long-Term CSO Control Plan (the "LTCP") to the United States Environmental Protection Agency ("EPA") and the Massachusetts Department of Environmental Protection ("DEP"). A copy of the report is attached as Exhibit A. The Authority also submitted copies of the report to the Boston Water and Sewer Commission and the cities of Cambridge, Chelsea and Somerville (together, the "CSO communities"), the Town of Brookline, the Charles River Watershed Association, and the Mystic River Watershed Association, as well as posted it to its website.

The first semiannual report covers the analyses of rainfall, wastewater system and CSO data collected in the two and one-half month period of April 15, through June 30, 2018, when more than 80 temporary overflow meters began collecting measurements of flow, flow level, and/or tide gate position at the 57

CSO regulators[1] that remain active. Future semiannual reports will cover subsequent 6-month data collection periods and will present the additional data, as well as comparisons of metered and model-predicted CSO discharges once the Authority's hydraulic model is updated and calibrated with the recently collected inspection results and meter data. The performance assessment required by the Court to verify whether the "Typical Year"[2] LTCP levels of CSO control are attained will await and be based on the full results of data collection, system evaluations, and model simulations that are the scope of the Authority's post-construction monitoring program through the next two years.[3] The first report includes a comparison of the characteristics of storms in the period of April 15 through June 30, 2018 to the characteristics of storms in the Typical Year to understand the measured CSO discharges in the context of the LTCP performance objectives. The report also describes the CSO and wastewater system metering plan and approach, the methodologies to quantify and validate

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[1] There are 57 CSO regulator structures that control and direct wastewater overflows to the 44 CSO outfalls that remain active. Of the original 84 outfalls addressed by the Authority's CSO program, CSO discharges are eliminated at 35 outfalls and are effectively eliminated, i.e., prevented up to the 25-year storm, at the 5 outfalls along the South Boston beaches.

[2] The Typical Year is a series of storms (93 storms with total precipitation of 46.8 inches) developed by the Authority in 1992 from a 40-year rainfall record (1949-1987 plus 1992) and approved by EPA and DEP that has served as the basis for development, recommendation and approval of the Authority's LTCP, establishment of the court mandated levels of control, and assessment of system performance.

[3] The long-term levels of CSO control - as to frequency of CSO activation and volume of discharge in the Typical Year - at the CSO outfalls within or hydraulically connected to the Authority's sewer system are set forth in Exhibit "B" to the March 15, 2006 Second Stipulation, as amended on April 30, 2008 ("Second Stipulation").

the CSO discharges estimated from the meter data, the evaluations the Authority conducts into questionable data and questionable CSO discharge estimates, and the correlation of measured CSO discharges to rainfall. The report presents rainfall data and rainfall evaluation summaries for the April 15 through June 30, 2018 time period, as well as the number of CSO discharge activations, total discharge duration, and total discharge volume from each outfall as measured by the meters during the period.

The report also describes ongoing work and work planned over the next several months toward submission of the second semiannual report in the spring of 2019, including investigations MWRA is currently conducting that respond to the data already collected and the analyses completed to date. In addition to continuing to collect rainfall, wastewater system and CSO data and conduct data analyses, the Authority is updating its hydraulic model with the results of the field inspections of all presumed closed and presumed active CSO regulators that the Authority conducted earlier this year. The Authority will then conduct verification and calibration of the updated hydraulic model using hundreds of validated meter measurements and discharge estimates from a set of metered rainfall events that cover a range of rainfall characteristics. Additionally, the Authority has begun investigating the locations where the metered CSO discharge activations or volumes differ from, i.e., are higher or lower than, the historical predictions of its hydraulic model, and where meter data or metered discharges are otherwise questionable. The Authority also continues to conduct its water quality monitoring program in CSO affected waters, with emphasis on the storm related impacts in the Charles River and the Alewife Brook/Upper Mystic River.

As previously noted, the Authority revised its CSO metering plan by installing temporary meters at all 57 potentially active regulators compared to the 33 regulators it had originally planned to meter based on historical activation predictions. The Authority had planned to maintain the temporary meters at the 33 potentially active regulators through most of the three-year performance assessment, in response to the drought years of 2014 through 2016 when the Authority's temporary flow metering programs for other purposes collected little wet weather data. Thus far, 2018 has been a relatively wet year. The Authority collected data for 27 rainfall events that occurred in the April 15 through June 30 period reported in the first semiannual report. From January 1 through November 30, 2018, the Boston area saw at least 133 days of rainfall, with total rainfall of 50.1 inches compared to the area averages over an entire year of 137 days and 43.8 inches. The Authority will soon begin a process of selective meter removal through careful consideration and validation of whether each meter installation has met its intended purpose(s), including the purposes of confirming overflow inactivity, calibrating the hydraulic model and/or ensuring that the model is accurately predicting CSO discharges across a range of storms. The Authority will identify its meter removals and provide supporting explanations in subsequent semiannual progress reports.

In addition to reporting on data collection and work progress, the report presents a summary of the accomplishments of the Authority and the CSO communities that have eliminated or greatly reduced CSO discharges to area waters since 1987. These efforts included early work to eliminate dry weather overflows from CSO outfalls in the late 1980's, hundreds of millions of dollars of major improvements to the Deer Island transport and treatment systems completed by the early 1990's, system optimization improvements that further reduced CSO discharges in the mid-1990's, and implementation of the LTCP that constructed and brought into operation the 35 LTCP projects in the period 1996 through 2015, resulting in significant environmental benefits. In just three decades, these major investments by the Authority's ratepayers produced tremendous, measurable CSO reduction.

Prior to the December 2020 report, the Authority intends to submit four more semiannual progress reports, which will track and report the progress of the three-year study, assess the quantity and quality of collected data, and bring metered and modeled CSO discharges closer together to ultimately justify confidence in the hydraulic model. The Authority also plans to share the interim results of these reports with stakeholders, including EPA and DEP, to allow for external review and input before December 2020. The Authority expects to complete the performance assessment and submit the results to EPA and DEP in December 2020, in compliance with the last milestone in Schedule Seven.

The Authority is using the performance assessment to collect extensive data at CSO regulator structures that control overflows to receiving waters, upgrade and recalibrate the Authority's collection system hydraulic model necessary to verify Typical Year CSO performance, evaluate physical or operational adjustments that may be needed to ensure attainment of LTCP levels of control, and assess remaining CSO water quality impacts against LTCP predicted impacts through statistical analyses of extensive water quality data collected from the Charles River and Alewife Brook/Upper Mystic River.

The Authority continues to conduct water quality monitoring in the Lower Charles River/Charles River Basin and Alewife Brook/Upper Mystic River as part of the CSO performance assessment and in compliance with the CSO variances to Water Quality Standards issued by DEP for these waterbodies. As anticipated in its June 2018 compliance and progress report, the Authority has had continued discussions with DEP and EPA regarding its scope of work for the performance assessment and the information DEP and EPA are seeking from the Authority. Through these discussions, the Authority understands that DEP and EPA seek a methodology that distinguishes the impacts of CSO sources from non-CSO sources (i.e., stormwater) in order to verify the level of attainment of water quality standards and are supportive of using a receiving water quality model. DEP and EPA have stated their view that such an approach is necessary for making final water quality standards determinations for the above receiving water segments and demonstrating compliance with the requirement for the three-year performance assessment which, according to DEP and EPA, requires assessing the volume and frequencies of all overflows and their impacts on receiving waters.

However, utilizing a receiving water quality model to assess the relative water quality impacts of CSO discharges differs from the approach employed in the Authority's ongoing three-year performance assessment, which, in addition to quantifying impacts from remaining CSOs in the Typical Year, utilizes a monitoring and statistical analysis approach to assess water quality. Such a receiving water quality model could not be completed by 2020.

While the Authority respectfully disagrees with DEP's and EPA's position, it intends to discuss with its Board of Directors DEP's and EPA's position with respect to a receiving water quality model for the Lower Charles River/Charles River Basin and Alewife Brook/Upper Mystic River waterbodies. In addition, the Authority will seek regulatory certainty in the form of continued variances through 2024, in accordance with state and federal regulations at 314 CMR 4.03(4) and 40 CFR 131.14 respectively. To that end, the Authority has initiated discussions with DEP and EPA to extend the variances. In the meantime, the Authority will continue with its performance assessment to meet the remaining Schedule Seven milestone by December, 2020.

The Authority, DEP, and EPA have had constructive, encouraging conversations regarding these issues. The Authority remains committed to working toward consensus and is optimistic that will be reached. The Authority intends to continue the discussions and will update the status in its June 2019 filing or sooner if the Court desires.

Respectfully submitted,

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CERTIFICATE OF SERVICE

I hereby certify that a true and accurate copy of this document, which was filed via the Court's ECF system, will be sent electronically by the ECF system to the registered participants as identified on the Notice of Electronic Filing (NEF) and paper copies will be sent to those indicated as non-registered participants on December 17, 2018.

/s/ Jonathan M. Ettinger
Jonathan M. Ettinger (BBO #552136)
Jettinger@foleyhoag.com

Dated: December 17, 2018

# Task 4: Semiannual CSO Discharge Report No.1
## April 15, 2018 – June 30, 2018

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

**November 30, 2018**

Project number: 60559027

# FORWARD

Over the last 30 years, the MWRA has invested over $900 million in a Long-Term Control Plan to reduce Combined Sewer Overflow (CSO) discharges into the rivers and harbor that are the environmental and recreational centerpieces of the Metropolitan Boston region. When combined with related local community projects, that investment is over $1 billion. MWRA, with support and collaboration from state and federal partners at MassDEP and EPA Region 1, along with the communities, has made dramatic improvements in the capacity and reliability of the systems that transport and treat wastewater. We have all seen the results with our own eyes:

- Boston Harbor, once derided as the dirtiest harbor in America, has rebounded; seals, whales, and other wildlife are returning;
- Boston's beaches are considered the cleanest urban beaches in the country, providing residents with safe access to the seaside without the need to travel;
- The EPA and local watershed organizations have given the Charles River, which had a failing grade of D in 1995, an A- for 2017, and there are considerations to opening it up to swimming once again;
- An innovative stormwater wetland in Cambridge has improved water quality in the Little River and Alewife Brook and created plant and wildlife habitats, recreational open space and educational opportunities;
- Water quality monitoring data show that bacterial contamination in the main stem of the Mystic River is very low on a regular basis and meets water quality standards in dry weather and most of the time in wet weather;
- The cleanup of Boston Harbor, the rivers and beaches has spawned a renaissance of recreational activity and waterfront development.

Since 1987, when the CSO control program began, the average annual volume of these discharges has been reduced from 3.3 billion gallons of treated and untreated overflow to less than 0.4 billion gallons; an 88% reduction, and 92% of that discharge is treated at MWRA's four new or upgraded CSO treatment facilities. MWRA recently added near-real-time posting of treated discharges to its website, which gives the public up-to-date information that they can rely on when making decisions about using the watershed for recreation.

The MWRA has achieved 183 CSO-related federal court milestones since 1987. MWRA, the Boston Water and Sewer Commission, the Town of Brookline, the City of Cambridge, the City of Chelsea, and the City of Somerville constructed and brought into environmental benefit the 35 wastewater system improvement projects in MWRA's approved Long-Term Control Plan in only 20 years, from 1996 to December 2015.

This document is the first of five planned semiannual progress reports on MWRA's three-year effort to collect and analyze rainfall, CSO and water quality data and to perform system inspections to verify attainment of the Long-Term Control Plan levels of CSO control, in compliance with the last milestone in the federal court schedule. This first progress report covers the period from April 15, 2018, to June 30, 2018, when MWRA began collecting data from more than one hundred temporary meters installed in 58 remaining active CSO regulators.

The next semiannual progress report, which MWRA plans to issue in the spring of 2019, will cover the collection and analysis of data in the period July 1, 2018, through December 31, 2018, as well as sewer system hydraulic model updates and recalibration from the recent system inspections and validated meter data. Ultimately, with an improved hydraulic model and extensive rainfall and meter data, MWRA hopes to document and verify achievement of the Long-Term Control Plan's Typical Year levels of control by December 2020, in compliance with the last court schedule milestone.

Since 1989, MWRA has collected thousands of water quality samples from the Alewife Brook, Mystic River, Charles River, Chelsea Creek, Boston Harbor, Fort Point Channel, and Reserved Channel. Bacteria results show that under all weather conditions there have been improvements, although other sources of contamination, including storm water, illicit connections, and remaining CSO continue to impact these water bodies. This was expected and described in the development of the Long-Term Control Plan. In a separate effort, MWRA will continue sample collection and analysis during this CSO post-construction monitoring period and will analyze that data to assess the performance of the CSO controls relative to water quality standards and background levels.

MWRA's ratepayers have made a substantial investment in the elimination or control of CSO discharges to protect the environment and public health. The MWRA and its combined sewer communities take pride in accomplishing what we set out to do many years ago. We appreciate the support from our state and federal regulators and are committed to optimizing our operations and maintaining our systems to further these achievements and benefits.

Frederick A. Laskey, Executive Director
Massachusetts Water Resources Authority

# Table of Contents

## Figures

# Tables

## 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 diversion 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.

**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 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. It is called the NPDES because the process was established under the National Pollutant Discharge Elimination System, under provisions of the Federal Clean Water Act.

**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 determined.

**Flow Sensor**: A device used to measure velocity and water level at a monitoring location from which the flowrate can be determined.

**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.

**Inclinometers:** 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 combined sewer overflow (CSO) Control Policy and part of the strategy to control CSOs. LTCPs aim to reduce the frequency, duration, and intensity 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 greater Boston area.

**Manning's Equation:** An empirical equation that applies to uniform flow in open channels and is a function of the channel velocity, flow area 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 CSO problems 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 within the system.

**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.

**Sediment:** Particulate material deposited at the bottom of a conduit or natural waterway.

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

**Typical Year Rainfall:** 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 determine the flow rate through a calculation or use of a chart or conversion table.

# 1. Introduction

## 1.1 CSO Post-Construction Monitoring and Performance Assessment

On November 8, 2017, the Massachusetts Water Resources Authority (MWRA) commenced a three-year study to measure the performance of its $910 million[1] long-term combined sewer overflow ("CSO") control plan (the "Long-Term Control Plan" or "LTCP"). The performance assessment is intended to comply with the last two schedule milestones in the now 33-year-old Federal District Court Order in the Boston Harbor Case (U.S. v. M.D.C., et al, No. 85-0489 MA).

From 1987 through 2015, MWRA addressed 182 CSO-related court schedule milestones, including completing the construction of the 35 wastewater system projects that comprise the LTCP by December 2015. The last two milestones require MWRA to commence by January 2018 a three-year performance assessment including post-construction monitoring, and to submit by December 2020 the results of its performance assessment to the U.S. Environmental Protection Agency ("EPA") and the Massachusetts Department of Environmental Protection ("DEP") demonstrating that it has achieved the levels of CSO control, "including as to frequency of activation and as to volume of discharge specified in its Long-Term CSO Control Plan," pursuant to 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, 2018 (the "Second Stipulation").

MWRA's CSO performance assessment includes the following key scope elements:

- Extensive survey and overflow data collection at remaining active CSO regulators
- Upgrades to and recalibration of MWRA's hydraulic model of the wastewater system
- Assessments of system performance for CSO control and the consideration of performance improvements
- Assessment of the water quality impacts of remaining CSOs through analyses of extensive water quality data collected during the performance assessment period

This Semiannual CSO Discharge Report No. 1 is the first of five interim reports MWRA plans to issue on the progress of the performance assessment (see Table 1-1 on the following page). It addresses the data collection period from April 15, 2018, through June 30, 2018. The beginning of the period coincides with the start of the extensive temporary CSO metering program and concurrent collection of data from permanent MWRA and community CSO and wastewater system meters. This first report includes:

- Description of the accomplishments and benefits of MWRA's CSO control program from 1987, when MWRA accepted responsibility for CSO control pursuant to the First CSO Stipulation entered in federal court, to 2015, when MWRA completed the 35 LTCP projects (Section 2).
- Description of rainfall data collection, and analyses of rainfall in the period April 15 to June 30, 2018 (Section 3)
- Description of the metering program, and analyses of meter data collected April 15 to June 30, 2018 (Section 4)
- Review of metered CSO discharges (Section 5)
- Changes made and planned calibration of the hydraulic model (Section 6)
- Ongoing work and planned progress over the next several months (Section 7)

The hydraulic model, which MWRA used to develop the LTCP and has used to track progress toward the attainment of the LTCP levels of control, has not yet been recalibrated with newly collected, extensive meter data. Model recalibration will be conducted in early 2019, as described in Section 6.2.

[1]In addition to MWRA's costs, MWRA's CSO communities incurred costs totaling more than $150 million to successfully implement, with necessary support from their residents and businesses, the Long-Term Control Plan projects in their impacted neighborhoods.

**Table 1-1: Semiannual CSO Discharge Reports**

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

## 1.2 MWRA's Federal Court Obligations for CSO Control

MWRA's obligations for CSO control in the Court Order are set forth 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* (the "Second Stipulation") as amended in April 2008. The Second Stipulation, which replaced the 1987 First CSO Stipulation by which MWRA originally assumed responsibility under the Court Order for CSO control, formalized agreements reached by EPA, DEP and MWRA in March 2006 over long-term levels of CSO control, the projects comprising the LTCP, and project implementation schedules.

The Second Stipulation requires MWRA to implement the CSO requirements on the Court's schedule, as well as meet the LTCP levels of control. (In July 2006, the Court accepted and incorporated the approved schedule revisions as Schedule Seven.) The approved LTCP levels of CSO control are set forth in Exhibit "B" to the Second Stipulation. Pursuant to the Second Stipulation, MWRA accepted legal liability to undertake such corrective action at each CSO outfall within or hydraulically connected to MWRA's sewer system as may be necessary to implement the CSO control set forth in the Court schedules and related orders of the Court, and to meet the levels of CSO control (including as to frequency of CSO activation and as to volume of discharge) recommended in MWRA's Long-Term Control Plan. With respect to the CSO outfalls owned and operated by the MWRA, MWRA also accepted legal liability to undertake such corrective future action (after 2020) as may be necessary to meet the CSO control requirements of the Clean Water Act.

The primary goal of the ongoing performance assessment is to demonstrate that MWRA has achieved compliance with the levels of control, including the frequencies of CSO discharges and volumes of discharge in a "Typical Year" specified in its Long-Term CSO Control Plan. This objective is being met by the ongoing collection of extensive temporary CSO meter data over an extended period of time to supplement permanent system meter data.

The long-term levels of CSO control recommended in MWRA's LTCP, approved by EPA and DEP with the 2006 Agreement, and included in Exhibit B to the Second Stipulation are presented in Section 2.6.1.

# 2. Long-Term Control Plan Accomplishments, Benefits and Performance Objectives

## 2.1 Three Decades of CSO Control Accomplishments and Benefits

MWRA's CSO control program began in 1987, when through a stipulation entered in the Boston Harbor Case (U.S. v. M.D.C., et al., No. 85-0489 MA) (the "First CSO Stipulation"), MWRA accepted responsibility for developing and implementing a region-wide plan to control CSOs hydraulically related to its wastewater system, including CSO discharges from its own outfalls and the outfalls permitted to and operated by the Boston Water and Sewer Commission (BWSC) and the cities of Cambridge, Chelsea and Somerville. Since then, MWRA, with the cooperation of the CSO communities, has achieved more than 180 CSO related milestones in the court ordered schedule (currently, "Schedule Seven").

MWRA's CSO efforts included development and implementation of projects to eliminate dry weather overflows and development of a first recommended CSO control plan (the Deep Rock Storage Tunnel Plan[1]) (1987 to 1991); development and implementation of more than 100 system optimization improvements that reduced average annual CSO discharge volume by nearly 25% (1992-96); development of the Long-Term CSO Control Plan (1992-97); reassessment and refinement of several CSO projects recommended in the 1997 plan, including the addition of several CSO projects to increase level of control for the Charles River (2006); and design and construction of the 35 CSO projects (1996-2015) in compliance with Schedule Seven. MWRA's efforts also included additional system optimization strategies that further reduced CSO discharges, including enhancements to the operational protocols for the Cottage Farm, Prison Point and Somerville Marginal CSO treatment facilities (2007-08). MWRA has continuously tracked the effect of these improvements on system performance and CSO discharges.

Development and implementation of the Long-Term Control Plan closely followed and conformed to the requirements of the National CSO Policy and EPA CSO-related guidelines, as well as Massachusetts Department of Environmental Protection CSO Policy and CSO Guidance, even as these federal and state CSO policies were evolving. Through extensive inspections, system monitoring and modeling beginning in 1992-93, MWRA conducted a detailed characterization and performance assessment of its then-existing collection and treatment system, but also incorporating major capital improvements already planned. The 1992 performance assessment incorporated major capital investments in the sewer system already underway or planned by MWRA, including upgrades to the transport system, pumping stations, headworks and Deer Island treatment plant ("Early CSO Related Improvements" in Figure 2-1 on the following page). In the period 1988 through 1992, total annual CSO discharge predicted for the Typical Year Rainfall dropped from 3.3 billion gallons to 1.5 billion gallons, with approximately 51% of the remaining discharge treated at five MWRA CSO screening and disinfection facilities. The Charles River especially benefited from these early system improvements.

EPA's National CSO Policy requires CSO permitees to develop and implement system optimization measures and reporting procedures intended in part to quantify, minimize and report CSO discharges in the short term, ahead of the implementation of a long-term control plan, as well as for the long term. These include detailed system characterization, easily implemented and less expensive system improvements that can reduce CSO, and optimized operations and maintenance. In 1993-1994, MWRA completed a System Optimization Plan ("SOP"), which recommended approximately 160 low cost, easily implemented system modifications to maximize wet weather storage and conveyance. The SOP projects, which were fully implemented by MWRA and the CSO communities by 1997, further reduced CSO discharge by about 20 percent from the 1992 level.

[1] In 1990, MWRA recommended a Deep Rock Storage Tunnel for CSO control, at an estimated capital cost of $1.2 billion in 1990 dollars (approx. $2.5 billion today), that conformed to the 1989 EPA CSO Strategy. In 1992, with the prospect of a more flexible EPA CSO policy (the 1994 National CSO Policy), MWRA began a new planning effort that culminated in the current Long-Term CSO Control Plan.

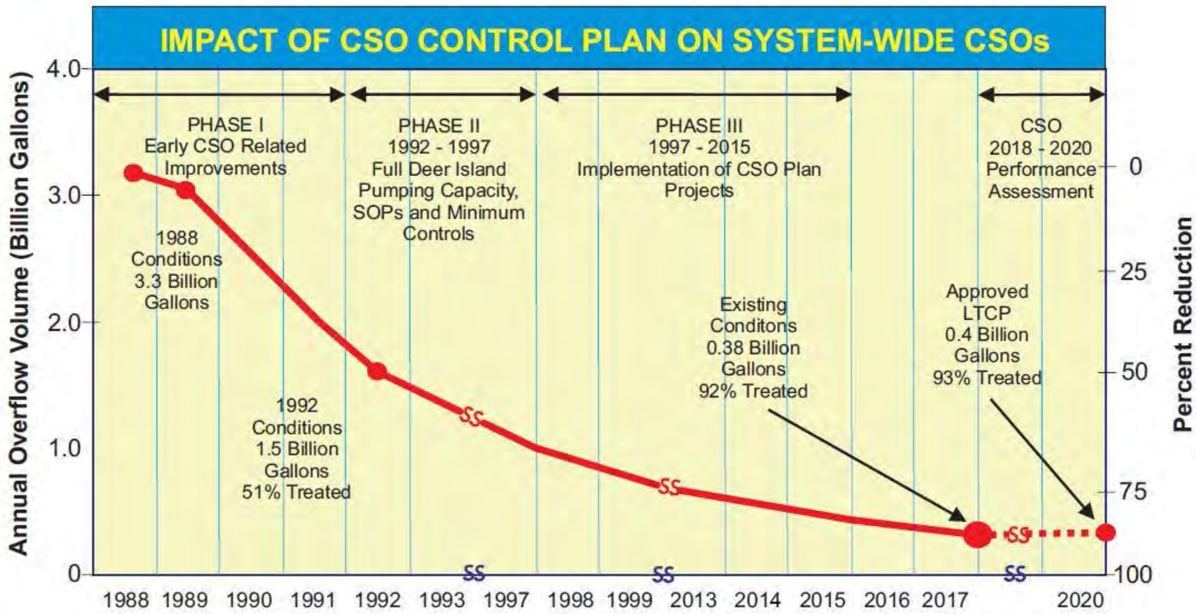



**Figure 2-1**: **Wastewater System Improvement Contributions to CSO Control***

** From MWRA hydraulic model predictions*

MWRA's CSO planning culminated in the recommendation of an extensive set of projects covering a range of control technologies to achieve long-term, site-specific CSO control goals using watershed-based assessments of receiving water impacts and uses. MWRA presented a conceptual plan of these improvements in 1994 and refined the recommendations in a facilities plan and environmental impact report it issued in 1997. The long-term plan received initial federal and state approvals in early 1998, allowing MWRA to move the projects into design and construction.

As MWRA proceeded with implementation of the projects, it evaluated and recommended several adjustments and additions to the long-term plan in the period 1998 through 2006. These adjustments and additions responded to regulatory inquiries seeking higher levels of control (Charles River) or to new information about construction requirements, cost or CSO control performance (North Dorchester Bay, Reserved Channel, East Boston, and Alewife Brook). A final, comprehensive long-term control plan, comprising 35 wastewater system projects, shown in Figure 2-2 on the following page, was approved by EPA and DEP in March 2006 and accepted by the Federal Court in April 2006 as part of the Second Stipulation, which replaced the 1987 First CSO Stipulation. Descriptions of the 35 projects and their individual CSO control benefits are presented in Section 2.4.

This approved plan and its recommended levels of CSO control were again updated by an amendment to the Second Stipulation in April 2008 that revised the long-term level of control at the Prison Point Facility. This was based on hydraulic optimization MWRA incorporated into the operations of the facility in response to federal and state regulators' requests and in compliance with related milestones in Schedule Seven. The final approved plan called for reducing total annual CSO discharge in the Typical Year to 0.4 billion gallons (an 88% reduction from the 1988 level), with 93% of the remaining discharge to be treated at four MWRA screening and disinfection/dechlorination facilities.

MWRA began design and construction of the CSO projects in 1996 in compliance with milestones in the federal court schedule and with cooperation from its member communities with permitted CSO outfalls. MWRA executed memoranda of understanding ("MOUs") and financial assistance agreements with BWSC, the City of Cambridge and the City of Somerville in 1996 by which each municipality agreed to implement the projects within the Long-Term Control Plan involving facilities that would be owned and operated by each community, such as the new storm drain systems that would be constructed as part of sewer separation projects. MWRA agreed to fund the "eligible" costs:  the costs of work to construct the facilities necessary to attain the long-term levels of CSO control.

In compliance with strict design and construction milestones in the court schedule, and within a timeframe of only 20 years, MWRA and the CSO communities completed the design and construction of all 35 projects (see Table 2-1 on Page 6). The capital (design and construction) cost of these projects ranged from less than $100,000 (for Prison Point CSO Facility Optimization) to $228.4 million (for the North Dorchester Bay CSO Tunnel). Most of the projects were major undertakings involving the construction of new wastewater facilities or extensive new storm drain or sewer systems, all in historical, densely-developed residential and commercial areas. In addition to the design and construction work, the projects also required extensive coordination with landowners, permitting agencies, transportation authorities and neighborhood residents. In some of the project areas, construction impacts were significant and unavoidable, and the collaboration, support and patience of residents and business owners should not be overlooked in understanding the effort borne by many parties to bring these projects to completion and achieve their benefits.


**Figure 2-2: The 35 Long-Term Control Plan Projects**

**Table 2-1: Long-Term CSO Control Plan Project Implementation Schedules**

| Project | | Commence Design | Commence Construction | Complete Construction |
|---|---|---|---|---|
| North Dorchester Bay Storage Tunnel and Related Facilities | | Aug-97 | Aug-06 | May-11 |
| Pleasure Bay Storm Drain Improvements | | Sep-04 | Sep-05 | Mar-06 |
| Hydraulic Relief Projects | CAM005 Relief | Aug-97 | Jul-99 | May-00 |
| | BOS017 Relief | | Jul-99 | Aug-00 |
| East Boston Branch Sewer Relief | | Mar-00 | Mar-03 | Jul-10 |
| BOS019 CSO Storage Conduit | | Jul-02 | Mar-05 | Mar-07 |
| Chelsea Relief Sewers | Chelsea Trunk Sewer Relief | Jun-97 | Sep-99 | Aug-00 |
| | Chelsea Branch Sewer Relief | | Dec-99 | Jun-01 |
| | CHE008 Outfall Repairs | | Dec-99 | Jun-01 |
| Union Park Detention/Treatment Facility | | Dec-99 | Mar-03 | Apr-07 |
| CSO Facility Upgrades and MWRA Floatables Control | Cottage Farm Upgrade | Jun-96 | Mar-98 | Jan-00 |
| | Prison Point Upgrade | | May-99 | Sep-01 |
| | Commercial Point Upgrade | | Nov-99 | Sep-01 |
| | Fox Point Upgrade | | Nov-99 | Sep-01 |
| | Somerville-Marginal Upgrade | | Nov-99 | Sep-01 |
| | MWRA Floatables Control and Outfall Closings | | Mar-99 | Mar-00 |
| Brookline Connection and Cottage Farm Overflow Interconnection and Gate | | Sep-06 | Jun-08 | Jun-09 |
| Prison Point Facility Optimization | | Mar-06 | Mar-07 | Apr-08 |
| South Dorchester Bay Sewer Separation | | Jun-96 | Apr-99 | Jun-07 |
| Stony Brook Sewer Separation | | Jul-98 | Jul-00 | Sep-06 |
| Neponset River Sewer Separation | | | Apr-96 | Jun-00 |
| Constitution Beach Sewer Separation | | Jan-97 | Apr-99 | Oct-00 |
| Fort Pt Channel Conduit Sewer Separation and System Optimization | | Jul-02 | Mar-05 | Mar-07 |
| Morrissey Boulevard Storm Drain | | Jun-05 | Dec-06 | Jul-09 |
| Reserved Channel Sewer Separation | | Jul-06 | May-09 | Dec-15 |
| Bulfinch Triangle Sewer Separation | | Nov-06 | Sep-08 | Jul-10 |
| Brookline Sewer Separation | | Nov-06 | Nov-08 | Apr-13 |
| Somerville Baffle Manhole Separation | | | Apr-96 | Dec-96 |
| Cambridge/Alewife Brook Sewer Separation | CAM004 Stormwater Outfall and Detention Basin | | Apr-11 | Apr-13 |
| | CAM004 Sewer Separation | Jan-97 | Jul 98/Sep 12 | Dec-15 |
| | CAM400 Manhole Separation | Oct-08 | Jan-10 | Mar-11 |
| | Interceptor Connection Relief/Floatables Control at Outfalls CAM002, CAM401B and CAM001 | Oct-08 | Jan-10 | Oct-10 |
| | MWR003 Gate and Rindge Ave. Siphon Relief | Mar-12 | Aug-14 | Oct-15 |
| | Connection Relief/Floatables Control at SOM01A | Mar-12 | Sep-13 | Dec-13 |
| Region-wide Floatables Control and Outfall Closings | | Sep-96 | Mar-99 | Dec-07 |

The MWRA and community CSO efforts included the management of 125 contracts, including 82 construction contracts, 33 engineering contracts and 10 planning and technical support contracts, as well as financial assistance agreements with five communities that assisted in designing and constructing the plan (represented below) with total award value of $423 million, 46% of the total $910 million budget for CSO control in MWRA's Capital Improvement Program (CIP). MWRA, BWSC, the City of Cambridge and the Town of Brookline installed nearly 100 miles of new storm drain and sewer pipe with the sewer separation, interceptor relief, hydraulic relief and storage projects in the Long-Term Control Plan. The sewer separation projects involved street-by-street separate storm drain and/or sewer construction that removed more than 4,300 acres of stormwater runoff from sewer systems in Boston, Brookline and Cambridge.

Prior to 1988, treated and untreated CSO discharges occurred in every rainfall event, approximately 100 times a year. Hydraulic model simulations performed by MWRA in the spring of 2018 to support submission of the 2017 annual CSO discharge report for 2017 to EPA and DEP estimated that untreated CSO discharges have been reduced to zero to 7 times a year in the Typical Year, depending on the outfall. The LTCP reduces total CSO discharge volume in the Typical Year by approximately 88%, from 3.3 billion gallons a year to 0.4 billion gallons, and 93% (0.38 billion gallons) of this remaining discharge volume is treated at MWRA's four new or upgraded CSO treatment facilities. Figure 2-3 shows the region-wide reduction with completion of the last of the 35 LTCP projects in December 2015. Figure 2-4 on page 8 shows this CSO reduction for each of the receiving water segments shown in the Figure 2-5 map, also on page 8. The levels of control and the associated CSO control projects for each receiving water segment are shown on pages 9 through 13.

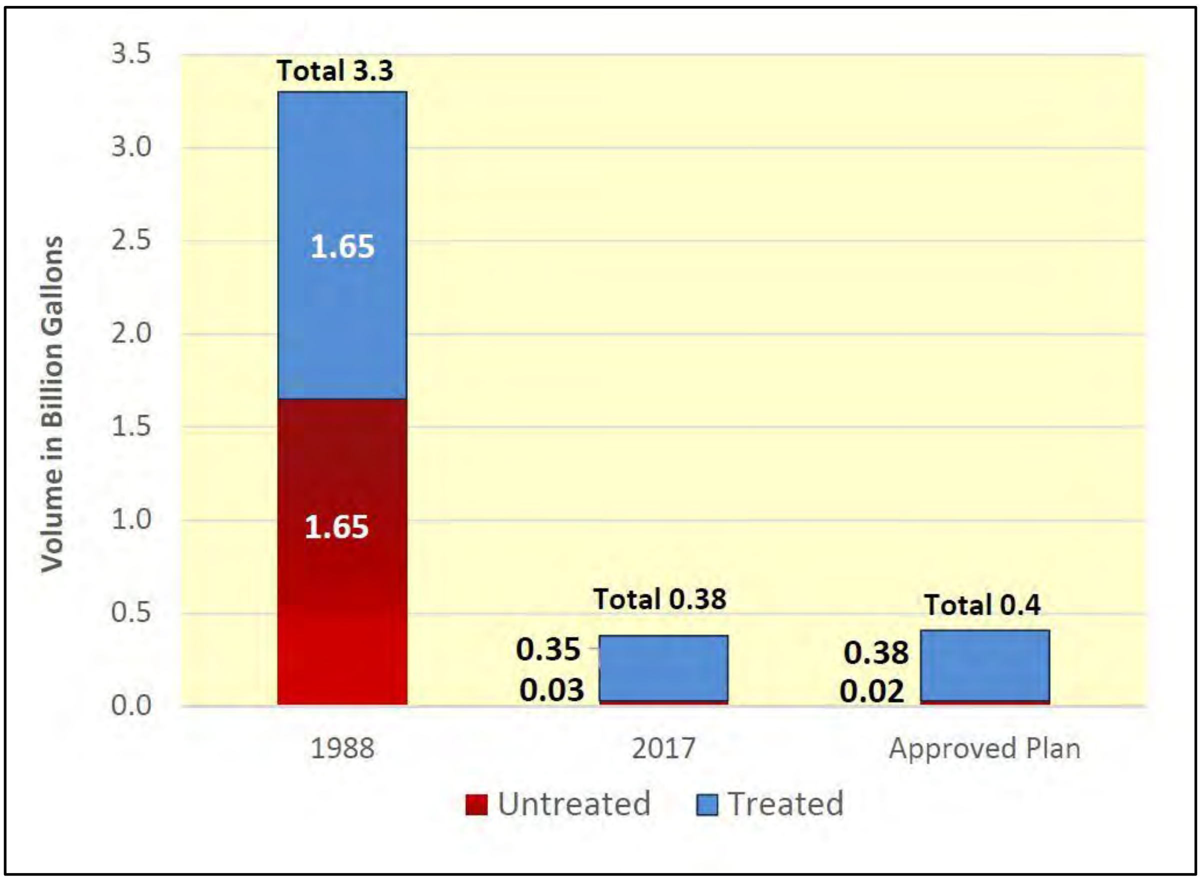



**Figure 2-3: Region-wide CSO Discharge Volume Reduction***

** From MWRA hydraulic model predictions*

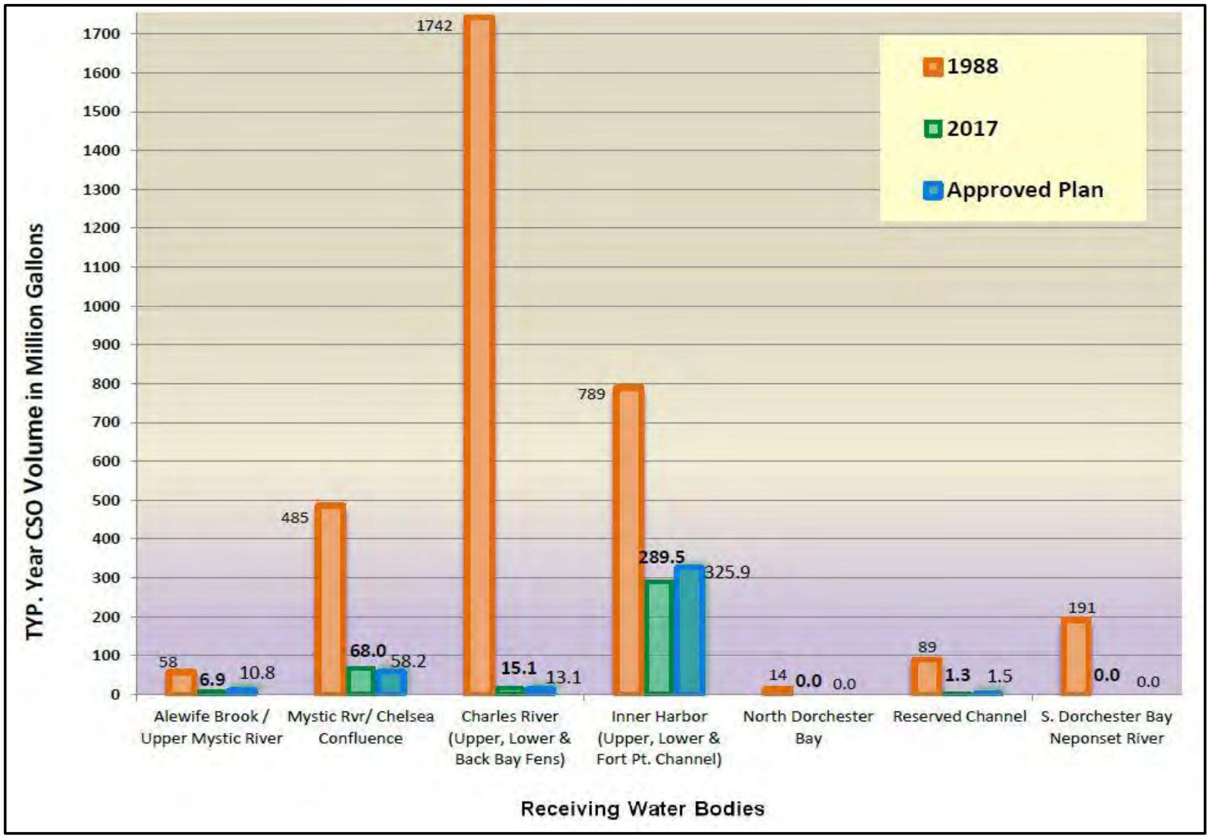
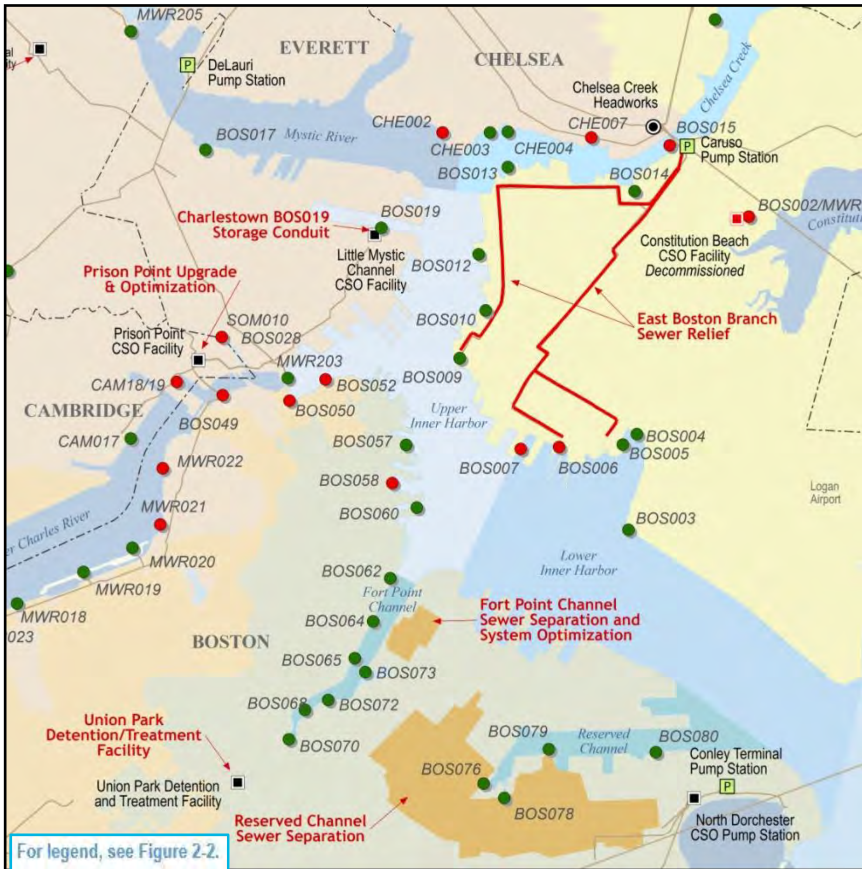



**Figure 2-4: Region-wide CSO Discharge Volume Reduction by Receiving Water***

** From MWRA hydraulic model predictions*


**Figure 2-5: Boston Harbor Waters and Tributaries**

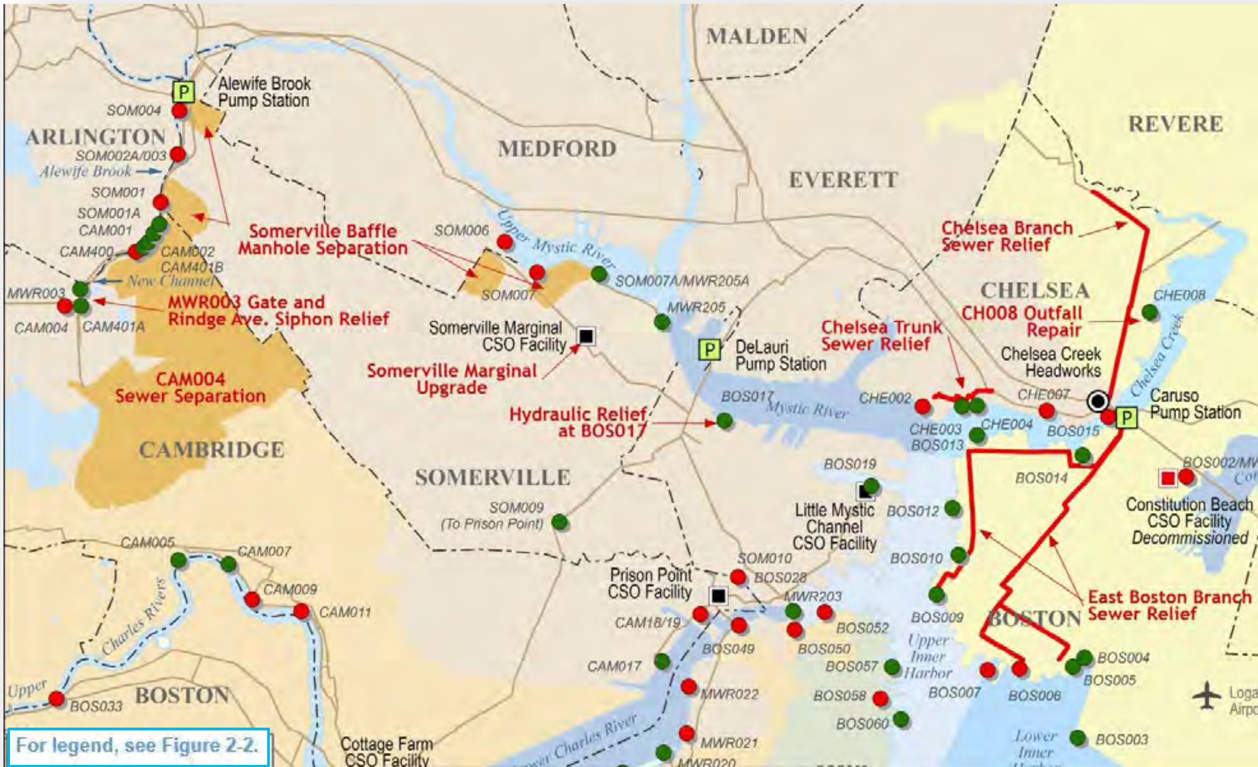
## Boston Inner Harbor, Fort Point Channel and Reserved Channel




| | | No. of CSO Outfalls | In the Typical Rainfall Year: Frequency of Most Active Outfall | Total Discharge Volume (million gallons) | Treated Discharge Volume (million gallons) |
|---|---|---|---|---|---|
| **Boston Inner Harbor** | 1992 | 12 | Up to 100 | 344.5 | 261.9 (76%)(1) |
| | 2017 | 10 | 17(1) | 251.8 | 237.8 (94%)(1) |
| | LTCP | 10 | 17(1) | 252.1 | 243.0 (96%)(1) |
| **Fort Point Channel** | 1992 | 7 | 23 | 298.8 | N/A |
| | 2017 | 7 | 11(2) | 37.7 | 33.8 (90%)(2) |
| | LTCP | 7 | 17(2) | 73.9 | 71.4 (97%)(2) |
| **Reserved Channel** | 1992 | 4 | 65 | 89.1 | N/A |
| | 2017 | 4 | 6 | 1.3 | N/A |
| | LTCP | 4 | 3 | 1.5 | N/A |

(1) At Prison Point CSO Facility
(2) At Union Park Detention/Treatment Facility (completed/brought on-line in 2007)

## Alewife Brook, Mystic River Basin and Mystic/Chelsea Confluence*

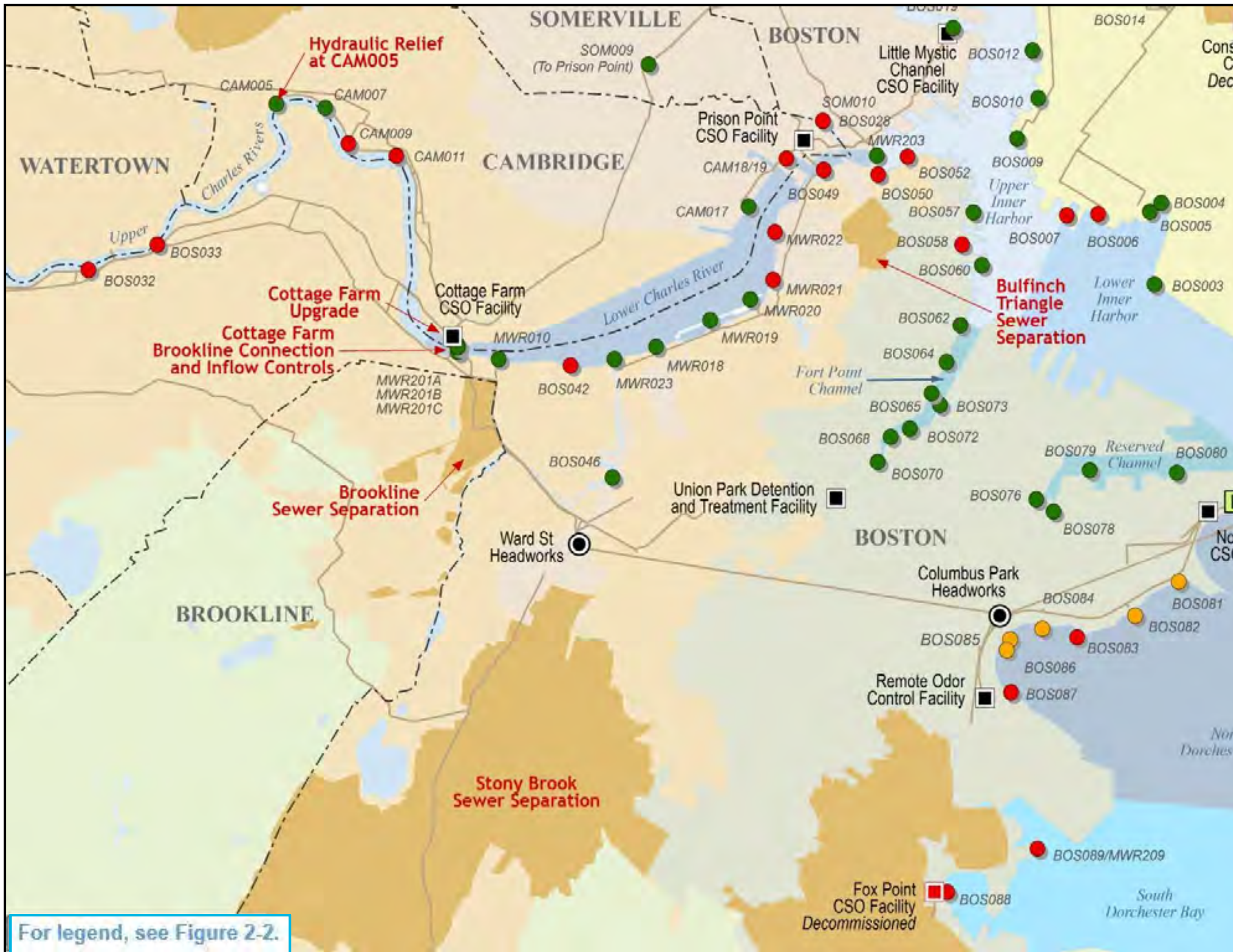



* Includes Lower Mystic River and Chelsea Creek.

| | | No. of CSO Outfalls | In the Typical Rainfall Year | | |
|---|---|---|---|---|---|
| | | | Frequency of Most Active Outfall | Total Discharge Volume (million gallons) | Treated Discharge Volume[1] (million gallons) |
| Alewife Brook/Upper Mystic River | 1992 | 15 | 63 | 57.6 | 7.6 (13%) |
| | 2017 | 7 | 5 | 6.9 | 1.8 (26%) |
| | LTCP | 7 | 7 | 10.8 | 3.5 (32%) |
| Mystic/Chelsea Confluence | 1992 | 9 | 76 | 186.0 | 120.4 (65%) |
| | 2017 | 7 | 22[1] | 68.0 | 65.5 (96%) |
| | LTCP | 8[2] | 39[1] | 58.2 | 57.1 (98%) |

[1] At Somerville Marginal CSO Facility (Upper Mystic Outfall MWR205A; Lower Mystic Outfall MWR205)
[2] The LTCP called for Outfall CHE002 to remain active. City of Chelsea permanently closed this outfall in 2014.

## Charles River and Back Bay Fens




<table>
<tr><th colspan="2"></th><th rowspan="2">No. of CSO Outfalls</th><th colspan="3">In the Typical Rainfall Year</th></tr>
<tr><th colspan="2"></th><th>Frequency of Most Active Outfall</th><th>Total Discharge Volume (million gallons)</th><th>Treated Discharge Volume(1) (million gallons)</th></tr>
<tr><td rowspan="3">Charles River Basin</td><td>1992</td><td>19</td><td>39</td><td>389.0</td><td>214.1 (55%)</td></tr>
<tr><td>2017</td><td>10</td><td>3(1)</td><td>13.5</td><td>10.6 (79%)</td></tr>
<tr><td>LTCP</td><td>10</td><td>2</td><td>7.8</td><td>6.3 (81%)</td></tr>
<tr><td rowspan="3">Back Bay Fens</td><td>1992</td><td>1</td><td>2</td><td>5.3</td><td>N/A</td></tr>
<tr><td>2017</td><td>1</td><td>1</td><td>1.6</td><td>N/A</td></tr>
<tr><td>LTCP</td><td>1</td><td>2</td><td>5.4</td><td>N/A</td></tr>
</table>

(1) At Cottage Farm CSO Facility

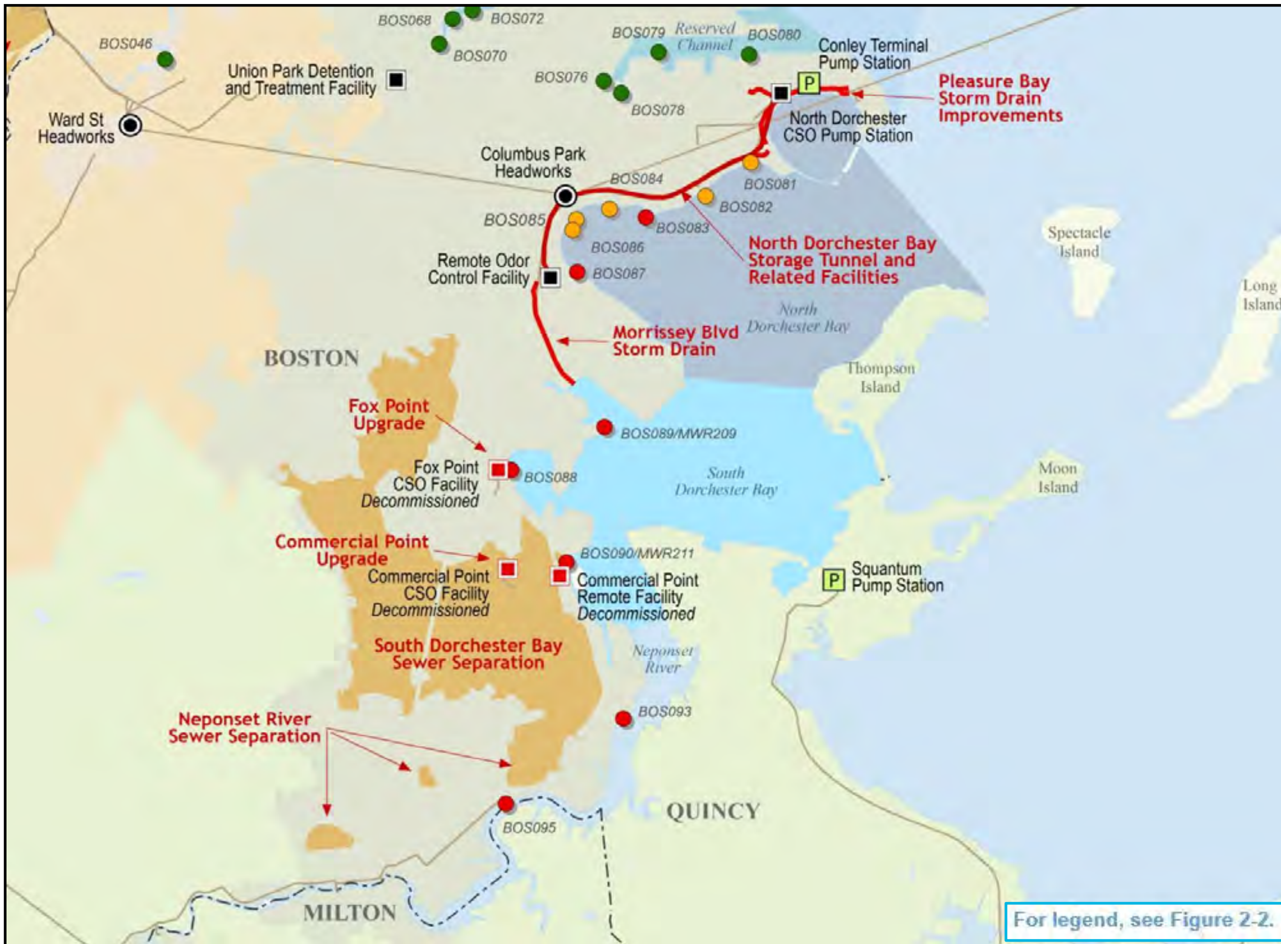
## Neponset River


## Constitution Beach


| | | No. of CSO Outfalls | In the Typical Rainfall Year: Frequency of Most Active Outfall | Total Discharge Volume (million gallons) | Treated Discharge Volume (million gallons) |
|---|---|---|---|---|---|
| **Neponset River** | 1992 | 2 | 72 | 6.98 | N/A |
| | 2017 | Eliminated | | | |
| | LTCP | Eliminated | | | |
| **Constitution Beach** | 1992 | 1 | 24 | 4.0 | 4.0 (100%)[1] |
| | 2017 | Eliminated | | | |
| | LTCP | Eliminated | | | |

[1] At Constitution Beach CSO Facility (decommissioned in 2000)

## Boston Harbor Beaches




| | | No. of CSO Outfalls | In the Typical Rainfall Year: Frequency of Most Active Outfall | Total Discharge Volume (million gallons) | Treated Discharge Volume (million gallons) |
|---|---|---|---|---|---|
| **North Dorchester Bay (South Boston Beaches)** | 1992 | 7 | 80 | 14.2 | N/A |
| | 2017 | 5 | 0[1] | 0[1] | |
| | LTCP | 5 | 0[1] | 0[1] | |
| **South Dorchester Bay** | 1992 | 3 | 87 | 186.0 | 186.0 (100%)[2] |
| | 2017 | Eliminated | | | |
| | LTCP | | | | |

[1] The South Boston CSO storage tunnel captures CSO up to the 25-year storm.
[2] At Commercial Point and Fox Point CSO facilities (both decommissioned in 2007)

## 2.2 Permanently Closed CSO Outfalls

MWRA and the CSO communities have eliminated CSO discharges at 35 of the original 84 CSO outfalls and virtually eliminated CSO discharges, i.e., achieved a 25-year storm level of control (along with a 5-year storm level of control of separate stormwater discharges) at the five remaining outfalls along the South Boston beaches. The 35 closed outfalls include six outfalls - two City of Cambridge outfalls to the Charles River, two BWSC outfalls in East Boston and one in Fort Point Channel, and one City of Chelsea outfall - that the Long-Term Control Plan and Court Order designate to remain active. The City of Cambridge closed the Charles River Basin outfalls, CAM009 and CAM011, in 2007 on an interim basis. The City of Cambridge maintains CAM009 and CAM011 in a closed condition while it continues to evaluate hydraulic conditions in the local sewer system before making a decision to close them permanently. BWSC permanently closed East Boston outfalls BOS 006 and BOS007 and Inner Harbor/ Fort Point Channel Outfall BOS072 in 2015. The City of Chelsea closed Outfall CHE002, which discharged to the Mystic River/Chelsea Creek Confluence, in 2014.

The LTCP has eliminated CSO discharges to sensitive receiving waters used for swimming and shell fishing. These areas include the beaches of South Dorchester Bay and Neponset River (Savin Hill, Malibu and Tenean beaches) and Constitution Beach. For the South Boston beaches (North Dorchester Bay), MWRA's CSO storage tunnel provides a 25-year storm level of CSO control and a 5-year storm level of separate stormwater control.

As part of this ongoing study, MWRA collected record information and performed field inspections in early 2018 of all of the CSO regulators that formerly contributed overflows to now closed outfalls. The records and inspections are intended to demonstrate that CSO discharges to each of the outfalls were permanently eliminated. The results of these inspections are presented in Appendix A: CSO and Regulator Open/Closed Status.

**Brick and mortar bulkhead of high outlet overflow in CSO regulator at Outfall CHE002.**

**Former CSO Outfall CHE002 now discharges stormwater, only.**

## 2.3 MWRA Ratepayers' Investment in CSO Control

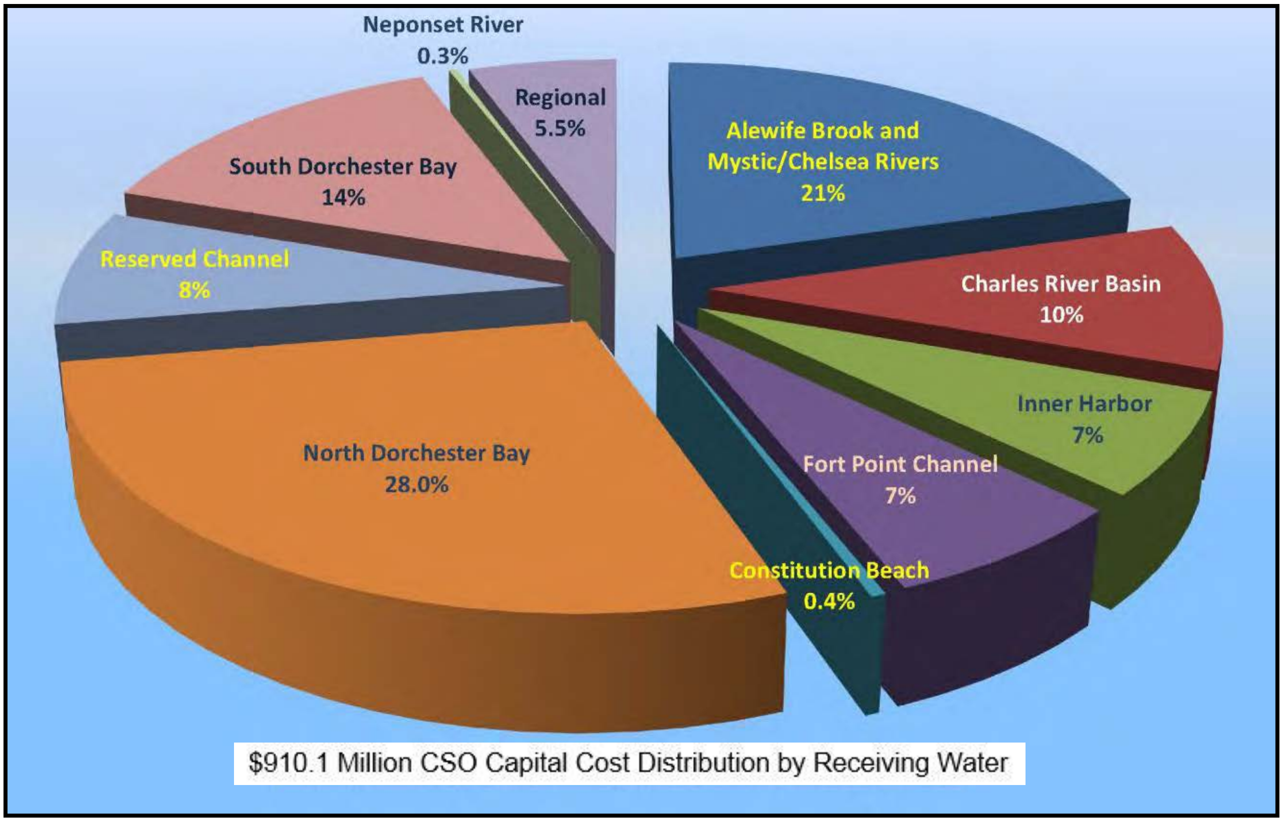
MWRA's Capital Improvement Program (CIP) includes $910.1 million for the CSO Control Program, including past planning, MWRA design and construction, financial assistance to communities to implement the LTCP projects resulting in facilities the communities own and operate, and the ongoing three-year CSO performance assessment. The allocation of these dollars to accomplish the approved levels of CSO control for the various receiving waters is shown in Figure 2-6 on the following page.

From 1987 through June 2018, MWRA spent approximately $902.6 million (99%) of the $910.1 million CSO Program budget, including $858 million for design and construction of the 35 LTCP projects. The remaining $7.5 million of CSO spending is for the following scheduled activities:

- $1.4 million MWRA share for rehabilitation of a large City of Somerville combined sewer for structural integrity and preservation of maximum in-system storage capacity.

- $3.8 million for BWSC construction projects that will further reduce stormwater inflow from the Dorchester Interceptor system to further reduce the risk of system flooding following the completion in 2007 of the South Dorchester Bay sewer separation project and the closing of related CSO outfalls.

- $2.3 million for MWRA's ongoing post-construction monitoring and performance assessment.




1. Does not include the >$200 million investment in the Deer Island transport and treatment system. which greatly reduced CSO discharge system-wide and especially benefited the Charles River.
2. "Regional" includes area-wide planning and system optimization measures.
3. "Charles River Basin" includes the Back Bay Fens.

**Figure 2-6: CSO Cost Allocation by Receiving Water**

In addition to the $910.1 million cost to MWRA for CSO control, BWSC, the City of Cambridge and the Town of Brookline incurred a total of more than $150 million of their own cost to successfully construct the LTCP projects they assumed responsibility for implementing pursuant to MOUs and financial assistance agreements with MWRA. The projects these communities managed primarily involved the construction of miles of new storm drains and sewers in dense residential neighborhoods. The neighborhoods were greatly affected by construction, and it was necessary to leave the construction areas, primarily neighborhood streets, in an improved condition for the long term. The successful construction of the CSO related work necessitated the provision of additional infrastructure and surface improvements for these neighborhoods.

## 2.4 The 35 Long-Term Control Plan Projects

### 1. SOMERVILLE BAFFLE MANHOLE SEPARATION


**Receiving Water:**
Alewife Brook, Upper Mystic River

**Completed:**
1996

**Capital Cost:**
$400,000

**Description:**
City of Somerville separated common manholes connecting local sewer and storm drain systems. City of Somerville performed design and construction with MWRA financial assistance.

**CSO Control**

**Water Quality Benefit:**
Eliminated CSO discharges at three City of Somerville outfalls.

**CSO Outfalls:**
SOM001, SOM006, SOM007

**Frequency of Discharge (Typical Year):**
**Before project:** 2
**With project:** Eliminated

**Annual Discharge Volume (Typical Year):**

**Before project:** 0.04 million gallons
**With project:** Eliminated

**CSO Reduction by Volume:** 100%

### 2. CONSTITUTION BEACH SEWER SEPARATION

MWRA decommissioned its Constitution Beach CSO Facility after CSO flows were eliminated by BWSC sewer separation.

**Receiving Water:**
Boston Harbor/Constitution Beach

**Completed:**
2000

**Capital Cost:**
$3,731,000

**Description:**
BWSC installed 14,000 linear feet of storm drain to separate the combined sewer system, remove stormwater flows from area sewers, and eliminate CSO discharges to Constitution Beach, allowing MWRA to decommission the Constitution Beach CSO treatment facility.

**CSO Control**

**Water Quality Benefit:**
Eliminated CSO discharges to Constitution Beach to comply with Class SB water quality standards.

**CSO Outfalls:**
MWR207(BOS002)

**Frequency of Discharge (Typical Year):**

**Before project:** 16 (treated)
**With project:** Eliminated

**Annual Discharge Volume (Typical Year):**

**Before project:** 1.35 million gallons
**With project:** Eliminated

**CSO Reduction by Volume:** 100%

## 3. HYDRAULIC RELIEF AT OUTFALL CAM005


**Receiving Water:**
Charles River Basin

**Completed:**
2000

**Capital Cost:**
$1,100,000

**Description:**
MWRA relieved the 40-foot long, 24-inch diameter dry weather connection between the CAM005 regulator and MWRA's North Charles Metropolitan Sewer with a 54-inch additional connection, on Mt. Auburn Street, Cambridge.

**CSO Control**

**Water Quality Benefit:**
Minimized CSO discharges to meet B(cso) water quality standards (>95% compliance with Class B).

**CSO Outfalls:**
CAM005

**Frequency of Discharge (Typical Year):**

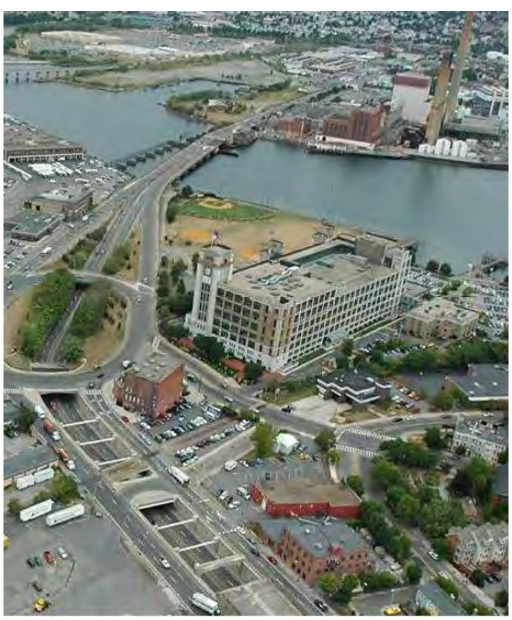
**Before project:** 11
**With project:** 3

**Annual Discharge Volume (Typical Year):**

**Before project:** 3.8 million gallons
**With project:** 0.84 million gallons

**CSO Reduction by Volume:** 78%

## 4. HYDRAULIC RELIEF AT OUTFALL B0S017



**Receiving Water:**
BOS017: Mystic River/Chelsea Creek Confluence

**Completed:**
2000

**Capital Cost:**
$1,195,000

**Description:**
MWRA installed 190 feet of 36-inch diameter pipe in Sullivan Square, Charlestown, to divert two local (BWSC) combined sewers to a direct connection with MWRA's Cambridge Branch Sewer. In addition, eliminated a 10-foot-long restriction between the Charlestown and Cambridge Branch Sewers.

**CSO Control**

**Water Quality Benefit:**
Minimized CSO discharges to meet SB(cso) water quality standards (>95% compliance with Class SB).

**CSO Outfalls:**
BOS017

**Frequency of Discharge (Typical Year):**

**Before project:** 18
**With project:** 1

**Annual Discharge Volume (Typical Year):**

**Before project:** 2.5 million gallons
**With project:** 0.02 million gallons

**CSO Reduction by Volume:** 99%

## 5. NEPONSET RIVER SEWER SEPARATION

**Receiving Water:**
Neponset River

**Completed:**
2000

**Capital Cost:**
$2,549,000

**Description:**
BWSC installed 8,000 linear feet of storm drain to separate the combined sewer system, remove stormwater flows from area sewers, and close CSO regulators, eliminating CSO discharges at the two remaining CSO outfalls to the Neponset River.

**CSO Control**

**Water Quality Benefit:**
Eliminated CSO discharges to Neponset River to comply with Class B water quality standards and protect South Dorchester Bay beaches (Tenean Beach).

**CSO Outfalls:**
BOS093, BOS095

**Frequency of Discharge (Typical Year):**

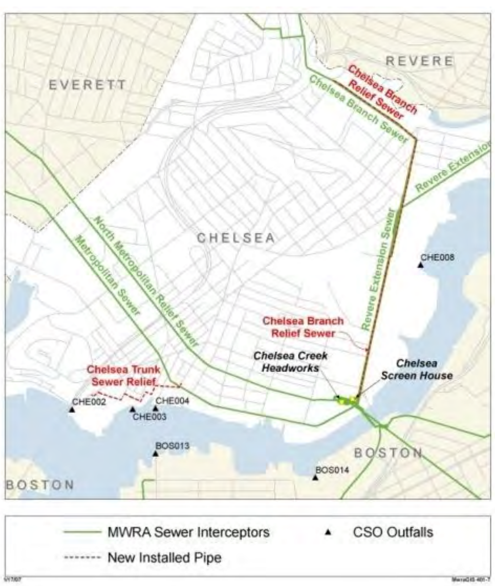
**Before project:** 17
**With project:** Eliminated

**Annual Discharge Volume (Typical Year):**

**Before project:** 5.8 million gallons
**With project:** Eliminated

**CSO Reduction by Volume:** 100%

## 6. CHELSEA TRUNK SEWER REPLACEMENT
## 7. CHELSEA BRANCH SEWER RELIEF
## 8. CHE008 OUTFALL REPAIRS




**Receiving Water:**
Mystic River/Chelsea Creek Confluence
Chelsea Creek

**Completed:**
2000-2001

**Capital Cost:**
$29,779,000

**Description:**
MWRA replaced 18-inch diameter city-owned trunk sewer with 30-inch pipe, relieved MWRA's Chelsea Branch and Revere Extension Sewers with 48-inch to 66-inch diameter pipe, and rehabilitated Outfall CHE008. Installed underflow baffles for floatables control at all outfalls.

**CSO Control**

**Water Quality Benefit:**
Minimized CSO discharges to meet Class SB(cso) water quality standards (>95% compliance with Class SB).

**CSO Outfalls:**
CHE002, CHE003, CHE004, CHE008

**Frequency of Discharge (Typical Year):**

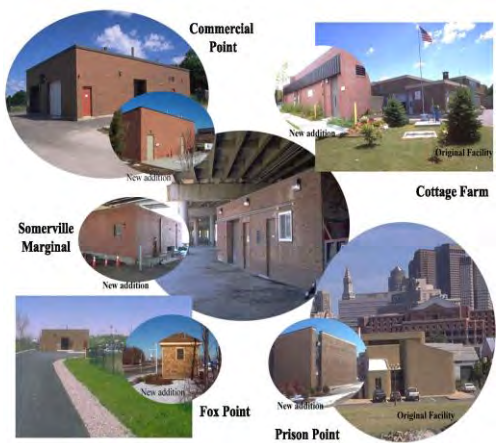
**Before project:** 8
**With project:** 4

**Annual Discharge Volume (Typical Year):**

**Before project:** 9.0 million gallons
**With project:** 0.6 million gallons

**CSO Reduction by Volume:** 93%

## 9. UPGRADE COTTAGE FARM CSO FACILITY
## 10. UPGRADE PRISON POINT CSO FACILITY
## 11. UPGRADE SOMERVILLE MARGINAL CSO FACILITY
## 12. UPGRADE FOX POINT CSO FACILITY
## 13. UPGRADE COMMERCIAL POINT CSO FACILITY




**Receiving Water:**
Charles River Basin
Upper Inner Harbor
Upper Mystic River
Mystic River/Chelsea Creek Confluence
South Dorchester Bay

**Completed:**
2001

**Capital Cost:**
$22,385,000

**Description:**
MWRA upgraded chlorine disinfection systems, added dechlorination systems, process control and safety improvements.

**CSO Control**

**Water Quality Benefit:**
Upgrade treatment to meet water quality standards criteria, including residual chlorine limits.

**CSO Outfalls:**
MWR201 (Cottage Farm Facility)
MWR203 (Prison Point Facility)
MWR205, MWR205A(SOM007A) (Somerville Marginal Facility)
MWR209(BOS088/BOS089) (Fox Point Facility)
MWR211(BOS090) (Commercial Point Facility)

These projects improved treatment performance, with no effect on discharge frequency or volume.

## 14. PLEASURE BAY STORM DRAIN IMPROVEMENTS


**Receiving Water:**
North Dorchester Bay

**Completed:**
2006

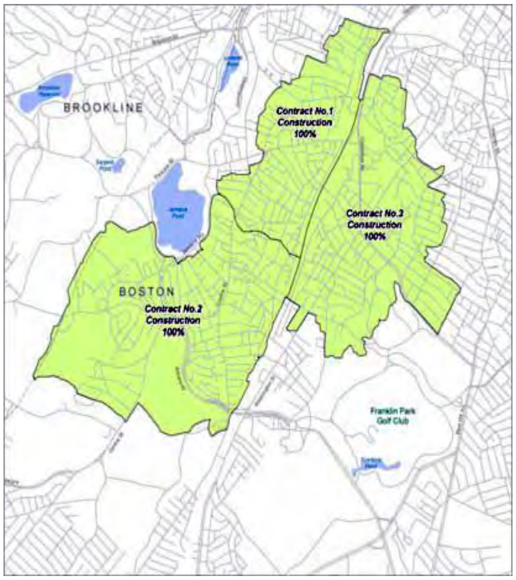
**Capital Cost:**
$3,195,000

**Description:**
MWRA constructed a new storm drain system to relocate stormwater discharge from Pleasure Bay to the Reserved Channel.

**CSO Control**

**Water Quality Benefit:**
Eliminated stormwater discharges to Pleasure Bay Beach.

## 15. STONY BROOK SEWER SEPARATION




**Receiving Water:**
Charles River Basin

**Completed:**
2006

**Capital Cost:**
$44,246,000

**Description:**
BWSC installed a total of 107,175 linear feet of storm drain and sanitary sewer to remove stormwater from local sewers serving a 609-acre area in Jamaica Plain, Mission Hill and Roxbury, and disconnected an already-separated storm drain system serving an adjacent 548-acre area from the sewer system.

### CSO Control

**Water Quality Benefit:**
Minimizes CSO discharges to meet B(cso) water quality standards (>95% compliance with Class B).

**CSO Outfalls:**
MWR023 (Stony Brook Conduit)

**Frequency of Discharge Typical Year):**

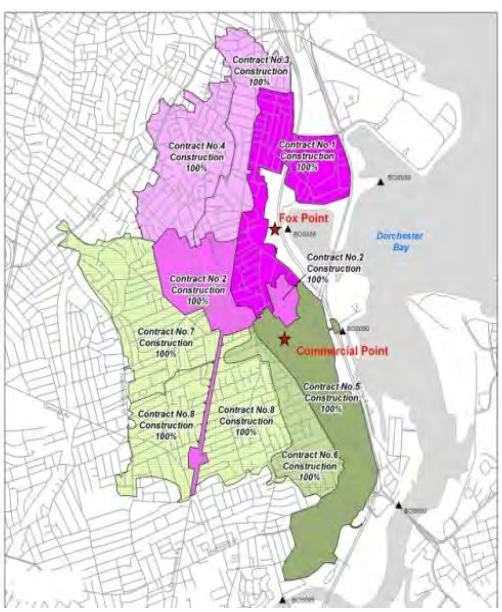
**Before project:** 22
**With project:** 2

**Annual Discharge Volume Typical Year):**

**Before project:** 44.5 million gallons
**With project:** 0.13 million gallons

**CSO Reduction by Volume:** 99.7%

## 16. SOUTH DORCHESTER BAY SEWER SEPARATION




**Receiving Water:**
South Dorchester Bay

**Completed:**
2007

**Capital Cost:**
$118,800,000

**Description:**
BWSC installed a total of 150,000 linear feet of storm drain and sanitary sewer to remove stormwater from local sewers serving a 1,750-acre area in Dorchester. Closed all CSO regulators, allowing MWRA to decommission its Fox Point and Commercial Point CSO facilities.

### CSO Control

**Water Quality Benefit:**
Eliminated CSO discharges to Savin Hill, Malibu and Tenean beaches, in compliance with Class SB water quality standards.

**CSO Outfalls:**
MWR209 (BOS088/BOS089)
MWR211 (BOS090)

**Frequency of Discharge (Typical Year):**

**Before project:** 20 (treated)
**With project:** Eliminated

**Annual Discharge Volume (Typical Year):**

**Before project:** 30 million gallons
**With project:** Eliminated

**CSO Reduction by Volume:** 100%

## 17. FORT POINT CHANNEL SEWER SEPARATION


**Receiving Water:**
Fort Point Channel

**Completed:**
2007

**Capital Cost:**
$11,917,000

**Description:**
BWSC installed 4,260 feet of storm drain and 4,300 feet of sanitary sewer to remove stormwater from local sewers serving 55 acres in the Fort Point Channel area. Raised overflow weirs at outfalls BOS072 and BOS073. Replaced tide gates and installed underflow baffles for floatables control at both outfalls.

**CSO Control**

**Water Quality Benefit:**
Minimizes CSO discharges to meet Class SB(cso) water quality standards (>95% compliance with Class SB).

**CSO Outfalls:**
BOS072, BOS073

**Frequency of Discharge (Typical Year):**

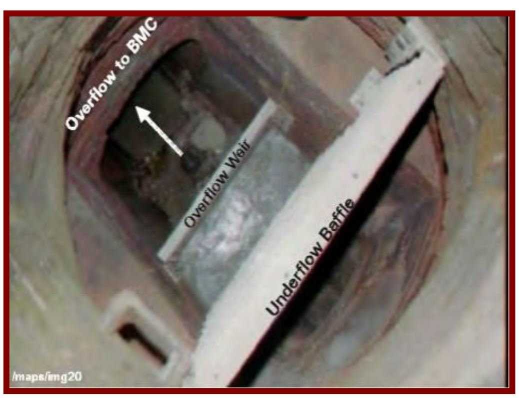
**Before project:** 9
**With project:** 0

**Annual Discharge Volume (Typical Year):**

**Before project:** 3.0 million gallons
**With project:** 0.0

**CSO Reduction by Volume:** 100%

## 18. REGION WIDE FLOATABLES CONTROL
## 19. MWRA FLOATABLES CONTROL AND OUTFALL CLOSING PROJECTS




**Receiving Water:**
Region-wide

**Completed:**
2007

**Capital Cost:**
$1,216,000

**Description:**
MWRA and the CSO communities installed underflow baffles for floatables control and closed several regulators and outfalls.

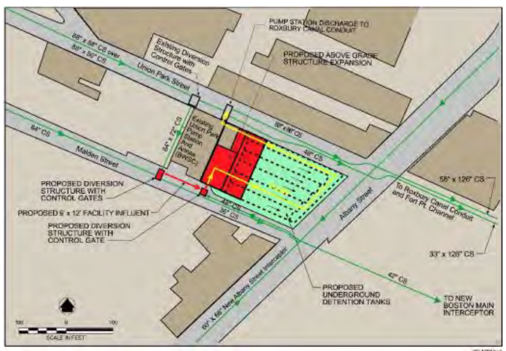
**CSO Control**

**Water Quality Benefit:**
Complies with EPA Policy Nine Minimum Controls requirement to control solid and floatable material. Eliminated CSO discharges at certain outfalls.

**CSO Outfalls:**
Various outfalls system-wide.

**CSO Control:**
The floatables controls do not affect CSO discharge frequency or volume.

## 20. UNION PARK DETENTION/TREATMENT FACILITY




**Receiving Water:**
Fort Point Channel

**Completed:**
2007

**Capital Cost:**
$49,583,000

**Description:**
MWRA added a CSO treatment facility to the existing BWSC Union Park Pumping Station, including fine screens, chlorine disinfection, dechlorination, and two million gallons of detention storage.

### CSO Control

**Water Quality Benefit:**
Provides treatment of Union Park pumping station discharges to Fort Point Channel to meet Class SB water quality criteria, including residual chlorine limits, and lowers discharge frequency and volume with on-site detention basins.

**CSO Outfall:**
BOS 070

**Frequency of Discharge (Typical Year):**

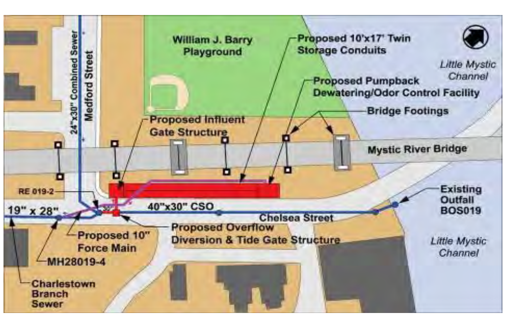
**Before project:** 25 (untreated)
**With project:** 17 (treated)

**Annual Discharge Volume (Typical Year):**

**Before project:** 132.0 million gallons
**With project:** 71.4 million gallons

**CSO Reduction by Volume:** 46%

## 21. BOS019 CSO STORAGE CONDUIT




**Receiving Water:**
Upper Inner Harbor (Little Mystic Channel)

**Completed:**
2007

**Capital Cost:**
$14,288,000

**Description:**
MWRA installed twin-barrel 10'x17' box conduit to provide 670,000 gallons of off-line storage, between Chelsea St. and the Mystic Tobin Bridge, Charlestown. Included above-ground dewatering pump station.

### CSO Control

**Water Quality Benefit:**
Minimizes CSO discharges to meet Class SB(cso) water quality standards (>95% compliance with Class SB).

**CSO Outfall:**
BOS019

**Frequency of Discharge (Typical Year):**

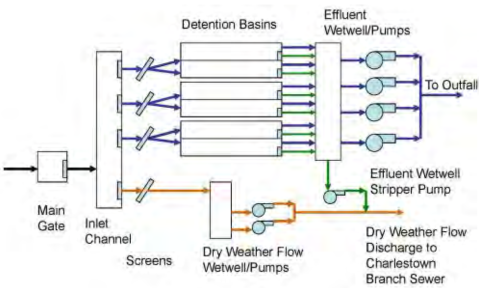
**Before project:** 13
**With project:** 2

**Annual Discharge Volume (Typical Year):**

**Before project:** 4.4 million gallons
**With project:** 0.6 million gallons

**CSO Reduction by Volume:** 86%

## 22. PRISON POINT CSO FACILITY OPTIMIZATION




**Receiving Water:**
Upper Inner Harbor

**Completed:**
2008

**Capital Cost:**
$50,000

**Description:**
MWRA minimized treated CSO discharges to the Inner Harbor by optimizing the operation of existing facility gates and pumps to maximize in-system storage and convey more flow to Deer Island.

**CSO Control**

**Water Quality Benefit:**
Reduces treated CSO discharges to Upper Inner Harbor.

**CSO Outfall:**
MWR203 (Prison Point Facility)

**Frequency of Discharge (Typical Year):**

**Before project:** 25 (treated)
**With project:** 19 (treated)

**Annual Discharge Volume (Typical Year):**

**Before project:** 370.2 million gallons
**With project:** 283.8 million gallons

**CSO Reduction by Volume:** 23%

## 23. COTTAGE FARM BROOKLINE CONNECTION AND INFLOW CONTROLS


**Receiving Water:**
Charles River Basin

**Completed:**
2009

**Capital Cost:**
$3,000,000

**Description:**
MWRA optimized the combined conveyance capacity of the two MWRA sewers that carry flows across the Charles River by interconnecting overflow chambers outside the Cottage Farm CSO facility, and MWRA supplemented this conveyance capacity by bringing into service a parallel, previously unutilized 54-inch diameter sewer (the “Brookline Connection”).

**CSO Control**

**Water Quality Benefit:**
Minimizes treated CSO discharges from the Cottage Farm CSO Facility to the Lower Charles River Basin.

**CSO Outfall:**
MWR201 (Cottage Farm Facility)

**Frequency of discharges (Typical Year):**

**Before project:** 7 (treated)
**With project:** 7 (treated)

**Annual Discharge Volume (Typical Year):**

**Before project:** 44.5 million gallons
**With project:** 24.0 million gallons

**CSO Reduction by Volume:** 46%

## 24. MORRISSEY BOULEVARD STORM DRAIN


**Receiving Water:**
North Dorchester Bay

**Completed:**
2009

**Capital Cost:**
$32,339,000

**Description:**
BWSC installed 2,800 linear feet of 12-foot by 12-foot and 8-foot by 8-foot box conduit for stormwater conveyance, with gated connection to North Dorchester Bay CSO Storage Tunnel at upstream end, new outfall to Savin Hill Cove, and pollution prevention measures.

**CSO Control**

**Water Quality Benefit:**
Maximizes the level of stormwater control provided by the CSO Storage Tunnel along the South Boston beaches by redirecting stormwater to Savin Hill Cove in large storms.

## 25. EAST BOSTON BRANCH SEWER RELIEF


**Receiving Water:**
Boston Harbor and Chelsea Creek

**Completed:**
2010

**Capital Cost:**
$85,637,000

**Description:**
MWRA upgraded its 115-year-old interceptor system serving most of East Boston, using a combination of construction methods: micro-tunneling, pipe-bursting, open-cut excavation and pipe relining.

**CSO Control**

**Water Quality Benefit:**
Minimizes CSO discharges to meet Class SB(cso) water quality standards (>95% compliance with Class SB).

**CSO Outfalls:**
BOS003, BOS004, BOS005, BOS009, BOS010, BOS012, BOS013, BOS014 (BOS006 and BOS007 closed by BWSC)

**Frequency of discharges (Typical Year):**

**Before project:** 31
**With project:** 6

**Annual Discharge Volume (Typical Year):**

**Before project:** 41.0 million gallons
**With project:** 8.6 million gallons

**CSO Reduction by Volume:** 79%

## 26. BULFINCH TRIANGLE SEWER SEPARATION


**Receiving Water:**
Boston Inner Harbor and Charles River Basin

**Completed:**
2010

**Capital Cost:**
$9,054,000

**Description:**
BWSC installed a total of 5,290 feet of storm drain and sanitary sewer to remove stormwater from local sewers in a 14-acre area of Bulfinch Triangle/North Station, allowing already-separated storm drains serving an additional 47-acre area of Government Center to be removed from the sewer system, as well. Closed Outfall BOS049 to CSO discharges.

**CSO Control**

**Water Quality Benefit:**
Eliminated CSO discharges at Outfall BOS049 to Lower Charles River Basin. Contribute to treated CSO reduction at the Prison Point CSO Facility.

**CSO Outfalls:**
BOS049

**Frequency of discharges (Typical Year):**

**Before project:** Larger storms only
**With project:** Eliminated

**Annual Discharge Volume (Typical Year):**

**Before project:** Larger storms only
**With project:** Eliminated

**CSO Reduction by Volume:** N/A

## 27. INTERCEPTOR CONNECTION RELIEF AND FLOATABLES CONTROL AT CAM002 AND CAM401B AND FLOATABLES CONTROL AT CAM001

CAM 002A & B inlet structure-baffle is visible in front of CAM 002A outlet with a steel plate (temporary condition) bolted on the left hand wall on the CAM 002B outlet.

**Receiving Water:**
Alewife Brook

**Completed:**
2010

**Capital Cost:**
$2,904,569

**Description:**
City of Cambridge upgraded the hydraulic capacities of its connections to MWRA interceptors and installed underflow baffles for floatables control.

**CSO Control**

**Water Quality Benefit:**
Together with other Alewife Brook CSO projects, minimizes CSO discharges and their impacts to meet Class B “fishable/ swimmable” criteria >95% of the time.

**CSO Outfalls:**
CAM002, CAM401B, CAM001

**Frequency of Discharge (Typical Year):**

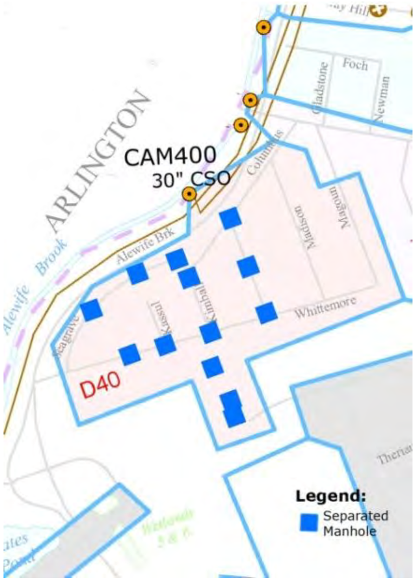
**Before project:** 25
**After project:** 7

**Annual Discharge Volume (Typical Year):**

**Before project:** 12.1 million gallon
**After project:** 3.2 million gallons

**CSO Reduction by Volume:** 74%

## 28. CAM400 COMMON MANHOLE SEPARATION




**Receiving Water:**
Alewife Brook

**Completed:**
March 2011

**Capital Cost:**
$4,776,000

**Description:**
City of Cambridge replaced common storm drain and sewer manholes with separate manholes and associated piping in the local, mostly residential streets bounded by Alewife Brook Parkway, Massachusetts Avenue, Magoun Street and Whittemore Avenue, as well as a portion of the WR Grace property off Whittemore Avenue. Closed Outfall CAM400 to CSO discharges.

**CSO Control**

**Water Quality Benefit:**
Together with other Alewife Brook CSO projects, minimizes CSO discharges and their impacts to meet Class B “fishable/ swimmable” criteria >95% of the time.
Eliminated CSO discharges to Alewife Brook at Outfall CAM400.

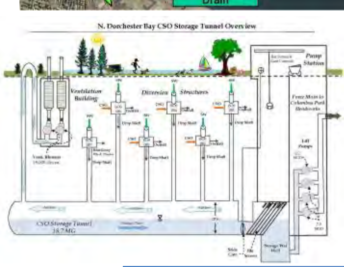
**CSO Outfalls:**
CAM400

**Frequency of Discharge (Typical Year):**
**Before project:** 10
**After project:** Eliminated

**Annual Discharge Volume (Typical Year):**
**Before project:** 0.8 million gallon
**After project:** Eliminated

**CSO Reduction by Volume:** 100%

## 29. NORTH DORCHESTER BAY STORAGE TUNNEL & RELATED FACILITIES



North Dorchester Bay CSO Storage Tunnel Dewatering Pump Station, Conley Terminal, South Boston

**Receiving Water:**
North Dorchester Bay

**Capital Cost:**
$228,405,000
(including Massport land agreement; not including the cost of Morrissey Boulevard storm drain (Project 24))

**Completed:** May 2011

**Description:**
MWRA constructed a 10,832-ft., 17-ft. diameter soft-ground tunnel, drop shafts and CSO and stormwater diversion structures along outfalls BOS081-BOS087; 15-mgd tunnel dewatering pump station at Massport’s Conley Terminal; 24-inch force main; and below-ground tunnel ventilation and odor control facility at the upstream end of the tunnel. Eliminated outfalls BOS083 and BOS087.

**CSO Control**

**Water Quality Benefit:**
Eliminated CSO and separate stormwater discharges up to the 25-year storm and 5-year storm, respectively.

**CSO Outfalls:**
BOS081 BOS083 BOS085 BOS087
BOS082 BOS084 BOS086

**Frequency of Discharge (typical year)**
**CSO:** **Before project:** 17
**After project:** 0

**Stormwater:** **Before project:** 93
**After project:** 0

**Annual Discharge Volume (typical year)**
**CSO:**
**Before project:** 8.6 million gallons
**After project:** 0

**Stormwater:**
**Before project:** 144 million gallons
**After project:** 0

**CSO Reduction by Volume:** 100%

**Stormwater Reduction by Volume:** 100%

## 30. BROOKLINE SEWER SEPARATION


**Receiving Water:**
Charles River Basin

**Capital Cost:**
$24,715,000

**Completed:** April 2013

**Description:**
Town of Brookline installed 9,448 linear feet of new storm drain and 5,840 linear feet of new sewer to separate the combined sewer systems serving a 72-acre area of the town to remove stormwater from the sewer system and reduce CSO discharges to the Charles River Basin.

MWRA rehabilitated its CSO outfall MWR010 in part to accommodate the stormwater flows.

**CSO Control**

**Water Quality Benefit:**
Supports the attainment of long term CSO control level at the Cottage Farm CSO facility. Reduces CSO discharges at Outfall MWR010, which activates in extreme storms, only.

**CSO Outfalls:**
MWR010
MWR201 (Cottage Farm Facility)

**Frequency of Discharge (Typical Year):**

**Cottage Farm Facility (treated)**
**Before project:** 7
**With project:** 5

**Annual Discharge Volume (Typical Year):**

**Cottage Farm Facility (treated)**
**Before project:** 27.2 million gallons
**With project:** 18.7 million gallons

**CSO Reduction by Volume:** 31%

## 31. CAM004 STORMWATER OUTFALL AND WETLAND BASIN

Rendering of Stormwater Wetland at Alewife Brook, Cambridge

**Receiving Water:**
Alewife Brook

**Capital Cost:**
$13,825,000

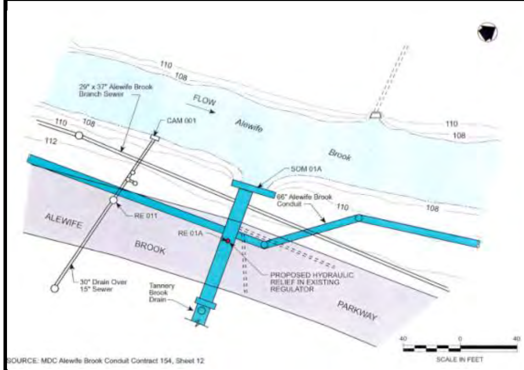
**Completed:** April 2013

**Description:**
Cambridge constructed a new 4-foot by 8-foot box culvert storm drain to convey the separated stormwater to a new 3.4-acre wetland in the Alewife Brook Reservation. The wetland will provide 10.3 acre-feet of detention storage of stormwater flows and the attenuation of stormwater flow rate to the Little River and Alewife Brook.

**CSO Control**

**Water Quality Benefit:**
Supports the CSO benefits of CAM004 Sewer Separation by mitigating the potential impacts of the separated stormwater on the high water levels and water quality of the Little River and Alewife Brook.

## 32. SOM01A INTERCEPTOR CONNECTION RELIEF AND FLOATABLES CONTROL




**Receiving Water:**
Alewife Brook

**Capital Cost:**
$0.8 M

**Completed:** December 2013

**Description:**
MWRA upgraded the size of the local sewer connection between City of Somerville's Tannery Brook Conduit and MWRA's interceptor system and installed an underflow baffle to control the discharge of floatable materials.

**CSO Control**

**Water Quality Benefit:**
Together with other Alewife Brook CSO projects, minimizes CSO discharges and their impacts to meet Class B "fishable/ swimmable" criteria >95% of the time.

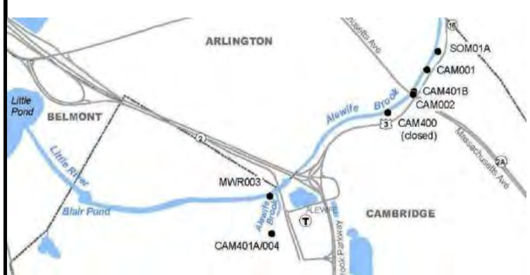
**CSO Outfalls:**
SOM01A

**Frequency of Discharge (Typical Year):**
**Before project:** 10
**With project (LTCP):** 3

**Annual Discharge Volume (Typical Year):**
**Before project:** 9.9 million gallons
**With project:** 1.7 million gallons

**CSO Reduction by Volume:** 83%

## 33. CONTROL GATE AND FLOATABLES CONTROL AT OUTFALL MWR003 AND MWRA RINDGE AVE. SIPHON RELIEF


**Receiving Water:**
Alewife Brook

**Capital Cost:**
$3,763,000

**Completed:**
October 2015

**Description:**
MWRA replaced the original static overflow weir with an automated weir gate; replaced the 30-inch diameter Rindge Avenue Sewer overflow siphon with a 48-inch diameter siphon; and installed an underflow baffle for floatables control. The project improves the balance of flows in MWRA's twin interceptors and provides greater system relief in large storms, in part to compensate for the closing of Outfall CAM004.

**CSO Control**

**Water Quality Benefit:**
Together with other Alewife Brook CSO projects, minimizes CSO discharges and their impacts to meet Class B "fishable/ swimmable" criteria >95% of the time.

**CSO Outfalls:**
MWR003 and CAM004

**Frequency of Discharge (Typical Year):**
**MWR003 before project:** 1
**MWR003 with project:** 5
**CAM004 before project:** 63
**CAM004 with project:** Eliminated

**Annual Discharge Volume (Typical Year):**

**Outfall MWR003**
**Before project:** 0.1 million gallons
**With project:** 1.0 million gallons

**Outfall CAM004**
**Before project:** 24.1 million gallons
**With project:** Eliminated

## 34. RESERVED CHANNEL SEWER SEPARATION


**Receiving Water:**
Reserved Channel

**Capital Cost:**
$70,559,000

**Completed:**
December 2015

**Description:**
BWSC installed 81,200 linear feet of new sewer and storm drain to separate the combined sewer systems serving a 365-acre area of South Boston tributary to four CSO outfalls along the Reserved Channel.

**CSO Control**

**Water Quality Benefit:**
Minimizes CSO discharges to meet Class SB(cso) water quality standards (>95% compliance with Class SB).

**CSO Outfalls:**
BOS076, BOS078, BOS079, BOS080

**Frequency of Discharge (Typical Year)**:

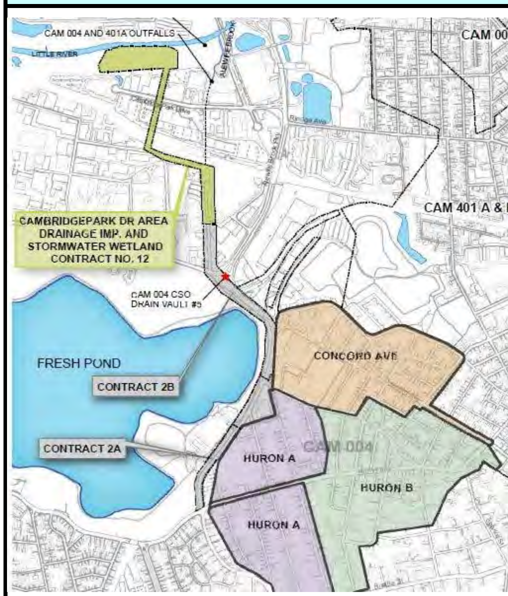
**Before project:** 37
**With project:** 3

**Annual Discharge Volume (Typical Year):**

**Before project:** 28 million gallons
**With project:** 1.5 million gallons

**CSO Reduction by Volume:** 95%

## 35. CAM004 SEWER SEPARATION




**Receiving Water:**
Alewife Brook

**Capital Cost:**
$100,000,000 (Cambridge and
MWRA)
$54,000,000 (MWRA share)

**Completed:**
December 2015

**Description:**
Cambridge installed 55,300 linear feet of new or rehabilitated sewer and storm drain to separate the combined sewers serving a 211-acre area of Cambridge east of Fresh Pond Parkway. With the project, the City of Cambridge permanently closed Outfall CAM004.

**CSO Control**

**Water Quality Benefit:**
Together with other Alewife Brook CSO projects, minimizes CSO discharges and their impacts to meet Class B “fishable/ swimmable” criteria >95% of the time.

**CSO Outfall:**
CAM004

**Frequency of Discharge (Typical Year):**

**Before project:** 10
**With project:** 0

**Annual Discharge Volume Typical Year)**:

**Before project** 4.6 million gallons
**With project:** 0.0 million gallons

**CSO Reduction by Volume:** 100%

## 2.5 **Environmental Quality Improvement**

This chapter summarizes current water quality and water quality improvement in the various receiving waters that benefit from the Long-Term Control Plan.

### 2.5.1 Recent Water Quality Conditions

CSO discharges have been vastly reduced, treated, or eliminated in all segments of the harbor with the completion of construction. Figure 2-7 and Figure 2-8, on pages 31 and 32, show the recent levels of compliance with swimming standards (2012 through 2016 data) in these segments, including harbor embayments, tributaries and beaches. These figures also show the reduced CSO volume discharged to each segment. The elimination of CSO discharges from waters where compliance levels are still not near 100%, such as the Neponset River and South Dorchester Bay, indicate that sources other than CSO are a cause of elevated bacteria. In areas such as the Inner Harbor and Lower Charles, where CSOs remain, the majority of CSO flow receives treatment, and CSO discharges comply with “fishable/swimmable” standards (i.e., have no impact) 99% of the time in a typical rainfall year.

The results of water quality sampling at harbor beaches show very good conditions, with the vast majority of samples meeting swimming standards. CSOs have been eliminated from all harbor beaches, and any remaining water quality violations are attributable to other sources. South Boston beaches meet standards 98% of the time.

### 2.5.2 Water Quality Improvement

The water quality of Boston Harbor and the Charles, Mystic and Neponset rivers has steadily improved as MWRA and the CSO communities completed the CSO projects and as communities along these waters have also implemented programs to control pollutant loadings from storm drains. Beach closings due to high bacteria are relatively infrequent, allowing for swimming on most summer days at all beaches.

The bar graph in Figure 2-8 on page 32 shows the marked reduction in samples failing to meet limits following start-up operation of the CSO storage tunnel in May 2011. The fraction of days failing to meet the bacteria limit at one or more South Boston beaches has dropped from an average of 18% in the five years prior to start-up of the storage tunnel to an average of 4% in the five years following start-up. The few remaining water quality violations and related beach closings are not CSO related (there has been no CSO discharge since the storage tunnel opened), and may be caused by environmental factors such as near-field overland stormwater runoff contaminated with pet waste or bird droppings.

During 2018, the storage tunnel has captured approximately 351 million gallons of CSO and separate stormwater and prevented any CSO or stormwater discharge to the beaches in the approximately 97 rainfall events that occurred that year.  From start-up on May 4, 2011, through October, 2018, the storage tunnel captured more than 1.4 billion gallons of CSO and stormwater, and there has been no discharge of CSO to the beaches. Hurricane Irene in August 2011 and the December 9, 2014, storm resulted in two discharges of separate stormwater to the beaches and Savin Hill Cove and three additional storms have resulted in transfers of some separate stormwater to Savin Hill Cove, in accordance with the operating protocols for the tunnel.

Save the Harbor/Save the Bay


**Figure 2-7: Water Quality in Boston Harbor & Tributary Rivers**

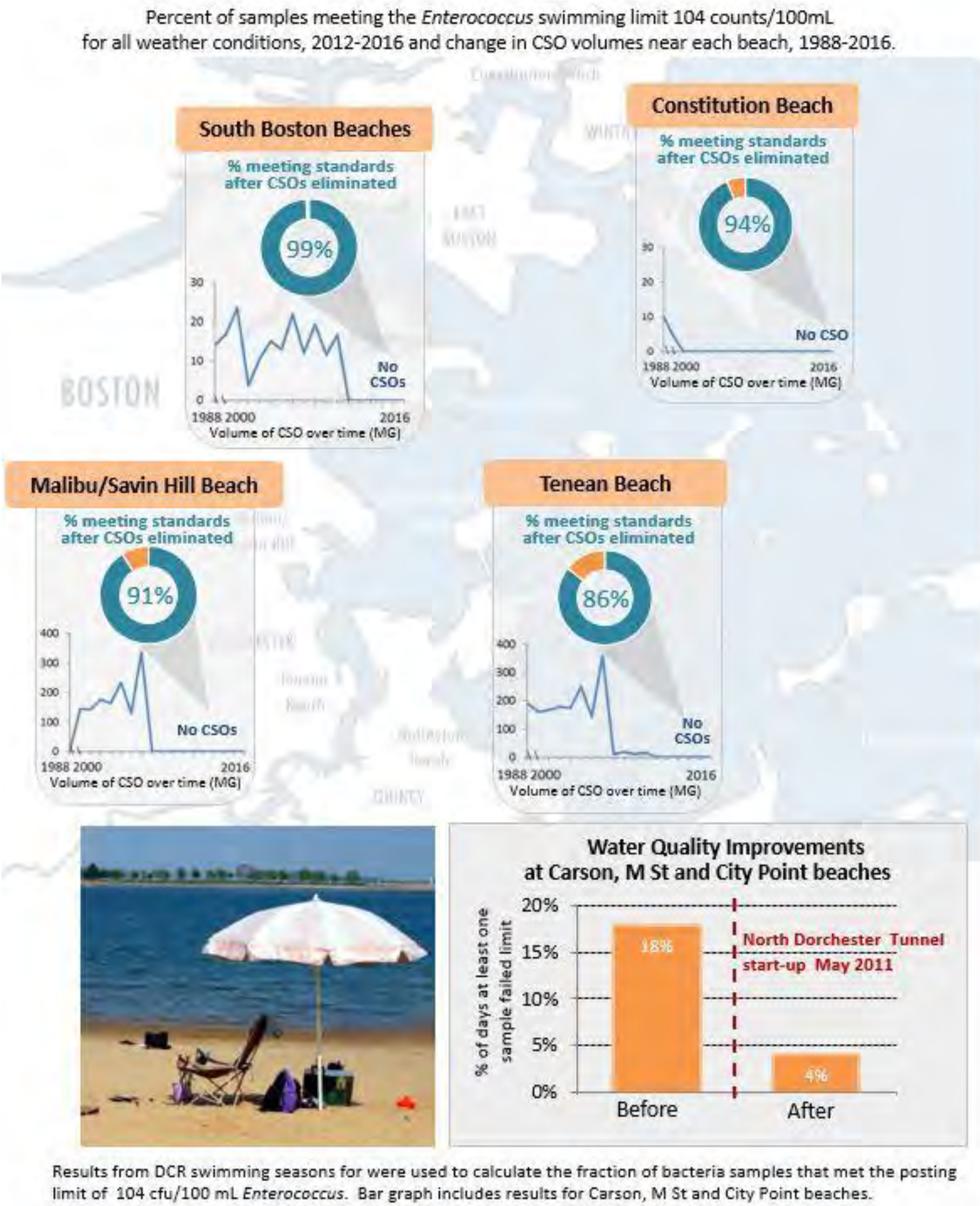



**Figure 2-8: Water Quality at Boston Harbor Beaches, 1988-2015**

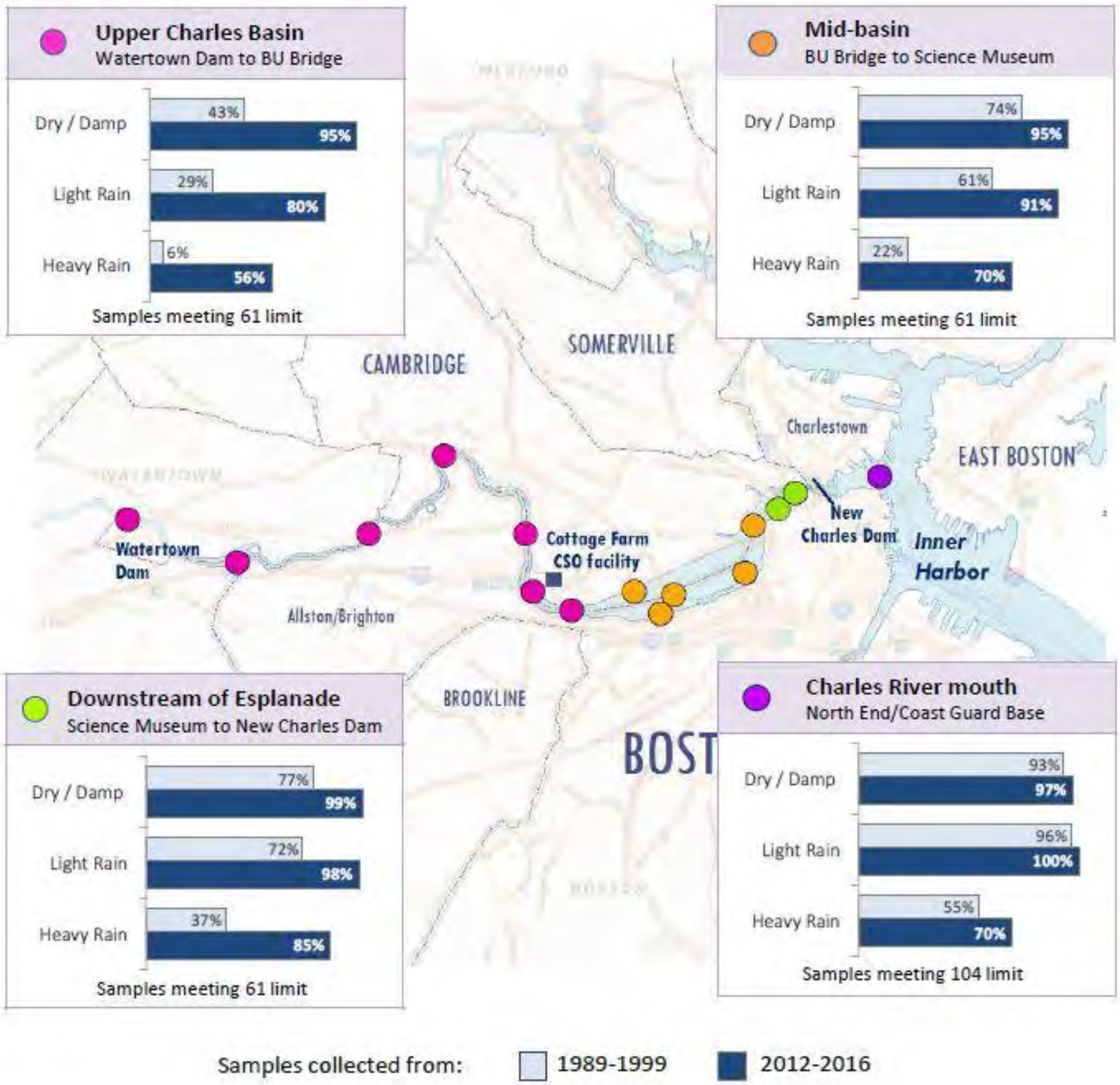
MWRA's major improvements to its collection and treatment systems and its completed CSO control projects have removed CSO as a major source of pollution to the Boston Harbor and its tributaries, and have the potential to enhance environmental conditions and promote safe public use. The benefits of these complementary pollution control programs are most evident in the Charles River. Tremendous water quality improvement has been observed and measured in the Charles River Basin, where average annual CSO discharge has been drastically cut from about 1.7 billion gallons in 1988 to 13.5 million gallons today, a greater than 99% reduction. Approximately 79% of this remaining overflow is treated at MWRA's Cottage Farm CSO facility.


These improvements are the result of major wastewater system projects, most notably the Deer Island Wastewater Treatment Plant and related conveyance and pumping systems, as well as the CSO control projects completed to date. MWRA and the CSO communities along the Charles River completed a set of improvements in the late 1980s that eliminated dry weather sewage overflows at CSO outfalls. They also completed a set of system optimization projects in the mid-1990s that maximized the wastewater system's hydraulic performance and lowered CSO discharges. MWRA and the communities have also completed six CSO control projects along the Charles River: Cottage Farm Facility Upgrade (2000), CAM005 Hydraulic Relief (2000), Independent Floatables Controls and Outfall Closings Project (2001), Stony Brook Sewer Separation (2006), Cottage Farm Brookline Connection and Inflow Controls (2009), Bulfinch Triangle Sewer Separation (2010) and Brookline Sewer Separation (2013). The City of Cambridge continues to perform sewer separation work under its capital improvement program that is projected to further reduce CSO discharges to the Charles River.

In the same period, communities along the Charles River have continued programs aimed at reducing pollution in separate stormwater discharges, including identifying and removing illicit sewer connections to storm drains. The CSO and stormwater related improvements have contributed to significant and steady water quality improvement in the Charles River Basin during dry and wet weather conditions, as shown in Figure 2-9 on the following page.

Figure 2-10 on page 35 shows the bacterial water quality in the Mystic River. The Lower Mystic and Mystic River mouth had the best water quality, meeting water quality limits most of the time, with the majority of bacteria samples meeting the *Enterococcus* swimming limit in all weather conditions for 2012 through 2016, and more than 90% of samples meeting standards in dry weather. While conditions worsen in heavy rain events, these rainfall conditions are relatively infrequent.

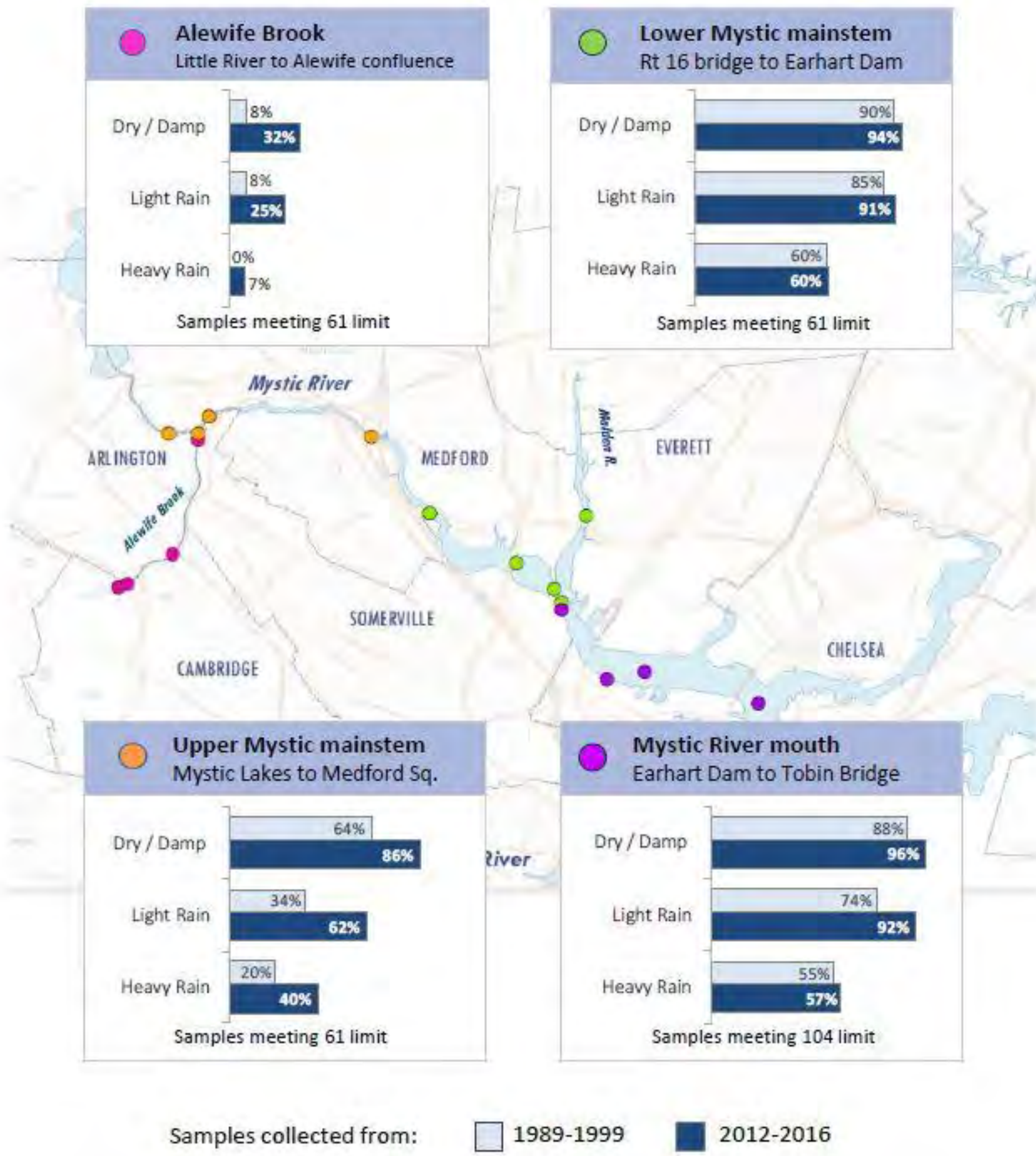
Graphs show the percent of samples meeting the *Enterococcus* bacteria limit for swimming, by river reach and weather condition.




Dots are MWRA sampling locations. State swimming standards for *Enterococcus* single sample limits are 104 cfu/100 mL for marine waters, and 61 cfu/100 mL in freshwater. Rainfall: Heavy Rain is at least 0.5 inches of rain in previous 48 hours; Light Rain is between 0.1 and 0.5 inches of rainfall in previous 48 hours. 2012 – 2016 period is considered current conditions, following substantial completion of infrastructure improvements. Data from intervening years (2000 – 2011) are excluded.

**Figure 2-9: Change in Lower Charles River Water Quality Over Time**

Graphs show the percent of samples meeting the *Enterococcus* bacteria limit for swimming, by river reach and weather condition.

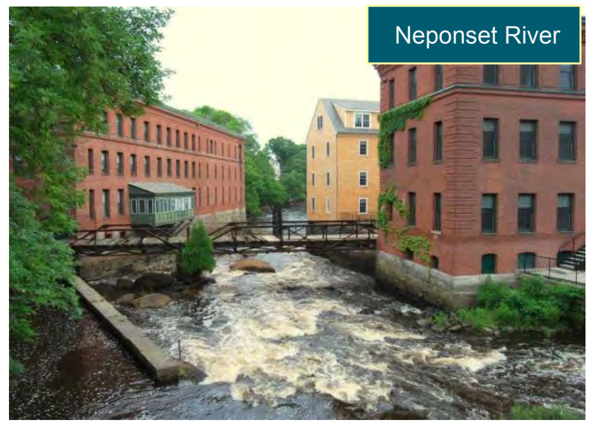



Dots are MWRA sampling locations. State swimming standards for *Enterococcus* single sample limits are 104 cfu/100 mL for marine waters, and 61 cfu/100 mL in freshwater. Rainfall: Heavy Rain is at least 0.5 inches of rain in previous 48 hours; Light Rain is between 0.1 and 0.5 inches of rainfall in previous 48 hours. 2012 – 2016 period is considered current conditions, following substantial completion of infrastructure improvements. Data from intervening years (2000 – 2011) are excluded.

**Figure 2-10: Change in Mystic River Water Quality Over Time**

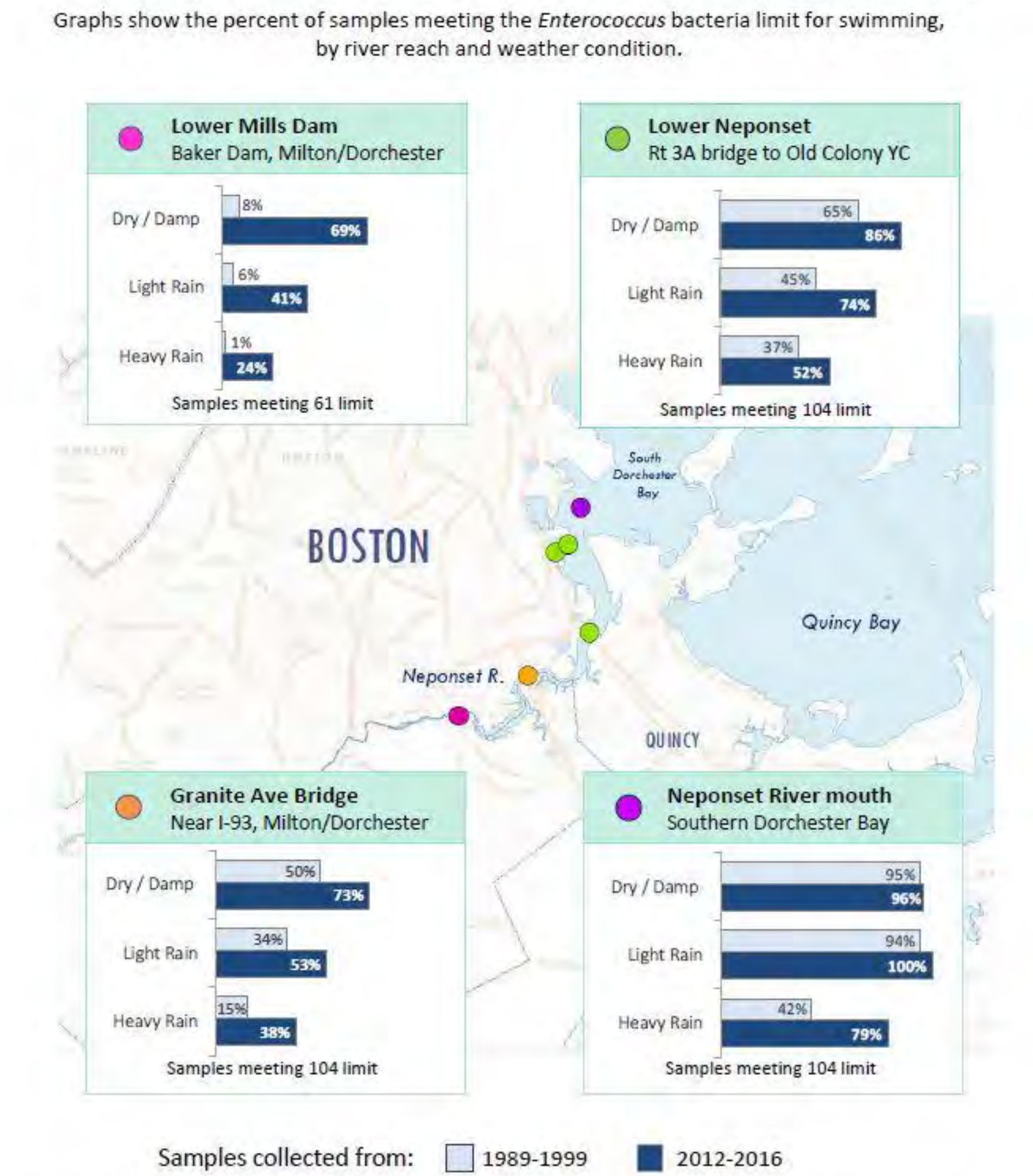
Bacteria counts in Alewife Brook (prior to the completion of the major CSO work in 2015) frequently fail to meet swimming limits in both dry and wet weather, and water quality is particularly poor after heavy rain. However, Alewife Brook's influence on downstream water quality conditions in the Mystic main stem is limited, with bacterial conditions downstream showing little influence downstream of the Alewife Brook confluence with the river.


Figure 2-11 on the following page shows substantial improvement in water quality over time in the Neponset River, though the magnitude of improvements varies by river segment, with upstream locations showing the most significant change, particularly at the Baker Dam. CSO discharges were eliminated in 2000 with completion of the Neponset River sewer separation project. Prior to the project, CSO flows were discharged at two BWSC outfalls in the lower Neponset, downstream of Granite Avenue bridge. Water quality data show improvement downstream of these former CSOs, and further upstream at the Baker Dam, which shows improvement in dry as well as wet weather conditions. Bacteria levels generally meet swimming standards at the mouth of the Neponset River in all but heavy rainfall conditions, where there is considerable dilution with the water of South Dorchester Bay.



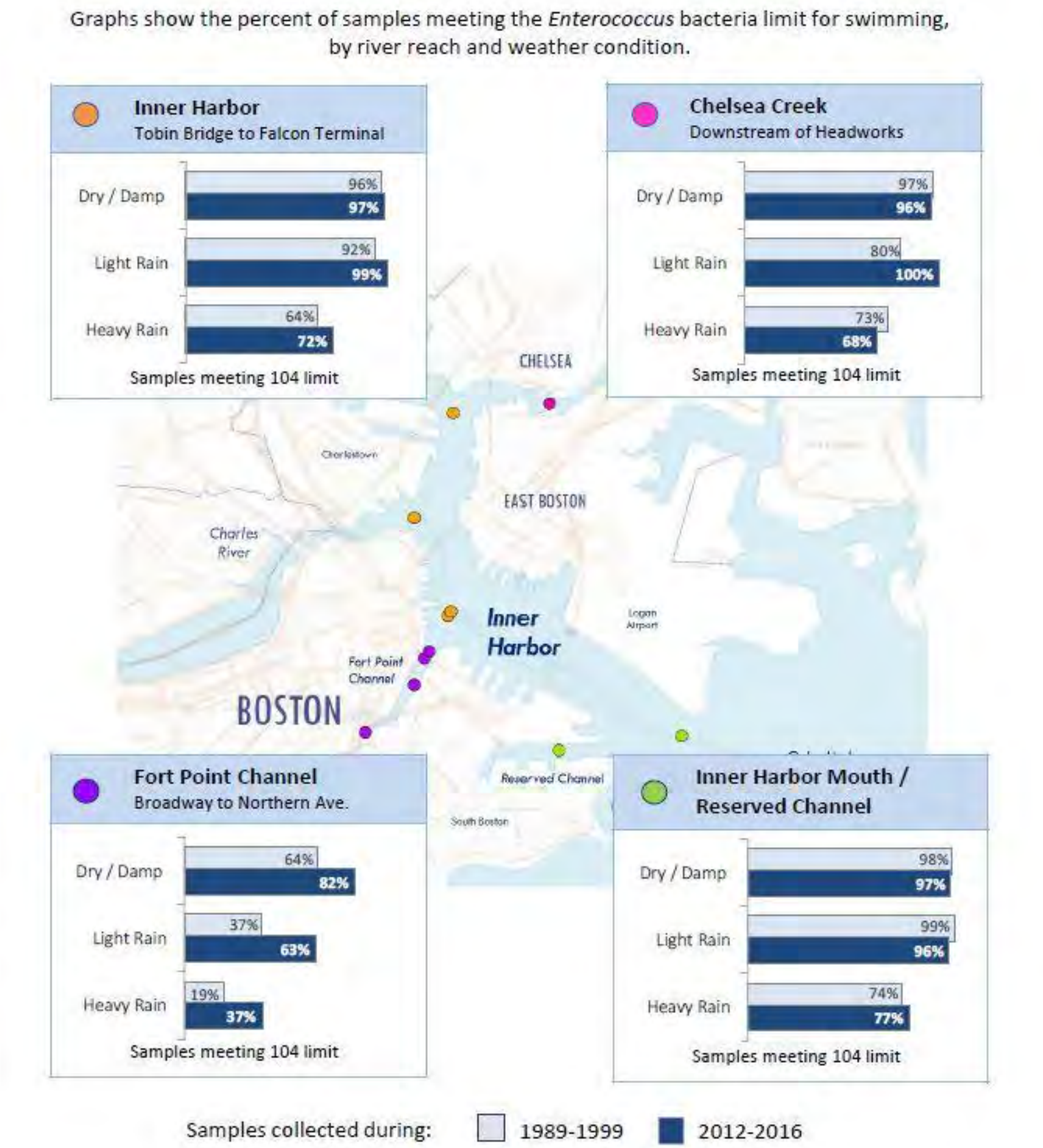

Improvement in the quality of Boston Inner Harbor waters is also seen in the changes to *Enterococcus* bacteria counts over the period 1989 to 2016, shown in Figure 2-12 on page 38. Water quality conditions improved with the significant increase in wastewater transport and treatment capacity (delivery to the Deer Island Treatment Plant) in the period prior to 1991. This increase in delivery capacity greatly reduced CSO discharges at most outfalls. Since then, wet-weather water quality continues to improve in Boston Harbor and its tributary rivers, but at a slower pace, due in part to diminishing returns on wastewater pollution investments and the dominance of other sources of pollution, including urban stormwater.

As shown in Figure 2-13, on page 39, wet weather water quality conditions in Boston Harbor and its tributary rivers improved after the significant increase in wastewater transport and treatment capacity in the early 1990's. Since then, wet weather conditions have continued to improve with implementation of the CSO projects. By 2008, MWRA and the CSO communities had completed many of the CSO control projects that further reduced or eliminated discharges at most CSO outfalls, including outfalls to the Charles River, Mystic River and Chelsea Creek. In the same period, community efforts to control urban stormwater pollution were underway, and these efforts have continued.




Dots are MWRA sampling locations. State swimming standards for *Enterococcus* single sample limits are 104 cfu/100 mL for marine waters, and 61 cfu/100 mL in freshwater. Rainfall: Heavy Rain is at least 0.5 inches of rain in previous 48 hours; Light Rain is between 0.1 and 0.5 inches of rainfall in previous 48 hours. 2012 – 2016 period is considered current conditions, following substantial completion of infrastructure improvements. Data from intervening years (2000 – 2011) are excluded.

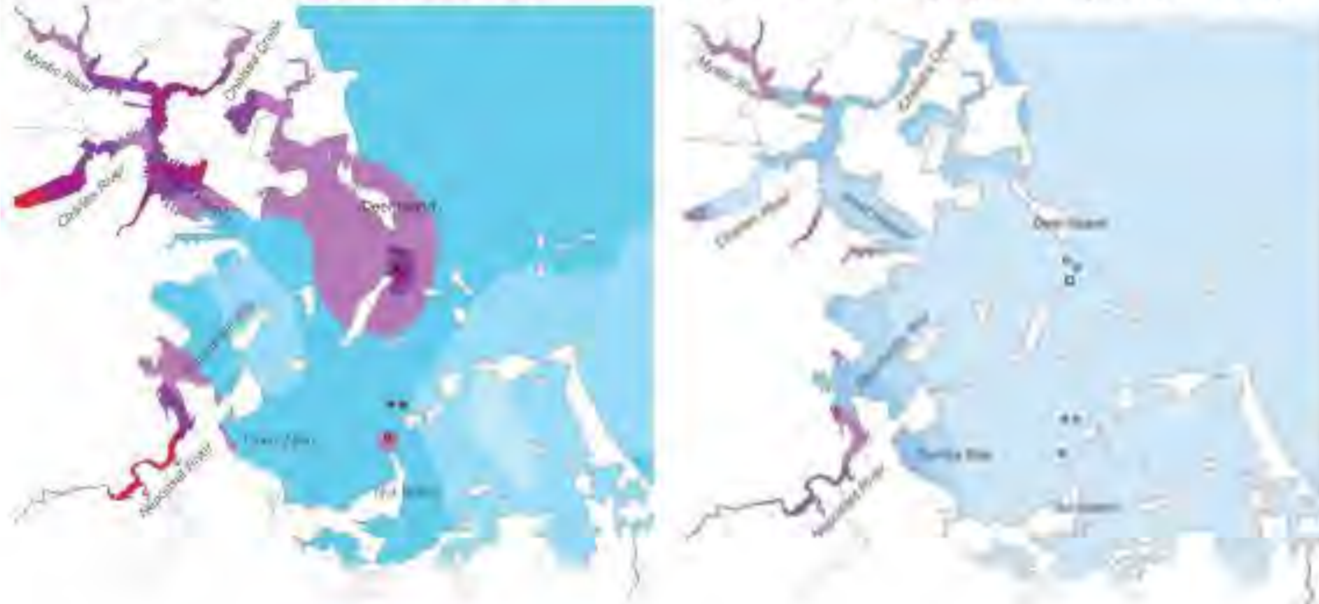
**Figure 2-11: Change in Lower Neponset River Water Quality Over Time**




Dots are MWRA sampling locations. State swimming standard for *Enterococcus* single sample limit is 104 cfu/100 mL for marine waters. Rainfall: Heavy Rain is at least 0.5 inches of rain in previous 48 hours; Light Rain is between 0.1 and 0.5 inches of rainfall in previous 48 hours. 2012 – 2016 period is considered current conditions, following substantial completion of infrastructure improvements. Data from intervening years (2000 – 2011) are excluded.

**Figure 2-12: Change in Inner Harbor Water Quality Over Time**

**Prior to Boston Harbor projects** (1989-1991) **Most Boston Harbor projects complete** (post-2007)



Geometric mean (colonies/100 mL)

Sampled during rainfall
>=0.2 inches within 24 hours

Blue contours meet swimming standard, red-purple contours exceed swimming standard

0 - 5
5 - 10
10 - 35
35 - 104
104 - 158
158 - 275
> 275

active treatment outfall
closed treatment outfall
active NITP sludge outfall
closed NITP sludge outfall

Contours show the geometric means of *Enterococcus* bacteria samples collected when more than 0.2 inches of rain fell in the previous day. Blue areas meet the EPA geometric mean standard for *Enterococcus* (35 cfu/100 mL) and red-purple areas exceed the standard.

**1989-1991**
This period precedes major improvements to upgrade MWRA's Deer Island treatment plant, including the closure of harbor treatment plant outfalls, and CSO controls. The period includes the final year that wastewater sludge was released to Boston Harbor (1991).

Harbor areas affected by the discharge of sewage and sludge from the old Deer Island and Nut Island treatment plants, as well as tributary rivers affected by CSO failed to meet the water quality standard in wet weather.

**Post-2007**
Data from these years reflect the effects of CSO upgrades, the ending of sludge discharges, improved treatment capacity and start of second treatment at the Deer Island Treatment Plant. This period also follows the ending of treatment plant discharges to the Harbor with startup of the Massachusetts Bay outfall in 2000.

**Figure 2-13: Changes in Boston Harbor *Enterococcus* Bacteria in Wet Weather**

## 2.6 **CSO Control Obligation and Performance Objective**

### 2.6.1 2006 Agreement, Second CSO Stipulation and LTCP Levels of Control

MWRA's obligations for CSO control in the Court Order are set forth 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* (the "Second Stipulation") as amended in April 2008. The Second Stipulation, which replaced the 1987 First Stipulation by which MWRA originally assumed responsibility under the Court Order for CSO control, formalized agreements reached by EPA, DEP and MWRA in March 2006 over long-term levels of CSO control, the projects comprising the LTCP, and project implementation schedules. In exchange for MWRA agreeing to supplement the 1997 Charles River CSO plan with additional projects that would achieve a higher level of control, MWRA was allowed a five-year period (2015-2020) of no additional CSO obligations or related capital project spending beyond the LTCP that was then approved. With the agreement, MWRA assumed the obligation of conducting a three-year post-construction monitoring program and performance assessment to assess attainment of the LTCP levels of control. With this agreement and associated approvals and court orders, MWRA gained greater certainty in managing its capital program and rate increases over the 15-year period through 2020.

At the same time, EPA and DEP considered adjusting the water quality standards for the Charles River and Alewife Brook/Upper Mystic River, but concluded that there continued to be uncertainty whether the Class B water quality standards would be achieved in the future and agreed that no additional CSO control measures should be imposed upon MWRA beyond those set forth in its Long-Term CSO Control Plan through 2020. To that end, DEP agreed to issue and EPA agreed to approve five (5) consecutive CSO variances of no more than a three-year duration each, through 2020, for the Charles River and Alewife Brook/Upper Mystic River that, as applied to MWRA only, that are consistent with and limited to the requirements of the Long-Term CSO Control Plan. EPA and DEP noted that the levels of CSO control to be achieved for the Charles River and Alewife Brook/Upper Mystic River under MWRA's Long-Term CSO Control Plan were expected to meet the water quality standards for the Charles River and Alewife Brook/Upper Mystic River, as modified by the variances, which was consistent with the 1994 CSO policy regarding water quality standards.

The Second Stipulation requires MWRA to implement the CSO requirements on the Court's schedule, as well as meet the LTCP levels of control. (In July 2006, the Court accepted and incorporated the approved schedule revisions as Schedule Seven.) The approved LTCP levels of CSO control are set forth in Exhibit "B" to the Second Stipulation. Pursuant to the Second Stipulation, MWRA accepted legal liability to undertake such corrective action at each CSO outfall within or hydraulically connected to MWRA's sewer system as may be necessary to implement the CSO control set forth in the Court schedules and related orders of the Court, and to meet the levels of CSO control (including as to frequency of CSO activation and as to volume of discharge) described in MWRA's in MWRA's Long-Term CSO Control Plan. With respect to all CSO outfalls owned and operated by the MWRA, including the CSO outfalls in Exhibit "B" identified with the prefix "MWR" and the Union Park CSO Treatment Facility CSO outfall, MWRA also accepted legal liability to undertake such corrective future action as may be necessary to meet the CSO control requirements of the Clean Water Act.

The primary goal of the ongoing performance assessment is to demonstrate that MWRA has achieved compliance with the levels of control, including the frequencies of CSO discharges and volumes of discharge in a "Typical Year" specified in its Long-Term CSO Control Plan. The Typical Year is an annual series of storms developed by MWRA in 1992 from a 40-year rainfall record and approved by EPA and DEP as a key performance measure. The Typical Year has been the basis for development, recommendation and approval of the levels of control in the LTCP; establishment of the federal court mandated levels of control; and assessment of system performance. Typical year performance can be measured and tracked only with MWRA's wastewater system hydraulic model, which MWRA continuously updates to incorporate new information about its system or the community systems that can affect CSO discharges, and to recalibrate against available new meter data. An overarching objective of the ongoing study is to increase confidence that the model is accurately predicting system conditions and CSO discharges when the model is used for final assessments of level of control that will be presented in the December 2020 performance assessment report. This objective is being met by the ongoing collection of extensive temporary CSO meter data over an extended period of time to supplement permanent system meter data.

The long-term levels of CSO control recommended by MWRA with its LTCP, approved by EPA and DEP with the 2006 Agreement, and included in Exhibit B to the Second Stipulation are presented in Table 2-2. Table 2-3 on page 44 presents the LTCP levels of control on a receiving water segment basis, along with the projects and total project cost that contribute to meeting the level of control for each water segment.

**Table 2-2: LTCP Levels of Control (from Exhibit B to the Second Stipulation)**

| CSO OUTFALL | LONG TERM CONTROL PLAN | |
|---|---|---|
| | TYPICAL YEAR | |
| | Activation Frequency | Volume (MG) |
| **ALEWIFE BROOK** | | |
| CAM001 | 5 | 0.19 |
| CAM002 | 4 | 0.69 |
| MWR003 | 5 | 0.98 |
| CAM004 | To be closed | N/A |
| CAM400 | To be closed | N/A |
| CAM401A | 5 | 1.61 |
| CAM401B | 7 | 2.15 |
| SOM001A | 3 | 1.67 |
| SOM001 | Closed | N/A |
| SOM002A | Closed | N/A |
| SOM003 | Closed | N/A |
| SOM004 | Closed | N/A |
| **TOTAL** | | **7.29** |
| **UPPER MYSTIC RIVER** | | |
| SOM007A/MWR205A (Somerville Marginal) | 3 | 3.48 |
| SOM007 | Closed | N/A |
| **TOTAL** | | **3.48** |
| **MYSTIC / CHELSEA CONFLUENCE** | | |
| MWR205 (Somerville Marginal) | 39 | 60.58 |
| BOS013 | 4 | 0.54 |
| BOS014 | 0 | 0.00 |
| BOS015 | Closed | N/A |
| BOS017 | 1 | 0.02 |
| CHE002 | 4 | 0.22 |
| CHE003 | 3 | 0.04 |
| CHE004 | 3 | 0.32 |
| CHE008 | 0 | 0.00 |
| **TOTAL** | | **61.72** |
| **UPPER INNER HARBOR** | | |
| BOS009 | 5 | 0.59 |
| BOS010 | 4 | 0.72 |
| BOS012 | 5 | 0.72 |
| BOS019 | 2 | 0.58 |
| BOS050 | Closed | N/A |
| BOS052 | Closed | N/A |
| BOS057 | 1 | 0.43 |
| BOS058 | Closed | N/A |
| BOS060 | 0 | 0.00 |
| MWR203 (Prison Point) | 17 | 243.00 |
| **TOTAL** | | **246.04** |

**Table 2-2 (continued): LTCP Levels of Control (from Exhibit B to the Second Stipulation)**

| CSO OUTFALL | LONG TERM CONTROL PLAN | |
|---|---|---|
| | TYPICAL YEAR | |
| | Activation Frequency | Volume (MG) |
| | | |
| **LOWER INNER HARBOR** | | |
| BOS003 | 4 | 2.87 |
| BOS004 | 5 | 1.84 |
| BOS005 | 1 | 0.01 |
| BOS006 | 4 | 0.24 |
| BOS007 | 6 | 1.05 |
| **TOTAL** | | **6.01** |
| **CONSTITUTION BEACH** | | |
| MWR207 | Closed | N/A |
| **TOTAL** | | **0.00** |
| **FORT POINT CHANNEL** | | |
| BOS062 | 1 | 0.01 |
| BOS064 | 0 | 0.00 |
| BOS065 | 1 | 0.06 |
| BOS068 | 0 | 0.00 |
| BOS070 | | |
| BOS070/DBC | 3 | 2.19 |
| UPPS | 17 | 71.37 |
| BOS070/RCC | 2 | 0.26 |
| BOS072 | 0 | 0.00 |
| BOS073 | 0 | 0.00 |
| **TOTAL** | | **73.89** |
| **RESERVED CHANNEL** | | |
| BOS076 | 3 | 0.91 |
| BOS078 | 3 | 0.28 |
| BOS079 | 1 | 0.04 |
| BOS080 | 3 | 0.25 |
| **TOTAL** | | **1.48** |
| **NORTHERN DORCHESTER BAY** | | |
| BOS081 | 0 / 25 year | N/A |
| BOS082 | 0 / 25 year | N/A |
| BOS083 | 0 / 25 year | N/A |
| BOS084 | 0 / 25 year | N/A |
| BOS085 | 0 / 25 year | N/A |
| BOS086 | 0 / 25 year | N/A |
| BOS087 | 0 / 25 year | N/A |
| **TOTAL** | | **0.00** |
| | | |
| **SOUTHERN DORCHESTER BAY** | | |
| BOS088 | To be closed | N/A |
| BOS089 (Fox Point) | To be closed | N/A |
| BOS090 (Commercial Point) | To be closed | N/A |
| **TOTAL** | | **0.00** |

**Table 2-2 (continued): LTCP Levels of Control (from Exhibit B to the Second Stipulation)**

| CSO OUTFALL | LONG TERM CONTROL PLAN | |
|---|---|---|
| | TYPICAL YEAR | |
| | Activation Frequency | Volume (MG) |
| **UPPER CHARLES** | | |
| BOS032 | Closed | N/A |
| BOS033 | Closed | N/A |
| CAM005 | 3 | 0.84 |
| CAM007 | 1 | 0.03 |
| CAM009 | 2 | 0.01 |
| CAM011 | 0 | 0.00 |
| **TOTAL** | | **0.88** |
| **LOWER CHARLES** | | |
| BOS028 | Closed | N/A |
| BOS042 | Closed | N/A |
| BOS049 | To be closed | N/A |
| CAM017 | 1 | 0.45 |
| MWR010 | 0 | 0.00 |
| MWR018 | 0 | 0.00 |
| MWR019 | 0 | 0.00 |
| MWR020 | 0 | 0.00 |
| MWR021 | Closed | N/A |
| MWR022 | Closed | N/A |
| MWR201 (Cottage Farm) | 2 | 6.30 |
| MWR023 | 2 | 0.13 |
| SOM010 | Closed | N/A |
| **TOTAL** | | **6.88** |
| | | |
| **NEPONSET RIVER** | | |
| BOS093 | Closed | N/A |
| BOS095 | Closed | N/A |
| **TOTAL** | | **0.00** |
| **BACK BAY FENS** | | |
| BOS046 | 2 | 5.38 |
| **TOTAL** | | **5.38** |

## Table 2-3: LTCP Levels of Control by Receiving Water and Related Projects and Cost

| Receiving Water | LTCP Levels of Control (Typical Year Rainfall) Activations | Volume (million gallons) | Projects* | Capital Cost* ($ millions) |
|---|---|---|---|---|
| Alewife Brook/Upper Mystic River | 7 untreated and 3 treated @ Somerville Marginal | 7.3<br>3.5 | • Cambridge/Alewife Sewer Separation<br>• MWR003 Gate and Rindge Siphon Relief<br>• Interceptor Connections/Floatables<br>• Connection/Floatables at Outfall SOM01A<br>• Somerville Baffle Manhole Separation<br>• Cambridge Floatables Control (portion) | 110.0 |
| Mystic River/Chelsea Creek Confluence and Chelsea Creek | 4 untreated and 39 treated @ Somerville Marginal | 1.1<br>57.1 | • Somerville Marginal CSO Facility Upgrade<br>• Hydraulic Relief at BOS017<br>• BOS019 Storage Conduit<br>• Chelsea Trunk Sewer Replacement<br>• Chelsea Branch Sewer Relief<br>• CHE008 Outfall Repairs<br>• East Boston Branch Sewer Relief (portion) | 92.0 |
| Charles River (including Stony Brook and Back Bay Fens) | 3 untreated and 2 treated @ Cottage Farm | 6.8<br>6.3 | • Cottage Farm CSO Facility Upgrade<br>• Stony Brook Sewer Separation<br>• Hydraulic Relief at CAM005<br>• Cottage Farm Brookline Connection and Inflow Controls<br>• Brookline Sewer Separation<br>• Bulfinch Triangle Sewer Separation<br>• MWRA Outfall Closings and Floatables Control<br>• Cambridge Floatables Control (portion) | 88.9 |
| Inner Harbor | 6 untreated and 17 treated @ Prison Point | 9.1<br>243.0 | • Prison Point CSO Facility Upgrade<br>• Prison Point Optimization<br>• East Boston Branch Sewer Relief (portion) | 47.5 |
| Fort Point Channel | 3 untreated and 17 treated @ Union Park | 2.5<br>71.4 | • Union Park Treatment Facility<br>• BOS072-073 Sewer Separation and System Optimization<br>• BWSC Floatables Control<br>• Lower Dorchester Brook Sewer Modifications | 62.0 |
| Constitution Beach | Eliminate | | • Constitution Beach Sewer Separation | 3.7 |
| North Dorchester Bay | Eliminate | | • N. Dorchester Bay Storage Tunnel and Related Facilities<br>• Pleasure Bay Storm Drain Improvements<br>• Morrissey Blvd Storm Drain | 253.7 |
| Reserved Channel | 3 untreated | 1.5 | • Reserved Channel Sewer Separation | 70.5 |
| South Dorchester Bay | Eliminate | | • Fox Point CSO Facility Upgrade (interim improvement)<br>• Commercial Pt. CSO Facility Upgrade (interim improvement)<br>• South Dorchester Bay Sewer Separation | 126.6 |
| Neponset River | Eliminate | | • Neponset River Sewer Separation | 2.4 |
| Regional | | | • Planning, Technical Support and Land Acquisition | 52.8 |
| **TOTAL**<br>**Treated** | | **410**<br>**381** | | **910.1** |

*Floatables controls are recommended at remaining outfalls and are included in the listed projects and capital budgets.

### 2.6.2 Remaining Court Schedule Requirements

With completion of the last of the 35 LTCP projects in December 2015, MWRA had addressed 182 milestones in the schedules issued by the Federal District Court since the First CSO Schedule in 1987. Milestones included planning activities, regulatory compliance submissions, and project design and construction. As of January 2016, two milestones remained, both relating to the requirement that MWRA conduct a CSO post-construction monitoring program and performance assessment to demonstrate attainment of the required long-term levels of control, "(including as to frequency of CSO activation and as to volume of discharge) specified in its approved Long-Term Control Plan."

| Post-Construction Court Milestones | |
|---|---|
| **Jan 2018** | *MWRA to commence three-year performance assessment of its Long-Term CSO Control Plan. The assessment shall include post-construction monitoring in accordance with EPA's Combined Sewer Overflow (CSO) Policy, 59 Fed. Reg. 18688 (Apr. 19, 1994).* |
| **Dec 2020** | *MWRA to submit results of its three-year performance assessment of its Long-Term CSO Control Plan to the EPA and DEP. MWRA to demonstrate that it has achieved compliance with the levels of control (including as to frequency of CSO activation and as to volume of discharge) specified in its Long-Term CSO Control Plan.* |

On October 18, 2017, MWRA's Board of Directors approved the award of a professional services contract to support its three-year post-construction monitoring program and performance assessment. MWRA executed the contract and issued the Notice to Proceed to the awarded consultant, AECOM Technical Services, Inc. (AECOM) effective November 8, 2017, in advance of and in compliance with the January 2018 milestone in Schedule Seven. With the assistance of the contract services, MWRA plans to complete the performance assessment and submit the results to EPA and DEP in December 2020, in compliance with the last milestone in Schedule Seven.

### 2.6.3 Performance Tracking

MWRA has conducted annual CSO performance assessments and CSO discharge tracking for more than a decade. These efforts have included:

- Annual collection and review of facility operation records, meter data and other system performance indicators
- Updates to the MWRA collection system hydraulic model with new information about system conditions
- Estimation, using model predictions and facility records, of CSO activations and discharge volume at all active outfalls during the previous calendar year
- Updated simulation of CSO discharges from Typical Year rainfall

These data reviews, updates, and discharge estimates are performed to satisfy annual tracking and reporting requirements in the MWRA and CSO community NPDES Permits and in the conditions of the CSO variances for the Charles River and Alewife Brook/Upper Mystic River. These annual updates and assessments have also allowed MWRA to measure and track system performance as it continued to implement the LTCP.

MWRA incorporates completed sewer system improvements, such as completed CSO projects, significant system or operational changes, and new information about system conditions into the model. Information from facility records is used to configure the facility operational assumptions in the model for each modeled storm event. Meter data and other system performance indicators are used to compare measured conditions to model results for selected storms, allowing MWRA to evaluate model accuracy prior to modeling the actual storms in the previous calendar year.

In addition to modeling all of the actual rainfall events for the previous calendar year, MWRA also models the Typical Year rainfall with end-of-year updated system conditions for each annual report. This has allowed MWRA to compare updated system performance against the levels of control in the LTCP and to track progress toward the CSO control goals, which are based on Typical Year rainfall. To be able to understand and explain the estimated discharges for each calendar year, which can vary greatly from Typical Year predictions, MWRA performs a detailed review and comparison of the characteristics of the year's actual storms to the characteristics of the storms in the Typical Year.

### 2.6.4 Water Quality Standards and CSO Variances

In 1998, when EPA and DEP issued their initial approvals of MWRA's 1997 recommended CSO plan, DEP also issued water quality standards determinations for CSO affected water segments. This brought the plan into compliance with state Water Quality Standards. MWRA's Long-Term Control Plan has eliminated CSO discharges to Class B and SB waters, where CSO discharges are prohibited primarily to protect beaches and shellfish beds. Class B waters are inland waters designated as a habitat for fish, other aquatic life, and wildlife, and for primary and secondary contract recreation. Class B water may be used as a source of water supply with appropriate treatment, as well as irrigation, agricultural, and industrial purposes. Class SB waters are coastal and marine waters designated as a habitat for fish, other aquatic life, and wildlife for primary and secondary recreation. Water meeting Class B or SB standards indicate that the water is fishable or swimmable.

The LTCP is intended to meet water quality standards designated as Class $B_{(CSO)}$ or $SB_{(CSO)}$ by DEP where CSO discharges must meet Class B or SB standards at least 95% of the time, or meet a higher level of compliance in accordance with the CSO discharge limits. Higher level of compliance discharge limits are the CSO activation frequencies and volumes in the Typical Year in the approved LTCP. Table 2-4 on the following page identifies the current water quality standards for Boston Harbor related waters addressed in the LTCP.

DEP did not change the Class B designations for the Charles River and the Alewife Brook/Upper Mystic River, at the time, but instead issued temporary variances to Class B standards for CSO. DEP has since issued a series of 3-year CSO variances that allow MWRA and the CSO communities to continue to discharge CSO to these waters. In accordance with the agreement MWRA reached with EPA and DEP in 2006, DEP will continue to reissue, and the EPA will continue to approve, the Charles River and Alewife Brook/Upper Mystic River CSO variances through 2020.

On September 1, 2016, DEP issued Final Determinations which extended the CSO-related variances from water quality standards for Alewife Brook/Upper Mystic River and the Lower Charles River/Charles River Basin through August 31, 2019. The variances apply only to the permitted CSO outfalls to these receiving waters and do not otherwise modify Class B water quality standards. In accordance with the variances, CSO discharges from permitted outfalls are not required to meet effluent limits based on the Class B criteria when flow in the collection system exceeds the system's conveyance capacity as a result of precipitation or snow melt.

Through its continued implementation of the Nine Minimum Controls, as defined in the CSO Policy, MWRA maintains the conveyance capacity of its collection system, and has improved the handling of wet weather flows through system optimization efforts. Examples of system optimization efforts include improvements to the operations of influent gates at the Prison Point and Cottage Farm CSO treatment facilities. The variances require continued implementation of CSO long-term control measures, consistent with the LTCP and compliance with other requirements referenced below.

**Table 2-4: State Water Quality Standards and Required Levels of CSO Control**

| Water Quality Standard Classification | Receiving Water Segment | Required Level of CSO Control | CSO Control Status |
|---|---|---|---|
| Class B | Neponset River | CSO prohibited (25-year storm control for the South Boston beaches) | South Boston (North Dorchester Bay) storage tunnel captures CSO up to 25-year storm. All CSO outfalls to the other sensitive waters are now permanently closed. |
| Class SB | North Dorchester Bay<br>South Dorchester Bay<br>Constitution Beach | | |
| Class B(cso) | Back Bay Fens | >95% compliance with Class B or SB ("fishable/swimmable")<br><br>Must meet level of control for CSO activation and frequency in the approved Long-Term Control Plan (LTCP) | All LTCP projects are complete; CSO discharges are greatly reduced. Ongoing performance assessment is intended to verify attainment of LTCP levels of control. |
| Class SB(cso) | Mystic/Chelsea Rivers Confluence<br>Boston Inner Harbor<br>Fort Point Channel<br>Reserved Channel | | |
| Class B (CSO Variance) | Alewife Brook<br>Upper Mystic River<br>Charles River | Class B standards sustained w/temporary authorizations for CSO discharges as the LTCP is implemented and verified (1998-2020) | All LTCP projects are complete; CSO discharges are greatly reduced. Ongoing performance assessment is intended to verify attainment of LTCP levels of control. |

Each variance extension, including the variances currently in effect (2016-2019), acknowledges that it would not be feasible to fully attain the Class B bacteria criteria and associated recreational uses for these receiving waters within the three-year period. The agreement reached by EPA, DEP and MWRA in March 2006 included an understanding that DEP would reissue, and that EPA would approve, a series of three-year variance extensions, effective through 2020. This agreement was based in part on the determination that implementation of controls necessary for full attainment of the Class B bacteria criteria and associated use (i.e. elimination of CSO) would result in substantial and widespread economic and social impact.

The variances include conditions that MWRA and the CSO communities have complied with for these waters. These include:

- Implementation of the LTCP
- Continued implementation of operation and maintenance measures that can minimize CSO discharges and impacts
- Dissemination of public information on CSO discharges and potential public health impacts
- 24-hour public notification of a treated CSO discharge to the Charles River from the Cottage Farm CSO Facility and discharge from the most active outfall into Alewife Brook
- Continuation of MWRA's water quality monitoring program
- Annual reporting of rainfall events and estimates of CSO activations and discharge volumes at each outfall

### 2.6.5 Water Quality Monitoring and Assessments

Coupled with the CSO performance assessment, MWRA will conduct analyses of historical and recent receiving water quality data to assess the water quality benefits of the MWRA CSO control program. For the receiving water segments covered by CSO variances, the primary approach is to analyze the extensive water quality monitoring data that have been and continue to be collected by the MWRA to assess the water quality impacts of remaining CSOs. Monitoring data have the benefit of representing actual conditions in the receiving waters rather than model predictions. Also, the monitoring data represent the range of conditions that occur and, thus, provide quantitative estimates of water quality variability with and without CSO discharges.

The objectives of the planned analyses are to address the following specific issues:

- Assess whether remaining CSOs preclude attainment of bacterial water quality standards and comply with the water quality-based requirements of the Clean Water Act.
- Assess the performance of the CSO controls relative to the CSO impact reduction and water quality improvement predictions of the Long-Term Control Plan that supported regulatory approvals.

Because of the different characteristics of the various CSO receiving waters, separate analyses will be conducted for the individual receiving water segments. For the water segments designated B(cso) or SB(cso) by DEP in 1998, the analyses will be limited to assessing the CSO discharge goals of the LTCP.

MWRA has been conducting water quality monitoring in Boston Harbor and its tributary rivers under several projects since 1989. Water quality monitoring projects include the Combined Sewer Receiving Water Monitoring Program, the Boston Harbor Water Quality Monitoring Program, and the Boston Harbor Water Quality Monitoring – Rivers Program.

The existing water quality monitoring dataset collected under the Combined Sewer Receiving Water Monitoring Program, the Boston Harbor Water Quality Monitoring Program, and the Boston Harbor Water Quality Monitoring – Rivers Program is extensive. Close to 17,000 Enterococcus results, 10,000 *E-coli* results, and 23,000 fecal coliform results were measured between 1989 and 2017 at stations in the Alewife Brook. Upper Mystic River, Charles River, Lower Mystic, Chelsea Creek, Inner Harbor, Fort Point Channel, and Reserved Channel. Sampling is ongoing for all three projects and additional microbial counts and field measurements continue to be collected.

# 3. Rainfall and Rainfall Analyses, April 15 – June 30, 2018

Rainfall is a driving factor in the analysis of CSOs as the occurrence of overflows within the MWRA sewer system is dependent on rainfall intensity and depth during storm events. Therefore, rainfall statistics such as peak intensity and depth are compared to metered CSO discharges through correlation to rainfall amounts. In addition, rainfall data is the primary input for the hydraulic model, which is being used to assess CSO performance in the MWRA sewer system.

This section presents the methodology for collecting and reviewing the rainfall data measured during the period of April 15 to June 30, 2018. It also describes the analysis of the rainfall data used to characterize the return period of each storm event and a comparison of measured rainfall for this period to the rainfall included in the Typical Year.

## 3.1 Rainfall Data Collection

Rainfall has been quantified for this analysis using 15-minute rainfall data collected at 20 rain gauges distributed over the MWRA system, generally within the interstate I-95 belt. Following the guidelines outlined in the EPA's 1999 CSO Guidance for Monitoring and Modeling, rain gauges have been spaced approximately three miles apart. Rain gauges are operated and maintained by MWRA, the Boston Water and Sewer Commission (BWSC), and the United States Geological Survey (USGS). Three additional project gauges were installed to achieve the three mile rain gauge density recommended in the 1999 guidance document. Rain gauges are listed in Table 3-1 and the locations are shown in Figure 3-1. It is noted that some of the BWSC gauges in Table 3-1 and Figure 3-1 are in the MWRA's South System tributary area, and may not be directly used in modeling to be performed.

Although the 20 rain gauges listed in Table 3-1 are used in the hydraulic modeling, four rain gauges in the combined sewer areas are analyzed in greater detail to characterize the storms that occurred during the monitoring period and how they compare to the Typical Year. These four rain gauges are located at Ward Street Headworks, Columbus Park Headworks, Chelsea Creek Headworks, and USGS Fresh Pond.

**Table 3-1: Rain Gauges**

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

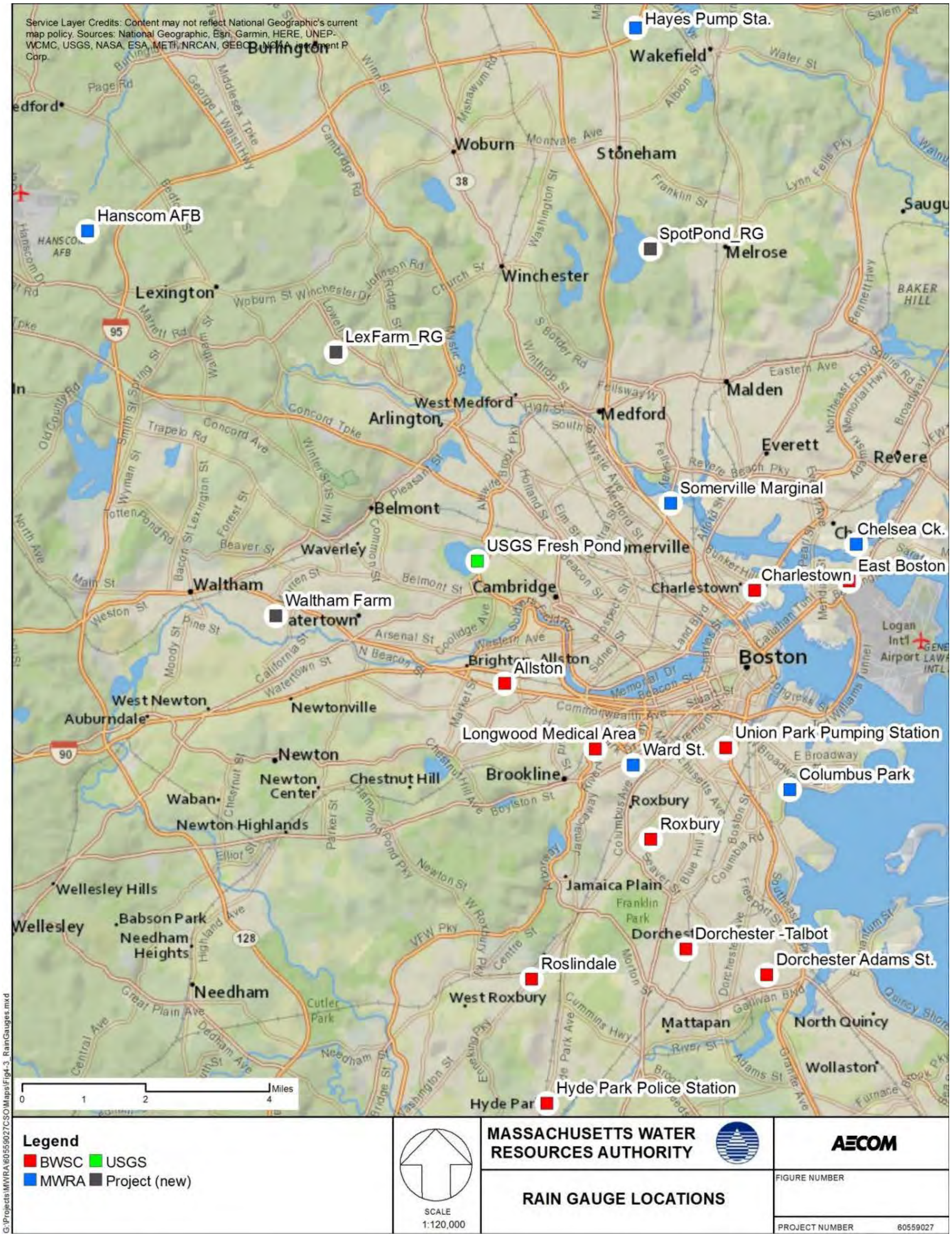



**Figure 3-1: Rain Gauge Location Plan**

Additional information on the placement and operation of the rain gauges can be found in Section 4.2, Rain Gauges, of the Task 2 Report: CSO Inspection, Metering Approach, and Meter Design and Installation Report (May 25, 2018),

## 3.2 Rainfall Data Review and Adjustments

The rainfall data are downloaded from FlowView™ on a monthly basis. FlowView™ is a software package that ADS Services, Inc. uses for data storage and analyses. FlowView™ is used to download the data from the meters every two hours. Data can be viewed online and login information has been provided to the project team members and MWRA. Quality assurance and quality control is provided by reviewing the data in PCSWMM. Rain gauge data are reviewed 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 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 3-2). Replacement of suspect data was recorded in Table 3-3. Rainfall data used for the analysis are provided in Appendix B.

**Table 3-2: 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 St. | BO-DI-1 | BWSC008 | 0.66 | Roxbury | 1.23 |
| Columbus Park | BO-DI-2 | BWSC001 | 1.24 | Roxbury | 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 | Roxbury | 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 | Roxbury | 1.86 |
| Charlestown | BWSC007 | East Boston | 1.53 | CH-BO-1 | 1.80 |
| Longwood Medical Area | BWSC008 | BO-DI-1 | 0.67 | Roxbury | 1.71 |
| Chelsea Ck. | CH-BO-1 | East Boston | 0.60 | BWSC007 | 1.80 |
| East Boston | East Boston | CH-BO-1 | 0.60 | BWSC007 | 1.53 |
| USGS Fresh Pond | FRESH_POND | BWSC004 | 2.21 | Somerville | 3.26 |
| Hanscom AFB | HF-1C | LexFarm_RG | 4.47 | WALTHAM | 6.92 |
| LexFarm_RG | LexFarm_RG | FRESH_POND | 4.08 | WALTHAM | 4.37 |
| Hayes Pump Sta. | RG-WF-1 | SpotPond_RG | 3.58 | LexFarm_RG | 7.13 |
| Roxbury | Roxbury | BO-DI-1 | 1.23 | BWSC008 | 1.71 |
| Somerville Marginal | Somerville | BWSC007 | 1.95 | CH-BO-1 | 3.07 |
| SpotPond_RG | SpotPond_RG | Somerville | 4.12 | LexFarm_RG | 5.34 |
| Waltham Farm | WALTHAM | FRESH_POND | 3.37 | BWSC004 | 3.86 |

**Table 3-3: Summary of Rainfall Data Replacement**

| Rain Gauge | Replacement Data Start Time | Replacement Data End Time | Replacement Rain Gauge |
|---|---|---|---|
| Somerville | 4/15/2018 0:00 | 6/30/2018 23:45 | Charlestown |
| Hanscom AFB | 4/15/2018 0:00 | 6/30/2018 23:45 | Lexington Farm |
| Ward St. | 5/21/2018 9:00 | 5/21/2018 10:30 | Longwood Medical |
| Chelsea Ck. | 6/5/2018 0:00 | 6/30/2018 23:45 | East Boston |

## 3.3 Intensity-Duration-Frequency (IDF) Analysis

Intensity-Duration-Frequency (IDF) analysis is used to characterize the return period of a given storm event. Storm recurrence intervals for 1-hour, 24-hour, and 48-hour durations are identified for each storm event based on the IDF analysis. Storm recurrence intervals are 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. Table 3-4 presents the rainfall intensities for 1-hour, 24-hour, and 48-hour duration storms with recurrence intervals ranging from 3 months to 100 years based on TP-40 and TP-49.

**Table 3-4: Rainfall Intensity-Duration-Frequency Data from TP-40/TP-49**

| Duration | Intensity for Recurrence Interval (in/hr) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 3-Month (1) | 6-Month (1) | 1-Year | 2-Year | 5-Year | 10-Year | 25-Year | 50-Year | 100-Year |
| **1-Hour** | 0.570 | 0.710 | 0.900 | 1.180 | 1.550 | 1.800 | 2.100 | 2.420 | 2.700 |
| **24-Hour** | 0.079 | 0.096 | 0.104 | 0.129 | 0.163 | 0.188 | 0.225 | 0.246 | 0.271 |
| **48-Hour** | N/A(2) | N/A(2) | N/A(2) | 0.078 | 0.102 | 0.121 | 0.141 | 0.160 | 0.177 |

(1) Denotes extrapolated values

(2) TP-40 does not provide 3-month, 6-month, or 1-year recurrence intervals for 48-hour duration storms

For the period of April 15 to June 20, 2018, 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 <3months, 3 months, 3-6 months, 6 months,1 year, or the nearest year, based on comparison to the IDF values from TP-40 shown in Table 3-4. Storm events were defined as having a minimum inter-event time of 12 hours and a threshold of 0.01 in/hr. Storm recurrence intervals would only be provided for 48-hour storms if the duration was greater than or equivalent to 48 hours. For the period of April 15 to June 30, 2018, no storms were recorded with durations of 48-hours or greater. Table 3-5 presents the Summary of Storm Events for April, May and June 2018 at Ward Street Headworks. Tables for all other gauges provided in Appendix C.

## 3.4 Comparison of Monitored Storms to Typical Year Storms

The characteristics of the rain events that occurred in the April 15 to June 30, 2018 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 April through June 2018, and the number of storms by volume were identified. These values were then compared to the values from the Typical Year. Table 3-6 presents this comparison. It should be noted that Table 3-6 summarizes the entirety of April instead of starting on April 15th. This was to allow for easier comparison against the typical year (3 full months representing approximately 25% of the year). As indicated in Table 3-6, the rainfall depth and number of storms for most of the rain gauges from the period of April 15 to June 30 are approximately one quarter of the values for the Typical Year, suggesting that the current period of rainfall is generally consistent with the Typical Year. The greatest difference in number of storms was in smaller storms (<0.5-inch volume). Most of the gauges had at least one more storm in the 0.5 to 1.0 inch range, while the number of storms in the 1.0 to 2.0 inch range and the greater than 2.0 inch range was about the same as the Typical Year. Thus, although the numbers of larger storms were generally similar, the impact of those larger storms on CSO volumes could be greater due to the wetter soil conditions, particularly in areas affected by high groundwater.

**Table 3-5: Summary of Storm Events at Ward St for April 15 to June 30, 2018 (2)**

| 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 | 4/15/2018 21:45 | 22 | 2.43 | 0.11 | 0.47 | 0.10 | 0.05 | <3m | 6m | <3m |
| 2 | 4/19/2018 7:00 | 8.75 | 0.24 | 0.03 | 0.09 | 0.01 | 0.01 | <3m | <3m | <3m |
| 3 | 4/25/2018 6:30 | 25.5 | 1.07 | 0.04 | 0.29 | 0.04 | 0.02 | <3m | <3m | <3m |
| 4 | 4/27/2018 13:30 | 4.5 | 0.42 | 0.09 | 0.15 | 0.02 | 0.02 | <3m | <3m | <3m |
| 5 | 4/29/2018 9:00 | 2.5 | 0.05 | 0.02 | 0.03 | 0.00 | 0.01 | <3m | <3m | <3m |
| 60 | 4/30/2018 11:00 | 12 | 0.17 | 0.01 | 0.05 | 0.01 | 0.00 | <3m | <3m | <3m |
| 7 | 5/3/2018 15:30 | 0.5 | 0.04 | 0.08 | 0.04 | 0.00 | 0.00 | <3m | <3m | N/A |
| 8 | 5/4/2018 5:15 | 6 | 0.02 | 0.00 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 9 | 5/6/2018 21:00 | 4 | 0.24 | 0.06 | 0.17 | 0.01 | 0.01 | <3m | <3m | N/A |
| 10 | 5/10/2018 4:15 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 11 | 5/12/2018 12:15 | 7.25 | 0.25 | 0.03 | 0.12 | 0.01 | 0.01 | <3m | <3m | N/A |
| 12 | 5/15/2018 17:15 | 3 | 0.98 | 0.33 | 0.67 | 0.04 | 0.02 | 3-6m | <3m | N/A |
| 13 | 5/19/2018 13:00 | 14.75 | 0.28 | 0.02 | 0.06 | 0.01 | 0.01 | <3m | <3m | N/A |
| 14 | 5/20/2018 15:45 | 3 | 0.04 | 0.01 | 0.03 | 0.01 | 0.01 | <3m | <3m | N/A |
| 15 | 5/22/2018 19:45 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 16 | 5/23/2018 20:30 | 1.25 | 0.05 | 0.04 | 0.04 | 0.00 | 0.00 | <3m | <3m | N/A |
| 17 | 5/27/2018 18:15 | 12.5 | 0.08 | 0.01 | 0.02 | 0.00 | 0.00 | <3m | <3m | N/A |
| 18 | 6/2/2018 15:30 | 1 | 0.03 | 0.03 | 0.03 | 0.00 | 0.00 | <3m | <3m | N/A |
| 19 | 6/4/2018 5:30 | 10.75 | 0.76 | 0.07 | 0.22 | 0.03 | 0.00 | <3m | <3m | N/A |
| 20 | 6/5/2018 13:30 | 6.25 | 0.26 | 0.04 | 0.18 | 0.01 | 0.00 | <3m | <3m | N/A |
| 21 | 6/18/2018 19:15 | 2.5 | 0.21 | 0.08 | 0.17 | 0.01 | 0.00 | <3m | <3m | N/A |
| 22 | 6/24/2018 19:00 | 10.25 | 0.48 | 0.05 | 0.22 | 0.02 | 0.00 | <3m | <3m | N/A |
| 23 | 6/27/2018 23:15 | 15.5 | 1.21 | 0.08 | 0.68 | 0.05 | 0.00 | 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-1year (6m-1yr) or the nearest year.

(2) Ward St. rainfall data was replaced with Longwood Medical rainfall data from 5/21/2018 9:00 through 5/21/2018 10:30

Storms with greater than 2 inches of total rainfall at the Ward Street, Columbus Park, Chelsea Creek Headworks, and USGS Fresh Pond rain gauges were identified and compared to storms with greater than 2 inches of total rainfall in the Typical Year (Table 3-7). These storms are of interest because they often account for a disproportionate amount of CSO.

Storms with greater than 0.40 in/hr of peak rainfall intensity 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 3-8). Storms with intensities greater than 0.40 in/hr are of importance because higher intensity storms have been found to produce more CSO than lower intensity storms. Results from the period of April 15 to June 30, 2018 indicate that the April 15, May 15, and June 27, 2018 storms were the events that produced greater than 0.40 in/hr of peak intensity. The Typical Year had two storm events with intensities greater than 0.40 in/hr per hour within the period of April 15-June 30, 1992. While the April 15 to June 30, 2018 period had only one more event with greater than 0.40 inches per hour of peak intensity than the typical year, this represents a 50% increase in higher intensity storms. The significance of this will continue to be assessed.

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 general distribution of rainfall during the storm. Rainfall distribution during a storm can impact the behavior of system hydraulics due to soil saturation. An example hyetograph is shown in Figure 3-2 with the remaining hyetographs in Appendix D.

### Table 3-6: Frequency of Rain Events within Selected Ranges of Total Rainfall for April, May, June 2018

| Conditions | Total Rainfall (inches) | Total Number of Storms | Number of Storms by Volume | | | | |
|---|---|---|---|---|---|---|---|
| | | | Volume < 0.25 inches | Volume 0.25 to 0.5 inches | Volume 0.5 to 1.0 inches | Volume 1.0 to 2.0 inches | Volume >= 2.0 inches |
| Typical Year | 46.8 | 93 | 49 | 14 | 16 | 8 | 6 |
| **MWRA Rain Gauges** | | | | | | | |
| Ward Street (1) | 10.46 | 27 | 16 | 5 | 3 | 2 | 1 |
| Columbus Park | 10.04 | 26 | 17 | 1 | 5 | 2 | 1 |
| Chelsea Creek (2) | 10.53 | 25 | 15 | 3 | 3 | 3 | 1 |
| Hanscom AFB (3) | 9.762 | 26 | 16 | 4 | 4 | 1 | 1 |
| Hayes Pump Sta. | 9.97 | 26 | 16 | 4 | 3 | 2 | 1 |
| **BWSC Rain Gauges** | | | | | | | |
| Allston | 11.17 | 28 | 15 | 5 | 5 | 2 | 1 |
| Charlestown | 10.09 | 27 | 16 | 4 | 4 | 2 | 1 |
| Dorchester - Adam Street | 10.41 | 29 | 17 | 6 | 2 | 3 | 1 |
| Dorchester-Talbot | 10.65 | 28 | 18 | 4 | 2 | 3 | 1 |
| Hyde Park | 10.52 | 27 | 16 | 5 | 3 | 2 | 1 |
| East Boston | 10.09 | 26 | 16 | 3 | 4 | 2 | 1 |
| Longwood | 10.26 | 26 | 16 | 4 | 3 | 2 | 1 |
| Roslindale | 11.09 | 28 | 17 | 5 | 2 | 3 | 1 |
| Roxbury | 10.96 | 28 | 17 | 5 | 2 | 3 | 1 |
| Union Park | 10.13 | 27 | 19 | 2 | 2 | 3 | 1 |
| **USGS Rain Gauge** | | | | | | | |
| USGS Fresh Pond | 11.31 | 27 | 15 | 5 | 3 | 3 | 1 |
| **Project Gauges** | | | | | | | |
| Lexington Farm | 11.11 | 28 | 15 | 4 | 4 | 2 | 1 |
| Spot Pond | 10.75 | 26 | 16 | 3 | 3 | 3 | 1 |
| Somerville(4) | 10.09 | 27 | 16 | 4 | 4 | 2 | 1 |
| Waltham Farm | 12.55 | 29 | 16 | 6 | 2 | 4 | 1 |

(1) Rainfall data replaced with BWSC008 from 5/21/2018 9:00 through 5/21/2018 10:30
(2) Rainfall data replaced with East Boston from 6/6/2018 0:00 through 6/30/2018 23:45
(3) Rainfall data replaced with LexFarm_RG from 4/15/2018 0:00 through 6/30/2018 23:45
(4) Rainfall data replaced with BWSC007 from 4/15/2018 0:00 through 6/30/2018 23:45

**Table 3-7: Comparison of Storms Between April 15 to June 30, 2018 and Typical Year with Greater than 2 Inches of Total Rainfall**

| Rain Gauge | Date | Duration (hr) | Total Rainfall (in) | Average Intensity (in/hr) | Peak Intensity (in/hr) | Storm Recurrence Interval (24-hr) |
|---|---|---|---|---|---|---|
| **Typical Year** | 12/11/92 | 50 | 3.89 | 0.08 | 0.2 | 1y |
| | 08/15/92 | 72 | 2.91 | 0.04 | 0.66 | 3m |
| | 09/22/92 | 23 | 2.76 | 0.12 | 0.65 | 1y |
| | 11/21/92 | 84 | 2.39 | 0.03 | 0.31 | 3m |
| | 05/31/92 | 30 | 2.24 | 0.07 | 0.37 | 3m-6m |
| | 10/09/92 | 65 | 2.04 | 0.03 | 0.42 | <3m |
| **Ward Street** | 04/15/18 | 24.75 | 2.32 | 0.11 | 0.47 | 6m |
| **Columbus Park** | 04/15/18 | 22.25 | 2.15 | 0.10 | 0.40 | 3-6m |
| **Chelsea Creek Headworks** | 04/15/18 | 25.5 | 2.23 | 0.09 | 0.28 | 3-6m |
| **USGS Fresh Pond** | 04/15/18 | 22.75 | 2.06 | 0.091 | 0.4 | 3-6m |

**Table 3-8: Comparison of Storms Between April 15 to June 30, 2018 and Typical Year with Peak Intensities Greater than 0.40 in/hr**

| Rain Gauge | Date | Duration (hr) | Total Rainfall (in) | Average Intensity (in/hr) | Peak Intensity (in/hr) | Storm Recurrence Interval (1-hr) |
|---|---|---|---|---|---|---|
| **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 |
| **Ward Street Headworks**(1) | 4/15/2018 | 22.00 | 2.43 | 0.11 | 0.47 | <3m |
| | 5/15/2018 | 3.00 | 0.98 | 0.33 | 0.67 | 3-6m |
| | 6/27/2018 | 15.50 | 1.21 | 0.08 | 0.68 | 3-6m |
| **Columbus Park Headworks** | 4/15/2018 | 22.25 | 2.15 | 0.10 | 0.40 | 3m |
| | 5/15/2018 | 3.75 | 1.06 | 0.28 | 0.73 | 6m |
| | 6/27/2018 | 15.75 | 1.22 | 0.08 | 0.73 | 6m |
| **Chelsea Creek Headworks**(2) | 5/15/2018 | 4.00 | 1.29 | 0.32 | 0.96 | 1y |
| | 6/27/2018 | 15.50 | 1.15 | 0.07 | 0.62 | 3-6m |
| **USGS Fresh Pond** | 4/15/2018 | 22.75 | 2.06 | 0.09 | 0.40 | <3m |
| | 5/15/2018 | 4.00 | 0.91 | 0.23 | 0.60 | 3m |
| | 6/27/2018 | 20.50 | 1.46 | 0.07 | 0.62 | 3-6m |

(1) Rainfall data replaced with Longwood Medical from 5/21/2018 9:00 through 5/21/2018 10:30

(2) Rainfall data replaced with East Boston from 6/6/2018 0:00 through 6/30/2018 23:45

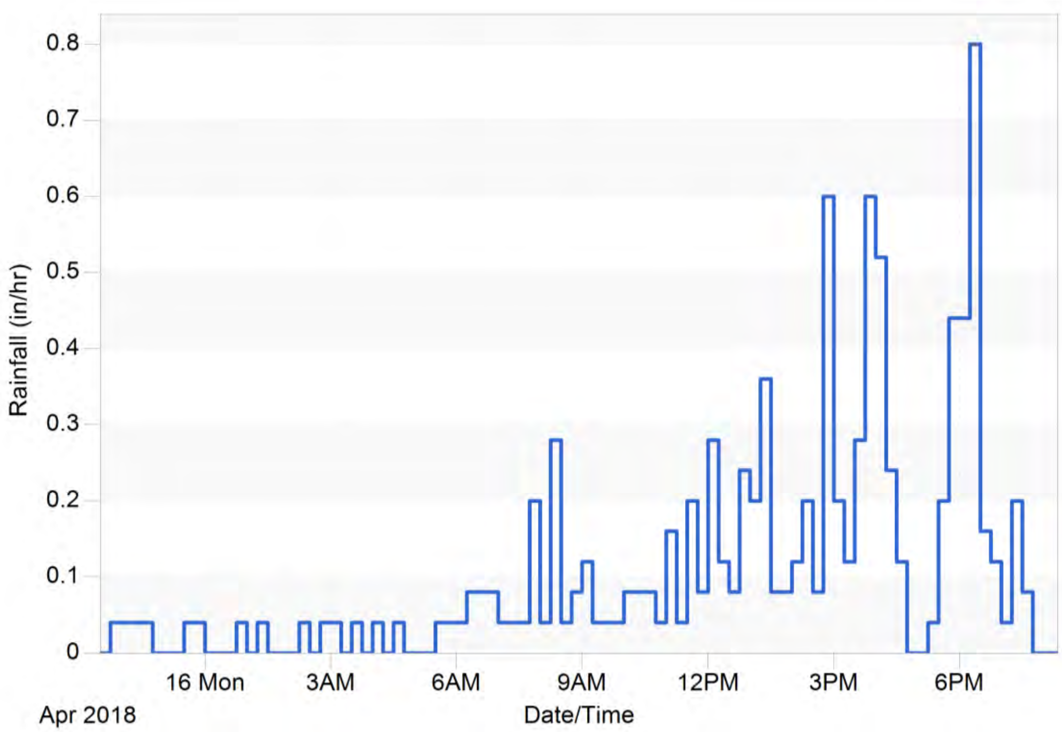



**Figure 3-2: 15-Minute Rainfall Hyetograph from the Ward Street Headworks Gauge for April 15, 2018**

# 4. CSO Metering

This section presents the metering plan and approach used to collect and process CSO metering data using existing MWRA and community meters, facility operational data, and project meters. Equipment used to augment existing meters includes flow meters, level sensors, and inclinometers installed specifically for this project. Before these topics are discussed, a brief overview of general flow metering concept is presented below.

## 4.1 CSO Flow Metering Background

Flow meters are installed in sewer collections systems in order to understand how water flows in the system. However, it is not possible to install flow meters in all the pipes and operate those meters continuously due to access and other concerns such as hydraulics that may interfere with meter readings or safety concerns. Instead, a hydraulic model of the collection system is more appropriately used to estimate flows. In order to use a hydraulic model for this purpose it should appropriately reproduce observed flows. Therefore, a secondary purpose of flow metering is to provide data for calibrating the hydraulic model.

Meter data collected for this project consist of both depth and flow measured at key locations, including CSO regulators. The metering configurations are installed to estimate whether an overflow occurs, and in some cases, can be used to measure the overflow volume and the flow entering the regulator from upstream pipes. Figure 4-1 is a schematic of a typical flow meter configuration at a generic CSO regulator.

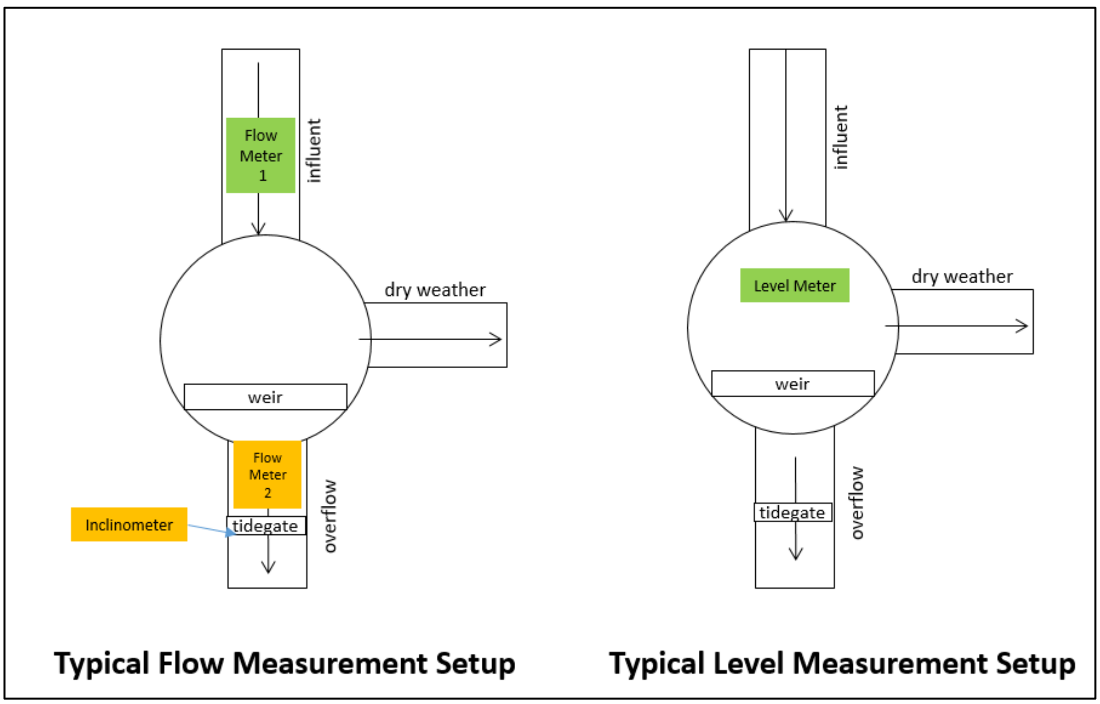



**Figure 4-1: Example Meter Setup at a Generic Regulator Structure (Plan View Shown)**

The regulator structure shown in Figure 4-1 is broken into the following components:

- The influent, which is defined as the line or lines coming into the structure
- The dry-weather flow connection, sometimes called the regulator pipe, is the path flow takes during dry weather. This flow is treated at Deer Island downstream.
- The overflow, the pipe that takes excess flow to the receiving water.
- The weir, the vertical structure in some regulators intended to let water build up before discharging in the overflow pipe. In some cases there is no weir and the overflow pipe is set at a higher elevation in lieu of a weir.

- The tidegate, a structure placed in some overflows to prevent water from coming into the system during high tide.

The configuration at an actual regulator may differ from Figure 4-1, but the general components remain the same.

In a regulator there are two general metering approaches taken for detecting overflows. In the first case, the project requires meter data to calculate overflow volumes. In this case, velocity and depth sensors are installed to measure flow in both the influent and overflow lines. In some instances, the overflow volume can be estimated using meter analysis techniques applied to the influent data. In other instances, measuring the overflow is impractical and the dry weather connection is monitored instead. In any instance, the intent is to quantify the volume of overflow from the regulator. In some configurations where a tide gate is present, an inclinometer is used. This device monitors the angle at a tide gate and indicates when a tide gate is actually open. This serves as an independent means to detect that a CSO activation may be occurring.

In the second metering case, previous analysis has indicated that overflows are not likely to occur at a regulator but confirmation of this is desired. In this case, a single level sensor is placed within the structure to assess if an overflow occurs. If the level indicates that an overflow may have occurred, field crews are sent to observe evidence of CSO occurrence, as apparent spikes in the data may occur for varying reasons not due to overflow occurrence.

Engineers analyze meter data for quality concerns before use in projects. Although a useful tool to assess a system, meter data is not always reliable for a number of reasons. For example, hydraulic turbulence at complicated structures such as regulators can interfere with meter readings. Tidal impacts may impact the quality of data as well. In many cases recorded flow data is compared to other flow estimates, such as the weir equation, for reasonableness. When anomalies occur they are investigated before meter data is applied to a project. Part of the review process is to assess the appropriate methodology to review meter data such as use of Manning's, the weir equation, or scattergraphs.

The remainder of this section describes the flow data collected and the procedures used to review the flow data.

## 4.2 Metering Plan and Approach

Many of the flow meters installed for this program are being used to quantify CSO activations and will be used for calibrating the MWRA collection system model. The meters for this program include a combination of existing MWRA meters, community meters, and project meters. Some meters installed for this program are being used to indicate if an overflow does or does not occur at particular sites.

### 4.2.1 MWRA Collection System Meters and Operational Data

Existing MWRA meter and system operation data are being collected and used to monitor CSO activations. Data are being provided for 32 interceptor meters. In addition, the project utilizes data for the stormwater and CSO regulators associated with outfalls BOS081, 082, 085, and BOS 086, the North Dorchester Bay Storage Tunnel, DeLauri Pump Station, and Caruso Pump Station.

Storm reports generated by MWRA provide additional operational data for storm events that result in CSO activations. These storm reports include information on Somerville Marginal Facility (MWR205), Prison Point (MWR203), Union Park (MWR215), Cottage Farm (MWR201), Chelsea Creek Headworks, Ward Street Headworks, Columbus Park Headworks, BOS019, and the Alewife Brook Pump Station Bypass system (see Section 6 for details).

### 4.2.2 Community Meters

Data from existing meters in CSO communities are being provided by the Cambridge Department of Public Works (DPW), BWSC, Somerville DPW and Chelsea DPW sites. Data are being provided for a total of 26 community meters.

### 4.2.3 CSO Project Meters

The existing MWRA collection system meters, community meters, and operational data are supplemented by temporary project meters. A flow metering plan was developed and documented in the Task 2 Draft Report: CSO Inspection, Metering Approach, and Meter Design and Installation Report (May 25, 2018). The metering plan includes meters, velocity sensors, level sensors, and inclinometers to measure the activation frequency, duration, and volume of CSO discharge. As indicated in the plan, flow meters are installed in locations where CSO activations are expected based on output from the MWRA collection system model for the Typical Year and/or the 2-year design storm. The 2-year design storm used for this evaluation was developed for the MWRA's LTCP, and has a 24-hour duration, total depth of 3.15 inches, maximum intensity of 1.18 inches/hour and an average intensity of 0.13 inches per hour.

Project meters are installed at 57 locations, which included a total of 81 meters, 106 flow sensors, 20 level sensors, and 16 inclinometers. FlowShark Triton flow monitors and their associated sensors are being used to measure depth and velocity at the monitoring locations.

Figure 4-2 presents the locations of each of the meters used for calibration and for quantifying CSO activation frequency, duration and volume. Most of the meters located in the interceptors will only be used for calibration. The meters located at the regulators will be used for calibration, to quantify CSO activations, or both in some cases. Table 4-1 presents a description of what the meter is measuring in the regulator and the purpose of each meter. For example:

1. To identify if an overflow activation occurred and for model calibration
2. For model calibration only
3. For calculating CSO volumes and for model calibration

Table 4-1 also indicates if a meter is identified as a trigger meter. For these meters, if the water exceeds a predetermined depth, it indicates the flow may be going over the weir or into a high pipe overflow. These meters are important for identifying if an overflow has occurred.

## 4.3 Meter Data Collection, Processing, and Review

This section discusses the steps taken to collect, process, and review the data for quality control purposes.

### 4.3.1 Meter Data Collection

Meter data are collected from the existing and temporary meters and stored in the ADS FlowView web-based data management system. The temporary meter data are downloaded every few hours and remotely analyzed by an ADS analyst using Profile^tm^/Qstart^tm^ desktop applications. Meter data from community meters and existing MWRA meters are provided to ADS on a monthly basis and are uploaded to the database. Data are submitted on a 5- or 15-minute basis, depending on the frequency of data being recorded. Wireless telemetry is used to access the meters remotely for activation, service, and data collection. Raw data from the meters are evaluated by an ADS Data Analyst three days per week during the flow-monitoring period to confirm that all equipment is functioning properly. When the analyst detects irregularities in the data or a loss of wireless communication, field crews are dispatched to perform the required maintenance to achieve accuracy and maintain adequate meter uptime.

### 4.3.2 Meter Data Processing

Data processing consists of a number of steps: data editing of invalid depth and velocity data reconstitution or use of alternate depth and velocity data, and identification of data anomalies that prevent meaningful calculations of site conditions. Raw sensor data for each location are retained in the FlowView system and remain unedited.

Conditions such as a build-up of debris, surcharging or hydraulic turbulence can result in the sensor equipment becoming fouled or incorrect. When this occurs, ADS uses all available sensor data and hydraulic theory to present a reasonable representation of the depth and/or velocity at the site. For this reason, the final data are edited to account for invalid data and the edited data are used in subsequent quantity calculations.

Data uptime is a measure of the proportion of sensor readings that are useable after the data are edited and processed. Suspect or unusable data are flagged (omitted from calculated flows) and downtime for a meter is based on the proportion of invalid and missing data. Uptime is an indicator of the effectiveness and timeliness of the maintenance and initial data review activities. ADS provides AECOM with an uptime report, which indicates meter uptime. The report for data used in this document indicates that meters were operating for at least 95% of the monitoring period. In locations where a meter is not functional for the majority or for the entire storm event, AECOM does not report a volume and flags the event as missing data. If the meter is functioning for the majority, but not the entire storm event, the meter is flagged but volume is reported; however a portion of the volume may be unaccounted for.

Depth and velocity are measured and flow is calculated from these data. Depth is measured with pressure sensors (Dp) and ultrasonic sensors (Du). Depth measurements are used to assess if the water level exceeds the height of a weir or other trigger elevation (e.g., a high pipe outlet), causing an overflow. Invalid depth data are identified through scattergraph analysis and/or hydrograph analysis. Data that do not indicate a repeatable depth versus velocity relationship or a standard hydraulic condition are further investigated.

Velocity is measured with the Peak Velocity sensor that is deployed in two modes: V = Doppler Velocity, with sensor facing into the flow (positive), and Vi = Intrusion Velocity, with sensor facing a tide gate to spot reverse flow through the gate. Invalid velocity data are spotted and flagged by using scattergraph and hydrograph analyses.

Velocity and depth measurements are used to calculate flow and total volume of CSO activations. CSO flowrate is calculated by using one of three methods: continuity, continuity by subtraction, or a weir equation. The continuity (Qc) method uses 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 uses the flow difference from two separate pipes as calculated by depth measurement multiplied by the velocity measurement. The Weir (Qw) method uses a depth measurement over a weir structure and an appropriate weir equation. CSO volume is computed by integrating CSO flowrate over time.

In locations where CSO flowrates and volumes cannot be measured by depth/velocity sensors in the outfall, an attempt is made to estimate the overflow volume using other means such as Manning's equation or the scattergraph method. Manning's equation requires knowledge of the outfall pipe diameter, slope, and roughness, and is based on the assumptions that the flow is not affected by downstream backwater and the hydraulic grade is normal to the pipe slope. These conditions are rarely met in tidal conditions. If the capacity of the dry-weather flow connection is consistent throughout the storm, and is full prior to the onset of the overflow, then the overflow can be estimated using the scattergraph method. With this method, scattergraphs of plotted velocity versus depth recorded by the influent meter are used to estimate the amount of flow going through the dry-weather flow connection. The volume of discharge going over the regulator weir is calculated by subtracting the flow through the dry-weather flow connection from the influent flow measurement. In contrast to the Manning's equation method, the scattergraph method depends only on the influent meter and can be used in tidal conditions. For locations where the overflow volume could not be calculated directly with a flow meter or estimated with Manning's equation or by using the scattergraph method the duration of the overflow is reported.

After initial review of the data, there will still be differences between metered and actual flow conditions. Any such differences will require additional review before adjusting the model since in some cases the meter data can be questionable. Flow measurements in hydraulically complex structures, such as regulators, is challenging due to flow turbulence in the structure. Turbulence can affect both depth and velocity measurements, especially during times when the flow is rapidly changing – such as during a CSO event. The presence of tidal conditions may also interfere with outfall measurements. Additional information, such as field team inspections or use of a third source of data, is required to check the meter data. This process requires fieldwork in many cases. As a result, the meter data presented in this report are subject to change.

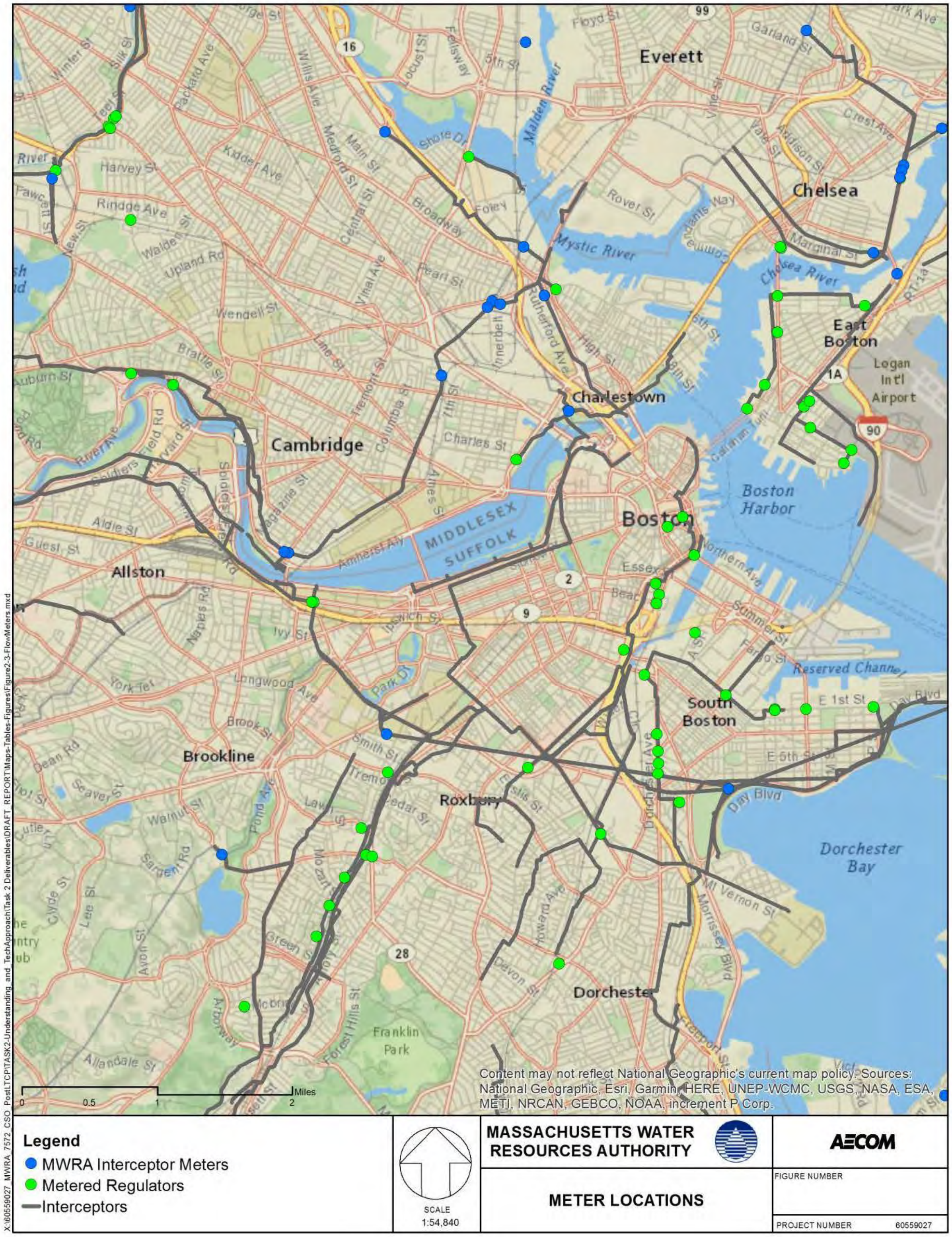



**Figure 4-2: Metered Regulator Locations**

## Table 4-1: CSO Project Meter Locations and Purpose of Meters

| Outfall | Regulator | ADS Meter Name | Description of Meter Location | Purpose of Meters | | | |
|---|---|---|---|---|---|---|---|
| | | | | To identify if overflow activation occurred and for model calibration | For model calibration only | For calculating CSO volumes and model calibration | Trigger Meter [(1)] |
| **Alewife Brook** | | | | | | | |
| CAM001 | RE011 | RE011_M1 | Influent Line #1 | X | | | Yes |
| | | RE011_M1(2) | DS of DWF Connection | | X | | |
| CAM002 | RE021 | RE021_M1 | Cambridge Meter | X | | | Yes |
| | | RE021_M1(2) | Cambridge Meter | | X | | |
| MWR003 | RE-031 | RE031_M1 | Influent Line #1 | X | | | Yes |
| | | RE031_M2 | Influent Line #2 | | X | | |
| | | RE031_M2(2) | Influent Line #3 | | X | | |
| | | RE031_M3 | Overflow Line (DS of weir)+Inclinometer | | | X | |
| CAM401A | RE-401 | RE401a_M1 | Influent Line #1 | X | | | Yes |
| | | RE401_M3 | DWF Line - Cambridge Owned | | X | | |
| CAM401B | RE-401B | RE401b_M3 | Overflow line | | | X | N/A[(2)] |
| SOM001A | RE-01A | RE01a_M1 | Influent Line #1 | X | | | Yes |
| | | RE01a_M1(2) | Influent Line #2 | | X | | |
| **Upper Mystic River** | | | | | | | |
| SOM007A/MWR205A | | MWRA205a_M3 | Overflow to 205a | X | | | Yes |
| | | MWRA Meter | Incoming flow | | X | | |
| **Mystic River/Chelsea Confluence** | | | | | | | |
| BOS013 | RE013-1 | RE013-1_M1 | Influent line #1 | X | | | Yes |
| | | RE013-1_M1(2) | Influent line #2 | | X | | |
| | | RE013-1_M3 | Influent line #3 | | X | | |
| | | RE013-1_M3(2) | Overflow Line (DS of weir) + Inclinometer | | | X | |
| BOS014 | RE014-2 | RE014-2_M1 | Influent line #1 | X | | | Yes |
| | | RE014-2_M1(2) | Influent line #2 | | X | | |
| | | RE014-2_M3 | Overflow Line (DS of weir) + Inclinometer | | | X | |
| BOS017 | RE017-3 | RE017-3_M1 | Influent Line #1 | | X | | |
| | | RE017-3_M2 | Influent Line #2 | X | | | Yes |
| | | RE017-3_M3 | Overflow Line (DS of weir) | | | X | |
| CHE003 | RE-031 | CHE003 | Flow Assessment Meters | | | | |
| CHE004 | RE-041 | CHE004 | Flow Assessment Meters | | | | |
| | | CH004_M1 | ADS | X | | | Yes |
| | | CH004_M1(2) | ADS | | X | | |
| | | CH004_M3 | Flow Assessment Meters | | | X | |
| CHE008 | RE-081 | CH008_M1 | ADS | X | | | Yes |
| | | CHE008 | Flow Assessment Meters | | X | | |

## Table 4-1. (Continued)

| Outfall | Regulator | ADS Meter Name | Description of Meter Location | Purpose of Meters: To identify if overflow activation occurred and for model calibration | For model calibration only | For calculating CSO volumes and model calibration | Trigger Meter [(1)] |
|---|---|---|---|---|---|---|---|
| **Upper Inner Harbor** | | | | | | | |
| BOS009 | RE009-2 | RE009-2_M1 | Influent line #1 | X | | | Yes |
| | | RE009-2_M1(2) | Influent line #2 | | X | | |
| | | RE009-2_M3 | Overflow Line (DS of weir) + Inclinometer | | | X | |
| BOS010 | RE010-2 | RE010-2_M1 | Influent line #1 | X | | | Yes |
| | | RE010-2_M1(2) | Influent line #2 | | X | | |
| | | RE010-2_M3 | Overflow Line (DS of weir) + Inclinometer | | | X | |
| BOS012 | RE012-2 | RE012-2_M1 | Influent Line | X | | | Yes |
| | | RE012-2_M3 | Overflow Line (DS of weir) + Inclinometer | | | X | |
| BOS057 | RE057 | RE057-6_M1 | Influent Line #1 | | X | | |
| | | RE057-6_M3 | Overflow Line | | | X | |
| | | RE057-6_M3(2) | Influent Line #2 | X | | | Yes |
| BOS060 | RE060-7 | RE060_7 | Influent Line #1 + Inclinometer | X | | | Yes |
| | RE060-20 | RE060-20 | Influent Line #1 | X | | X | Yes |
| **Lower Inner Harbor** | | | | | | | |
| BOS003 | RE003-2 | RE003-2_M1 | Influent Line | X | | | Yes |
| | | RE003-2_M3 | Overflow Line (DS of weir) + Inclinometer | | | X | |
| | RE003-7 | RE003-7_M1 | Influent Line | | X | | |
| | | RE003-7_M3 | Overflow Line (DS of weir) + Inclinometer | X | | | N/A [(2)] |
| | RE003-12 | RE003-12_M1 | Influent line #1 | | X | | |
| | | RE003-12_M1(2) | Influent line #2 | X | | | Yes |
| | | RE003-12_M2 | Influent line #3 | | X | | |
| | | RE003-12_M3 | Overflow Line (DS of weir) + Inclinometer | | | X | |
| BOS004 | RE004-6 | RE004_6_M1 | Influent Line | X | | | Yes |
| BOS005 | RE005-1 | RE005_1_M1 | Influent Line | X | | | Yes |
| **Fort Point Channel** | | | | | | | |
| BOS062 | RE062-4 | RE062-4_M1 | Influent Line #1 | X | | | Yes |
| | | RE062-4 M1(2) | Overflow Line (DS Weir) +Inclinometer | | | X | |
| BOS064 | RE064-4 | RE064-4_M1 | Influent Line #1 | X | | | Yes |
| | | RE064-4_M2 | Influent Line #2 | | X | | |
| | | RE064-4_M3 | Overflow Line (DS Weir) +Inclinometer | | | X | |
| | RE064-5 | RE064-5 | Incoming combined sewer- Level Only | X | | | Yes |
| BOS065 | RE065-2 | RE065-2_M1 | Influent Line #1 | X | | | Yes |
| | | RE065-2_M3 | Overflow Line (DS Weir) +Inclinometer | | | X | |
| BOS068 | RE068-1A | RE068-1A_M1 | Incoming combined sewer- Level Only | X | | | Yes |
| BOS070 RCC | RE070/5-3 | RE070_5-3 | Incoming combined sewer- Level Only | X | | | Yes |

## Table 4-1. (Continued)

| Outfall | Regulator | ADS Meter Name | Description of Meter Location | Purpose of Meters | | | |
|---|---|---|---|---|---|---|---|
| | | | | To identify if overflow activation occurred and for model calibration | For model calibration only | For calculating CSO volumes and model calibration | Trigger Meter (1) |
| BOS070 | RE070/7-2 | RE070-7-2_M1 | Influent Line #1 | X | | | Yes |
| | | RE070-7-2_M1(2) | Overflow Line (DS Weir) +Inclinometer | | | | |
| | RE070/8-3 | RE070_8-3_M1 | Influent Line #1 | X | | | Yes |
| | | RE070_8-3_M3 | Overflow Line (DS Weir) +Inclinometer | | | X | |
| BOS070 DBC | RE070/8-6 | RE070_8-6_M1 | Level Only | X | | | |
| BOS070 | RE070/8-7 | RE070_8-7 | Incoming combined sewer- Level Only | X | | | Yes |
| | RE070/8-8 | RE070_8-8 | Incoming combined sewer- Level Only | X | | | Yes |
| | RE070/8-13 | RE070_8-13 | Incoming combined sewer- Level Only | X | | | Yes |
| | RE070/8-15 | RE070_8-15 | Incoming combined sewer- Level Only | X | | | Yes |
| | RE070/9-4 | RE070_9-4_M1 | Influent Line #1 | X | | | Yes |
| | | RE070_9-4_M1(2) | Influent Line #2 | | X | | |
| | | RE070_9-4_M3 | Overflow Line (DS Weir) +Inclinometer | | | X | |
| | RE070/10-5 | RE070_10-5_M1 | Influent Line #1 | | X | | |
| | | RE070_10-5_M2 | Influent Line #2 | X | | | Yes |
| | | RE070_10-5_M2(2) | Overflow Line (DS Weir) | | | X | |
| BOS073 | RE073-4 | RE073-4_M3 | Influent Line #1 | X | | | Yes |
| | | RE073-4_M3(2) | Overflow Line (DS Weir) | | | X | |
| **Reserved Channel** | | | | | | | |
| BOS076 | RE076/2-3 | RE076_2-3_M1 | Influent Line #1 | | X | | Yes |
| | | RE076_2-3_M2 | Influent Line #2 | X | | | |
| | | RE076_2-3_M3 | Overflow Line (DS Weir) | | | X | |
| | RE076/4-2 | RE076_4-2 | Influent Line #1 | | X | | Yes |
| | RE076/4-3 | RE076_4-3 | Influent Line #1 | | X | | Yes |
| | | RE076_4-3(2) | Overflow Line(DS Weir) | | | X | |
| BOS078 | RE078-1 | RE078-1_M1 | Influent Line #1 | X | | | Yes |
| | | RE078-1_M1(2) | Influent Line #2 | | X | | |
| | RE078-2 | RE078-2_M1 | Dry weather Flow Line | X | | | Yes |
| | TG78 | RE078_M3 | Overflow Line (DS Weir) +Inclinometer | | | X | Yes |
| BOS079 | RE079-3 | RE079-3 | Incoming combined sewer- Level Only | X | | | Yes |
| BOS080 | RE080-2B | RE080-2B | Incoming combined sewer- Level Only | X | | | Yes |
| **Upper Charles** | | | | | | | |
| CAM005 | RE-051 | RE051_M1 | Influent Line #1 | | X | | |
| | | RE051_M1(2) | Influent Line #2 | X | | | Yes |
| | | RE051_M2 | Influent Line #3 | | X | | |
| CAM007 | RE-071 | RE071_M1 | Influent Line #1 | X | | | Yes |
| | | RE071_M1 (2) | Influent Line #2 (observed to be dry) | | X | | |
| | | RE071_(M2) | Influent Line #3 (observed to be dry) | | X | | |
| | | RE071_M3 | Overflow (DS Weir) | | | X | |

## Table 4-1. (Continued)

| Outfall | Regulator | ADS Meter Name | Description of Meter Location | Purpose of Meters | | | |
|---|---|---|---|---|---|---|---|
| | | | | To identify if overflow activation occurred and for model calibration | For model calibration only | For calculating CSO volumes and model calibration | Trigger Meter (1) |
| **Lower Charles** | | | | | | | |
| CAM017 | CAM017 | CAM017_M3 | Overflow #1+inclonometer | X | | | |
| | | CAM017_M3(2) | Overflow #2 | | | X | |
| MWR010 | RE37 | RE037_M1 | Influent Line #1 | X | | | Yes |
| | RE036-9 | RE036-9 | Meter configuration under review | X | | | Yes |
| MWR023 | RE046-19 | RE046_19 | Incoming combined sewer- Level Only | X | | | Yes |
| | RE046-30 | RE046_30_M1 | Influent line #1 | X | | | Yes |
| | | RE046_30_M3 | Overflow Line (DS Weir) +Inclinometer | | | X | |
| | RE046-50 | RE046_50_M1 | Incoming combined sewer- Level Only | X | | | Yes |
| | RE046-54 | RE046_54_M1 | Incoming combined sewer- Level Only | X | | | Yes |
| | RE046-55 | RE046_55_M1_MP1 | Incoming combined sewer- Level Only | X | | | Yes |
| | RE046-62A | RE046_62A_M1 | Incoming combined sewer- Level Only | X | | | Yes |
| | RE046-90 | RE046_90_M1 | Incoming combined sewer- Level Only | X | | | Yes |
| | RE046-100 | RE046_100_M1 | Influent Line #1 | X | | | Yes |
| | | RE046_100_M1(2) | Influent Line #2 | | X | | |
| | | RE046_100_M3 | Overflow Line (DS Weir) +Inclinometer | | | X | |
| | RE046-105 | RE046_105_M1 | Influent Line #1 | | X | | |
| | | RE046_105_M1(2) | Influent Line #2 | X | | | Yes |
| | | RE046_105_M3 | Overflow Line (DS Weir) | | | X | |
| | RE046-192 | RE046_192_M1 | Incoming combined sewer- Level Only | X | | | Yes |
| | RE046-381 | RE046_381_M1 | Influent Line #1 | X | | | Yes |
| | | RE046_381_M3 | Ultrasonic Depth US of Weir and DS of Weir | | | X | |

(1) Trigger meters are used to indicate when the water level in the sewer exceeds the overflow.
(2) This location does not have a trigger. Any flow indicates an activation. Overflow is located downstream of the regulator. The inclinometer is used as indicator of overflow.

# 5. Metered CSO Discharge Review

Each CSO regulator has a unique flow metering configuration designed to estimate CSO activations or confirm that the regulator is not active. Section 4 described meter data collection and processing. The objective of this section is to review the accuracy and reasonableness of the measured CSO activations. Engineers review CSO discharges using various methods, described below. Following this, the results of the meter review are discussed as well as the next steps for either continuing flow monitoring at specific locations, refining the meter configuration, or removing the flow monitoring equipment.

## 5.1 Methods Used for Metered CSO Discharge Review

This section describes the methods used to check metered CSO activations. Not all of the methods are applicable to each of the meter configurations, but the intent is 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 include 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 conform to hydraulic theory
- Comparison of influent meter volume with rainfall to assess how well the volumes are correlated with rainfall
- Field inspection of level only meter configurations to check for evidence of CSO discharges
- Chalking of level only meter configurations to assess how well the meter depth compares depth recorded by the chalk
- Correlation of CSO activation with rainfall depth and intensity
- Calculation of CSO discharge using alternate methods
- Evaluation of reasonableness of meter data

Each of these methods is discussed further below.

### 5.1.1 Direct Measurement

When the meters are installed, and at site visits, direct measurements of the depth recorded by the meter are made using a ruler and deviations are corrected. The depth measurements are made during dry weather due to the danger of entering the manhole during storm events. However, confirmation of depth measurements during dry weather provides an indication that the meter is functioning properly.

### 5.1.2 Comparison with Other Meters

In many cases, multiple meters are installed at a regulator (see example sketch in Figure 4-1). For example, there may be two influent meters installed at a particular regulator, and comparison of the depth measurements recorded by the two meters provides indication that the depth sensors are operating properly. In other cases, there may be a depth sensor upstream of the overflow weir and a flow meter installed downstream in the overflow line. The depth sensor upstream of the weir is used as a “trigger” meter to identify if the water level exceeded the overflow elevation. In this case, comparison of the times when the water level upstream of the weir exceeds the weir elevation with the flow recorded downstream in the overflow line increases confidence that flow recorded by the flow meter are reasonable. Comparing inclinometer readings to overflow meters can provide another useful comparison. If the flow meter is located downstream of a tidegate and the inclinometer shows the tidegate did not open, then the flow recorded by the flow meter is likely not due to CSO but due to some other source such as stormwater entering downstream of the tidegate.

### 5.1.3 Assessment of How Flow Meters Conform to Hydraulic Theory

Scattergraphs of velocity versus depth are analyzed to assess if data collected by the flow meters on the influent lines adhere to hydraulic theory, forming expected hydraulic patterns. If the data conform to hydraulic theory, then there the data is considered reasonable. An example of a velocity versus depth scattergraph is shown in Figure 5-1 for regulator RE04-6 (BOS004) for the period of April 15-June 30, 2018. This scattergraph shows a repeatable pattern in open channel depths, indicating the data adhere to hydraulic theory and form a reasonable hydraulic pattern. If the data do not conform to hydraulic theory, then the data should be confirmed by other means.

### 5.1.4 Correlation of Flow Volume with Rainfall

Flow in influent lines is expected to be correlated with rainfall. The higher the rainfall, the higher the flow. Plots of flow volume versus rainfall depth are analyzed at regulator sites with flow meters installed on incoming lines. An example is shown in Figure 5-2 for regulator RE03-7. This evaluation is not applied at sites that do not have metering of incoming lines. For example, meter results for overflow lines would not be expected to show a strong correlation between rainfall and flow because of the variable fraction of flow passing through the dry weather flow connection. This occurs because flow in low intensity storms passes through the dry weather flow connection, while higher intensities storms result in overflows. If flow volume is correlated with rainfall, that provides additional confirmation that the results are reasonable. If the flow volume is not well correlated, then additional investigation may be required. For example, poor correlation could be due to factors such as seasonal variation, in which a storm in the spring produces more flow than a similar storm in the summer or fall.

### 5.1.5 Field Observations

Field observations are performed at locations where visual confirmation of meter results are required. For example, level only meters are installed at locations where CSO activations are not predicted to occur during the typical year or the 2-year design storm. For some of these locations, the meters indicate an overflow occurred. Field observations are performed at these locations to observe whether there is evidence of an overflow.

### 5.1.6 Chalking

Chalking is another method that is used to confirm whether level sensors are operating correctly. Chalking is applied at sites where only level is measured and when meter results indicate an overflow occurred, but the field inspection observations that it did not. Chalking provides additional confirmation of field observation findings.

### 5.1.7 Correlation of CSO Activation with Rainfall Depth and Intensity

Scattergraphs correlating rainfall intensity and rainfall volume are used to check the reasonableness of metered CSO discharges. A scattergraph is created for each regulator, plotting rainfall depth against rainfall intensity for each monitored storm event, and indicating whether a CSO activation was measured or predicted for each event. An example is provided in Figure 5-3 and the remaining scattergraphs are in Appendix E. The meter data from the April 15 to June 30 monitoring period are plotted, with solid circles representing metered activations and hollow circles representing no activation per the meters. If a meter shows an activation for a rainfall event in which the intensity and rainfall depth are not consistent with the other plotted activations then the data point are considered to be potentially suspect. Suspect meter results are reviewed with the data analysts at ADS. In some instances, this review assists in identifying locations where the trigger level is not applied properly or where the meter needs to be adjusted to improve capture of CSO activations. In some cases, activations are recorded by the flow meter during dry weather, and these were subsequently assessed to be due to non-activation causes such as leaky tide gates. If metering data are suspect or missing for part or all of a storm event, the point is excluded from the scattergraph analysis.

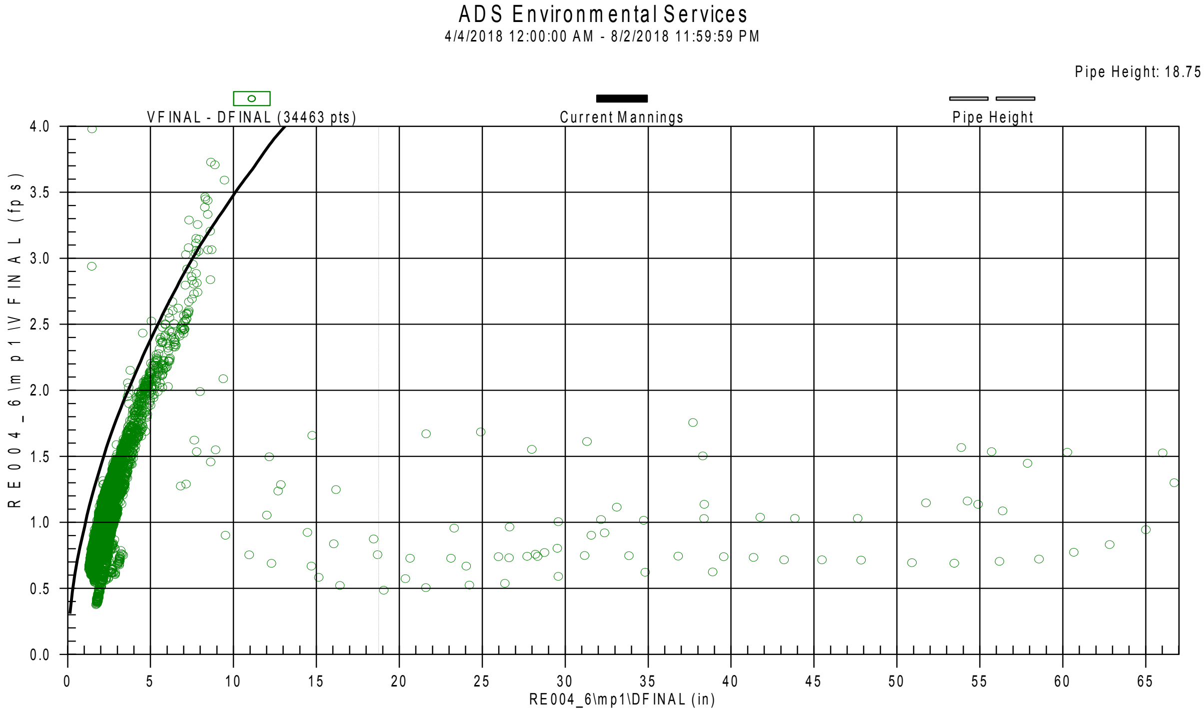



**Figure 5-1: Scattergraph for RE04-6 (BOS004) Indicates Meter Conforms to Hydraulic Theory**

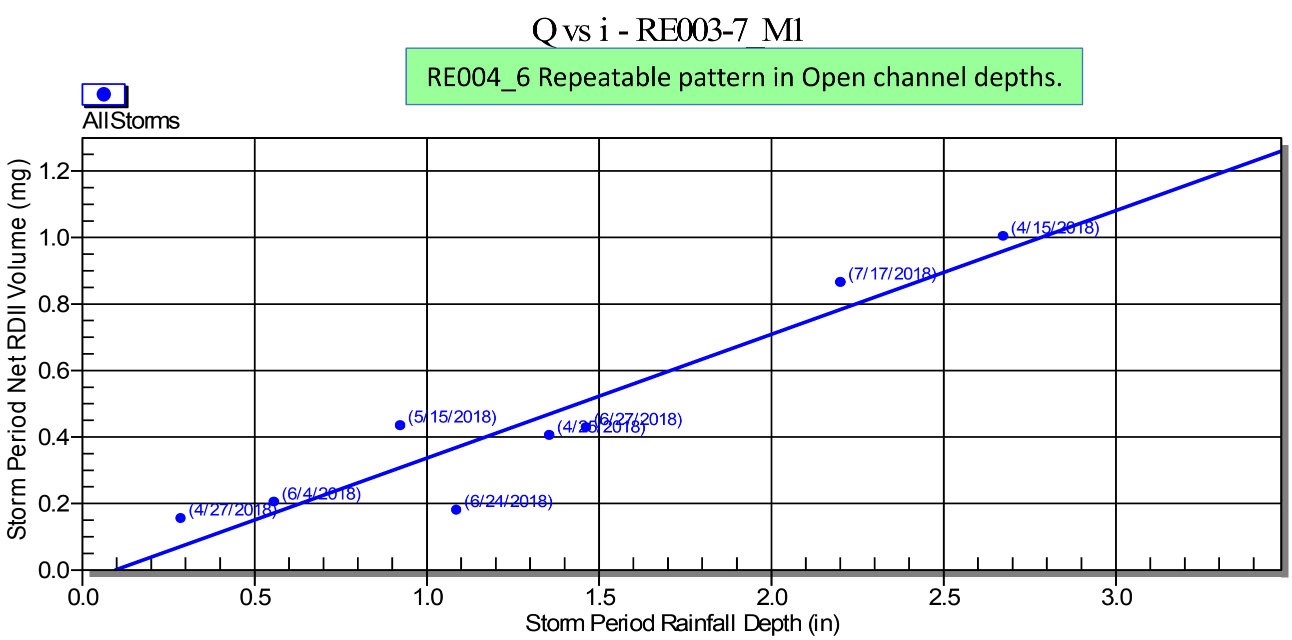



**Figure 5-2: Plot of Wet Weather Volume versus Storm Depth for RE03-7 (BOS003)**

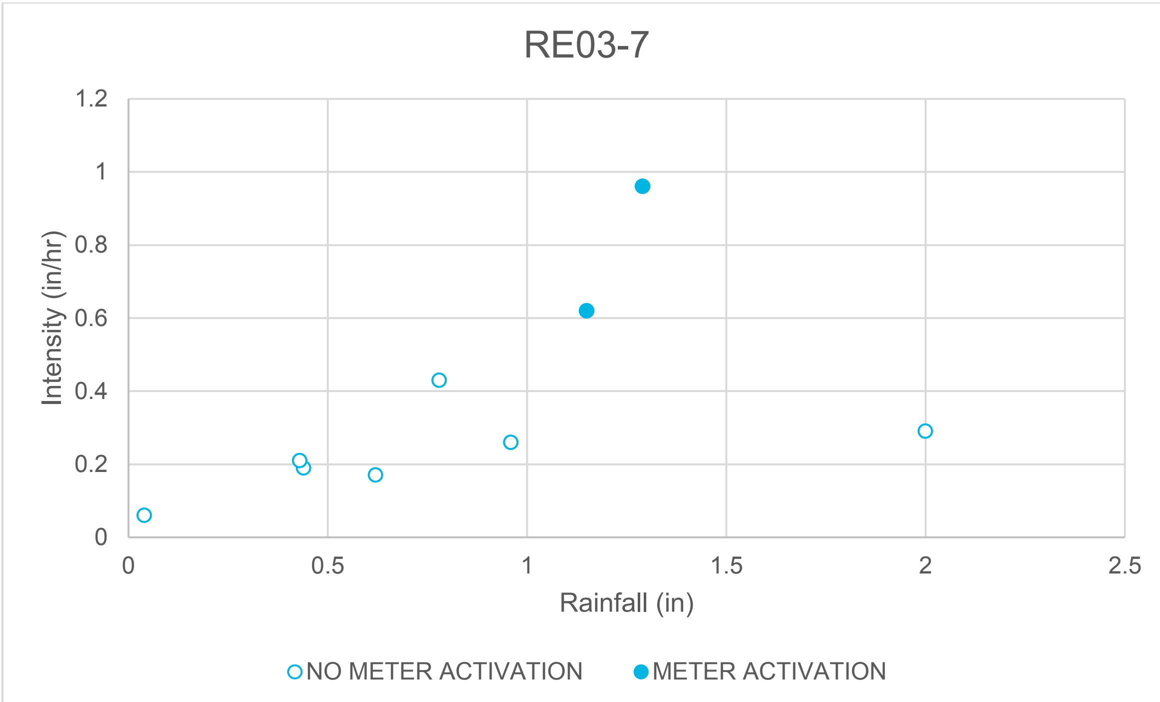



**Figure 5-3: Meter Review Scattergraph for Regulator RE03-7**

### 5.1.8 Calculation of CSO Discharge Using Alternate Methods

The meter configurations are designed to produce reasonable overflow measurements, and generally use velocity sensors in the overflow flow line. In some cases, it is possible to check the accuracy of the calculations using alternative methods, such as a weir equation. The volumes calculated using alternative methods are typically not as accurate as the primary method, but provide an order of magnitude estimate of CSO volumes which is helpful in assessing the reasonableness of the results.

### 5.1.9 General Reasonableness of Data

In some cases, meter data are provided by the communities. These data are reviewed to assess if the data appear reasonable. If the review finds the data is not reasonable then it will be flagged as questionable.

## 5.2 Meter Review Results

The results of the CSO discharge and meter data review are summarized in this section. The meters with flagged data for the April 15 to June 30, 2018 fall into the following categories:

- Unanticipated activations
- Unreasonable data
- Inconsistent CSO volumes
- Questionable overflow elevations

As new data are obtained, these results may be revised.

### 5.2.1 Unanticipated Activations

Level sensor only configurations are installed at locations where the hydraulic model predicted that no overflows would occur during either the typical year and/or the 2-year design storms. However, the monitoring data indicated that overflows occurred at the following seven locations:

Lower Charles

- RE046-54
- RE046-55

Fort Point Channel

- RE070/5-3
- RE070/8-7
- RE070/8-8
- RE070/8-13
- RE070/8-15

These data were reviewed to assess if the overflows were reasonable. The meter data at RE046-55 showed water levels that exceeded the overflow elevation even during periods when it was not raining. On June 21, 2018, the water levels dropped to normal levels, suggesting that a blockage may have been cleared. The BWSC was not aware of elevated water levels, but noted that sewers were cleaned in the area. This location will be monitored to confirm that activations do not occur going forward.

Site inspections were conducted at the other sites listed above. These inspections showed no evidence of CSO at RE070/8-7, RE070/8-8, RE070/8-13 and RE046-54. These CSO activations are believed to be false positives and are flagged in the summary table. The sites have been chalked and are being monitored to confirm that the sites are not activating.

The inspections at RE070/5-3 and RE070/8-15 confirmed that activations are likely to have occurred. These sites may require additional flow metering to understand why the activations are occurring.

### 5.2.2 Unreasonable Data

The original meter configuration at RE011 (CAM001) consisted of an area velocity meter in the influent line, a level only sensor in the manhole, and an area velocity meter in the overflow line. The meter in the overflow line is operated by the City of Cambridge. CSO volume would be calculated using the meter installed in the outfall line when the level only meter indicates the water level is above the outfall pipe invert. However, review of the meter data for the outfall line indicated some of the depths were negative. Some of the velocities were very low and are believed to be below the operating range of the sensor. Therefore, the overflow volume recorded by the overflow meter was deemed questionable and the site was converted to a level only site. No additional metering is required for this site because the influent meter and the level only meter are producing useable data which is sufficient for understanding when CSO activations occur and for model calibration.

The level data at RE036-9 (MWR010) indicated the level was much higher than expected. A review of the available information indicated the meter was installed in the wrong location. The meter is being relocated.

### 5.2.3 Inconsistent CSO Volumes

The meter configuration at CHE008 consists of an area velocity meter on the 74” x 60” influent line, an existing MWRA meter on the dry weather outlet, and an area velocity meter on the overflow weir operated by the City of Chelsea. The site presents significant challenges for flow metering, particularly in regards to the area velocity sensor installed on the weir, just downstream from a baffle and upstream of a tidegate. Therefore, an attempt was made to compare the CSO volume recorded by the City of Chelsea’s area velocity meter on the weir with flow calculated by subtraction and using the weir equation. The subtraction method used the area velocity meter installed in the 74” x 60” influent line and subtracted flows from the MWRA’s dry weather outlet meter. Based on this method, the difference calculated is an estimate of the overflow volume. A limitation of the subtraction method for this location is that the velocities are very low in the 74” x 60” influent line during dry weather and therefore it is not possible to calibrate the velocity sensor. The second means of estimating overflows is to apply the weir equation using the water level recorded by the influent meter. A limitation of the weir method is that the outfall pipe may be submerged during high tide, or during very large storms, and the weir equation would not be applicable during those times. The results of calculating the CSO volume using both alternative methods are inconclusive. Additional investigation may be required to confirm the CSO volumes at this location. Although the CSO volumes could not be confirmed, the CSO activations are consistent with the level data and rainfall.

### 5.2.4 Questionable Overflow Elevation

A key component of the data analysis is evaluating when the water level in the regulator exceeds the overflow elevation. These elevations were measured during the field inspection. The reported trigger level for RE012-2 (BOS012) is 2.25 inches, which appears to be too low. Further review of the system indicates that there may be an overflow weir located in the overflow line downstream of the regulator. Additional inspection and possibly additional metering may be required to determine if the water level exceeds the overflow elevation at this location.

## 5.3 **Meter Results**

Table 5-1 presents a summary of the April 15 to June 30, 2018 meter results. The meter data are flagged if the data review found that the data is questionable, as described in Section 5.2. The remaining meter data are considered reasonable. As discussed in Section 4, metering in regulators is more challenging than metering in single pipe structures. The turbulence present in the structure can interfere with recorded measurements. In addition, regulators are inherently complicated structures and it is sometimes difficult in the field to identify the proper location to place the meter.

The New York City Department of Environmental Protection conducted a multiple year metering pilot program to identify favorable methodologies to quantify overflows. A Water Environment Research Foundation report dated May 2015 summarizes this work. The report concluded that differences between metered and modeled discharges are not always due to an incorrect model. Rather, when CSO discharges recorded by a meter are significantly different from model predictions, the modelers should compare CSO discharges against an independent data source. In some cases, this may take the form of visits to the field to confirm both the meter location and visual indications of an overflow. In other cases, it may take the form of comparing metered flows against other measurements such as inclinometer readings (if the inclinometer indicates that the flap valve did not open then a CSO is unlikely to have occurred). Fieldwork may also include investigations upstream to identify sources of inflow that should not be present, including incorrectly connected drains. MWRA is conducting such investigations, but these will take time. Investigations will continue through the model calibration process and therefore results presented in this report are subject to change.

## Table 5-1: Summary of April 15 to June 30, 2018 Meter Results

| Outfall | Regulator ID | Level Only | April 15-June 30, 2018 Meter Results | | |
|---|---|---|---|---|---|
| | | | Activation Frequency | Duration (hrs) | Volume (MG) |
| **Alewife Brook** | | | | | |
| CAM001 | RE-011 | Y | Meter data under review | | |
| CAM002 | RE-021 | | 2 | 1 | 0.16 |
| MWR003 | RE-031 | | 0 | 0 | 0 |
| CAM401A | RE-401 | | 0 | 0 | 0 |
| CAM401B | RE-401B (1) | | 5 (0) (2) | 3.25 | 0 |
| SOM001A | RE-01A | | 6 | 9 | 5.66 |
| **Upper Mystic River** | | | | | |
| SOM007A/MWR205A (3) | | Y | 4 | 6.5 | N/A |
| **Upper Inner Harbor** | | | | | |
| MWR205 (Somerville Marginal Facility) (4) | | | 7 | 20.42 | 21.98 |
| BOS013 | RE013-1 | | 4 (1) (2) | 2.75 | 0.09 |
| BOS014 | RE014-2 | | 2 | 1.25 | 0.54 |
| BOS017 | RE017-3 | | 2 (1) (2) | 2.25 | 0.02 |
| CHE003 | RE-031 | Y | 0 | 0 | N/A |
| CHE004 | RE-041 | | 3 | 2.25 | 0.93 |
| CHE008 | RE-081 | | 4 | 2.75 | Volume data under review |
| **Upper Inner Harbor** | | | | | |
| BOS009 | RE009-2 | | 5 (1) (2) | 5 | 0.12 |
| BOS010 | RE010-2 | | 2 | 2.25 | 0.23 |
| BOS012 | RE012-2 | | Meter data under review | | |
| BOS019 | RE019-2 | Y | 1 | 2.22 | N/A |
| BOS057 | RE057-6 | | 0 | 0 | 0 |
| BOS060 | RE060-7 | | 3 | 1.5 | 0.83 |
| | RE060-20 | | 0 | 0 | 0 |
| MWR203 (Prison Point) | | | 4 | 16.33 | 69.45 |
| **Lower Inner Harbor** | | | | | |
| BOS003 | RE003-2(1) | | 1 (0) (2) | 0.25 | 0.00 |
| | RE003-7 | | 1 | 1 | 0.03 |
| | RE003-12 | | 6 (4) (2) | 12.75 | 1.86 |
| BOS004 | RE004-6 | | 0 | 0 | 0 |
| BOS005 | RE005-1(5) | Y | 0 | 0 | N/A |
| **Fort Point Channel** | | | | | |
| BOS062 | RE062-4 | | 3 | 2.5 | 0.68 |
| BOS064 | RE064-4(5) | | 0 | 0 | 0 |
| | RE064-5 | | 0 | 0 | N/A |
| BOS065 | RE065-2 | Y | 0 | 0 | N/A |
| BOS068 | RE068-1A | Y | 0 | 0 | N/A |
| BOS070/DBC | RE070/8-3 | | 3 | 2 | 0.47 |
| | RE070/8-6 | Y | 0 | 0 | N/A |
| | RE070/8-7 | Y | Meter data under review | | |
| | RE070/8-8 | Y | Meter data under review | | |
| | RE070/8-13 | Y | Meter data under review | | |
| | RE070/8-15 | Y | 3 | 2.25 | N/A |
| | RE070/9-4 (5) | | 2 | 2 | 0.53 |
| | RE070/10-5 (5) | | 1 | 0.5 | 0.12 |
| | RE070/7-2 (5) | | 3 (2) | 5 | 0.74 |
| MWR215 (Union Park) | | | 1 | 4.1 | 4.3 |
| BOS070/RCC | RE070/5-3(5) | Y | 1 | 0.25 | N/A |
| BOS073 | RE073-4 | | 0 | 0 | 0 |

## Table 5-1. (Continued)

| Outfall | Regulator ID | Level Only | April 15-June 30, 2018 Meter Results | | |
|---|---|---|---|---|---|
| | | | Activation Frequency | Duration (hrs) | Volume (MG) |
| **Reserved Channel** | | | | | |
| BOS076 | RE076/2-3 | | 0 | 0 | 0 |
| | RE076/4-3 | | 0 | 0 | 0 |
| BOS078 | RE078-1<br>RE078-2 | | 0 | 0 | 0 |
| BOS079 | RE079-3 | Y | 0 | 0 | N/A |
| BOS080 | RE080-2B(5) | Y | 0 | 0 | N/A |
| **Upper Charles** | | | | | |
| CAM005 | RE-051 | | 6 | 11.75 | 3.4 |
| CAM007 | RE-071 (1) (5) | | 1 (0) (2) | 4 | 0 |
| **Lower Charles** | | | | | |
| CAM017 | CAM017 | | 0 | 0 | 0 |
| MWR010 | RE37 | Y | 0 | 0 | N/A |
| | RE036-9 | Y | Meter data under review | | |
| MWR018 | Charles River | | 0 | 0 | 0 |
| MWR019 | Charles River | | 0 | 0 | 0 |
| MWR020 | Charles River | | 0 | 0 | 0 |
| MWR201 (Cottage Farm) | Cottage Farm | | 1 | 3.46 | 8.5 |
| MWR023 (6) | RE046-19 | Y | 0 | 0 | N/A |
| | RE046-30 | | 0 | 0 | 0 |
| | RE046-50 | Y | 0 | 0 | N/A |
| | RE046-54(5) | Y | 1 | 1.75 | N/A |
| | RE046-55 (7) | Y | 3 | 15 | N/A |
| | RE046-62A | Y | 0 | 0 | N/A |
| | RE046-90 (5) | Y | 0 | 0 | N/A |
| | RE046-100(1) | | 2 (0) (2) | 1 | 0.00 |
| | RE046-105 | | 0 | 0 | 0 |
| | RE046-381 | Y | 0 | 0 | N/A |
| | RE046-192(5) | Y | 0 | 0 | N/A |
| **Back Bay Fens** | | | | | |
| BOS046 (6) | Fens Gatehouse #1 | | 3 | 15 | 0.00 |

(1) Metered activation caused discharge with volume less than 0.01 MG during monitoring period
(2) Numbers in parenthesis indicate number of activations with volumes greater than 0.01 MG
(3) Includes portion of flow treated at Somerville Marginal facility and separate stormwater entering the Somerville Marginal Conduit (outfall) downstream of the facility Volume represents all flow through the CSO treatment facility
(4) Volume represents all flow through the CSO treatment facility
(5) Indicates there are some missing data during storm events that occurred between April 15 and June 30, 2018.
(6) Boston Gatehouse 1 was opened April 10 and remained open for the period, dividing the flow between MWR023 and BOS046. Proportion of flow was estimated to be 25% to MWR023 and 75% to BOS046 and was applied to meter results. Some of the volume of flow at BOS046 is not accounted for as some activated regulators may be level only sites.
(7) There may have been a blockage cleared on or about June 21, 2018

## 5.4 Evaluation of Current Meter Configurations

In some cases, the current flow metering configurations may warrant modifications to improve data collection for intended purposes. These modifications fall into three categories, which are discussed below.

### 5.4.1 Removal of Calibration Meters

The flow meters were installed for various purposes, and these are described in Table 4-1. Some of the meters are for model calibration only. An analysis of the first 6 months of rainfall data will be performed to assess whether there are sufficient data to calibrate the model. Once sufficient data are available, the calibration only meters can be removed.

### 5.4.2 Modifications to Meter Configurations

Based on data review, it may be necessary to modify certain meter configurations. Modifications may involve changing the meter type or adding additional meters and/or sensors.

As described in Section 4, there are two types of meter configurations: flow and level only. The level only meter types are installed at locations where CSO activations are not predicted to occur for the typical year or the 2-year storm. In some cases, CSO activations have been observed at the level only sites. Field inspections and chalking are being performed to assess whether CSO activations actually occurred or were due to meter spikes. If these CSO activations are found to be reasonable, then it may be necessary to add flow meters so that additional data can be obtained to assess why the activations occurred and to obtain information for model calibration. At regulators RE070/5-3, RE070/8-7, RE070/8-8, RE070/8-13, and RE070/8-15, the April 15 to June 30, 2018 level only metering data indicated activations. Site inspections of these regulators suggested that only RE070/5-3 and RE070/8-15 appeared to have activated. Chalk markings have been added to these sites by ADS to improve the ability to estimate CSO activations. Further evaluation of these locations will be performed.

In some cases, the current metering configuration is not able to produce sufficient CSO data. Therefore, it may be necessary to install additional meters in order to confirm CSO activations. This evaluation will be made after review of the first 6-months of meter data. For example, at RE012-2 (BOS012), there may be a weir downstream of the regulator that was not identified during the initial field inspection. Since the weir is remote from the existing meters, it is not possible to use the existing meters determine whether the water level exceeds the weir elevation. It may be necessary to install an additional meter to measure the water level at the weir.

Based on the assessment of data for the period of April 15 to June 30, 2018, three sites have been identified as locations where metering configurations could be modified to improve the measurement of CSO activations. At CAM001 and CAM002, the metering data were not adequate for assessing CSO volumes. As a result, this report presents data for CAM002 in terms of frequency and duration, only, and no data are presented for CAM001. The meter configurations at these locations have been modified to improve accuracy with the goal of being able to report volumes for future CSO activations.

For the SOM007A outfalls, the installed level sensor was not close enough to the SOM007A diversion weir to confirm whether the SOM007A outfall activates. Following discussions with MWRA on August 15, 2018, the level sensor was moved to the weir at SOM007A to provide a better measurement of when SOM007A discharges.

A review of the data for RE036-9 (MWR010) indicates that the meter was installed at the wrong location. The meter is being relocated.

As discussed previously, the flow meter at CHE008 is not in an ideal location and it has not been possible to confirm the reasonableness of CSO flow data collected to date. Additional investigations are underway.

### 5.4.3 Removal of Meters

As noted above (Section 5.4.1), the meters used for calibration only can be removed once it is assessed that sufficient data have been obtained to calibrate the model. It may be possible to remove additional meters if the sites are not active. Rainfall data will be analyzed and compared to the typical year. If sufficient storms have been obtained to approximate the storms that occur during the typical year, then the response at the meters will be examined to assess if sufficient meter data have been obtained and the meter can be removed. For example, if the depth at a particular regulator did not come close to overtopping the weir during storms that are representative of the storms in the typical year, then it may be appropriate to remove the meter.

# 6. Hydraulic Modeling

The MWRA's hydraulic model is the primary tool used to evaluate the performance of the MWRA system during a typical year. Environmental variables such as rainfall, tide, and evaporation serve as inputs to the model, which uses this information to estimate the flow coming into the sewer system as well as the hydraulic performance of the system at regulator locations. Hydraulic modeling has historically served as the basis for evaluating performance of the MWRA's CSO system. The hydraulic model was first developed during development of the Long-Term Control Plan using the EPA Storm Water Management Model (SWMM) software. It was then updated and converted to InfoWorks CS in the early 2000s to better serve MWRA's needs during LTCP implementation. The InfoWorks CS model is the tool that has been used for multiple years to estimate CSO volumes for the purpose of NPDES reporting.

The purpose of the performance assessment is to demonstrate the attainment of the levels of CSO control recommended in MWRA's LTCP. The levels of CSO control in the MWRA's LTCP are based on CSO discharge volume and activation at each CSO outfall based on Typical Year precipitation. Model simulations will be run for all rainfall events for calendar years (January 1- December 31) 2018, 2019, 2020 and the Typical Year to generate model predicted CSO discharge frequency, durations and volumes. These results will be summarized in future reports.

For the performance assessment the InfoWorks CS model has been converted to InfoWorks ICM, the successor model software to InfoWorks CS. Infoworks CS is no longer a product supported by Innovyze Software. InfoWorks ICM has similar hydraulic computation abilities as CS but adds additional capabilities such as improved database management and the ability to handle 2D surface routing. The version used for this report is ICM 8.5, which was the most current at the time of the analysis. The model may be updated to a newer version of the software during model calibration.

Each year, MWRA makes edits to the hydraulic model so that the model can reflect current conditions more accurately. This section details the edits made to the MWRA model for the purposes of this report.

## 6.1 Model Updates

The model was modified to reflect changes such as structural changes to the MWRA and municipal sewer system that could affect CSO discharges, flow changes, and operational changes. The following modifications were made to the MWRA model: the addition of known sediment, the Alewife Bypass, the addition and removal of regulators, and the configuration of Boston Gatehouse 1. Each of these changes is described in the subsections below.

### 6.1.1 Sediment

MWRA measured sediment in interceptors in the surrounding CSO communities. These data were used to update the model to reflect the latest sediment depth information. In some cases sediment depth increased and in other cases it decreased. Locations where sediment data were provided are shown in Figure 6-1.

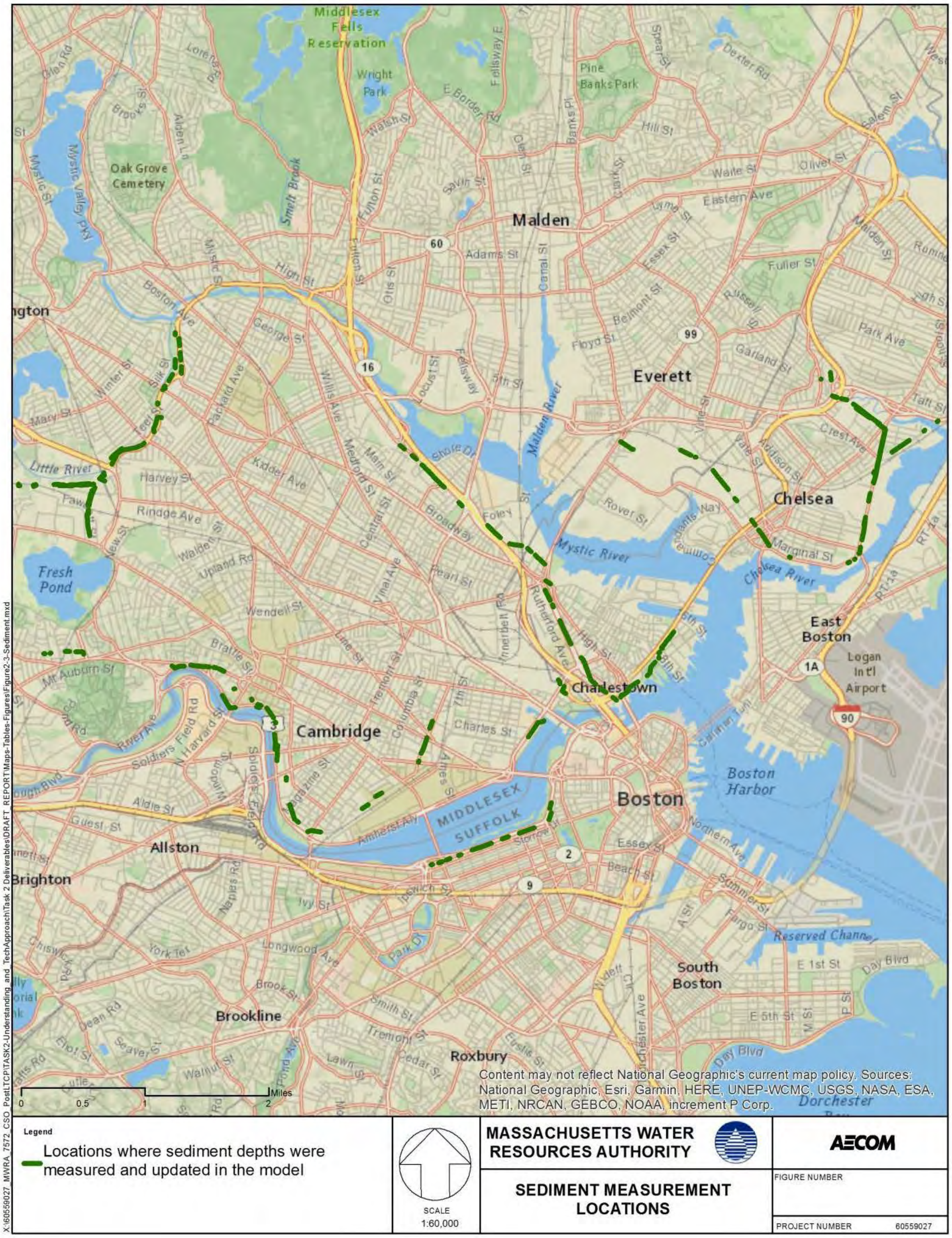



**Figure 6-1: Sediment Measurement Locations**

### 6.1.2 Alewife Bypass

The Alewife Brook Pump Station is currently being rehabilitated, and as a result is being bypassed. The model was modified to account for the bypass configuration. Three dry weather pumps discharge to the 24-inch line downstream of the Alewife Brook Pump Station. Two of the pumps are electric pumps and are normally on, while the third pump is a spare. Six additional pumps are wet weather diesel pumps and discharge to the 66-inch line downstream of the Alewife Brook Pump Station. One wet-weather pump is normally used as a spare, but can be turned on if needed for high flows. The primary objective of the bypass pumping installation is to keep the hydraulic grade line upstream of the pumps below elevation 101 feet (MDC datum). This work is expected to be complete by the next semiannual report and the bypass removed.

### 6.1.3 Addition and Removal of Regulators

In accordance with Task 2.3 of the performance assessment, ADS Environmental Services and SDE Civil and Environmental Engineering conducted CSO Inspections at both active regulators and regulators closed under the LTCP. Field inspections found that RE046-80 was closed although it was still configured as open in the model. Regulators RE046-54 and RE078-2 were found to be open, but were not included in the model. The model was updated to close RE046-80 and open/add RE046-54 and RE078-2.

### 6.1.4 Tracer Application for Boston Gatehouse 1

In the 2017 NPDES version of the model, Boston Gatehouse 1 is normally modeled as closed. Flow can discharge to the Back Bay Fens if the hydraulic grade line exceeds the top of the gate at an elevation of 112.97 feet (MDC datum). However, short duration, intense, and unpredicted thunderstorms have led BWSC to leave the gates in Boston Gatehouse 1 open during the summer months. Opening Boston Gatehouse 1 allows some of the flow in the Stony Brook Conduit to discharge to the Back Bay Fens at outfall BOS046, while the remainder continues to discharge at MWR023. Based on information provided by BWSC on their standard operating procedure for Gatehouse 1, AECOM modeled the Boston Gatehouse 1 with real time control (RTC) logic to open two of the gates by 4 feet during July and August for the 2018 conditions typical year model run. BWSC indicated that in 2018 it deviated from its standard procedure, and opened the gates on April 10, 2018. Therefore, for the assessment of model versus actual April 15 to June 30, 2018 conditions, the model reflected the Gatehouse 1 gates being open for the entire April 15 to June 30 metering period.

To estimate the flow split between BOS046 and MWR023 when Gatehouse 1 is open, a conservative tracer was added to the sanitary flow in the ICM model, and the model was run for the typical year with Gatehouse 1 open during July and August, as per the standard operating procedure. The amount of sanitary flow going through Gatehouse 1 was estimated by calculating the amount of tracer (i.e. sanitary flow) going through the gate in the model. The resulting distribution of volume during the period when the gate was open was determined to be 75% through BOS046 and 25% through MWR023. This distribution is assumed for all model runs simulating conditions when the gate is open. When calculating the CSO volume in Table 6-1 the proportions presented above are applied when Boston Gatehouse 1 is open to split flow between outfalls BOS046 and MWR023.

## 6.2 Model Calibration

Model calibration will begin in January, 2019. Model calibration will use a minimum of three storm events from the post-construction flow monitoring period. The model was edited to reflect the changes listed in this section. Storms within the calibration period will consider rainfall analysis and system conditions. The calibration storms should vary in magnitude, intensity, and duration and include minimal system malfunctions.

## 7. Progress Toward The Second Semiannual Report

MWRA plans to issue the next semiannual report (Semiannual Report No. 2) in April 2019. The following efforts are underway or planned to be conducted over the next several months.

- MWRA continues to collect data from rainfall gauges, CSO and sewer system meters and operational records for all rainfall events. Analyses of the rainfall data and meter data are being conducted and will be presented in Semiannual Report No. 2 for the metering period July 1, 2018, through December 31, 2018.
- MWRA continues to quantify and validate CSO discharges from the meter data collected at CSO regulators.
- Temporary meters are currently installed at all 58 potentially active CSO regulators, and these meters have recorded overflow conditions for the many storms that have occurred since April 15, 2018. MWRA will begin to remove temporary CSO meters where sufficient data have been collected to accurately characterize overflow conditions at the outfall across a range of storm sizes. Semiannual Report No. 2 (and subsequent semiannual reports) will document the meters removed and explain the adequacy of the data collected.
- MWRA is incorporating the results of detailed CSO regulator structure inspections conducted in 2018 and other new information about system conditions into its hydraulic model.
- MWRA will recalibrate its hydraulic model in early 2019 utilizing validated meter data collected in 2018. Model predictions can then be compared to meter data and CSO discharges quantified from meter data, with the objective of bringing the modeled and metered discharge estimates closer together and ultimately gaining confidence in the model for estimating CSO discharges in the Typical Year and comparing the results to LTCP levels of control.
- MWRA will continue to conduct receiving water quality monitoring in waters affected by CSO, with a focus on the storm impacts and recovery times in the variance waters (Charles River and Alewife Brook/Upper Mystic River).
- As noted in preceding chapters, system performance assessments from meter data remain subject to change as additional data are collected. MWRA expects to conduct additional system inspections where meter data are questionable or to help explain meter vs. model differences. The effect of seasonal groundwater and specific rainfall characteristics on CSO discharges is also being considered, including the impacts of short duration, high intensity (less-than-1-hour peak rainfall) storms.

MWRA has also begun investigations into the overflow conditions at CSO outfalls and regulators where meter data collected in the April 15, 2018 through June 30, 2018, period suggest that discharges are not consistent with MWRA's CSO discharge estimates from previous model simulations. Table 7-1 on the following page provides a list of the outfalls where these investigations are underway.

Depending on the location and the discharge differences recorded by the meters, the investigations may include adjustment of the meter installation for improved data collection and overflow quantification, additional inspections, evaluation of inflows to the regulator, evaluation of the hydraulic conditions within the CSO regulator(s), the dry weather connection(s) and/or the receiving interceptor, and the evaluation of structural or operational adjustments that have the potential to further reduce overflows. At some of the locations, specific information is known that may be contributing to higher CSO discharge activation and/or volume.

- At SOM01A, which discharges to Alewife Brook, MWRA plans to increase the size of the connection between the City of Somerville's Tannery Brook Conduit and MWRA's Alewife Brook Conduit to reduce overflows at SOM01A without increasing overflows at other Alewife Brook CSO outfalls.

- At the Cottage Farm CSO Facility (MWR201), which discharges to the Charles River Basin, treated overflow volumes are expected to be lowered as the City of Cambridge continues to implement sewer separation projects.

- At BOS003 in East Boston, which discharges to the Inner Harbor, an old, abandoned hydraulic control device within a dry weather connection may be unnecessarily restricting flow from entering the MWRA interceptor. The condition of dry weather connections, including restrictions or restrictive pipe size, may be limiting the flow that can enter the interceptor system at other CSO regulators and outfalls, as well.

**Table 7-1: Outfall Investigations**

| Receiving Water | Outfall |
|---|---|
| Alewife Brook | CAM001 |
| | SOM001A |
| Mystic River | SOM007A/ MWR205A |
| | MWR205 (Somerville Marginal) |
| Chelsea Creek | CHE004 |
| | CHE008 |
| Inner Harbor | BOS060 |
| | BOS003 |
| Fort Point Channel | BOS062 |
| | BOS070 |
| Reserved Channel | BOS076 |
| | BOS080 |
| Charles River | CAM005 |
| | CAM017 |
| | MWR201<br>(Cottage Farm Facility) |
| | MWR023 |

## Appendix A CSO and Regulator Open/Closed Status

| Outfall | Outfall Status [1] | Regulator | Inspection Confirmed Status | Metering Plan [2] |
|---|---|---|---|---|
| **ALEWIFE BROOK** | | | | |
| CAM001 | Open | RE011 | Open | PCCMP Flow Meter/ Existing Meter |
| CAM002 | Open | RE021 | Open | PCCMP Flow Meter/Existing Meter |
| MWR003 | Open | RE-031 | Open | PCCMP Flow Meter/ Existing MWRA Meter |
| CAM004 | Closed | RE-041 | Could Not Locate | |
| CAM400 | Closed | RE-400 | Could Not Locate | Regulator is not shown on BWSC drawings. |
| CAM401A | Open | RE-401 | Open | PCCMP Flow Meter/Existing Meter |
| CAM401B | Open | RE-401B | Open | PCCMP Flow Meter/Existing Meter Not Used |
| SOM001A | Open | RE-01A | Open | PCCMP Flow Meter/Existing Somerville Meter |
| SOM001 | Closed | RE-001 | Closed | |
| SOM002A | Closed | RE-002A | Closed | |
| SOM003 | Closed | RE-031 | Closed | |
| SOM004 | Closed | RE-041 | Could Not Locate | |
| | | RE-042 | Could Not Locate | |
| **UPPER MYSTIC RIVER** | | | | |
| SOM007A/MWR205A | Open | | | PCCMP Flow Meter/Existing Meter |
| SOM007 | Closed | RE-007 | Closed | |
| **MYSTIC/CHELSEA CONFLUENCE** | | | | |
| MWR205 (Somerville Marginal Facility) | Open | | | |
| BOS013 | Open | RE013-1 | Open | PCCMP Flow Meter |
| BOS014 | Open | RE014-2 | Open | PCCMP Flow Meter |
| BOS015 | Closed | RE015-7 | Closed | |
| BOS017 | Open | RE017-3 | Open | PCCMP Flow Meter |
| CHE002 | Closed | RE-002 | Closed | |
| CHE003 | Open | RE031 | Open | PCCMP Flow Meter/Existing Chelsea Meter |
| CHE004 | Open | RE041 | Open | PCCMP Flow Meter/Existing Meter |
| CHE008 | Open | RE081 | Open | PCCMP Flow Meter/Existing Chelsea & MWRA Meter |
| **UPPER INNER HARBOR** | | | | |
| BOS009 | Open | RE009-2 | Open | PCCMP Flow Meter |
| BOS010 | Open | RE010-2 | Open | PCCMP Flow Meter |
| BOS012 | Open | RE012-2 | Open | PCCMP Flow Meter |
| BOS019 | Open | RE019-2 | | Existing MWRA Meter/Existing MWRA Meter |
| BOS050 | Closed | RE050-2 | | |
| BOS052 | Closed | RE052-2 | Closed | |
| BOS057 | Open | RE057 | | Existing BWSC Meter |
| | | RE-051 | Closed | |
| | | RE-109 | Closed | |
| BOS058 | Closed | RE-051 | Closed | |
| | | RE058-7 | Open - Evidence of Flow | |
| | | RE-076 | Could Not Locate | Regulator is not shown on BWSC drawings. |
| BOS060 | Open | RE060-7 | Open | PCCMP Flow Meter |
| | | RE060-20 | Open | PCCMP Flow Meter |
| | | RE060-4 | Closed | |
| | | RE-123 | Closed | |
| | | RE-127 | Closed | |
| | | RE-130 | Could Not Locate | Regulator is not shown on BWSC drawings. |
| | | RE-192 | Closed | |
| | | RE-200 | Closed | |

| Outfall | Outfall Status (1) | Regulator | Inspection Confirmed Status | Metering Plan (2) |
|---|---|---|---|---|
| | | RE-213 | Other | Regulator is not shown on BWSC drawings. |
| | | RE-228 | Open - Dry | |
| | | RE-336 | Could Not Locate | Regulator is not shown on BWSC drawings. |
| MWR203 (Prison Point) | | | | Existing MWRA Meter |
| **LOWER INNER HARBOR** | | | | |
| BOS003 | Open | RE003-2 | Open | PCCMP Flow Meter |
| | | RE003-7 | Open | PCCMP Flow Meter |
| | | RE003-12 | Open | Existing BWSC Meter |
| BOS004 | Open | RE004-6 | Open | PCCMP Flow Meter |
| BOS005 | Open | RE005-1 | Open | PCCMP Flow Meter |
| BOS006 | Closed | RE006-2 | Closed | |
| BOS007 | Closed | RE007-2 | Closed | |
| **CONSTITUTION BEACH** | | | | |
| MWR207/BOS002 | Closed | RE002-2 | Closed | |
| **FORT POINT CHANNEL** | | | | |
| BOS062 | Open | RE062-4 | Open | PCCMP Flow Meter |
| BOS064 | Open | RE064-4 | Open | PCCMP Flow Meter |
| | | RE064-5 | Open | PCCMP Flow Meter |
| | | RE-295 | Closed | |
| BOS065 | Open | RE065-2 | Open | Existing BWSC Meter |
| BOS068 | Open | RE068-1A | Open | |
| BOS070/DBC | Open | RE070/8-3 | Open | PCCMP Flow Meter |
| | | RE070/8-6 | Open | PCCMP Flow Meter |
| | | RE070/8-7 | Open | PCCMP Flow Meter |
| | | RE070/8-8 | Open | PCCMP Flow Meter |
| | | RE070/8-13 | Open | PCCMP Flow Meter |
| | | RE070/8-15 | Open | PCCMP Flow Meter |
| | | RE070/9-4 | Open | PCCMP Flow Meter |
| | | RE070/10-5 | Open | PCCMP Flow Meter |
| | | RE070/11-2 | Closed | |
| | | RE070/7-2 | | Existing BWSC Meter |
| | | RE-061 | Closed | |
| | | RE070/10-7 | Closed | |
| | | RE070/7-1 | Closed | |
| | | RE070/8-11 | Open - Evidence of Flow | Internal regulator tributary to 070/8-13 |
| | | RE070/8-12 | Other- Upstream of 19KMH216, pipe full of sediment, unable to confirm open/close. It was determined that Regulator 070/8-12 is upstream of RE070/8-13 and therefore does not need to be monitored. | |
| | | RE070/8-5 | Closed | |
| | | RE-370 | Closed | |
| | | RE-381 | Open - Evidence of Flow | Internal regulator tributary to Union Park Pump Station |
| MWR215 (Union Park) | | | Open | Existing MWRA Meter |
| BOS070/RCC | | RE070/5-3 | Open | PCCMP Flow Meter |
| | | RE070/6-1 | Closed | |
| | | RE070/6-1A | Could Not Locate | Regulator is not shown on BWSC drawings. |
| | | RE070/5-4 | Closed | |
| | | RE070/4-3 | Could Not Locate | Regulator is not shown on BWSC drawings. |
| | | RE070/1-3 | Other- Sump not visible, unable to confirm existence. Regulator no longer exists on sewer. Area has been separated. | |
| BOS072 | Closed | RE072-2 | Closed | |
| | | RE072-3 | Closed | |
| | | RE072-4 | Closed | |

| Outfall | Outfall Status (1) | Regulator | Inspection Confirmed Status | Metering Plan (2) |
|---|---|---|---|---|
| BOS073 | Open | RE073-4 | | Existing BWSC Meter |
| **RESERVED CHANNEL** | | | | |
| BOS076 | Open | RE076/2-3 | Open | PCCMP Flow Meter |
| | | RE076/3-3 | Could Not Locate | Regulator is not shown on BWSC drawings. |
| | | RE076/4-2 | Open - Evidence of Flow | PCCMP Flow Meter |
| | | RE076/4-3 | Open | PCCMP Flow Meter |
| | | RE-091 | Could Not Locate | Regulator is not shown on BWSC drawings. |
| BOS078 | Open | RE078-1 | Open | PCCMP Flow Meter |
| | | RE078-2 | Open | PCCMP Flow Meter |
| | | TG78 | Open | PCCMP Flow Meter |
| | | RE-022 | Could Not Locate | Regulator is not shown on BWSC drawings. |
| BOS079 | Open | RE079-3 | Open | PCCMP Flow Meter |
| | | RE-057 | Closed | |
| BOS080 | Open | RE080-2B | Open | PCCMP Flow Meter |
| **NORTHERN DORCHESTER BAY** *Regulators are tributary to the South Boston Tunnel which is intended to achieve CSO elimination in events up to the 25-year, 24-hour storm* | | | | |
| BOS081 | Open | RE081-2 | Open | |
| BOS082 | Open | RE082-2 | Open | |
| BOS083 | Closed | RE083-1 | Open - Evidence of Flow | Unmapped sewer manhole downstream of 19MMH158. |
| | | RE-099 | Could Not Locate | Regulator is not shown on BWSC drawings. |
| BOS084 | Open | RE084-3 | Open | |
| | | RE-020 | Open - Evidence of Flow | Same structure as 084-6. Unmapped combined manhole upstream of 19MMH10. Open line also visible at manhole 19MMH10. |
| | | RE084-6 | Other- Same structure as RE-020. Assessment of CSO activation at BOS 084 will be based on operational gate and will not require flow metering. | |
| BOS085 | Open | RE085-4 | Closed | |
| | | RE-183 | Open - Evidence of Flow | At the intersection of Dorchester Street. |
| | | RE085-5 | Open | No Meter Recommended |
| BOS086 | Open | RE086-1 | Open | No Meter Recommended |
| | | RE086-8 | Closed | |
| BOS087 | Closed | RE087-1 | Could Not Locate | Regulator is not shown on BWSC drawings. |
| | | RE087-7 | Closed | Same as RE-129. |
| **SOUTHERN DORCHESTER BAY** | | | | |
| BOS088/BOS089 (Fox Point) | Closed | RE-009 | Could Not Locate | Regulator is not shown on BWSC drawings. |
| | | RE088-1 | Closed | |
| | | RE088-10 | Could Not Locate | Regulator is not shown on BWSC drawings. |
| | | RE088-15 | Closed | |
| | | RE088-18 | Could Not Locate | Regulator is not shown on BWSC drawings. |
| | | RE088-20 | Closed | |
| | | RE088-22 | Closed | |
| | | RE088-27 | Closed | |
| | | RE088-7 | Closed | |
| | | RE-110 | Closed | |
| | | RE089-1 | Other- Regulator no longer exists | |
| | | RE-235 | Could Not Locate | Regulator is not shown on BWSC drawings. |

| Outfall | Outfall Status (1) | Regulator | Inspection Confirmed Status | Metering Plan (2) |
|---|---|---|---|---|
| BOS090 (Commercial Point) | Closed | RE-013 | Closed | |
| | | RE-063 | Could Not Locate | Regulator is not shown on BWSC drawings. |
| | | RE090-1 | Closed, but in need of repair | |
| | | RE090-14 | Open - Evidence of Flow | |
| | | RE090-15 | Could Not Locate | BWSC drawings show this structure is a tide gate |
| | | RE090-4 | Closed | |
| | | RE090-7 | Closed | |
| | | RE090-8 | Could Not Locate | Regulator is not shown on BWSC drawings. |
| | | RE099-12 | Open - Evidence of Flow | |
| | | RE-224 | Could Not Locate | Regulator is not shown on BWSC drawings. |
| **UPPER CHARLES** | | | | |
| BOS032 | Closed | RE032-1 | Closed | |
| | | RE032-2 | Closed | |
| | | RE032-7 | Closed | |
| BOS033 | Closed | RE033-1 | Closed | |
| | | RE025 | Other- Sewer manhole has what appears to be floatable control device. . Appears to be reconfigured per new BWSC maps. Outfall is closed and therefore it is assumed the regulator is not active. | |
| CAM005 | Open | RE-051 | Open | PCCMP Flow Meter/Existing Meter |
| CAM007 | Open | RE-071 | Open | PCCMP Flow Meter/Existing Meter Not Used |
| CAM009 | Closed | RE-091 | Other-Regulator closed based on information provided by the City of Cambridge | |
| CAM011 | Closed | RE-111 | Other--Regulator closed based on information provided by the City of Cambridge | |
| **LOWER CHARLES** | | | | |
| BOS028 | Closed | RE028-2 | Other-Appears to have been reconfigured. Sump pipe blocked off and pipe shown as 78 inch inlet serving as outlet. Pipe mapped as overflow pipe is partially blocked but has water rushing into structure from hole in bricks. | |
| BOS042 | Closed | RE042-1 | Closed | |
| | | RE079 | Closed | |
| | | RE086-1 | Closed | |
| | | RE-197 | Closed | |
| | | RE-326 | Closed | |
| | | RE-029 | Other-Unable to confirm whether or not the regulator structure is located below what appears to be some sort of floatable control device. Outfall is closed and therefore it is assumed the regulator is not active. | |
| BOS049 | Closed | RE049-10 | Could Not Locate | Regulator is not shown on BWSC drawings. |
| | | RE049-3 | Closed | |
| | | RE049-4 | Could Not Locate | Regulator is not shown on BWSC drawings. |
| | | RE-058 | Could Not Locate | Regulator is not shown on BWSC drawings. |
| | | RE-105 | Could Not Locate | Regulator is not shown on BWSC drawings. |
| CAM017 | Open | CAM017 | Open | PCCMP Flow Meter/Existing Cambridge Meter |
| MWR010 | Open | RE37 | Open | PCCMP Flow Meter |
| | | RE036-9 | Open - Evidence of Flow | PCCMP Flow Meter |
| | | RE-002 | Closed | |
| | | RE-021 | Closed | |

| Outfall | Outfall Status (1) | Regulator | Inspection Confirmed Status | Metering Plan (2) |
|---|---|---|---|---|
| | | RE036-1 | Closed | |
| | | RE036-5 | Closed | |
| | | RE036-62 | Closed | |
| MWR018 | Open | | | Existing MWRA Meter |
| MWR019 | Open | | | No Meter Recommended |
| MWR020 | Open | | | Existing MWRA Meter |
| MWR021 | Closed | RE-161 | Unmapped location. | Internal regulator |
| | | MC-03 | Open - Evidence of Flow | Internal regulator |
| | | MC-05 | Open - Evidence of Flow | Internal regulator |
| | | MC-06 | Closed | |
| | | MC-07 | Closed | |
| MWR022 | Closed | MC-02 | Open - Evidence of Flow | Internal regulator |
| | | MC-09 | Open - Evidence of Flow | Internal regulator |
| | | MC-29 | Open - Evidence of Flow | Internal regulator |
| MWR201 (Cottage Farm) | Open | RE-042 | | Existing MWRA Meter |
| MWR023 | Open | RE046-19 | Open | PCCMP Flow Meter |
| | | RE046-30 | Open | PCCMP Flow Meter |
| | | RE046-50 | Open | PCCMP Flow Meter |
| | | RE046-55 | Open | PCCMP Flow Meter |
| | | RE046-62A | Open | PCCMP Flow Meter |
| | | RE046-80 | Closed | |
| | | RE046-90 | Open | PCCMP Flow Meter |
| | | RE046-100 | Open | PCCMP Flow Meter |
| | | RE046-105 | Open | PCCMP Flow Meter |
| | | RE046-110 | Closed | |
| | | RE046-381 | Open | PCCMP Flow Meter |
| | | RE-192 | Open - Evidence of Flow | PCCMP Flow Meter |
| | | RE-040 | Could Not Locate | Regulator is not shown on BWSC drawings. |
| | | RE-045 | Could Not Locate | Regulator is not shown on BWSC drawings. |
| | | RE046-1 | Open - Dry | MH appeared to be dry. Might act solely as a storm drain and no longer combined. |
| | | RE046-40 | Open - Evidence of Flow | Internal regulator |
| | | RE046-48 | Closed | |
| | | RE046-52 | Closed | |
| | | RE046-54 | Open - Evidence of Flow | PCCMP Flow Meter. Unmapped manhole next to 18HMH515. Blocked pipe located in 18HMH240. Unable to confirm if this inlet connects to 046-54. |
| | | RE046-59 | Other-Tidegate on pipe that is mapped as overflow. Tidegate is oriented so that it blocks flow exiting that direction. One inlet is partially blocked with sediment. This is an internal regulator which diverts flow to BMC/Prison Point and therefore does not require flow monitoring. | |
| | | RE046-60 | Closed | |

| Outfall | Outfall Status (1) | Regulator | Inspection Confirmed Status | Metering Plan (2) |
|---|---|---|---|---|
| | | RE046-61 | Other-Additional information cites mechanical fixture that needs removal. Fixture still in manhole. This is an internal regulator which diverts flow to BMC/Prison Point and therefore does not require flow monitoring. | |
| | | RE046-63 | Closed | |
| | | RE046-7 | Open - Dry | Inspection found no evidence of flow |
| | | RE046-73 | Closed | |
| | | RE-047 | Other-This MH is actually a tide gate. We could not confirm whether or not the pipes were open or closed. The structure is part of the RE046-46 regulator which diverts flow to the BMI/Prison Point and therefore does not require flow monitoring. | |
| | | RE-048 | Closed | |
| | | RE-054 | Open - Dry | Unmapped manhole upstream of 14GMH374. At the intersection of Rossmore Road and McBride Street. |
| | | RE-065 | Could Not Locate | Regulator is not shown on BWSC drawings. |
| | | RE080 | Could Not Locate | Regulator is not shown on BWSC drawings. |
| | | RE-103 | Closed | |
| | | RE-106 | Closed | |
| | | RE-128 | Closed | |
| | | RE-159 | Could Not Locate | Regulator is not shown on BWSC drawings. |
| | | RE-189 | Closed | |
| | | RE-191 | Could Not Locate | Regulator is not shown on BWSC drawings. |
| | | RE-200 | Open - Evidence of Flow | Pipes appear open but structure appears to be relatively recent construction. May have been reconfigured. |
| | | RE-296 | Closed | |
| | | RE-297 | Closed | |
| | | RE-328 | Closed | |
| | | RE-355 | Could Not Locate | Regulator is not shown on BWSC drawings. |
| | | RE-462 | Could Not Locate | Regulator is not shown on BWSC drawings. |
| SOM010 | Closed | RE-101 | Closed | |
| **NEPONSET RIVER** | | | | |
| BOS093 | Closed | RE093-2 | Closed | |
| | | RE093-4 | Closed | |
| BOS095 | Closed | RE095-1 | Could Not Locate | Structure shown on BWSC drawings |
| **BACK BAY FENS** | | | | |
| BOS046 | Open | | | Outfalls not inspected as part of this program. |

(1) Outfall status is based on Exhibit 4 Post-Construction Compliance Monitoring Plan Request for Proposal.
(2) Locations where no meter to be installed were left blank, PCCMP indicates Post-construction compliance monitoring temporary plan meter locations.

# Appendix B Rainfall Data for April, May and June , 2018

# Appendix C Rainfall Summary Tables

## Summary of Storm Events at Each Rain Gauge: April

### 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 | 4/2/2018 9:30 | 1.25 | 0.08 | 0.06 | 0.07 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 4/3/2018 13:30 | 26.5 | 0.72 | 0.03 | 0.16 | 0.03 | 0.02 | <3m | <3m | N/A |
| 3 | 4/6/2018 12:15 | 17.25 | 0.27 | 0.02 | 0.08 | 0.01 | 0.01 | <3m | <3m | N/A |
| 4 | 4/12/2018 19:00 | 1 | 0.06 | 0.06 | 0.06 | 0.00 | 0.00 | <3m | <3m | N/A |
| 5 | 4/15/2018 18:00 | 24.75 | 2.66 | 0.11 | 0.47 | 0.11 | 0.06 | <3m | 6m-1yr | N/A |
| 6 | 4/19/2018 6:00 | 8 | 0.21 | 0.03 | 0.08 | 0.01 | 0.00 | <3m | <3m | N/A |
| 7 | 4/25/2018 5:15 | 25.75 | 1.3 | 0.05 | 0.3 | 0.05 | 0.03 | <3m | <3m | N/A |
| 8 | 4/27/2018 12:15 | 4.75 | 0.33 | 0.07 | 0.13 | 0.01 | 0.03 | <3m | <3m | N/A |
| 9 | 4/29/2018 7:45 | 2.75 | 0.04 | 0.01 | 0.02 | 0.00 | 0.01 | <3m | <3m | N/A |
| 10 | 4/30/2018 9:45 | 12 | 0.16 | 0.01 | 0.05 | 0.01 | 0.00 | <3m | <3m | N/A |

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

### 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 | 4/2/2018 9:30 | 3 | 0.11 | 0.04 | 0.06 | 0.00 | 0.00 | <3m | <3m | <3m |
| 2 | 4/3/2018 14:45 | 26.25 | 0.75 | 0.03 | 0.16 | 0.03 | 0.02 | <3m | <3m | <3m |
| 3 | 4/6/2018 13:15 | 17 | 0.21 | 0.01 | 0.08 | 0.01 | 0.01 | <3m | <3m | <3m |
| 4 | 4/12/2018 20:15 | 1 | 0.06 | 0.06 | 0.06 | 0.00 | 0.00 | <3m | <3m | <3m |
| 5 | 4/15/2018 21:45 | 22 | 2.43 | 0.11 | 0.47 | 0.10 | 0.05 | <3m | 6m | <3m |
| 6 | 4/19/2018 7:00 | 8.75 | 0.24 | 0.03 | 0.09 | 0.01 | 0.01 | <3m | <3m | <3m |
| 7 | 4/25/2018 6:30 | 25.5 | 1.07 | 0.04 | 0.29 | 0.04 | 0.02 | <3m | <3m | <3m |
| 8 | 4/27/2018 13:30 | 4.5 | 0.42 | 0.09 | 0.15 | 0.02 | 0.02 | <3m | <3m | <3m |
| 9 | 4/29/2018 9:00 | 2.5 | 0.05 | 0.02 | 0.03 | 0.00 | 0.01 | <3m | <3m | <3m |
| 10 | 4/30/2018 11:00 | 12 | 0.17 | 0.01 | 0.05 | 0.01 | 0.00 | <3m | <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.

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 | 4/2/2018 9:45 | 2.25 | 0.09 | 0.04 | 0.06 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 4/3/2018 14:30 | 26.75 | 0.7 | 0.03 | 0.16 | 0.02 | 0.01 | <3m | <3m | N/A |
| 3 | 4/6/2018 14:00 | 11.25 | 0.19 | 0.02 | 0.08 | 0.01 | 0.01 | <3m | <3m | N/A |
| 4 | 4/12/2018 20:15 | 1 | 0.04 | 0.04 | 0.04 | 0.00 | 0.00 | <3m | <3m | N/A |
| 5 | 4/15/2018 21:30 | 22.25 | 2.15 | 0.10 | 0.4 | 0.09 | 0.04 | <3m | 3-6m | N/A |
| 6 | 4/19/2018 7:00 | 9.75 | 0.22 | 0.02 | 0.08 | 0.01 | 0.00 | <3m | <3m | N/A |
| 7 | 4/25/2018 6:30 | 25.5 | 0.99 | 0.04 | 0.26 | 0.04 | 0.02 | <3m | <3m | N/A |
| 8 | 4/27/2018 13:15 | 5 | 0.56 | 0.11 | 0.28 | 0.02 | 0.02 | <3m | <3m | N/A |
| 9 | 4/29/2018 10:15 | 1.25 | 0.04 | 0.03 | 0.03 | 0.00 | 0.01 | <3m | <3m | N/A |
| 10 | 4/30/2018 12:15 | 11 | 0.19 | 0.02 | 0.06 | 0.01 | 0.00 | <3m | <3m | N/A |

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

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 | 4/2/2018 10:30 | 2 | 0.1 | 0.05 | 0.09 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 4/3/2018 13:45 | 26.25 | 0.68 | 0.03 | 0.14 | 0.02 | 0.01 | <3m | <3m | N/A |
| 3 | 4/6/2018 13:15 | 16.25 | 0.23 | 0.01 | 0.08 | 0.01 | 0.01 | <3m | <3m | N/A |
| 4 | 4/12/2018 19:15 | 1 | 0.05 | 0.05 | 0.05 | 0.00 | 0.00 | <3m | <3m | N/A |
| 5 | 4/15/2018 20:00 | 28.5 | 2 | 0.07 | 0.41 | 0.08 | 0.04 | <3m | 3m | N/A |
| 6 | 4/19/2018 6:15 | 3.75 | 0.21 | 0.06 | 0.09 | 0.01 | 0.00 | <3m | <3m | N/A |
| 7 | 4/25/2018 5:45 | 25.25 | 0.98 | 0.04 | 0.25 | 0.04 | 0.02 | <3m | <3m | N/A |
| 8 | 4/27/2018 12:30 | 4.5 | 0.38 | 0.08 | 0.14 | 0.02 | 0.02 | <3m | <3m | N/A |
| 9 | 4/29/2018 7:45 | 2.75 | 0.06 | 0.02 | 0.04 | 0.00 | 0.01 | <3m | <3m | N/A |
| 10 | 4/30/2018 10:15 | 11.75 | 0.26 | 0.02 | 0.11 | 0.01 | 0.01 | <3m | <3m | N/A |

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

## 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 | 4/2/2018 11:45 | 2.25 | 0.08 | 0.04 | 0.07 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 4/3/2018 15:00 | 26.75 | 0.65 | 0.02 | 0.13 | 0.02 | 0.01 | <3m | <3m | N/A |
| 3 | 4/6/2018 13:45 | 23 | 0.22 | 0.01 | 0.08 | 0.01 | 0.01 | <3m | <3m | N/A |
| 4 | 4/12/2018 20:30 | 0.75 | 0.04 | 0.05 | 0.04 | 0.00 | 0.00 | <3m | <3m | N/A |
| 5 | 4/15/2018 18:30 | 25.5 | 2.23 | 0.09 | 0.28 | 0.09 | 0.05 | <3m | 3-6m | N/A |
| 6 | 4/19/2018 7:15 | 3.25 | 0.21 | 0.06 | 0.09 | 0.01 | 0.00 | <3m | <3m | N/A |
| 7 | 4/25/2018 6:45 | 25.5 | 1.01 | 0.04 | 0.28 | 0.04 | 0.02 | <3m | <3m | N/A |
| 8 | 4/27/2018 13:30 | 6.75 | 0.48 | 0.07 | 0.2 | 0.02 | 0.02 | <3m | <3m | N/A |
| 9 | 4/29/2018 9:15 | 2.5 | 0.05 | 0.02 | 0.03 | 0.00 | 0.01 | <3m | <3m | N/A |
| 10 | 4/30/2018 11:00 | 12 | 0.2 | 0.02 | 0.07 | 0.01 | 0.01 | <3m | <3m | N/A |

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

## 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 | 4/2/2018 10:30 | 0.5 | 0.09 | 0.18 | 0.09 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 4/3/2018 13:15 | 26.75 | 0.68 | 0.03 | 0.16 | 0.02 | 0.01 | <3m | <3m | N/A |
| 3 | 4/6/2018 12:15 | 11.25 | 0.21 | 0.02 | 0.13 | 0.01 | 0.01 | <3m | <3m | N/A |
| 4 | 4/12/2018 19:15 | 1.25 | 0.05 | 0.04 | 0.04 | 0.00 | 0.00 | <3m | <3m | N/A |
| 5 | 4/15/2018 17:00 | 25.75 | 2.27 | 0.09 | 0.51 | 0.09 | 0.05 | <3m | 3-6m | N/A |
| 6 | 4/19/2018 6:15 | 9.25 | 0.2 | 0.02 | 0.08 | 0.01 | 0.00 | <3m | <3m | N/A |
| 7 | 4/25/2018 5:30 | 25.75 | 1.01 | 0.04 | 0.24 | 0.04 | 0.02 | <3m | <3m | N/A |
| 8 | 4/27/2018 12:45 | 11.25 | 0.49 | 0.04 | 0.24 | 0.02 | 0.02 | <3m | <3m | N/A |
| 9 | 4/29/2018 9:15 | 1 | 0.03 | 0.03 | 0.03 | 0.00 | 0.01 | <3m | <3m | N/A |
| 10 | 4/30/2018 10:15 | 12 | 0.26 | 0.02 | 0.08 | 0.01 | 0.01 | <3m | <3m | N/A |

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

## 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 | 4/2/2018 10:15 | 0.75 | 0.08 | 0.11 | 0.08 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 4/3/2018 13:15 | 26.75 | 0.73 | 0.03 | 0.18 | 0.03 | 0.02 | <3m | <3m | N/A |
| 3 | 4/6/2018 12:15 | 12 | 0.21 | 0.02 | 0.11 | 0.01 | 0.01 | <3m | <3m | N/A |
| 4 | 4/12/2018 19:15 | 1 | 0.05 | 0.05 | 0.05 | 0.00 | 0.00 | <3m | <3m | N/A |
| 5 | 4/15/2018 17:00 | 25.75 | 2.6 | 0.10 | 0.44 | 0.11 | 0.05 | <3m | 6m-1yr | N/A |
| 6 | 4/19/2018 6:00 | 9.5 | 0.22 | 0.02 | 0.09 | 0.01 | 0.00 | <3m | <3m | N/A |
| 7 | 4/25/2018 5:15 | 25.75 | 1.01 | 0.04 | 0.27 | 0.04 | 0.02 | <3m | <3m | N/A |
| 8 | 4/27/2018 12:15 | 7.25 | 0.49 | 0.07 | 0.25 | 0.02 | 0.02 | <3m | <3m | N/A |
| 9 | 4/29/2018 9:00 | 1.5 | 0.05 | 0.03 | 0.04 | 0.00 | 0.01 | <3m | <3m | N/A |
| 10 | 4/30/2018 12:00 | 10 | 0.19 | 0.02 | 0.05 | 0.01 | 0.01 | <3m | <3m | N/A |

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

## 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 | 4/2/2018 10:15 | 0.75 | 0.06 | 0.08 | 0.06 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 4/3/2018 13:45 | 26.25 | 0.68 | 0.03 | 0.15 | 0.02 | 0.01 | <3m | <3m | N/A |
| 3 | 4/6/2018 12:30 | 16.75 | 0.22 | 0.01 | 0.07 | 0.01 | 0.01 | <3m | <3m | N/A |
| 4 | 4/12/2018 19:15 | 1 | 0.05 | 0.05 | 0.05 | 0.00 | 0.00 | <3m | <3m | N/A |
| 5 | 4/15/2018 18:00 | 24.75 | 2 | 0.08 | 0.29 | 0.08 | 0.04 | <3m | 3m | N/A |
| 6 | 4/19/2018 6:15 | 9.75 | 0.22 | 0.02 | 0.09 | 0.01 | 0.00 | <3m | <3m | N/A |
| 7 | 4/25/2018 5:45 | 25.25 | 0.96 | 0.04 | 0.26 | 0.04 | 0.02 | <3m | <3m | N/A |
| 8 | 4/27/2018 12:15 | 4.75 | 0.44 | 0.09 | 0.19 | 0.02 | 0.02 | <3m | <3m | N/A |
| 9 | 4/29/2018 8:00 | 2.75 | 0.05 | 0.02 | 0.03 | 0.00 | 0.01 | <3m | <3m | N/A |
| 10 | 4/30/2018 13:00 | 9 | 0.22 | 0.02 | 0.09 | 0.01 | 0.01 | <3m | <3m | N/A |

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

## Rain Gauge 9: Hanscom AFB [2]

| 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 | 4/2/2018 9:45 | 3 | 0.07 | 0.02 | 0.04 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 4/3/2018 14:45 | 36 | 0.63 | 0.02 | 0.13 | 0.02 | 0.01 | <3m | <3m | N/A |
| 3 | 4/6/2018 13:30 | 17.25 | 0.25 | 0.01 | 0.09 | 0.01 | 0.01 | <3m | <3m | N/A |
| 4 | 4/12/2018 20:15 | 1.25 | 0.07 | 0.06 | 0.06 | 0.00 | 0.00 | <3m | <3m | N/A |
| 5 | 4/16/2018 0:00 | 29.5 | 2.69 | 0.09 | 0.56 | 0.11 | 0.06 | 3m | 1y | N/A |
| 6 | 4/19/2018 7:15 | 11.25 | 0.22 | 0.02 | 0.09 | 0.01 | 0.00 | <3m | <3m | N/A |
| 7 | 4/25/2018 6:45 | 25.5 | 1.42 | 0.06 | 0.36 | 0.06 | 0.03 | <3m | <3m | N/A |
| 8 | 4/27/2018 13:45 | 4.25 | 0.3 | 0.07 | 0.17 | 0.01 | 0.03 | <3m | <3m | N/A |
| 9 | 4/29/2018 8:45 | 6.25 | 0.13 | 0.02 | 0.08 | 0.01 | 0.01 | <3m | <3m | N/A |
| 10 | 4/30/2018 11:15 | 10 | 0.09 | 0.01 | 0.05 | 0.00 | 0.00 | <3m | <3m | N/A |

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

(2) Hanscom AFB rainfall data was replaced with LexFarm_RG rainfall data from 4/15/2018 0:00 through 6/30/2018 23:45

## 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 | 4/2/2018 10:15 | 0.75 | 0.09 | 0.12 | 0.09 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 4/3/2018 13:15 | 26.75 | 0.71 | 0.03 | 0.18 | 0.03 | 0.01 | <3m | <3m | N/A |
| 3 | 4/6/2018 12:00 | 12 | 0.22 | 0.02 | 0.09 | 0.01 | 0.01 | <3m | <3m | N/A |
| 4 | 4/12/2018 19:00 | 1 | 0.04 | 0.04 | 0.04 | 0.00 | 0.00 | <3m | <3m | N/A |
| 5 | 4/15/2018 15:30 | 27.25 | 2.61 | 0.10 | 0.55 | 0.11 | 0.05 | 3m | 6m-1yr | N/A |
| 6 | 4/19/2018 6:00 | 12.25 | 0.26 | 0.02 | 0.09 | 0.01 | 0.01 | <3m | <3m | N/A |
| 7 | 4/25/2018 5:15 | 25.75 | 1.06 | 0.04 | 0.23 | 0.04 | 0.02 | <3m | <3m | N/A |
| 8 | 4/27/2018 12:15 | 4.5 | 0.45 | 0.10 | 0.2 | 0.02 | 0.02 | <3m | <3m | N/A |
| 9 | 4/29/2018 7:45 | 2.5 | 0.04 | 0.02 | 0.02 | 0.00 | 0.01 | <3m | <3m | N/A |
| 10 | 4/30/2018 9:00 | 13.25 | 0.3 | 0.02 | 0.07 | 0.01 | 0.01 | <3m | <3m | N/A |

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

## 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 | 4/2/2018 9:45 | 3 | 0.07 | 0.02 | 0.04 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 4/3/2018 14:45 | 36 | 0.63 | 0.02 | 0.13 | 0.02 | 0.01 | <3m | <3m | N/A |
| 3 | 4/6/2018 13:30 | 17.25 | 0.25 | 0.01 | 0.09 | 0.01 | 0.01 | <3m | <3m | N/A |
| 4 | 4/12/2018 20:15 | 1.25 | 0.07 | 0.06 | 0.06 | 0.00 | 0.00 | <3m | <3m | N/A |
| 5 | 4/16/2018 0:00 | 29.5 | 2.69 | 0.09 | 0.56 | 0.11 | 0.06 | 3m | 1y | N/A |
| 6 | 4/19/2018 7:15 | 11.25 | 0.22 | 0.02 | 0.09 | 0.01 | 0.00 | <3m | <3m | N/A |
| 7 | 4/25/2018 6:45 | 25.5 | 1.42 | 0.06 | 0.36 | 0.06 | 0.03 | <3m | <3m | N/A |
| 8 | 4/27/2018 13:45 | 4.25 | 0.3 | 0.07 | 0.17 | 0.01 | 0.03 | <3m | <3m | N/A |
| 9 | 4/29/2018 8:45 | 6.25 | 0.13 | 0.02 | 0.08 | 0.01 | 0.01 | <3m | <3m | N/A |
| 10 | 4/30/2018 11:15 | 10 | 0.09 | 0.01 | 0.05 | 0.00 | 0.00 | <3m | <3m | N/A |

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

## 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 | 4/2/2018 10:15 | 1.25 | 0.08 | 0.06 | 0.07 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 4/3/2018 13:30 | 27.5 | 0.74 | 0.03 | 0.15 | 0.03 | 0.02 | <3m | <3m | N/A |
| 3 | 4/6/2018 12:15 | 17 | 0.24 | 0.01 | 0.08 | 0.01 | 0.01 | <3m | <3m | N/A |
| 4 | 4/12/2018 19:00 | 1 | 0.05 | 0.05 | 0.05 | 0.00 | 0.00 | <3m | <3m | N/A |
| 5 | 4/15/2018 17:15 | 25.5 | 2.38 | 0.09 | 0.44 | 0.10 | 0.05 | <3m | 6m | N/A |
| 6 | 4/19/2018 6:00 | 9.75 | 0.23 | 0.02 | 0.09 | 0.01 | 0.00 | <3m | <3m | N/A |
| 7 | 4/25/2018 5:30 | 25.5 | 1.07 | 0.04 | 0.28 | 0.04 | 0.02 | <3m | <3m | N/A |
| 8 | 4/27/2018 12:30 | 4.25 | 0.34 | 0.08 | 0.13 | 0.01 | 0.02 | <3m | <3m | N/A |
| 9 | 4/29/2018 7:45 | 6 | 0.05 | 0.01 | 0.03 | 0.00 | 0.01 | <3m | <3m | N/A |
| 10 | 4/30/2018 9:30 | 13.5 | 0.17 | 0.01 | 0.04 | 0.01 | 0.00 | <3m | <3m | N/A |

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

## 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 | 4/2/2018 10:45 | 1.75 | 0.08 | 0.05 | 0.07 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 4/3/2018 15:45 | 25.75 | 0.66 | 0.03 | 0.15 | 0.02 | 0.01 | <3m | <3m | N/A |
| 3 | 4/6/2018 13:30 | 17.25 | 0.36 | 0.02 | 0.11 | 0.02 | 0.01 | <3m | <3m | N/A |
| 4 | 4/12/2018 20:00 | 1.25 | 0.1 | 0.08 | 0.09 | 0.00 | 0.00 | <3m | <3m | N/A |
| 5 | 4/15/2018 21:00 | 25.75 | 2.49 | 0.10 | 0.54 | 0.10 | 0.05 | 3m | 6m-1yr | N/A |
| 6 | 4/19/2018 7:15 | 11.5 | 0.23 | 0.02 | 0.1 | 0.01 | 0.00 | <3m | <3m | N/A |
| 7 | 4/25/2018 7:15 | 24.75 | 1.25 | 0.05 | 0.43 | 0.05 | 0.03 | <3m | <3m | N/A |
| 8 | 4/27/2018 13:45 | 4.25 | 0.25 | 0.06 | 0.12 | 0.01 | 0.03 | <3m | <3m | N/A |
| 9 | 4/29/2018 9:00 | 6.25 | 0.08 | 0.01 | 0.05 | 0.00 | 0.01 | <3m | <3m | N/A |
| 10 | 4/30/2018 19:00 | 3.5 | 0.06 | 0.02 | 0.03 | 0.00 | 0.00 | <3m | <3m | N/A |

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

## 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 | 4/2/2018 10:15 | 0.75 | 0.08 | 0.11 | 0.08 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 4/3/2018 13:15 | 26.75 | 0.78 | 0.03 | 0.17 | 0.03 | 0.02 | <3m | <3m | N/A |
| 3 | 4/6/2018 12:15 | 16.75 | 0.24 | 0.01 | 0.16 | 0.01 | 0.01 | <3m | <3m | N/A |
| 4 | 4/12/2018 19:00 | 1 | 0.05 | 0.05 | 0.05 | 0.00 | 0.00 | <3m | <3m | N/A |
| 5 | 4/15/2018 14:45 | 27.75 | 2.8 | 0.10 | 0.56 | 0.12 | 0.06 | 3m | 1y | N/A |
| 6 | 4/19/2018 6:00 | 9.75 | 0.21 | 0.02 | 0.09 | 0.01 | 0.00 | <3m | <3m | N/A |
| 7 | 4/25/2018 5:15 | 25.5 | 1.15 | 0.05 | 0.27 | 0.05 | 0.02 | <3m | <3m | N/A |
| 8 | 4/27/2018 12:30 | 4.75 | 0.42 | 0.09 | 0.17 | 0.02 | 0.02 | <3m | <3m | N/A |
| 9 | 4/29/2018 7:45 | 2.5 | 0.04 | 0.02 | 0.02 | 0.00 | 0.01 | <3m | <3m | N/A |
| 10 | 4/30/2018 9:00 | 11.75 | 0.22 | 0.02 | 0.06 | 0.01 | 0.01 | <3m | <3m | N/A |

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

## 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 | 4/2/2018 10:15 | 0.75 | 0.09 | 0.12 | 0.09 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 4/3/2018 13:15 | 26.75 | 0.82 | 0.03 | 0.19 | 0.03 | 0.02 | <3m | <3m | N/A |
| 3 | 4/6/2018 12:15 | 17.5 | 0.25 | 0.01 | 0.13 | 0.01 | 0.01 | <3m | <3m | N/A |
| 4 | 4/12/2018 19:15 | 1 | 0.05 | 0.05 | 0.05 | 0.00 | 0.00 | <3m | <3m | N/A |
| 5 | 4/15/2018 16:45 | 26 | 2.63 | 0.10 | 0.45 | 0.11 | 0.05 | <3m | 6m-1yr | N/A |
| 6 | 4/19/2018 6:15 | 9.75 | 0.23 | 0.02 | 0.09 | 0.01 | 0.00 | <3m | <3m | N/A |
| 7 | 4/25/2018 5:30 | 26.25 | 1.06 | 0.04 | 0.28 | 0.04 | 0.02 | <3m | <3m | N/A |
| 8 | 4/27/2018 12:30 | 9.5 | 0.42 | 0.04 | 0.18 | 0.02 | 0.02 | <3m | <3m | N/A |
| 9 | 4/29/2018 9:00 | 1.5 | 0.05 | 0.03 | 0.04 | 0.00 | 0.01 | <3m | <3m | N/A |
| 10 | 4/30/2018 10:15 | 12 | 0.22 | 0.02 | 0.06 | 0.01 | 0.01 | <3m | <3m | N/A |

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

## Rain Gauge 16: Somerville (2)

| 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 | 4/2/2018 10:30 | 2 | 0.1 | 0.05 | 0.04 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 4/3/2018 13:45 | 26.25 | 0.68 | 0.03 | 0.05 | 0.02 | 0.01 | <3m | <3m | N/A |
| 3 | 4/6/2018 13:15 | 16.25 | 0.23 | 0.01 | 0.03 | 0.01 | 0.01 | <3m | <3m | N/A |
| 4 | 4/12/2018 19:15 | 1 | 0.05 | 0.05 | 0.02 | 0.00 | 0.00 | <3m | <3m | N/A |
| 5 | 4/15/2018 20:00 | 28.5 | 2 | 0.07 | 0.26 | 0.08 | 0.04 | <3m | 3m | N/A |
| 6 | 4/19/2018 6:15 | 3.75 | 0.21 | 0.06 | 0.03 | 0.01 | 0.00 | <3m | <3m | N/A |
| 7 | 4/25/2018 5:45 | 25.25 | 0.98 | 0.04 | 0.1 | 0.04 | 0.02 | <3m | <3m | N/A |
| 8 | 4/27/2018 12:30 | 4.5 | 0.38 | 0.08 | 0.07 | 0.02 | 0.02 | <3m | <3m | N/A |
| 9 | 4/29/2018 7:45 | 2.75 | 0.06 | 0.02 | 0.02 | 0.00 | 0.01 | <3m | <3m | N/A |
| 10 | 4/30/2018 10:15 | 11.75 | 0.26 | 0.02 | 0.04 | 0.01 | 0.01 | <3m | <3m | N/A |

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

(2) Somerville rainfall data was replaced with Charleston rainfall data from 4/15/2018 0:00 through 6/30/2018 23:45

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 | 4/2/2018 10:30 | 2 | 0.1 | 0.05 | 0.09 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 4/3/2018 13:45 | 26.25 | 0.68 | 0.03 | 0.14 | 0.02 | 0.01 | <3m | <3m | N/A |
| 3 | 4/6/2018 13:15 | 16.25 | 0.23 | 0.01 | 0.08 | 0.01 | 0.01 | <3m | <3m | N/A |
| 4 | 4/12/2018 19:15 | 1 | 0.05 | 0.05 | 0.05 | 0.00 | 0.00 | <3m | <3m | N/A |
| 5 | 4/15/2018 15:00 | 29 | 2.58 | 0.09 | 0.54 | 0.11 | 0.05 | 3m | 6m-1yr | N/A |
| 6 | 4/19/2018 7:15 | 10.5 | 0.23 | 0.02 | 0.12 | 0.01 | 0.00 | <3m | <3m | N/A |
| 7 | 4/25/2018 7:00 | 25.25 | 1.27 | 0.05 | 0.31 | 0.05 | 0.03 | <3m | <3m | N/A |
| 8 | 4/27/2018 13:30 | 16.25 | 0.3 | 0.02 | 0.14 | 0.01 | 0.02 | <3m | <3m | N/A |
| 9 | 4/29/2018 9:00 | 6 | 0.06 | 0.01 | 0.04 | 0.00 | 0.01 | <3m | <3m | N/A |
| 10 | 4/30/2018 13:00 | 9.75 | 0.13 | 0.01 | 0.03 | 0.01 | 0.00 | <3m | <3m | N/A |

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

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 | 4/2/2018 10:00 | 1 | 0.08 | 0.08 | 0.08 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 4/3/2018 13:15 | 26.75 | 0.75 | 0.03 | 0.17 | 0.03 | 0.02 | <3m | <3m | N/A |
| 3 | 4/6/2018 12:30 | 16.5 | 0.23 | 0.01 | 0.08 | 0.01 | 0.01 | <3m | <3m | N/A |
| 4 | 4/12/2018 19:15 | 1 | 0.05 | 0.05 | 0.05 | 0.00 | 0.00 | <3m | <3m | N/A |
| 5 | 4/15/2018 18:00 | 24.75 | 2.49 | 0.10 | 0.49 | 0.10 | 0.05 | <3m | 6m-1yr | N/A |
| 6 | 4/19/2018 6:00 | 9.75 | 0.22 | 0.02 | 0.09 | 0.01 | 0.00 | <3m | <3m | N/A |
| 7 | 4/25/2018 5:30 | 25.5 | 1.01 | 0.04 | 0.28 | 0.04 | 0.02 | <3m | <3m | N/A |
| 8 | 4/27/2018 12:30 | 4.25 | 0.41 | 0.10 | 0.17 | 0.02 | 0.02 | <3m | <3m | N/A |
| 9 | 4/29/2018 7:45 | 2.5 | 0.06 | 0.02 | 0.05 | 0.00 | 0.01 | <3m | <3m | N/A |
| 10 | 4/30/2018 12:45 | 9.25 | 0.19 | 0.02 | 0.08 | 0.01 | 0.01 | <3m | <3m | N/A |

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

## 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 | 4/2/2018 9:45 | 3 | 0.07 | 0.02 | 0.04 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 4/3/2018 14:45 | 36 | 0.63 | 0.02 | 0.13 | 0.02 | 0.01 | <3m | <3m | N/A |
| 3 | 4/6/2018 13:30 | 17.25 | 0.25 | 0.01 | 0.09 | 0.01 | 0.01 | <3m | <3m | N/A |
| 4 | 4/12/2018 20:15 | 1.25 | 0.07 | 0.06 | 0.06 | 0.00 | 0.00 | <3m | <3m | N/A |
| 5 | 4/15/2018 21:30 | 22.75 | 2.06 | 0.09 | 0.4 | 0.09 | 0.04 | <3m | 3-6m | N/A |
| 6 | 4/19/2018 7:30 | 10.75 | 0.21 | 0.02 | 0.09 | 0.01 | 0.00 | <3m | <3m | N/A |
| 7 | 4/25/2018 6:45 | 25.5 | 1.3 | 0.05 | 0.28 | 0.05 | 0.03 | <3m | <3m | N/A |
| 8 | 4/27/2018 10:15 | 7.75 | 0.88 | 0.11 | 0.62 | 0.04 | 0.04 | 3-6m | <3m | N/A |
| 9 | 4/29/2018 8:45 | 7.5 | 0.06 | 0.01 | 0.03 | 0.00 | 0.02 | <3m | <3m | N/A |
| 10 | 4/30/2018 11:30 | 10.75 | 0.15 | 0.01 | 0.04 | 0.01 | 0.00 | <3m | <3m | N/A |

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

## 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 | 4/2/2018 9:30 | 1.25 | 0.08 | 0.06 | 0.07 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 4/3/2018 13:30 | 26.5 | 0.72 | 0.03 | 0.16 | 0.03 | 0.02 | <3m | <3m | N/A |
| 3 | 4/6/2018 12:15 | 17.25 | 0.27 | 0.02 | 0.08 | 0.01 | 0.01 | <3m | <3m | N/A |
| 4 | 4/12/2018 19:00 | 1 | 0.06 | 0.06 | 0.06 | 0.00 | 0.00 | <3m | <3m | N/A |
| 5 | 4/15/2018 18:00 | 25.75 | 2.78 | 0.11 | 0.54 | 0.12 | 0.06 | 3m | 1y | N/A |
| 6 | 4/19/2018 7:15 | 10.25 | 0.22 | 0.02 | 0.09 | 0.01 | 0.00 | <3m | <3m | N/A |
| 7 | 4/25/2018 6:45 | 25.25 | 1.42 | 0.06 | 0.32 | 0.06 | 0.03 | <3m | <3m | N/A |
| 8 | 4/27/2018 13:30 | 4 | 0.27 | 0.07 | 0.15 | 0.01 | 0.03 | <3m | <3m | N/A |
| 9 | 4/29/2018 8:30 | 6.25 | 0.06 | 0.01 | 0.03 | 0.00 | 0.01 | <3m | <3m | N/A |
| 10 | 4/30/2018 10:45 | 11 | 0.1 | 0.01 | 0.04 | 0.00 | 0.00 | <3m | <3m | N/A |

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

## Summary of Storm Events at Each Rain Gauge: May

### 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 | 5/3/2018 14:30 | 0.5 | 0.05 | 0.10 | 0.05 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 5/4/2018 6:15 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 3 | 5/6/2018 20:15 | 2.25 | 0.25 | 0.11 | 0.21 | 0.01 | 0.01 | <3m | <3m | N/A |
| 4 | 5/10/2018 3:15 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 5 | 5/12/2018 11:00 | 9 | 0.28 | 0.03 | 0.66 | 0.01 | 0.01 | 3-6m | <3m | N/A |
| 6 | 5/15/2018 16:15 | 2.75 | 0.95 | 0.35 | 0.66 | 0.04 | 0.02 | 3-6m | <3m | N/A |
| 7 | 5/19/2018 12:00 | 14.5 | 0.29 | 0.02 | 0.07 | 0.01 | 0.01 | <3m | <3m | N/A |
| 8 | 5/20/2018 17:15 | 0.5 | 0.02 | 0.04 | 0.02 | 0.01 | 0.01 | <3m | <3m | N/A |
| 9 | 5/22/2018 13:15 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 10 | 5/23/2018 19:15 | 1.25 | 0.07 | 0.06 | 0.05 | 0.00 | 0.00 | <3m | <3m | N/A |
| 11 | 5/27/2018 16:45 | 12.25 | 0.08 | 0.01 | 0.03 | 0.00 | 0.00 | <3m | <3m | N/A |

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

### Rain Gauge 2: Ward St. (2)

| 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 | 5/3/2018 15:30 | 0.5 | 0.04 | 0.08 | 0.04 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 5/4/2018 5:15 | 6 | 0.02 | 0.00 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 3 | 5/6/2018 21:00 | 4 | 0.24 | 0.06 | 0.17 | 0.01 | 0.01 | <3m | <3m | N/A |
| 4 | 5/10/2018 4:15 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 5 | 5/12/2018 12:15 | 7.25 | 0.25 | 0.03 | 0.12 | 0.01 | 0.01 | <3m | <3m | N/A |
| 6 | 5/15/2018 17:15 | 3 | 0.98 | 0.33 | 0.67 | 0.04 | 0.02 | 3-6m | <3m | N/A |
| 7 | 5/19/2018 13:00 | 14.75 | 0.28 | 0.02 | 0.06 | 0.01 | 0.01 | <3m | <3m | N/A |
| 8 | 5/20/2018 15:45 | 3 | 0.04 | 0.01 | 0.03 | 0.01 | 0.01 | <3m | <3m | N/A |
| 9 | 5/22/2018 19:45 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 10 | 5/23/2018 20:30 | 1.25 | 0.05 | 0.04 | 0.04 | 0.00 | 0.00 | <3m | <3m | N/A |
| 11 | 5/27/2018 18:15 | 12.5 | 0.08 | 0.01 | 0.02 | 0.00 | 0.00 | <3m | <3m | N/A |

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

(2) Ward St. rainfall data was replaced with Longwood Medical rainfall data from 5/21/2018 9:00 through 5/21/2018 10:30

## 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 | 5/3/2018 15:45 | 0.25 | 0.03 | 0.12 | 0.03 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 5/4/2018 5:45 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 3 | 5/6/2018 21:15 | 7 | 0.23 | 0.03 | 0.16 | 0.01 | 0.00 | <3m | <3m | N/A |
| 4 | 5/10/2018 2:00 | 2.75 | 0.02 | 0.01 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 5 | 5/12/2018 12:30 | 7 | 0.21 | 0.03 | 0.1 | 0.01 | 0.00 | <3m | <3m | N/A |
| 6 | 5/15/2018 17:15 | 3.75 | 1.06 | 0.28 | 0.73 | 0.04 | 0.02 | 6m | <3m | N/A |
| 7 | 5/19/2018 13:00 | 13.25 | 0.3 | 0.02 | 0.06 | 0.01 | 0.01 | <3m | <3m | N/A |
| 8 | 5/20/2018 15:45 | 3 | 0.05 | 0.02 | 0.04 | 0.01 | 0.01 | <3m | <3m | N/A |
| 9 | 5/22/2018 19:45 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 10 | 5/27/2018 17:30 | 14.75 | 0.12 | 0.01 | 0.02 | 0.01 | 0.00 | <3m | <3m | N/A |

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

## 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 | 5/3/2018 14:45 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 5/6/2018 20:30 | 2 | 0.22 | 0.11 | 0.18 | 0.01 | 0.00 | <3m | <3m | N/A |
| 3 | 5/10/2018 2:45 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 4 | 5/12/2018 11:15 | 6.75 | 0.2 | 0.03 | 0.1 | 0.01 | 0.00 | <3m | <3m | N/A |
| 5 | 5/15/2018 16:15 | 2.5 | 1.08 | 0.43 | 0.78 | 0.05 | 0.02 | 6m-1yr | <3m | N/A |
| 6 | 5/19/2018 12:15 | 14.5 | 0.25 | 0.02 | 0.05 | 0.01 | 0.01 | <3m | <3m | N/A |
| 7 | 5/20/2018 14:45 | 0.5 | 0.05 | 0.10 | 0.05 | 0.01 | 0.01 | <3m | <3m | N/A |
| 8 | 5/22/2018 12:45 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 9 | 5/23/2018 19:15 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 10 | 5/27/2018 19:15 | 12.25 | 0.07 | 0.01 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |

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

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 | 5/4/2018 8:45 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 5/6/2018 21:15 | 2.25 | 0.23 | 0.10 | 0.18 | 0.01 | 0.00 | <3m | <3m | N/A |
| 3 | 5/10/2018 0:00 | 4.25 | 0.03 | 0.01 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 4 | 5/12/2018 12:30 | 6.25 | 0.2 | 0.03 | 0.11 | 0.01 | 0.00 | <3m | <3m | N/A |
| 5 | 5/15/2018 17:15 | 4 | 1.29 | 0.32 | 0.96 | 0.05 | 0.03 | 1y | <3m | N/A |
| 6 | 5/19/2018 13:30 | 14 | 0.26 | 0.02 | 0.05 | 0.01 | 0.01 | <3m | <3m | N/A |
| 7 | 5/20/2018 15:45 | 0.5 | 0.05 | 0.10 | 0.05 | 0.01 | 0.01 | <3m | <3m | N/A |
| 8 | 5/22/2018 13:45 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 9 | 5/27/2018 19:15 | 13 | 0.12 | 0.01 | 0.02 | 0.01 | 0.00 | <3m | <3m | N/A |

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

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 | 5/3/2018 14:45 | 0.25 | 0.03 | 0.12 | 0.03 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 5/4/2018 5:15 | 1 | 0.02 | 0.02 | 0.02 | 0.00 | 0.00 | <3m | <3m | N/A |
| 3 | 5/6/2018 20:15 | 6.5 | 0.2 | 0.03 | 0.12 | 0.01 | 0.00 | <3m | <3m | N/A |
| 4 | 5/10/2018 2:15 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 5 | 5/12/2018 11:15 | 7.5 | 0.15 | 0.02 | 0.06 | 0.01 | 0.00 | <3m | <3m | N/A |
| 6 | 5/15/2018 16:30 | 4 | 1.07 | 0.27 | 0.75 | 0.04 | 0.02 | 6m-1yr | <3m | N/A |
| 7 | 5/19/2018 12:15 | 13.75 | 0.26 | 0.02 | 0.06 | 0.01 | 0.01 | <3m | <3m | N/A |
| 8 | 5/20/2018 14:30 | 0.5 | 0.05 | 0.10 | 0.05 | 0.01 | 0.01 | <3m | <3m | N/A |
| 9 | 5/22/2018 13:15 | 4.75 | 0.03 | 0.01 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 10 | 5/23/2018 19:45 | 1 | 0.22 | 0.22 | 0.22 | 0.01 | 0.01 | <3m | <3m | N/A |
| 11 | 5/27/2018 0:45 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 12 | 5/27/2018 16:45 | 13.75 | 0.11 | 0.01 | 0.03 | 0.00 | 0.00 | <3m | <3m | N/A |

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

## 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 | 5/3/2018 14:30 | 0.5 | 0.04 | 0.08 | 0.04 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 5/4/2018 6:00 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 3 | 5/6/2018 20:15 | 2.5 | 0.18 | 0.07 | 0.13 | 0.01 | 0.00 | <3m | <3m | N/A |
| 4 | 5/10/2018 3:00 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 5 | 5/12/2018 11:15 | 8 | 0.15 | 0.02 | 0.06 | 0.01 | 0.00 | <3m | <3m | N/A |
| 6 | 5/15/2018 16:30 | 3.75 | 1 | 0.27 | 0.72 | 0.04 | 0.02 | 6m | <3m | N/A |
| 7 | 5/19/2018 11:45 | 13.5 | 0.29 | 0.02 | 0.06 | 0.01 | 0.01 | <3m | <3m | N/A |
| 8 | 5/20/2018 14:30 | 0.5 | 0.11 | 0.22 | 0.11 | 0.01 | 0.01 | <3m | <3m | N/A |
| 9 | 5/22/2018 13:45 | 5.5 | 0.03 | 0.01 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 10 | 5/23/2018 19:45 | 1 | 0.2 | 0.20 | 0.2 | 0.01 | 0.00 | <3m | <3m | N/A |
| 11 | 5/27/2018 0:45 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 12 | 5/27/2018 16:30 | 12.75 | 0.1 | 0.01 | 0.03 | 0.00 | 0.00 | <3m | <3m | N/A |

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

## 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 | 5/1/2018 5:00 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 5/3/2018 14:45 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 3 | 5/6/2018 20:15 | 2.25 | 0.2 | 0.09 | 0.16 | 0.01 | 0.00 | <3m | <3m | N/A |
| 4 | 5/10/2018 1:00 | 2.25 | 0.02 | 0.01 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 5 | 5/12/2018 11:30 | 6.25 | 0.19 | 0.03 | 0.1 | 0.01 | 0.00 | <3m | <3m | N/A |
| 6 | 5/15/2018 16:15 | 3.75 | 1.26 | 0.34 | 0.93 | 0.05 | 0.03 | 1y | <3m | N/A |
| 7 | 5/19/2018 12:30 | 14.25 | 0.25 | 0.02 | 0.05 | 0.01 | 0.01 | <3m | <3m | N/A |
| 8 | 5/20/2018 14:45 | 0.5 | 0.03 | 0.06 | 0.03 | 0.01 | 0.01 | <3m | <3m | N/A |
| 9 | 5/22/2018 13:00 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 10 | 5/27/2018 18:15 | 13.5 | 0.1 | 0.01 | 0.02 | 0.00 | 0.00 | <3m | <3m | N/A |

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

## 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 | 5/1/2018 6:45 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 5/6/2018 19:15 | 3.25 | 0.34 | 0.10 | 0.17 | 0.01 | 0.01 | <3m | <3m | N/A |
| 3 | 5/10/2018 2:15 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 4 | 5/12/2018 11:00 | 7.25 | 0.14 | 0.02 | 0.04 | 0.01 | 0.00 | <3m | <3m | N/A |
| 5 | 5/15/2018 16:00 | 13.5 | 0.88 | 0.07 | 0.6 | 0.04 | 0.02 | 3m | <3m | N/A |
| 6 | 5/19/2018 12:15 | 26.75 | 0.5 | 0.02 | 0.15 | 0.02 | 0.01 | <3m | <3m | N/A |
| 7 | 5/22/2018 9:30 | 8.75 | 0.03 | 0.00 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 8 | 5/23/2018 19:15 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 9 | 5/27/2018 0:15 | 30 | 0.12 | 0.00 | 0.02 | 0.00 | 0.00 | <3m | <3m | N/A |

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

(2) Hanscom AFB rainfall data was replaced with LexFarm_RG rainfall data from 4/15/2018 0:00 through 6/30/2018 23:45

## 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 | 5/3/2018 14:30 | 0.5 | 0.15 | 0.30 | 0.15 | 0.01 | 0.00 | <3m | <3m | N/A |
| 2 | 5/4/2018 5:15 | 0.75 | 0.02 | 0.03 | 0.02 | 0.01 | 0.00 | <3m | <3m | N/A |
| 3 | 5/6/2018 20:00 | 2.5 | 0.17 | 0.07 | 0.11 | 0.01 | 0.00 | <3m | <3m | N/A |
| 4 | 5/10/2018 3:00 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 5 | 5/12/2018 11:15 | 7.75 | 0.15 | 0.02 | 0.06 | 0.01 | 0.00 | <3m | <3m | N/A |
| 6 | 5/15/2018 16:30 | 11.5 | 0.87 | 0.08 | 0.54 | 0.04 | 0.02 | 3m | <3m | N/A |
| 7 | 5/19/2018 12:15 | 13.5 | 0.25 | 0.02 | 0.07 | 0.01 | 0.01 | <3m | <3m | N/A |
| 8 | 5/20/2018 14:30 | 0.25 | 0.01 | 0.04 | 0.01 | 0.01 | 0.01 | <3m | <3m | N/A |
| 9 | 5/22/2018 13:30 | 4.5 | 0.02 | 0.00 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 10 | 5/23/2018 19:45 | 0.75 | 0.19 | 0.25 | 0.19 | 0.01 | 0.00 | <3m | <3m | N/A |
| 11 | 5/27/2018 0:30 | 0.5 | 0.04 | 0.08 | 0.04 | 0.00 | 0.00 | <3m | <3m | N/A |
| 12 | 5/27/2018 18:30 | 11.75 | 0.1 | 0.01 | 0.03 | 0.00 | 0.00 | <3m | <3m | N/A |

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

## 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 | 5/1/2018 6:45 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 5/6/2018 19:15 | 3.25 | 0.34 | 0.10 | 0.17 | 0.01 | 0.01 | <3m | <3m | N/A |
| 3 | 5/10/2018 2:15 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 4 | 5/12/2018 11:00 | 7.25 | 0.14 | 0.02 | 0.04 | 0.01 | 0.00 | <3m | <3m | N/A |
| 5 | 5/15/2018 16:00 | 13.5 | 0.88 | 0.07 | 0.6 | 0.04 | 0.02 | 3m | <3m | N/A |
| 6 | 5/19/2018 12:15 | 26.75 | 0.5 | 0.02 | 0.15 | 0.02 | 0.01 | <3m | <3m | N/A |
| 7 | 5/22/2018 9:30 | 8.75 | 0.03 | 0.00 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 8 | 5/23/2018 19:15 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 9 | 5/27/2018 0:15 | 30 | 0.12 | 0.00 | 0.02 | 0.00 | 0.00 | <3m | <3m | N/A |

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

## 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 | 5/3/2018 14:30 | 0.5 | 0.06 | 0.12 | 0.06 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 5/4/2018 6:00 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 3 | 5/6/2018 20:00 | 2.5 | 0.21 | 0.08 | 0.16 | 0.01 | 0.00 | <3m | <3m | N/A |
| 4 | 5/12/2018 11:15 | 7.25 | 0.23 | 0.03 | 0.11 | 0.01 | 0.00 | <3m | <3m | N/A |
| 5 | 5/15/2018 16:15 | 2.75 | 0.93 | 0.34 | 0.66 | 0.04 | 0.02 | 3-6m | <3m | N/A |
| 6 | 5/19/2018 12:00 | 14.5 | 0.28 | 0.02 | 0.07 | 0.01 | 0.01 | <3m | <3m | N/A |
| 7 | 5/20/2018 14:30 | 1.25 | 0.07 | 0.06 | 0.06 | 0.01 | 0.01 | <3m | <3m | N/A |
| 8 | 5/22/2018 13:00 | 6 | 0.02 | 0.00 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 9 | 5/23/2018 19:30 | 1 | 0.04 | 0.04 | 0.04 | 0.00 | 0.00 | <3m | <3m | N/A |
| 10 | 5/27/2018 16:45 | 12.5 | 0.08 | 0.01 | 0.03 | 0.00 | 0.00 | <3m | <3m | N/A |

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

## 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 | 5/1/2018 9:00 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 5/4/2018 9:15 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 3 | 5/6/2018 20:30 | 3 | 0.24 | 0.08 | 0.16 | 0.01 | 0.01 | <3m | <3m | N/A |
| 4 | 5/12/2018 12:30 | 5.75 | 0.1 | 0.02 | 0.04 | 0.00 | 0.00 | <3m | <3m | N/A |
| 5 | 5/15/2018 16:45 | 3 | 0.59 | 0.20 | 0.31 | 0.02 | 0.01 | <3m | <3m | N/A |
| 6 | 5/19/2018 13:30 | 25.5 | 0.4 | 0.02 | 0.12 | 0.02 | 0.01 | <3m | <3m | N/A |
| 7 | 5/22/2018 12:30 | 1.5 | 0.02 | 0.01 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 8 | 5/27/2018 1:15 | 5 | 0.06 | 0.01 | 0.05 | 0.00 | 0.00 | <3m | <3m | N/A |
| 9 | 5/27/2018 20:00 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |

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

## 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 | 5/1/2018 3:15 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 5/3/2018 14:30 | 0.5 | 0.06 | 0.12 | 0.06 | 0.00 | 0.00 | <3m | <3m | N/A |
| 3 | 5/4/2018 5:15 | 2.25 | 0.02 | 0.01 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 4 | 5/6/2018 20:00 | 2.5 | 0.19 | 0.08 | 0.14 | 0.01 | 0.00 | <3m | <3m | N/A |
| 5 | 5/10/2018 3:00 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 6 | 5/12/2018 11:15 | 7.5 | 0.15 | 0.02 | 0.06 | 0.01 | 0.00 | <3m | <3m | N/A |
| 7 | 5/15/2018 16:30 | 3.75 | 1.04 | 0.28 | 0.73 | 0.04 | 0.02 | 6m | <3m | N/A |
| 8 | 5/19/2018 11:45 | 13.25 | 0.26 | 0.02 | 0.05 | 0.01 | 0.01 | <3m | <3m | N/A |
| 9 | 5/20/2018 14:30 | 0.25 | 0.11 | 0.44 | 0.11 | 0.01 | 0.01 | <3m | <3m | N/A |
| 10 | 5/22/2018 13:30 | 5.5 | 0.03 | 0.01 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 11 | 5/23/2018 19:45 | 0.75 | 0.34 | 0.45 | 0.34 | 0.01 | 0.01 | <3m | <3m | N/A |
| 12 | 5/27/2018 0:45 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 13 | 5/27/2018 16:45 | 13.5 | 0.11 | 0.01 | 0.03 | 0.00 | 0.00 | <3m | <3m | N/A |

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

## 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 | 5/3/2018 14:30 | 0.5 | 0.1 | 0.20 | 0.1 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 5/4/2018 4:15 | 3.75 | 0.02 | 0.01 | 0.01 | 0.01 | 0.00 | <3m | <3m | N/A |
| 3 | 5/6/2018 20:00 | 8.25 | 0.21 | 0.03 | 0.14 | 0.01 | 0.00 | <3m | <3m | N/A |
| 4 | 5/10/2018 2:15 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 5 | 5/12/2018 11:15 | 7.25 | 0.17 | 0.02 | 0.06 | 0.01 | 0.00 | <3m | <3m | N/A |
| 6 | 5/15/2018 16:15 | 11.75 | 1.14 | 0.10 | 0.83 | 0.05 | 0.02 | 6m-1yr | <3m | N/A |
| 7 | 5/19/2018 12:00 | 13.25 | 0.26 | 0.02 | 0.06 | 0.01 | 0.01 | <3m | <3m | N/A |
| 8 | 5/20/2018 14:30 | 3.25 | 0.2 | 0.06 | 0.19 | 0.01 | 0.01 | <3m | <3m | N/A |
| 9 | 5/22/2018 14:00 | 5 | 0.02 | 0.00 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 10 | 5/23/2018 19:45 | 0.75 | 0.13 | 0.17 | 0.13 | 0.01 | 0.00 | <3m | <3m | N/A |
| 11 | 5/27/2018 0:30 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 12 | 5/27/2018 16:30 | 14.75 | 0.12 | 0.01 | 0.03 | 0.01 | 0.00 | <3m | <3m | N/A |

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

## Rain Gauge 16: Somerville (2)

| 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 | 5/3/2018 14:45 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 5/6/2018 20:30 | 2 | 0.22 | 0.11 | 0.18 | 0.01 | 0.00 | <3m | <3m | N/A |
| 3 | 5/10/2018 2:45 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 4 | 5/12/2018 11:15 | 6.75 | 0.2 | 0.03 | 0.1 | 0.01 | 0.00 | <3m | <3m | N/A |
| 5 | 5/15/2018 16:15 | 2.5 | 1.08 | 0.43 | 0.78 | 0.05 | 0.02 | 6m-1yr | <3m | N/A |
| 6 | 5/19/2018 12:15 | 14.5 | 0.25 | 0.02 | 0.05 | 0.01 | 0.01 | <3m | <3m | N/A |
| 7 | 5/20/2018 14:45 | 0.5 | 0.05 | 0.10 | 0.05 | 0.01 | 0.01 | <3m | <3m | N/A |
| 8 | 5/22/2018 12:45 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 9 | 5/23/2018 19:15 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 10 | 5/27/2018 19:15 | 12.25 | 0.07 | 0.01 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |

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

(2) Somerville rainfall data was replaced with Charlestown rainfall data from 4/15/2018 0:00 through 6/30/2018 23:45

## 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 | 5/6/2018 18:45 | 7.5 | 0.28 | 0.04 | 0.14 | 0.01 | 0.01 | <3m | <3m | N/A |
| 2 | 5/10/2018 2:15 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 3 | 5/12/2018 11:30 | 7 | 0.11 | 0.02 | 0.04 | 0.00 | 0.00 | <3m | <3m | N/A |
| 4 | 5/15/2018 16:00 | 5 | 0.83 | 0.17 | 0.53 | 0.03 | 0.02 | 3m | <3m | N/A |
| 5 | 5/19/2018 12:15 | 26.5 | 0.46 | 0.02 | 0.15 | 0.02 | 0.01 | <3m | <3m | N/A |
| 6 | 5/22/2018 9:45 | 3.25 | 0.03 | 0.01 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 7 | 5/27/2018 0:15 | 2 | 0.04 | 0.02 | 0.03 | 0.00 | 0.00 | <3m | <3m | N/A |
| 8 | 5/27/2018 18:00 | 13.25 | 0.09 | 0.01 | 0.02 | 0.00 | 0.00 | <3m | <3m | N/A |

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

## 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 | 5/1/2018 8:30 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 5/3/2018 14:45 | 0.25 | 0.03 | 0.12 | 0.03 | 0.00 | 0.00 | <3m | <3m | N/A |
| 3 | 5/4/2018 4:15 | 3.75 | 0.02 | 0.01 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 4 | 5/6/2018 20:00 | 2.75 | 0.22 | 0.08 | 0.15 | 0.01 | 0.00 | <3m | <3m | N/A |
| 5 | 5/10/2018 2:15 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 6 | 5/12/2018 11:15 | 7.25 | 0.23 | 0.03 | 0.13 | 0.01 | 0.00 | <3m | <3m | N/A |
| 7 | 5/15/2018 16:15 | 4 | 1.06 | 0.27 | 0.75 | 0.04 | 0.02 | 6m-1yr | <3m | N/A |
| 8 | 5/19/2018 12:00 | 13.25 | 0.24 | 0.02 | 0.05 | 0.01 | 0.01 | <3m | <3m | N/A |
| 9 | 5/20/2018 14:45 | 0.25 | 0.07 | 0.28 | 0.07 | 0.01 | 0.01 | <3m | <3m | N/A |
| 10 | 5/22/2018 18:30 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 11 | 5/27/2018 16:45 | 12.75 | 0.08 | 0.01 | 0.02 | 0.00 | 0.00 | <3m | <3m | N/A |

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

## 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 | 5/3/2018 15:45 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 5/4/2018 8:15 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 3 | 5/6/2018 18:45 | 5.5 | 0.27 | 0.05 | 0.17 | 0.01 | 0.01 | <3m | <3m | N/A |
| 4 | 5/10/2018 4:30 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 5 | 5/12/2018 12:30 | 6.25 | 0.2 | 0.03 | 0.09 | 0.01 | 0.00 | <3m | <3m | N/A |
| 6 | 5/15/2018 17:15 | 4 | 0.91 | 0.23 | 0.6 | 0.04 | 0.02 | 3m | <3m | N/A |
| 7 | 5/19/2018 13:15 | 27 | 0.32 | 0.01 | 0.08 | 0.01 | 0.01 | <3m | <3m | N/A |
| 8 | 5/22/2018 11:00 | 9.5 | 0.04 | 0.00 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 9 | 5/23/2018 20:45 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 10 | 5/27/2018 18:15 | 14.75 | 0.09 | 0.01 | 0.03 | 0.00 | 0.00 | <3m | <3m | N/A |

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

## 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 | 5/3/2018 15:30 | 0.5 | 0.03 | 0.06 | 0.03 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 5/6/2018 20:45 | 3.25 | 0.29 | 0.09 | 0.21 | 0.01 | 0.01 | <3m | <3m | N/A |
| 3 | 5/12/2018 11:00 | 7.25 | 0.25 | 0.03 | 0.12 | 0.01 | 0.01 | <3m | <3m | N/A |
| 4 | 5/15/2018 16:15 | 4 | 1.07 | 0.27 | 0.74 | 0.04 | 0.02 | 6m-1yr | <3m | N/A |
| 5 | 5/19/2018 11:45 | 14.75 | 0.32 | 0.02 | 0.06 | 0.01 | 0.01 | <3m | <3m | N/A |
| 6 | 5/20/2018 14:30 | 3 | 0.15 | 0.05 | 0.12 | 0.01 | 0.01 | <3m | <3m | N/A |
| 7 | 5/21/2018 5:30 | 0.25 | 0.01 | 0.04 | 0.01 | 0.01 | 0.01 | <3m | <3m | N/A |
| 8 | 5/22/2018 11:00 | 2.5 | 0.02 | 0.01 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 9 | 5/23/2018 20:15 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 10 | 5/27/2018 0:00 | 2 | 0.02 | 0.01 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 11 | 5/27/2018 18:45 | 12 | 0.12 | 0.01 | 0.04 | 0.01 | 0.00 | <3m | <3m | N/A |

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

## Summary of Storm Events at Each Rain Gauge: June

### 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 | 6/2/2018 12:30 | 2.75 | 0.06 | 0.02 | 0.05 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 6/4/2018 4:30 | 7.5 | 0.71 | 0.09 | 0.26 | 0.03 | 0.02 | <3m | <3m | N/A |
| 3 | 6/5/2018 12:15 | 2.5 | 0.51 | 0.20 | 0.26 | 0.02 | 0.03 | <3m | <3m | N/A |
| 4 | 6/13/2018 15:00 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 5 | 6/18/2018 18:00 | 2.75 | 0.18 | 0.07 | 0.6 | 0.01 | 0.00 | 3m | <3m | N/A |
| 6 | 6/24/2018 18:00 | 10 | 0.6 | 0.06 | 0.26 | 0.03 | 0.01 | <3m | <3m | N/A |
| 7 | 6/27/2018 22:00 | 17 | 1.25 | 0.07 | 0.6 | 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-1year (6m-1yr) or the nearest year.

### Rain Gauge 2: Ward Street

| 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 | 6/2/2018 15:30 | 1 | 0.03 | 0.03 | 0.03 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 6/4/2018 5:30 | 10.75 | 0.76 | 0.07 | 0.22 | 0.03 | 0.00 | <3m | <3m | N/A |
| 3 | 6/5/2018 13:30 | 6.25 | 0.26 | 0.04 | 0.18 | 0.01 | 0.00 | <3m | <3m | N/A |
| 4 | 6/18/2018 19:15 | 2.5 | 0.21 | 0.08 | 0.17 | 0.01 | 0.00 | <3m | <3m | N/A |
| 5 | 6/24/2018 19:00 | 10.25 | 0.48 | 0.05 | 0.22 | 0.02 | 0.00 | <3m | <3m | N/A |
| 6 | 6/27/2018 23:15 | 15.5 | 1.21 | 0.08 | 0.68 | 0.05 | 0.00 | 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-1year (6m-1yr) or the nearest year.

### 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 | 6/2/2018 15:30 | 1.75 | 0.09 | 0.05 | 0.08 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 6/4/2018 6:00 | 14.5 | 0.67 | 0.05 | 0.18 | 0.03 | 0.02 | <3m | <3m | N/A |
| 3 | 6/5/2018 13:30 | 6.25 | 0.18 | 0.03 | 0.12 | 0.01 | 0.02 | <3m | <3m | N/A |
| 4 | 6/18/2018 19:15 | 2.5 | 0.16 | 0.06 | 0.12 | 0.01 | 0.00 | <3m | <3m | N/A |
| 5 | 6/24/2018 19:00 | 17 | 0.51 | 0.03 | 0.24 | 0.02 | 0.01 | <3m | <3m | N/A |
| 6 | 6/27/2018 23:15 | 15.75 | 1.22 | 0.08 | 0.73 | 0.05 | 0.03 | 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-1year (6m-1yr) 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 | 6/2/2018 14:15 | 0.25 | 0.04 | 0.16 | 0.04 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 6/4/2018 4:45 | 9.25 | 0.64 | 0.07 | 0.19 | 0.03 | 0.01 | <3m | <3m | N/A |
| 3 | 6/5/2018 12:30 | 6 | 0.39 | 0.07 | 0.21 | 0.02 | 0.02 | <3m | <3m | N/A |
| 4 | 6/13/2018 14:45 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 5 | 6/18/2018 18:15 | 2.5 | 0.08 | 0.03 | 0.05 | 0.00 | 0.00 | <3m | <3m | N/A |
| 6 | 6/24/2018 17:30 | 10.5 | 0.8 | 0.08 | 0.4 | 0.03 | 0.02 | <3m | <3m | N/A |
| 7 | 6/27/2018 22:15 | 20.25 | 1.27 | 0.06 | 0.69 | 0.05 | 0.03 | 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-1year (6m-1yr) or the nearest year.

## Rain Gauge 5: Chelsea Creek (2)

| 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 | 6/4/2018 5:45 | 14.75 | 0.68 | 0.05 | 0.18 | 0.03 | 0.01 | <3m | <3m | N/A |
| 2 | 6/5/2018 12:30 | 6.25 | 0.43 | 0.07 | 0.21 | 0.02 | 0.02 | <3m | <3m | N/A |
| 3 | 6/13/2018 14:45 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 4 | 6/18/2018 18:15 | 2.5 | 0.08 | 0.03 | 0.06 | 0.00 | 0.00 | <3m | <3m | N/A |
| 5 | 6/24/2018 17:30 | 14 | 0.81 | 0.06 | 0.43 | 0.03 | 0.02 | <3m | <3m | N/A |
| 6 | 6/27/2018 22:15 | 15.5 | 1.15 | 0.07 | 0.62 | 0.05 | 0.02 | 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-1year (6m-1yr) or the nearest year.

(2) CH-BO-1 rainfall data was replaced with East Boston rainfall data from 6/5/2018 0:00 through 6/30/2018 23:45

## 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 | 6/2/2018 14:45 | 1 | 0.11 | 0.11 | 0.11 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 6/4/2018 4:45 | 14.75 | 0.71 | 0.05 | 0.21 | 0.03 | 0.02 | <3m | <3m | N/A |
| 3 | 6/5/2018 12:30 | 6.5 | 0.25 | 0.04 | 0.2 | 0.01 | 0.02 | <3m | <3m | N/A |
| 4 | 6/18/2018 18:30 | 2.25 | 0.29 | 0.13 | 0.27 | 0.01 | 0.01 | <3m | <3m | N/A |
| 5 | 6/19/2018 8:45 | 0.25 | 0.01 | 0.04 | 0.01 | 0.01 | 0.01 | <3m | <3m | N/A |
| 6 | 6/24/2018 18:15 | 16.75 | 0.34 | 0.02 | 0.17 | 0.01 | 0.01 | <3m | <3m | N/A |
| 7 | 6/27/2018 22:15 | 24 | 1.25 | 0.05 | 0.76 | 0.05 | 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-1year (6m-1yr) 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 | 6/2/2018 15:30 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 6/4/2018 4:30 | 12 | 0.77 | 0.06 | 0.21 | 0.03 | 0.02 | <3m | <3m | N/A |
| 3 | 6/5/2018 12:15 | 6.5 | 0.23 | 0.04 | 0.16 | 0.01 | 0.02 | <3m | <3m | N/A |
| 4 | 6/18/2018 18:30 | 2.25 | 0.31 | 0.14 | 0.28 | 0.01 | 0.01 | <3m | <3m | N/A |
| 5 | 6/24/2018 18:00 | 10 | 0.35 | 0.04 | 0.18 | 0.01 | 0.01 | <3m | <3m | N/A |
| 6 | 6/27/2018 22:15 | 19.75 | 1.22 | 0.06 | 0.71 | 0.05 | 0.03 | 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-1year (6m-1yr) 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 | 6/4/2018 4:45 | 18.75 | 0.63 | 0.03 | 0.17 | 0.03 | 0.01 | <3m | <3m | N/A |
| 2 | 6/5/2018 12:30 | 6.25 | 0.43 | 0.07 | 0.21 | 0.02 | 0.02 | <3m | <3m | N/A |
| 3 | 6/13/2018 14:45 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 4 | 6/18/2018 18:15 | 2.5 | 0.08 | 0.03 | 0.06 | 0.00 | 0.00 | <3m | <3m | N/A |
| 5 | 6/24/2018 17:30 | 14 | 0.81 | 0.06 | 0.43 | 0.03 | 0.02 | <3m | <3m | N/A |
| 6 | 6/27/2018 22:15 | 15.5 | 1.15 | 0.07 | 0.62 | 0.05 | 0.02 | 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-1year (6m-1yr) or the nearest year.

## Rain Gauge 9: Hanscom AFB (2)

| 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 | 6/4/2018 4:30 | 14 | 0.44 | 0.03 | 0.21 | 0.02 | 0.01 | <3m | <3m | N/A |
| 2 | 6/5/2018 12:15 | 2.25 | 0.2 | 0.09 | 0.19 | 0.01 | 0.01 | <3m | <3m | N/A |
| 3 | 6/15/2018 6:15 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 4 | 6/18/2018 18:00 | 2.5 | 0.15 | 0.06 | 0.08 | 0.01 | 0.00 | <3m | <3m | N/A |
| 5 | 6/23/2018 9:45 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 6 | 6/24/2018 17:30 | 11 | 0.92 | 0.08 | 0.54 | 0.04 | 0.02 | 3m | <3m | N/A |
| 7 | 6/27/2018 22:15 | 19.75 | 1.47 | 0.07 | 0.7 | 0.06 | 0.03 | 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-1year (6m-1yr) or the nearest year.

(2) Hanscom AFB rainfall data was replaced with LexFarm_RG rainfall data from 4/15/2018 0:00 through 6/30/2018 23:45

## 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 | 6/4/2018 4:30 | 16.25 | 0.69 | 0.04 | 0.18 | 0.03 | 0.01 | <3m | <3m | N/A |
| 2 | 6/5/2018 12:30 | 6.25 | 0.21 | 0.03 | 0.17 | 0.01 | 0.02 | <3m | <3m | N/A |
| 3 | 6/18/2018 18:30 | 8.75 | 0.16 | 0.02 | 0.12 | 0.01 | 0.00 | <3m | <3m | N/A |
| 4 | 6/24/2018 18:15 | 9.75 | 0.39 | 0.04 | 0.16 | 0.02 | 0.01 | <3m | <3m | N/A |
| 5 | 6/27/2018 22:15 | 19.5 | 1.31 | 0.07 | 0.82 | 0.05 | 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-1year (6m-1yr) 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 | 6/4/2018 4:30 | 14 | 0.44 | 0.03 | 0.21 | 0.02 | 0.01 | <3m | <3m | N/A |
| 2 | 6/5/2018 12:15 | 2.25 | 0.2 | 0.09 | 0.19 | 0.01 | 0.01 | <3m | <3m | N/A |
| 3 | 6/15/2018 6:15 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 4 | 6/18/2018 18:00 | 2.5 | 0.15 | 0.06 | 0.08 | 0.01 | 0.00 | <3m | <3m | N/A |
| 5 | 6/23/2018 9:45 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 6 | 6/24/2018 17:30 | 11 | 0.92 | 0.08 | 0.54 | 0.04 | 0.02 | 3m | <3m | N/A |
| 7 | 6/27/2018 22:15 | 19.75 | 1.47 | 0.07 | 0.7 | 0.06 | 0.03 | 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-1year (6m-1yr) or the nearest year.

## Rain Gauge 12: Longwood

| Event | Date & Start Time | Duration (hr) | Volume (in) | Average Intensity (in/hr) | Peak 1-hr Intensity (in/hr) | Peak 24-hr Intensity (in/hr) | Peak 48-hr Intensity (in/hr) | Storm Recurrence Interval (1) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | 1-hr | 24-hr | 48-hr |
| 1 | 6/2/2018 15:00 | 0.5 | 0.03 | 0.06 | 0.03 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 6/4/2018 4:45 | 10.5 | 0.67 | 0.06 | 0.19 | 0.03 | 0.01 | <3m | <3m | N/A |
| 3 | 6/5/2018 12:30 | 2.25 | 0.28 | 0.12 | 0.17 | 0.01 | 0.02 | <3m | <3m | N/A |
| 4 | 6/18/2018 18:15 | 8 | 0.19 | 0.02 | 0.16 | 0.01 | 0.00 | <3m | <3m | N/A |
| 5 | 6/24/2018 18:00 | 9 | 0.44 | 0.05 | 0.21 | 0.02 | 0.01 | <3m | <3m | N/A |
| 6 | 6/27/2018 22:15 | 15.5 | 1.37 | 0.09 | 0.82 | 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-1year (6m-1yr) 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 | 6/2/2018 14:30 | 1 | 0.03 | 0.03 | 0.03 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 6/4/2018 6:00 | 6.25 | 0.48 | 0.08 | 0.27 | 0.02 | 0.01 | <3m | <3m | N/A |
| 3 | 6/5/2018 14:30 | 4.5 | 0.12 | 0.03 | 0.08 | 0.01 | 0.01 | <3m | <3m | N/A |
| 4 | 6/18/2018 19:00 | 2.5 | 0.21 | 0.08 | 0.14 | 0.01 | 0.00 | <3m | <3m | N/A |
| 5 | 6/24/2018 18:15 | 10.5 | 0.55 | 0.05 | 0.32 | 0.02 | 0.01 | <3m | <3m | N/A |
| 6 | 6/27/2018 23:15 | 19.5 | 1.57 | 0.08 | 0.75 | 0.07 | 0.03 | 6m-1yr | <3m | N/A |
| 7 | 6/29/2018 9:45 | 0.25 | 0.01 | 0.04 | 0.01 | 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-1year (6m-1yr) or the nearest year.

## Rain Gauge 14: Roslindale

| Event | Date & Start Time | Duration (hr) | Volume (in) | Average Intensity (in/hr) | Peak 1-hr Intensity (in/hr) | Peak 24-hr Intensity (in/hr) | Peak 48-hr Intensity (in/hr) | Storm Recurrence Interval (1) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | 1-hr | 24-hr | 48-hr |
| 1 | 6/2/2018 15:30 | 0.25 | 0.02 | 0.08 | 0.02 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 6/4/2018 4:30 | 14.75 | 0.75 | 0.05 | 0.18 | 0.03 | 0.02 | <3m | <3m | N/A |
| 3 | 6/5/2018 12:15 | 6.5 | 0.22 | 0.03 | 0.19 | 0.01 | 0.02 | <3m | <3m | N/A |
| 4 | 6/13/2018 15:00 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 5 | 6/18/2018 18:30 | 8 | 0.29 | 0.04 | 0.65 | 0.01 | 0.01 | 3-6m | <3m | N/A |
| 6 | 6/24/2018 18:00 | 10.25 | 0.39 | 0.04 | 0.17 | 0.02 | 0.01 | <3m | <3m | N/A |
| 7 | 6/27/2018 22:15 | 19.5 | 1.08 | 0.06 | 0.65 | 0.05 | 0.02 | 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-1year (6m-1yr) 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 | 6/2/2018 15:15 | 0.25 | 0.03 | 0.12 | 0.03 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 6/4/2018 4:30 | 14.75 | 0.75 | 0.05 | 0.17 | 0.03 | 0.02 | <3m | <3m | N/A |
| 3 | 6/5/2018 12:15 | 6.5 | 0.16 | 0.02 | 0.12 | 0.01 | 0.02 | <3m | <3m | N/A |
| 4 | 6/18/2018 18:30 | 2.25 | 0.32 | 0.14 | 0.3 | 0.01 | 0.01 | <3m | <3m | N/A |
| 5 | 6/24/2018 18:00 | 10.5 | 0.36 | 0.03 | 0.16 | 0.02 | 0.01 | <3m | <3m | N/A |
| 6 | 6/27/2018 22:15 | 20.25 | 1.13 | 0.06 | 0.6 | 0.05 | 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-1year (6m-1yr) or the nearest year.

## Rain Gauge 16: Somerville [2]

| 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 | 6/2/2018 14:15 | 0.25 | 0.04 | 0.16 | 0.04 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 6/4/2018 4:45 | 9.25 | 0.64 | 0.07 | 0.19 | 0.03 | 0.01 | <3m | <3m | N/A |
| 3 | 6/5/2018 12:30 | 6 | 0.39 | 0.07 | 0.21 | 0.02 | 0.02 | <3m | <3m | N/A |
| 4 | 6/13/2018 14:45 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 5 | 6/18/2018 18:15 | 2.5 | 0.08 | 0.03 | 0.05 | 0.00 | 0.00 | <3m | <3m | N/A |
| 6 | 6/24/2018 17:30 | 10.5 | 0.8 | 0.08 | 0.4 | 0.03 | 0.02 | <3m | <3m | N/A |
| 7 | 6/27/2018 22:15 | 20.25 | 1.27 | 0.06 | 0.69 | 0.05 | 0.03 | 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-1year (6m-1yr) or the nearest year.

(2) Somerville rainfall data was replaced with Charleston rainfall data from 4/15/2018 0:00 through 6/30/2018 23:45

## 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 | 6/2/2018 14:15 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 6/4/2018 4:45 | 16.5 | 0.59 | 0.04 | 0.21 | 0.02 | 0.01 | <3m | <3m | N/A |
| 3 | 6/5/2018 13:30 | 5.75 | 0.19 | 0.03 | 0.17 | 0.01 | 0.02 | <3m | <3m | N/A |
| 4 | 6/15/2018 6:45 | 0.25 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 5 | 6/18/2018 18:15 | 6 | 0.12 | 0.02 | 0.08 | 0.01 | 0.00 | <3m | <3m | N/A |
| 6 | 6/23/2018 9:30 | 9.75 | 0.02 | 0.00 | 0.01 | 0.00 | 0.00 | <3m | <3m | N/A |
| 7 | 6/24/2018 17:45 | 14.5 | 1.03 | 0.07 | 0.41 | 0.04 | 0.02 | <3m | <3m | N/A |
| 8 | 6/27/2018 22:15 | 25.25 | 1.3 | 0.05 | 0.47 | 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-1year (6m-1yr) 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 | 6/2/2018 14:30 | 0.25 | 0.05 | 0.20 | 0.05 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 6/4/2018 4:45 | 15 | 0.71 | 0.05 | 0.17 | 0.03 | 0.02 | <3m | <3m | N/A |
| 3 | 6/5/2018 12:30 | 2.25 | 0.21 | 0.09 | 0.17 | 0.01 | 0.02 | <3m | <3m | N/A |
| 4 | 6/18/2018 18:15 | 2.5 | 0.17 | 0.07 | 0.13 | 0.01 | 0.00 | <3m | <3m | N/A |
| 5 | 6/24/2018 18:00 | 9.75 | 0.45 | 0.05 | 0.22 | 0.02 | 0.01 | <3m | <3m | N/A |
| 6 | 6/27/2018 22:15 | 15.5 | 1.07 | 0.07 | 0.53 | 0.04 | 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-1year (6m-1yr) 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 | 6/2/2018 13:45 | 0.75 | 0.03 | 0.04 | 0.03 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 6/4/2018 5:45 | 8.25 | 0.49 | 0.06 | 0.18 | 0.02 | 0.01 | <3m | <3m | N/A |
| 3 | 6/5/2018 13:30 | 2.5 | 0.45 | 0.18 | 0.4 | 0.02 | 0.02 | <3m | <3m | N/A |
| 4 | 6/13/2018 15:45 | 0.25 | 0.02 | 0.08 | 0.02 | 0.00 | 0.00 | <3m | <3m | N/A |
| 5 | 6/18/2018 19:15 | 2.5 | 0.14 | 0.06 | 0.07 | 0.01 | 0.00 | <3m | <3m | N/A |
| 6 | 6/24/2018 18:30 | 11 | 1.17 | 0.11 | 0.57 | 0.05 | 0.02 | 3m | <3m | N/A |
| 7 | 6/27/2018 23:15 | 20.5 | 1.46 | 0.07 | 0.62 | 0.06 | 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-1year (6m-1yr) 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 | 6/2/2018 12:45 | 0.25 | 0.07 | 0.28 | 0.07 | 0.00 | 0.00 | <3m | <3m | N/A |
| 2 | 6/4/2018 4:30 | 17.25 | 0.65 | 0.04 | 0.29 | 0.03 | 0.01 | <3m | <3m | N/A |
| 3 | 6/5/2018 12:15 | 2.5 | 0.37 | 0.15 | 0.32 | 0.02 | 0.02 | <3m | <3m | N/A |
| 4 | 6/13/2018 14:30 | 0.5 | 0.02 | 0.04 | 0.02 | 0.00 | 0.00 | <3m | <3m | N/A |
| 5 | 6/18/2018 18:00 | 2.5 | 0.15 | 0.06 | 0.1 | 0.01 | 0.00 | <3m | <3m | N/A |
| 6 | 6/23/2018 9:00 | 6.25 | 0.05 | 0.01 | 0.04 | 0.00 | 0.00 | <3m | <3m | N/A |
| 7 | 6/24/2018 17:30 | 10.5 | 1.32 | 0.13 | 0.75 | 0.06 | 0.03 | 6m-1yr | <3m | N/A |
| 8 | 6/27/2018 22:00 | 26.25 | 1.65 | 0.06 | 0.6 | 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-1year (6m-1yr) or the nearest year.

## Appendix D  Rainfall Hyetographs

All hyetographs are plotted using 15-minute  intensities.

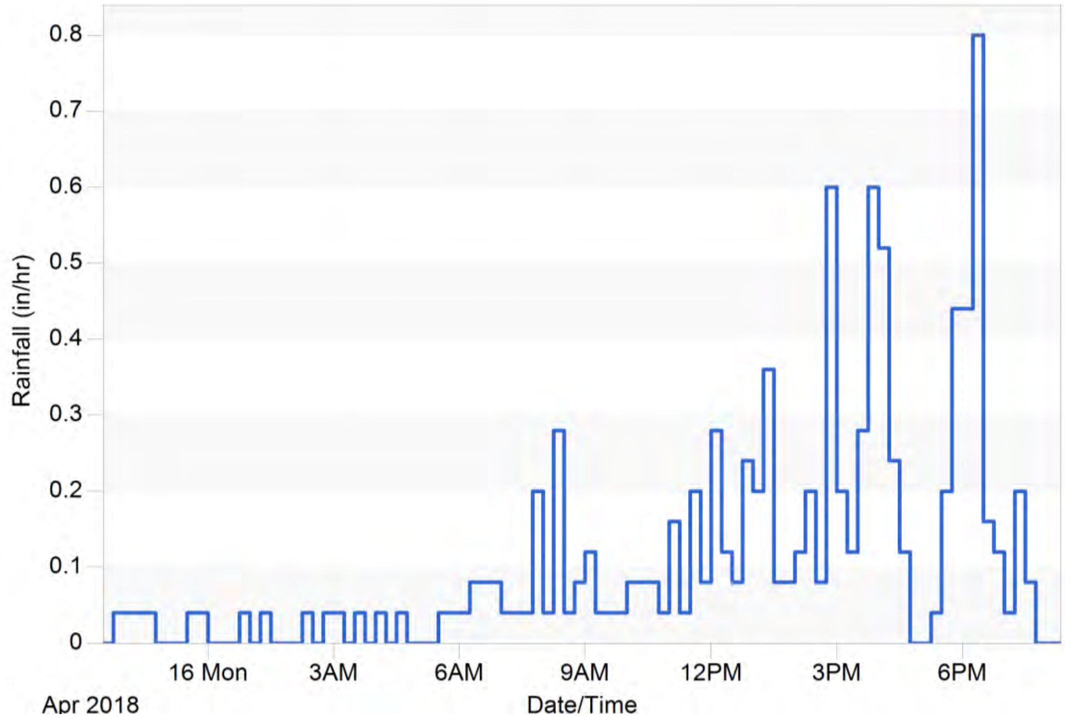



**Figure D-1.  Ward Street April 15, 2018**

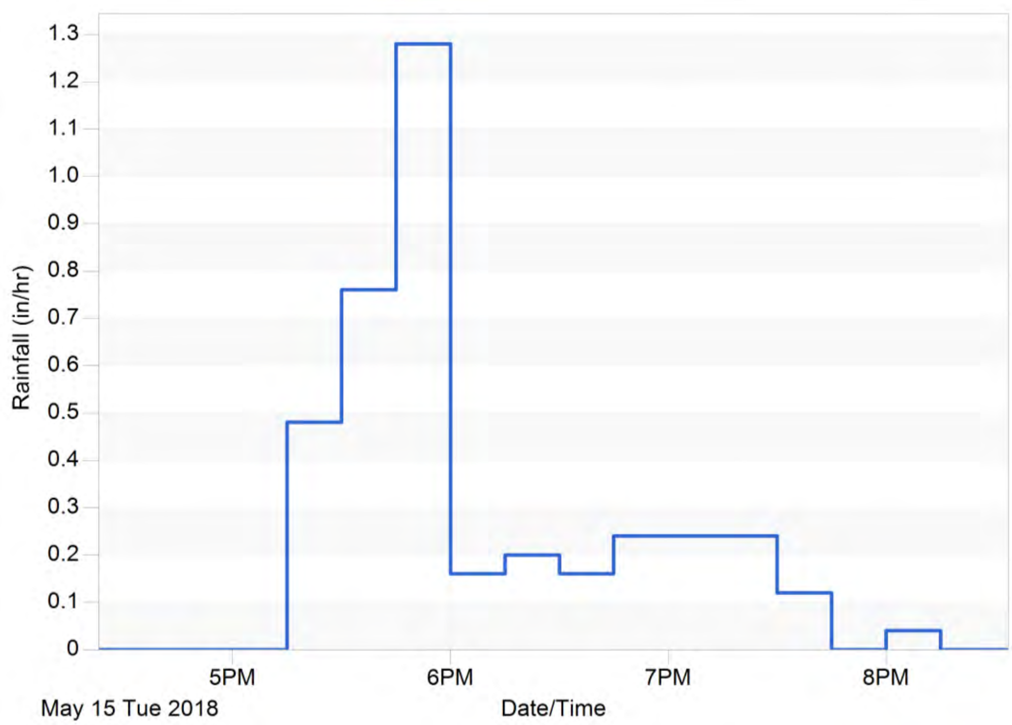



**Figure D-2. Ward Street May 15, 2018**

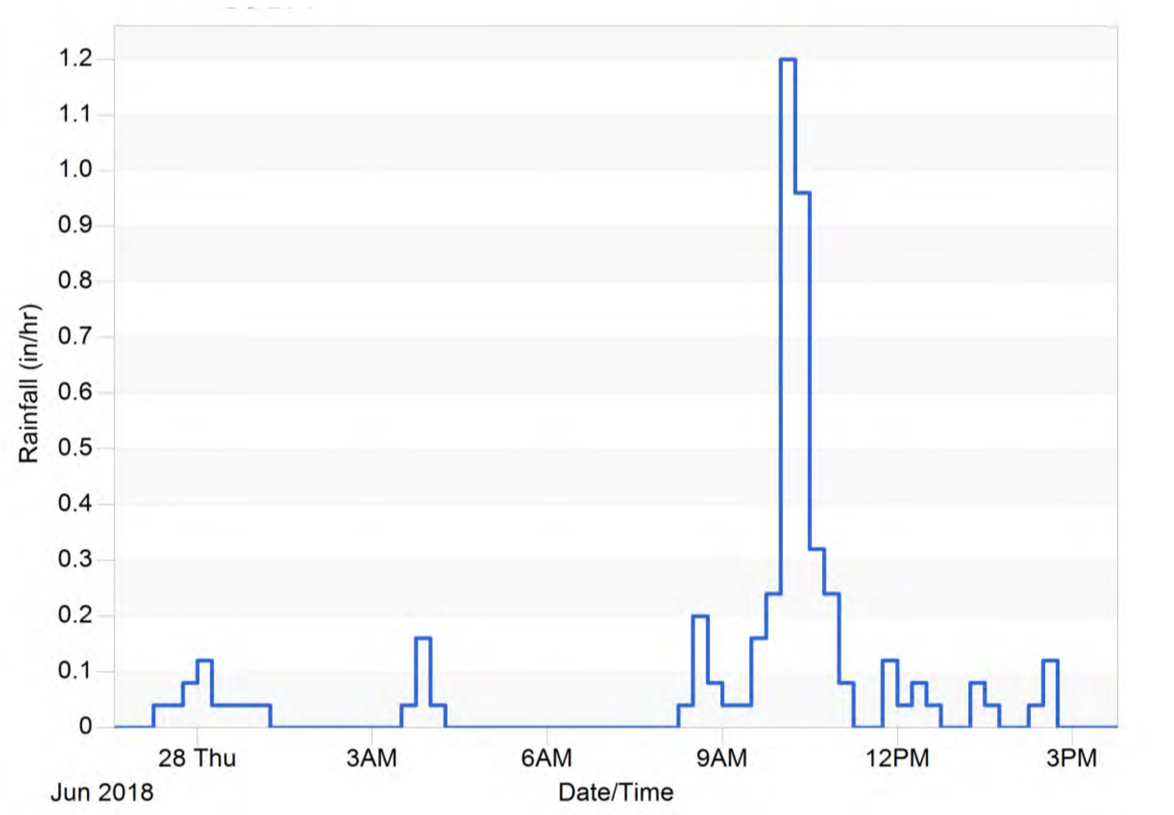



**Figure D-3. Ward Street June 27, 2018**

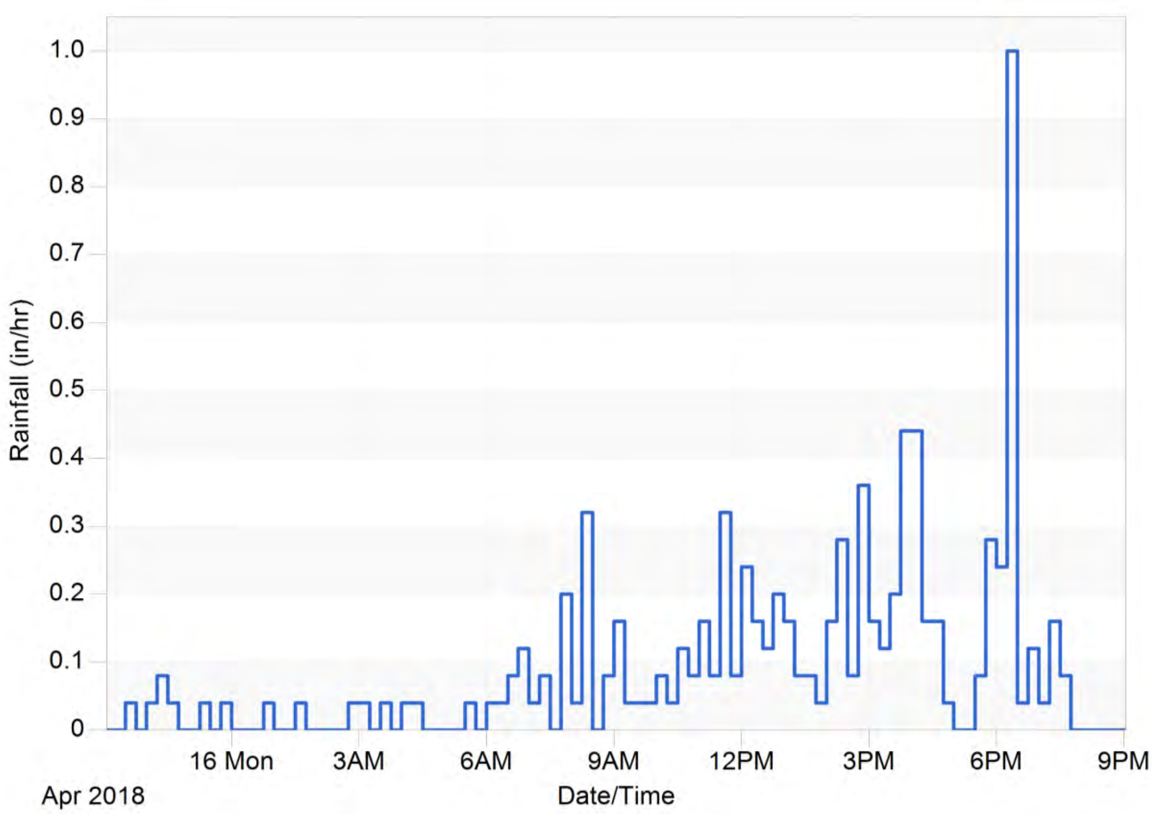



**Figure D-4. Columbus Park April 15, 2018**

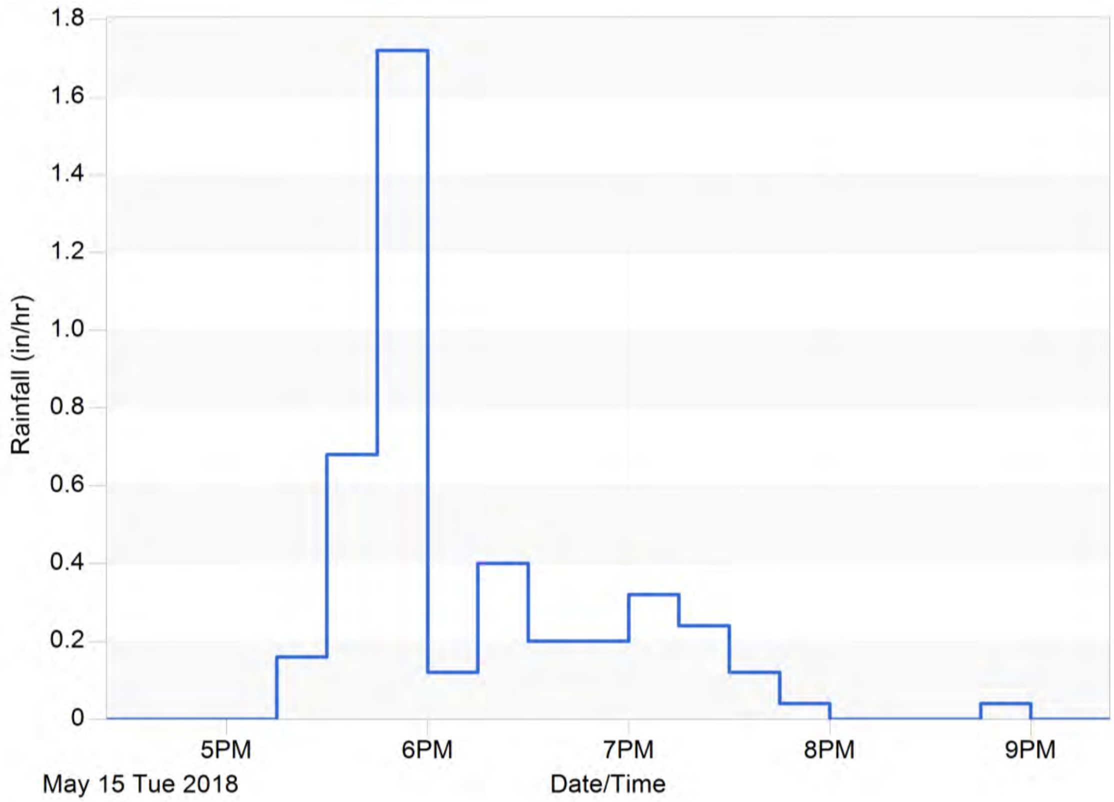



**Figure D-5. Columbus Park May 15, 2018**

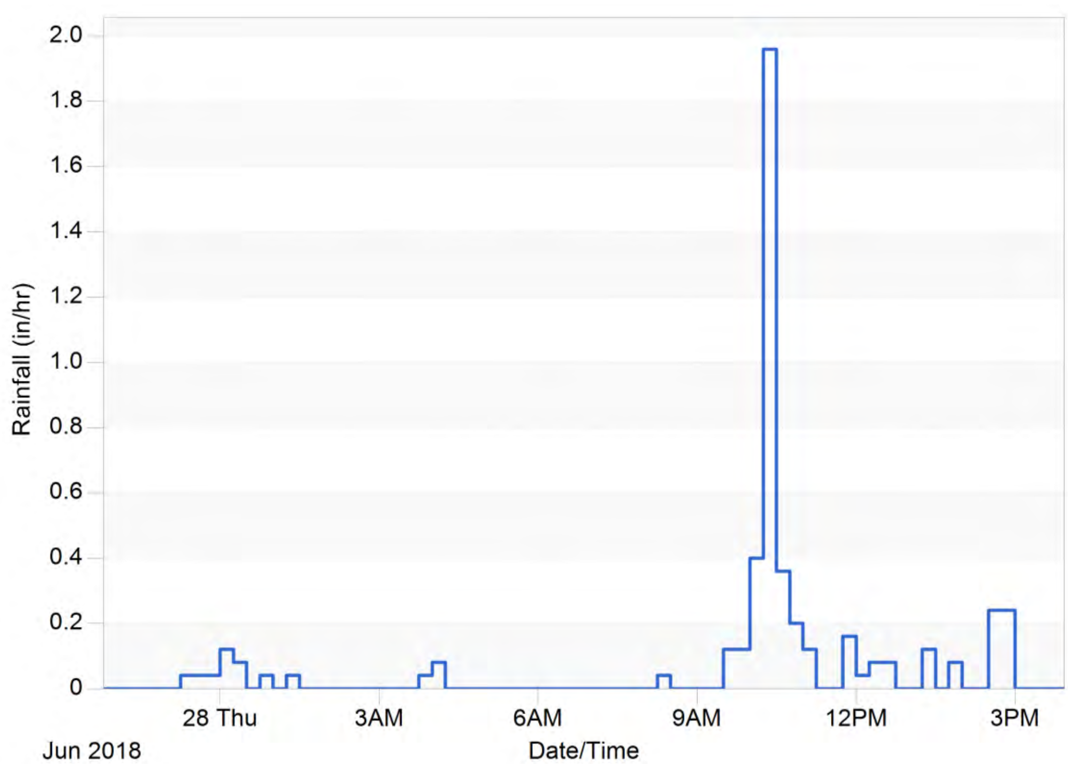



**Figure D-6. Columbus Park June 27, 2018**

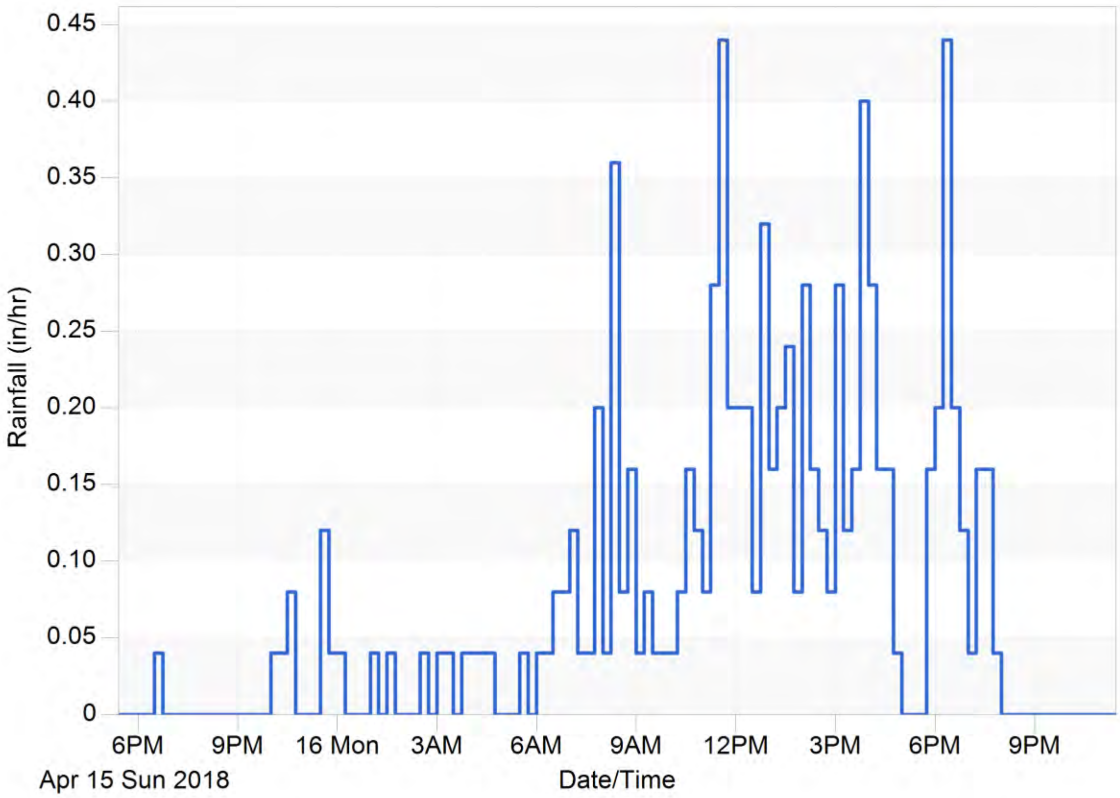



**Figure D-7. Chelsea Creek Headworks April 15, 2018**

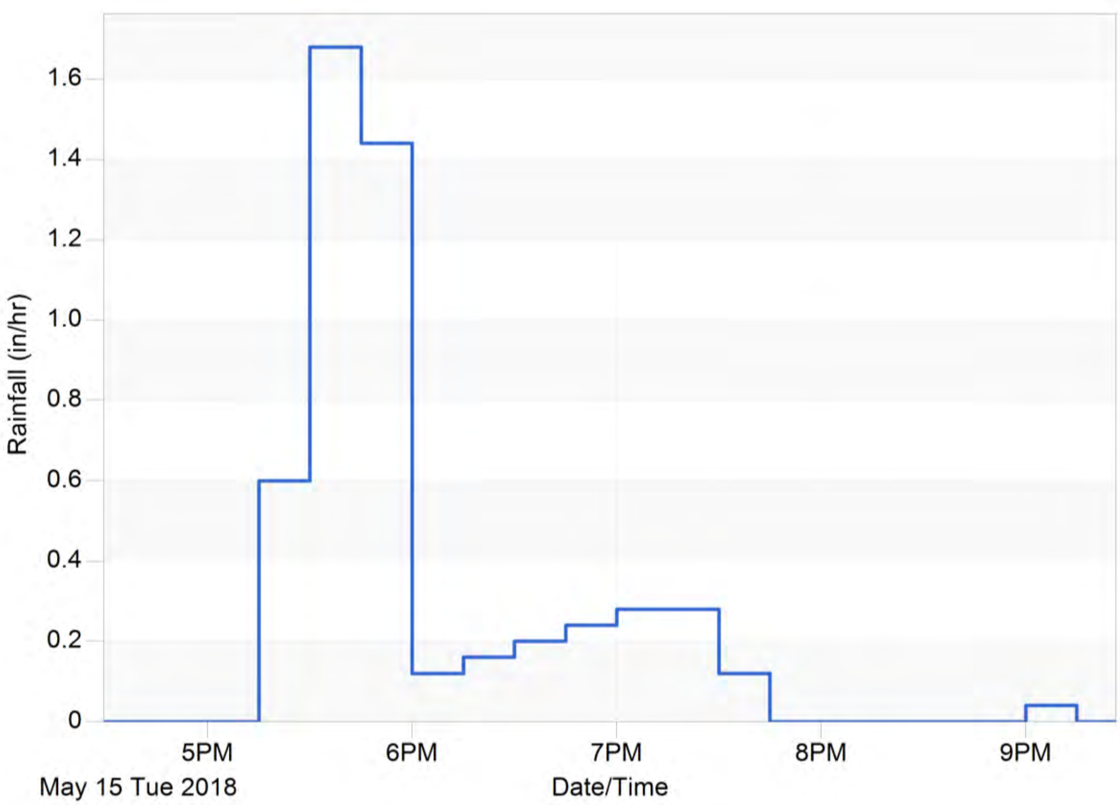



**Figure D-8. Chelsea Creek Headworks May 15, 2018**

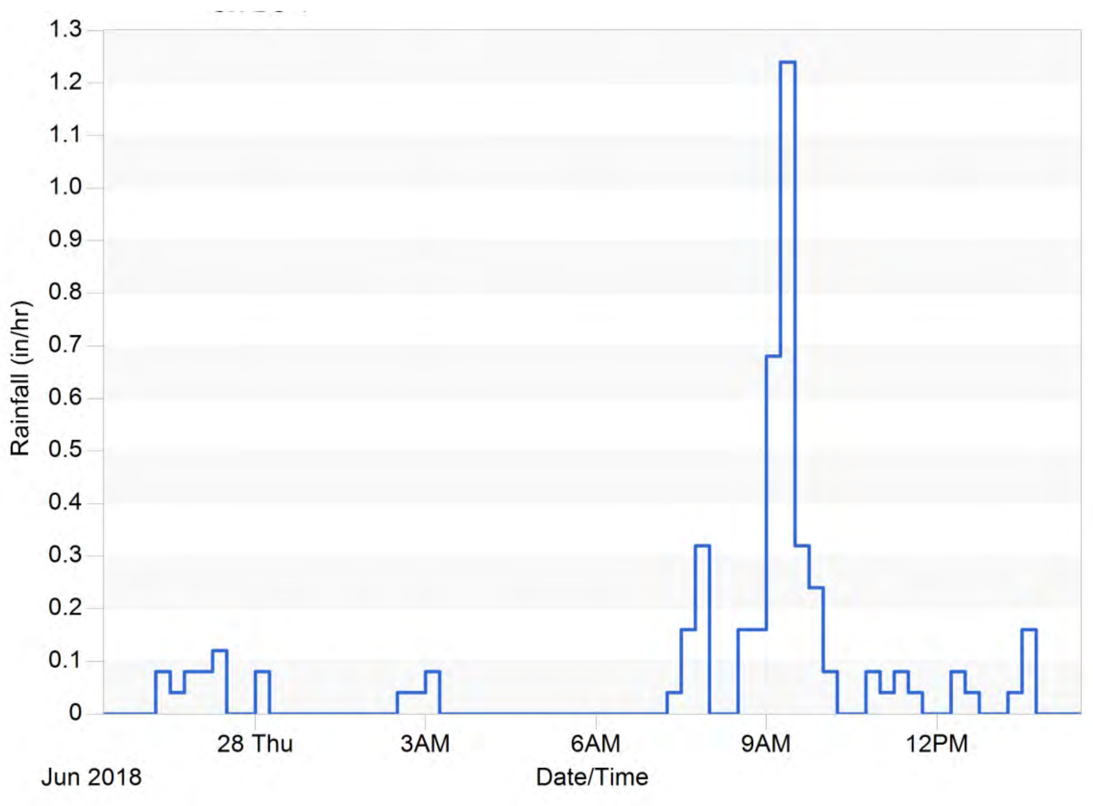



**Figure D-9. Chelsea Creek Headworks June 27, 2018**

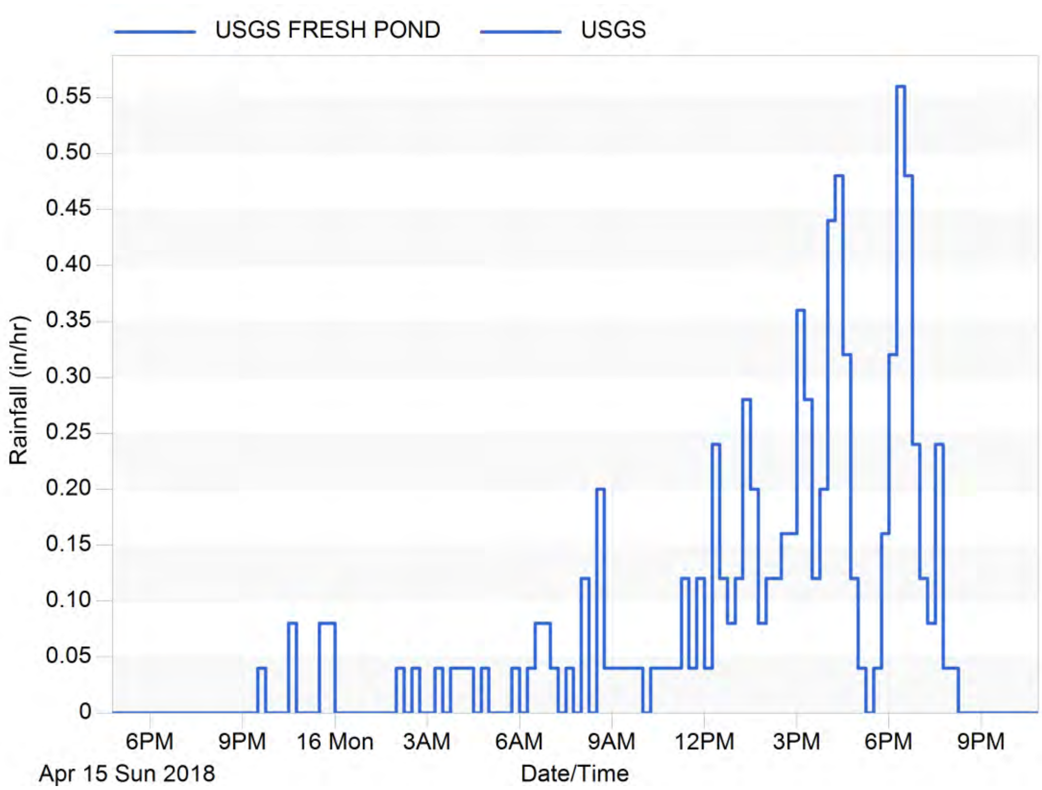



**Figure D-10. Fresh Pond April 15, 2018**

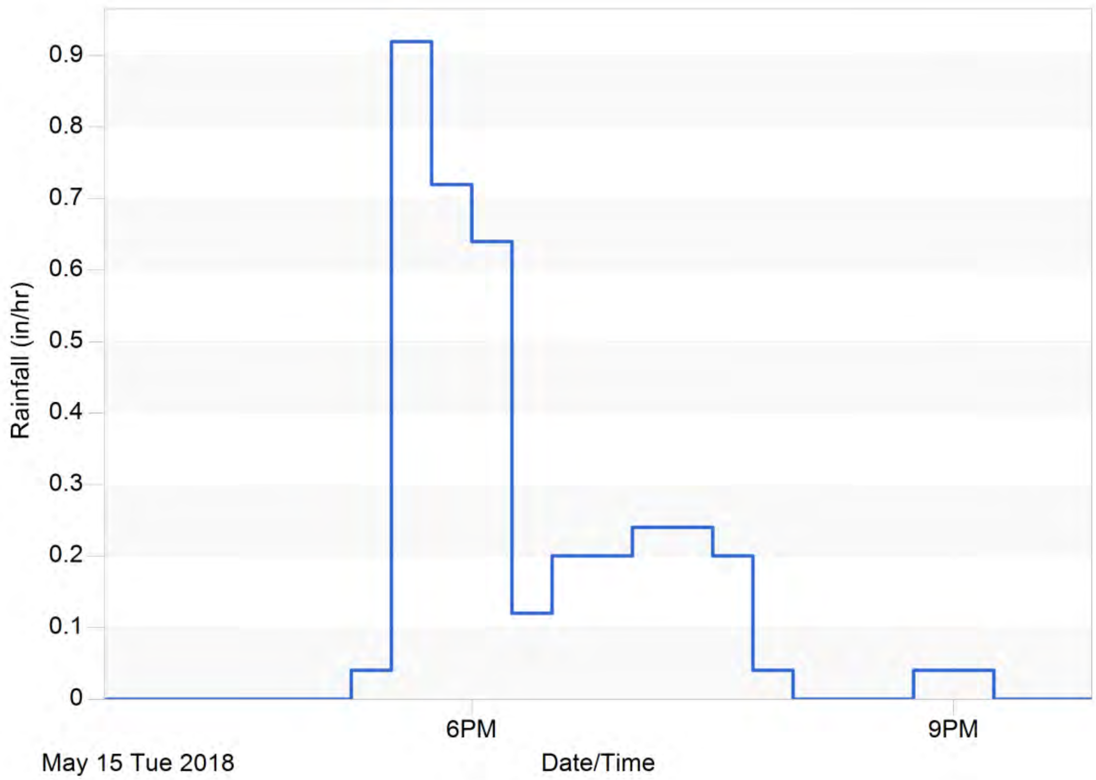



**Figure D-11. Fresh Pond May 15, 2018**

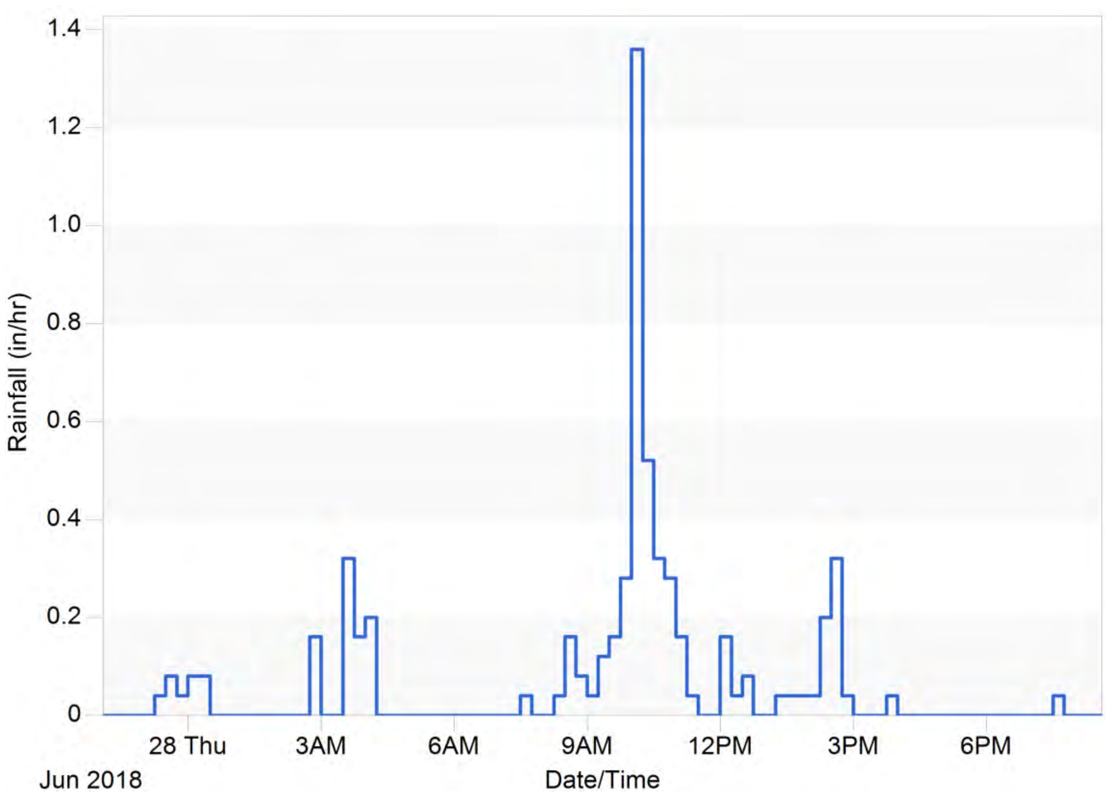
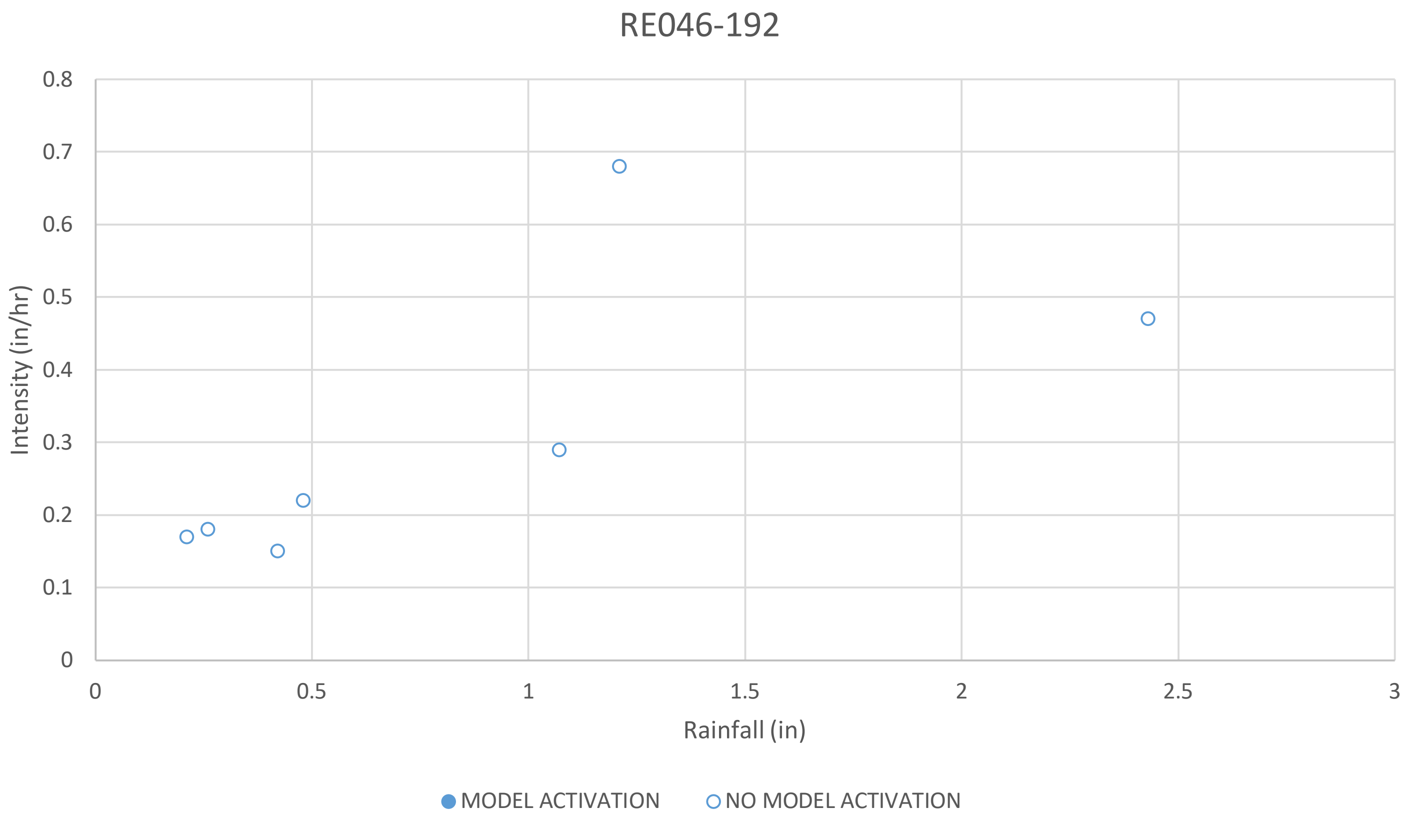


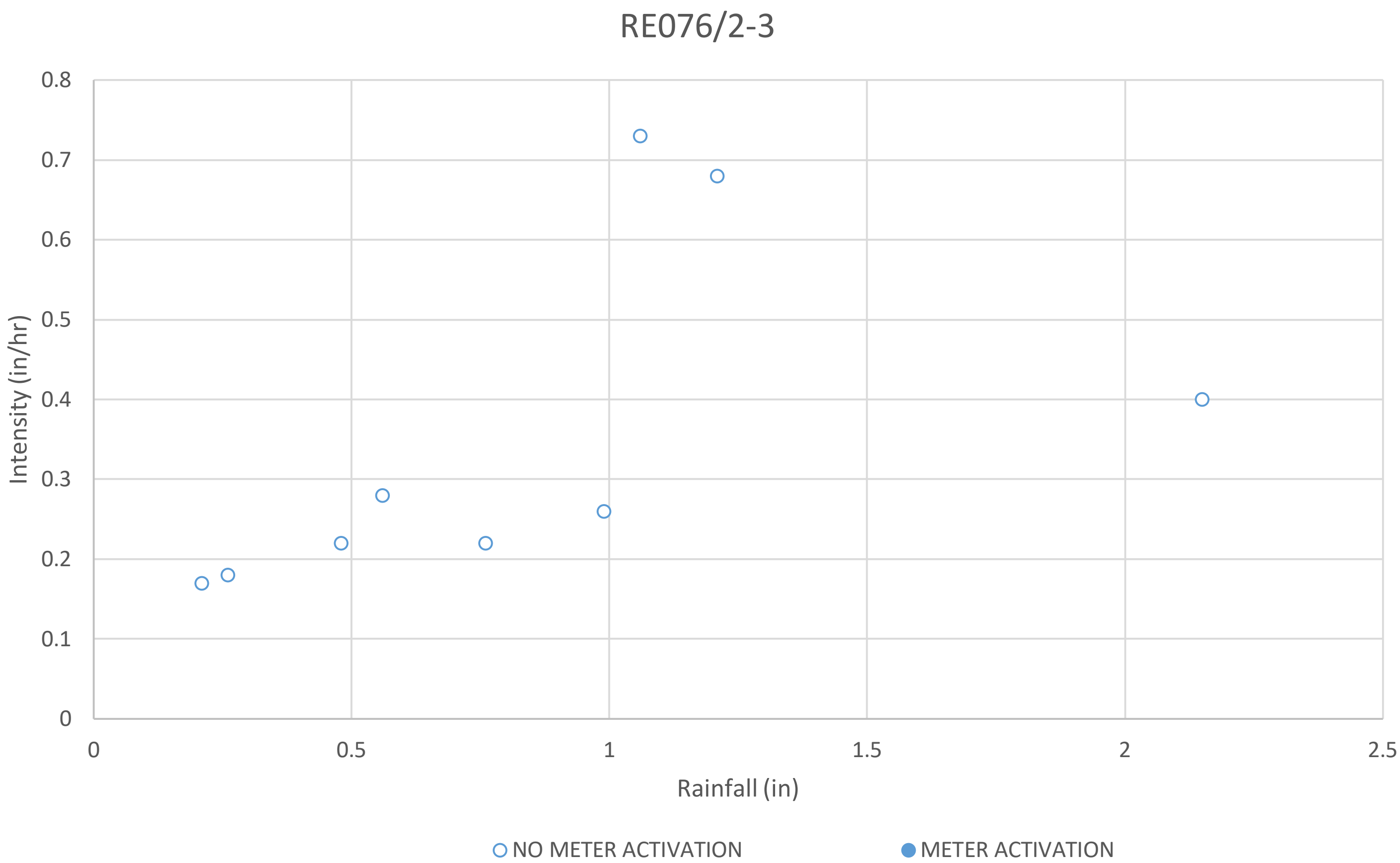

**Figure D-12. Fresh Pond June 27. 2018**

# Appendix E Meter Data Review Scattergraphs

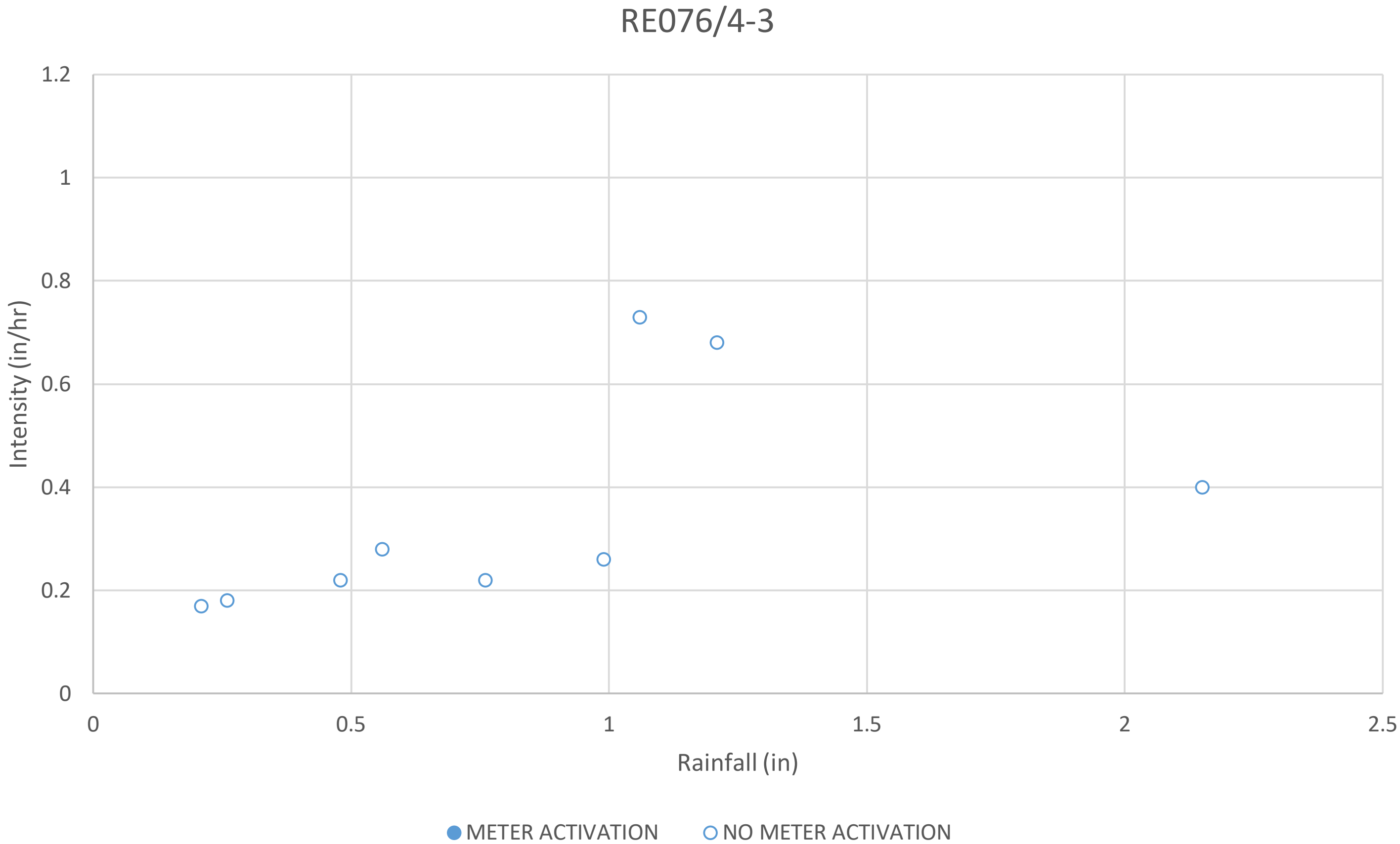
Outfall: MWR023
Regulator: RE046-192
Related Rain Gauge: 2



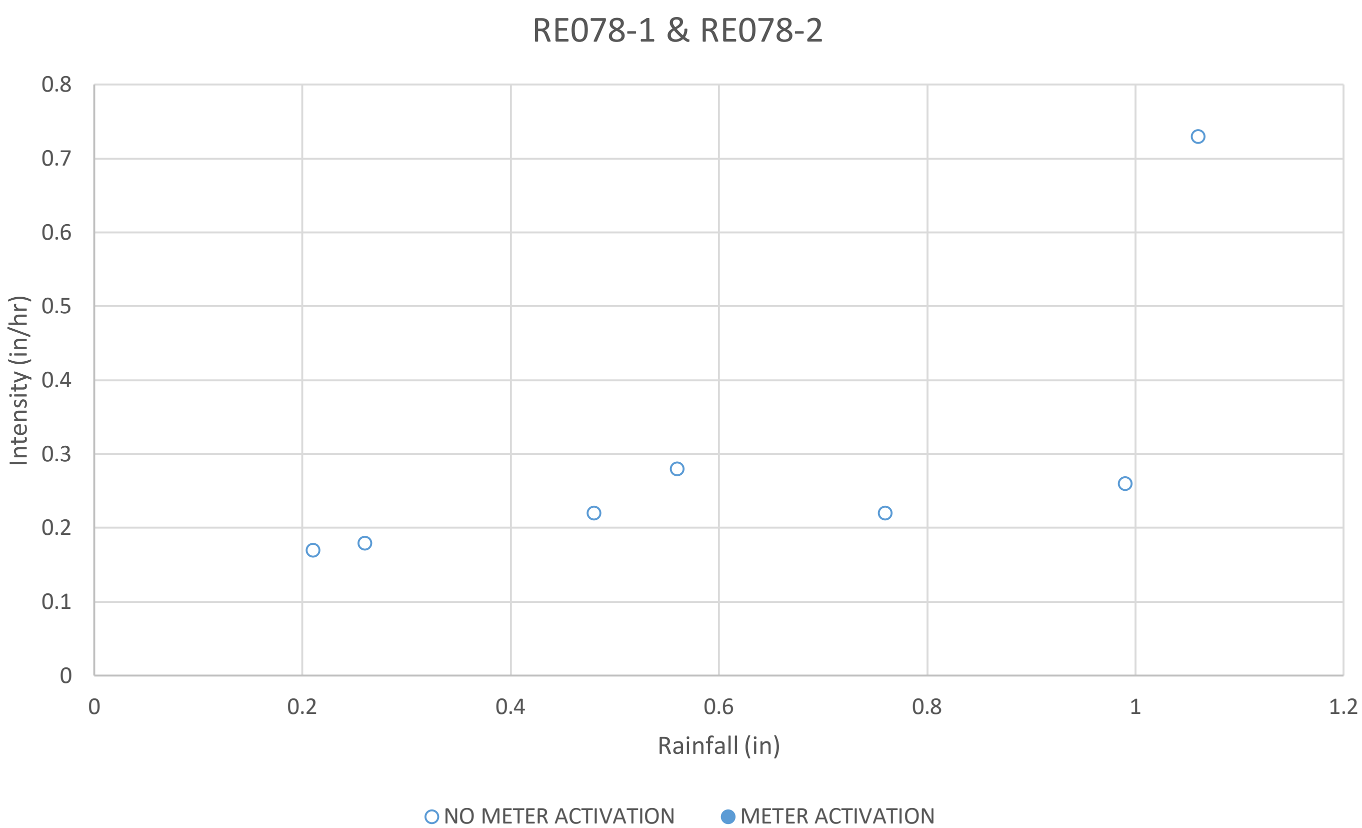
Outfall: BOS076
Regulator: RE076/2-3
Related Rain Gauge: 3



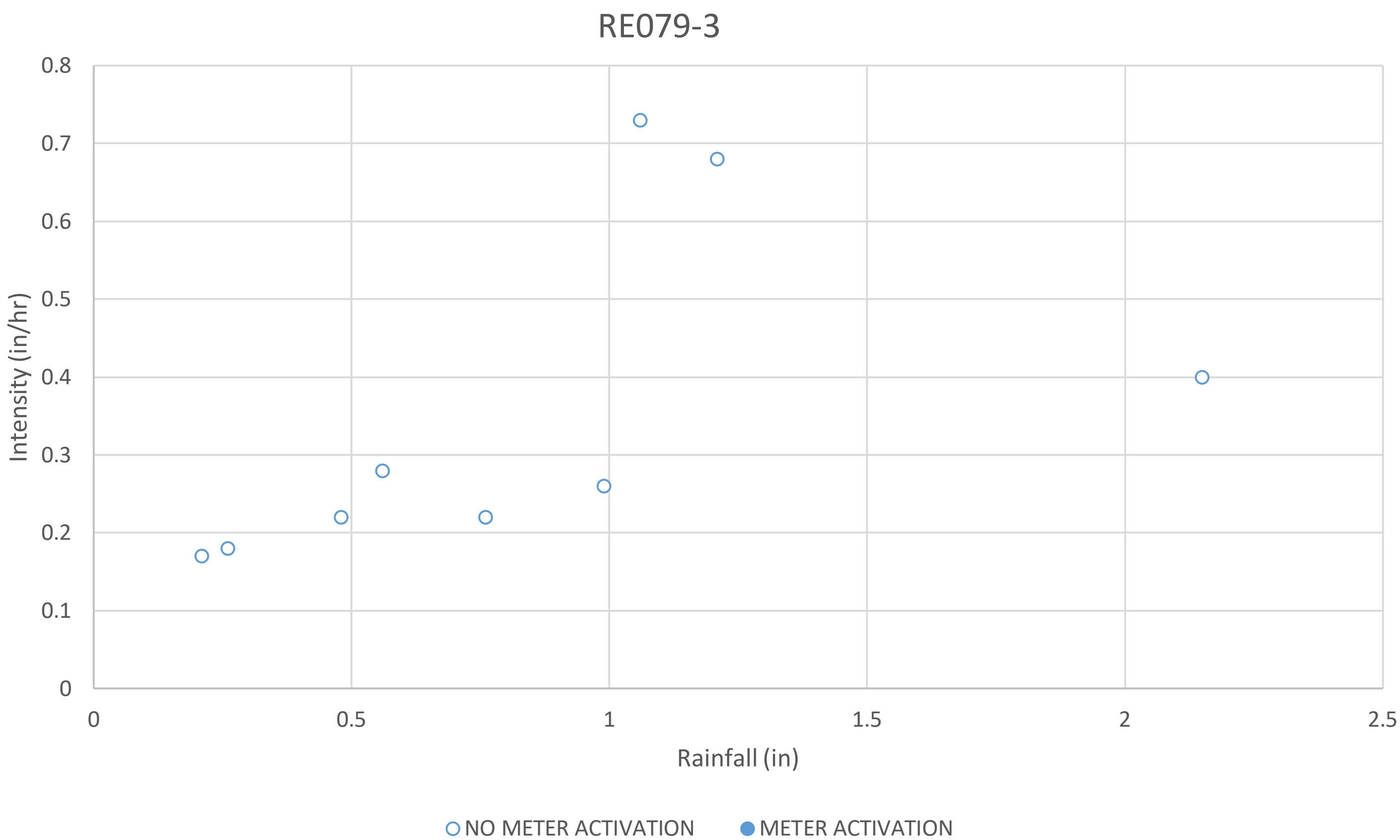
Outfall: BOS076
Regulator: RE076/4-3
Related Rain Gauge: 3



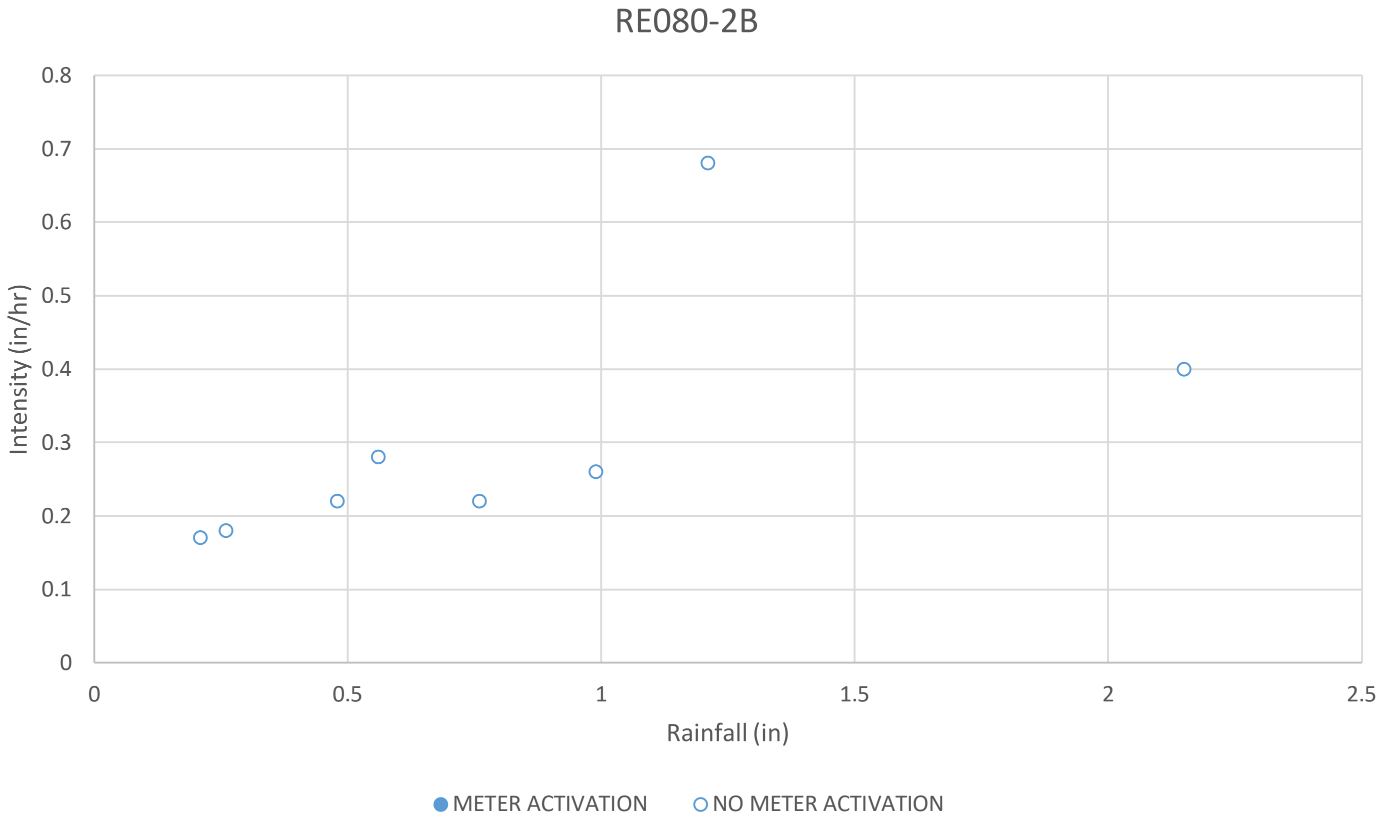
Outfall: BOS078
Regulator: RE078-1 & RE078-2
Related Rain Gauge: 3



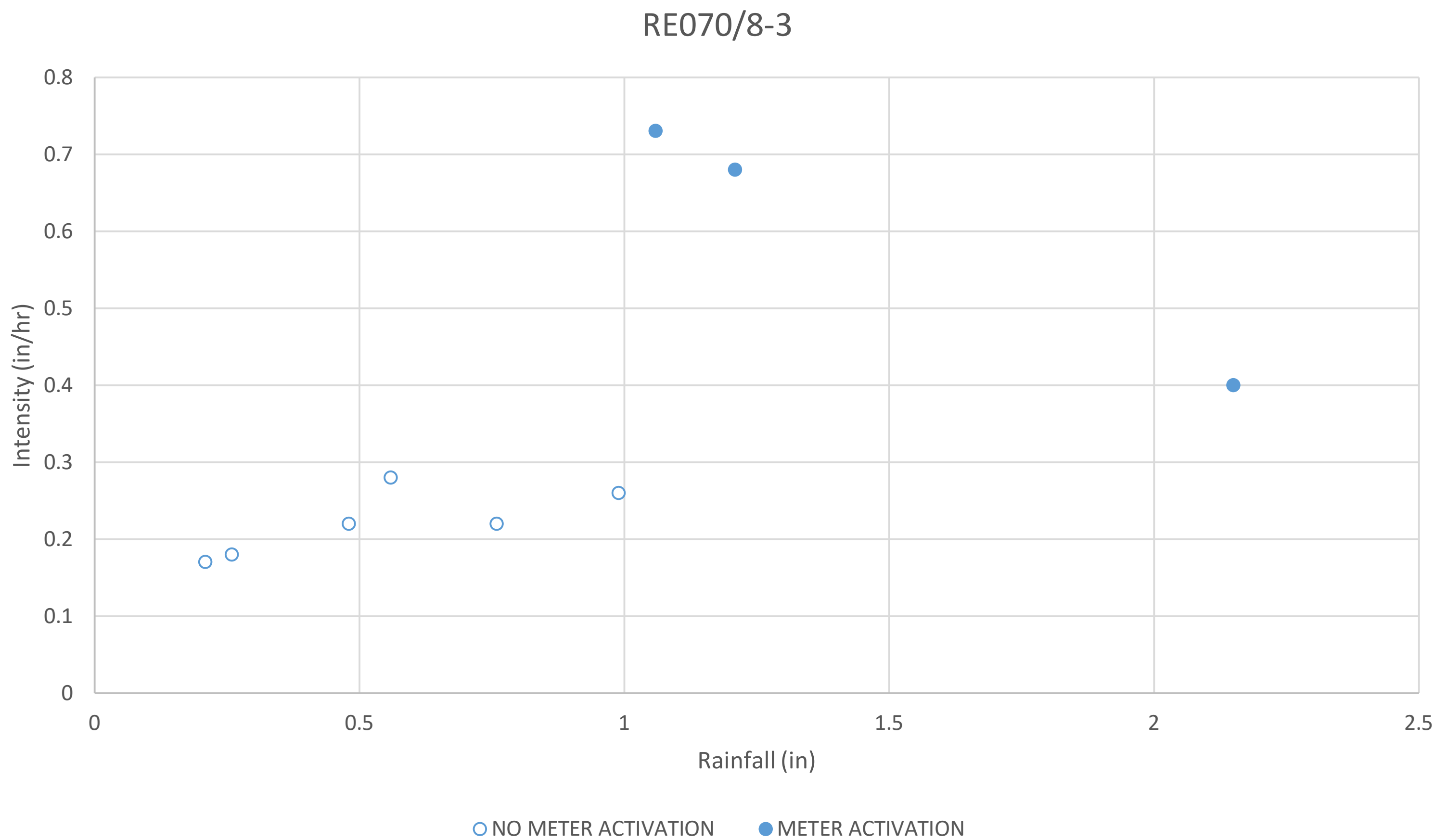
Outfall: BOS079
Regulator: RE079-3
Related Rain Gauge: 3



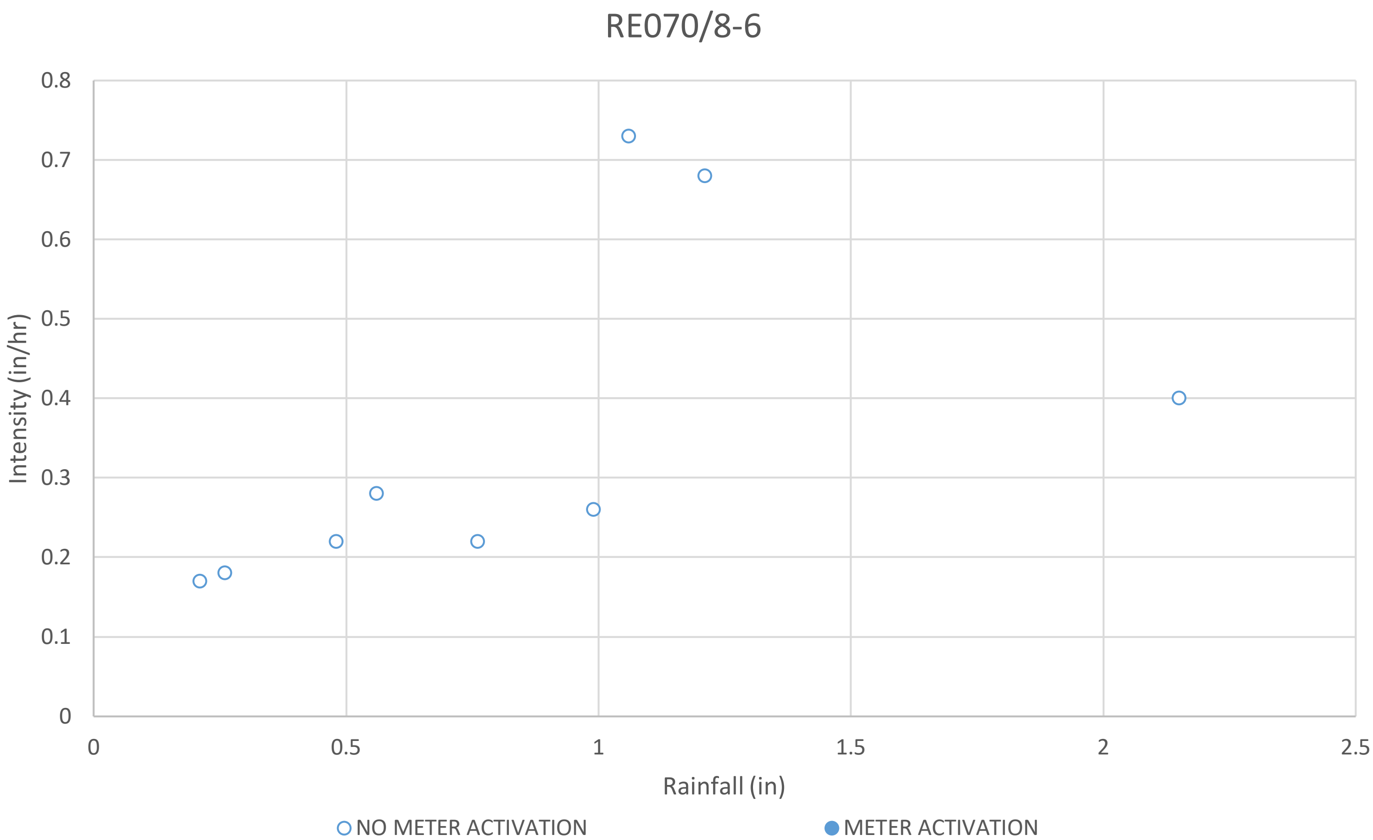
Outfall: BOS080
Regulator: RE080-2B
Related Rain Gauge: 3



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

*Meter data not validated for the period of April 15-June 30, 2018*

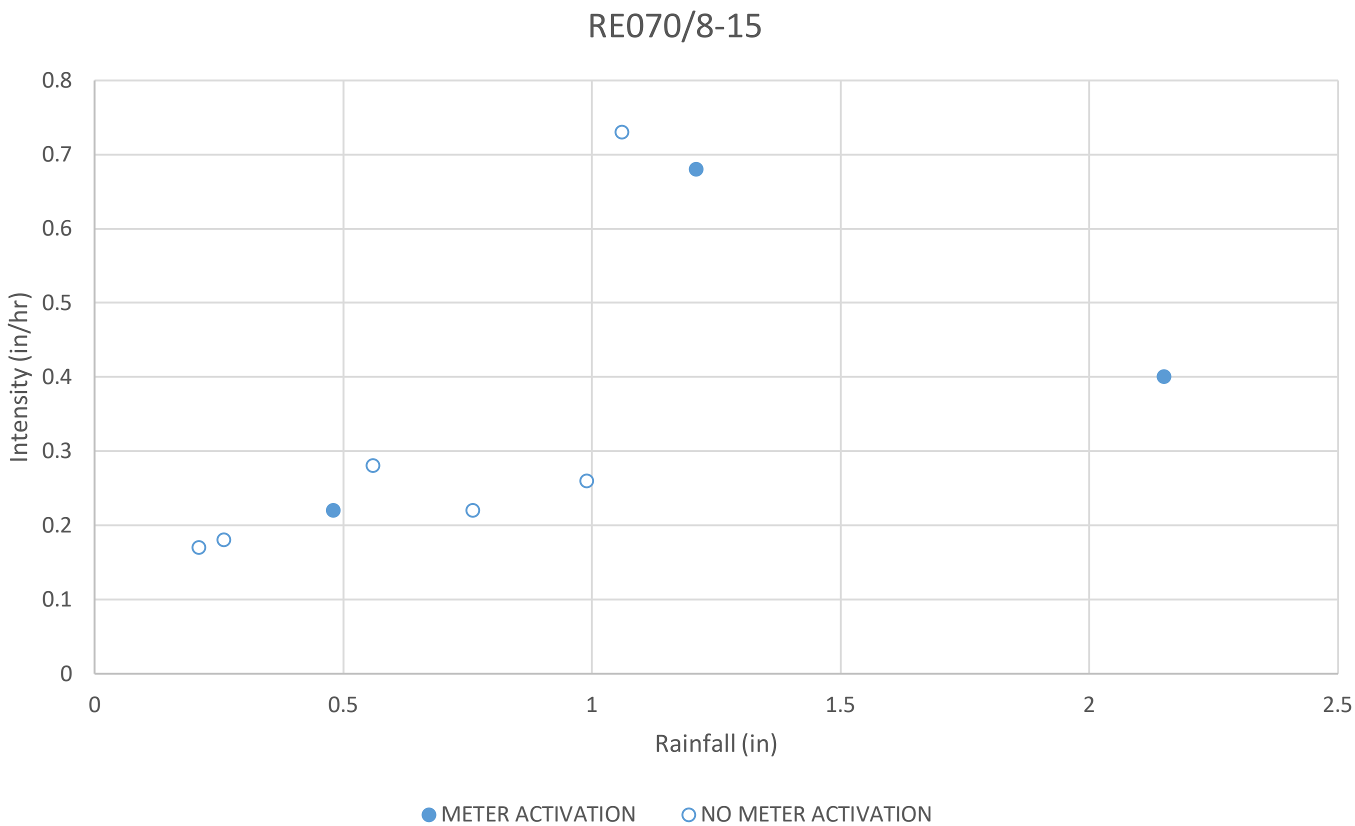
Outfall:BOS70/DBC
Regulator: RE070/8-8
Related Rain Gauge: 3

*Meter data not validated for the period of April 15-June 30, 2018*

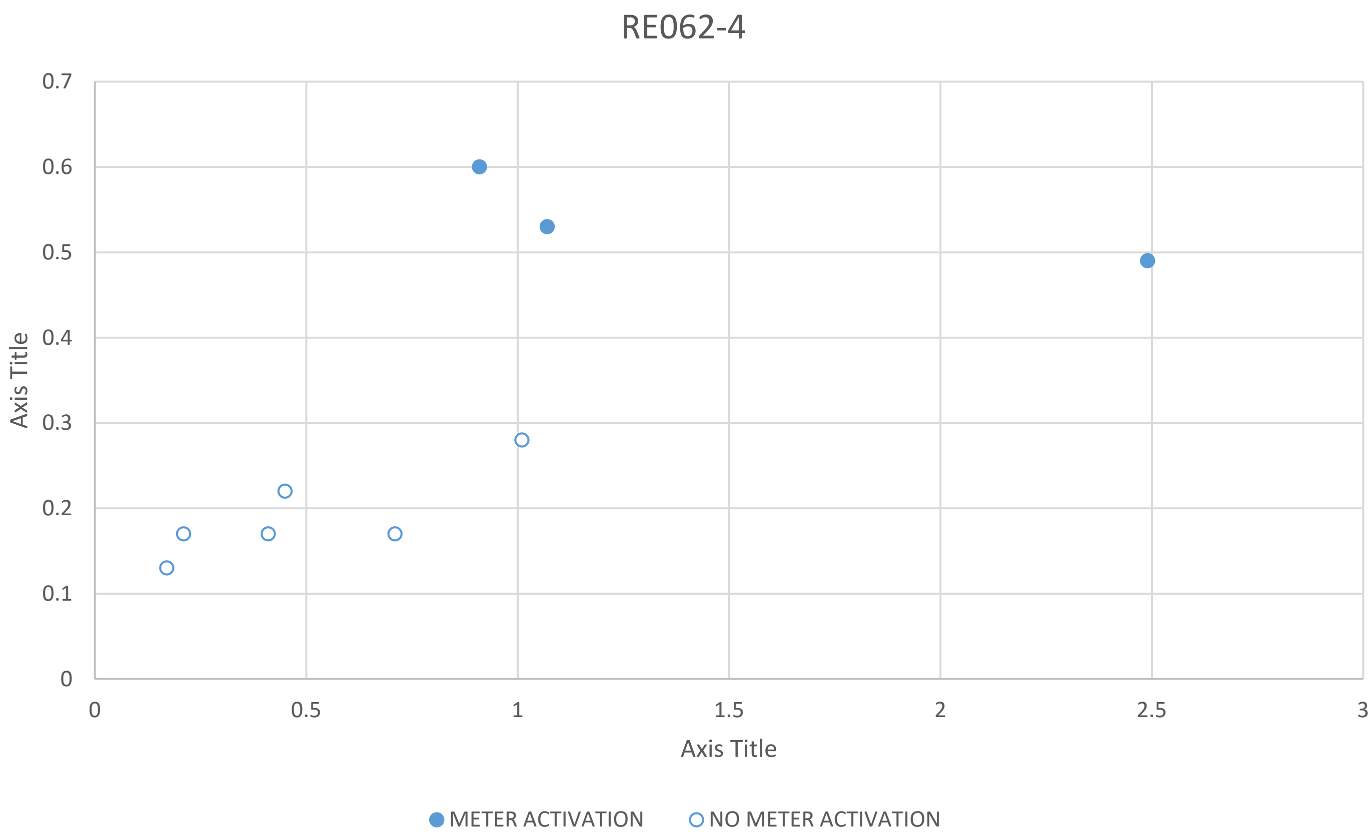
Outfall:BOS70/DBC
Regulator: RE070/8-13
Related Rain Gauge: 3

*Meter data not validated for the period of April 15-June 30, 2018*

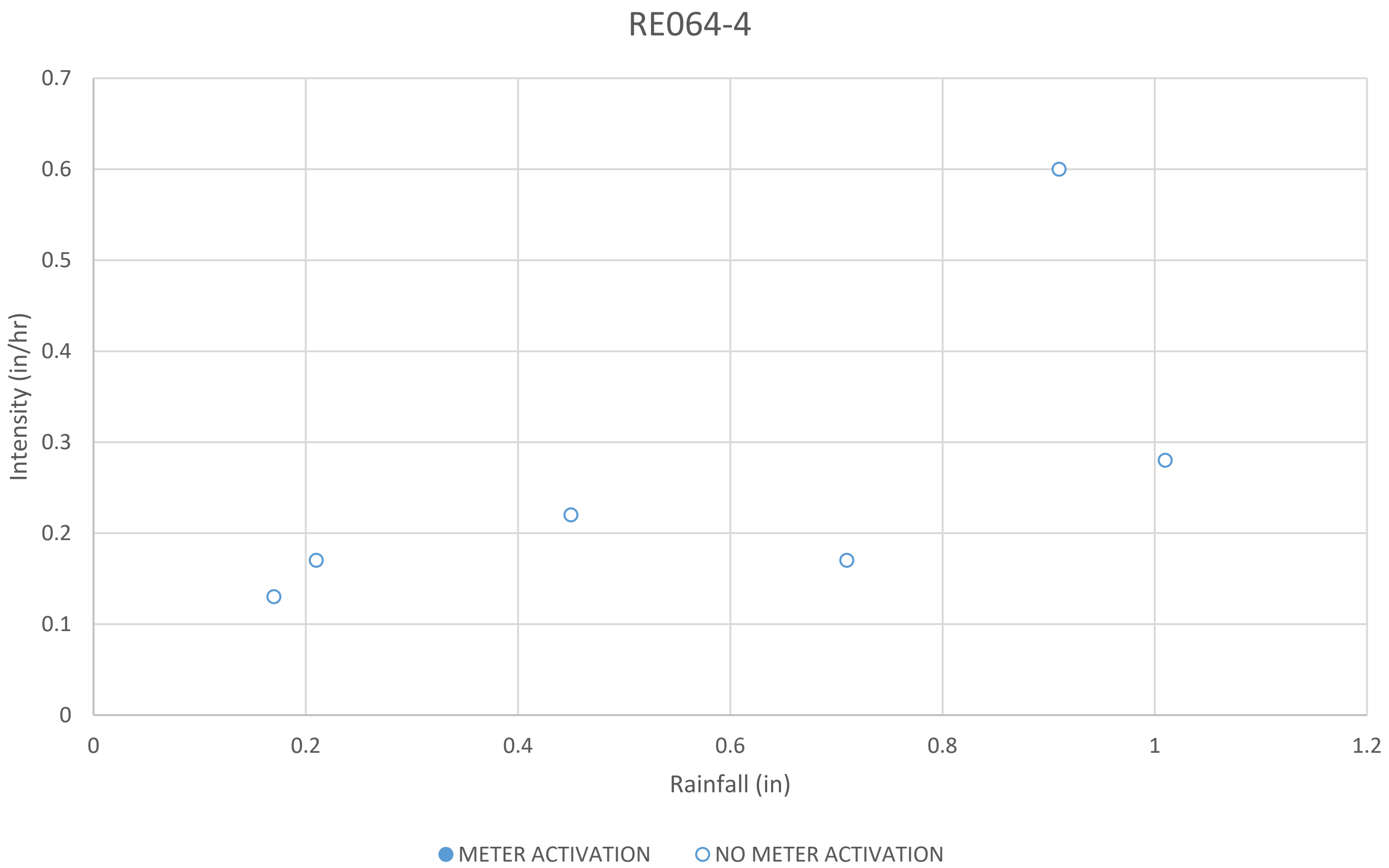
Outfall:BOS70/DBC
Regulator: RE070/8-15
Related Rain Gauge: 3



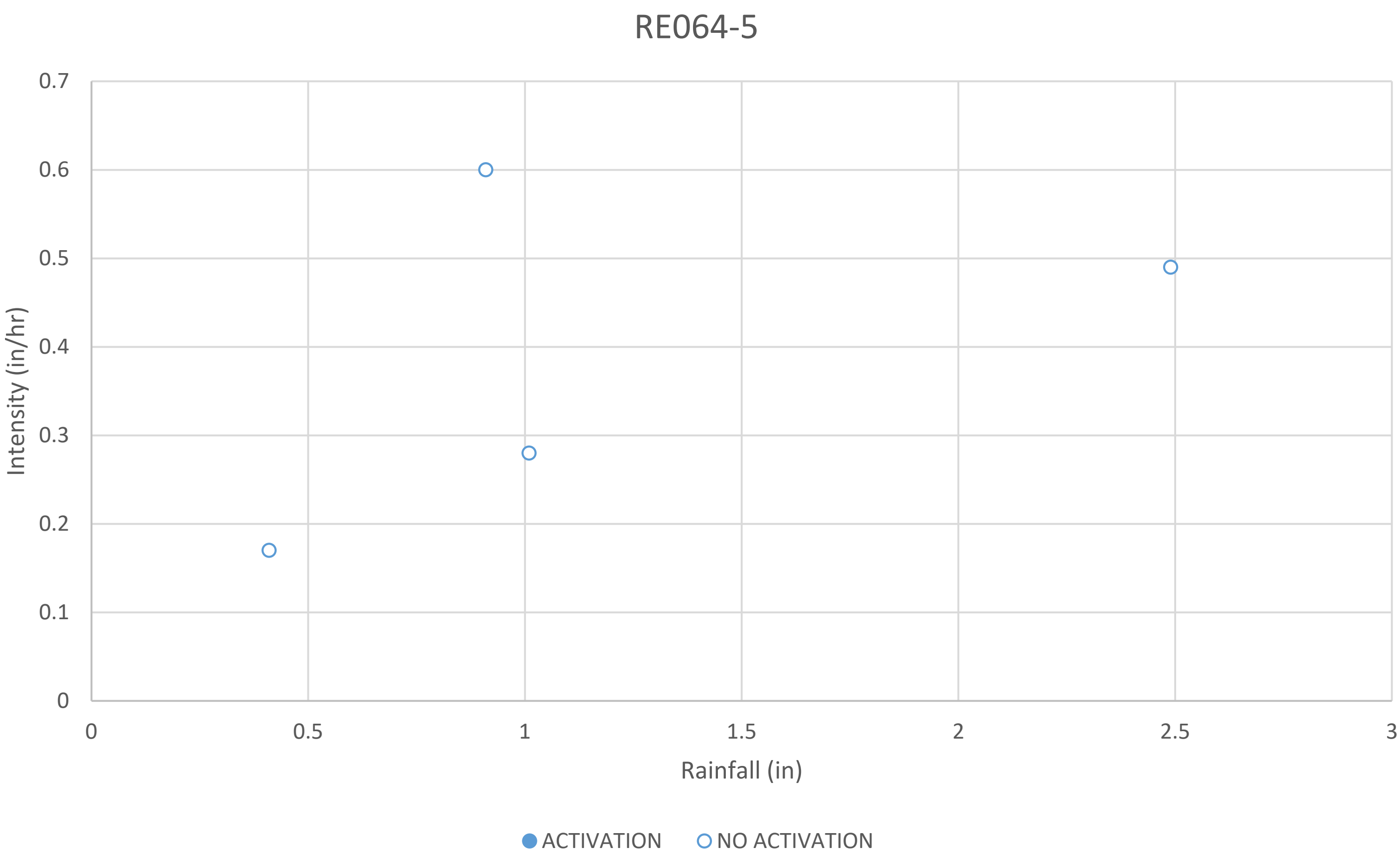
Outfall:BOS062
Regulator: RE62-4
Related Rain Gauge: 18



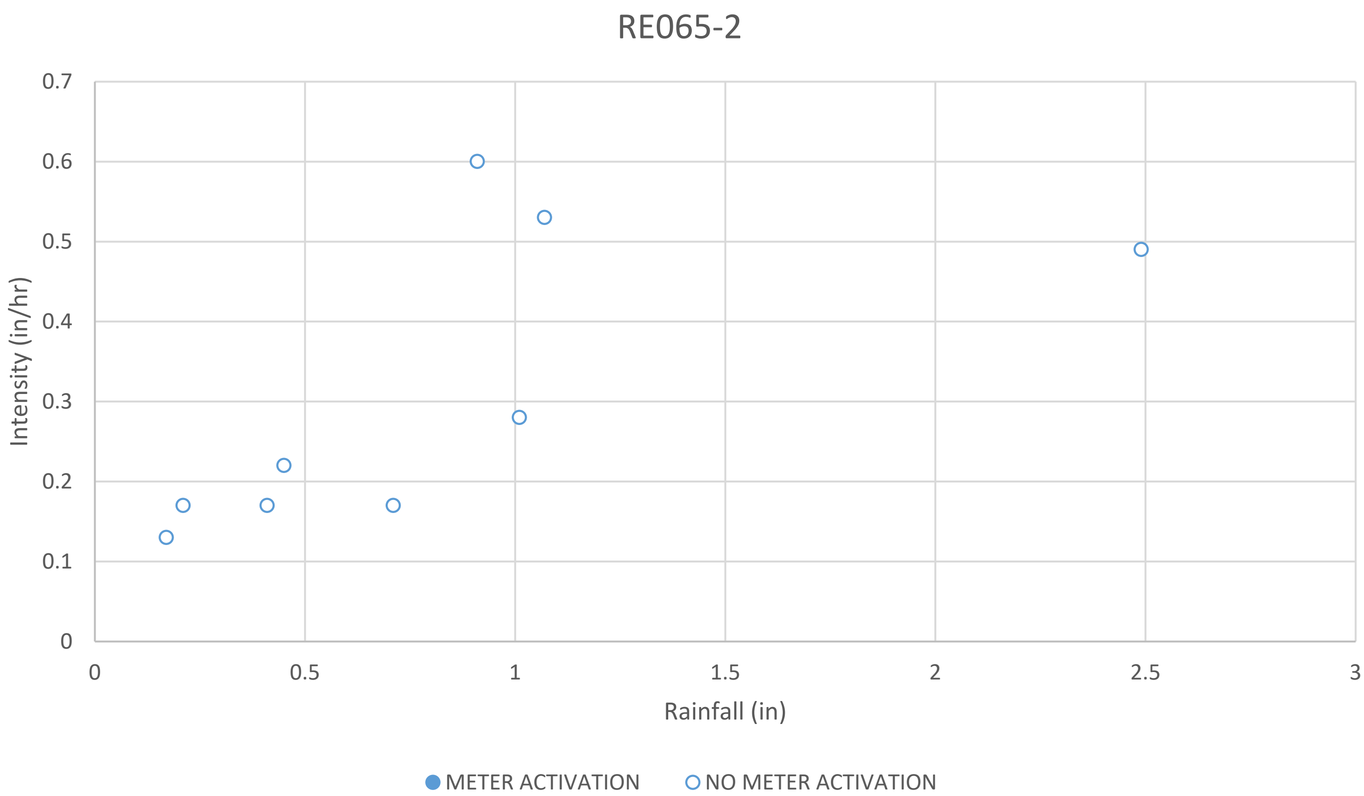
Outfall:BOS064
Regulator: RE64-4
Related Rain Gauge: 18



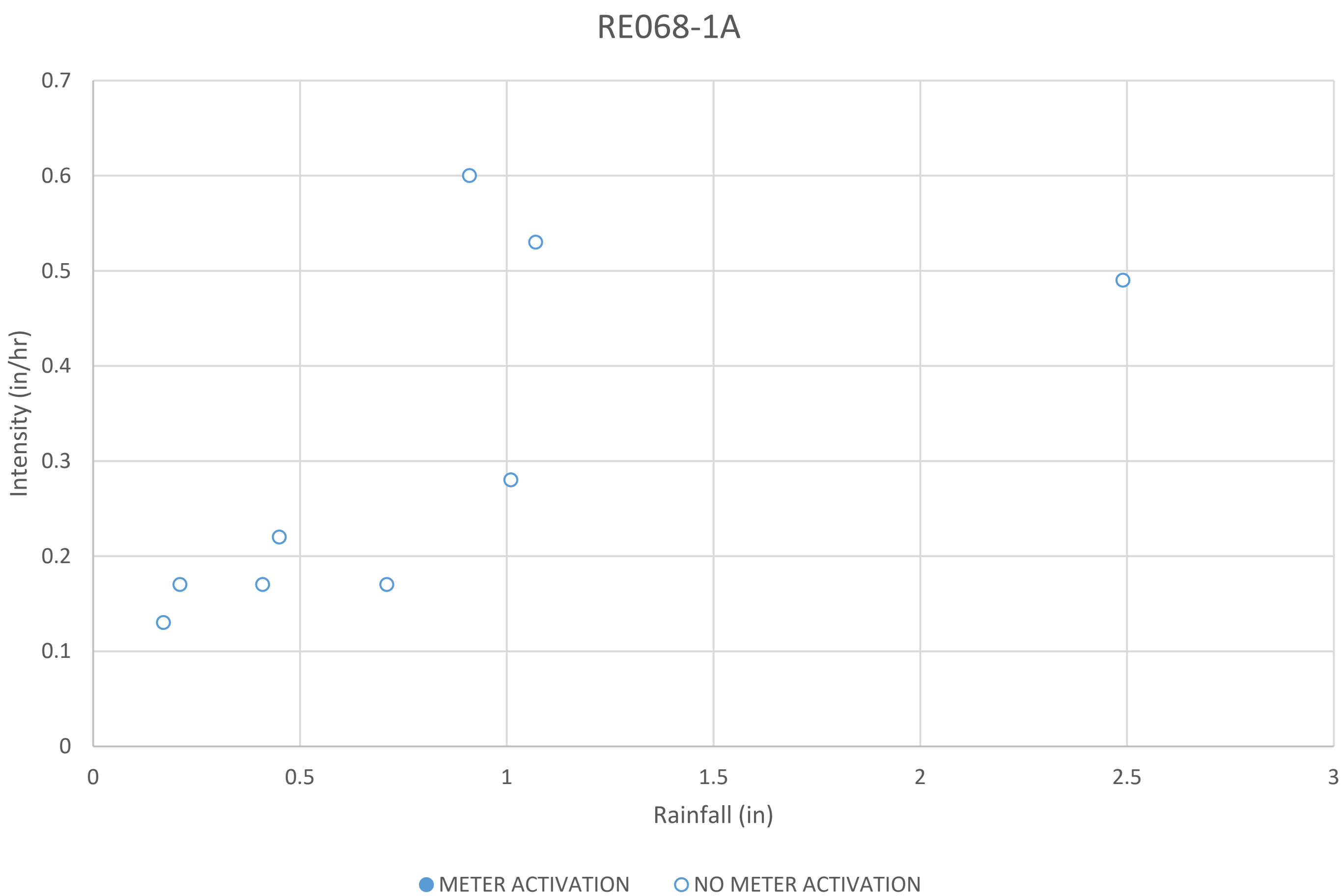
Outfall:BOS064
Regulator: RE64-5
Related Rain Gauge: 18



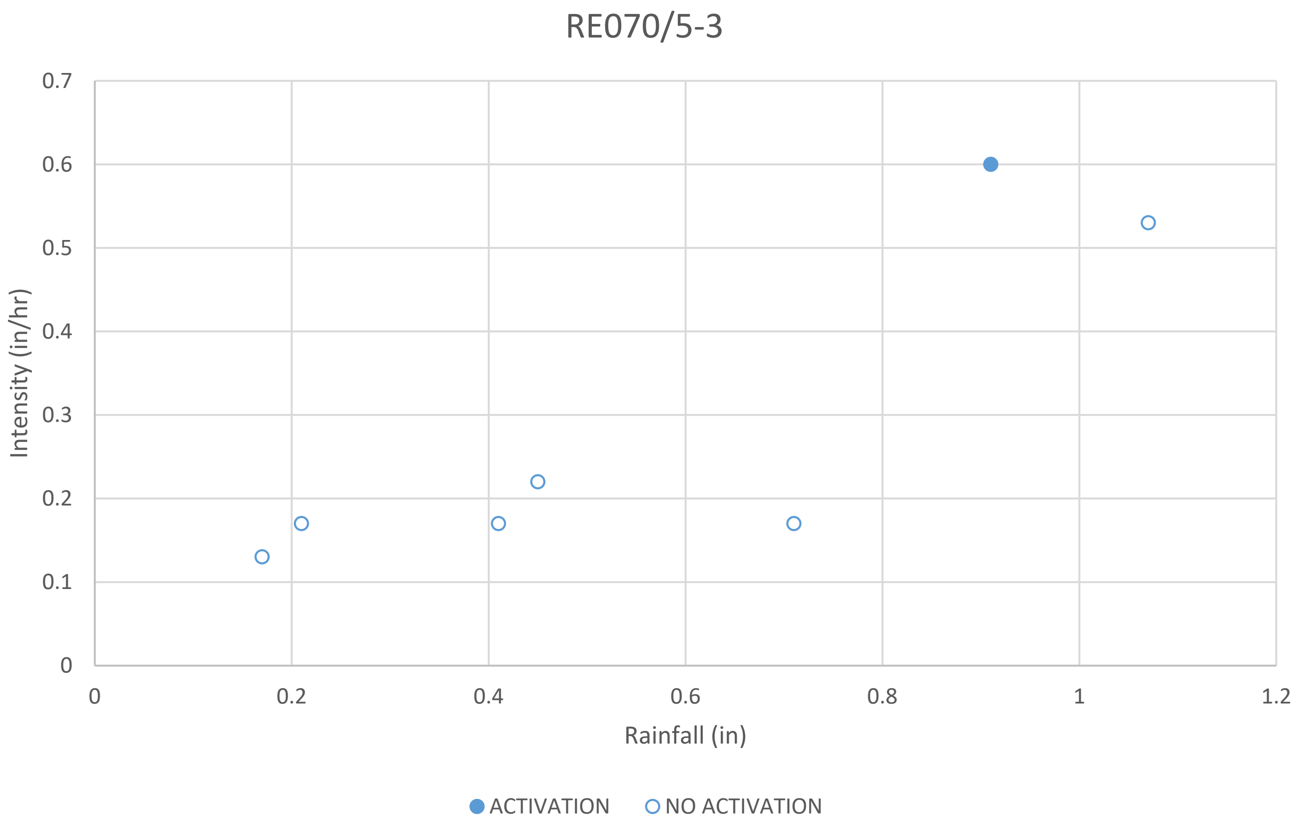
Outfall:BOS065
Regulator: RE65-2
Related Rain Gauge: 18



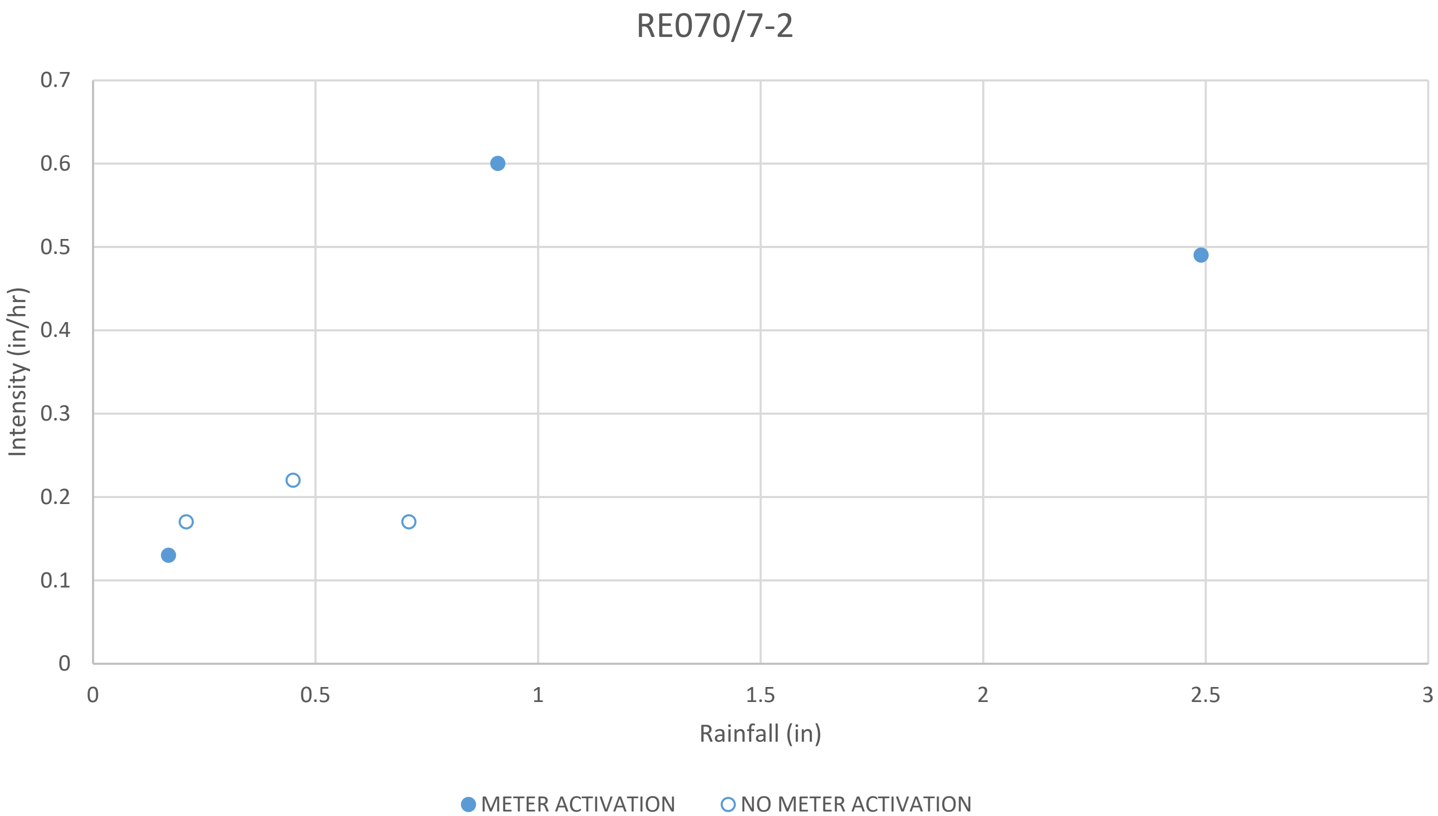
Outfall:BOS068
Regulator: RE68-1A
Related Rain Gauge: 18



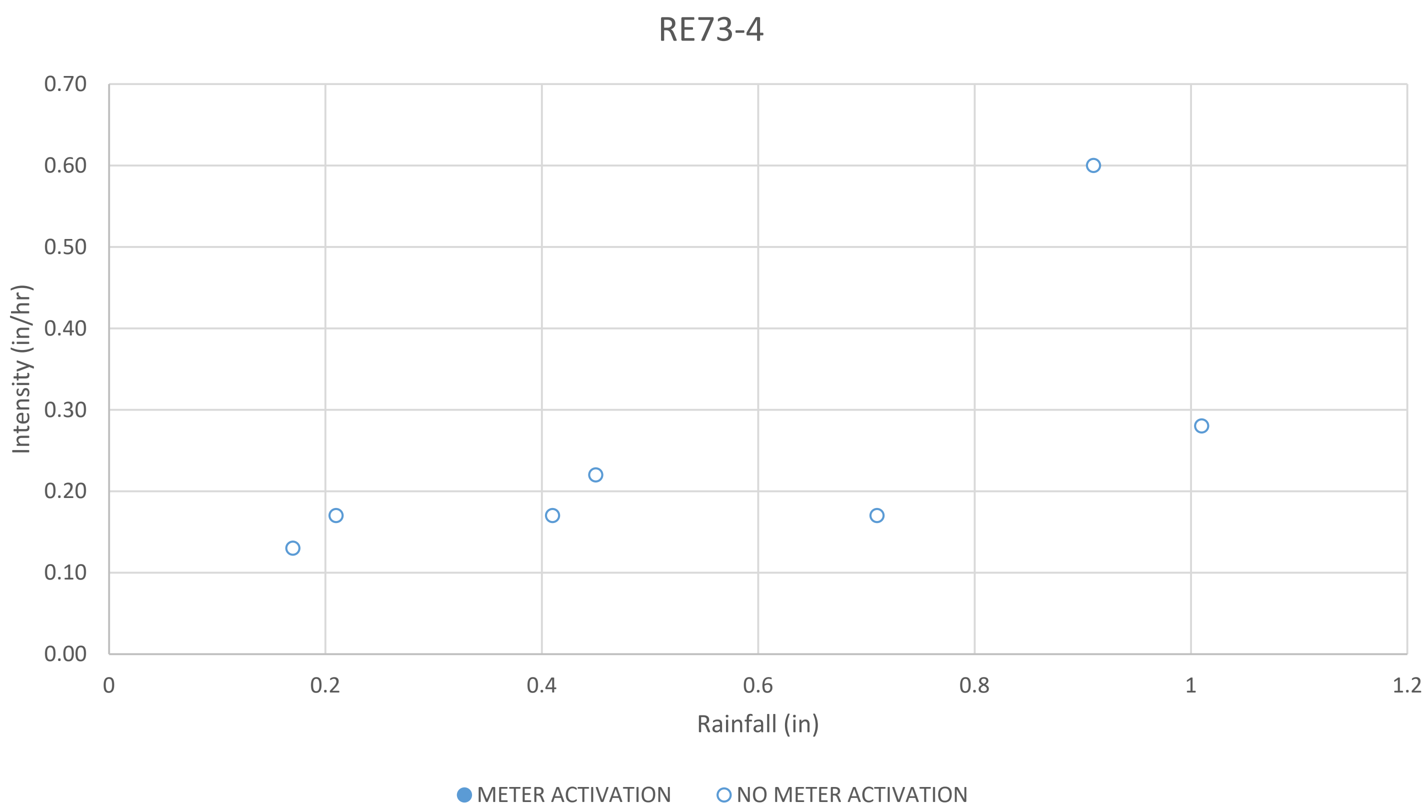
Outfall:BOS070/RRCC
Regulator: RE70/5-3
Related Rain Gauge: 18



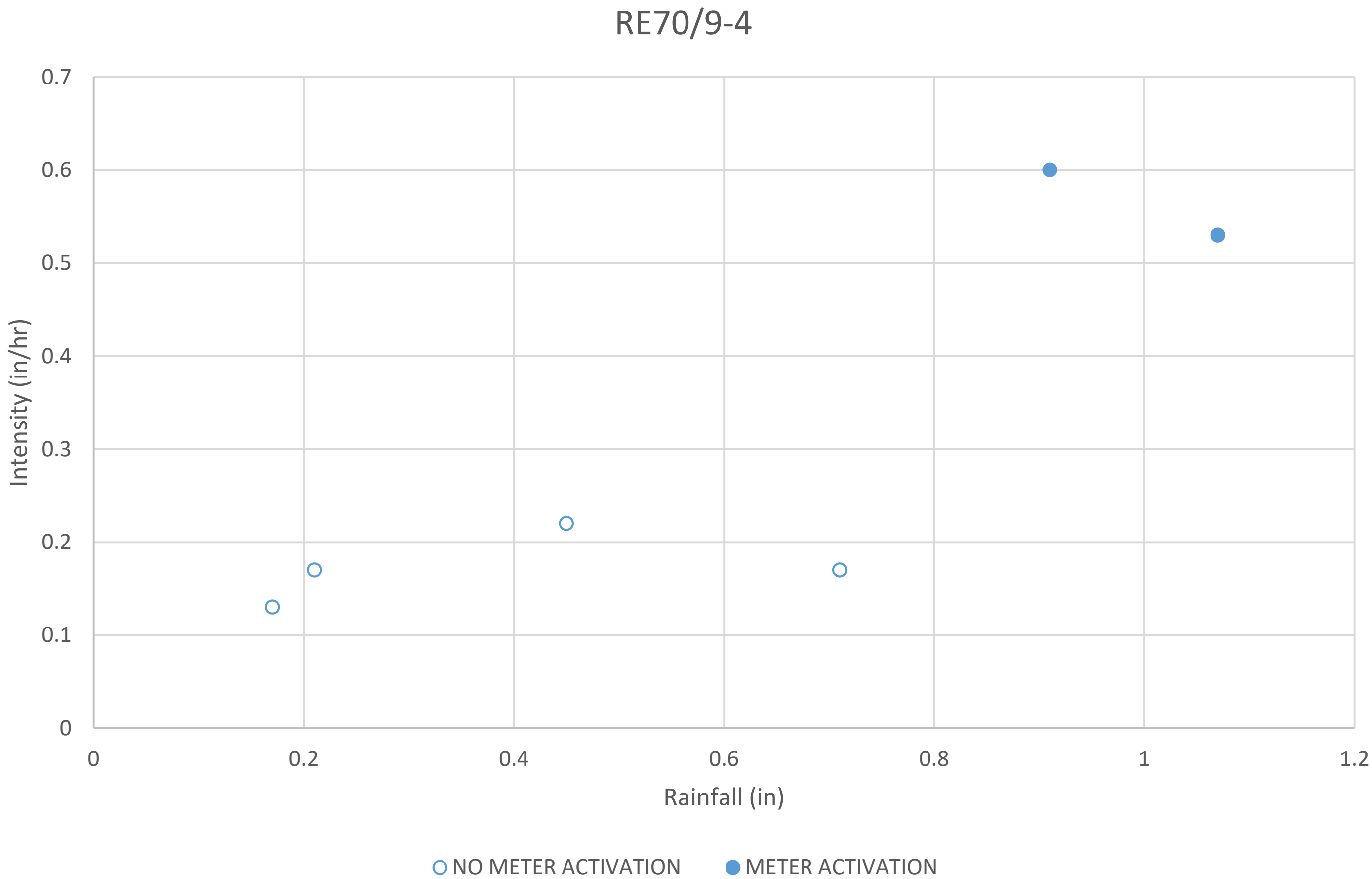
Outfall:BOS070/DBC
Regulator: RE70/7-2
Related Rain Gauge: 18



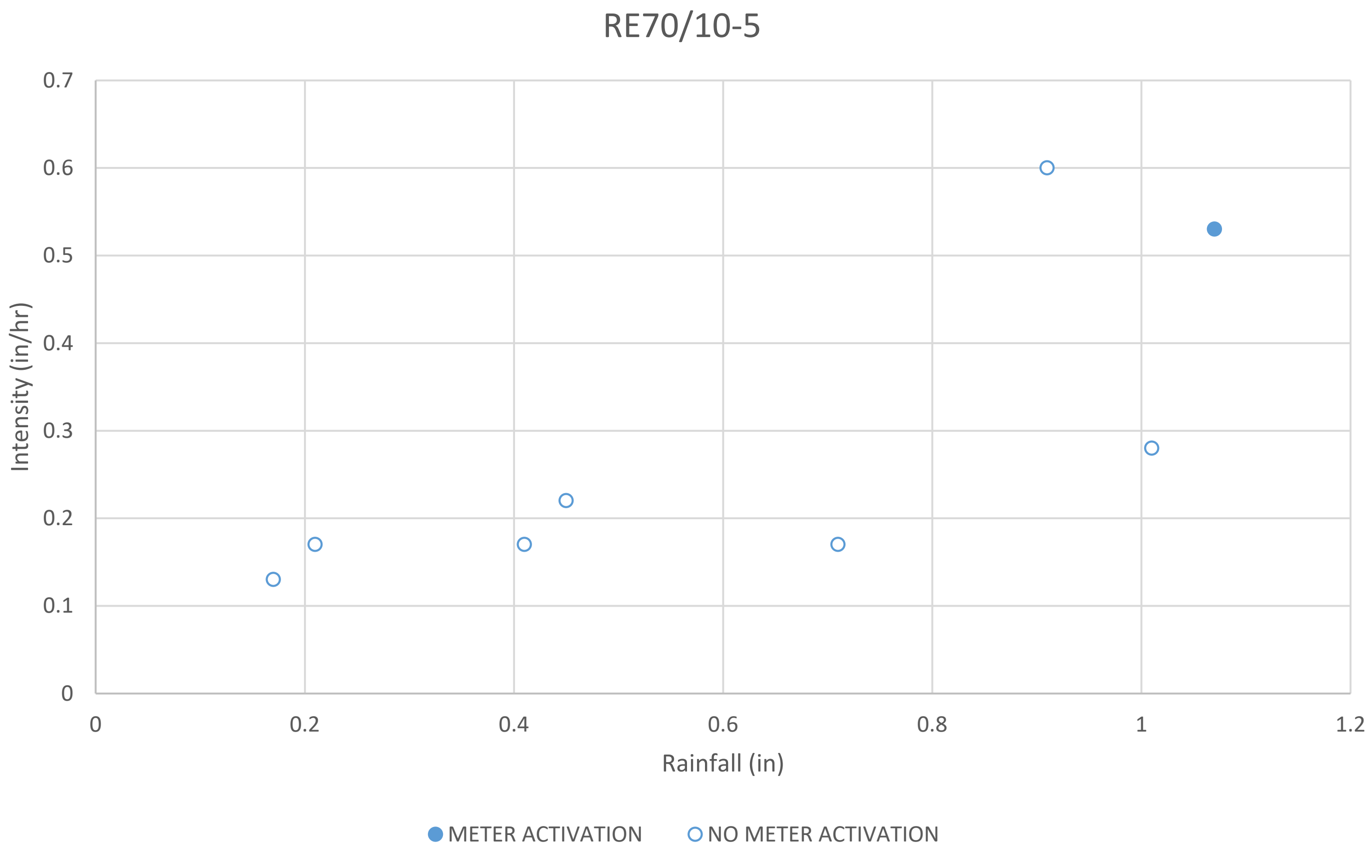
Outfall:BOS073
Regulator: RE073-4
Related Rain Gauge: 18



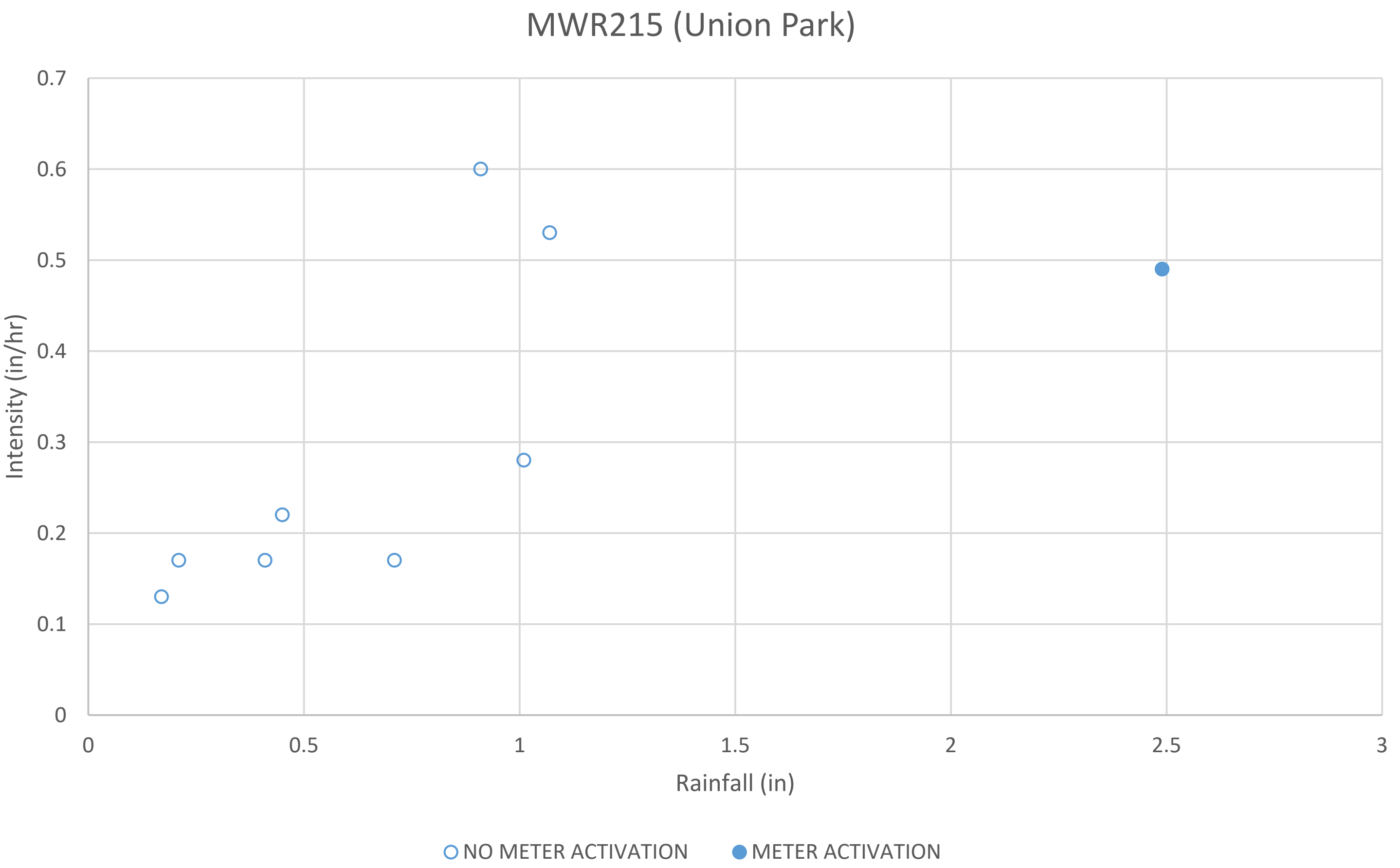
Outfall:BOS070/DBC
Regulator: RE70/9-4
Related Rain Gauge: 18



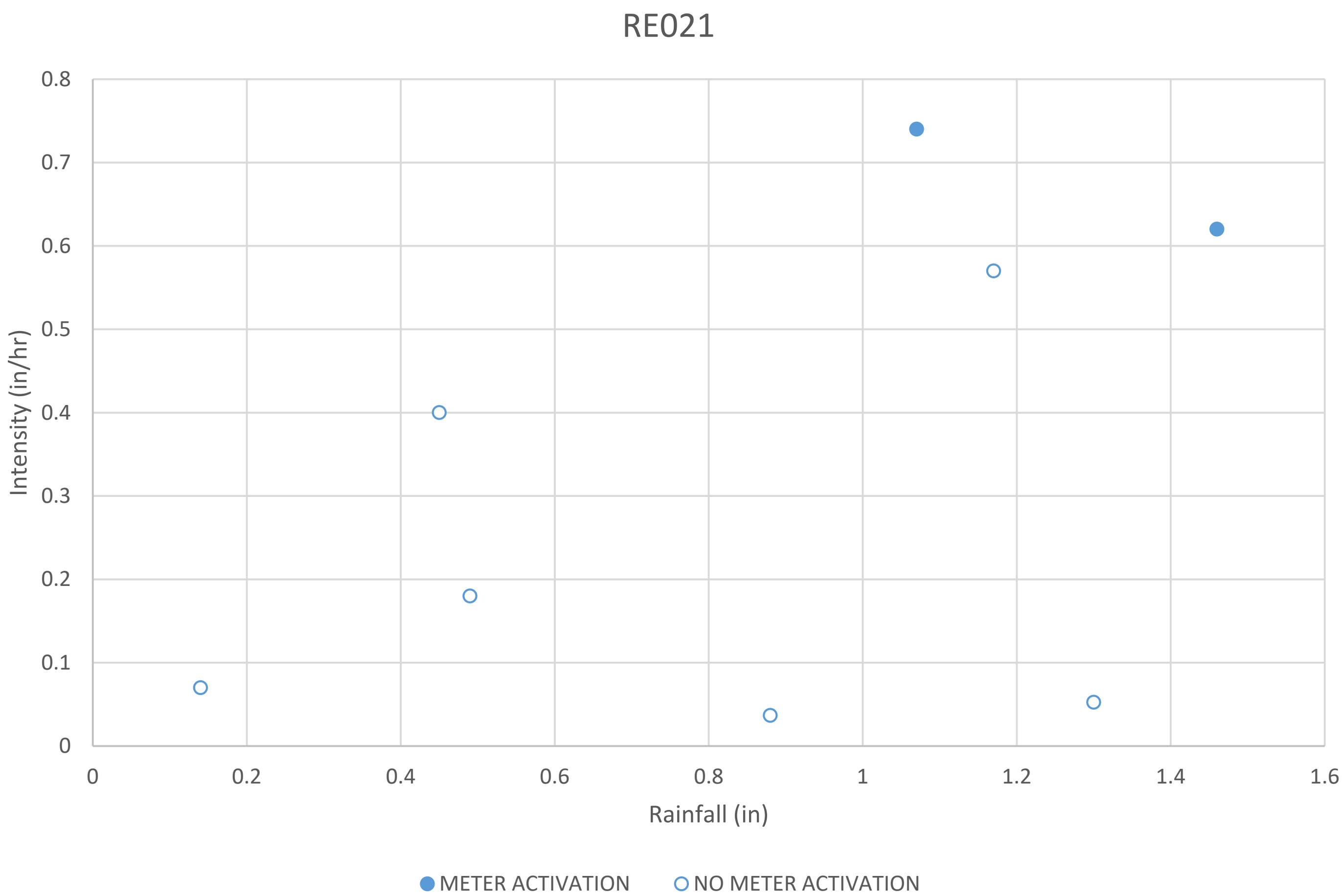
Outfall:BOS070/DBC
Regulator: RE70/10-5
Related Rain Gauge: 18



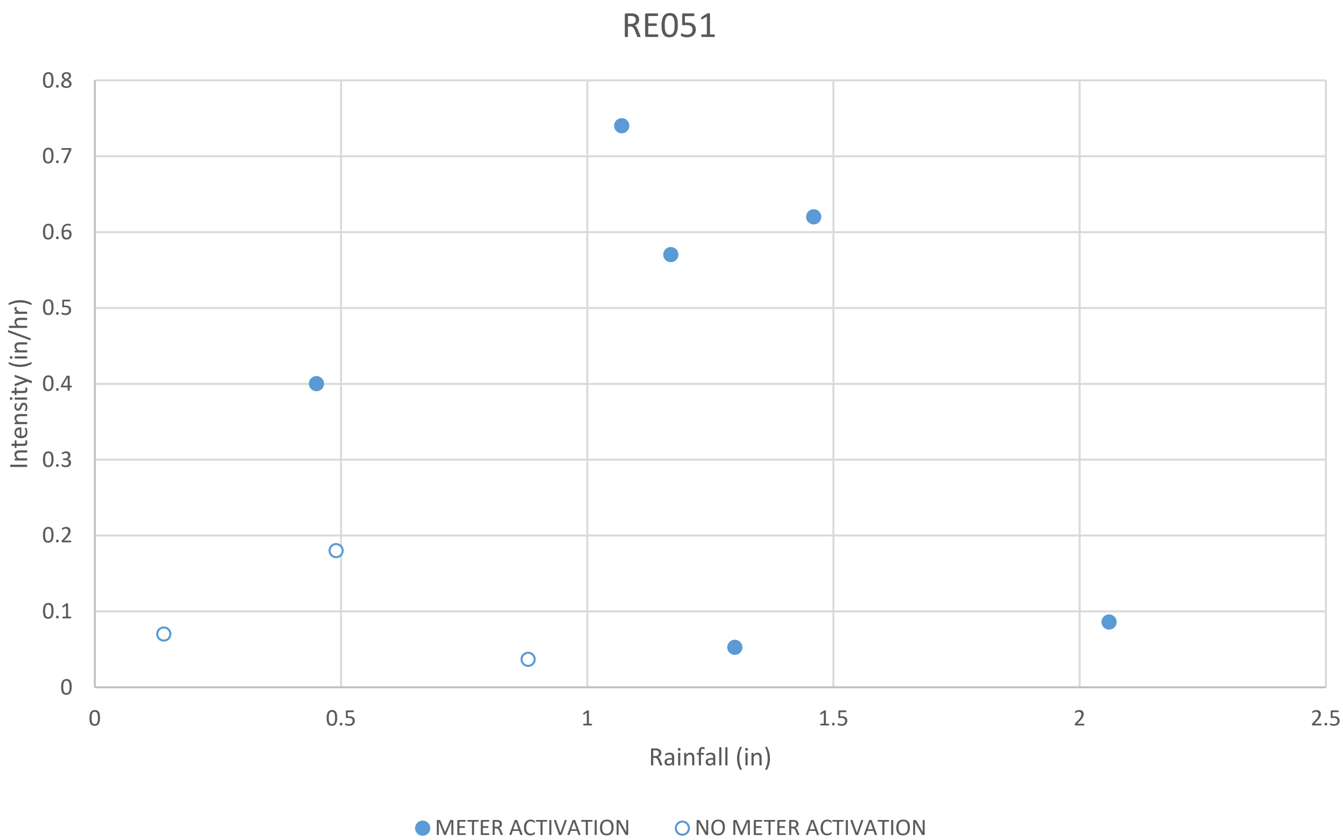
Outfall:MWR215 (Union Park)
Regulator: N/A
Related Rain Gauge: 18



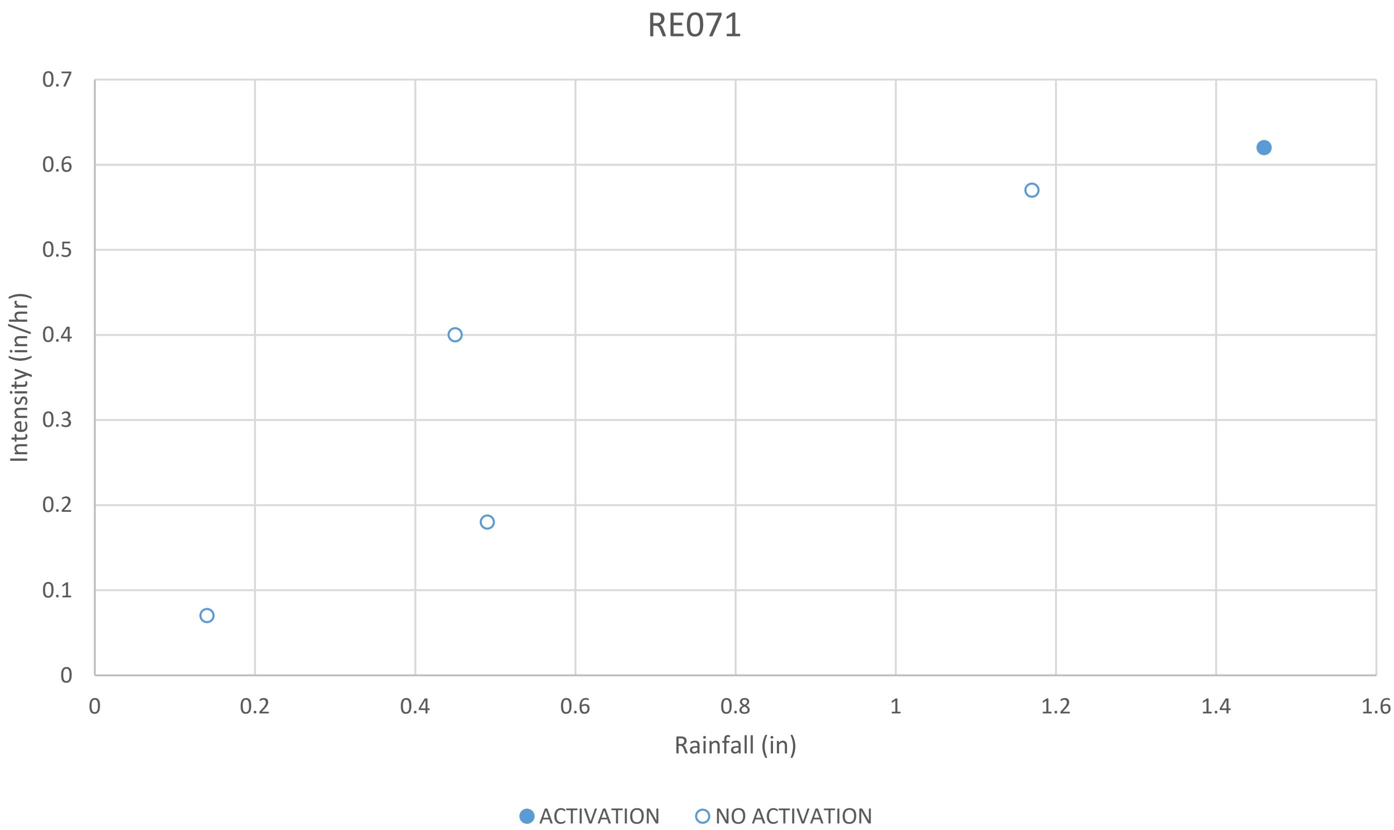
Outfall:CAM002
Regulator: RE021
Related Rain Gauge: 19



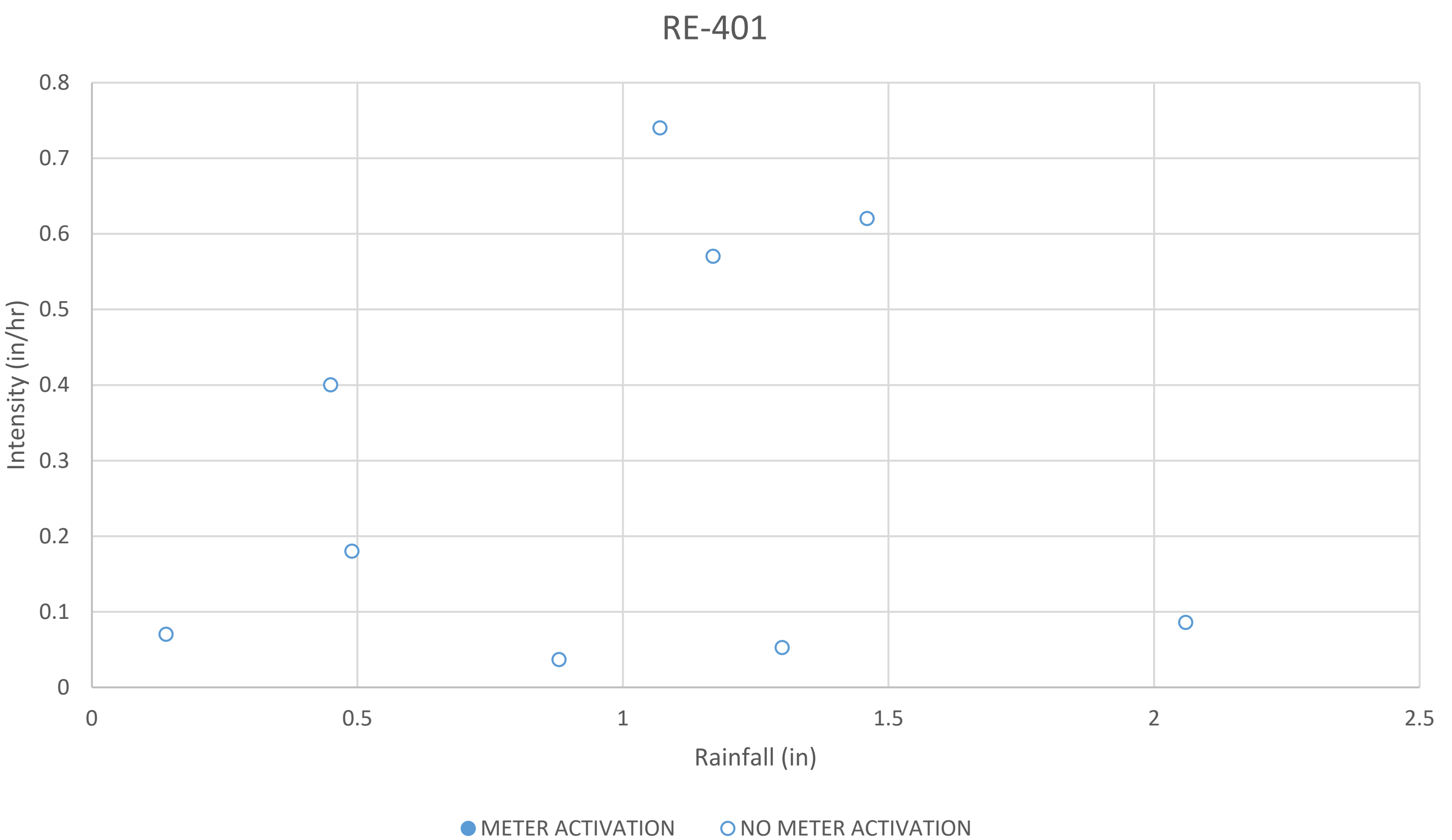
Outfall:CAM005
Regulator: RE051
Related Rain Gauge: 19



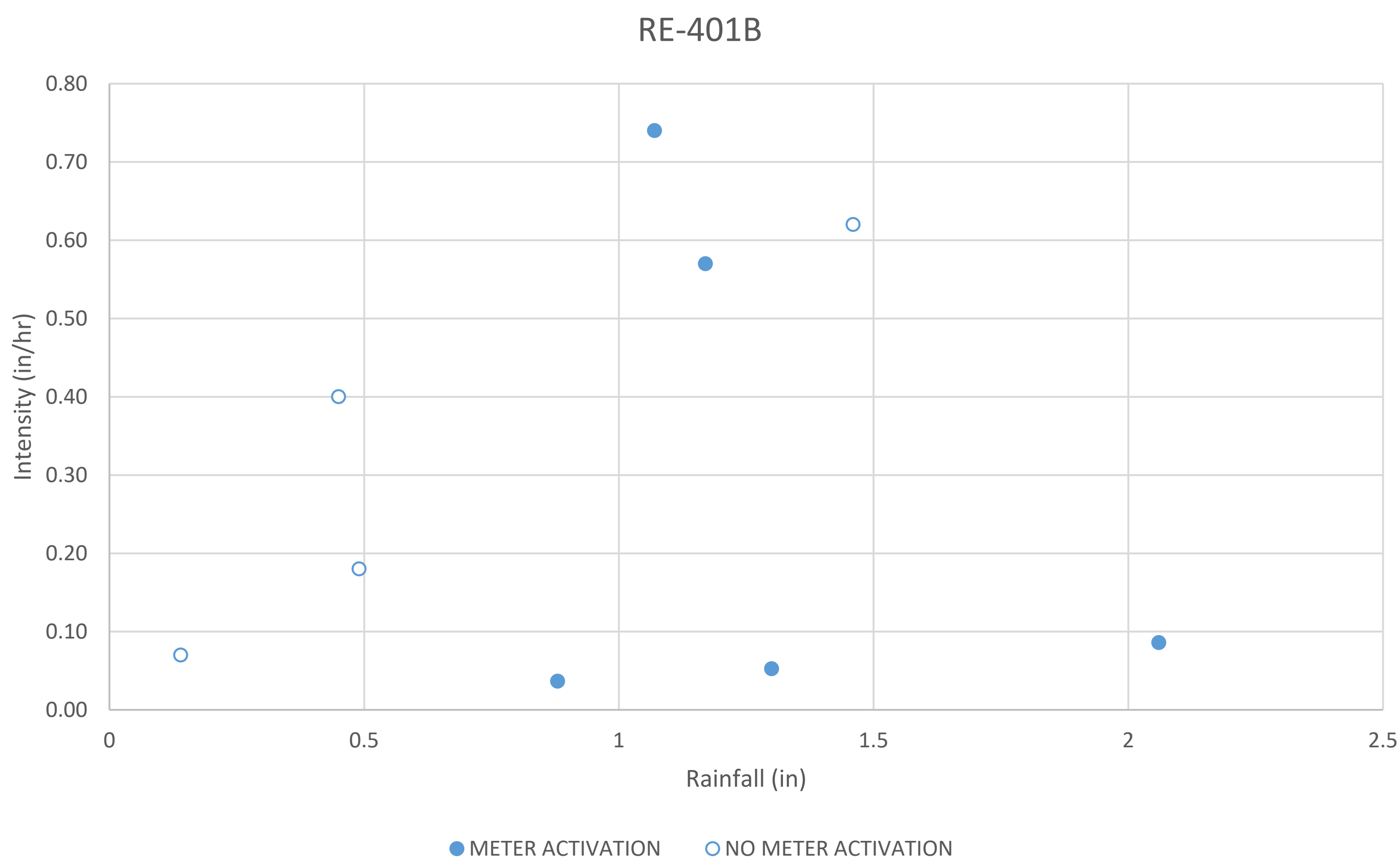
Outfall:CAM007
Regulator: RE071
Related Rain Gauge: 19



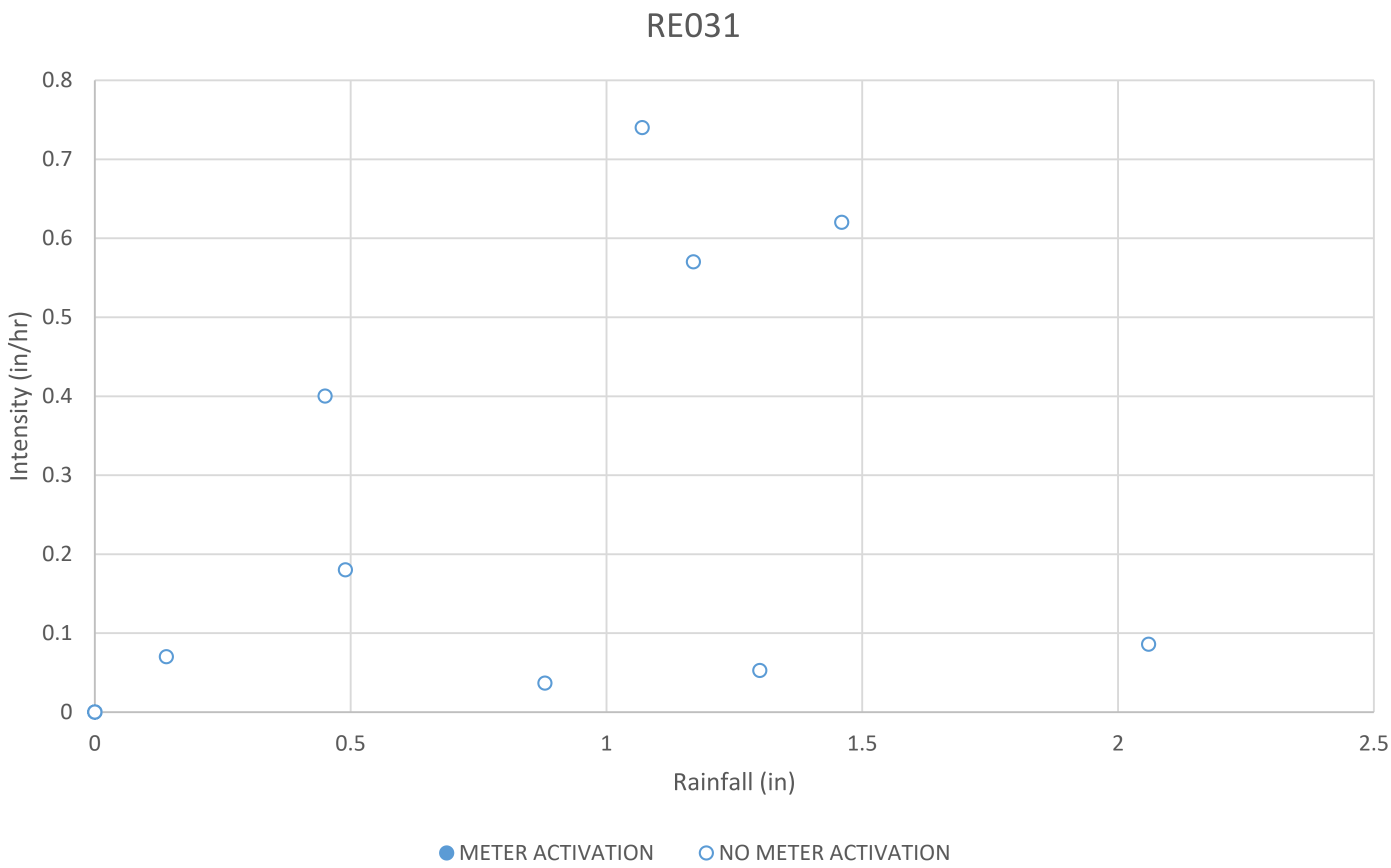
Outfall:CAM401a
Regulator: RE401
Related Rain Gauge: 19



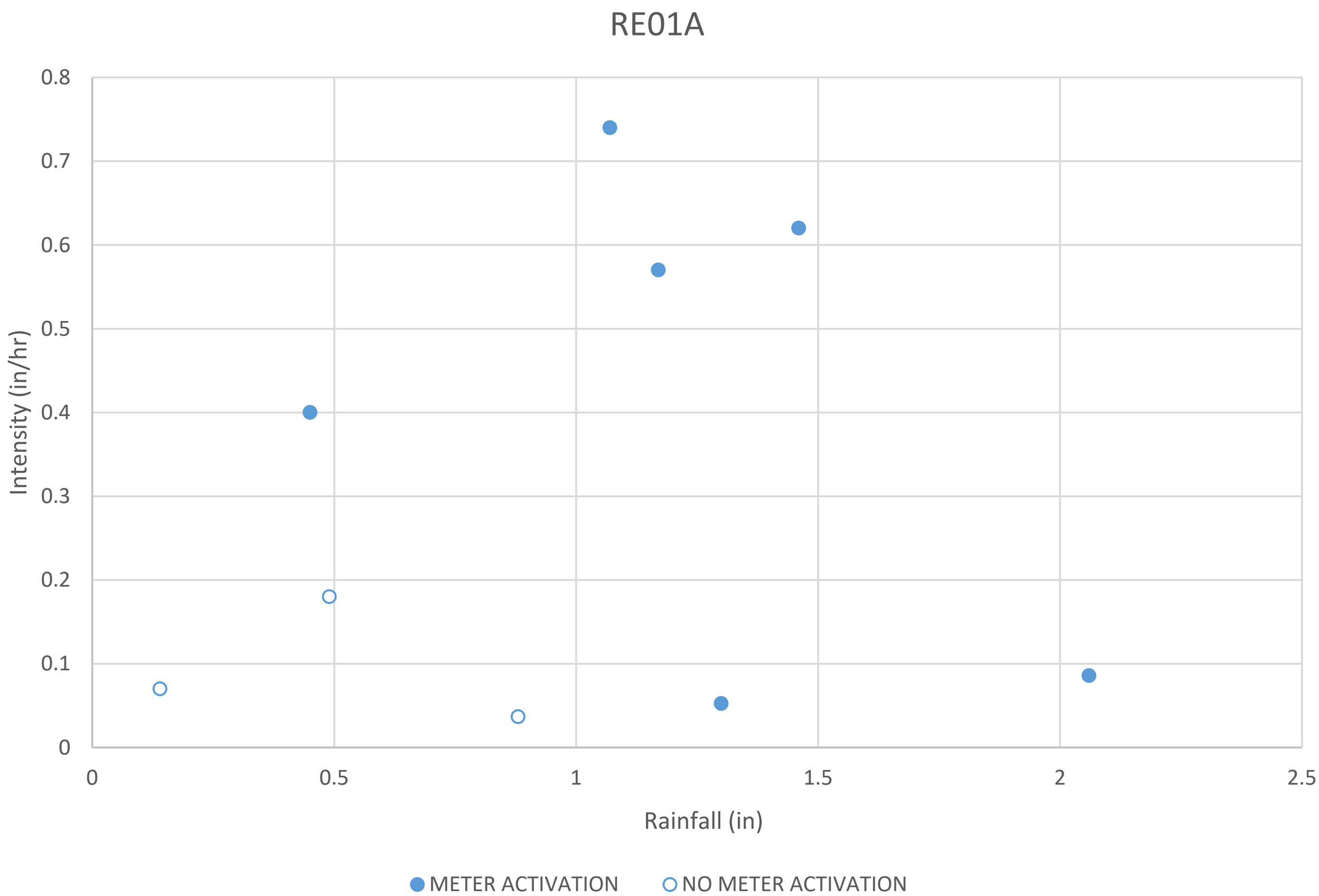
Outfall:CAM401B
Regulator: RE401B
Related Rain Gauge: 19



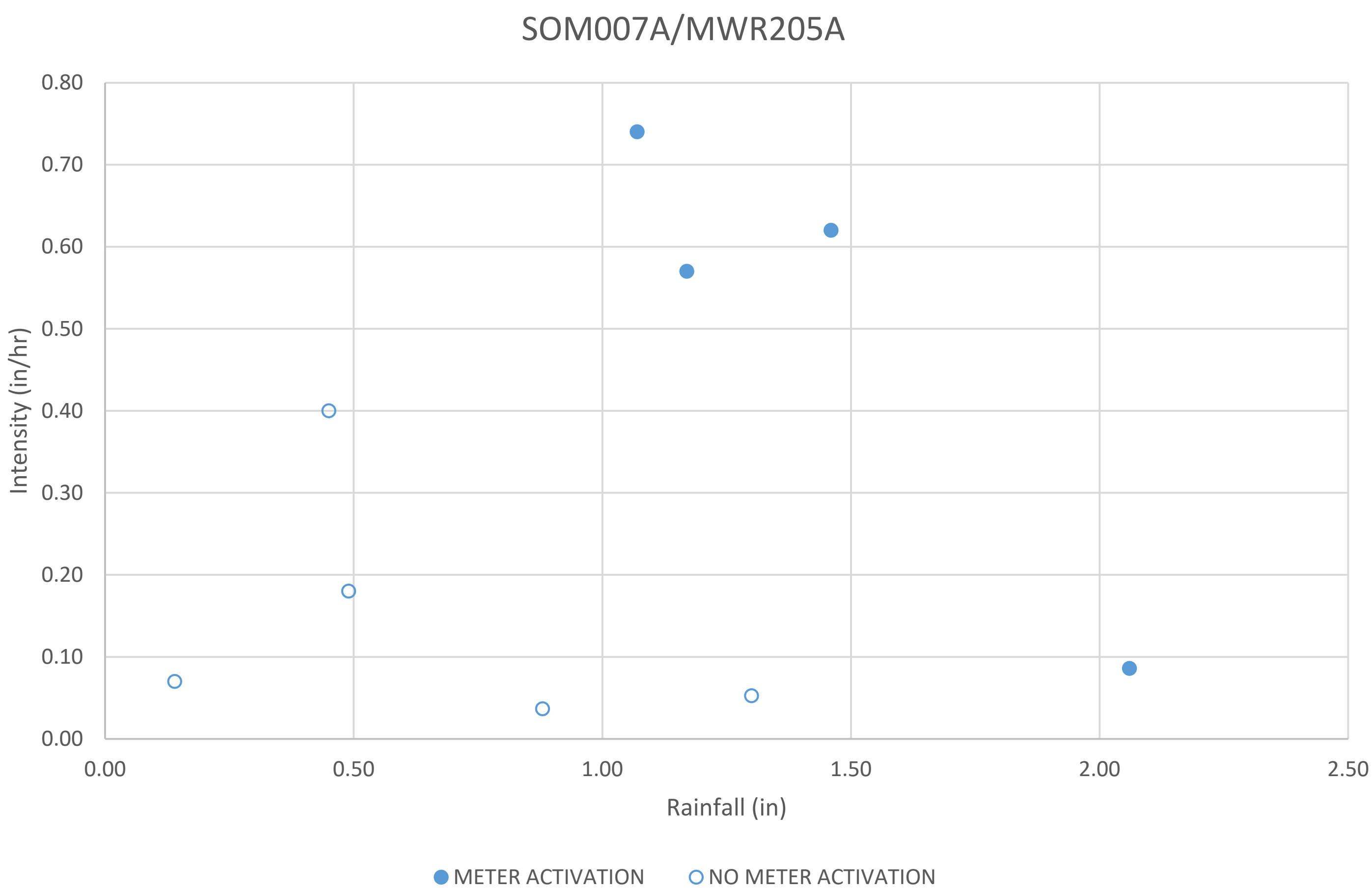
Outfall:MWR003
Regulator: RE031
Related Rain Gauge: 19



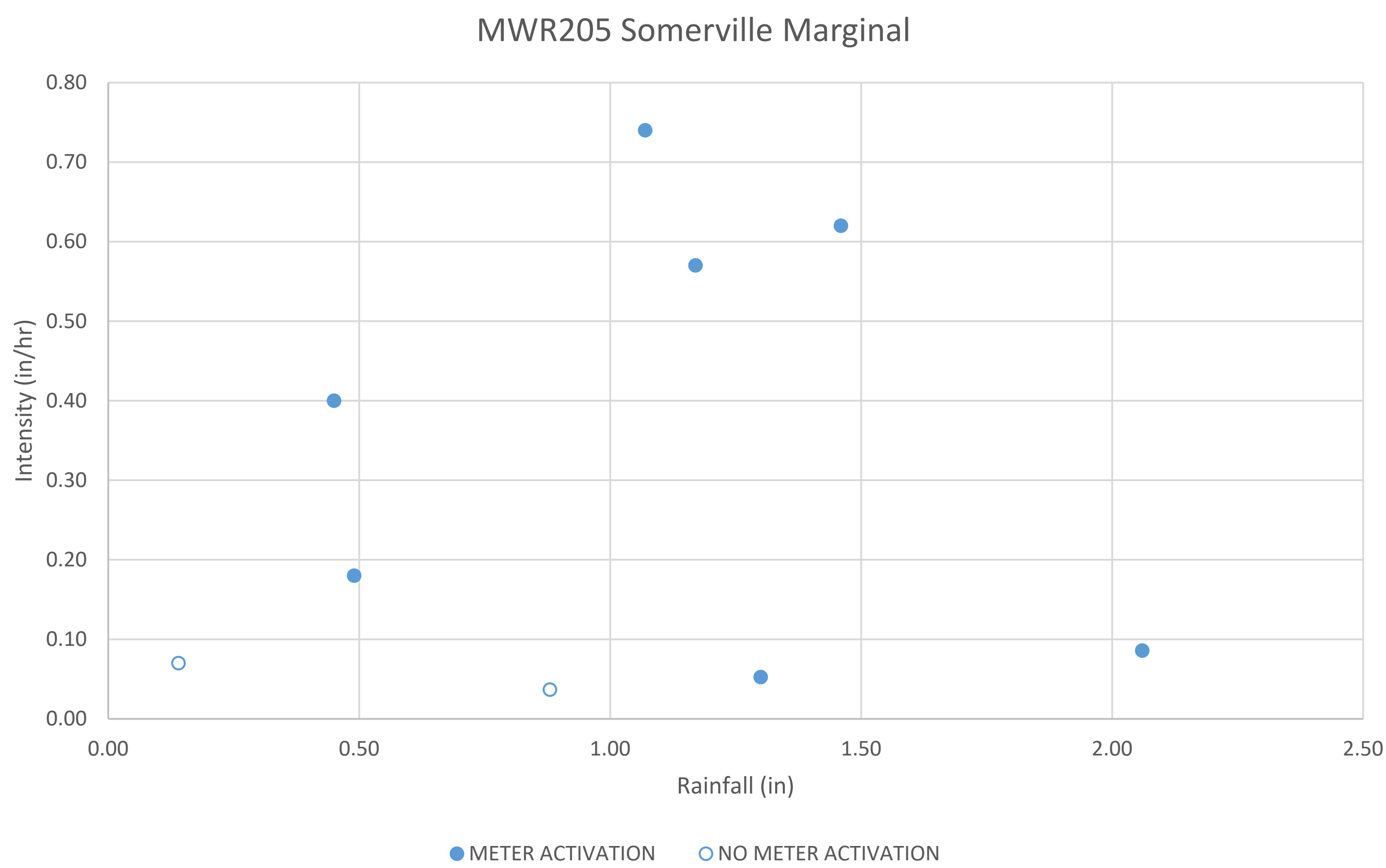
Outfall:SOM001A
Regulator: RE01A
Related Rain Gauge: 19



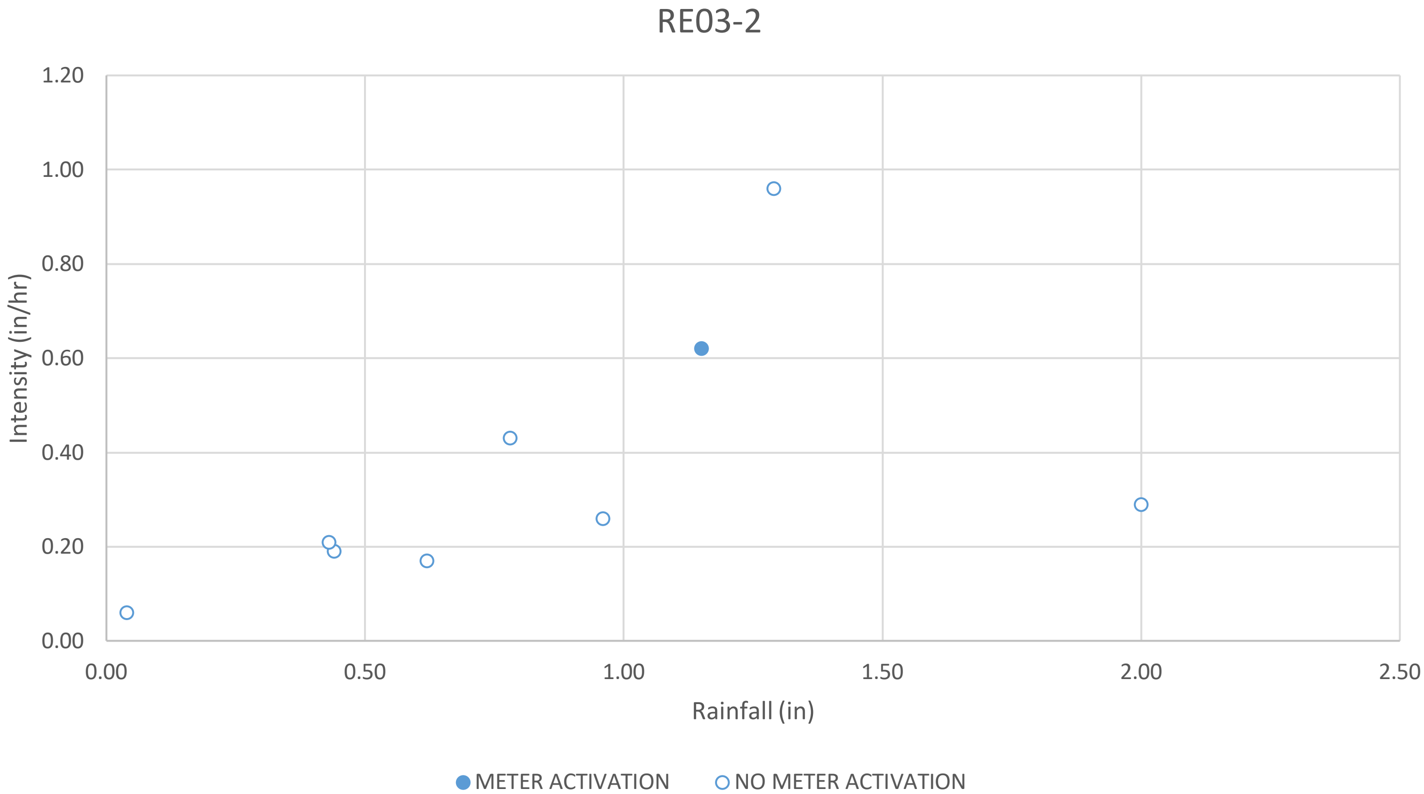
Outfall:SOM007A/MWR205A
Related Rain Gauge: 19



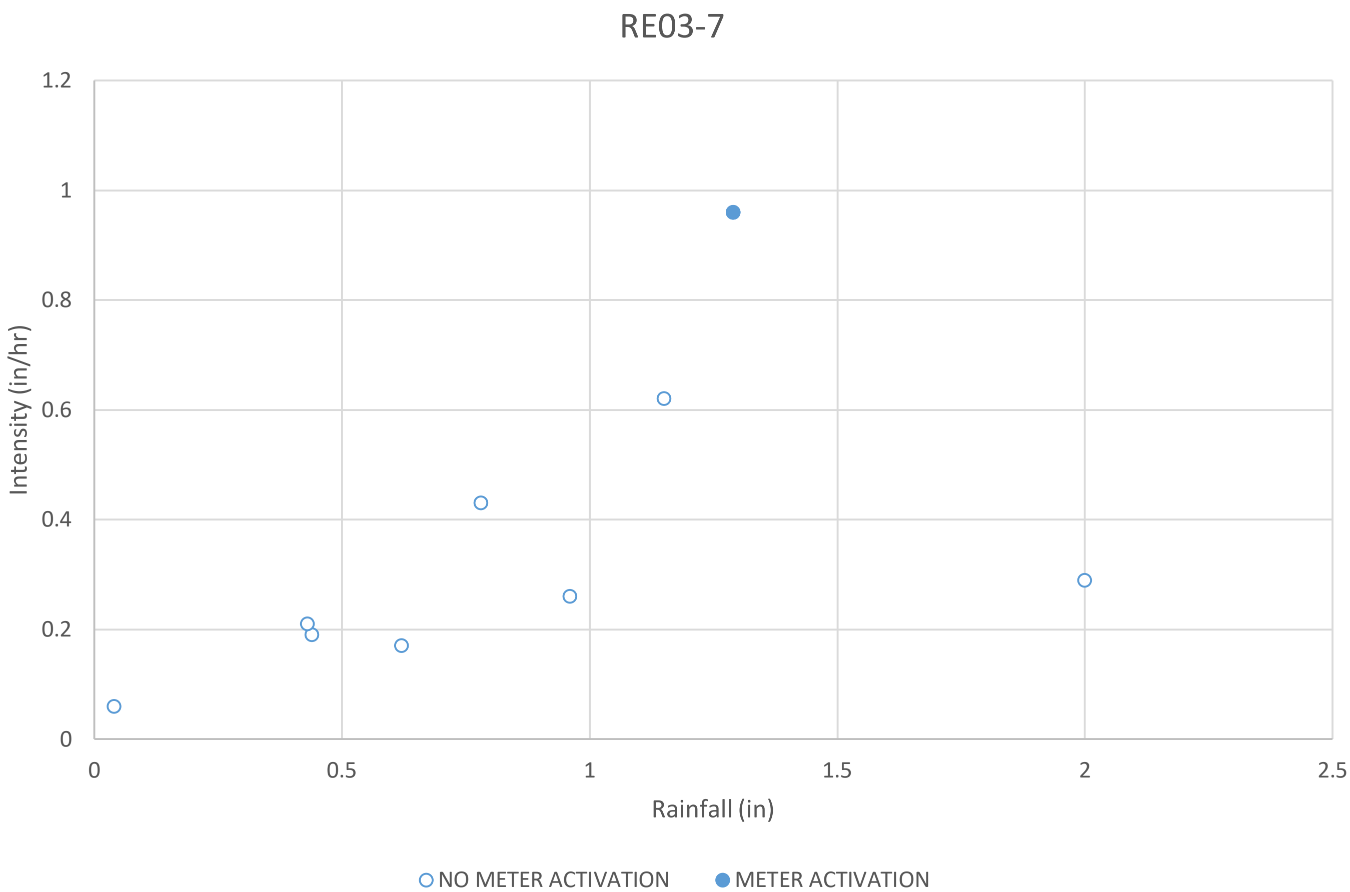
Outfall:MWR205A (Somerville Marginal)
Related Rain Gauge: 19



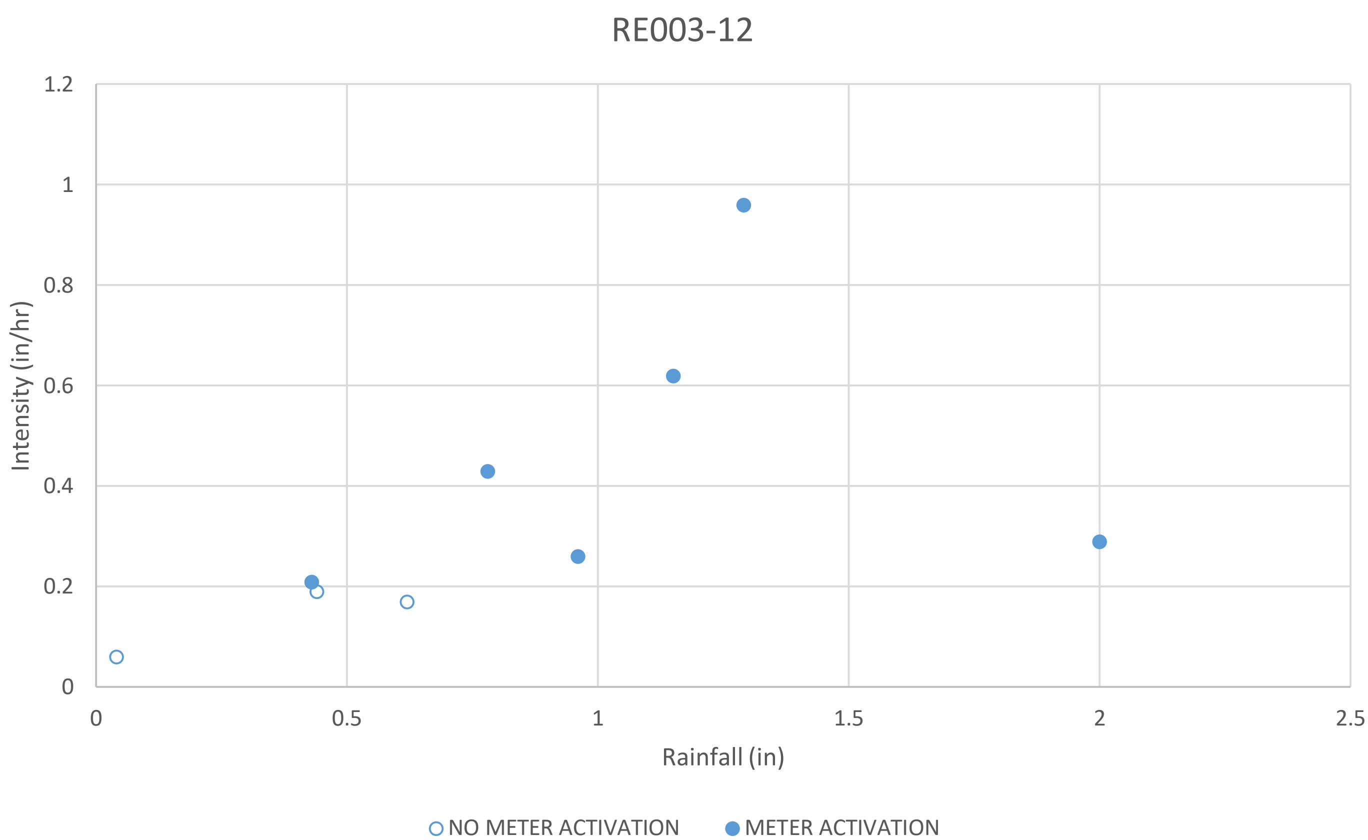
Outfall: BOS003
Regulator: RE03-2
Related Rain Gauge: 8



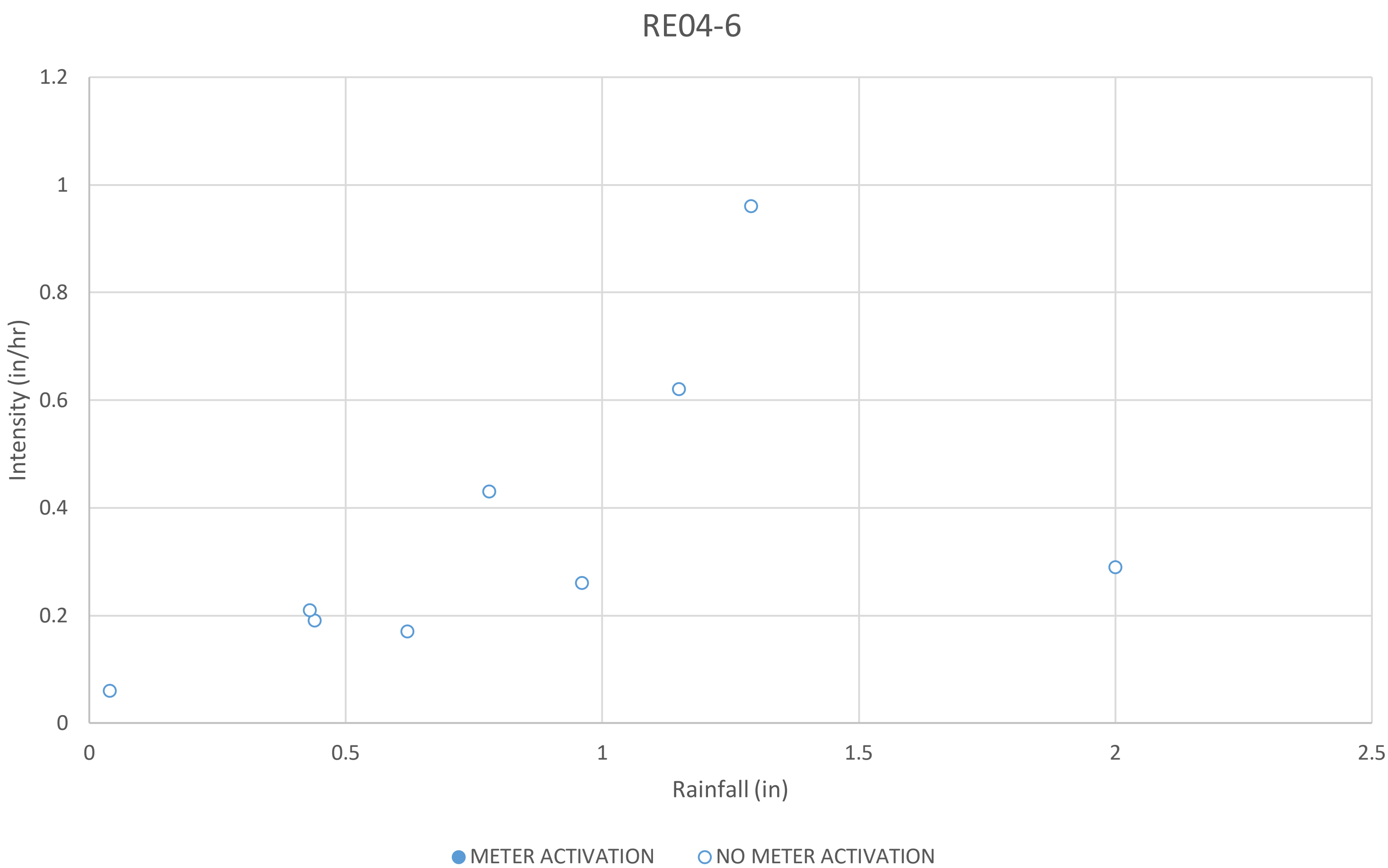
Outfall: BOS003
Regulator: RE03-7
Related Rain Gauge: 8



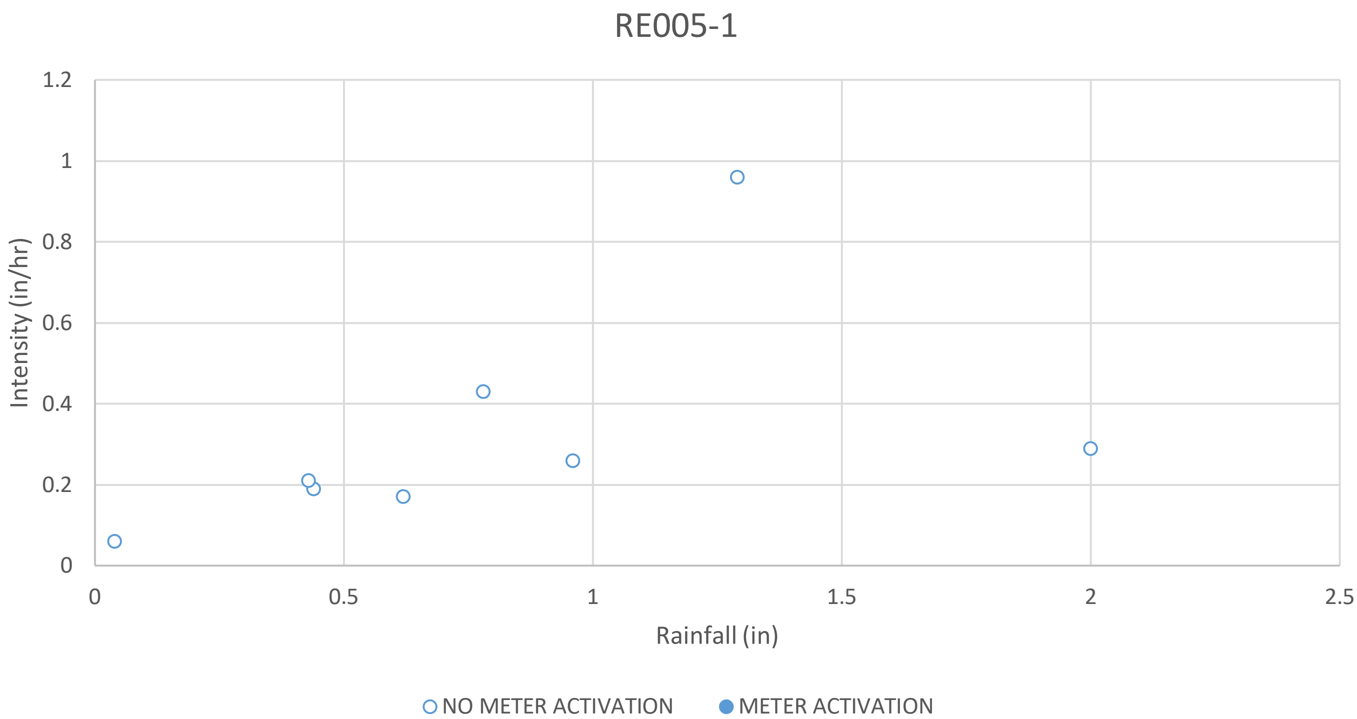
Outfall: BOS003
Regulator: RE03-12
Related Rain Gauge: 8



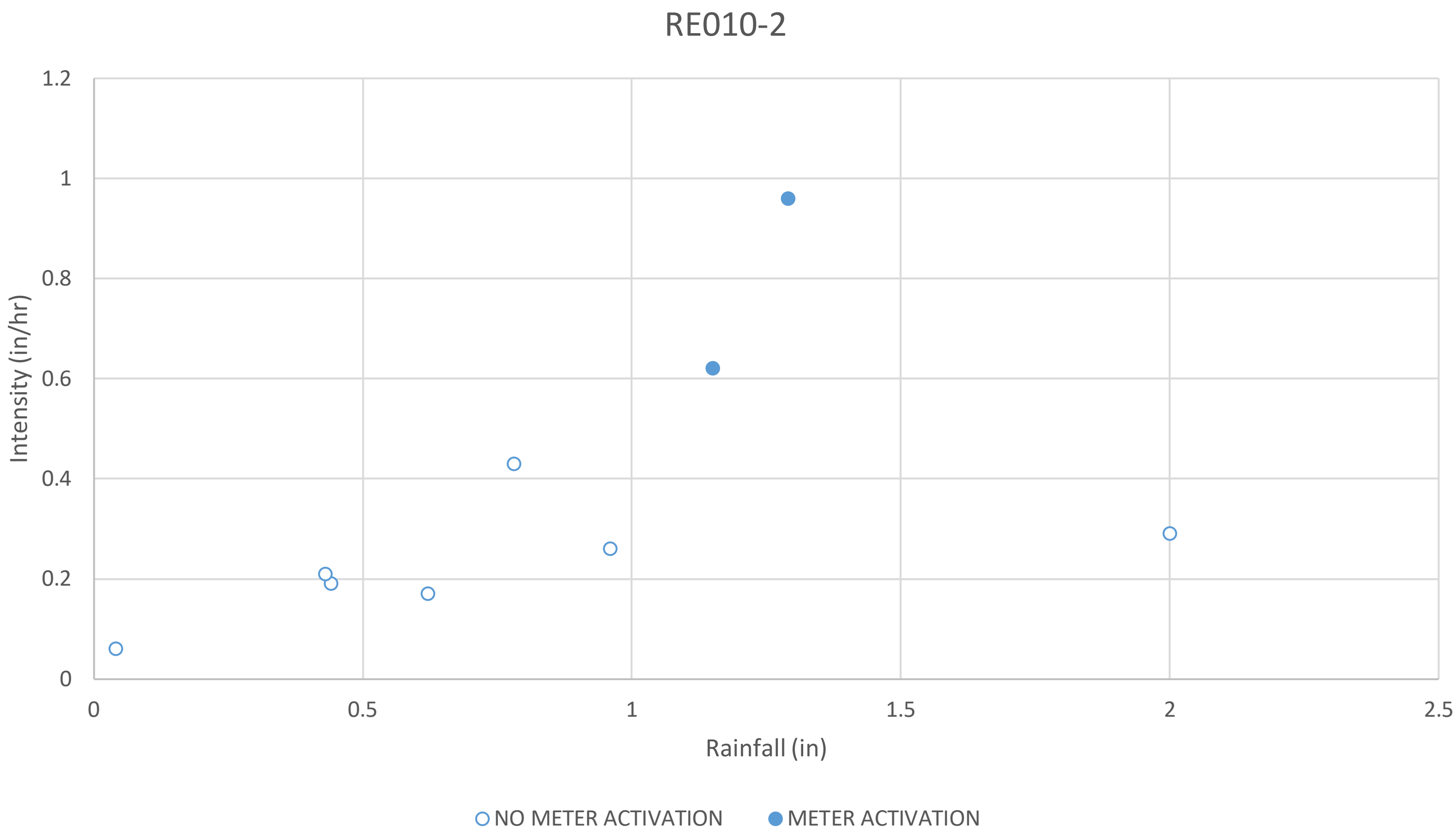
Outfall: BOS004
Regulator: RE04-6
Related Rain Gauge: 8



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



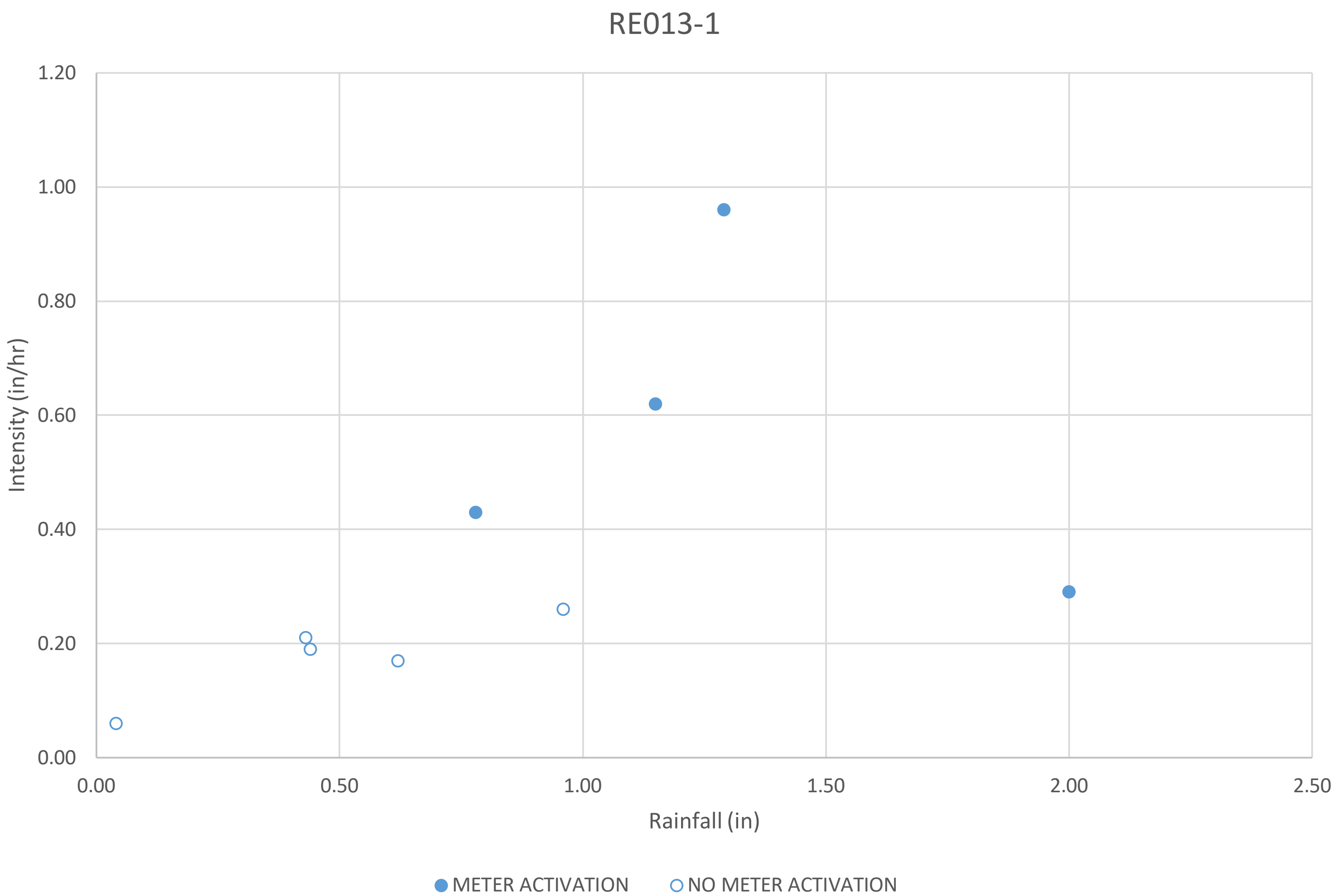
Outfall: BOS010
Regulator: RE010-2
Related Rain Gauge: 8



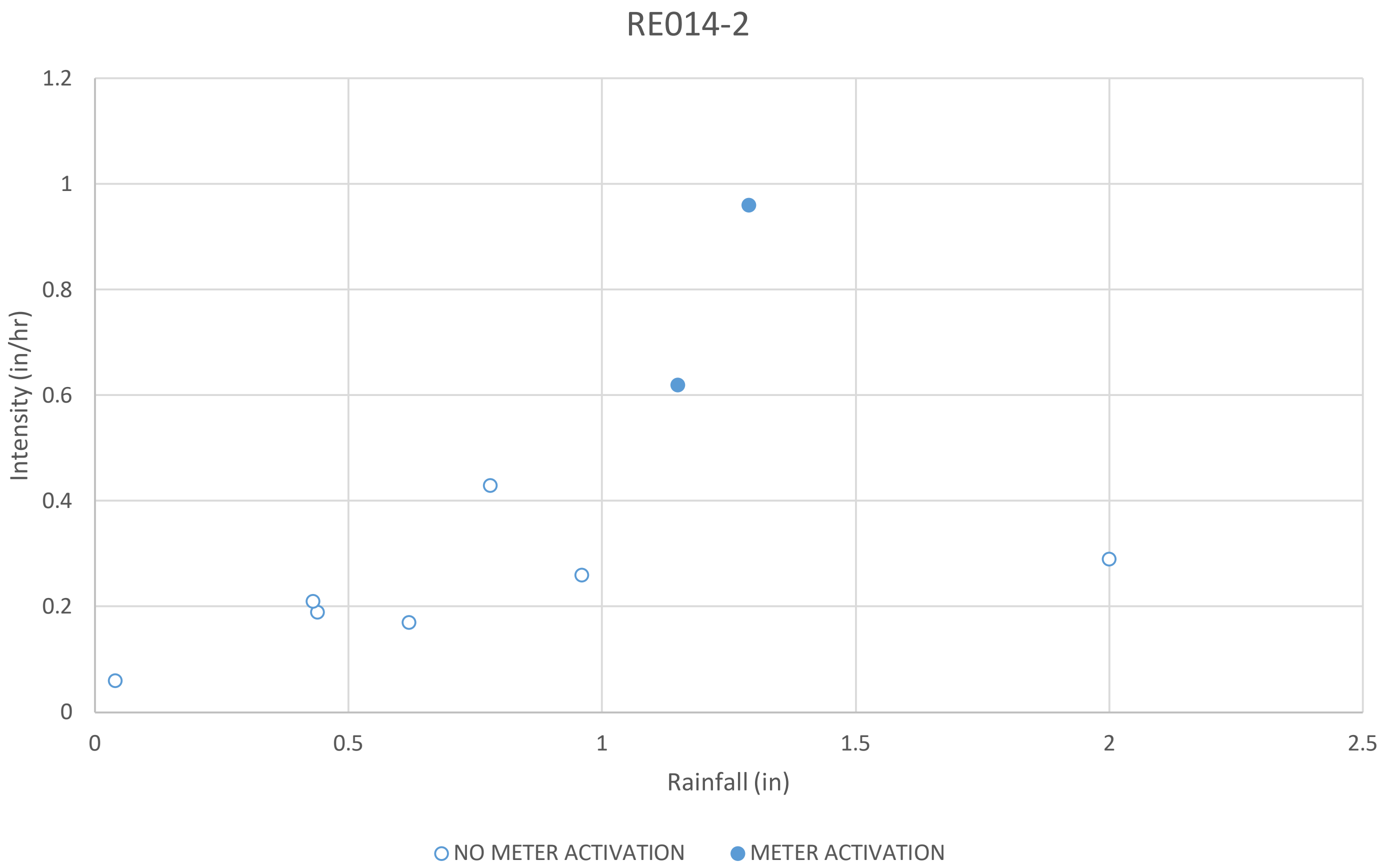
Outfall: BOS012
Regulator: RE012-2
Related Rain Gauge: 8

*Meter data not validated for the period of April 15-June 30, 2018*

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



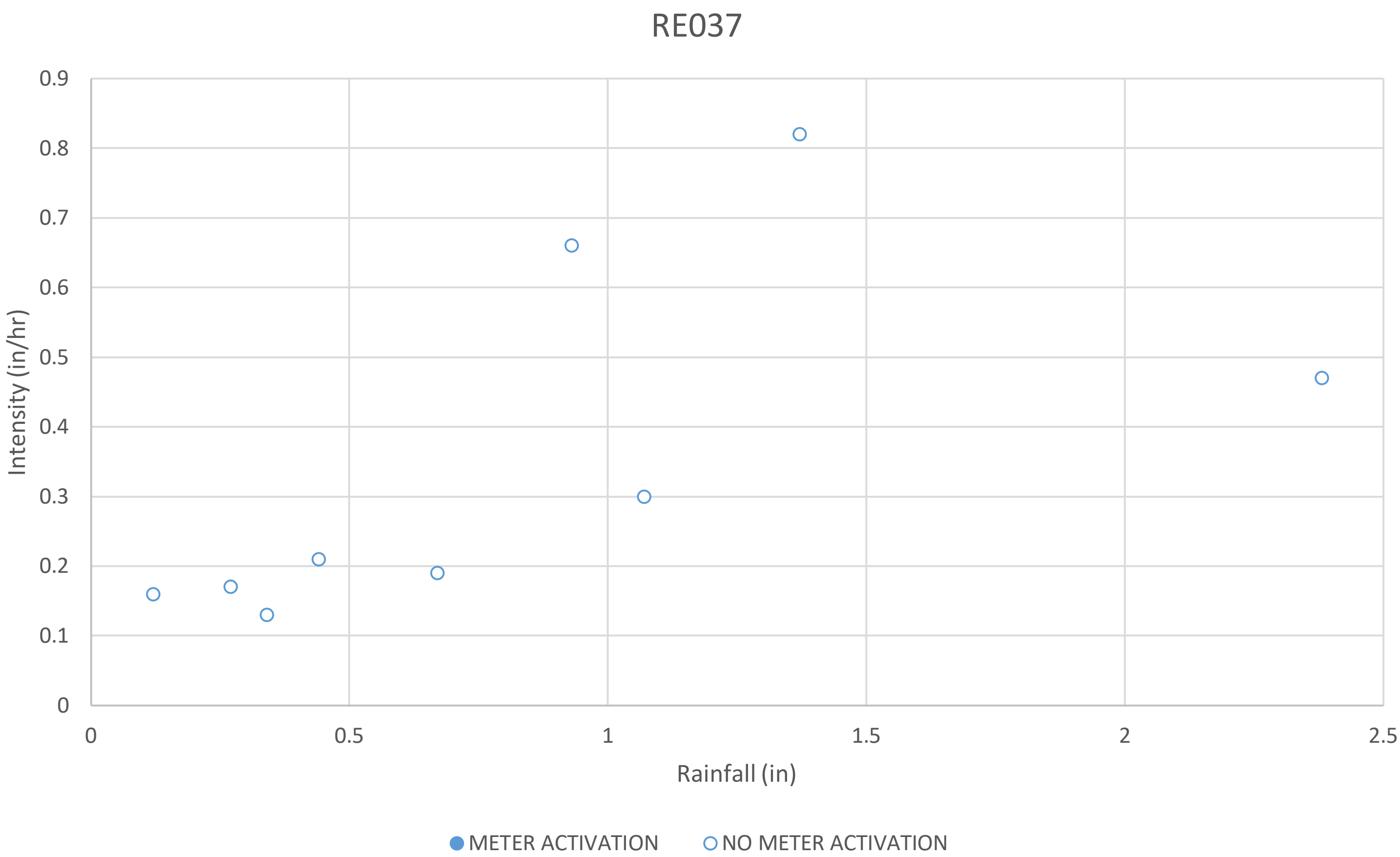
Outfall: BOS014
Regulator: RE014-2
Related Rain Gauge: 8



Outfall: CAM001
Regulator: RE011
Related Rain Gauge: 16

*Meter data not validated for the period of April 15-June 30, 2018*

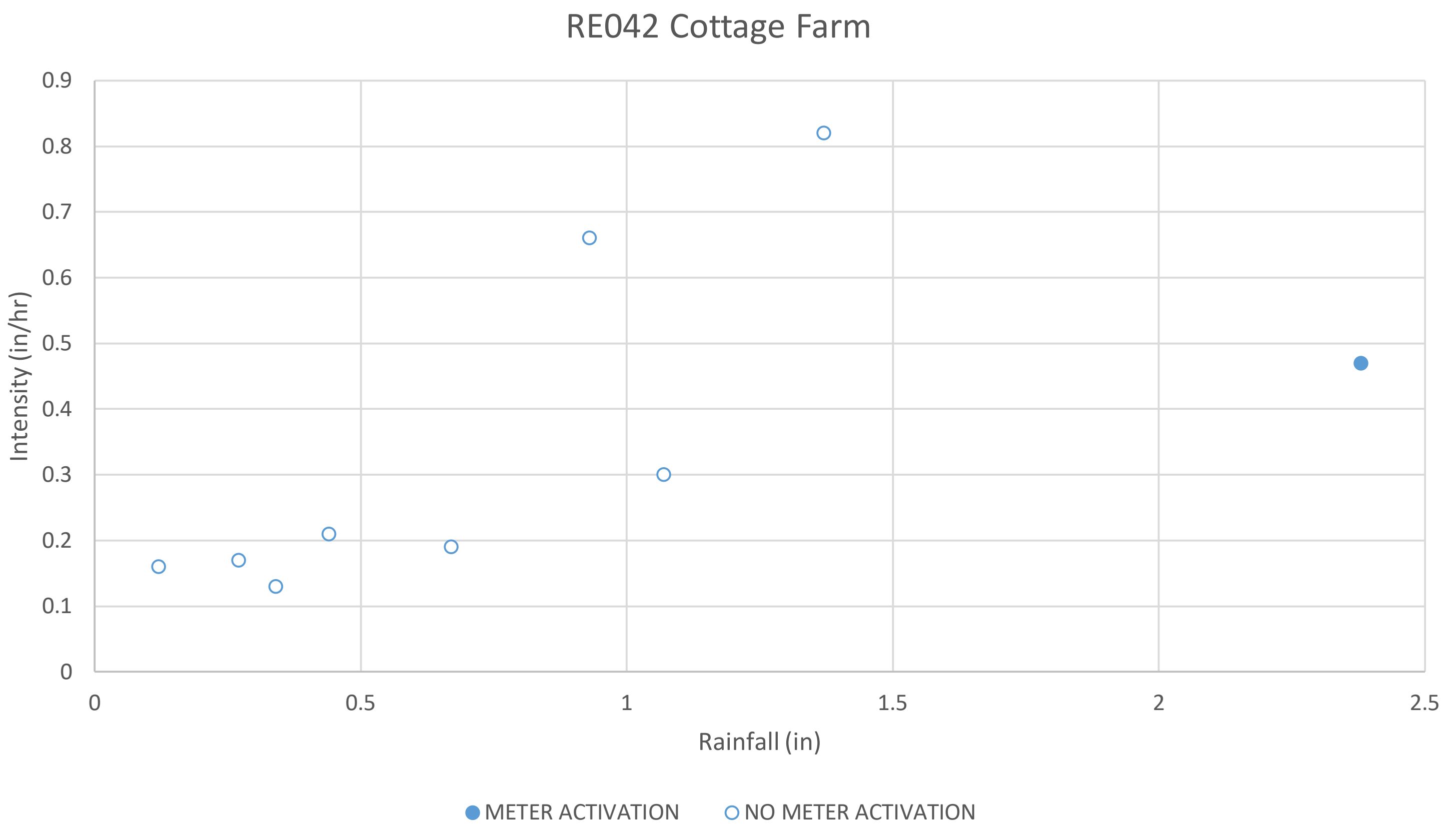
Outfall: MWR010
Regulator: RE037
Related Rain Gauge: 12



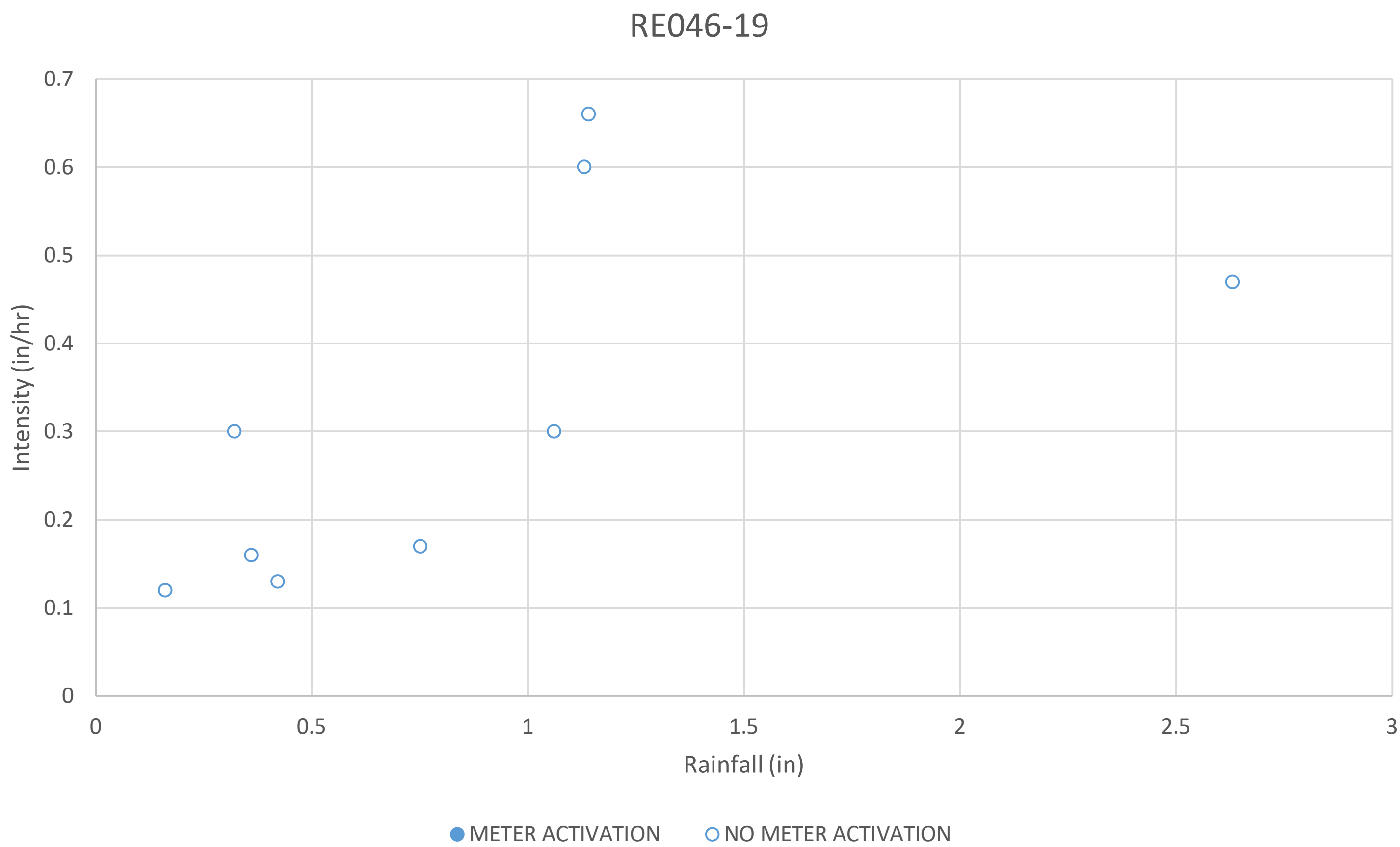
Outfall: MWR010
Regulator: RE036-9
Related Rain Gauge: 12

*Meter data not validated for the period of April 15-June 30, 2018*

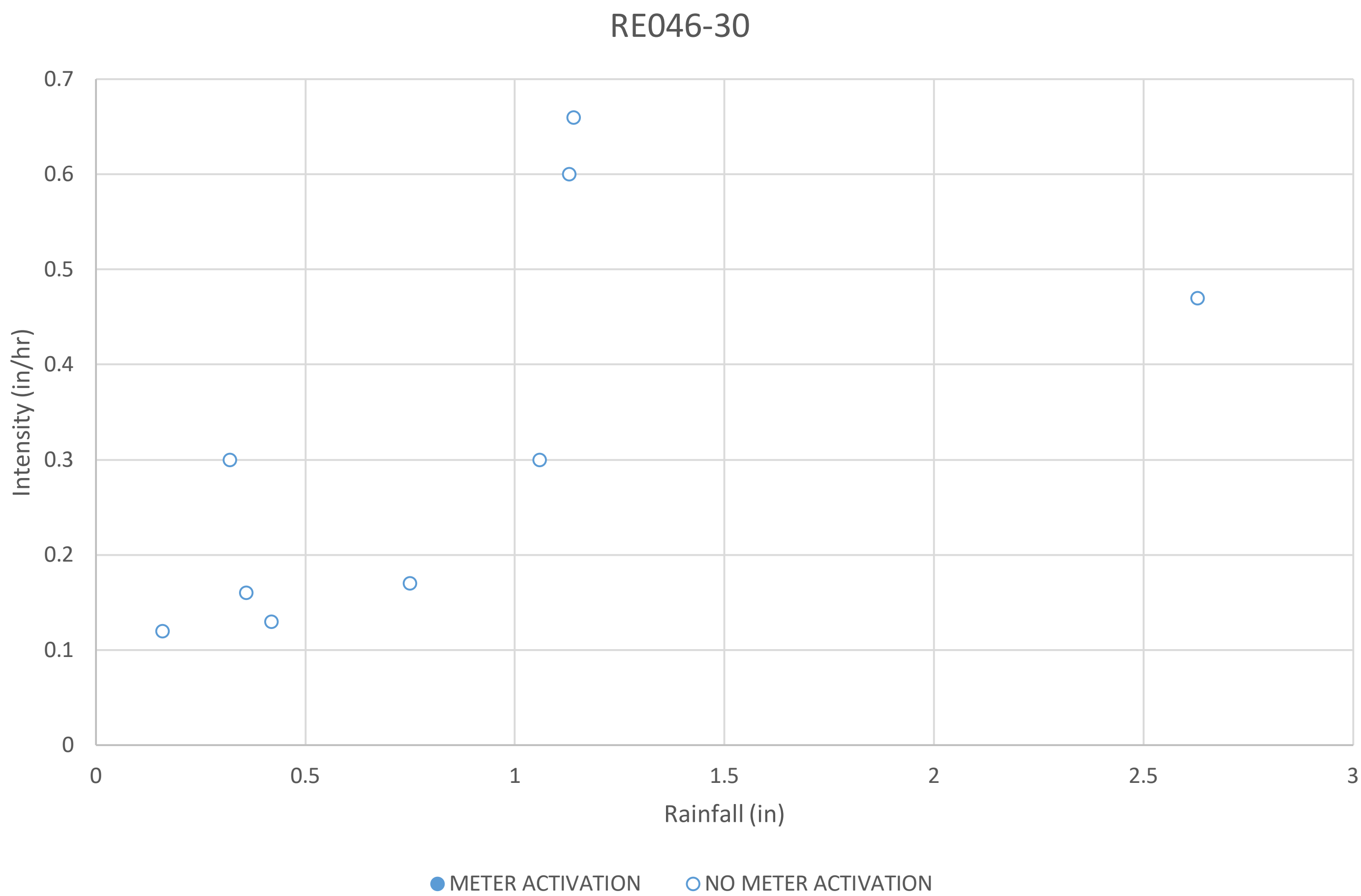
Outfall: MWR201 (Cottage Farm)
Regulator: RE042
Related Rain Gauge: 12



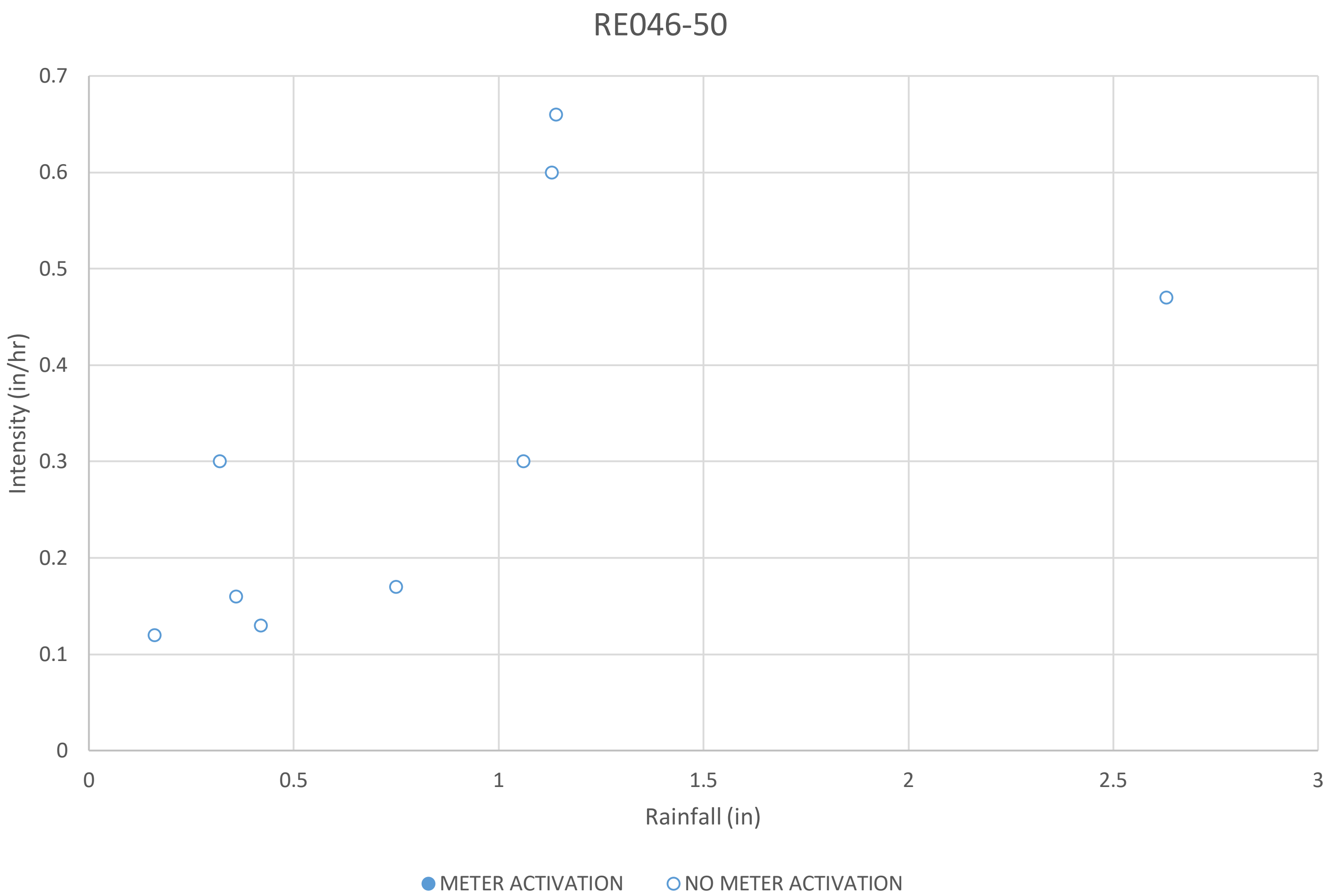
Outfall: MWR023
Regulator: RE046-19
Related Rain Gauge: 15



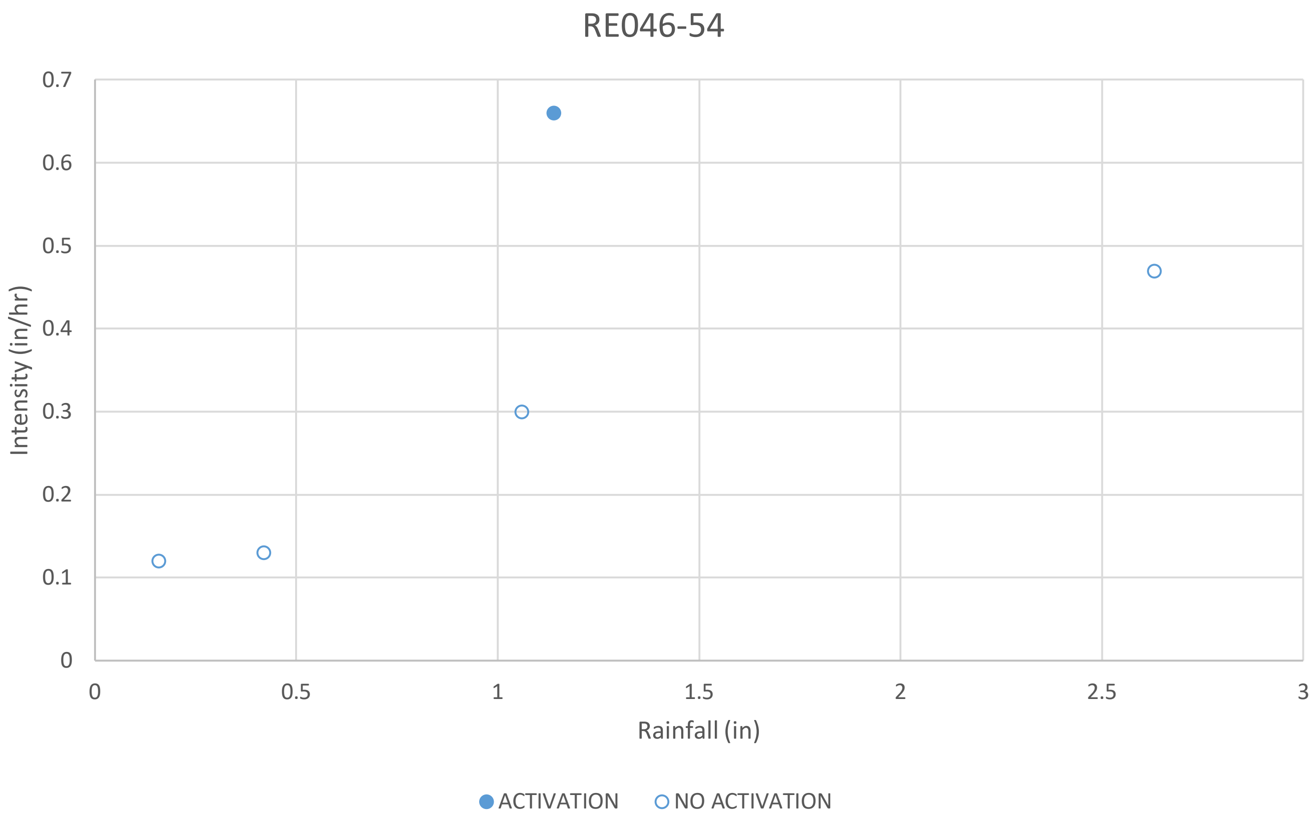
Outfall: MWR023
Regulator: RE046-30
Related Rain Gauge: 15



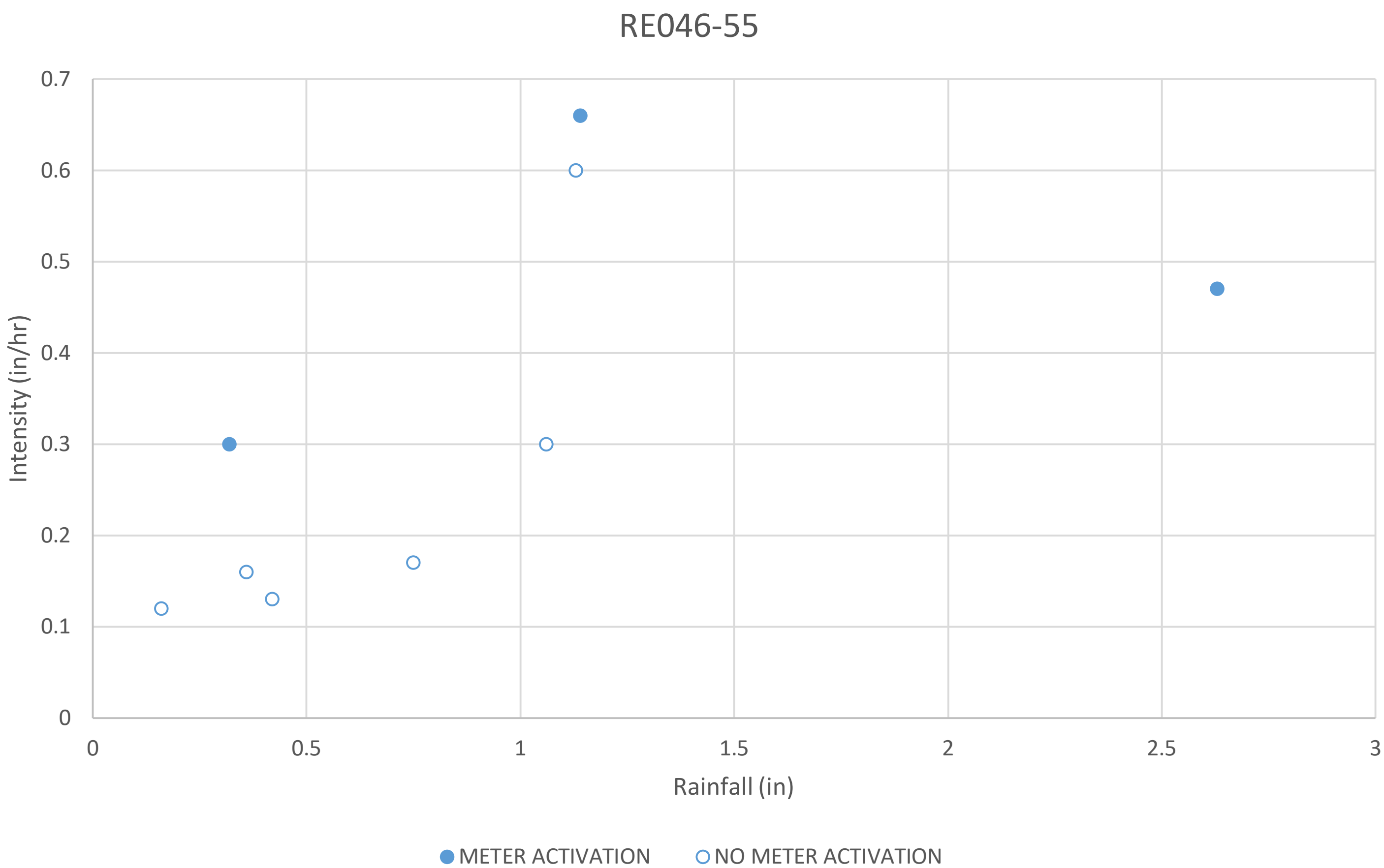
Outfall: MWR023
Regulator: RE046-50
Related Rain Gauge: 15



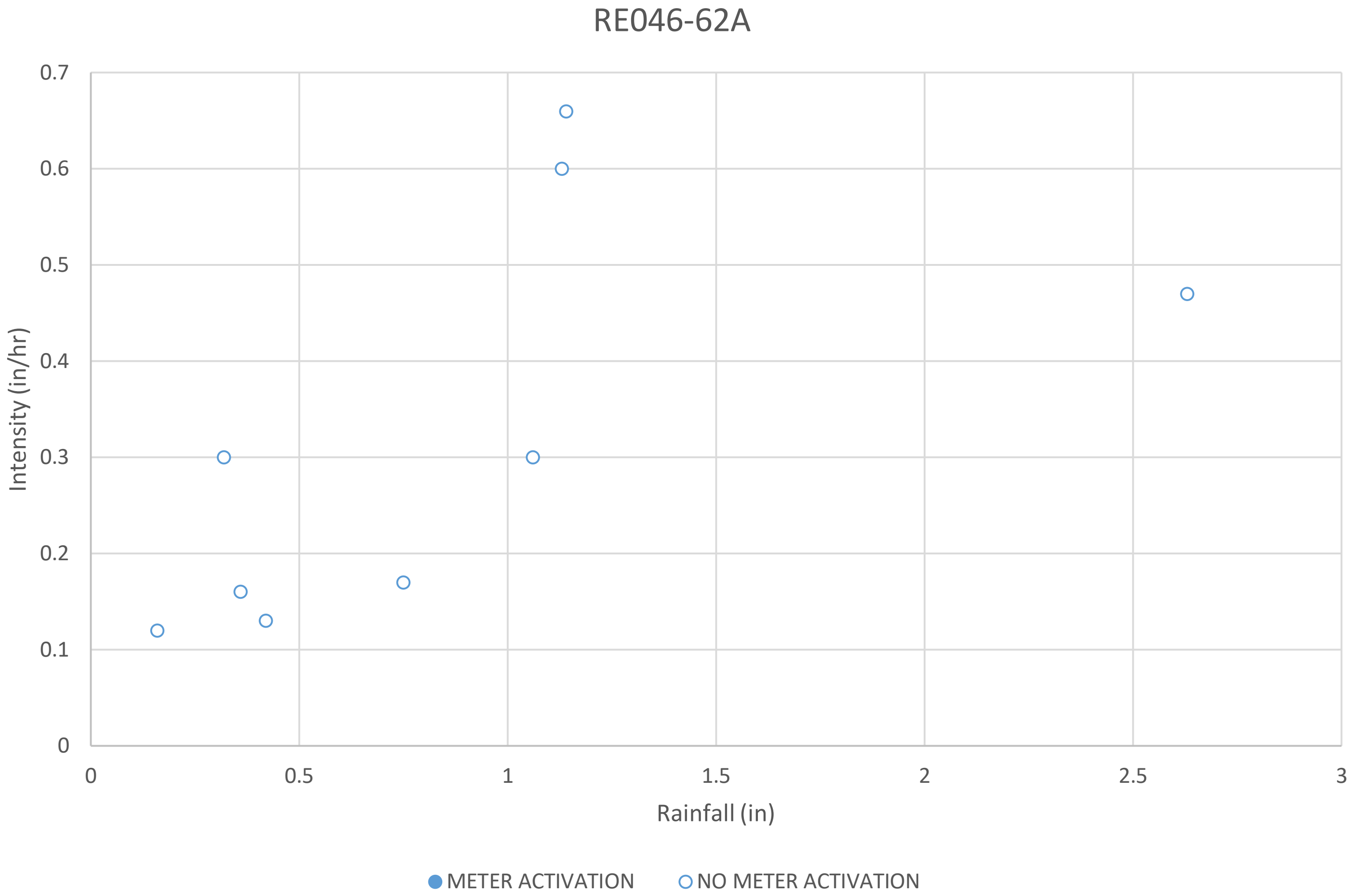
Outfall: MWR023
Regulator: RE046-54
Related Rain Gauge: 15



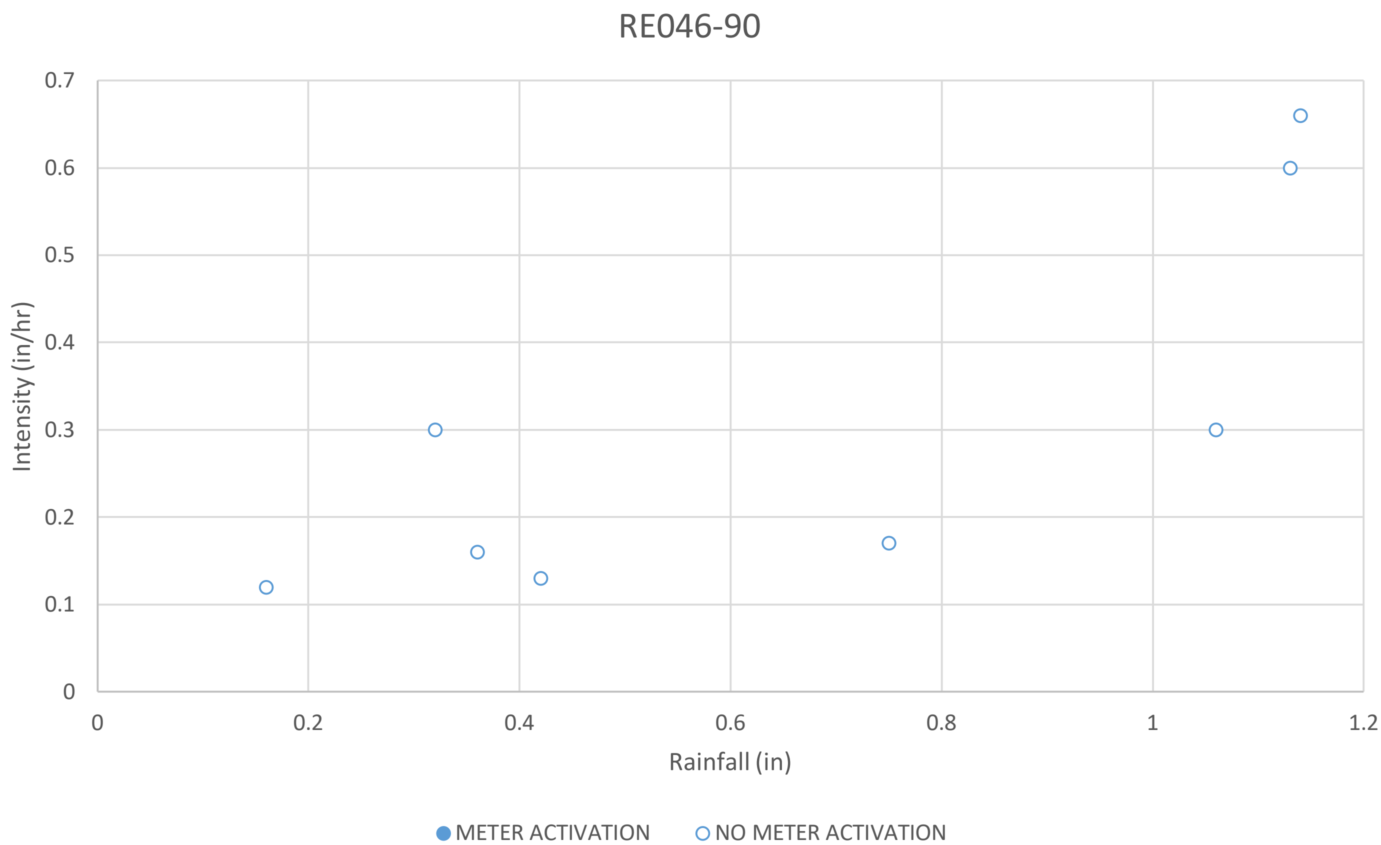
Outfall: MWR023
Regulator: RE046-55
Related Rain Gauge: 15



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



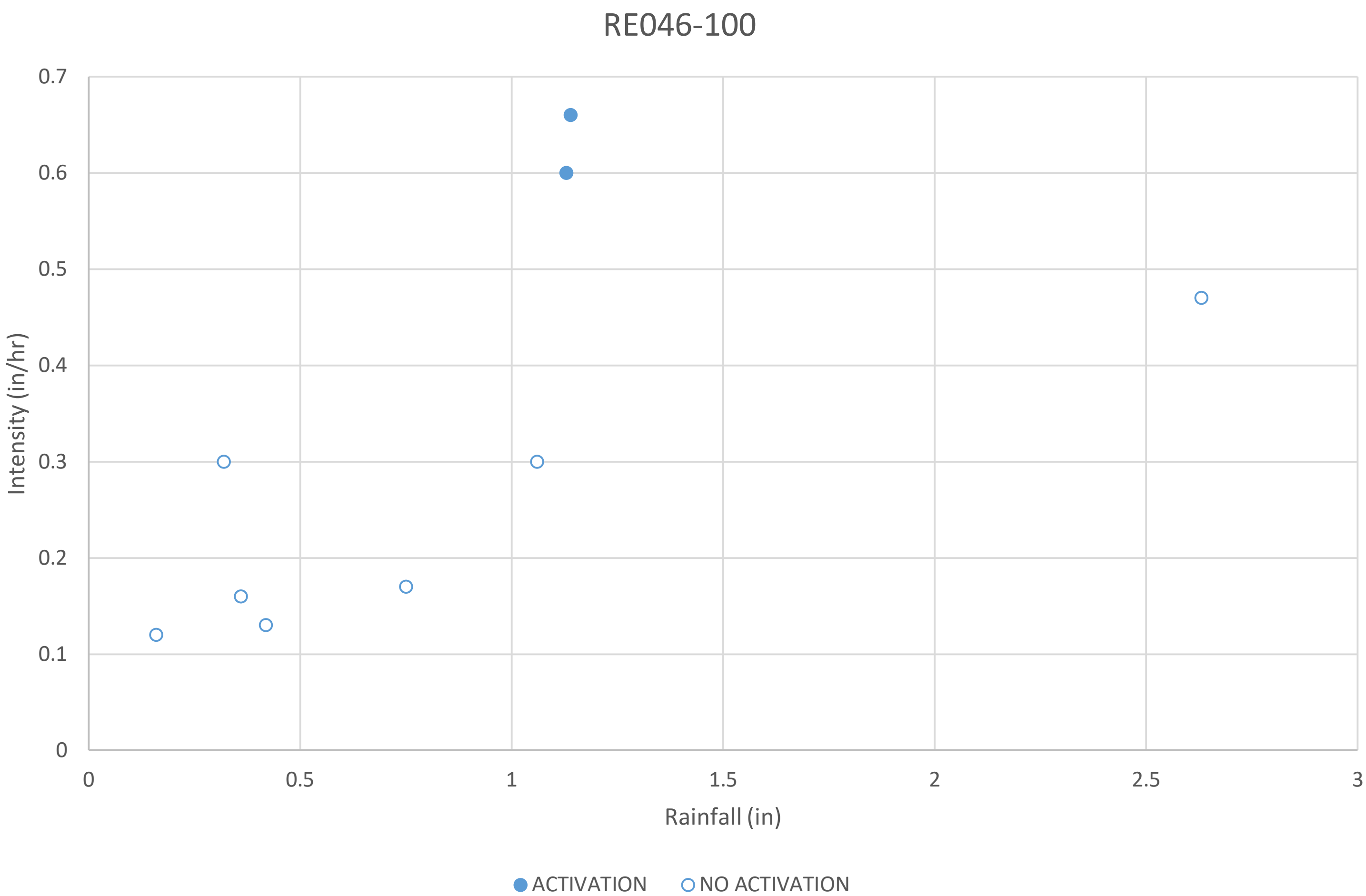
Outfall: MWR023
Regulator: RE046-90
Related Rain Gauge: 15



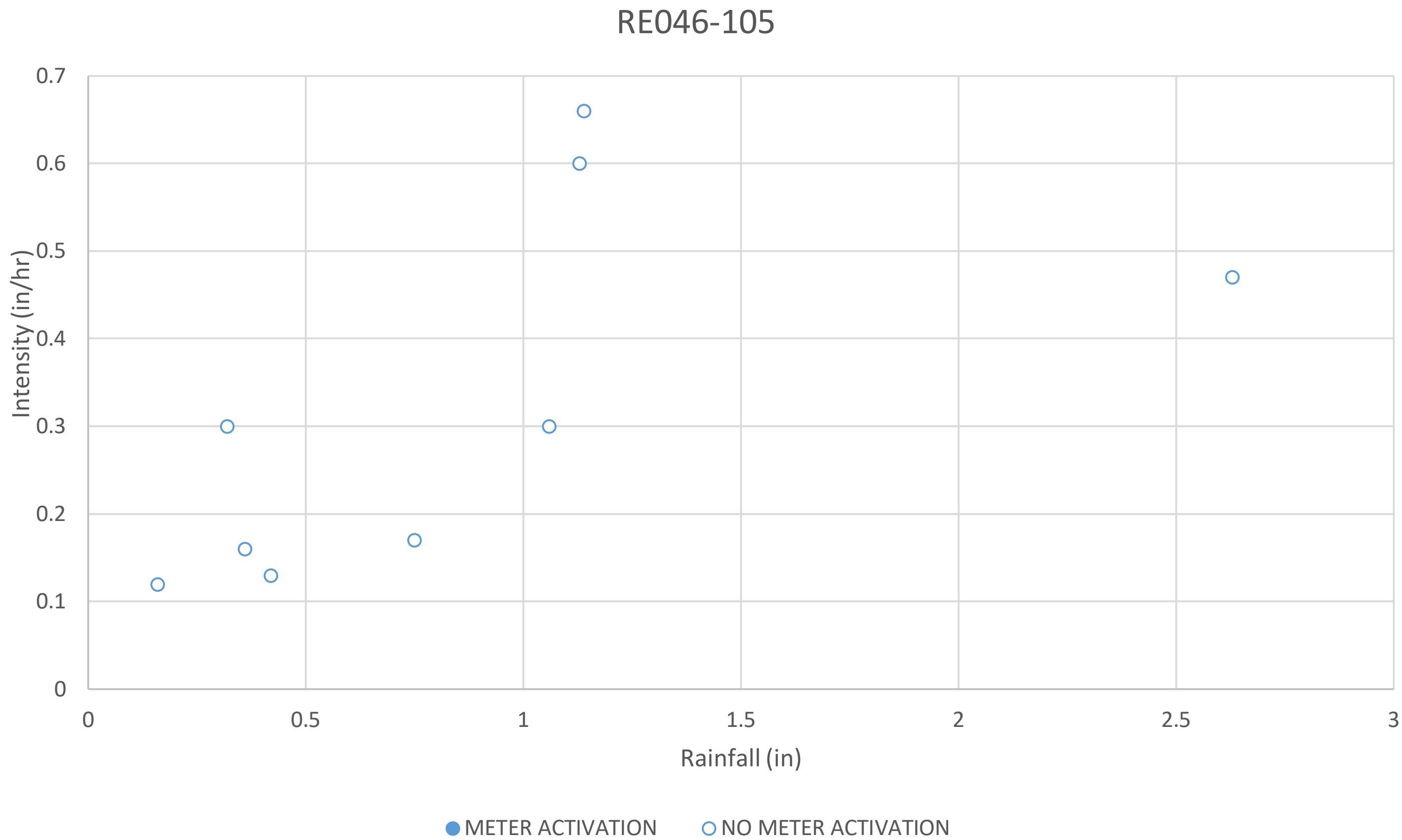
Outfall: MWR023

Regulator: RE046-100

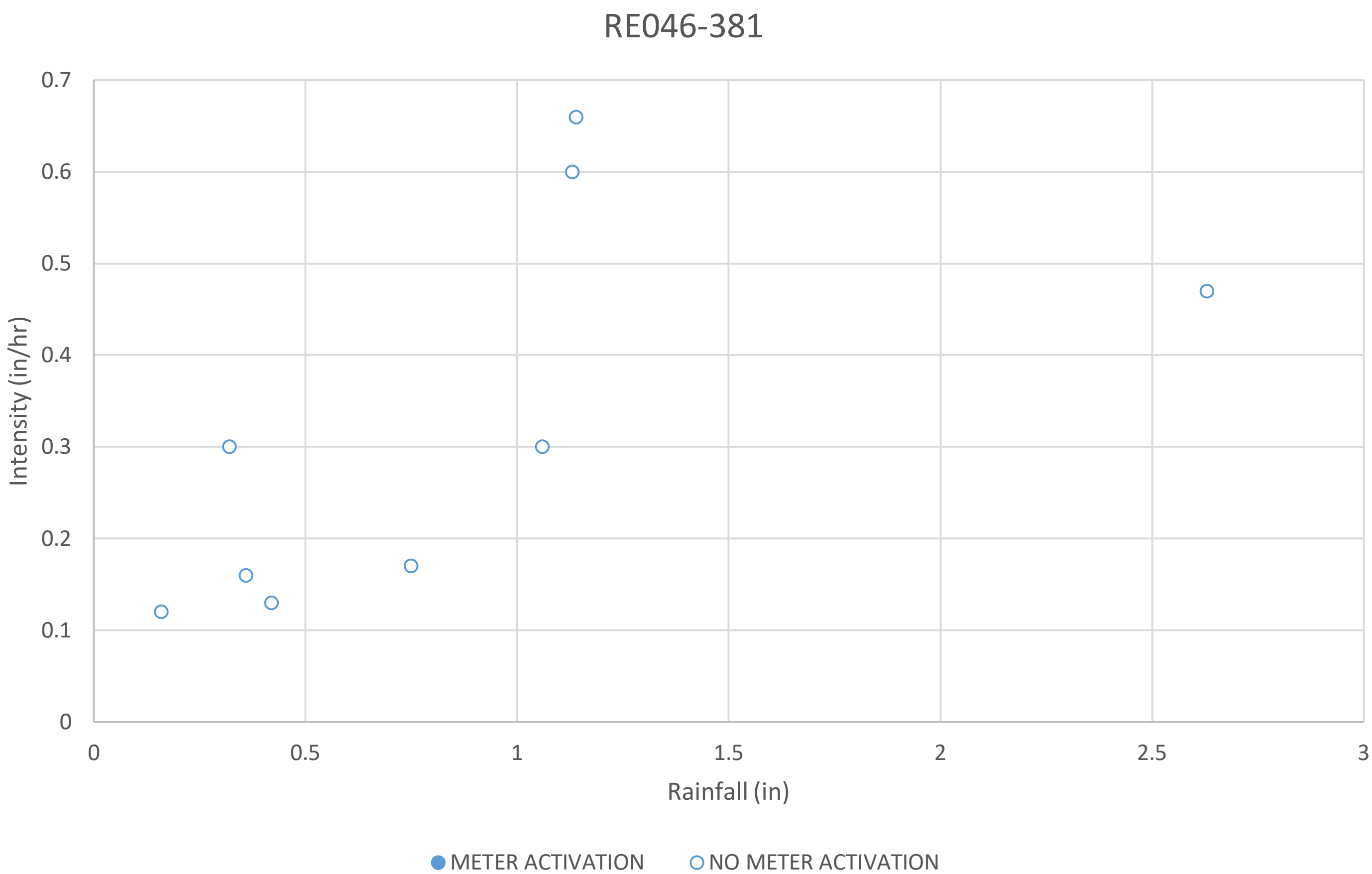
Related Rain Gauge: 15



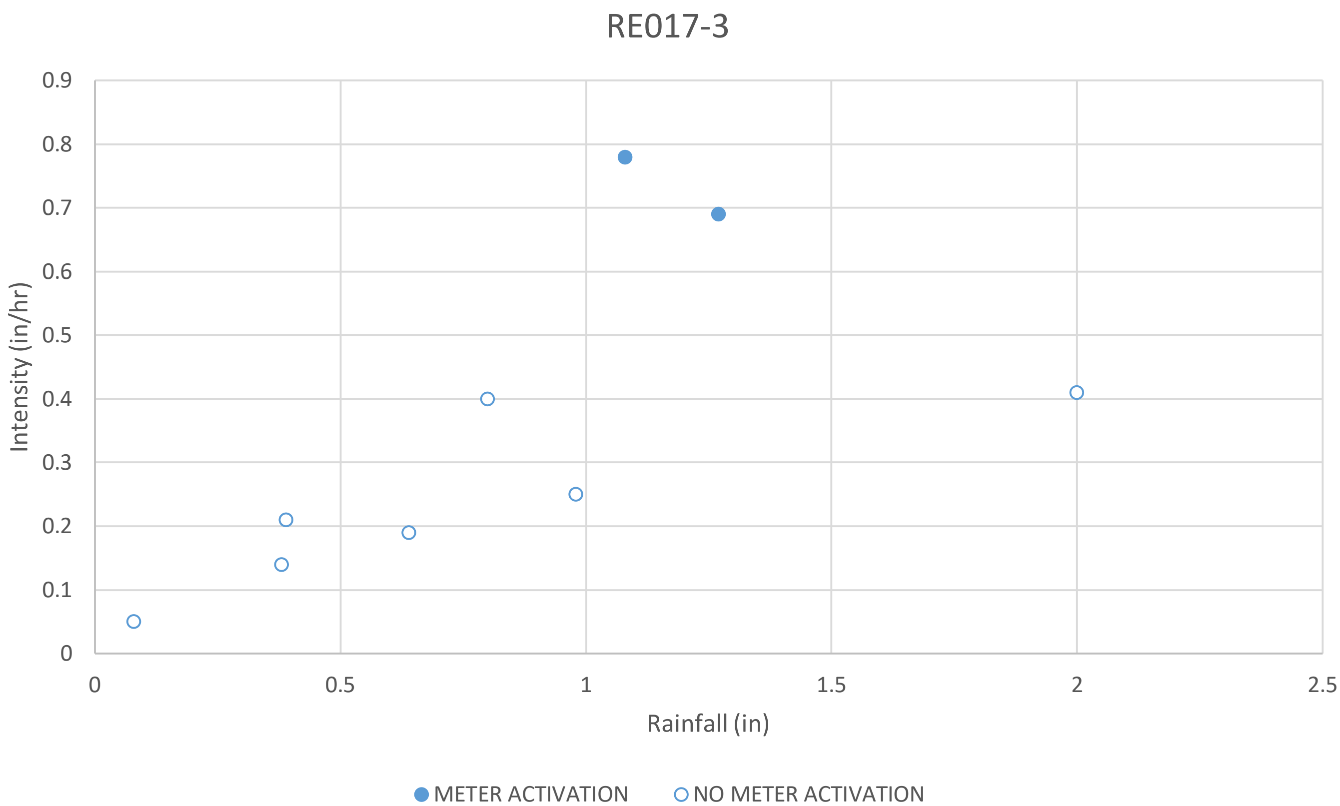
Outfall: MWR023
Regulator: RE046-105
Related Rain Gauge: 15



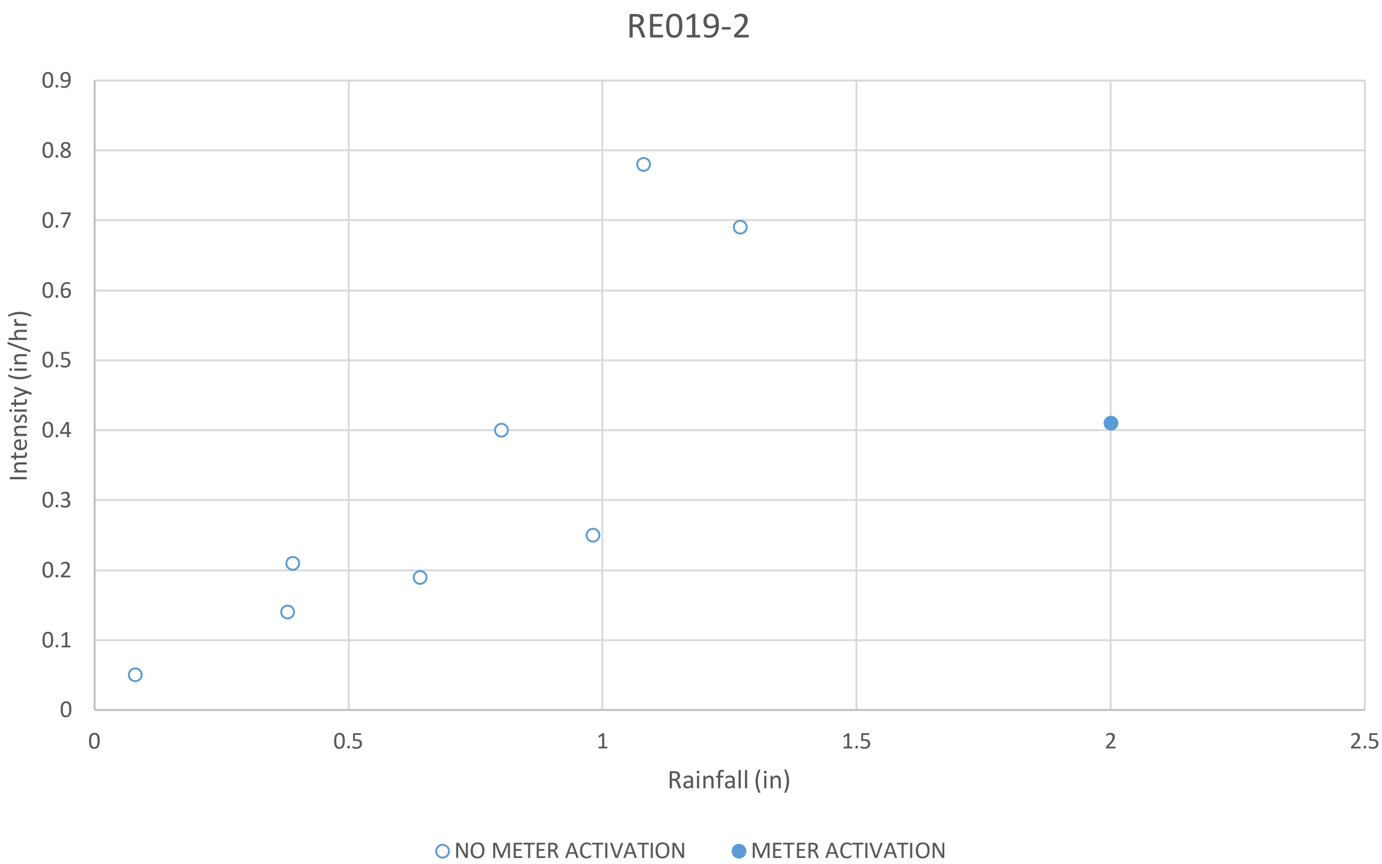
Outfall: MWR023
Regulator: RE046-381
Related Rain Gauge: 15



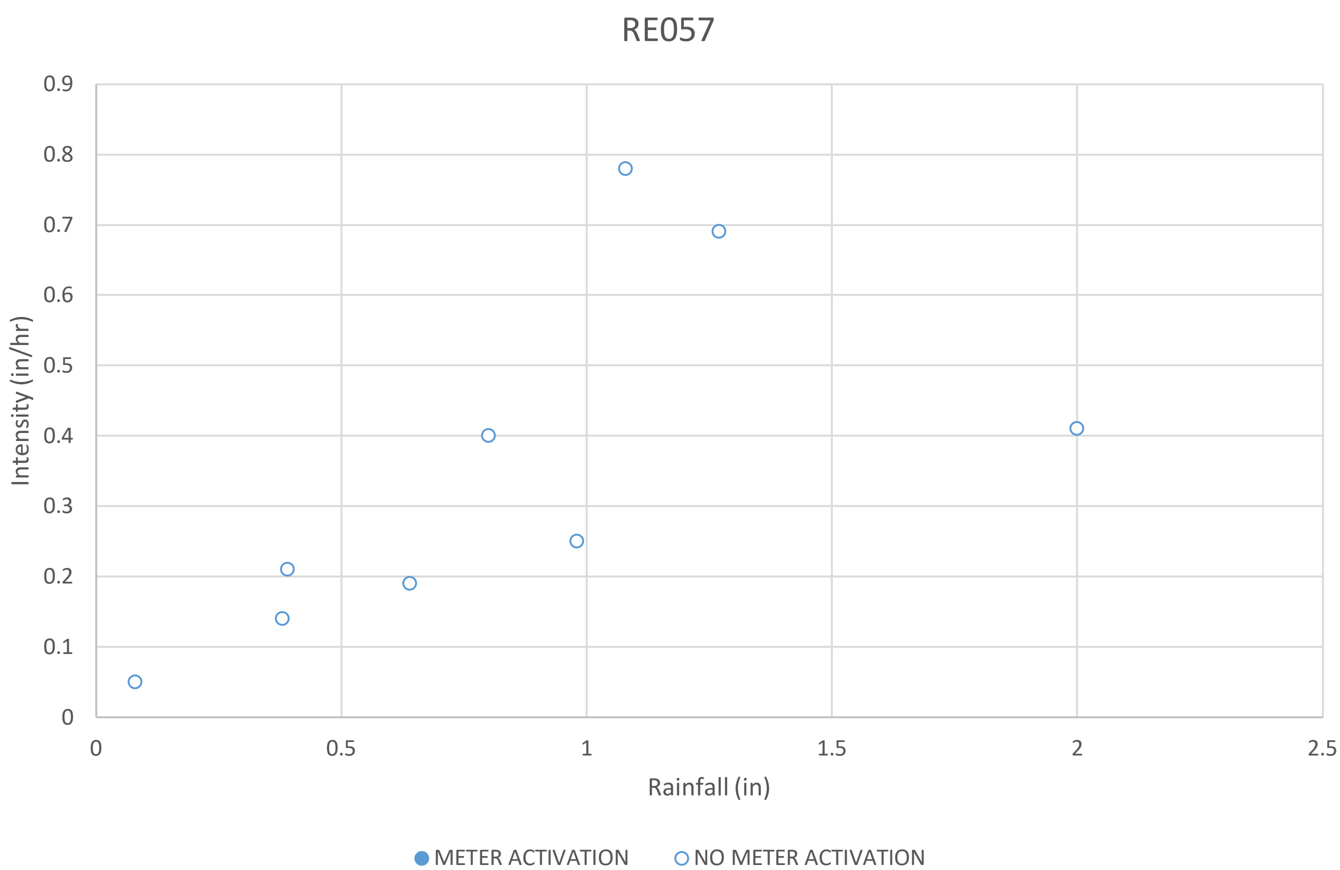
Outfall: BOS017
Regulator: RE017-3
Related Rain Gauge: 4



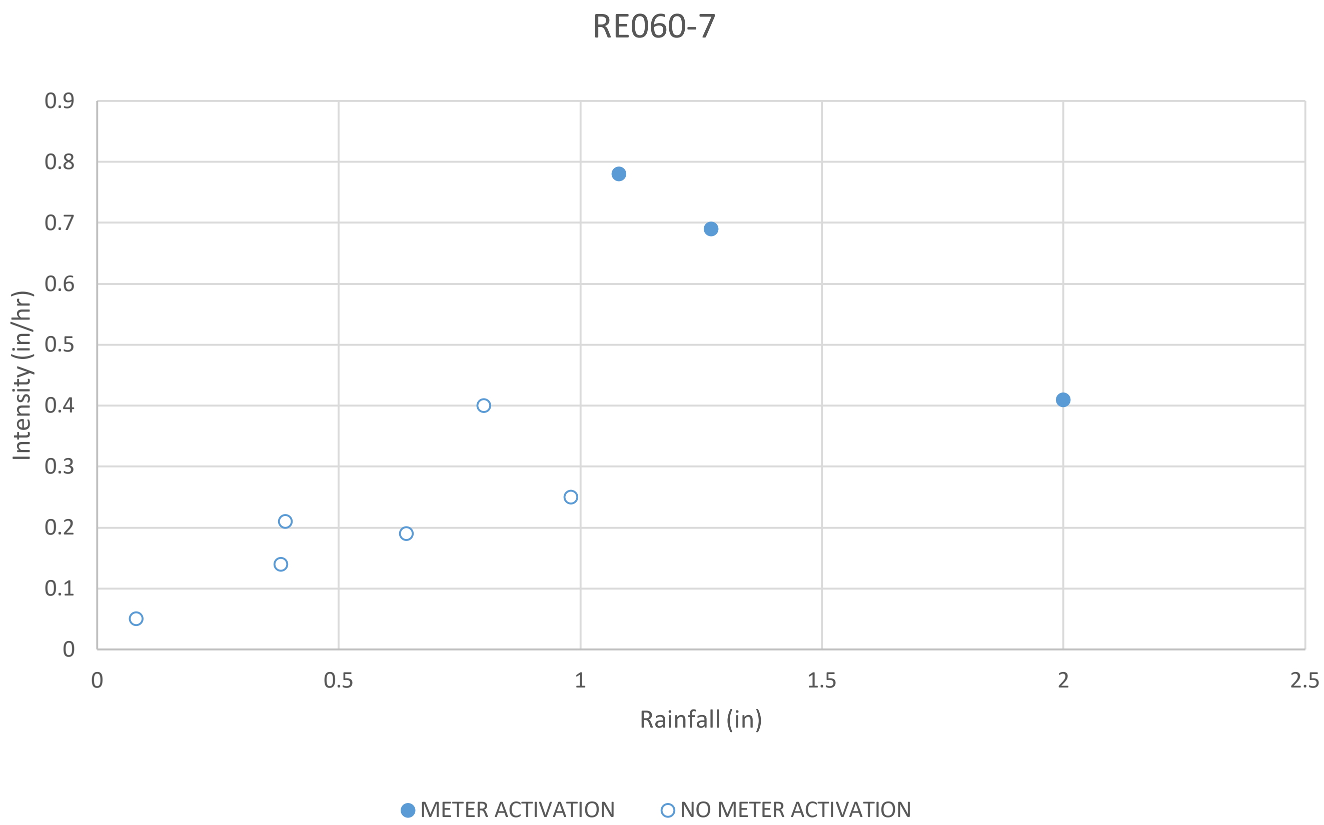
Outfall: BOS019
Regulator: RE019-2
Related Rain Gauge: 4



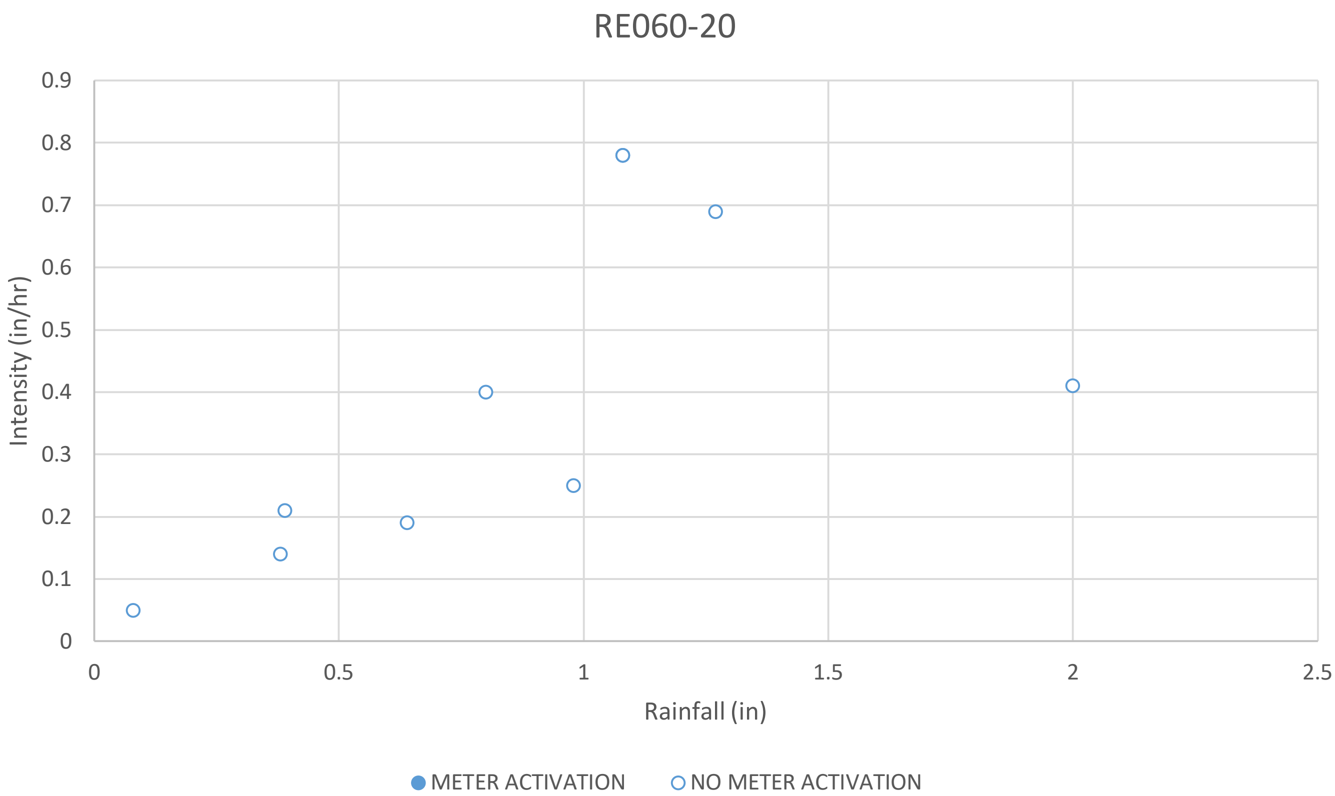
Outfall: BOS057
Regulator: RE057
Related Rain Gauge: 4



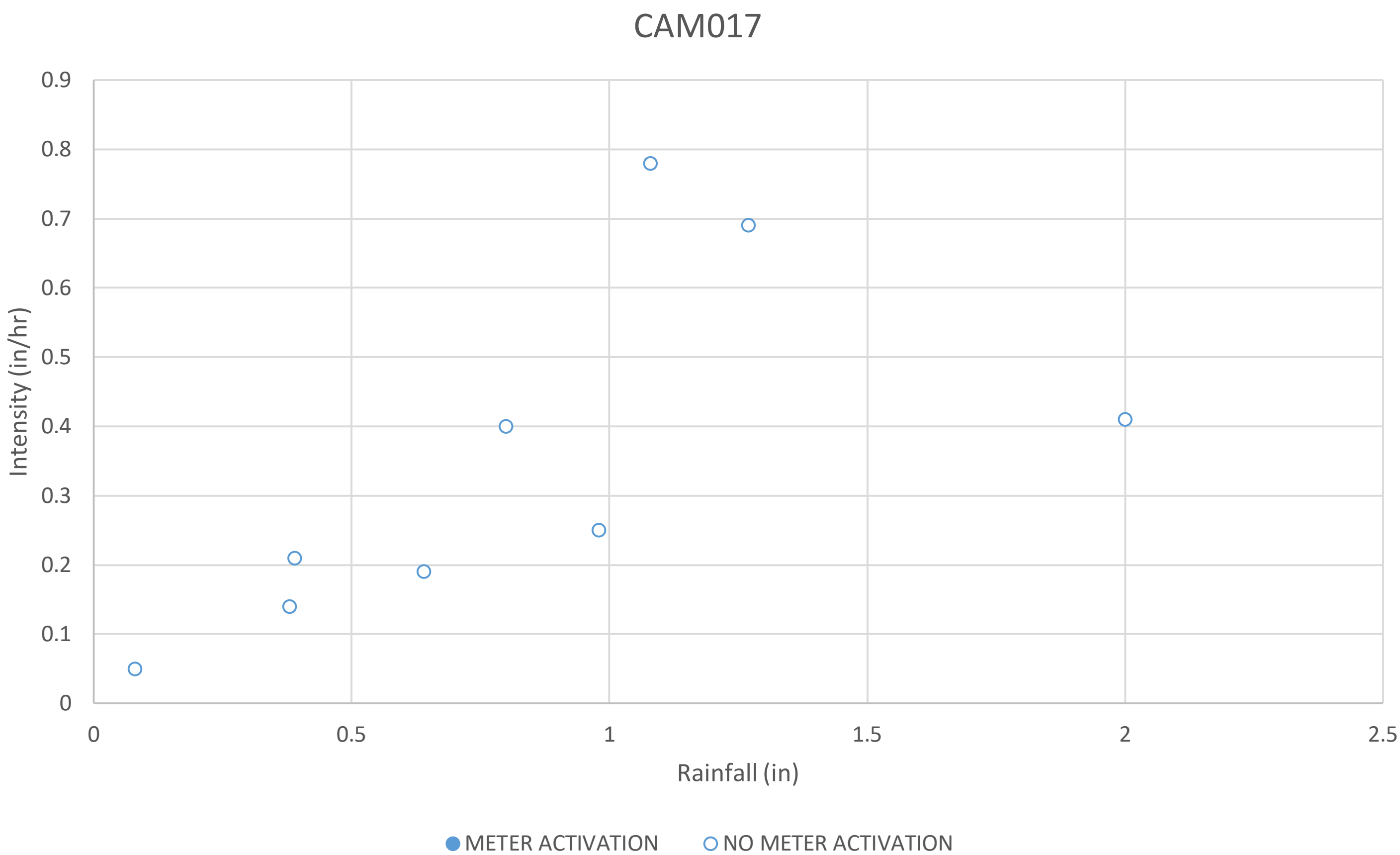
Outfall: BOS060
Regulator: RE060-7
Related Rain Gauge: 4



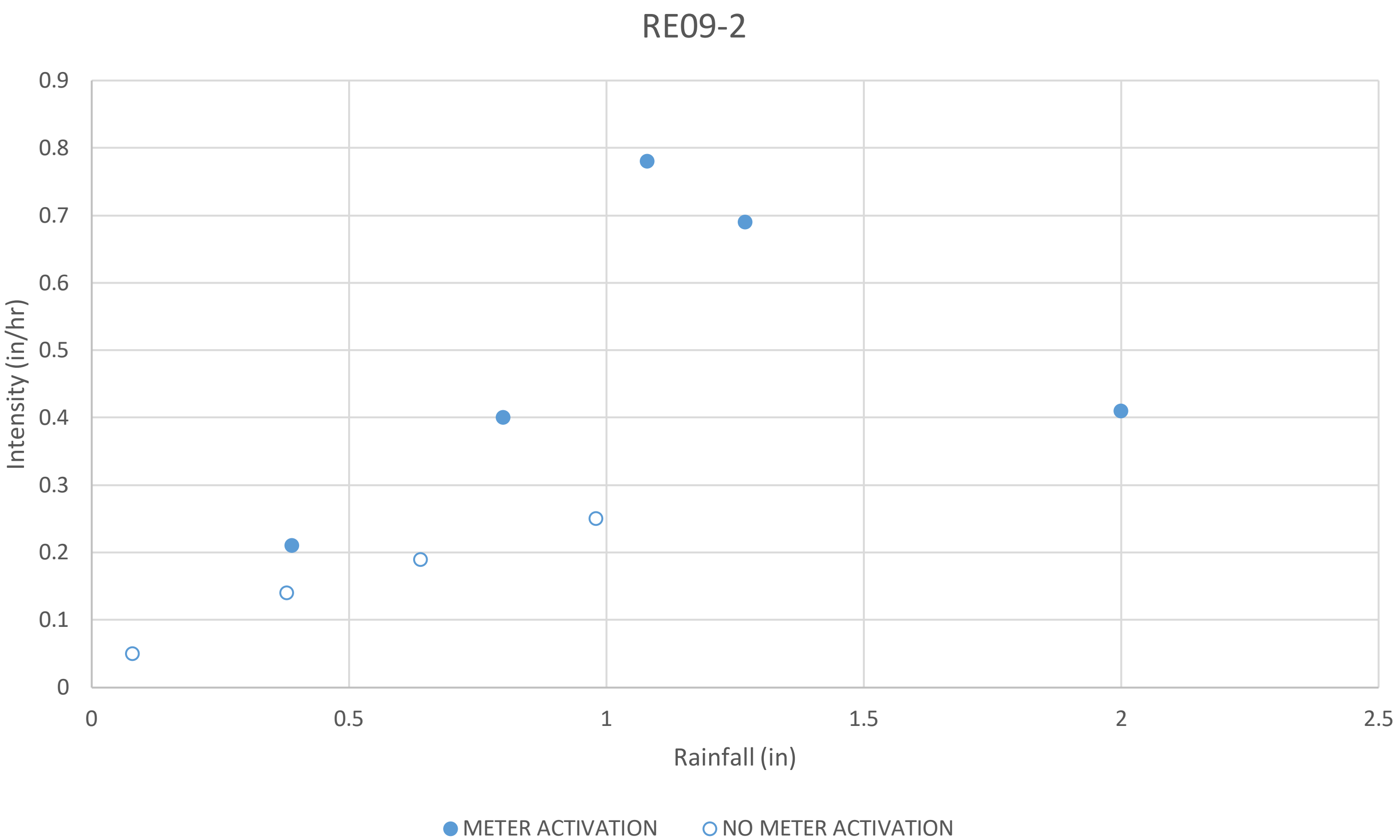
Outfall: BOS060
Regulator: RE060-20
Related Rain Gauge: 4



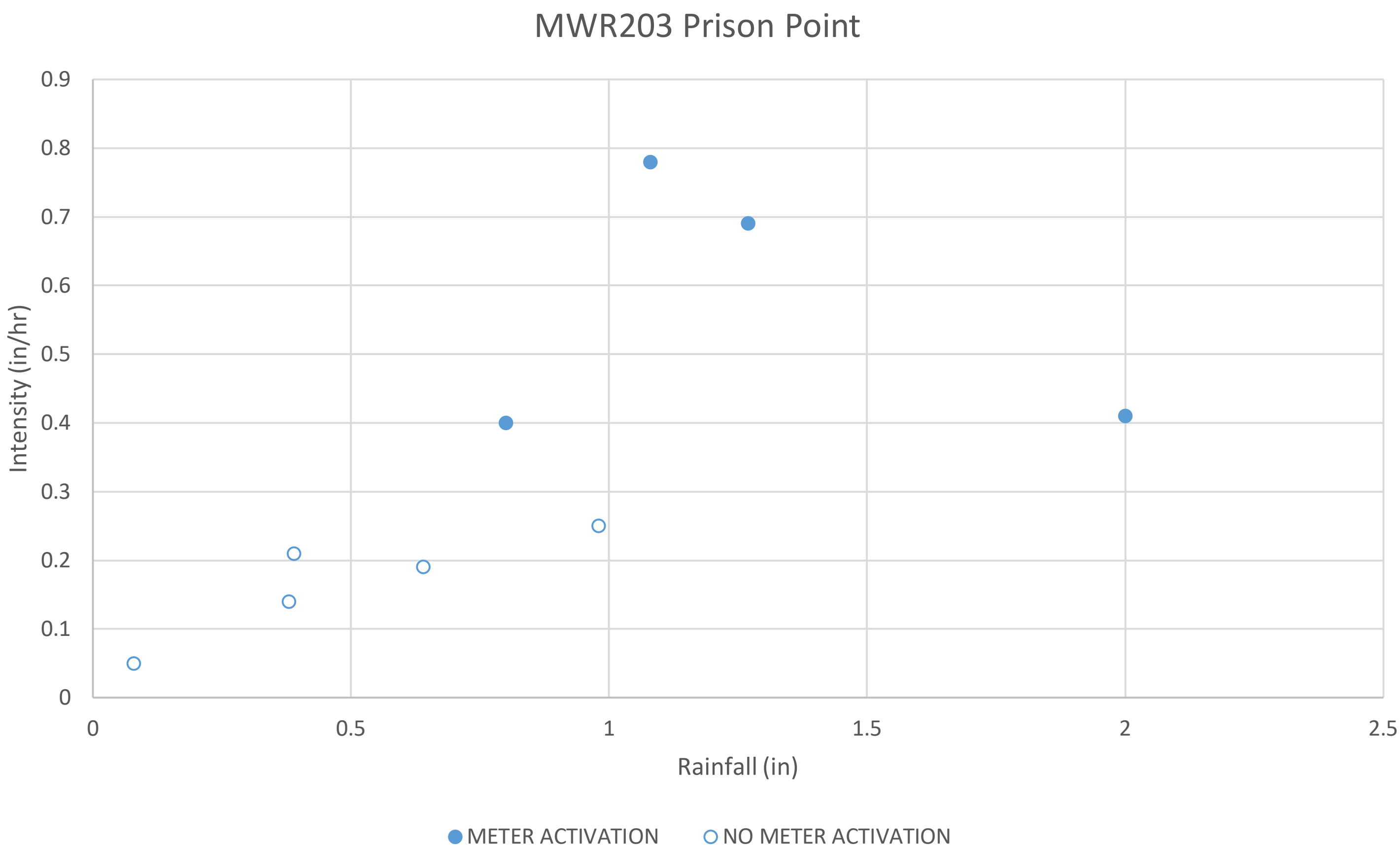
Outfall: CAM017
Regulator: CAM017
Related Rain Gauge: 4



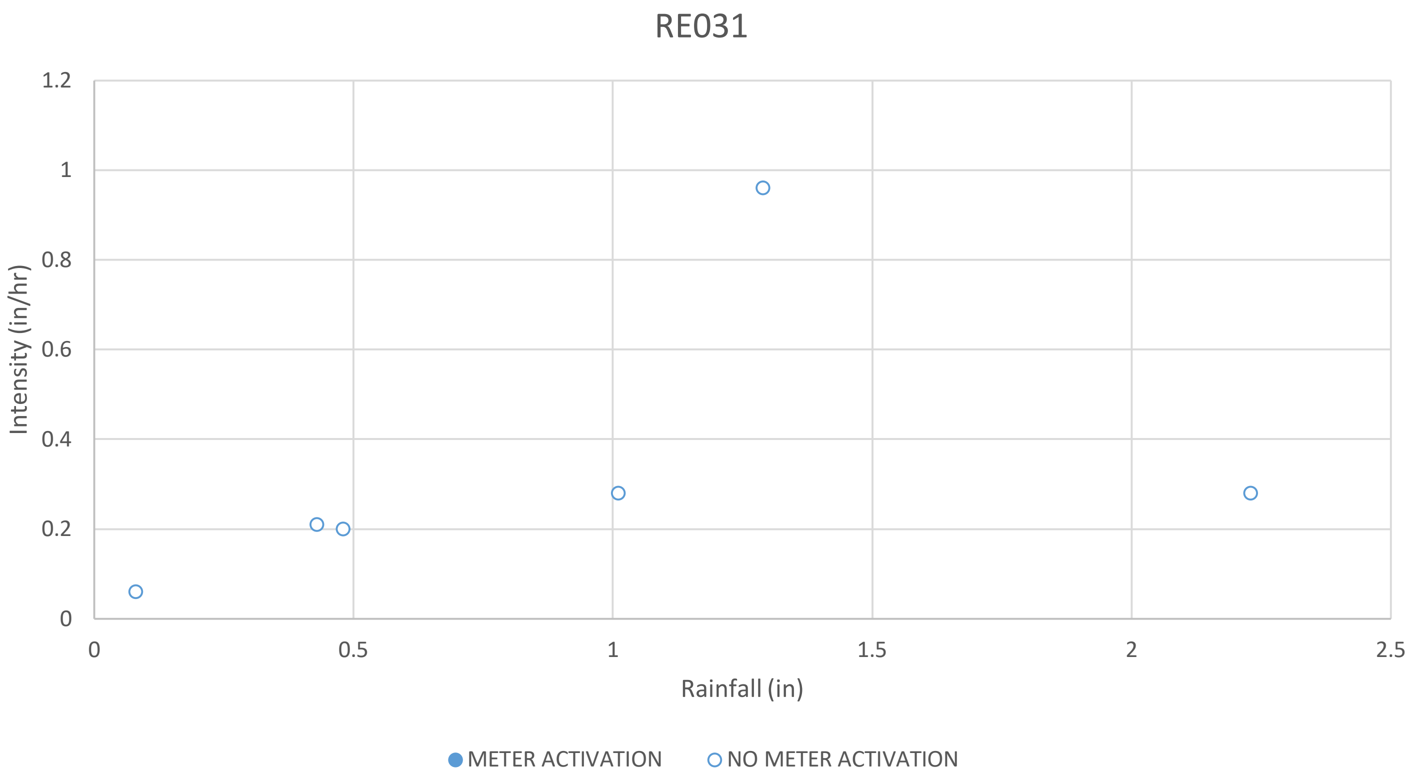
Outfall: BOS09
Regulator: RE0-2
Related Rain Gauge: 4



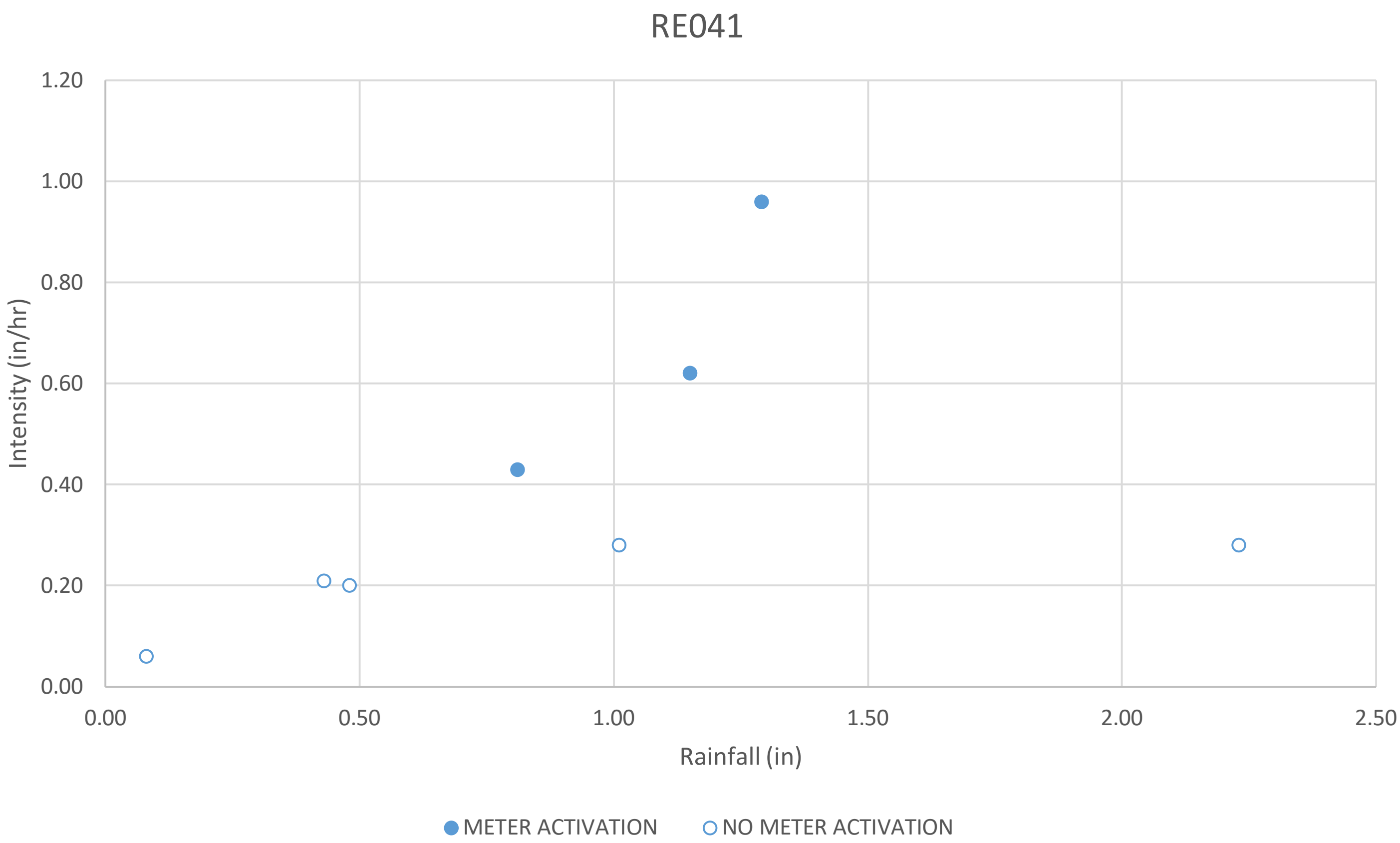
Outfall: MWR203
Regulator: Prison Point
Related Rain Gauge: 4



Outfall: CHE003
Regulator: RE031
Related Rain Gauge: 5



Outfall: CHE004
Regulator: RE041
Related Rain Gauge: 5



Outfall: CHE008
Regulator: RE081
Related Rain Gauge: 5