Task 4: Semiannual CSO Discharge Report No. 2
July 1, 2018 – December 31, 2018

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

May 3, 2019

Project number: 60559027

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Definitions

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

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

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

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

Diversion Structure: A 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.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

1. Introduction

1.1 Purpose and Scope of the Semiannual CSO Discharge Report

On November 8, 2017, the Massachusetts Water Resources Authority (MWRA) commenced a three-year study to measure the performance of its $910 million 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 scheduled milestones in the nearly 35-year-old Federal District Court Order in the Boston Harbor Case (U.S. v. M.D.C., et al, No. 85-0489 MA).

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. To date all of the court imposed deadlines have been met. The last two court milestones require MWRA to:

- Commence by January 2018 a three-year performance assessment including post-construction monitoring in compliance with EPA's CSO Policy (59 Fed. Reg. 18688 (April 19, 1994)
- 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, specified in the LTCP.

These requirements are 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") (see Section 1.3.5).

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

- Inspections at all CSO regulators addressed in the LTCP to confirm closed or active status and confirm or update physical conditions
- Extensive overflow data collection at remaining active CSO regulators
- Upgrade and improved calibration of MWRA's hydraulic model of the wastewater system using recent inspection information and overflow data
- Assessments of system performance for CSO control and the consideration of performance improvements
- Assessment of the water quality impacts of remaining CSOs and compliance with Massachusetts Water Quality Standards (separately reported; not reported herein)

Table 1-1 on the following page shows current Water Quality Standards designations by DEP. For fresh water designated Class B (Neponset River) and marine waters designated Class SB, MWRA has confirmed through its inspections in 2018 that all CSO regulators other than those tributary to the South Boston beaches are closed and CSO is eliminated. The South Boston CSO Storage Tunnel captures overflows from all regulators tributary to the South Boston beaches. The ongoing CSO performance assessment will include an assessment of whether the tunnel's performance in the many storms since start-up in May 2011 confirms it can provide total CSO capture up to and including the 25-year storm.

For waters designated Class B(cso) or SB(cso) in Table 1-1, compliance with water quality standards will be demonstrated by verifying attainment of the LTCP levels of CSO control (Typical Year activation frequency and volume). For Class B waters where DEP has issued water quality standards variances for CSO discharges (Lower Charles River/Charles Basin and Alewife Brook/Upper Mystic River), MWRA is conducting water quality monitoring and will perform receiving water quality modeling assessments to support eventual long-term water quality standards designations and associated CSO control determinations by DEP. In accordance with the variances, MWRA issues a report every July 15 that summarizes the water quality data it collected in the previous calendar year. MWRA plans to issue separate reports that will document the progress of its water quality assessments of remaining CSO impacts. Presently, the term of the variances expires in September 2019 and MWRA is actively working with DEP and EPA on an extension of these variances.

Table 1-1. 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 South Dorchester Bay Constitution Beach		
Class B(cso)	Back Bay Fens	>95% compliance with Class B or SB ("fishable/swimmable") Must meet level of control for CSO activation and frequency in the approved Long-Term Control Plan (LTCP)	All LTCP projects are complete and CSO discharges are greatly reduced. Ongoing performance assessment is intended to verify whether LTCP levels of control are attained.
Class SB(cso)	Mystic/Chelsea Rivers Confluence Boston Inner Harbor Fort Point Channel Reserved Channel		
Class B (CSO Variance)	Alewife Brook Upper Mystic River Charles River	Class B standards sustained with temporary authorizations for CSO discharges as the LTCP is implemented and verified (1998-2020)	All LTCP projects are complete and CSO discharges are greatly reduced. Ongoing performance assessment is intended to verify whether LTCP levels of control are attained and to support long-term WQS designations.

This Semiannual CSO Discharge Report No. 2 is the second of five interim reports MWRA plans to issue on the progress of the performance assessment (see Table 1-2 on the following page). This report addresses the data collection period from July 1, 2018 through December 31, 2018. It follows on Semiannual CSO Discharge Report No. 1, which addressed the data collected from April 15, 2018 through June 30, 2018. Semiannual report No. 2 includes:

- Description of rainfall data collection, and analyses of rainfall in the period July 1 to December 31, 2018 (Section 2)
- Description of the CSO metering program, (Section 3)
- Description of CSO meter data review and analysis for data collected July 1 to December 31, 2018 (Section 4)
- Description of hydraulic model updates and calibration (Section 5)
- Investigation into overflow activity at select locations (Section 6)
- Progress toward the 3rd semiannual report (Oct. 2019), for data collected January 1 through June 30, 2019 (Section 7)

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Table 1-2. 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)	Oct. 2019
4	July 1 to December 31, 2019 (6 months)	Apr. 2020
5	January 1 to June 30, 2020 (6 months)	Oct. 2020

1.2 Progress of CSO Post-Construction Monitoring and Performance Assessment

Since the submittal of Semiannual Report No. 1 on November 30, 2018, MWRA has continued to make substantial progress with the performance assessment. This second semiannual progress report documents continuing activities MWRA conducted in the period July 31, 2018 through December 31, 2018, including follow-up site-specific inspections, the collection and analyses of rainfall data, and the collection and analyses of CSO and wastewater system flow data and operational records. In this period, MWRA continued to collect and analyze data at 20 rain gauges within the MWRA wastewater service area, with most of these gauges located in or near areas served by combined sewers. MWRA continued to employ metering technology at all 57 potentially active CSO regulators, and continued to collect other wastewater system data. All of these sources of data are then used to understand wet weather system performance, to validate the CSO discharges quantified from the meter data, and to improve the calibration of MWRA's hydraulic model of the wastewater system.

This report also describes the progress of ongoing work that responds to and utilizes the inspection, rainfall, flow and overflow data collected in 2018, as well as additional information obtained from MWRA's continuing coordination with its CSO communities (Boston Water and Sewer Commission (BWSC), Cambridge, Chelsea and Somerville). In particular, MWRA is focusing investigative attention on the system and system overflow conditions where measured CSO discharges differ from past hydraulic model predictions, with the goals of better understanding the factors that contribute to discharges at individual CSO regulators and outfalls and potentially affecting these conditions to improve CSO performance.

In developing the LTCP beginning in 1992, MWRA's hydraulic model was used to evaluate CSO control alternatives and gain regulatory and court approvals for the LTCP, which is intended to result in closing many of the original outfalls[1] and minimizing CSO activations and volumes in the Typical Year at remaining outfalls. It has since been used to track progress toward the attainment of the LTCP levels of control. MWRA is currently upgrading and improving the calibration of the model using the extensive inspections and overflow meter data it collected in 2018. MWRA expects to complete the model upgrades and calibration in August 2019.

Once recalibration of the hydraulic model is completed, the model will be used to facilitate comparisons between metered and model-predicted overflow volumes and durations for storm events in each subsequent semiannual reporting period. MWRA will utilize the improved model to assess and understand hydraulic performance in the collection system, such as the precipitation characteristics that cause certain overflows to activate, and to understand how system modifications may improve upon overflow frequency, duration and volume, where warranted. Ultimately, the hydraulic model is the tool by which Typical Year levels of control will be determined and attainment of the LTCP levels can be verified in compliance with the last federal court milestone.

[1] Implementation of the LTCP and related community efforts have resulted in permanently closing 35 of the 84 formerly active outfalls addressed in the plan and attaining a 25-year storm level of control at the five remaining outfalls along the South Boston beaches.

In summary, the main tasks continued, completed, or commenced since MWRA issued the first semiannual report in November 2018 include:

- Continued collection and analysis of rainfall and meter data
- Hydraulic model updates to reflect system inspections and updated information from the CSO communities
- Improved calibration of the hydraulic model using data collected in 2018, scheduled to be complete in August 2019
- Continued coordination with BWSC, Cambridge, Chelsea and Somerville on system performance evaluations, the measurements and model predictions of CSO discharges, and the CSO communities' maintenance and project plans
- Continued assessments of and adjustment to the metering program

MWRA employed temporary CSO meters at all 57 potentially active CSO regulators beginning April 15, 2018. MWRA also collected data from permanent CSO meters at its four CSO treatment facilities – Cottage Farm, Prison Point, Somerville Marginal and Union Park – and from permanent meters maintained at certain other CSO outfalls by MWRA or its CSO communities. MWRA collected data during each of the many rainfall events that occurred in the period April 15 through December 31, 2018, a relative wet period based on number of storms and total rainfall.

With sufficient data to characterize CSO discharges and to improve the calibration of the hydraulic model at most of the CSO regulators, MWRA took temporary meters out of service at 21 of the 57 CSO regulators on March 1, 2019 (see Section 4.4 for more information). Temporary meters will remain in place and operational until June 30, 2020 at the other 36 CSO regulators, along with the permanent meters. Some of the temporary meters that will remain in place are intended to support site-specific investigations and the evaluation of potential system modifications that may improve CSO performance (Section 6). Temporary meters will remain in place at CSO regulators associated with outfalls along the Charles River, the Alewife Brook and the Upper Mystic River to support variance related water quality analyses and assessments.

1.3 MWRA's CSO Control Accomplishments and Compliance

1.3.1 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 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[2]) (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

[2] 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.

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 LTCP closely followed and conformed to the requirements of the National CSO Policy[3] 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 1-1. 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 that were in operation at that time[4]. The Charles River especially benefited from these early system improvements.

EPA's National CSO Policy[3] 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, 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 system modifications to maximize wet weather storage and conveyance. The SOP projects, which were fully implemented by MWRA and the CSO communities by 1997, and further reduced CSO discharges by about 20 percent from the 1992 levels.

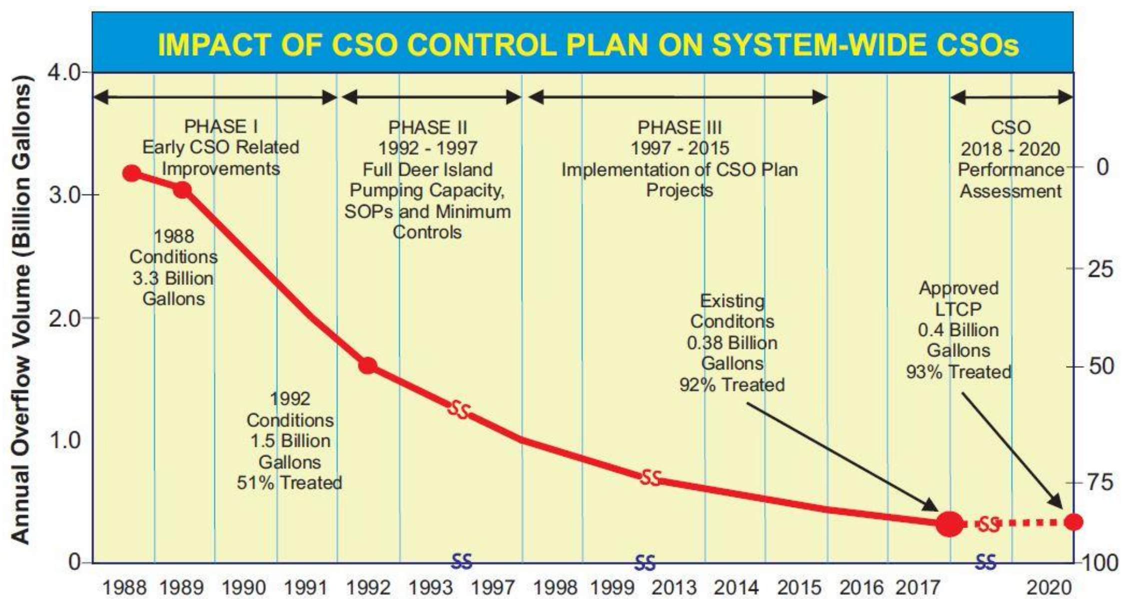


Figure 1-1. Wastewater System Improvement Contributions to CSO Control*

** From past 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

[3] EPA's Combined Sewer Overflow Policy, 59 Fed. Reg. 18688 (April 19, 1994)

[4] Since that time, MWRA has decommissioned the Constitution Beach, Commercial Point and Fox Point CSO facilities following completion of sewer separation projects, upgraded the Cottage Farm, Prison Point and Somerville-Marginal CSO facilities, and brought into operation the newly constructed Union Park Detention and Treatment facility.

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 1-2 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 were presented in Section 2.4 of MWRA's Semiannual Report No. 1, November 30, 2018 (http://www.mwra.com/cso/pcmpa-reports/01_041518-063018.pdf).

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 1-3 on page 8). 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 1-2. The 35 Long-Term Control Plan Projects

Table 1-3. Long-Term CSO Control Plan Project Implementation Schedules

<table>
<tr><th colspan="2">Project</th><th>Commence Design</th><th>Commence Construction</th><th>Complete Construction</th></tr>
<tr><td colspan="2">North Dorchester Bay Storage Tunnel and Related Facilities</td><td>Aug-97</td><td>Aug-06</td><td>May-11</td></tr>
<tr><td colspan="2">Pleasure Bay Storm Drain Improvements</td><td>Sep-04</td><td>Sep-05</td><td>Mar-06</td></tr>
<tr><td rowspan="2">Hydraulic Relief Projects</td><td>CAM005 Relief</td><td rowspan="2">Aug-97</td><td>Jul-99</td><td>May-00</td></tr>
<tr><td>BOS017 Relief</td><td>Jul-99</td><td>Aug-00</td></tr>
<tr><td colspan="2">East Boston Branch Sewer Relief</td><td>Mar-00</td><td>Mar-03</td><td>Jul-10</td></tr>
<tr><td colspan="2">BOS019 CSO Storage Conduit</td><td>Jul-02</td><td>Mar-05</td><td>Mar-07</td></tr>
<tr><td rowspan="3">Chelsea Relief Sewers</td><td>Chelsea Trunk Sewer Relief</td><td rowspan="3">Jun-97</td><td>Sep-99</td><td>Aug-00</td></tr>
<tr><td>Chelsea Branch Sewer Relief</td><td>Dec-99</td><td>Jun-01</td></tr>
<tr><td>CHE008 Outfall Repairs</td><td>Dec-99</td><td>Jun-01</td></tr>
<tr><td colspan="2">Union Park Detention/Treatment Facility</td><td>Dec-99</td><td>Mar-03</td><td>Apr-07</td></tr>
<tr><td rowspan="6">CSO Facility Upgrades and MWRA Floatables Control</td><td>Cottage Farm Upgrade</td><td rowspan="6">Jun-96</td><td>Mar-98</td><td>Jan-00</td></tr>
<tr><td>Prison Point Upgrade</td><td>May-99</td><td>Sep-01</td></tr>
<tr><td>Commercial Point Upgrade</td><td>Nov-99</td><td>Sep-01</td></tr>
<tr><td>Fox Point Upgrade</td><td>Nov-99</td><td>Sep-01</td></tr>
<tr><td>Somerville-Marginal Upgrade</td><td>Nov-99</td><td>Sep-01</td></tr>
<tr><td>MWRA Floatables Control and Outfall Closings</td><td>Mar-99</td><td>Mar-00</td></tr>
<tr><td colspan="2">Brookline Connection and Cottage Farm Overflow Interconnection and Gate</td><td>Sep-06</td><td>Jun-08</td><td>Jun-09</td></tr>
<tr><td colspan="2">Prison Point Facility Optimization</td><td>Mar-06</td><td>Mar-07</td><td>Apr-08</td></tr>
<tr><td colspan="2">South Dorchester Bay Sewer Separation</td><td>Jun-96</td><td>Apr-99</td><td>Jun-07</td></tr>
<tr><td colspan="2">Stony Brook Sewer Separation</td><td>Jul-98</td><td>Jul-00</td><td>Sep-06</td></tr>
<tr><td colspan="2">Neponset River Sewer Separation</td><td></td><td>Apr-96</td><td>Jun-00</td></tr>
<tr><td colspan="2">Constitution Beach Sewer Separation</td><td>Jan-97</td><td>Apr-99</td><td>Oct-00</td></tr>
<tr><td colspan="2">Fort Pt Channel Conduit Sewer Separation and System Optimization</td><td>Jul-02</td><td>Mar-05</td><td>Mar-07</td></tr>
<tr><td colspan="2">Morrissey Boulevard Storm Drain</td><td>Jun-05</td><td>Dec-06</td><td>Jul-09</td></tr>
<tr><td colspan="2">Reserved Channel Sewer Separation</td><td>Jul-06</td><td>May-09</td><td>Dec-15</td></tr>
<tr><td colspan="2">Bulfinch Triangle Sewer Separation</td><td>Nov-06</td><td>Sep-08</td><td>Jul-10</td></tr>
<tr><td colspan="2">Brookline Sewer Separation</td><td>Nov-06</td><td>Nov-08</td><td>Apr-13</td></tr>
<tr><td colspan="2">Somerville Baffle Manhole Separation</td><td></td><td>Apr-96</td><td>Dec-96</td></tr>
<tr><td rowspan="6">Cambridge/Alewife Brook Sewer Separation</td><td>CAM004 Stormwater Outfall and Detention Basin</td><td></td><td>Apr-11</td><td>Apr-13</td></tr>
<tr><td>CAM004 Sewer Separation</td><td>Jan-97</td><td>Jul 98/Sep 12</td><td>Dec-15</td></tr>
<tr><td>CAM400 Manhole Separation</td><td>Oct-08</td><td>Jan-10</td><td>Mar-11</td></tr>
<tr><td>Interceptor Connection Relief/Floatables Control at Outfalls CAM002, CAM401B and CAM001</td><td>Oct-08</td><td>Jan-10</td><td>Oct-10</td></tr>
<tr><td>MWR003 Gate and Rindge Ave. Siphon Relief</td><td>Mar-12</td><td>Aug-14</td><td>Oct-15</td></tr>
<tr><td>Connection Relief/Floatables Control at SOM01A</td><td>Mar-12</td><td>Sep-13</td><td>Dec-13</td></tr>
<tr><td colspan="2">Region-wide Floatables Control and Outfall Closings</td><td>Sep-96</td><td>Mar-99</td><td>Dec-07</td></tr>
</table>

The MWRA and community CSO control 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 LTCP. 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. The LTCP is intended to reduce 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 estimated to be treated at MWRA's four new or upgraded CSO treatment facilities. Figure 1-3 shows the region-wide Typical Year CSO volume reduction with completion of the last of the 35 LTCP projects in December 2015. Figure 1-4 on page 10 shows this CSO reduction for each of the receiving water segments shown in the Figure 1-5 map, also on page 10. The CSO control projects for each receiving water segment and the Typical Year CSO levels predicted by MWRA's hydraulic model for 1992, 2017 and LTCP system conditions are shown on pages 11 through 15.

The CSO activation frequencies and volumes in Figure 1-3 and Figure 1-4 and on pages 11 through 15 are from past MWRA hydraulic model predictions. Model updates and calibration now underway as part of this CSO Performance Assessment are expected to change these predictions. Updated predictions for current system conditions will be presented in future semiannual progress reports once calibration is complete. Metering conducted in 2018 indicated at some CSO locations that the model might (or may) be underestimating CSO discharges. MWRA is currently recalibrating the hydraulic model using the 2018 meter data.

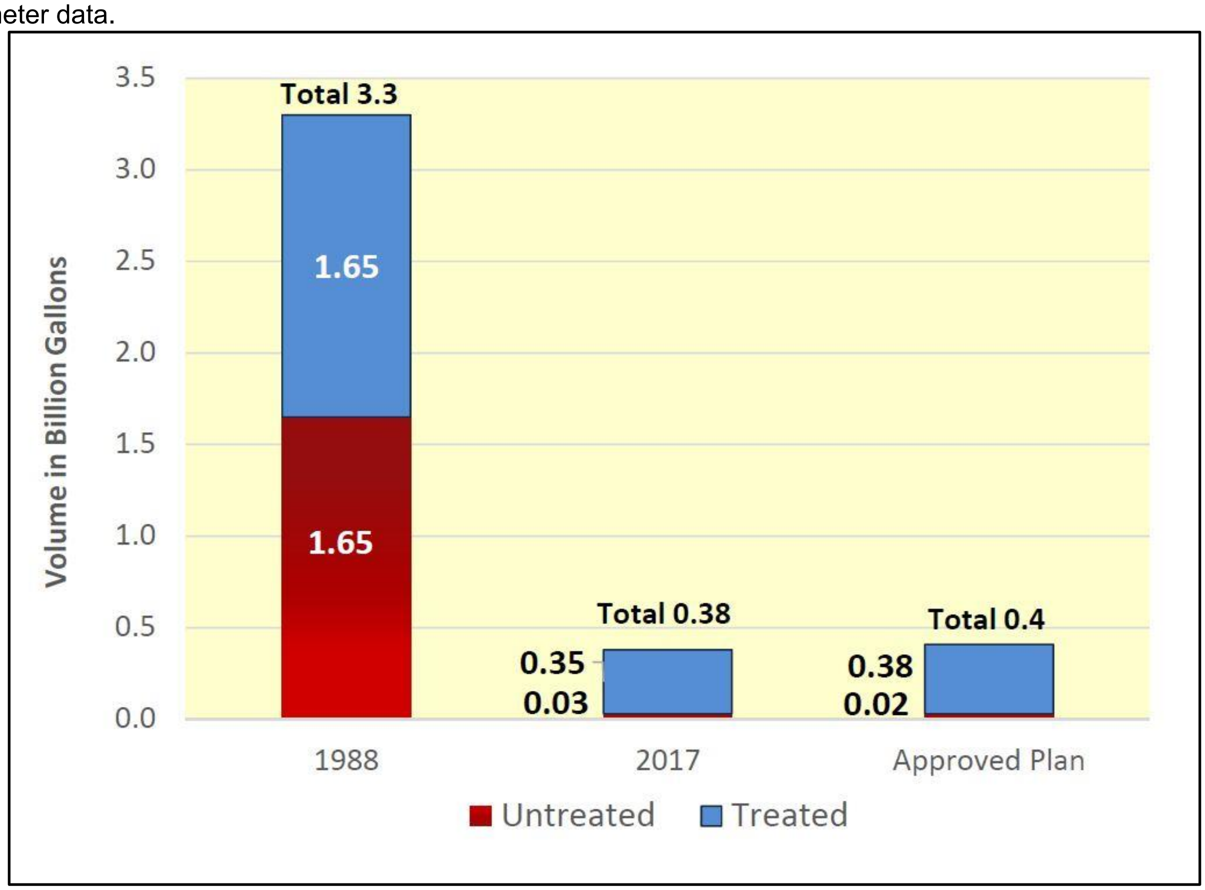


Figure 1-3. Region-wide CSO Discharge Volume Reduction*

** From past MWRA hydraulic model predictions*

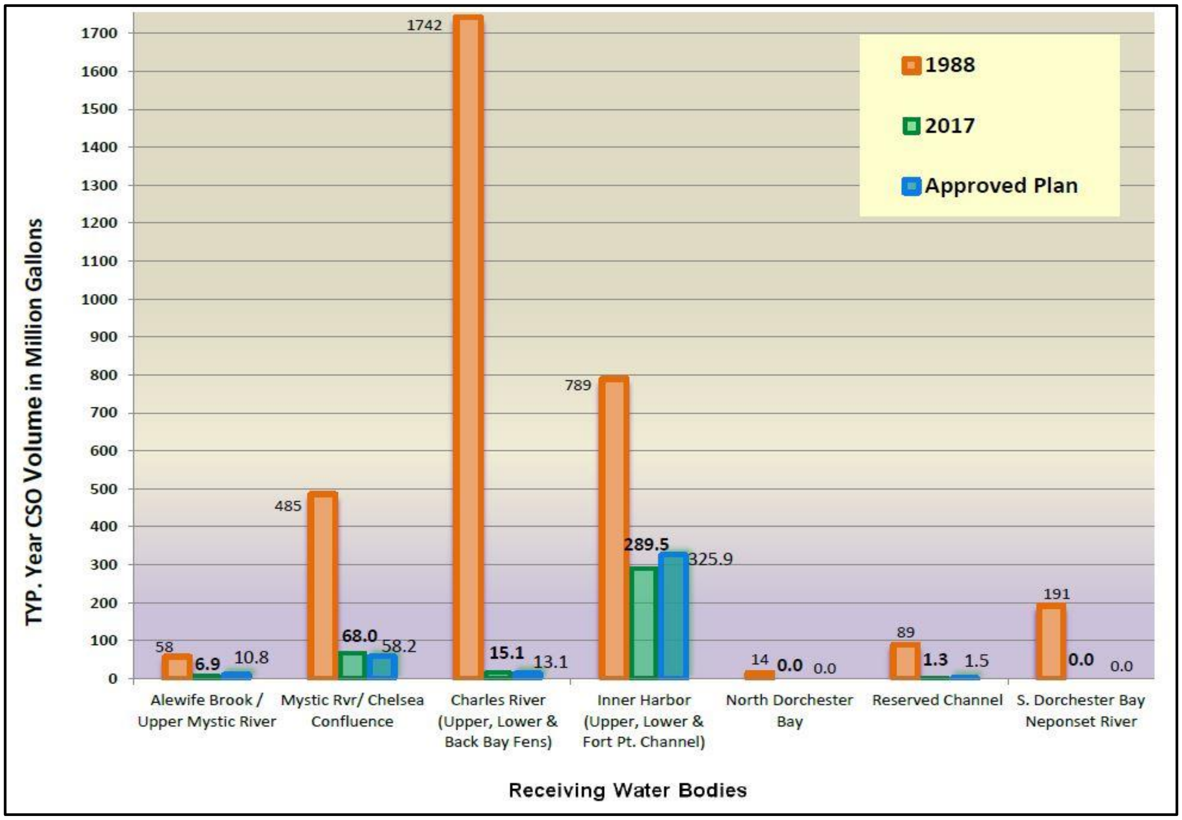
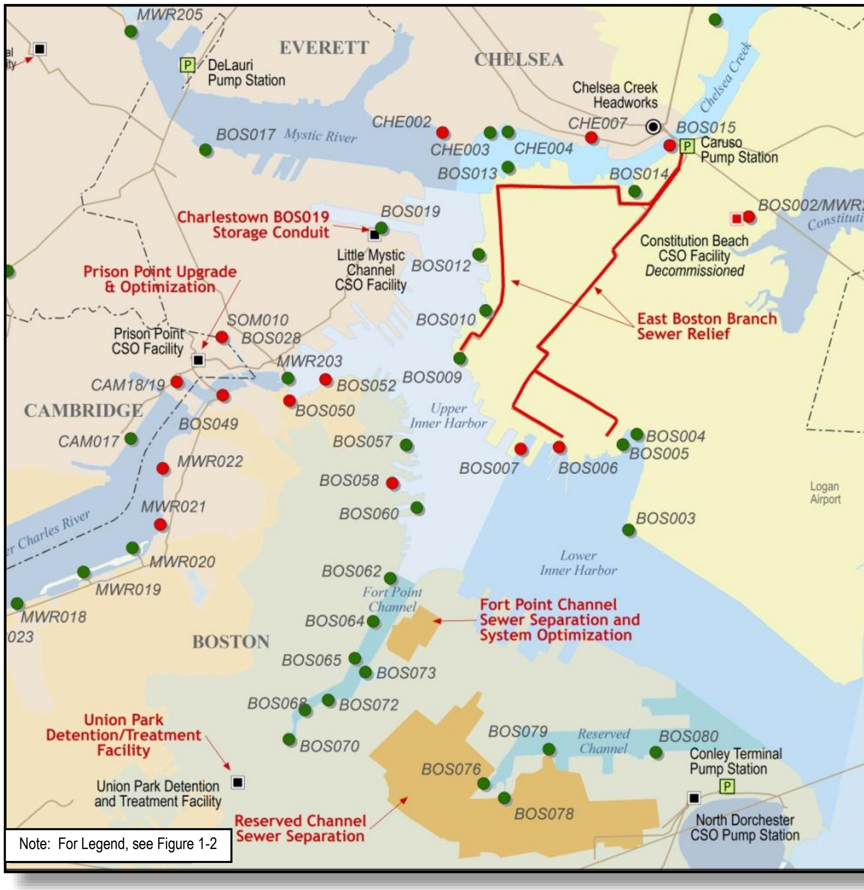


Figure 1-4. Region-wide CSO Discharge Volume Reduction by Receiving Water*

** From past MWRA hydraulic model predictions*

Figure 1-5. Boston Harbor Waters and Tributaries

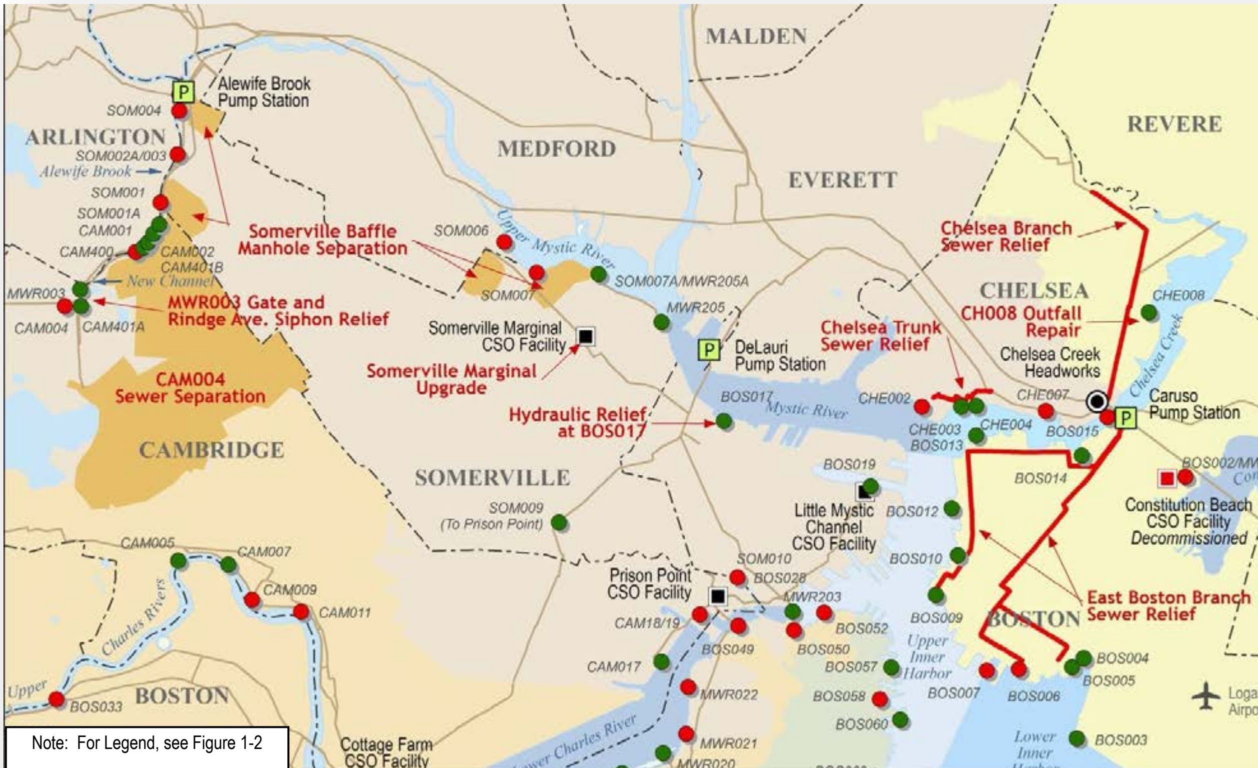
Boston Inner Harbor, Fort Point Channel and Reserved Channel



		No. of CSO Outfalls	In the Typical Rainfall Year[1]		
			Frequency of Most Active Outfall	Total Discharge Volume (million gallons)	Treated Discharge Volume (million gallons)
Boston Inner Harbor	1992	15	107	344.5	261.9 (76%)[2]
	2017	10	18[3]	251.8	237.8 (94%)[2]
	LTCP	12	17[2]	252.1	243.0 (96%)[2]
Fort Point Channel	1992	7	23	298.8	N/A
	2017	6	11[4]	37.7	33.8 (90%)[4]
	LTCP	7	17[4]	73.9	71.4 (97%)[4]
Reserved Channel	1992	4	65	89.1	N/A
	2017	4	6	1.3	N/A
	LTCP	4	3	1.5	N/A

(1) From past MWRA hydraulic model predictions
(2) From Prison Point CSO Facility
(3) From Outfall BOS003 in East Boston
(4) From Union Park Detention/Treatment Facility (completed and brought online in 2007)

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

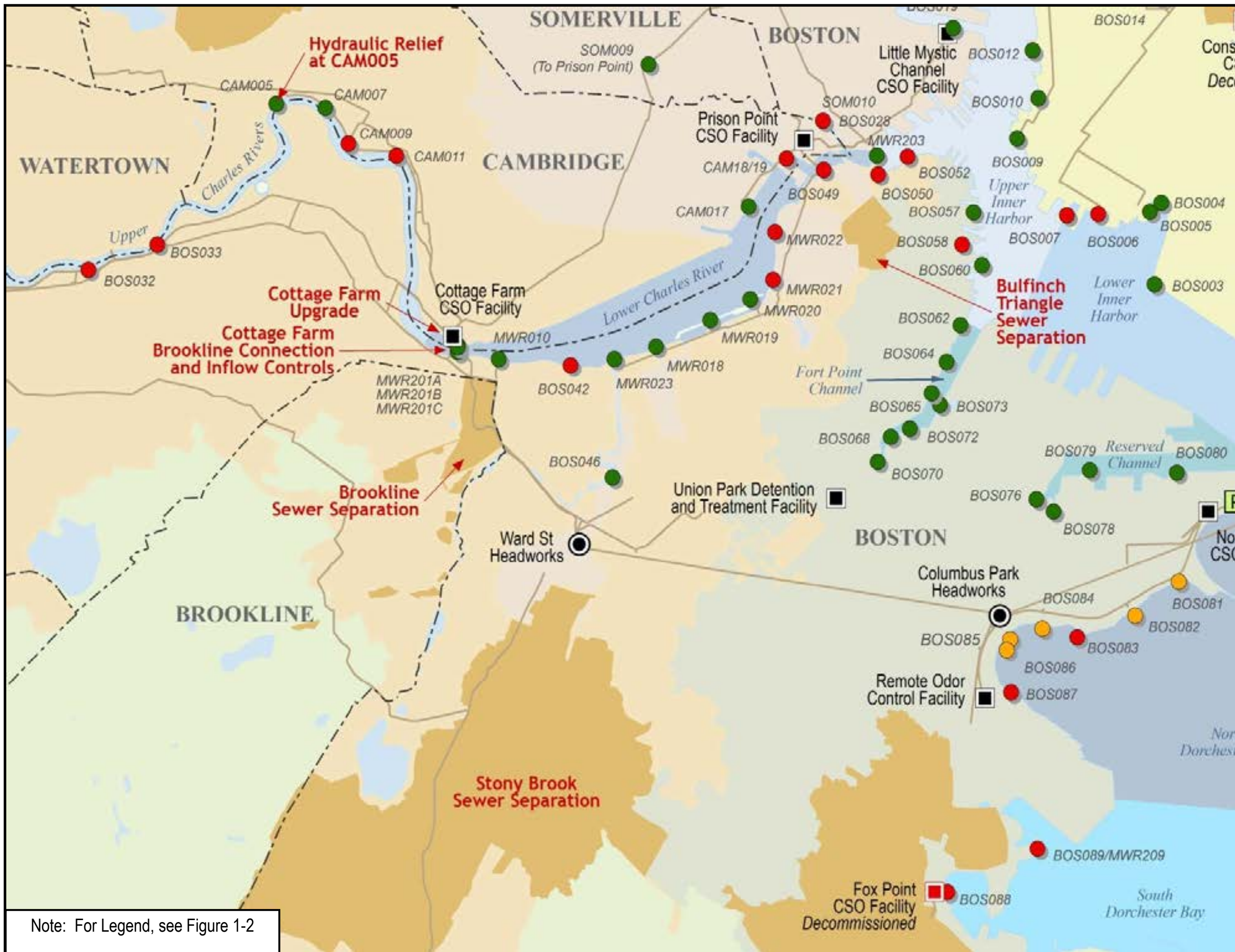


* Includes Lower Mystic River and Chelsea Creek.

		No. of CSO Outfalls	In the Typical Rainfall Year[1] Frequency of Most Active Outfall	Total Discharge Volume (million gallons)	Treated Discharge Volume[2] (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[2]	69.8	67.3 (96%)
	LTCP	8[3]	39[2]	61.7	60.6 (98%)

(1) From past MWRA hydraulic model predictions
(2) From Somerville Marginal CSO Facility (Upper Mystic Outfall MWR205A; Lower Mystic Outfall MWR205)
(3) The LTCP called for Outfall CHE002 to remain active. City of Chelsea permanently closed this outfall in 2014.

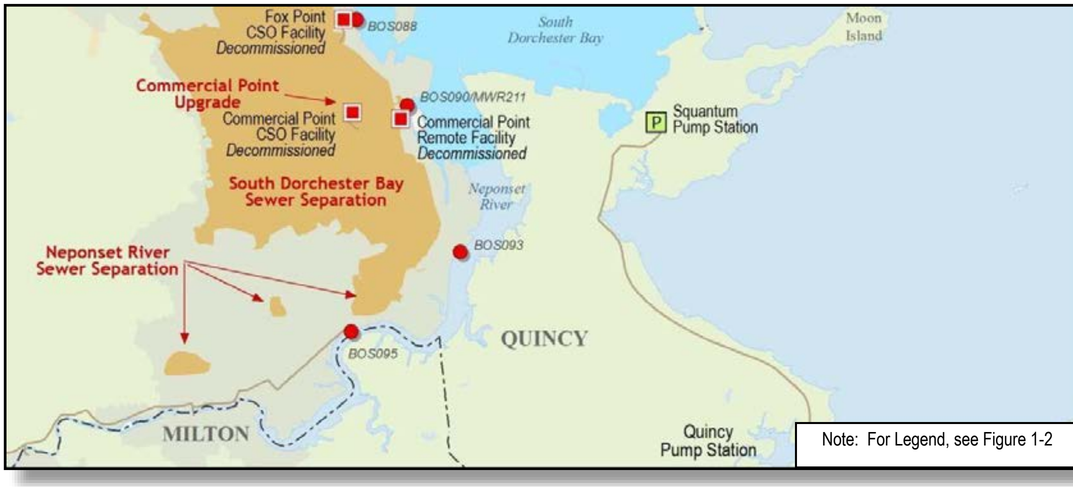
Charles River and Back Bay Fens



		No. of CSO Outfalls	In the Typical Rainfall Year[1]		
			Frequency of Most Active Outfall	**Total Discharge Volume** (million gallons)	**Treated Discharge Volume[2]** (million gallons)
Charles River Basin[3]	1992	19	39	389.0	214.1 (55%)
	2017	9	3	13.5	10.6 (79%)
	LTCP	11	3	7.8	6.3 (81%)
Back Bay Fens[4]	1992	1	2	5.3	N/A
	2017	1	1	1.6	N/A
	LTCP	1	2	5.4	N/A

(1) From past MWRA hydraulic model predictions
(2) From Cottage Farm CSO Facility
(3) CSO component of discharges from Outfall MWR023 (Stony Brook Conduit)
(4) Outfall BOS046; includes CSO and stormwater from Stony Brook Conduit

Neponset River

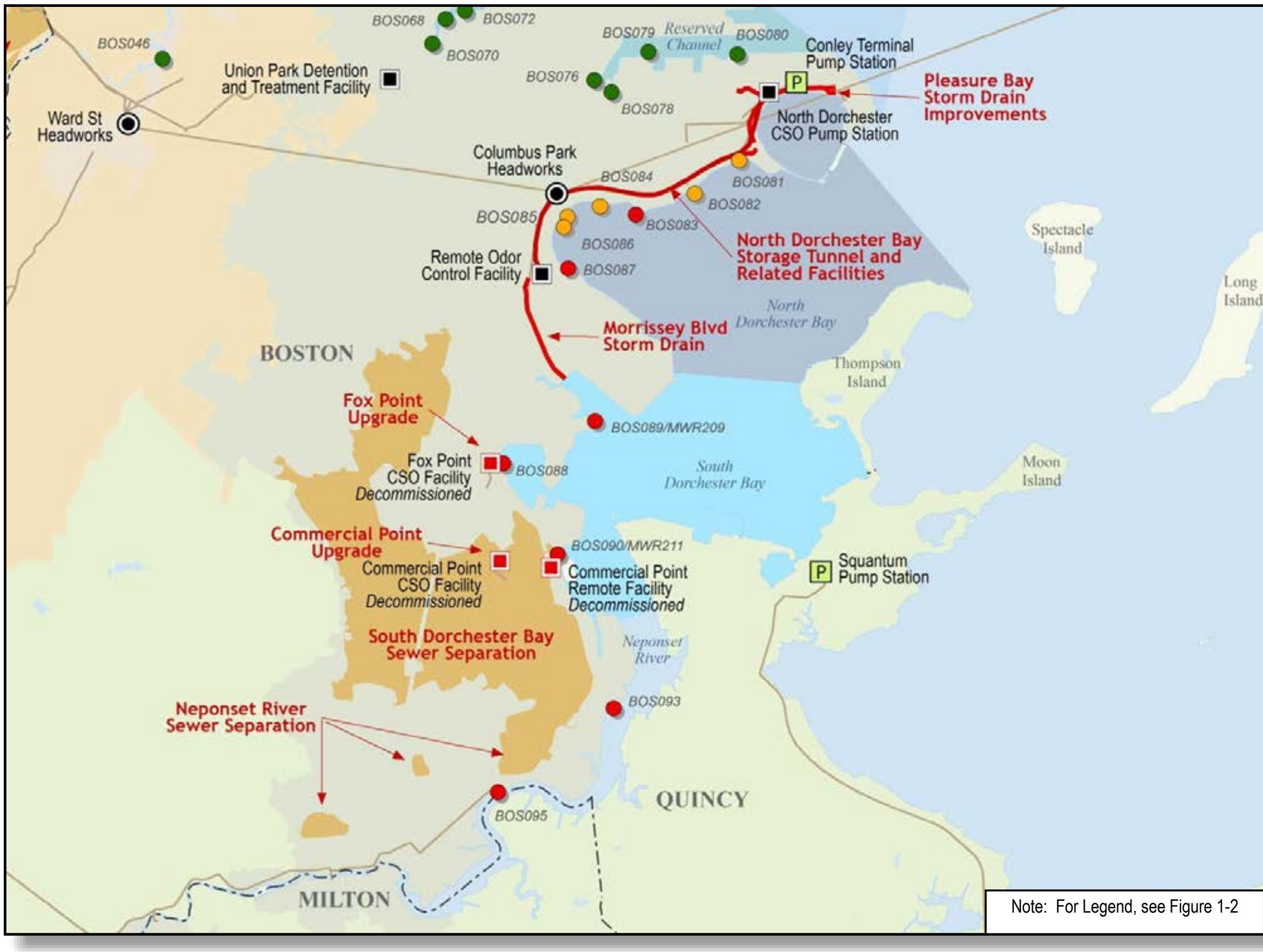


Constitution Beach

		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[1] 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[2]	0[2]	
	LTCP	5	0[2]	0[2]	
South Dorchester Bay	1992	3	87	186.0	186.0 (100%)[3]
	2017	Eliminated			
	LTCP				

[1] From past MWRA hydraulic model predictions
[2] The South Boston CSO storage tunnel captures CSO up to the 25-year storm.
[3] From Commercial Point and Fox Point CSO facilities (both decommissioned in 2007)

1.3.2 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.

Implementation of the LTCP has resulted in the elimination of 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 were presented in Appendix A: CSO and Regulator Open/Closed Status in MWRA's Semiannual Report No. 1, November 30, 2018 (http://www.mwra.com/cso/pcmpa-reports/01_041518-063018.pdf).

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

Former CSO Outfall CHE002 now discharges stormwater, only.

1.3.3 MWRA Ratepayers' Investment in CSO Control

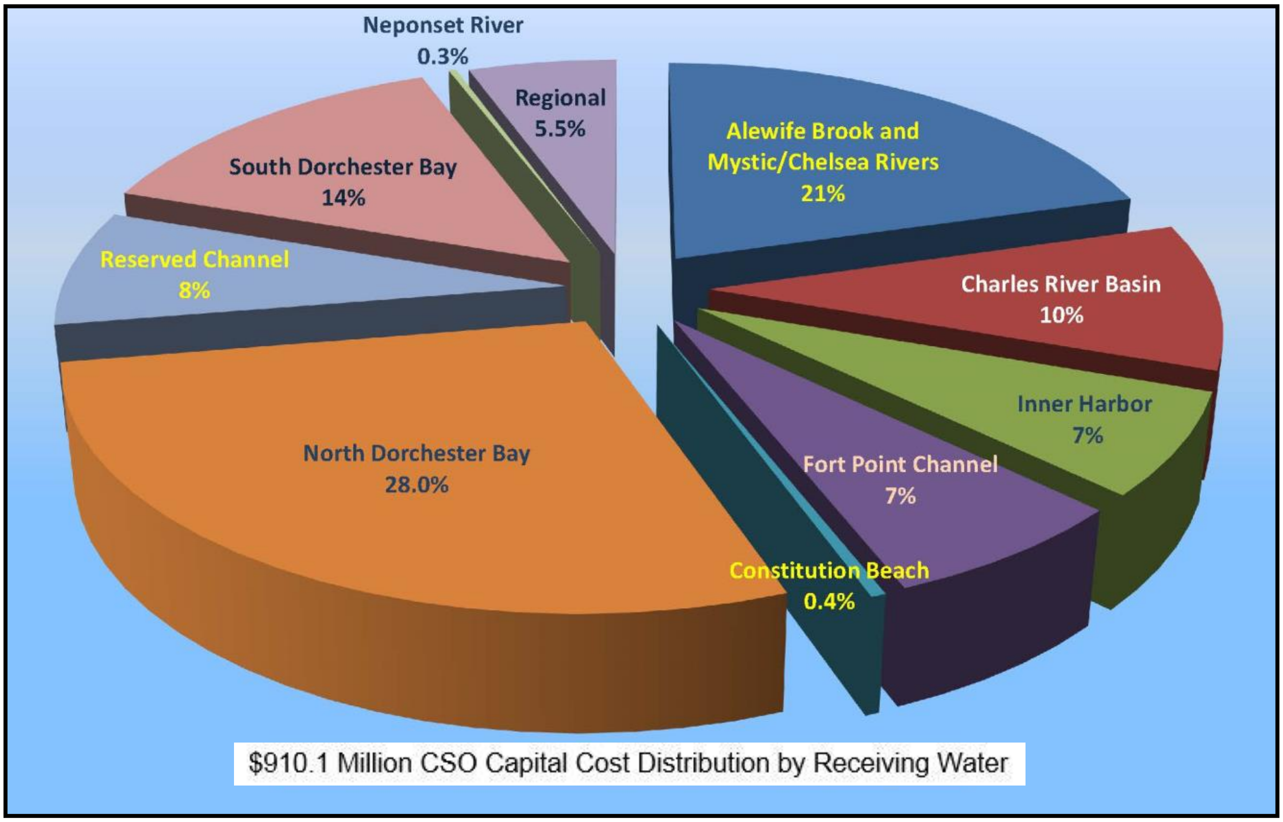
MWRA's Capital Improvement Program (CIP) includes $910.1 million for the CSO Control Program, including past planning, MWRA design and construction, financial assistance to communities to implement the LTCP projects resulting in facilities the communities own and operate, and the ongoing three-year CSO performance assessment. The allocation of these dollars to accomplish the approved levels of CSO control for the various receiving waters is shown in Figure 1-6 on the following page.

From 1987 through December 2018, MWRA spent approximately $903.3 million (99%) of the $910.1 million CSO Program budget, including $858 million for design and construction of the 35 LTCP projects. The remaining $6.8 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 minimize 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.

- $1.6 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 1-6. 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.

1.3.4 Environmental Quality Improvement

CSO discharges have been vastly reduced, treated, or eliminated in all segments of the harbor, including harbor embayments, tributaries and beaches, with the completion of construction in 2015. 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 for bacteria 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. South Boston beaches meet standards 98% of the time. CSOs have been eliminated from all harbor beaches, and any remaining water quality violations are attributable to other sources.

Additional information on environmental quality improvement was presented in Section 2.5 of MWRA’s Semiannual Report No. 1, November 30, 2018 (http://www.mwra.com/cso/pcmpa-reports/01_041518-063018.pdf).

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 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. There has been a 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 South Boston storage tunnel captured more than 350 million gallons of CSO and separate stormwater and prevented any CSO or stormwater discharge to the beaches in the approximately 103 rainfall events that occurred that year. From start-up on May 4, 2011, through 2018, the storage tunnel captured 1.5 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

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 completed CSO control projects. 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 also completed seven 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.


Charles River

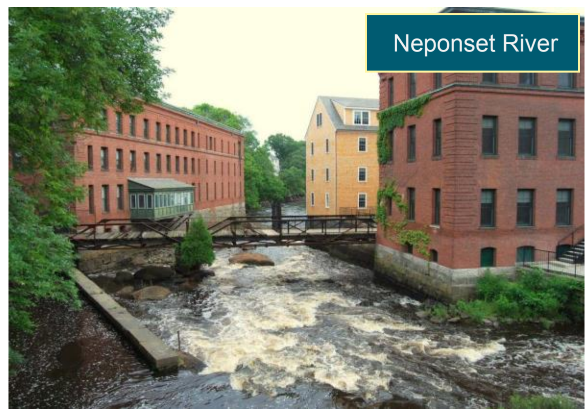
In the same period, communities along the Charles River have continued programs aimed at reducing pollution in separate stormwater discharges, including identifying and removing illicit sewer connections to storm drains. The CSO and stormwater related improvements have contributed to significant and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

In the Mystic River Watershed, the Lower Mystic and Mystic River mouth have 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.

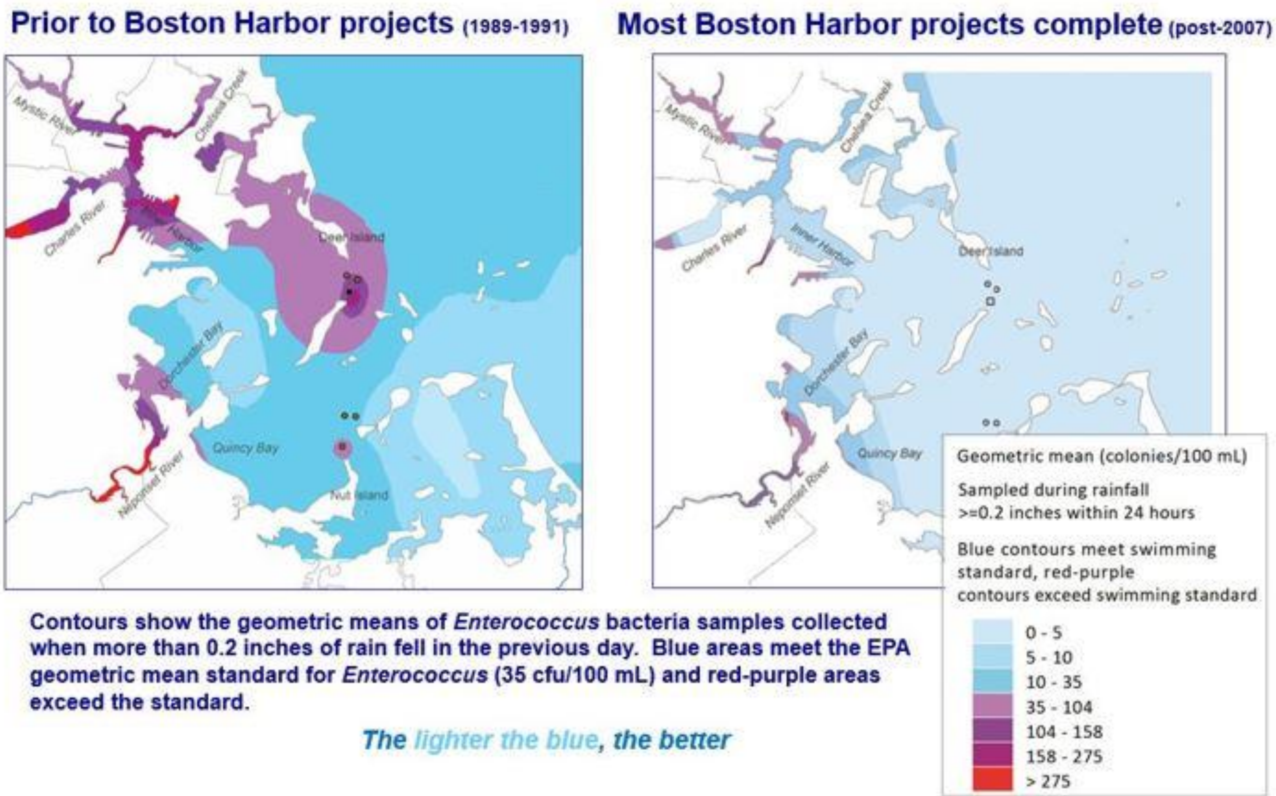

Mystic River

Despite significant CSO discharge reductions with completion of the LTCP projects for the Alewife Brook, bacteria counts in the brook continue to frequently fail to meet swimming limits in both dry and wet weather, and water quality is particularly poor after heavy rain. During development of the LTCP, MWRA predicted with receiving water modeling that the LTCP projects and their CSO reduction benefits would have limited impact to water quality due to bacteria loadings from separate stormwater discharges. More recent sampling supports this conclusion. 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.

The water quality of the Neponset River has substantially improved, 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. As shown in Figure 1-7 on the following page, water quality conditions have improved beginning with the significant increase in wastewater transport and treatment capacity (delivery to the Deer Island Treatment Plant) in the early 1990s. This increase in delivery capacity greatly reduced CSO discharges at most outfalls. Wet weather conditions 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.



1989-1991

This period precedes major improvements to upgrade MWRA's Deer Island treatment plant, including the closure of treatment plant outfalls that discharged to Boston Harbor, and preceded the implementation of the CSO control projects. This 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 the start of secondary 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 1-7. Changes in Boston Harbor *Enterococcus* Bacteria in Wet Weather

1.3.5 Federal Court and Regulatory Obligations, Performance Objectives and Tracking

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 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 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 whether 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 to supplement permanent system meter data, all of which are being used in the ongoing recalibration of the model.

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 1-4. Table 1-5 on page 26 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 1-4. 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 1-4 (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 1-4 (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 1-5. 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 at Somerville Marginal	7.3 3.5	• Cambridge/Alewife Sewer Separation • MWR003 Gate and Rindge Siphon Relief • Interceptor Connections/Floatables • Connection/Floatables at Outfall SOM01A • Somerville Baffle Manhole Separation • Cambridge Floatables Control (portion)	110.0
Mystic River/Chelsea Creek Confluence and Chelsea Creek	4 untreated and 39 treated at Somerville Marginal	1.1 57.1	• Somerville Marginal CSO Facility Upgrade • Hydraulic Relief at BOS017 • BOS019 Storage Conduit • Chelsea Trunk Sewer Replacement • Chelsea Branch Sewer Relief • CHE008 Outfall Repairs • East Boston Branch Sewer Relief (portion)	92.0
Charles River (including Stony Brook and Back Bay Fens)	3 untreated and 2 treated at Cottage Farm	6.8 6.3	• Cottage Farm CSO Facility Upgrade • Stony Brook Sewer Separation • Hydraulic Relief at CAM005 • Cottage Farm Brookline Connection and Inflow Controls • Brookline Sewer Separation • Bulfinch Triangle Sewer Separation • MWRA Outfall Closings and Floatables Control • Cambridge Floatables Control (portion)	88.9
Inner Harbor	6 untreated and 17 treated at Prison Point	9.1 243.0	• Prison Point CSO Facility Upgrade • Prison Point Optimization • East Boston Branch Sewer Relief (portion)	47.5
Fort Point Channel	3 untreated and 17 treated at Union Park	2.5 71.4	• Union Park Treatment Facility • BOS072-073 Sewer Separation and System Optimization • BWSC Floatables Control • 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 • Pleasure Bay Storm Drain Improvements • 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) • Commercial Pt. CSO Facility Upgrade (interim improvement) • 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 **Treated**		**410** **381**		**910.1**

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

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. Modeled operation of MWRA facilities, such as pumping stations and CSO treatment facilities, are updated to reflect current operating protocols. While Typical Year simulations employ updated standard operating procedures, these standard procedures are adjusted to reflect actual operating conditions from facility records when the model is used to simulate individual storms. 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.

For the storms of 2018, the data MWRA collected from its extensive CSO metering program (Section 3) indicated that the MWRA hydraulic model was in need of improved calibration, which is now underway (Section 5). This calibration effort will improve CSO discharge predictions compared to past model results and bring model predicted CSO discharges and metered discharge estimates closer together.

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 (see Table 1-1 on page 2). This brought the plan into compliance with state Water Quality Standards. MWRA's Long-Term Control Plan has eliminated or "effectively eliminated" (i.e., 25-year storm level of control at South Boston beaches) CSO discharges to Class B and Class 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 contact 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, and for primary and secondary recreation. Water meeting Class B or SB standards indicate that the water is "fishable and swimmable."

The LTCP is also intended to meet water quality standards for waters designated by DEP as Class $B_{(CSO)}$ or $SB_{(CSO)}$. For these waters, 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 levels of CSO control (activation frequencies and volumes in the Typical Year) in the approved 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 water quality standards 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 that 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. The variances authorize limited CSO discharges to these receiving waters subject to conditions in the variances. 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 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 notifications of a treated CSO discharge to the Charles River from the Cottage Farm CSO Facility and discharges to 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

The variances have required continued implementation of CSO long-term control measures consistent with the LTCP and compliance with the Nine Minimum Controls defined in the EPA National CSO Policy. In compliance with the Nine Minimum Controls, MWRA maintains the conveyance capacity of its collection system and, with the cooperation of its CSO communities has improved the conveyance and treatment of wet weather flows through system optimization improvements. Examples of system optimization improvements include the raising of overflow weirs, the implementation of SCADA monitoring and control systems, optimized handling of flows at MWRA's Columbus Park and Ward Street headworks, and improved operation (opening and closing) of influent gates at MWRA CSO treatment facilities.

2. Rainfall and Rainfall Analyses

Rainfall is a driving factor in the analysis of CSOs, as the occurrence of overflows within the MWRA sewer system is dependent on rainfall intensity and/or depth. Therefore, rainfall statistics such as peak intensity and depth are compared to metered CSO discharges to establish thresholds for CSO activations and to enhance understanding of CSO regulator performance. In addition, rainfall data are 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 July 1 to December 31, 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.

2.1 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 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 being used for this analysis 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 2-1 and the locations are shown in Figure 2-1.

Although the 20 rain gauges listed in Table 2-1 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 include the MWRA's gauges located at Ward Street Headworks, Columbus Park Headworks, and Chelsea Creek Headworks, and the USGS gauge located at Fresh Pond in Cambridge.

Table 2-1. Rain Gauges

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

(1) Somerville rain gauge data was not used in the period July 1-December 31, 2018

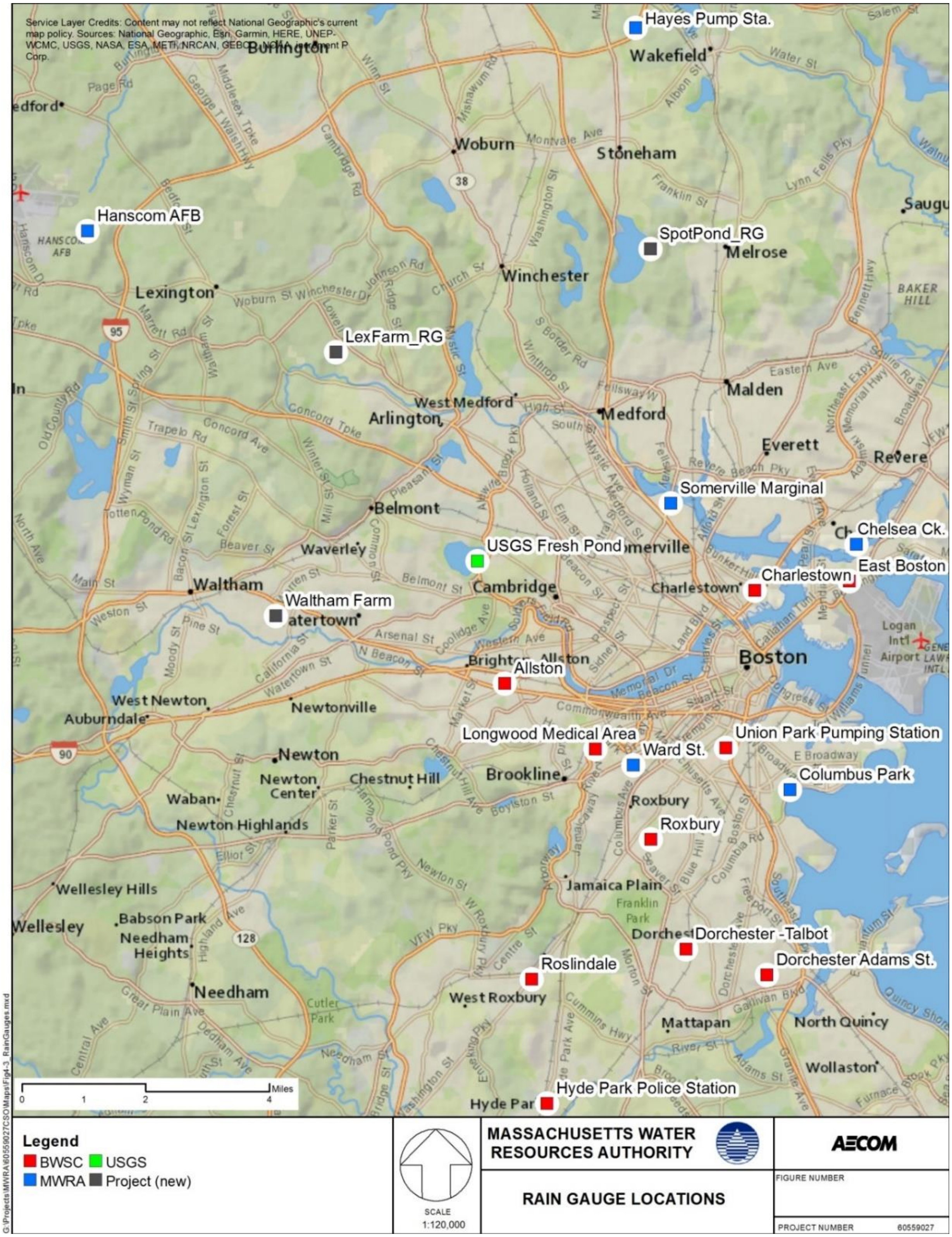


Figure 2-1. Rain Gauge Location Plan

2.2 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 individual rain gauges every two hours, allowing MWRA and the project team to view the data online. Quality assurance and quality control are provided by reviewing the data using 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 or missing rain gauge data were replaced with data from the rain gauge in closest linear proximity. If the closest gauge also had suspect data, the second closest rain gauge was used (Table 2-2). Replacement of suspect data was recorded in Table 2-3. Rainfall data used for the analysis are provided in Appendix A.

Table 2-2. 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 2-3. Summary of Rainfall Data Replacement

Rain Gauge	Replacement Data Start Time	Replacement Data End Time	Replacement Rain Gauge
Ward St. (BO-DI-1)	July 17, 2018 9:00	July 17, 2018 10:00	Longwood Medical
	July 17, 2018 22:45	July 23, 2018 11:30	
Columbus Park (BO-DI-2)	July 17, 2018 12:00	July 17, 2018 13:00	Union Park Pumping Station
	July 29, 2018 6:30	July 31, 2018 11:30	
Chelsea Ck. (CH-BO-1)	July 1, 2018 0:00	July 20, 2018 0:00	East Boston
	September 17, 2018 10:00	September 17, 2018 11:00	
	October 22, 2018 7:30	October 22, 2018 10:30	
	December 14, 2018 13:00	December 14, 2018 14:00	
Hanscom AFB (HF-1C)	July 1, 2018 0:00	December 31, 2018 23:45	Lexington Farm
Allston	October 8, 2018 0:00	December 31, 2018 23:45	Longwood Medical
Dorchester Adams	November 23, 2018 0:00	December 31, 2018 23:45	Roxbury
Dorchester Talbot	September 26, 2018 0:00	October 21, 2018 0:00	Dorchester Adams
	November 20, 2018 0:00	December 31, 2018 23:45	Roxbury
USGS Fresh Pond	October 30, 2018 10:30	October 30, 2018 12:30	Longwood Medical (1)
	December 28, 2018 0:00	December 28, 2018 23:45	
Somerville	July 1, 2018 0:00	December 31, 2018 23:45	Charlestown

(1) Replacement gauges for USGS were unavailable for the period. The third closest gauge, Longwood Medical, was used as the replacement.

2.3 Intensity-Duration-Frequency (IDF) Analysis

Intensity-Duration-Frequency (IDF) analysis was used to characterize the return periods of the storm events in the July- December 2018 metering period. Storm recurrence intervals for 1-hour, 24-hour, and 48-hour durations were identified for each storm event based on the IDF analysis. Storm recurrence intervals were based on Technical Paper 40, Rainfall Frequency Atlas of the United States (TP-40), and Technical Paper 49, Two-To Ten-Day Precipitation for Return Periods of 2 to 100 Years in the Contiguous United States (TP-49), with values extrapolated for the 3- and 6-month storms. Table 2-4 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 2-4. Rainfall Intensity-Duration-Frequency Data from TP-40/TP-49

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

(1) 1-hour and 24-hour recurrence intervals are from TP-40. 48-hour recurrence intervals are from TP-49.

(2)Denotes extrapolated values; TP-40 and TP-49 do not provide 3-month, or 6-month recurrence intervals for 1-hour or 24-hour duration storms

(3) TP-40 and TP49 do not provide recurrence intervals for these storms, and extrapolations were not computed.

For the period of July 1 to December 31, 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 <3 months, 3 months, 3-6 months, 6 months,1 year, or the nearest year, based on comparison to the IDF values from TP-40/TP-49 shown in Table 2-4. An algorithm was used to interpolate between recurrence intervals. 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 were only calculated for 48-hour storms if the duration was greater than or equivalent to 48 hours. Table 2-5 presents the summary of storm events for Ward Street Headworks for the period July- December 2018. These data show that 51 storm events occurred in the 6-month period July-December 2018 at the Ward Street rain gauge. Most of the events had recurrence intervals of less than 3 months, while two events reached a 3 month recurrence interval at 24-hour duration. Two events reached 2-year recurrence intervals at 1-hour duration, but had lower recurrence intervals at 24-hour duration. Tables summarizing the storm events from July-December 2018 for the other rain gauges are provided in Appendix B.

Table 2-5. Summary of Storm Events at Ward Street Headworks Rain Gauge for July- December 2018

Event	Date & Start Time[(2)]	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval [(1)]		
								1-hr	24-hr	48-hr
1	7/6/2018 10:30	1.75	0.37	0.21	0.26	0.02	0.01	<3m	<3m	N/A
2	7/11/2018 0:00	6.75	0.13	0.02	0.12	0.01	0.00	<3m	<3m	N/A
3	7/14/2018 22:45	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
4	7/17/2018 13:15	13	2.39	0.18	1.14	0.10	0.05	2 yr	6m	N/A
5	7/22/2018 4:00	33.5	0.38	0.01	0.12	0.01	0.01	<3m	<3m	N/A
6	7/25/2018 2:30	38.5	0.68	0.02	0.36	0.02	0.01	<3m	<3m	N/A
7	8/3/2018 13:00	0.25	0.1	0.40	0.1	0.00	0.00	<3m	<3m	N/A
8	8/4/2018 9:30	2.5	0.66	0.26	0.52	0.03	0.02	<3m	<3m	N/A
9	8/8/2018 13:45	16.25	0.73	0.04	0.32	0.03	0.02	<3m	<3m	N/A
10	8/11/2018 10:30	34.75	2.36	0.07	1.46	0.09	0.05	4 yr	3-6m	N/A
11	8/13/2018 17:00	6.75	0.28	0.04	0.2	0.01	0.04	<3m	<3m	N/A
12	8/14/2018 12:30	0.25	0.01	0.04	0.01	0.01	0.01	<3m	<3m	N/A
13	8/17/2018 16:15	9	0.2	0.02	0.16	0.01	0.00	<3m	<3m	N/A
14	8/18/2018 16:00	7.25	0.15	0.02	0.08	0.01	0.01	<3m	<3m	N/A
15	8/19/2018 21:45	0.25	0.02	0.08	0.02	0.00	0.00	<3m	<3m	N/A
16	8/22/2018 6:45	8.75	0.12	0.01	0.1	0.01	0.00	<3m	<3m	N/A
17	9/6/2018 15:45	2.25	0.11	0.05	0.08	0.00	0.00	<3m	<3m	N/A
18	9/7/2018 7:15	0.25	0.01	0.04	0.01	0.01	0.00	<3m	<3m	N/A
19	9/10/2018 16:30	15.75	1.31	0.08	0.32	0.05	0.03	<3m	<3m	N/A
20	9/12/2018 10:45	18.25	0.9	0.05	0.44	0.04	0.03	<3m	<3m	N/A
21	9/18/2018 1:30	12.75	1.18	0.09	0.63	0.05	0.02	3-6m	<3m	N/A
22	9/19/2018 3:30	0.25	0.01	0.04	0.01	0.05	0.02	<3m	<3m	N/A
23	9/22/2018 2:00	0.75	0.06	0.08	0.06	0.00	0.00	<3m	<3m	N/A
24	9/25/2018 11:00	18.25	1.82	0.10	0.84	0.08	0.04	6m-1yr	3m	N/A
25	9/26/2018 22:15	10.5	0.36	0.03	0.27	0.02	0.05	<3m	<3m	N/A
26	9/28/2018 5:45	5.5	0.44	0.08	0.16	0.02	0.02	<3m	<3m	N/A
27	10/1/2018 15:45	37.25	0.67	0.02	0.15	0.02	0.01	<3m	<3m	N/A
28	10/7/2018 17:00	2	0.03	0.02	0.02	0.00	0.00	<3m	<3m	N/A
29	10/8/2018 16:45	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
30	10/11/2018 13:30	18.5	0.71	0.04	0.28	0.03	0.01	<3m	<3m	N/A
31	10/13/2018 7:45	4.25	0.14	0.03	0.05	0.01	0.02	<3m	<3m	N/A
32	10/15/2018 14:00	11	0.11	0.01	0.06	0.00	0.00	<3m	<3m	N/A
33	10/21/2018 7:00	0.5	0.02	0.04	0.02	0.00	0.00	<3m	<3m	N/A

Table 2-5. Summary of Storm Events at Ward Street Headworks Rain Gauge for July- December 2018

Event	Date & Start Time(2)	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
34	10/23/2018 13:00	5.25	0.29	0.06	0.13	0.01	0.01	<3m	<3m	N/A
35	10/24/2018 10:15	2.75	0.04	0.01	0.03	0.01	0.01	<3m	<3m	N/A
36	10/27/2018 6:00	26	1.65	0.06	0.27	0.07	0.03	<3m	<3m	N/A
37	10/29/2018 4:15	8.5	0.77	0.09	0.41	0.03	0.04	<3m	<3m	N/A
38	11/1/2018 8:00	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
39	11/2/2018 3:15	33.75	1.91	0.06	0.53	0.07	0.04	3m	3m	N/A
40	11/5/2018 17:45	26.75	1.2	0.04	0.17	0.05	0.03	<3m	<3m	N/A
41	11/9/2018 18:30	19.75	1.6	0.08	0.45	0.07	0.03	<3m	<3m	N/A
42	11/13/2018 1:00	13	1.23	0.09	0.18	0.05	0.03	<3m	<3m	N/A
43	11/16/2018 1:45	7.75	1.43	0.18	0.39	0.06	0.03	<3m	<3m	N/A
44	11/19/2018 1:45	40	0.63	0.02	0.09	0.02	0.01	<3m	<3m	N/A
45	11/25/2018 1:00	10.5	0.84	0.08	0.39	0.04	0.02	<3m	<3m	N/A
46	11/26/2018 8:45	22.25	1.58	0.07	0.19	0.07	0.04	<3m	<3m	N/A
47	12/2/2018 2:45	15.75	0.8	0.05	0.16	0.03	0.00	<3m	<3m	N/A
48	12/16/2018 11:45	16.75	0.65	0.04	0.18	0.03	0.01	<3m	<3m	N/A
49	12/21/2018 5:45	18.75	0.77	0.04	0.13	0.03	0.02	<3m	<3m	N/A
50	12/28/2018 8:00	11.25	0.33	0.03	0.11	0.01	0.01	<3m	<3m	N/A
51	12/31/2018 19:45	4	0.4	0.10	0.18	0.02	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) Ward St. rainfall data was replaced with Longwood Medical rainfall data from July 17, 2018 9:00 through July 17, 2018 10:00 and July 17, 2018 22:45 through July 23, 2018 11:30

2.4 Comparison of Monitored Storms to Typical Year Storms

The characteristics of the rain events that occurred in the July 1 to December 31, 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 July 1 through December 31, 2018, and the number of storms by depth identified. These values were then compared to the values from the Typical Year. Table 2-6 presents this comparison. The six month monitoring period is approximately half of the Typical Year period. As indicated in Table 2-6, the rainfall depth for the six month period exceeds half of the Typical Year total rainfall depth. This suggests that the monitoring period is wetter than the Typical Year conditions for this period. During 2018, rain gages measured an average of 103 storms with total rainfall volume of 54 inches, compared with 93 storms and 46.8 inches in the Typical Year. As indicated by Table 2-6, when comparing the current monitoring period to the Typical Year, the greatest difference is found between the storms with depths of 0.5 to 1.0 inches and 1.0 inches to 2.0 inches. Within the six-month period, at all of the rain gauges, the number of storms with 1.0 to 2.0 inches exceeded the annual number in the Typical Year. The number of storms with volumes greater than 2.0 inches for the current monitoring period is less than the number in the Typical Year. These observations suggest that more short duration intense storms and fewer long duration large volume storms occurred during the monitoring period than in the Typical Year. CSO discharges may be impacted by this difference in rainfall characteristics in locations where regulators are more significantly impacted by rainfall intensity than by rainfall volume.

Table 2-6: Frequency of Events within Selected Ranges of Total Rainfall for July-December, 2018

Rain Gage	Total Rainfall (inches)	Total Number of Storms	Number of Storms by Depth				
			Depth	Depth	Depth	Depth	Depth
			< 0.25 inches	0.25 to 0.5 inches	0.5 to 1.0 inches	1.0 to 2.0 inches	≥2.0 inches
Typical Year	46.8	93	49	14	16	8	6
July-December 2018 Metering Data							
MWRA Rain Gauges							
Ward Street (1)	32.61	51	19	8	12	10	2
Columbus Park (2)	32.93	50	17	9	12	10	2
Chelsea Creek (3)	32.16	55	22	11	10	10	2
HF-1C (4)	30.06	55	22	10	13	9	1
RG-WF-1	30.99	44	14	9	10	9	2
BWSC Rain Gauges							
Allston (5)	30.85	51	18	11	10	11	1
Charlestown	30.12	51	16	12	11	10	2
Dorchester – Adam (6)	33.85	50	13	11	13	13	0
Dorchester-Talbot (7)	32.97	49	13	11	12	12	1
Hyde Park	33.01	54	19	7	14	14	0
East Boston	31.38	51	16	11	12	10	2
Longwood	30.26	53	20	9	12	12	0
Roslindale	34.21	48	14	10	11	12	1
Roxbury	33.34	48	14	10	11	12	1
Union Park	31.19	52	17	11	13	10	1
USGS Rain Gauge							
Fresh Pond (8)	29.79	48	16	7	14	10	1
Project Gauges							
Lex Farm	30.06	51	22	10	13	9	1
Spot Pond	33.39	49	17	8	12	10	2
Somerville (9)	30.12	51	16	12	11	10	2
Waltham Farm	33.75	56	23	9	11	11	2

(1) Rainfall data replaced with Longwood Medical from July 17, 2018 9:00 through July 17, 2018 10:00 and July 17, 2018 22:45 through July 23, 2018 11:30

(2) Rainfall data replaced with Union Park Pumping Station from July 17, 2018 12:00 through July 17, 2018 13:00 and July 29, 2018 6:30 through July 31, 2018 11:30

(3) Rainfall data replaced with East Boston from July 1, 2018 0:00 through July 20, 2018 0:00, September 17, 2018 10:00 through September 17, 2018 11:00, October 22, 2018 7:30 through October 22, 2018 10:30, and December 14, 2018 13:00 through December 14, 2018 14:00

(4) Rainfall data replaced with Lexington Farm from July 1, 2018 0:00 through December 31, 2018 23:45

(5) Rainfall data replaced with Longwood Medical from October 8, 2018 0:00 through December 31, 2018 23:45

(6) Rainfall data replaced with Roxbury from November 23, 2018 0:00 through December 31, 2018 23:45

(7) Rainfall data replaced with Dorchester Adams from September 26, 2018 0:00 through October 21, 2018 0:00 and with Roxbury from November 20, 2018 0:00 through December 31, 2018 23:45

(8) Rainfall data replaced with Allston from October 30, 2018 10:30 through October 30, 2018 12:30 and December 28, 2018 0:00 through December 28, 2018 23:45

(9) Rainfall data replaced with Longwood Medical from July 1, 2018 0:00 through December 31, 2018 23:45

Storms with greater than two inches of total rainfall at the Ward Street, Columbus Park, Chelsea Creek Headworks, and USGS Fresh Pond rain gauges were identified and compared to storms with greater than two inches of total rainfall in the Typical Year (Table 2-7). Experience has shown that large storms often account for a disproportionate volume of CSO. Table 2-7, which indicates storms observed in the monitoring period with greater than two inches of rainfall in general had higher peak hourly intensities than the Typical Year.

Table 2-7. Comparison of Storms Between July 1 and December 31, 2018 and Typical Year with Greater than Two Inches of Total Rainfall

Rain Gauge	Date	Duration (hr)	Total Rainfall (in)	Average Intensity (in/hr)	Peak Intensity (in/hr)	Storm Recurrence Interval (24-hr)
Typical Year	12/11/1992	50	3.89	0.08	0.2	1y
	8/15/1992	72	2.91	0.04	0.66	3m
	9/22/1992	23	2.76	0.12	0.65	1y
	11/21/1992	84	2.39	0.03	0.31	3m
	5/31/1992	30	2.24	0.07	0.37	3m-6m
	10/9/1992	65	2.04	0.03	0.42	<3m
July-December 2018 Metering Data						
Ward Street (1)	7/17/2018	13	2.39	0.18	1.14	6m
	8/11/2018	34.75	2.36	0.07	1.46	3m-6m
Columbus Park (2)	7/17/2018	13.5	2.44	0.18	0.92	6m
	10/27/2018	25.25	2.03	0.08	0.35	3m
Chelsea Creek (3)	7/17/2018	11.25	2.12	0.19	0.97	3-6m
	8/11/2018	62.25	2.95	0.05	0.82	3-6m
Fresh Pond	7/17/2018	17.25	2.03	0.12	0.67	3m

(1) Rainfall data replaced with Longwood Medical from July 17, 2018 9:00 through July 17, 2018 10:00 and July 17, 2018 22:45 through July 23, 2018 11:30

(2) Rainfall data replaced with Union Park Pumping Station from July 17, 2018 12:00 through July 17, 2018 13:00 and July 29, 2018 6:30 through July 31, 2018 11:30

(3) Rainfall data replaced with East Boston from July 1, 2018 0:00 through July 20, 2018 0:00, September 17, 2018 10:00 through September 17, 2018 11:00, October 22, 2018 7:30 through October 22, 2018 10:30, and December 14, 2018 13:00 through December 14, 2018 14:00

Storms with peak rainfall intensities greater than 0.40 in/hr at the Ward Street, Columbus Park, Chelsea Creek Headworks, and USGS Fresh Pond rain gauges were identified and compared to storms with greater than 0.40 in/hr of peak intensity in the Typical Year (Table 2-8). Storms with intensities greater than 0.40 in/hr are of importance because higher intensity storms have been found to produce more CSO activations and volumes than lower intensity storms. Results from the period of July 1 to December 31, 2018 indicate that within the six-month monitoring period, the number of storms with intensities greater than 0.4 in/hr matches or nearly matches the annual number of storms in the Typical Year. The six-month monitoring period had three rain gauges with nine storms and one gauge with seven storms exceeding 0.4 inches per hour, while the Typical Year had nine storms with intensities greater than 0.4 in/hr. Recognizing that higher intensity storms have been found to produce more CSO activations and volumes than lower intensity storms, it is anticipated that for the full 2018 monitoring period, CSO discharges would likely exceed the Typical Year discharges of the LTCP.

Table 2-8. Comparison of Storms with Peak Intensities Greater than 0.40 inches/hour Between July 1 and December 31, 2018 versus the Full Typical Year

Rain Gauge	Date	Duration (hours)	Total Rainfall (inches)	Average Intensity (inch/hour)	Peak Intensity (inch/hour)	Storm Recurrence Interval (1-hour)
Typical Year	10/23/1992	4	1.18	0.29	1.08	1-2y
	8/11/1992	11	0.87	0.08	0.75	6m-1y
	8/15/1992	72	2.91	0.04	0.66	3m-6m
	9/22/1992	23	2.76	0.12	0.65	3m-6m
	5/2/1992	7	1.14	0.16	0.63	3m-6m
	9/9/1992	1	0.57	0.57	0.57	3m
	9/3/1992	13	1.19	0.09	0.51	< 3m
	6/5/1992	18	1.34	0.07	0.44	< 3m
	10/9/1992	65	2.04	0.03	0.42	< 3m
July-December 2018 Metering Data						
Ward Street Headworks (BO-DI-1) (1)	7/17/2018	13	2.39	0.18	1.14	1.8 yr
	8/4/2018	2.5	0.66	0.26	0.52	<3m
	8/11/2018	34.75	2.36	0.07	1.46	4 yr
	9/12/2018	18.25	0.9	0.05	0.44	<3m
	9/18/2018	12.75	1.18	0.09	0.63	3-6m
	9/25/2018	18.25	1.82	0.10	0.84	6m-1y
	10/29/2018	8.5	0.77	0.09	0.41	<3m
	11/2/2018	33.75	1.91	0.06	0.53	3m
	11/9/2018	19.75	1.6	0.08	0.45	<3m
Columbus Park Headworks (BO-DI-2) (2)	7/17/2018	13.5	2.44	0.18	0.92	1 y
	7/26/2018	1.75	0.64	0.37	0.59	3m
	8/4/2018	3.25	0.88	0.27	0.66	3-6m
	8/8/2018	16	0.94	0.06	0.7	6m
	8/11/2018	37	1.43	0.04	0.59	3m
	9/18/2018	13.25	1.29	0.10	0.67	3-6m
	9/25/2018	19.25	1.42	0.07	0.74	6m-1y
	11/2/2018	35.75	1.98	0.06	0.64	3-6m
	11/9/2018	15.75	1.72	0.11	0.45	<3m
Chelsea Creek Headworks (CH-BO-1) (3)	7/17/2018	11.25	2.12	0.19	0.97	1 y
	7/26/2018	1.75	0.56	0.32	0.53	3m
	8/4/2018	4	0.58	0.15	0.46	<3m
	8/11/2018	62.25	2.95	0.05	0.82	6m-1yr
	8/17/2018	8.75	0.44	0.05	0.42	<3m
	9/18/2018	12.75	1.6	0.13	1.05	1.5 yr
	9/25/2018	13	1.52	0.12	0.73	6m
	11/2/2018	33.75	1.87	0.06	0.5	<3m
	11/9/2018	16	1.65	0.10	0.47	<3m

Rain Gauge	Date	Duration (hours)	Total Rainfall (inches)	Average Intensity (inch/hour)	Peak Intensity (inch/hour)	Storm Recurrence Interval (1-hour)
Fresh Pond (USGS) (4)	7/6/2018	2	0.56	0.28	0.52	<3m
	7/17/2018	17.25	2.03	0.12	0.67	3-6m
	7/25/2018	37.75	0.75	0.01	0.50	<3m
	8/11/2018	38	1.87	0.05	0.78	6m-1y
	8/14/2018	2.5	0.77	0.31	0.45	<3m
	8/22/2018	8.5	0.51	0.06	0.46	<3m
	9/18/2018	14	1.75	0.13	1.11	1.5 yr
	9/25/2018	21.75	1.61	0.07	0.46	<3m
	10/29/2018	9	0.81	0.09	0.55	3m
	11/2/2018	34	1.79	0.05	0.41	<3m

(1) Rainfall data replaced with Longwood Medical from July 17, 2018 9:00 through July 17, 2018 10:00 and July 17, 2018 22:45 through July 23, 2018 11:30

(2) Rainfall data replaced with Union Park Pumping Station from July 17, 2018 12:00 through July 17, 2018 13:00 and July 29, 2018 6:30 through July 31, 2018 11:30

(3) Rainfall data replaced with East Boston from July 1, 2018 0:00 through July 20, 2018 0:00, September 17, 2018 10:00 through September 17, 2018 11:00, October 22, 2018 7:30 through October 22, 2018 10:30, and December 14, 2018 13:00 through December 14, 2018 14:00

(4) Rainfall data replaced with Longwood Medical from October 30, 2018 10:30 through October 30, 2018 12:30 and December 28, 2018 0:00 through December 28, 2018 23:45

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

In summary, comparisons of the Typical Year to the six-month monitoring period suggest that this monitoring period was wetter than the Typical Year, with more short-duration, high intensity storms and fewer large-volume storms. The short-duration high intensity storms, particularly thunderstorms in the summer months, may have significant spatial variation, which will need to be accounted for in the hydraulic modeling efforts, as further discussed in Section 5. Higher-intensity storms observed during this monitoring period may result in more CSO discharge volume than would be predicted for the Typical Year.

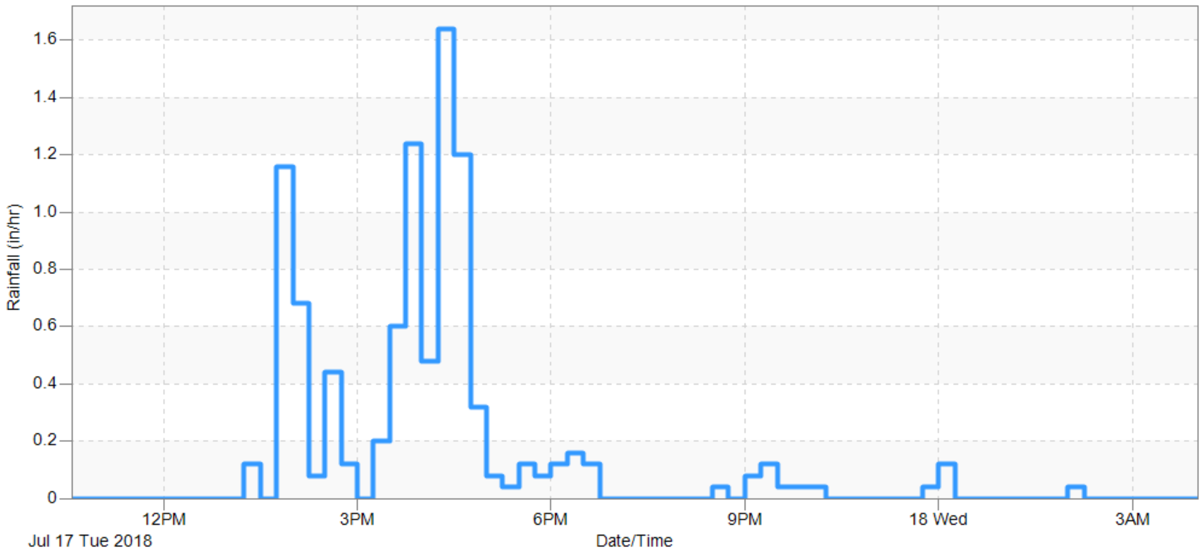


Figure 2-2. Hyetograph from the Ward Street Headworks Gauge for July 17, 2018

3. CSO Metering and Data Review

This section discusses the metering plan and approach used to collect and process CSO metering data using existing MWRA and community meters, facility operational data, and meters installed for the current assessment. 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 concepts is presented below.

3.1 CSO Flow Metering Background

Flow meters are installed in sewer collections systems to understand how water flows in the system. However, it is not feasible to install flow meters in every pipe and operate those meters continuously due to access and other concerns, nor is it necessary to understand system performance. Instead, a hydraulic model of the collection system is used to estimate flows. 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 and checking the hydraulic model.

Meter data collected for this project consists of both depth and velocity 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 3-1 is a schematic of a typical flow meter configuration at a generic CSO regulator.

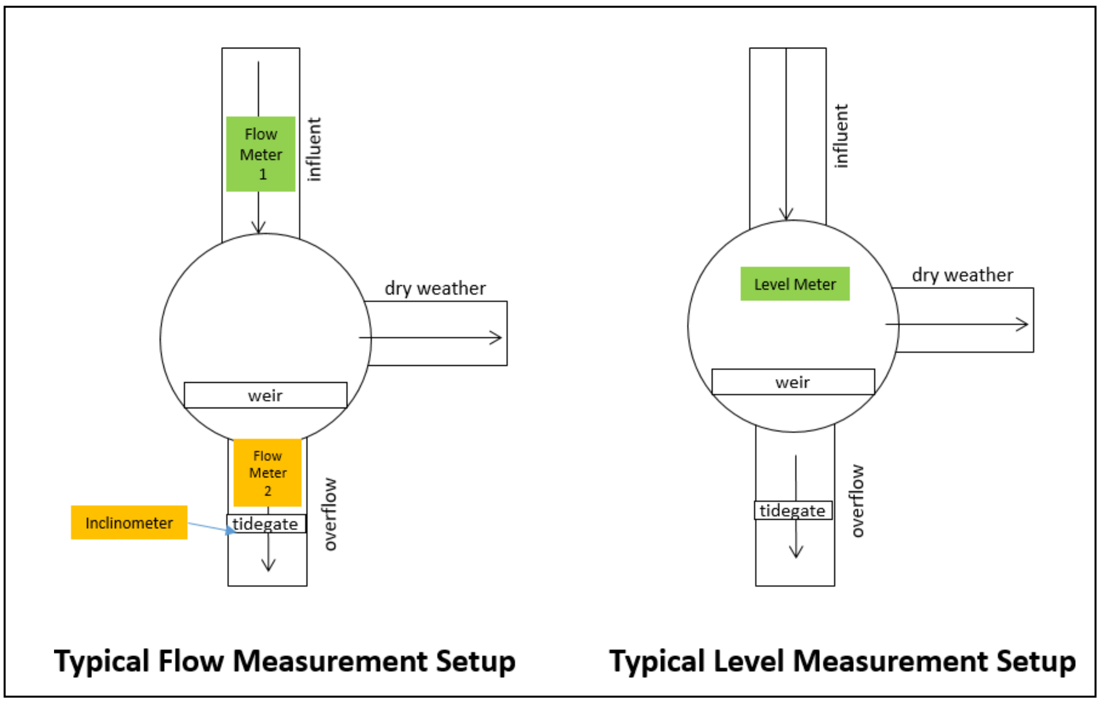


Figure 3-1. Example Meter Setup at a Generic Regulator Structure (Plan View Shown)

The regulator structure shown in Figure 3-1 consists of the following components:

- The influent is defined as the pipe or pipes conveying flow into the structure. The dry-weather flow connection, sometimes called the regulator pipe, is the path flow takes during dry weather. This flow is conveyed to the major wastewater interceptors that carry flows to the Deer Island WWTP.
- The overflow is the pipe that conveys excess flow to the receiving water. The flow conveyed to the receiving water is the flow quantified as "CSO," or overflow.
- The weir is the vertical structure in some regulators intended to prevent dry weather flow from discharging to the outfall. Weir elevations are typically set to also capture some fraction of the wet

weather flow before discharging to the overflow pipe while avoiding upstream flooding. Some regulators have no weir, and the overflow pipe is set at a higher elevation to prevent dry weather discharge and to allow for some wet weather capture.

- The tide gate is a structure placed in some overflows to prevent the receiving water from backing up into the regulator during high tide. During higher tides that push the tide gate closed, CSO discharge is prevented until the tide recedes, or the water level in the regulator exceeds the tide elevation.

The configuration at an actual regulator may differ from Figure 3-1, but the general components remain the same.

Two general metering approaches are taken for detecting overflows in a regulator: calculation of overflow volume, or monitoring of depth (Figure 3-1). Where the intent is to calculate overflow volumes, velocity and depth sensors are typically installed to measure flow in both the influent and overflow lines. In some cases, directly measuring the overflow volume may be impractical. As an alternative, the overflow volume can sometimes be estimated using meter analysis techniques applied to the influent data. Another option can be to monitor the dry weather connection and compute the overflow volume by subtraction from the influent volume. In some configurations where a tide gate is present, an inclinometer is used to establish when an activation is occurring. This device monitors the angle at a tide gate and indicates when a tide gate moves. Inclinometers can also indicate when the tide gate may be in need of maintenance to check that the gate seats properly.

Where previous analysis has indicated that overflows are not likely to occur at a regulator, a single level sensor was placed within the structure to measure the activation frequency based on depth of flow in the regulator.

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

3.2 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.

3.2.1 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, MWR003, the South Boston Tunnel, and the Alewife Brook Pump Station Bypass system, which was operational through 2018 as MWRA completed rehabilitation of the pumping station.

3.2.2 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 245 community meters listed in Table 3-1.

Table 3-1. Community Meters

Outfall	Regulator	Number of Meters	Owner
BOS003	RE03-12	4	BWSC
BOS057	RE057	3	BWSC
BOS065	RE065-2	2	BWSC
BOS070	RE070/7-2	2	BWSC
BOS073	RE073-4	2	BWSC
CAM001	RE011	1	Cambridge
CAM002	RE021	2	Cambridge
CAM005	RE051	1	Cambridge
CAM007	RE071	1	Cambridge
CAM017	CAM017	1	Cambridge
CAM401A	RE-401	1	Cambridge
CAM401B	RE-401B	1	Cambridge
CHE003	RE031	1	Chelsea
CHE004	RE041	1	Chelsea
CHE008	RE081	1	Chelsea
SOM01A	RE01A	1	Somerville
Total	**16**	**25**	

3.2.3 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).

For the July -December 2018 monitoring period project meters were installed at each of the 57 locations identified as a potentially active regulator. This included a total of 81 meters, 106 depth and velocity sensors, 20 level sensors, and 16 inclinometers. FlowShark Triton flow monitors and their associated sensors were used to measure depth and velocity at the monitoring locations. Temporary meters were installed by April 15, 2018 and remained in place through the end of year.

Figure 3-2 presents the locations of each of the meters used for calibration and for quantifying CSO activation frequency, duration and volume. Most of the permanent MWRA interceptor meters will only be used to improve model calibration. The meters located at the regulators will be used for calibration, to quantify CSO activations, or both in some cases. Table 3-2 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 3-2 also indicates if a meter is identified as a trigger meter. For these meters, if the water exceeds a previously identified 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. Table 3-2 has been updated from the Semi Annual Report No. 1 to include an additional meter at SOM001A. .

3.3 Meter Data Collection, Processing, and Review

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

3.3.1 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 Profiletm/Qstart™ 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 the 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. Uptime is defined as the percentage of the monitoring period that is recording usable data. For example, the meter below would not show 100% uptime during December since meter data were not available for the entire period. Uptime reports for each meter are currently being reviewed.

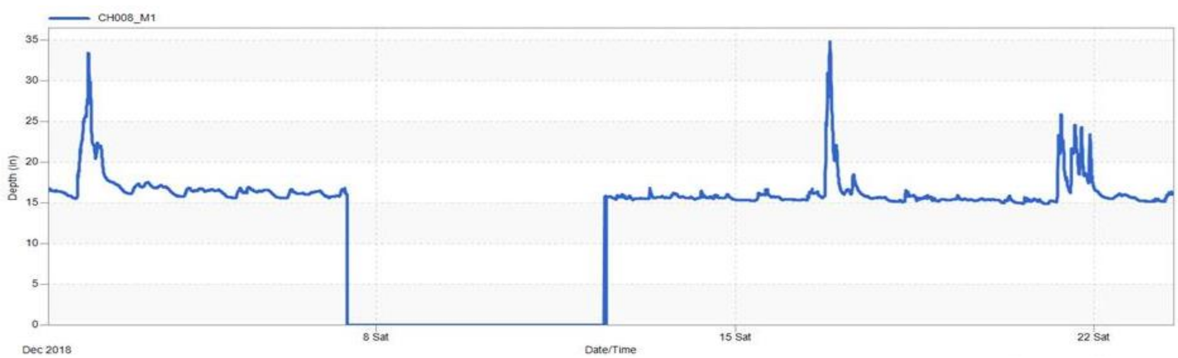


Figure 3-2. Example of Meter Data with Less than 100% Uptime

3.3.2 Meter Data Processing

Data processing consists of a number of steps: data editing of depth and velocity data, identified to be inaccurate, reconstitution or use of alternate depth and velocity data, and identification of data anomalies that prevent meaningful calculations of site conditions. Processing the meter data allows the project team to identify data that are suitable for project use versus data that should be disregarded due to quality concerns. 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 generating incorrect data. For example, the meter in shows several spikes in depth multiple days after a storm event. When this occurs, ADS uses available sensor data and hydraulic theory to present a reasonable representation of the depth and/or velocity at the site. For this reason, the processed data are edited to account for inaccurate data and the edited data are used in subsequent quantity calculations.

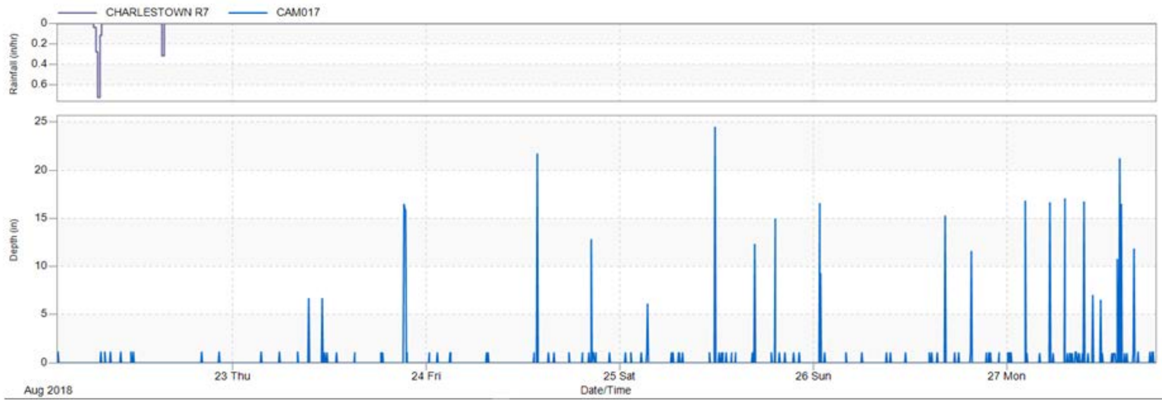


Figure 3-3. Example of Meter with Likely Incorrect Depth Measurements

Uptime is an indicator of the effectiveness and timeliness of the maintenance. In locations where a meter is not functional for most or the entire duration of a storm event, a volume is not reported and the event is flagged for missing data. If the meter is functioning for most, but not the entire duration of a 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 flowrate 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 (i.e. influent and DWF connection) 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. In each case, 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. If the capacity of the dry-weather flow connection is consistent throughout the storm, the overflow can be estimated using the Scattergraph method by using a single flow meter in the influent line. Scattergraphs, consisting 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 to the outfall is calculated by subtracting the flow through the dry-weather flow connection from the influent flow measurement. In locations where the Manning's Equation or Scattergraph methods are not applicable, the overflow is reported as duration only.

After initial review of the data, differences between metered and actual flow conditions may still exist. Any differences require additional review before adjusting the model since in some cases the meter data can be questionable. Flow measurement in hydraulically complex structures, such as regulators, is challenging due to turbulence in and around 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 field work in many cases, which is still underway. As a result, the meter data presented in this report are subject to change.

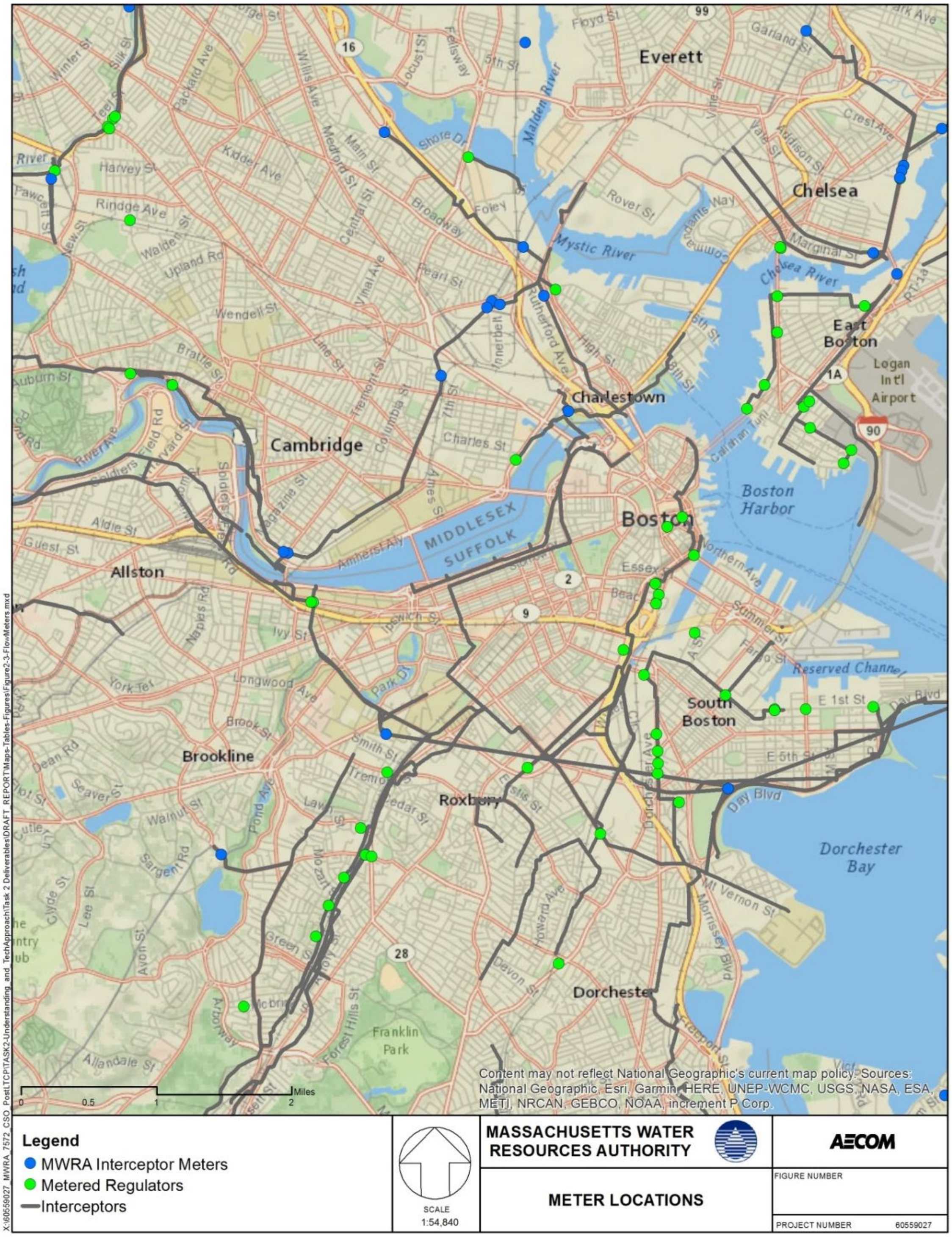


Figure 3-4. Metered Regulator Locations

Table 3-2. CSO Regulator 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			
		RE011_M1(2)	Depth only		X		Yes
		CAM001	Cambridge meter on overflow line	X			
CAM002	RE021	RE021_M1	Effluent line		X		
		RE021_M1(2)	Depth only	X			Yes
		CAM002	Cambridge meter on effluent	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)
		CAM401B	MWRA influent meter		X		
SOM001A	RE-01A	RE01a_M1	Influent Line #1	X			Yes
		RE01a_M1(2)	Influent Line #2		X		
		SOM01A	Flow Assessment overflow meter			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	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 3-2. CSO Regulator Meter Locations and Purpose of Meters (Continued)

Outfall	Regulator	ADS Meter Name	Description of Meter Location	Purpose of Meters: To identify if overflow activation occurred and for model calibration	Purpose of Meters: For model calibration only	Purpose of Meters: For calculating CSO volumes and model calibration	Purpose of Meters: 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 3-2. CSO Regulator Meter Locations and Purpose of Meters (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			X	
	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		
		RE051_M2	Influent Line #3	X			Yes
		CAM005	Overflow line			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_M2(2)	Overflow (DS Weir)			X	
		CAM007	Overflow meter (on Weir)			X	

Table 3-2. CSO Regulator Meter Locations and Purpose of Meters (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 amount of flow indicates an activation. Overflow is located downstream of the regulator. The inclinometer is used as indicator of overflow.

4. Metered CSO Discharge Review

Each CSO regulator was configured with a unique flow metering configuration designed to estimate CSO activations or confirm that the regulator is not active. Section 3 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.

4.1 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 with 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.

4.1.1 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. Confirmation of depth measurements during dry weather provides an indication that the meter is functioning properly.

4.1.2 Comparison with Other Meters

In many cases, multiple meters are installed at a regulator. For example, two influent meters may be 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, a depth sensor may be located 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 is reasonable.

Comparing inclinometer readings to overflow meters can provide another useful comparison. If the flow meter is located downstream of a tide gate and the inclinometer shows the tide gate 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 tide gate.

4.1.3 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 the data are considered reasonable. An example of a velocity versus depth scattergraph is shown in Figure 4-1 for regulator RE04-6 (BOS004). This scattergraph shows a repeatable pattern in open channel depths given that the data predominately follow the expected hydraulic theory (Manning's equation) as represented by the solid black line. If the data do not conform to hydraulic theory, then the data should be confirmed by other means.

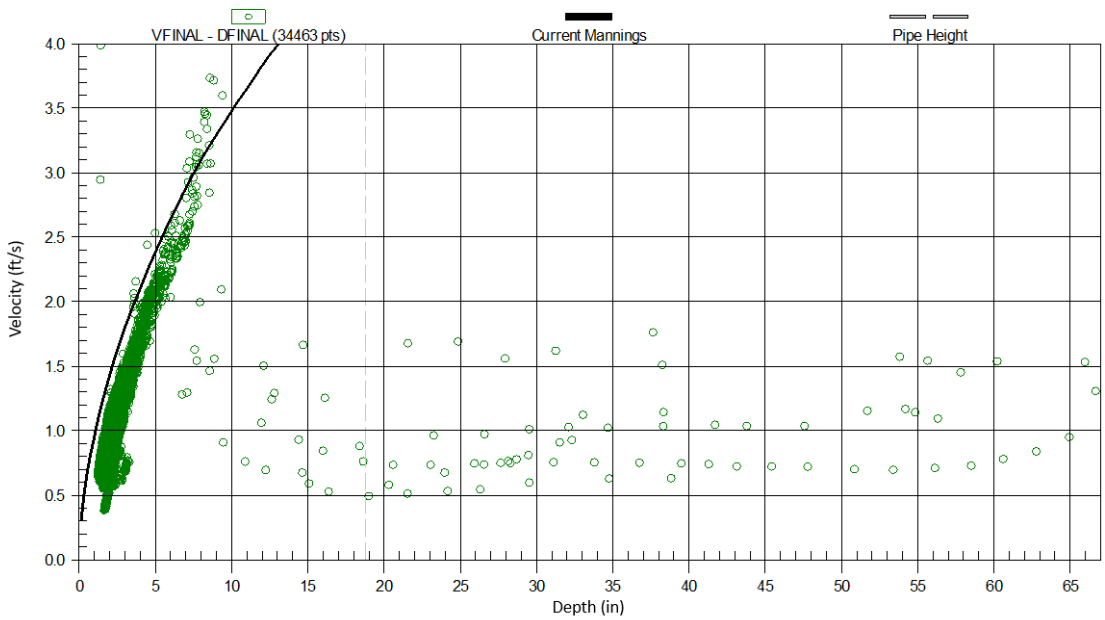


Figure 4-1. Scattergraph for RE04-6 (BOS004) Indicates Meter Conforms to Hydraulic Theory

4.1.4 Correlation of Influent Flow Volume with Rainfall

Flow in influent lines is expected to be correlated with rainfall. In general terms, 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 4-2 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. If influent flow volume is correlated with rainfall, additional confirmation that the results are reasonable is provided. If the influent flow volume is not reasonably 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.

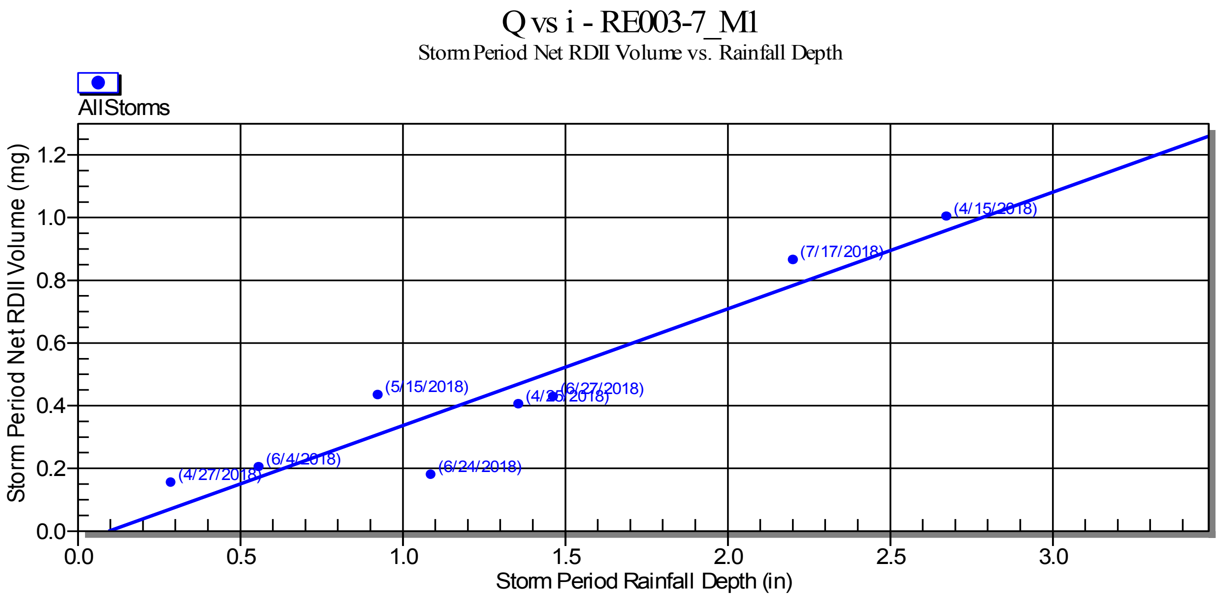


Figure 4-2: Plot of Wet Weather Volume versus Storm Depth for RE03-7 (BOS003)

4.1.5 Field Observations

Field observations are performed where data is suspect and it is believed that additional field information would improve the interpretation of the meter data.

4.1.6 Chalking

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

Chalking was applied at a number of level-only sites at which depth meters recorded unanticipated activations. These activations could not be validated by additional data. Chalk was applied in the upstream invert of the overflow pipe or weir structure. Figure 4-3 shows an example of chalking at regulator RE070/8-8. Following a storm event, the regulator structure was re-visited to identify if the chalk in the overflow pipe had been washed away by an overflow. However, in many locations where chalking was applied, results were inconclusive. Chalk may have been washed away by non-CSO activity, such as groundwater or tidal water leaking into the regulator structure.

Figure 4-3. Chalking Applied to the Overflow Pipe at RE070/8-8

4.1.7 Correlation of CSO Activation with Rainfall Depth and Intensity

Scattergraphs correlating rainfall intensity and rainfall volume are used to identify if a CSO is triggered by rainfall intensity or volume and 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 for each event. An example is provided in Figure 4-4 and the scattergraphs for each of the metered regulator locations are provided in Appendix D. The meter data are plotted, with solid circles representing metered activations and hollow circles representing no activation per the meters. Scattergraphs include the activation and non-activation events from April 15-December 30, 2018. The scattergraph for regulator RE03-7, presented in Figure 4-4, shows that an activation at this location appears to be driven by rainfall intensity as opposed to rainfall depth. The regulator appears to activate when a rainfall event has an intensity of 0.6 in/hr or greater.

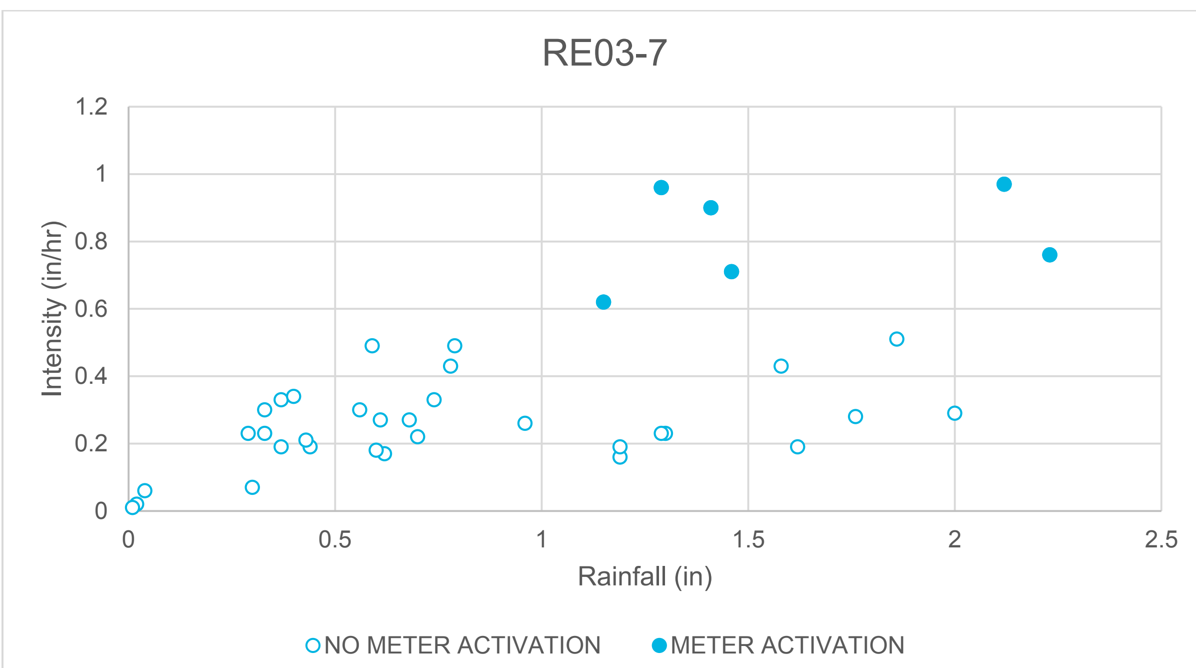


Figure 4-4: Meter Review Scattergraph for Regulator RE03-7

Each of the scattergraphs prepared was reviewed to see if a meter showed an activation for a rainfall event in which the intensity and rainfall depth were not consistent with the other plotted activations. If this were the case, then the data point would be considered 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 configuration needs to be adjusted to improve capture of CSO activations. If metering data are suspect or missing for part or the entire duration of a storm event, the point is excluded from the scattergraph analysis.

4.1.8 Calculation of CSO Discharge

When the meter data indicate that an activation has occurred, the CSO volume is calculated using various methods depending on the meter configuration. As described above under Section 3.3.2 Meter Data Processing, the methods include Continuity, Continuity by subtraction, or a weir equation. Refer to Section 3.3.2 for more detail on these methods. Table 4-1 identifies the locations where alternative CSO calculation methods to the continuity equation are being applied. In locations where the continuity methods or alternative methods were not used, then the overflow is reported as duration only.

Table 4-1. Locations Using Alternative (non-continuity equation) CSO Calculation Methods

Outfall	Regulator	Calculation Method
BOS014	RE014-2	Scattergraph Method
BOS09	RE09-2	Scattergraph Method
BOS010	RE010-2	Scattergraph Method
BOS057	RE057-6	Weir Equation
BOS060	RE060-7	Scattergraph Method
BOS004	RE04-6	Scattergraph Method
SOM007A/MWR205		Weir Equation

Volumes were not calculated using alternate means for a number of reasons:

- Use of the weir equation or scattergraph methods assume a free discharge condition. Therefore, the presence of backwater from conditions such as high tide may prevent use of such methods.
- CSO volumes were not calculated at level only sites.
- In some cases CSO volumes are not provided because the meter data are under review.

The CSO discharged at the outfalls MWR023 and BOS046 is reported as a proportion of the flow from the BOS046/MWR023 regulators from April 10 through the end of October (when Boston Gatehouse No. 1 was open). Based on tracer modeling, it was estimated that 75% and 25% of the CSO discharge went to BOS046 and MWR023, respectively. The volume of discharge at BOS046 identified in this report does not include stormwater, however stormwater has been included in previous reports. It should also be noted that a portion of the volume of CSO discharge at BOS046 and MWR023 may be unaccounted for as a number of regulators were level-only sites and no volumes could be estimated based on available data.

4.2 Meter Review Results

Metering data were used to identify CSO activation frequency, duration, and volumes where applicable. However, at a few locations, CSO metering data are suspect for the July 1-December 31, 2018 monitoring period. These suspect data fall into the following categories:

- Level sensor activations
- Unreasonable data
- Inconsistent CSO volumes

- Questionable overflow elevations

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

4.2.1 Level Sensor 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 storm. However, the data indicated that overflows occurred during the July 1-December 31, 2018 monitoring period at the following level-only monitoring locations for the durations indicated below:

Lower Charles

- RE046-90 (1 activation, August 12, 2018, 15 min.)

Fort Point Channel

- RE068-1A (1 activation, July 17, 2018, 35 min.)
- RE070/8-6 (1 activation, July 17, 2018, 55 min.)
- RE070/8-7 (6 activations, multiple dates, 240 min.)
- RE070/8-8 (1 activation, July 17, 2018, 15 min.)
- RE070/8-15 (2 activations, July 17 2018, 75 min. and September 25, 2018, 5 min.)
- RE070/5-3 (1 activation, July 17, 2018, 10 min.)
- RE080-2B (1 activation, July 17, 2018, 45 min.)

Activations at these level-only sites occurred during storms with the highest intensities and volumes from July 1-December 31, 2018, with the exception of RE070/8-7 which is further discussed in section 6.7. Assessments of scattergraphs of rainfall depth and intensity from the nearest rain gauge suggest that these are realistic activations caused by high-intensity storm events.

4.2.2 Unreasonable Data

Metering equipment can occasionally become fouled and produce unreasonable results, or even not record any data. Metering data were reviewed to assess reasonableness based on neighboring meters, storm characteristics, and system conditions. In some locations, meter data were found to be missing or unreasonable, and as a result CSO activations could not be assessed for part or all of the monitoring period. Efforts have been taken to improve future metering data at these locations where feasible.

Unreasonable data were identified and action taken to improve metering at regulators RE036-9, SOM007A/MWR205A, RE046-54, and RE017-3. The metering configuration at regulator RE036-9 did not effectively capture CSO activations and the meter was relocated on December 5, 2018. At SOM007A/MWR205A, the meter installed in the outfall line was relocated closer to the weir on August 22, 2018. At regulator RE046-54, the level sensor consistently reported unrealistic water depth measurements during wet and dry periods. In December 2018 a pressure sensor was added to the regulator RE046-54 meter to improve depth measurement accuracy. At regulator RE017-3, a depth meter was installed on top of the weir on July 18, 2018 to capture CSO events.

4.2.3 Inconsistent CSO Volumes

The CSO volumes were identified as inconsistent when comparing multiple sources of data at some regulators including RE081 (CHE008), RE401A (CAM401A), RE011 (CAM001), and RE021 (CAM002).

The regulator configuration at outfall CHE008 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 tide gate. 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 uses the area velocity meter installed in the influent line and subtracts 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 influent line during dry weather and therefore it is not possible to calibrate the velocity sensor. The second means of estimating overflows at outfall CHE008 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. While the CSO volume computed using these alternative methods may be conclusive for some storm events, the volume is still questionable for other CSO events. Although the CSO volumes cannot be confirmed, the CSO activations are consistent with the level data and rainfall.

CSO discharges to outfall CAM401A were anticipated to be estimated using the weir equation. However, a screening facility with brushes, as shown in Figure 4-5, make a standard weir equation inapplicable. Additional investigation into estimating the CSO discharge with alternative weir equations provided by the City of Cambridge is ongoing.

Figure 4-5. Brushes at CAM401A

At outfalls CAM001 and CAM002, it was anticipated that the Cambridge meters on the outfall pipes could be used to quantify CSO discharge volumes. Confidence in the volumes estimated at these locations is low. Further investigation is necessary to assess if CSO volumes can be approximated at these locations.

4.2.4 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 inspections and were used to identify the "trigger" elevation with a corresponding "trigger" meter. Additional months of metering data and assessment of the regulators during calibration have refined trigger values. The use of scattergraphs, additional field measurements, and further investigations into meter configurations have improved the accuracy of many of these values. These trigger elevations will continue to be refined through model calibration and the refinements may improve predictions of reported CSO activation frequencies.

4.3 Meter Results

A summary of the July 1 to December 31, 2018 meter results is provided in Table 4-2. As discussed in Sections 3 and 4.2, metering in regulators is more challenging than metering in single pipe structures. The turbulence present in a regulator 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. There may be unanticipated activations, unreasonable data, inconsistent CSO volumes, and/or questionable overflow elevations.

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 be a field visit to confirm both the meter location and visual indications of an overflow. In other cases, it may be 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). Field work may also include investigations upstream to identify sources of inflow that were not anticipated, such as incorrectly connected roof or storm 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.

Field inspections, model calibration investigations, and the additional six months of metering data have led to a number of findings that have resulted in modified CSO activations for the April 15-June 30, 2018 monitoring period that were previously reported in Semiannual CSO Discharge Report No.1. Table 4-3 provides an updated table for April 15-June 30, 2018 based on the current understanding of the system. These values are also subject to change as investigations continue through the model calibration process and the analysis of additional metering data.

Table 4-2: Summary of July 1 to December 31, 2018 Meter Results

Outfall	Regulator ID	Level Only	July 1-December 31, 2018 Meter Results		
			Activation Frequency	Duration (hrs) (1)	Volume (MG) (2)
Alewife Brook					
CAM001	RE-011(3)		3	0.75	N/A
CAM002	RE-021		2	0.25	N/A
MWR003	RE-031(3)		0	0	0.00
CAM401A	RE-401		12	14.5	N/A
CAM401B	RE-401B		1 (0) (4)	0.75	0.00
SOM001A	RE-01A		10	7.5	9.89
Upper Mystic River					
SOM007A/MWR205A (3) (5)		Y	11	26.25	N/A
Mystic/Chelsea Confluence					
MWR205 (Somerville Marginal Facility) (6)			26	93.58	81.7
BOS013	RE013-1		10 (8)	4	0.42
BOS014	RE014-2		8 (5) (4)	7.5	1.71
BOS017	RE017-3 (7)		5 (4) (4)	3.5	0.71
CHE003	RE-031	Y	0	0	0.00
CHE004	RE-041 (3)		14 (4) (4)	10.25	0.86
CHE008	RE-081		15 (7) (4)	29	3.00
Upper Inner Harbor					
BOS009	RE009-2		11 (4) (4)	17	0.29
BOS010	RE010-2 (3)		5	5.5	1.12
BOS012	RE012-2		9	3.25	0.98
BOS019	RE019-2	Y	3	5.47	N/A
BOS057	RE057-6		4	4.25	2.98
BOS060	RE060-7		6(4)	9.5	0.98
	RE060-20 (3)		4	1.25	N/A
MWR203 (Prison Point) (6)			14	53.48	202.35
Lower Inner Harbor					
BOS003	RE003-2		2 (0) (4)	0.5	0.00
	RE003-7		4	4.75	0.49
	RE003-12		24	105	18.03
BOS004	RE004-6		6 (3) (4)	5.25	0.10
BOS005	RE005-1	Y	0	0	0.00
Fort Point Channel					
BOS062	RE062-4		8 (1) (4)	7.75	0.06
BOS064	RE064-4		2	2.5	0.20
	RE064-5		3	2	N/A
BOS065	RE065-2		8	14.25	N/A
BOS068	RE068-1A	Y	1	0.5	N/A
BOS070/DBC	RE070/8-3		7 (6) (4)	6.5	1.67
	RE070/8-6	Y	1	1	N/A
	RE070/8-7 (3)	Y	6	3.5	N/A
	RE070/8-8	Y	1	0.25	N/A
	RE070/8-13 (3)	Y	0	0	0.00
	RE070/8-15 (3)	Y	2	1.25	N/A
	RE070/9-4		9 (6) (4)	8.0	1.72
	RE070/10-5		2	0.5	0.31
	RE070/7-2 (3)		19 (5) (4)	17.5	1.07
MWR215 (Union Park) (6)			6	16.43	19.58
BOS070/RCC	RE070/5-3 (3)	Y	1	0.25	N/A
BOS073	RE073-4		1	2.5	0.04

Table 4-2: Summary of July 1 to December 31, 2018 Meter Results (Continued)

Outfall	Regulator ID	Level Only	July 1-December 31 , 2018 Meter Results		
			Activation Frequency	Duration (hrs)	Volume (MG)
Reserved Channel					
BOS076	RE076/2-3 (3)		0	0	0.00
	RE076/4-3		1	2.5	0.12
BOS078	RE078-1 RE078-2		1	0.75	0.11
BOS079	RE079-3	Y	0	0	0.00
BOS080	RE080-2B (3)	Y	1	0.75	N/A
Upper Charles					
CAM005	RE-051 (8)		10 (6) (4)	8	3.12
CAM007	RE-071 (3)		1	0.5	0.14
Lower Charles					
CAM017	CAM017		0	0	0.00
MWR010	RE37	Y	0	0	0.00
	RE036-9	Y	*No meter data available*		
MWR018	Charles River		2	1.75	N/A
MWR019	Charles River		2	1.75	N/A
MWR020	Charles River		2	2	N/A
MWR201 (Cottage Farm) (6)	Cottage Farm		3	6.79	21.64
MWR023 (9)	RE046-19 (3)	Y	0	0	0.00
	RE046-30 (3)		0	0	0.00
	RE046-50 (3)	Y	0	0	0.00
	RE046-54 (3)	Y	0	0	0.00
	RE046-55 (3)	Y	0	0	0.00
	RE046-62A	Y	0	0	0.00
	RE046-90	Y	1	0.25	N/A
	RE046-100		4 (1) (4)	1	0.00
	RE046-105 (3)		1	0.5	0.01
	RE046-381		2	1	N/A
	RE046-192 (3)	Y	0	0	0.00
Back Bay Fens					
BOS046 (9)	Boston Gatehouse #1		4 (1) (4)	1	0.03

(1) Duration of CSO activations are rounded to the nearest 0.25 hour.

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

(3) Indicates there are missing data during one or more storm events that occurred between July 1 and December 31, 2018.

(4) Numbers in parenthesis indicate number of activations with volumes greater than 0.01 MG

(5) Meter was moved on August 22 to better assess CSO activations. Prior to this date CSO activations are based on storm reports. Volume was not directly metered at this location. The depth sensor was relocated and method of calculating volume is being investigated.

(6) CSO facility frequency, duration, and volume are provided by MWRA.

(7) The meter configuration was adjusted on July 18 to improve monitoring of CSO activations. Activation data for RE017-3 reflects the period of July 19-December 31, 2018.

(8) Field measurements are necessary to confirm overflow elevation at CAM005.

(9) The volume is reported as discharging at MWR023. However, Boston Gatehouse 1 was opened April 10 and remained open through the end of October. Therefore, the total discharge volume is estimated to be divided so that 25% of the CSO flow discharges to MWR023 and 75% discharges to BOS046. Some of the volume of flow is not accounted for as some regulators that activated may be level only sites. Stormwater is not included in the volume, however it has been included in previous reports.

Table 4-3: Summary of Updated April 15-June 30, 2018 Meter Results

Outfall	Regulator ID	Level Only	April 15-June 30, 2018 Meter Results		
			Activation Frequency	Duration (hrs) (1)	Volume (MG) (2)
Alewife Brook					
CAM001	RE-011		0	0	N/A
CAM002	RE-021		2	1	N/A
MWR003	RE-031		0	0	0.00
CAM401A	RE-401		6	6.25	N/A
CAM401B	RE-401B		2 (0) (3)	1.5	0.00
SOM001A	RE-01A		4	1.75	4.75
Upper Mystic River					
SOM007A/MWR205A (4)		Y	4	6.5	N/A
Mystic/Chelsea Confluence					
MWR205 (Somerville Marginal Facility) (5)			7	20.50	21.98
BOS013	RE013-1		4 (1) (3)	2.75	0.09
BOS014	RE014-2		3 (2) (3)	1.5	0.54
BOS017	RE017-3		*No meter data available*		
CHE003	RE-031	Y	0	0	0.00
CHE004	RE-041		3	2.25	0.93
CHE008	RE-081		4 (3) (3)	3.25	0.46
Upper Inner Harbor					
BOS009	RE009-2		3 (1) (3)	1.5	0.11
BOS010	RE010-2		2	2.25	0.23
BOS012	RE012-2		3	0.75	0.17
BOS019	RE019-2	Y	1	2.22	N/A
BOS057	RE057-6		0	0	0.00
BOS060	RE060-7		3	1.5	0.35
	RE060-20		0	0	0.00
MWR203 (Prison Point) (5)			4	16.33	69.45
Lower Inner Harbor					
BOS003	RE003-2		1 (0) (3)	0.25	0.00
	RE003-7		2 (1) (3)	1.75	0.03
	RE003-12		6 (5) (3)	12.75	1.88
BOS004	RE004-6		0	0	0.00
BOS005	RE005-1 (6)	Y	0	0	0.00
Fort Point Channel					
BOS062	RE062-4		3	2.5	0.05
BOS064	RE064-4		0	0	0.00
	RE064-5		2	0.25	N/A
BOS065	RE065-2		2	1.75	N/A
BOS068	RE068-1A	Y	0	0	0.00
BOS070/DBC	RE070/8-3		3	2	0.47
	RE070/8-6	Y	0	0	0.00
	RE070/8-7 (6)	Y	1	0.75	0.00
	RE070/8-8 (6)	Y	0	0	0.00
	RE070/8-13 (6)	Y	0	0	0.00
	RE070/8-15 (6)	Y	0	0	0.00
	RE070/9-4 (6)		3 (2) (3)	2	0.53
	RE070/10-5 (6)		0	0	0.00
	RE070/7-2 (6)		6 (2) (3)	5.5	0.74
MWR215 (Union Park) (5)			1	4.1	4.30
BOS070/RCC	RE070/5-3 (6)	Y	1	0.25	N/A
BOS073	RE073-4		0	0	0.00

Table 4-3: Summary of Updated April 15-June 30, 2018 Meter Results (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	0.00
	RE076/4-3		0	0	0.00
BOS078	RE078-1 RE078-2		0	0	0.00
BOS079	RE079-3	Y	0	0	0.00
BOS080	RE080-2B (6)	Y	0	0	0.00
Upper Charles					
CAM005	RE-051 (7)		5	3.5	1.85
CAM007	RE-071 (6)		1 (0) (3)	4	0.00
Lower Charles					
CAM017	CAM017		0	0	0.00
MWR010	RE37	Y	0	0	0.00
	RE036-9	Y	*No meter data available*		
MWR018	Charles River		0	0	0.00
MWR019	Charles River		0	0	0.00
MWR020	Charles River		0	0	0.00
MWR201 (Cottage Farm) (5)	Cottage Farm		1	3.46	8.50
MWR023 (8)	RE046-19	Y	0	0	0.00
	RE046-30		0	0	0.00
	RE046-50	Y	0	0	0.00
	RE046-54 (6)	Y	0	0	0.00
	RE046-55 (9)	Y	3	15	0.00
	RE046-62A	Y	0	0	0.00
	RE046-90 (6)	Y	0	0	0.00
	RE046-100		2 (0) (3)	1	0.00
	RE046-105		0	0	0.00
	RE046-381	Y	0	0	0.00
	RE046-192 (6)	Y	0	0	0.00
Back Bay Fens					
BOS046 (8)	Boston Gatehouse #1		3	15	0.00

(1) Duration of CSO activations are rounded to the nearest 0.25 hour.

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

(3) Numbers in parenthesis indicate number of activations with volumes greater than 0.01 MG

(4) Volume was not directly metered at this location. The depth sensor was relocated and method of calculating volume is being investigated.

(5) CSO facility frequency, duration, and volume are provided by MWRA

(6) Indicates there are missing data during one or more storm events that occurred between April 15 and June 30, 2018.

(7) Field measurements are necessary to confirm overflow elevation at CAM005.

(8) The volume is reported as discharging at MWR023. However, Boston Gatehouse 1 was opened April 10 and remained open through the end of October. Therefore, the total discharge volume is estimated to be divided so that 25% of the CSO flow discharges to MWR023 and 75% discharges to BOS046. Some of the volume of flow is not accounted for as some regulators that activated may be level only sites. Stormwater is not included in the volume, however it has been included in previous reports.

(9) There may have been a blockage cleared on or about June 21, impacting the number of CSO activations at this location.

4.4 Evaluation of Metering Program

Meter configurations were designed to quantify the CSO activation frequency, duration, and volumes, as well as calibrate MWRA's hydraulic model. The project metering program has been continuously evaluated since its implementation on April 15, 2018. These evaluations included a review of meter data for quality and applicability to this performance assessment, a review of rainfall conditions for the period, and an assessment of whether sufficient data were available for model calibration. As discussed above, the review of meter quality and applicability of this assessment resulted in several changes to the meter configuration at specific sites. For calibration, the meter data and rainfall data collected from April 15, 2018 through December 31, 2018 were reviewed. Based on this review the period was found to have many storms of various sizes and durations that resulted in CSO activations, thus it was found that sufficient meter data have been collected for model calibration and calibration meters are no longer needed.

Once it was decided that sufficient data had been collected for model calibration, the metering program was revised to focus on flow monitoring at regulator locations that may impact the variance waters, as well as at regulators where system changes may be made. The variance waters include the Charles River, the Alewife Brook, and the Mystic River. Based on this metering approach, the flow meters at 21 of the 57 locations were removed as of March 1, 2019. The table of meters removed is below.

Table 4-4. Meters Removed from the Metering Program as of March 1, 2019

Outfall	Regulator
BOS013	RE013-1
BOS014	RE014-2
BOS017	RE017-3
BOS009	RE009-2
BOS010	RE010-2
BOS012	RE012-2
BOS003	RE003-2
BOS003	RE003-7
BOS004	RE004-6
BOS005	RE005-1
BOS062	RE062-4
BOS064	RE064-4
BOS064	RE064-5
BOS068	RE068-2 (1a)
BOS070/RCC	RE070/5-3
BOS076	RE076/4-2
BOS078	RE078-1
BOS078	RE078-2
BOS078	TG 78 at outfall for RE078-1 & RE078-2
BOS079	RE079-3
BOS080	RE080-2B

5. Hydraulic Modeling

This section details the updates made to the MWRA's collection system model and the procedures being utilized for model calibration. Model calibration is anticipated to be complete in August of 2019.

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. These variables are used to estimate the flow entering the sewer system, as well as the hydraulic performance of the system at regulators. Hydraulic modeling has historically served as the basis for evaluating performance of the MWRA's CSO system. The hydraulic model was first established during development of the Long Term Control Plan using the USEPA 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.

The purpose of the Post Construction Compliance Monitoring Program (PCCMP) 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 at each CSO outfall are based on Typical Year precipitation. Model simulations will be run for all rainfall events for the 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 once the model has been calibrated.

For the PCCMP, the InfoWorks CS model has been converted to InfoWorks ICM, the successor modeling 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 simulate 2D surface routing. The version used for this report is ICM 8.5, which was the most current version at the time of conversion from InfoWorks CS.

5.1 Model Updates

Semiannual report No. 1, published November 30, 2018, presented updates made to the model in terms of sediment, facilities such as Alewife Brook Pump Station, and the removal/addition of regulators based on regulator inspections. Information on those updates can be found in that report.

Additional regulator updates are part of the model calibration process, which is discussed in Section 5.2.3.

5.2 Model Calibration

The process of calibrating the MWRA's hydraulic model to the meter data collected from the temporary, permanent, and community meters began in January 2019. The model is expected to be calibrated in August 2019, prior to the next semiannual report.

Model calibration is a multiple-step process, outlined by the following seven steps. These steps are further discussed in the sections to follow:

1. Identify the calibration period.
2. Collect and QA/QC the data necessary for model calibration.
3. Update the model's physical configuration at the regulator based on site inspections, record drawings, rim measurements, and other available information.
4. Calibrate the dry weather and wet weather flows at the influent meters.
5. Calibrate the overflow meters to achieve as close a match as possible to the observed CSO activations.

For coordination and efficiency purposes, the model has been divided into submodels for calibration. These submodels will be combined after calibration of those areas is complete.

5.2.1 Calibration Period

The model calibration period is April 15, 2018 through September 30, 2018. Meter data collected after September 30, 2018 will be used to serve as an independent check of the calibration. The calibration period includes a number of storms of varying sizes and intensities, occurring during spring conditions, where groundwater is typically high, and fall conditions, when groundwater is typically lower. The objective of calibration is to replicate a variety of storm events at each meter location. The model will be calibrated to multiple storms within the calibration period, comparing depth, volumes, and peak flows.

5.2.2 Data for Model Calibration

The data used for model calibration includes flow monitoring data, rainfall data, temperature data, and tide data.

Depth and velocity metering data: The project team is calibrating to data from temporary project meters, permanent community meters, and MWRA meters. Data flagged as questionable is not used for model calibration. Additional information on the metering data is presented in Sections 3 and 4.

Rainfall: Rainfall data collected from 20 rain gauges are used in the calibration. The rainfall data are summarized in Section 2.

Temperature: Daily temperature data downloaded from NOAA is an input to compute potential evapotranspiration (PET), which is required for simulating seasonal ground infiltration.

Tide: Hourly tidal data are used as a boundary condition at outfalls and was downloaded from NOAA.

SCADA data: SCADA data provided by MWRA are being reviewed to assess whether there were operational anomalies or issues that differ from typical operations or the hydraulic model configuration to simulate the facilities operational settings.

5.2.3 Model Updates to Reflect Field Inspection Information

Before the model is adjusted for model calibration, the network is updated using the base maps and regulator schematics created following field inspections. The schematics include the location of the meters, rim to invert measurements for the pipes and weirs, and pipe sizes. An example regulator schematic is shown in Figure 5-1. In locations where the configuration of the regulator remains in question, additional resources such as community models, GIS data, system drawings, or further field investigations are used. Modifications made to the model are recorded within the model and in a model log.

Accurate measurements of the overflow elevation are important in the calibration of the hydraulic model. These measurements require having rim measurements of each regulator structure. The project team is in the process of collecting rim measurements at regulators. Rim elevations are used in conjunction with information on the base maps to update the model.

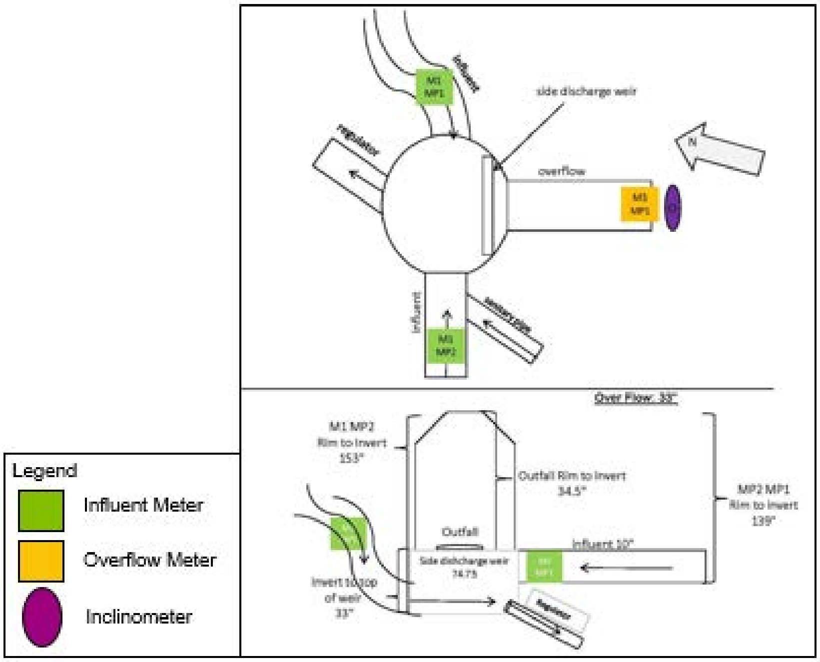


Figure 5-1. Example Regulator Schematic for RE009-2

5.2.4 Influent Meter Calibration

Influent meters, installed upstream of regulators where CSO activations were anticipated to occur during a less than 2-year storm, are being calibrated first to simulate the flows entering the regulator structure.

5.2.4.1 Dry Weather Calibration

Dry weather calibration requires adjusting the dry weather parameters in the model to the meter data. The period of August 29 to September 2, 2018 is serving as the dry weather calibration period, as there was continuous dry weather during this period. An example dry weather calibration plot is shown in Figure 5-2.

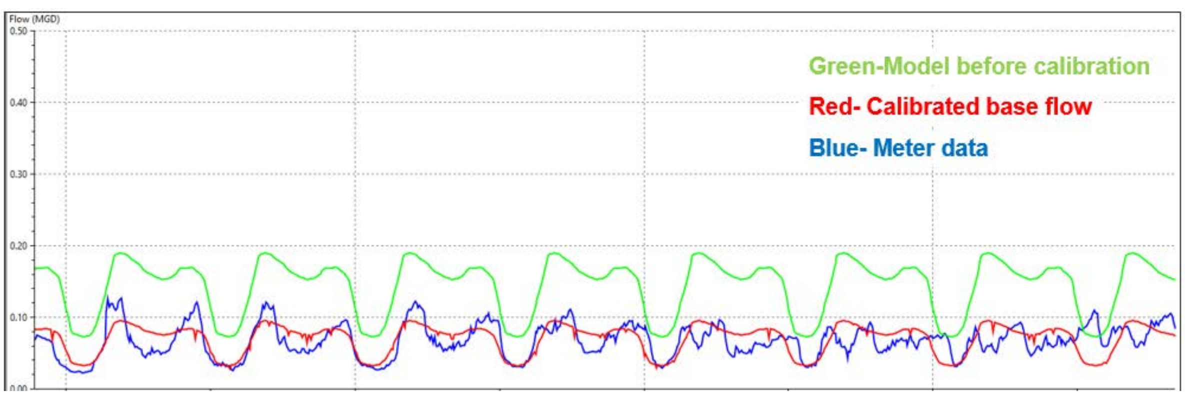


Figure 5-2. Base Flow Calibration

When a significant difference is noted between the base flow observed in the spring and summer, then the groundwater impacts are assessed. Base flow is calibrated for the summer period, and the groundwater infiltration module of ICM is used to adjust base flow during the spring when groundwater impacts occur. Preliminary base flow calibration and assessments of the metering data suggest that significant groundwater impacts are seen in some of the upstream areas.

5.2.4.2 Wet Weather Calibration

Wet weather calibration requires adjusting the model to match as closely as possible the response observed by the influent meters during wet weather events. Adjustments include changes to parameters that affect total volume or peak flow in the model.

The metered storm response volume (MG) and peak flow (MGD) were calculated for a number of storm events and compared to the modeled response in plots such as the one shown in Figure 5-3. Each red dot represents a storm event. If the metered and modeled volumes and peak flows matched exactly, the red dots would fall on the dotted blue line. The lines on either side of the dotted blue line represent the calibration standards set forth by the Chartered Institution of Water and Environmental Management (CIWEM) in the UK, which state that a calibrated model should predict volumes and peak flows within the range of +20% and -15% (CIWEM, 2017). Predicted volumes and peak flows for most storm events should fall within the lines on either side of the dotted blue line. Due to the spatial variation of rainfall, especially during isolated thunderstorm events, not all of the storm events will fall within those lines.

Calibration plots, shown in Figure 5-4, are also used to assess if the meter is calibrated. The model and meter should follow similar shapes during the storm response.

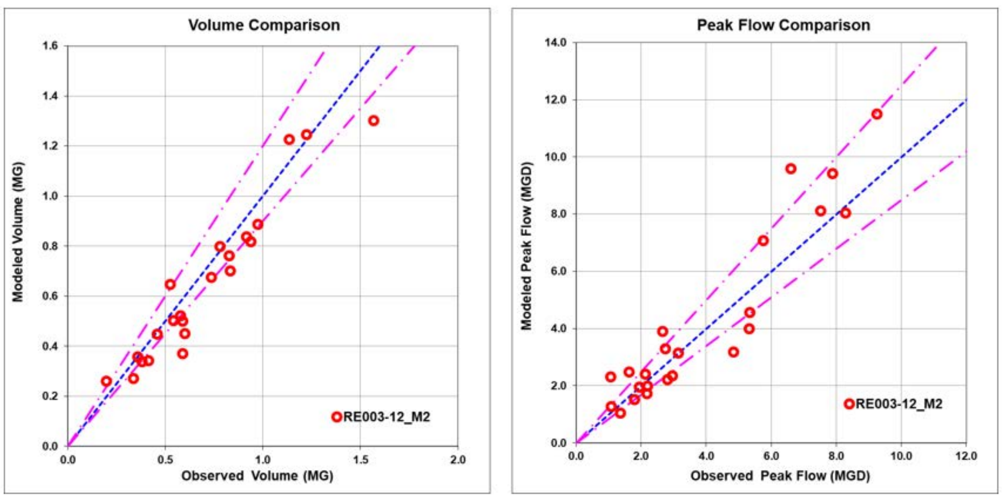


Figure 5-3. Storm Volume and Peak Flow Calibration Plots

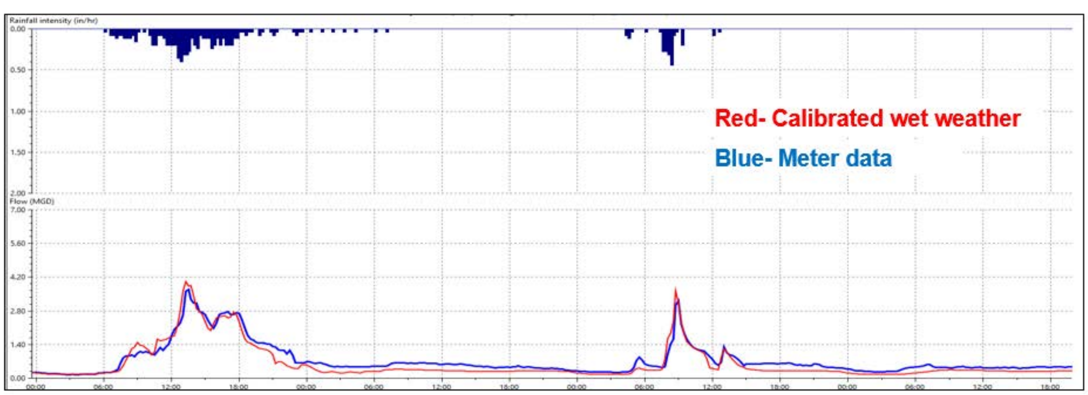


Figure 5-4. RE003-12 Influent Meter Calibration Plot

5.2.5 Overflow Calibration

Once the influent meters are calibrated, then the next step is to calibrate the overflow from the regulator. Overflow calibration requires adjusting the regulator to achieve as close a match as possible to the observed overflow frequency and volume. An example of a preliminary calibrated overflow is provided in Table 5-1.

Table 5-1. Preliminary Calibration Results for RE003-12 Overflow

Activations	Metered	Model Predicted
Overflow Frequency	26	23
Volume of CSO (MG)	11.7	15.2

Calibrating the model to the metered overflow results requires controlling the amount of volume going to the dry weather flow connection and the overflow pipe. In locations where calibrating the influent meters is not sufficient for simulating the overflow activations, simulating the activations can be achieved by adjusting the roughness of the dry weather flow connection or by modifying the diameter of the dry weather flow connection (if supported by field observations/data). Adjustments should only be made within reasonable limitations. This portion of the calibration process also requires consideration of the downstream conditions of the interceptor, as those conditions can affect the flow through the dry weather flow connection.

5.3 Model Calibration Status

Model calibration is currently proceeding using the multi-step process described above. At this time calibration efforts include updating the model's physical configuration, calibrating the dry and wet weather flows at the influent meters, and calibrating the overflow meters to achieve as close a match to the metered CSO activations as possible. In addition, coordination with the CSO communities is ongoing in an effort to incorporate system knowledge into model.

6. Overflow Activity Investigations

The metering program produced measured CSO activation frequency at each regulator and measured discharge volume at most regulators. The measurements were compared with the outfall by outfall frequencies and volumes in the LTCP in an effort to provide an initial assessment of the likelihood of meeting the LTCP levels. The meter data for 2018, a wetter than average year, do not provide a direct measure of likelihood of compliance since the basis of compliance is the established Typical Year Rainfall. In addition, less than a full year of data is available for 2018 (April 15 through December 31, 2018), so extrapolations to assess full-year performance would be rough estimates, at best. However, this initial assessment can be used as a tool to identify regulators that may not be meeting the goals of the LTCP and warrant further investigation. As noted in the hydraulic modeling section above, the flow monitoring data are being used to calibrate the hydraulic model, which in-turn will be used to estimate CSO volumes and activation frequencies for the Typical Year Rainfall. Since the hydraulic model is currently undergoing calibration, this initial assessment of performance was made by comparing activations and volumes from available flow metering data to the LTCP goals.

Table 6-1 shows locations where this initial assessment suggests that certain CSO outfalls may not meet the goals of the LTCP and may not be consistent with prior model predictions of discharge frequency and volume. MWRA is currently conducting detailed investigations into the measured overflow activity and potential causes of discharges at the outfalls highlighted in Table 6-1, as discussed below. The higher measured activations at the outfalls listed but not highlighted in Table 6-1 may be due solely to the significantly higher number of storms and total rainfall in 2018 compared to the Typical Year. Activation frequency at these locations will be further investigated once MWRA has completed the recalibration of its hydraulic model.

Table 6-1: Overflow Activity Investigation Locations

Receiving Water	Outfall
Alewife Brook	SOM001A
	CAM401A
Upper Mystic River	MWR205A/ SOM007A
Mystic/Chelsea Confluence	MWR205 (Somerville Marginal)
	BOS013
	BOS014
	BOS017
	CHE004
	CHE008
Upper Inner Harbor	BOS009
	BOS010
	BOS012
	BOS019
	BOS057
	BOS060
Lower Inner Harbor	BOS003
Fort Point Channel	BOS062
	BOS064
	BOS065
	BOS070
Upper Charles River	CAM005
Lower Charles River	CAM017
	MWR201 (Cottage Farm)
	MWR018

Receiving Water	Outfall
	MWR019
	MWR020
	MWR023
Back Bay Fens	BOS046

6.1 General Approach for Overflow Activity Investigations

The following general approach describes the steps currently underway to investigate the discharges at the CSO outfalls highlighted in Table 6-1.

Check Regulator Configuration and Flow Meter Data. The first step in the overflow activity investigation is to confirm the regulator configuration and meter data interpretation. Available information, including record drawings and field inspection data, are reviewed to confirm that the regulator configuration is understood and properly applied in interpreting the flow data. For example, a key element of the regulator configuration is establishing the trigger elevation, the water level elevation at which an overflow can occur. The review checks if the correct elevation is used. Other conditions, such as the potential impact of stormwater sources on flow meter data collected in the overflow line, are also investigated.

Discuss with Community. The results of the flow metering and other data are discussed with the community where the CSO discharge is located. This is an on-going process. The objective is to capture the system knowledge and expertise of the community and incorporate it into the analysis. The communities may also have developed detailed GIS and modeling data. These resources are beneficial because they may contain more detailed information than is currently in the MWRA model, and therefore may supplement MWRA's knowledge of a particular regulator system.

Assess Downstream Hydraulics. It is important to assess whether downstream water levels are causing a backwater effect at the regulator. In some cases, the water level in the interceptor downstream of a regulator can affect the amount of flow that can be conveyed from the regulator to the interceptor. Surcharging in the downstream interceptor can be caused by limitations in the interceptor capacity, by a hydraulic restriction further downstream (such as the hydraulic capacity limit of a pumping station or headworks facility or an obstruction), or a combination of both. It is important, therefore, to assess whether the regulator is affected by downstream water levels, and to understand the cause of the downstream water levels. Various sources of information are used for this purpose, including flow metering, pump station data, and headworks data.

Update Hydraulic Model. Once model calibration is complete, the model can also be applied to assess the cause of the higher-than-expected overflow frequency/volume and to analyze potential mitigation measures. The hydraulic model can be applied to generate predicted flow and water surface elevation data at the regulator and throughout the portion of the system hydraulically related to regulator performance. Assessment of model predictions can help to spot anomalies, which, in turn, lead to testing of options to improve regulator performance. As noted earlier in this section, model calibration is ongoing and the model will be used to assess higher-than-expected overflow frequency/volume at regulators once calibration is complete.

Progress is being made in investigating the locations where the 2018 flow metering data (April 15 – December 31, 2018) indicate that overflows may be occurring more frequently than expected based on the LTCP goals, and potential reasons for the higher activations have been identified at some locations. This work is described in the sections that follow, organized by receiving water. For all locations discussed below, the updated and recalibrated hydraulic model will be used to further investigate the cause(s) of the higher-than-expected overflow frequency and/or volumes, as well as potential measures to meet the LTCP goals at these locations.

6.2 Alewife Brook

Outfall SOM001A 14 overflows were measured between April 15, 2018 and December 31, 2018 based on meter data, while the LTCP goal is 3 activations in the Typical Year. Subsequent investigations at this regulator identified an apparent hydraulic restriction not represented in the model. Figure 6-1 is a photograph of the dry weather flow connection from the SOM001A regulator to the Alewife Brook Conduit. The picture shows a cover over the connection supported on cinder blocks that appears to create a hydraulic restriction, which could potentially increase overflows. This structure was removed during the week of January 21, 2019. There was also a metal plate installed over the dry weather flow connection that restricted the opening to 24-inch diameter. This metal plate was removed on March 27, 2019, opening the connection to 32-inch x 32-inch square (36-inch diameter equivalent). Continued metering at this location will provide information on the CSO control benefit of removing the hydraulic restriction and increasing the size of the dry weather flow connection.

In addition, comparison of the metering results with predictions from the current version of the model suggests that wet weather flows from Somerville to the SOM001A regulator may have increased since the model was initially calibrated in the 1990s. This increase in wet weather inflow may be contributing to the higher measured overflow frequency at SOM001A. Additional investigations indicated that water levels in Alewife Brook Conduit were not likely a contributing factor to the higher metered overflow frequency.

Figure 6-1. SOM001A, RE01A Hydraulic Restriction

Outfall CAM401A receives flow from regulator RE-401. A flow meter is located in the influent line to regulator RE-401. The depth sensor for the meter is correlated with the overflow elevation to identify overflow frequency and duration. Accurate quantification of the overflow volume is not feasible at regulator RE-401 because the weir system is equipped with a brush to control floatables discharging to Alewife Brook (see Figure 4-5 on page 56). The meter at this location recorded 18 overflows between April 15, 2018 and December 31, 2018 based on meter data, while the LTCP goal is 5 activations.

The performance of both SOM001A and CAM401A were discussed with the cities of Somerville and Cambridge, respectively, to incorporate their system knowledge and identify factors which may be contributing to the higher-than-expected CSO discharges. Both cities provided their hydraulic models, which may include updated information on the collection systems tributary to the regulators. These models are under review and will be used as appropriate to update MWRA's hydraulic model.

6.3 Mystic / Chelsea Confluence

Outfalls BOS013 and BOS014 are located in East Boston. Outfall BOS013 receives flow from regulator RE013-1 and outfall BOS014 receives flow from regulator RE014-2. The flow metering data for the period between April 15, 2018 and December 31, 2018 indicate that outfall BOS013 had 14 overflows

(LTCP goal 4) and outfall BOS014 had 10 overflows (LTCP goal 0). Detailed record drawings and field inspection data for outfalls BOS013 and BOS014 are being reviewed to confirm that the regulator configurations are appropriately represented in the hydraulic model. The regulators from both of these outfalls discharge into the relatively new Condor Street interceptor, which conveys flow to the Caruso Pumping Station. An initial assessment of the pumping station operation suggests that backwater from the pumping station is not likely a contributing factor to the overflows. The BWSC has provided its hydraulic model to MWRA, which may include updated information or additional detail on the collection system tributary to these regulators. The BWSC model is currently being reviewed and will be used as appropriate to update the MWRA hydraulic model. One potential measure that is expected to be assessed with the updated/recalibrated hydraulic models is increasing the size of the dry weather flow connections to the Condor Street interceptor.

Outfall BOS017 is located in Charlestown and receives flow from regulator RE017-3. Flow meters were installed in the overflow and influent lines. However, tidal interference made it difficult to interpret the data. A new depth sensor was installed on the weir on July 18, 2018 to more accurately assess when overflows occur. Meter data for the period July 18, 2018 through December 31, 2018 indicate that 5 overflows occurred at outfall BOS017. The LTCP goal for outfall BOS017 is 1 activation per year. Flow metering data indicate that up to 2.5 MGD of tidal inflow may be entering one of the influent lines. MWRA will coordinate with BWSC regarding tidal influence. The data are being reviewed to see if a correlation exists between CSO activations and tidal influence. Available information, including record drawings and field inspection data, are being reviewed to confirm the regulator configuration at this location. As noted above, BWSC has provided its hydraulic model to MWRA. The model is currently being reviewed and will be used as appropriate to update the MWRA hydraulic model.

Outfalls CHE004 and CHE008 are located in Chelsea. Outfall CHE004 receives flow from regulator RE041, which connects to a City of Chelsea trunk sewer, and outfall CHE008 receives flow from RE081, which connects to MWRA's Chelsea Branch Sewer. The trunk sewer connects to MWRA's North Metropolitan Trunk Sewer upstream of Chelsea Creek Headworks, and the Chelsea Branch Sewer connects to MWRA's Chelsea Screenhouse, which sends flow to Caruso Pumping Station. The flow metering data for the period April 15, 2018 through December 31, 2018 indicate that outfall CHE004 had 17 overflows (LTCP goal 3) and outfall CHE008 had 19 overflows (LTCP goal 0). It is noted, however, that 11 of the 17 measured activations at CHE004 and 12 of the 19 measured activations at CHE008 each had a measured discharge volume of less than 0.01 MG. Available information, including record drawings, field inspection data and meter data, are being reviewed. An assessment of flows into Chelsea Creek Headworks indicates that capacity limit at the headworks is not likely a factor in the higher-than-expected overflow frequency at CHE004. High head loss within the regulators, due in part to the structural configuration and smaller size of the dry weather connections relative to the sizes and direction of incoming flow, may be a factor. The performance of the regulators was discussed with the City of Chelsea to incorporate their system knowledge and assess if other factors may be contributing to the higher-than-expected CSO discharges. The City of Chelsea is developing a hydraulic model and will make the model available to MWRA when it is complete. The MWRA hydraulic model is being updated and recalibrated to accurately represent the observed conditions.

6.4 Upper Inner Harbor

Outfalls BOS009, BOS010, and BOS012 are located in East Boston. Outfall BOS009 receives flow from regulator RE009-2, outfall BOS010 receives flow from regulator RE010-2, and outfall BOS012 receives flow from regulator RE012-2. The flow metering data for the period April 15, 2018 through December 31, 2018 indicate that outfall BOS009 had 14 overflows (LTCP goal 5), outfall BOS010 had 7 overflows (LTCP goal 5), and outfall BOS012 had 12 overflows (LTCP goal 4). Available information, including record drawings and field inspection data, are being reviewed to confirm that the regulator configurations are properly represented in the hydraulic model. The regulators from all three outfalls discharge into the Condor Street interceptor, which conveys flow to the Caruso Pumping Station. An initial assessment of the pumping station operation suggests that backwater from the pumping station is not likely a contributing factor to the higher-than-expected number of overflows. The BWSC hydraulic model is currently being reviewed and will be used as appropriate to update the MWRA hydraulic model. A potential measure that will be evaluated with the updated/recalibrated hydraulic model is increasing the size of the dry weather connections to the Condor Street interceptor, at the three regulators.

<u>Outfalls BOS057 and BOS060</u> discharge to the Upper Inner Harbor. Outfall BOS057 receives flow from regulator RE057-6, while outfall BOS060 receives flow from regulators RE060-7 and RE060-20. Flow meters are installed in the influent lines of the three regulators. An inclinometer is also installed on the tidegate at regulator RE060-7 to identify when the tidegate opens and discharge occurs. The flow metering data for the period between April 15, 2018 and December 31, 2018 indicate that regulator RE057-6 overflowed 4 times (LTCP goal 1), regulator RE060-7 overflowed 9 times (LTCP goal 0), and regulator RE060-20 overflowed 4 times (LTCP goal 0).

Available information, including record drawings and field inspection data, are being reviewed to confirm that the regulator configurations are appropriately represented in the hydraulic model. The regulators for outfalls BOS057 and BOS060 discharge into BWSC's East Side Interceptor, which is tributary to the Columbus Park Headworks.

Flow metering data show 2 to 3 MGD of tidal inflow at one of the influent meters for regulator RE057-6 (outfall BOS057). The flow metering data also show periodic spikes of 5 to 10 MGD during dry weather and up to 39.5 MGD during wet weather at regulator RE060-20 (outfall BOS060). Spikes in flow are lower at regulator RE060-7. The performance of these regulators was discussed with BWSC, and BWSC is investigating potential sources for the flow spikes observed in the flow monitoring data. The BWSC hydraulic model is currently being reviewed and will be used as appropriate to update the MWRA hydraulic model.

6.5 Lower Inner Harbor

<u>Outfall BOS003</u> is located in East Boston and discharges to the Lower Inner Harbor. The outfall receives flow from three regulators: RE003-2, RE003-7, and RE003-12. The largest of these is regulator RE003-12, located at Porter Street and Bremen Street in East Boston. During dry weather, the flow from this regulator discharges to the East Boston Branch Sewer, where it is conveyed to the Caruso Pump Station. During larger storms, the water level in the regulator rises and discharges over a weir to outfall BOS003. Flow meters are installed in the three influent lines to regulator RE003-12 and in the overflow. An inclinometer is also installed on the tidegate to identify when the tidegate opens and discharge occurs. The flow metering data indicate that regulator RE003-12 activated 30 times in the period April 15, 2018 through December 31, 2018. The LTCP goal is 4 activations in the Typical Year.

Available information, including record drawings and field inspection data, are being reviewed to confirm that the configuration of regulator RE003-12 is appropriately represented in the hydraulic model. Record drawings of the regulator indicate that the remnants of an old mechanical regulator could potentially be causing a restriction in the dry weather connection to the East Boston Branch Sewer. This potential restriction is being investigated further. An initial assessment of the flow in the East Boston Branch Sewer suggests that the higher-than-expected overflow frequency at regulator RE003-12 is not caused by surcharging of the interceptor, but this is being analyzed further. MWRA has discussed the performance of the regulator with BWSC. BWSC's hydraulic model is currently being reviewed and will be used as appropriate to update the MWRA hydraulic model.

6.6 Fort Point Channel

<u>Outfalls BOS062, BOS064, and BOS065</u> discharge to Fort Point Channel. Outfall BOS062 receives flow from regulator RE062-4, outfall BOS064 receives flow from regulators RE64-4 and RE064-5, and outfall BOS065 receives flow from regulator RE065-2. Each of these regulators conveys dry weather flow to BWSC's New East Side Interceptor, which is tributary to the Columbus Park Headworks. The flow metering data for the period April 15, 2018 through December 31, 2018 indicate that regulator RE062-4 had 11 overflows (LTCP goal 1), regulator RE064-4 had 2 overflows (LTCP goal 1), regulator RE064-5 had 5 overflows (LTCP goal 0), and regulator RE065-2 had 10 overflows (LTCP goal 0).

Available information, including record drawings and field inspection data, are being reviewed to confirm that the regulator configurations are appropriately represented in the hydraulic model. The BWSC hydraulic model is currently being reviewed and will be used as appropriate to update the MWRA hydraulic model.

Outfall BOS070 receives overflows from multiple regulators, four of which overflowed more frequently than expected based on the 2018 meter data: regulators RE070/7-2, RE070/8-3, RE070/8-7, and RE070/9-4.

Regulator RE070/7-2 is located on BWSC's Dorchester Brook Sewer. During dry weather, the flow enters the Boston Main Interceptor where it is conveyed to the Columbus Park Headworks. During larger storms, the regulator overflows to BWSC's Dorchester Brook Conduit (a large storm drain and overflow conduit) and eventually discharges to Fort Point Channel. Flow metering data indicate that in the period April 15, 2018 through December 31, 2018, regulator RE070/7-2 overflowed 23 times. The LTCP goal for this regulator is 3 overflows per year. Regulator RE070/7-2 was reconstructed as part of a sewer separation project. The BWSC hydraulic model is currently being reviewed and will be used as appropriate to update the MWRA hydraulic model. Future analyses to be performed after the hydraulic model update/recalibration may include raising the weir and improving the connection to the Boston Main Interceptor.

Regulators RE070/8-3, RE070/8-7, and RE070/9-4 are located along Dorchester Avenue in South Boston. Flow metering data indicate that in the period April 15, 2018 through December 31, 2018, regulator RE070/8-3 overflowed 10 times, regulator RE070/8-7 overflowed seven times, and regulator RE070/9-4 overflowed 12 times. The LTCP goal for these regulators is 3 overflows per year. The higher-than-expected overflow frequency at these regulators could be the result of sediment in the South Boston Interceptor. The performance of these regulators was discussed with BWSC. BWSC identified a potential hydraulic restriction that they are working to remove along with cleaning of the interceptor. This information, in addition to the BWSC collection system model, will be used as appropriate to update the MWRA model.

6.7 Upper Charles

Outfall CAM005 receives overflow from regulator RE051. Flow meters were installed on the influent and overflow lines at this regulator. The flow metering data for the period April 15, 2018 through December 31, 2018 indicate that regulator RE051 had 15 overflows. The LTCP goal is three overflows for this regulator. Preliminary investigations into the regulator have found possible hydraulic restrictions in the regulator that could impede flows getting to the downstream interceptor. MWRA is working with Cambridge to determine if this restriction can be removed.

The higher-than-expected overflow frequency could also be due to the water level in the interceptor backing up when flows exceed downstream capacity in the interceptor system. Additional investigation is underway into the hydraulic conditions of the interceptor downstream of the regulator and its potential impact. The City of Cambridge has provided its hydraulic model which may contain updated information on the collection system tributary to the regulator. The Cambridge model is currently being reviewed and will be used as appropriate to update the MWRA hydraulic model.

6.8 Lower Charles

The Cottage Farm CSO Facility (MWR 201) discharges to the Lower Charles River. The LTCP goal is two activations with a volume of 6.30 MG of treated CSO discharge. From April 15, 2018 through October 31, 2018, MWRA facility records indicate three activations with a total CSO discharge volume of 23.94 MG. Reasons for the higher discharge volume, aside from the additional activation due to storm activity during 2018, are being investigated. Initial review of flow monitoring data indicate that the flow in some of the interceptors tributary to Cottage Farm may have a strong seasonal infiltration component, which may contribute to the higher-than-expected CSO volumes. Potential sewer separation plans upstream of Cottage Farm are currently being investigated. These plans include constructing a new storm drain outfall to the Charles River at Talbot Street and bulkheading an existing stormwater connection to the interceptor upstream of the Cottage Farm facility. The impact of the planned sewer separation work on Cottage Farm discharges is one potential measure that will be investigated further.

6. 9 Back Bay Fens

The Back Bay Fens receives overflow from upstream BOS046 regulators when gates within the Boston Gatehouse No. 1 (BOS046) are overtopped or when these gates are manually opened. In the past, the gates at Boston Gatehouse No. 1 were normally kept closed. To reduce flooding during severe storm events, during a portion of the reporting period (summer months) BWSC kept the gates open. Since much of the flow that is discharged at Boston Gatehouse No. 1 is stormwater, and some of the CSO from the upstream regulators continues past Boston Gatehouse No. 1 and discharges at outfall MWR023, the CSO volume being discharged at Boston Gatehouse No. 1 is calculated as a fraction of CSO flow discharged from the upstream regulators as noted in section 4.1.8. For the April 15, 2018 through December 31, 2018 metering period, this approach resulted in the calculation of 7 CSO events at Boston Gatehouse No. 1. The LTCP goal for this location is 2 overflows. However, this goal was established based on the past operating plan under which the gates were normally closed and that an overflow occurred only when the water level overtopped the gates. Boston Gatehouse No. 1 is not actually a regulator. The CSO regulators are upstream. Boston Gatehouse No. 1 is a flood control gate that is designed to provide relief to the Stony Brook Conduit by discharging flow into the Back Bay Fens. Flow discharged into the Back Bay Fens enters the Charles River a short distance downstream near the MWR023 outfall.

7. Progress Toward The Third Semiannual Report

MWRA plans to issue the next semiannual report (Semiannual CSO Discharge Report No. 3) in October 2019. The following efforts are underway or are planned to be conducted over the next several months.

- MWRA will continue to investigate system and regulator conditions and work with member CSO communities to better understand the measured CSO discharges that may be higher than past model predictions and/or LTCP levels of control, as discussed in Section 6.

- MWRA continues to collect data from rainfall gauges, CSO and sewer system meters, and facility operational records for all rainfall events. MWRA continues to quantify and validate CSO discharges from the meter data collected at the 36 CSO regulators where the meters remain in place.

- Data analyses are being conducted and findings will be presented in Semiannual Report No. 3 for the period January 1 through July 1, 2019. Temporary meters are currently installed at 36 CSO regulators where additional data will support evaluation of changes to system configurations or to support receiving water quality evaluations for the CSO variance waters.

- MWRA is continuing to incorporate the results of CSO regulator structure inspections conducted in 2018, additional site-specific inspections in 2019, and other new information about system conditions into its hydraulic model, including additional information from BWSC, Cambridge, Somerville and Chelsea.

- MWRA is in the process of recalibrating its hydraulic model utilizing validated meter data collected in 2018. Once the recalibration process is complete (expected August 2019), model predictions will be compared to meter data to demonstrate that modeled and metered discharge estimates are calibrated within accepted standards. This will provide confidence in the model for estimating CSO discharges in the Typical Year to allow comparison with LTCP levels of control.

- MWRA will continue to conduct receiving water quality monitoring in waters potentially impacted by CSO, with a focus on the storm impacts and recovery times in the variance waters (Lower Charles River/Charles Basin and Alewife Brook/Upper Mystic River).

Appendix A Rainfall Data for July 1, 2018 through December 31, 2018

Appendix B Rainfall Summary Tables

Rain Gauge 1: Allston

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval [(1)]		
								1-hr	24-hr	48-hr
1	7/6/2018 10:30	1.5	0.4	0.27	0.34	0.02	0.01	<3m	<3m	N/A
2	7/10/2018 23:45	0.5	0.09	0.18	0.09	0.00	0.00	<3m	<3m	N/A
3	7/14/2018 22:30	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
4	7/17/2018 13:00	13.25	2.26	0.17	0.96	0.09	0.05	1 yr	3-6m	N/A
5	7/22/2018 5:45	29.75	0.25	0.01	0.06	0.01	0.01	<3m	<3m	N/A
6	7/25/2018 13:45	26.5	0.82	0.03	0.49	0.03	0.02	<3m	<3m	N/A
7	8/2/2018 18:15	0.5	0.35	0.70	0.35	0.01	0.00	<3m	<3m	N/A
8	8/3/2018 12:45	0.25	0.02	0.08	0.02	0.02	0.01	<3m	<3m	N/A
9	8/4/2018 9:30	4	0.48	0.12	0.34	0.02	0.02	<3m	<3m	N/A
10	8/8/2018 14:30	27.25	0.38	0.01	0.18	0.02	0.01	<3m	<3m	N/A
11	8/11/2018 10:30	35.75	1.35	0.04	0.65	0.05	0.03	3-6m	<3m	N/A
12	8/13/2018 17:00	5.25	0.31	0.06	0.23	0.02	0.02	<3m	<3m	N/A
13	8/14/2018 12:30	2	0.24	0.12	0.15	0.02	0.01	<3m	<3m	N/A
14	8/17/2018 16:30	8.5	0.15	0.02	0.12	0.01	0.00	<3m	<3m	N/A
15	8/18/2018 15:45	7.5	0.14	0.02	0.07	0.01	0.01	<3m	<3m	N/A
16	8/19/2018 22:15	1	0.04	0.04	0.04	0.00	0.00	<3m	<3m	N/A
17	8/22/2018 6:45	8.5	0.44	0.05	0.35	0.02	0.01	<3m	<3m	N/A
18	9/6/2018 15:30	2.25	0.08	0.04	0.05	0.00	0.00	<3m	<3m	N/A
19	9/10/2018 16:30	12.75	1.3	0.10	0.3	0.05	0.03	<3m	<3m	N/A
20	9/12/2018 2:00	27.5	0.66	0.02	0.23	0.03	0.03	<3m	<3m	N/A
21	9/18/2018 1:30	12.75	1.63	0.13	1.12	0.07	0.03	2 yr	<3m	N/A
22	9/22/2018 2:00	0.5	0.03	0.06	0.03	0.00	0.00	<3m	<3m	N/A
23	9/25/2018 9:45	13.25	1.47	0.11	0.45	0.06	0.03	<3m	<3m	N/A
24	9/26/2018 22:15	2	0.32	0.16	0.25	0.01	0.04	<3m	<3m	N/A
25	9/28/2018 5:45	5.75	0.44	0.08	0.17	0.02	0.02	<3m	<3m	N/A
26	10/1/2018 15:15	36.25	0.76	0.02	0.18	0.03	0.02	<3m	<3m	N/A
27	10/7/2018 15:15	3.75	0.08	0.02	0.05	0.00	0.00	<3m	<3m	N/A
28	10/8/2018 17:00	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
29	10/11/2018 13:30	19.25	0.61	0.03	0.26	0.03	0.01	<3m	<3m	N/A
30	10/13/2018 8:15	3.5	0.12	0.03	0.34	0.01	0.02	<3m	<3m	N/A
31	10/15/2018 23:15	1.5	0.1	0.07	0.07	0.00	0.00	<3m	<3m	N/A
32	10/21/2018 7:00	0.5	0.02	0.04	0.02	0.00	0.00	<3m	<3m	N/A
33	10/23/2018 13:00	5	0.24	0.05	0.13	0.01	0.01	<3m	<3m	N/A
34	10/24/2018 9:15	3	0.04	0.01	0.02	0.01	0.01	<3m	<3m	N/A

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval [1]		
								1-hr	24-hr	48-hr
35	10/27/2018 5:45	25	1.67	0.07	0.27	0.07	0.03	<3m	<3m	N/A
36	10/29/2018 4:00	8.75	0.78	0.09	0.34	0.03	0.04	<3m	<3m	N/A
37	11/1/2018 8:00	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
38	11/2/2018 3:15	35	1.9	0.05	0.47	0.07	0.04	<3m	3m	N/A
39	11/5/2018 17:45	26.25	1.12	0.04	0.17	0.04	0.02	<3m	<3m	N/A
40	11/9/2018 18:30	15.75	1.51	0.10	0.42	0.06	0.03	<3m	<3m	N/A
41	11/13/2018 1:00	12.75	1.14	0.09	0.5	0.05	0.02	<3m	<3m	N/A
42	11/16/2018 1:45	8	1.18	0.15	0.5	0.05	0.02	<3m	<3m	N/A
43	11/19/2018 2:30	40	0.59	0.01	0.09	0.02	0.01	<3m	<3m	N/A
44	11/25/2018 1:15	10.5	0.76	0.07	0.37	0.03	0.02	<3m	<3m	N/A
45	11/26/2018 9:45	21.5	1.62	0.08	0.2	0.07	0.04	<3m	<3m	N/A
46	12/2/2018 2:45	14	0.72	0.05	0.15	0.03	0.00	<3m	<3m	N/A
47	12/3/2018 7:45	0.25	0.01	0.04	0.01	0.02	0.02	<3m	<3m	N/A
48	12/16/2018 11:30	16.25	0.67	0.04	0.2	0.03	0.01	<3m	<3m	N/A
49	12/21/2018 5:45	18.75	0.8	0.04	0.13	0.03	0.02	<3m	<3m	N/A
50	12/28/2018 8:00	11	0.33	0.03	0	0.01	0.01	<3m	<3m	N/A
51	12/31/2018 19:45	4	0.4	0.10	0.18	0.02	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 2: Ward Street

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
1	7/6/2018 10:30	1.75	0.37	0.21	0.26	0.02	0.01	<3m	<3m	N/A
2	7/11/2018 0:00	6.75	0.13	0.02	0.12	0.01	0.00	<3m	<3m	N/A
3	7/14/2018 22:45	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
4	7/17/2018 13:15	13	2.39	0.18	1.14	0.10	0.05	2 yr	6m	N/A
5	7/22/2018 4:00	33.5	0.38	0.01	0.12	0.01	0.01	<3m	<3m	N/A
6	7/25/2018 2:30	38.5	0.68	0.02	0.36	0.02	0.01	<3m	<3m	N/A
7	8/3/2018 13:00	0.25	0.1	0.40	0.1	0.00	0.00	<3m	<3m	N/A
8	8/4/2018 9:30	2.5	0.66	0.26	0.52	0.03	0.02	<3m	<3m	N/A
9	8/8/2018 13:45	16.25	0.73	0.04	0.32	0.03	0.02	<3m	<3m	N/A
10	8/11/2018 10:30	34.75	2.36	0.07	1.46	0.09	0.05	4 yr	3-6m	N/A
11	8/13/2018 17:00	6.75	0.28	0.04	0.2	0.01	0.04	<3m	<3m	N/A
12	8/14/2018 12:30	0.25	0.01	0.04	0.01	0.01	0.01	<3m	<3m	N/A
13	8/17/2018 16:15	9	0.2	0.02	0.16	0.01	0.00	<3m	<3m	N/A
14	8/18/2018 16:00	7.25	0.15	0.02	0.08	0.01	0.01	<3m	<3m	N/A
15	8/19/2018 21:45	0.25	0.02	0.08	0.02	0.00	0.00	<3m	<3m	N/A
16	8/22/2018 6:45	8.75	0.12	0.01	0.1	0.01	0.00	<3m	<3m	N/A
17	9/6/2018 15:45	2.25	0.11	0.05	0.08	0.00	0.00	<3m	<3m	N/A
18	9/7/2018 7:15	0.25	0.01	0.04	0.01	0.01	0.00	<3m	<3m	N/A
19	9/10/2018 16:30	15.75	1.31	0.08	0.32	0.05	0.03	<3m	<3m	N/A
20	9/12/2018 10:45	18.25	0.9	0.05	0.44	0.04	0.03	<3m	<3m	N/A
21	9/18/2018 1:30	12.75	1.18	0.09	0.63	0.05	0.02	3-6m	<3m	N/A
22	9/19/2018 3:30	0.25	0.01	0.04	0.01	0.05	0.02	<3m	<3m	N/A
23	9/22/2018 2:00	0.75	0.06	0.08	0.06	0.00	0.00	<3m	<3m	N/A
24	9/25/2018 11:00	18.25	1.82	0.10	0.84	0.08	0.04	6m-1yr	3m	N/A
25	9/26/2018 22:15	10.5	0.36	0.03	0.27	0.02	0.05	<3m	<3m	N/A
26	9/28/2018 5:45	5.5	0.44	0.08	0.16	0.02	0.02	<3m	<3m	N/A
27	10/1/2018 15:45	37.25	0.67	0.02	0.15	0.02	0.01	<3m	<3m	N/A
28	10/7/2018 17:00	2	0.03	0.02	0.02	0.00	0.00	<3m	<3m	N/A
29	10/8/2018 16:45	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
30	10/11/2018 13:30	18.5	0.71	0.04	0.28	0.03	0.01	<3m	<3m	N/A
31	10/13/2018 7:45	4.25	0.14	0.03	0.05	0.01	0.02	<3m	<3m	N/A
32	10/15/2018 14:00	11	0.11	0.01	0.06	0.00	0.00	<3m	<3m	N/A
33	10/21/2018 7:00	0.5	0.02	0.04	0.02	0.00	0.00	<3m	<3m	N/A
34	10/23/2018 13:00	5.25	0.29	0.06	0.13	0.01	0.01	<3m	<3m	N/A

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
35	10/24/2018 10:15	2.75	0.04	0.01	0.03	0.01	0.01	<3m	<3m	N/A
36	10/27/2018 6:00	26	1.65	0.06	0.27	0.07	0.03	<3m	<3m	N/A
37	10/29/2018 4:15	8.5	0.77	0.09	0.41	0.03	0.04	<3m	<3m	N/A
38	11/1/2018 8:00	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
39	11/2/2018 3:15	33.75	1.91	0.06	0.53	0.07	0.04	3m	3m	N/A
40	11/5/2018 17:45	26.75	1.2	0.04	0.17	0.05	0.03	<3m	<3m	N/A
41	11/9/2018 18:30	19.75	1.6	0.08	0.45	0.07	0.03	<3m	<3m	N/A
42	11/13/2018 1:00	13	1.23	0.09	0.18	0.05	0.03	<3m	<3m	N/A
43	11/16/2018 1:45	7.75	1.43	0.18	0.39	0.06	0.03	<3m	<3m	N/A
44	11/19/2018 1:45	40	0.63	0.02	0.09	0.02	0.01	<3m	<3m	N/A
45	11/25/2018 1:00	10.5	0.84	0.08	0.39	0.04	0.02	<3m	<3m	N/A
46	11/26/2018 8:45	22.25	1.58	0.07	0.19	0.07	0.04	<3m	<3m	N/A
47	12/2/2018 2:45	15.75	0.8	0.05	0.16	0.03	0.00	<3m	<3m	N/A
48	12/16/2018 11:45	16.75	0.65	0.04	0.18	0.03	0.01	<3m	<3m	N/A
49	12/21/2018 5:45	18.75	0.77	0.04	0.13	0.03	0.02	<3m	<3m	N/A
50	12/28/2018 8:00	11.25	0.33	0.03	0.11	0.01	0.01	<3m	<3m	N/A
51	12/31/2018 19:45	4	0.4	0.10	0.18	0.02	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 3: Columbus Park

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval [1]		
								1-hr	24-hr	48-hr
1	7/6/2018 10:30	1.75	0.39	0.22	0.29	0.02	0.01	<3m	<3m	N/A
2	7/11/2018 0:00	8.25	0.47	0.06	0.38	0.02	0.01	<3m	<3m	N/A
3	7/14/2018 21:15	0.75	0.07	0.09	0.07	0.00	0.00	<3m	<3m	N/A
4	7/17/2018 13:00	13.5	2.44	0.18	0.92	0.10	0.05	1y	6m	N/A
5	7/22/2018 4:00	31.5	0.2	0.01	0.05	0.01	0.00	<3m	<3m	N/A
6	7/25/2018 13:45	13.25	0.1	0.01	0.04	0.00	0.00	<3m	<3m	N/A
7	7/26/2018 15:00	1.75	0.64	0.37	0.59	0.03	0.02	3m	<3m	N/A
8	8/3/2018 12:45	0.5	0.11	0.22	0.11	0.00	0.00	<3m	<3m	N/A
9	8/4/2018 10:00	3.25	0.88	0.27	0.66	0.04	0.02	3-6m	<3m	N/A
10	8/8/2018 14:00	16	0.94	0.06	0.7	0.04	0.02	6m	<3m	N/A
11	8/11/2018 8:00	37	1.43	0.04	0.59	0.05	0.03	3m	<3m	N/A
12	8/13/2018 16:15	9.25	0.35	0.04	0.23	0.02	0.03	<3m	<3m	N/A
13	8/17/2018 16:00	9.25	0.2	0.02	0.12	0.01	0.00	<3m	<3m	N/A
14	8/18/2018 16:00	7.75	0.15	0.02	0.07	0.01	0.01	<3m	<3m	N/A
15	8/22/2018 6:15	9.5	0.44	0.05	0.33	0.02	0.01	<3m	<3m	N/A
16	9/6/2018 16:00	2	0.06	0.03	0.04	0.00	0.00	<3m	<3m	N/A
17	9/7/2018 7:15	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
18	9/10/2018 16:30	12.5	1.41	0.11	0.27	0.06	0.03	<3m	<3m	N/A
19	9/12/2018 2:15	26.75	0.98	0.04	0.34	0.04	0.04	<3m	<3m	N/A
20	9/18/2018 1:15	13.25	1.29	0.10	0.67	0.05	0.03	3-6m	<3m	N/A
21	9/19/2018 4:15	0.25	0.01	0.04	0.01	0.05	0.03	<3m	<3m	N/A
22	9/22/2018 2:00	0.75	0.06	0.08	0.06	0.00	0.00	<3m	<3m	N/A
23	9/25/2018 11:15	19.25	1.42	0.07	0.74	0.06	0.03	6m-1yr	<3m	N/A
24	9/26/2018 22:30	2.75	0.48	0.17	0.31	0.02	0.04	<3m	<3m	N/A
25	9/28/2018 5:45	7.25	0.5	0.07	0.22	0.02	0.02	<3m	<3m	N/A
26	10/1/2018 16:00	36.25	0.81	0.02	0.21	0.03	0.02	<3m	<3m	N/A
27	10/7/2018 15:30	4.75	0.09	0.02	0.05	0.00	0.00	<3m	<3m	N/A
28	10/8/2018 17:15	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
29	10/11/2018 13:30	19.5	0.82	0.04	0.33	0.03	0.02	<3m	<3m	N/A
30	10/13/2018 7:30	4.75	0.13	0.03	0.04	0.01	0.02	<3m	<3m	N/A
31	10/15/2018 23:15	1.75	0.12	0.07	0.09	0.01	0.00	<3m	<3m	N/A
32	10/21/2018 7:00	1.25	0.03	0.02	0.02	0.00	0.00	<3m	<3m	N/A
33	10/23/2018 13:00	5.5	0.36	0.07	0.16	0.02	0.01	<3m	<3m	N/A
34	10/24/2018 10:15	5	0.03	0.01	0.02	0.02	0.01	<3m	<3m	N/A
35	10/27/2018 6:00	25.25	2.03	0.08	0.35	0.08	0.04	<3m	3m	N/A

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
36	10/29/2018 4:15	8.5	0.52	0.06	0.33	0.02	0.05	<3m	<3m	N/A
37	11/1/2018 8:15	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
38	11/2/2018 3:15	35.75	1.98	0.06	0.64	0.08	0.04	3-6m	3m	N/A
39	11/5/2018 18:00	26	1.24	0.05	0.23	0.05	0.03	<3m	<3m	N/A
40	11/9/2018 18:30	15.75	1.72	0.11	0.45	0.07	0.04	<3m	<3m	N/A
41	11/13/2018 1:00	12.25	1.09	0.09	0.17	0.05	0.02	<3m	<3m	N/A
42	11/15/2018 22:00	11.5	1.28	0.11	0.25	0.05	0.03	<3m	<3m	N/A
43	11/19/2018 2:15	40	0.71	0.02	0.11	0.02	0.01	<3m	<3m	N/A
44	11/25/2018 1:15	10.5	0.84	0.08	0.36	0.04	0.02	<3m	<3m	N/A
45	11/26/2018 8:30	25.25	1.51	0.06	0.2	0.06	0.04	<3m	<3m	N/A
46	12/2/2018 3:00	18.75	0.75	0.04	0.14	0.03	0.00	<3m	<3m	N/A
47	12/16/2018 17:15	13.75	0.73	0.05	0.2	0.03	0.02	<3m	<3m	N/A
48	12/21/2018 6:00	18.5	0.46	0.02	0.11	0.02	0.01	<3m	<3m	N/A
49	12/28/2018 8:30	10.75	0.28	0.03	0.09	0.01	0.01	<3m	<3m	N/A
50	12/31/2018 20:00	3.75	0.35	0.09	0.18	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 4: Charlestown

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
1	7/3/2018 19:30	2.5	0.03	0.01	0.02	0.00	0.00	<3m	<3m	N/A
2	7/6/2018 10:30	1.5	0.43	0.29	0.38	0.02	0.01	<3m	<3m	N/A
3	7/11/2018 0:00	0.25	0.03	0.12	0.03	0.00	0.00	<3m	<3m	N/A
4	7/14/2018 21:15	6	0.3	0.05	0.21	0.01	0.01	<3m	<3m	N/A
5	7/17/2018 13:00	13.25	2.27	0.17	0.99	0.09	0.05	1yr	3-6m	N/A
6	7/22/2018 4:00	31.5	0.34	0.01	0.1	0.01	0.01	<3m	<3m	N/A
7	7/25/2018 23:00	17.5	0.65	0.04	0.53	0.03	0.01	3m	<3m	N/A
8	8/2/2018 18:30	0.25	0.1	0.40	0.1	0.00	0.00	<3m	<3m	N/A
9	8/3/2018 12:45	0.5	0.06	0.12	0.06	0.01	0.00	<3m	<3m	N/A
10	8/4/2018 9:30	4	0.6	0.15	0.47	0.03	0.02	<3m	<3m	N/A
11	8/8/2018 14:15	24.5	0.37	0.02	0.1	0.02	0.01	<3m	<3m	N/A
12	8/11/2018 10:30	35.75	2.18	0.06	1.06	0.08	0.05	1.5 yr	3m	N/A
13	8/13/2018 16:15	6.25	0.37	0.06	0.25	0.02	0.04	<3m	<3m	N/A
14	8/14/2018 12:45	2	0.07	0.04	0.04	0.02	0.01	<3m	<3m	N/A
15	8/17/2018 16:45	30.25	0.48	0.02	0.36	0.02	0.01	<3m	<3m	N/A
16	8/19/2018 22:45	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
17	8/22/2018 6:45	8.75	0.37	0.04	0.29	0.02	0.01	<3m	<3m	N/A
18	9/6/2018 16:00	2	0.05	0.03	0.03	0.00	0.00	<3m	<3m	N/A
19	9/10/2018 16:45	13.5	1.26	0.09	0.27	0.05	0.03	<3m	<3m	N/A
20	9/12/2018 2:15	26.75	0.53	0.02	0.18	0.02	0.03	<3m	<3m	N/A
21	9/18/2018 1:30	12.75	1.41	0.11	0.93	0.06	0.03	1 yr	<3m	N/A
22	9/22/2018 2:00	0.75	0.03	0.04	0.03	0.00	0.00	<3m	<3m	N/A
23	9/25/2018 11:15	12	1.59	0.13	0.71	0.07	0.03	6m	<3m	N/A
24	9/26/2018 22:15	2.25	0.34	0.15	0.26	0.02	0.04	<3m	<3m	N/A
25	9/28/2018 5:45	6	0.33	0.06	0.12	0.01	0.01	<3m	<3m	N/A
26	10/1/2018 15:45	36.25	0.62	0.02	0.14	0.02	0.01	<3m	<3m	N/A
27	10/7/2018 15:15	4.25	0.07	0.02	0.03	0.00	0.00	<3m	<3m	N/A
28	10/8/2018 17:30	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
29	10/11/2018 13:45	18.25	0.63	0.03	0.23	0.03	0.01	<3m	<3m	N/A
30	10/13/2018 8:15	3.75	0.13	0.03	0.04	0.01	0.02	<3m	<3m	N/A
31	10/15/2018 9:15	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
32	10/15/2018 23:15	1.5	0.15	0.10	0.11	0.01	0.00	<3m	<3m	N/A
33	10/21/2018 7:00	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
34	10/23/2018 13:00	5.5	0.37	0.07	0.21	0.02	0.01	<3m	<3m	N/A
35	10/24/2018 11:00	4.25	0.03	0.01	0.02	0.02	0.01	<3m	<3m	N/A

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval [(1)]		
								1-hr	24-hr	48-hr
36	10/27/2018 6:30	24.75	1.41	0.06	0.24	0.06	0.03	<3m	<3m	N/A
37	10/29/2018 4:15	9.25	0.57	0.06	0.38	0.02	0.04	<3m	<3m	N/A
38	11/2/2018 3:15	33.75	1.82	0.05	0.48	0.07	0.04	<3m	<3m	N/A
39	11/5/2018 18:00	26	1.05	0.04	0.16	0.04	0.02	<3m	<3m	N/A
40	11/9/2018 18:30	15.75	1.37	0.09	0.4	0.06	0.03	<3m	<3m	N/A
41	11/13/2018 1:00	13	1.16	0.09	0.19	0.05	0.02	<3m	<3m	N/A
42	11/16/2018 1:45	8	1.17	0.15	0.33	0.05	0.02	<3m	<3m	N/A
43	11/19/2018 2:45	39	0.63	0.02	0.09	0.02	0.01	<3m	<3m	N/A
44	11/25/2018 1:15	10.25	0.65	0.06	0.29	0.03	0.01	<3m	<3m	N/A
45	11/26/2018 8:45	21.75	1.39	0.06	0.17	0.06	0.04	<3m	<3m	N/A
46	12/2/2018 3:00	13.75	0.77	0.06	0.16	0.03	0.00	<3m	<3m	N/A
47	12/3/2018 5:45	0.25	0.01	0.04	0.01	0.03	0.02	<3m	<3m	N/A
48	12/16/2018 17:15	12.25	0.59	0.05	0.19	0.02	0.01	<3m	<3m	N/A
49	12/21/2018 6:00	18.5	0.67	0.04	0.11	0.03	0.01	<3m	<3m	N/A
50	12/28/2018 7:45	11.25	0.3	0.03	0.11	0.01	0.01	<3m	<3m	N/A
51	12/31/2018 19:30	4.25	0.33	0.08	0.17	0.02	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	7/6/2018 10:30	1.75	0.37	0.21	0.33	0.02	0.01	<3m	<3m	N/A
2	7/11/2018 0:00	0.25	0.02	0.08	0.02	0.00	0.00	<3m	<3m	N/A
3	7/14/2018 21:45	5.5	0.29	0.05	0.23	0.01	0.01	<3m	<3m	N/A
4	7/17/2018 13:15	11.25	2.12	0.19	0.97	0.09	0.04	1yr	3-6m	N/A
5	7/22/2018 4:15	31.5	0.28	0.01	0.07	0.01	0.01	<3m	<3m	N/A
6	7/25/2018 10:15	16.5	0.23	0.01	0.12	0.01	0.00	<3m	<3m	N/A
7	7/26/2018 14:45	1.75	0.56	0.32	0.53	0.03	0.02	3m	<3m	N/A
8	7/27/2018 12:15	0.25	0.02	0.08	0.02	0.02	0.02	<3m	<3m	N/A
9	8/2/2018 18:30	0.5	0.04	0.08	0.04	0.00	0.00	<3m	<3m	N/A
10	8/3/2018 13:00	0.25	0.04	0.16	0.04	0.00	0.00	<3m	<3m	N/A
11	8/4/2018 9:45	4	0.58	0.15	0.46	0.03	0.01	<3m	<3m	N/A
12	8/8/2018 14:15	24.5	0.44	0.02	0.12	0.02	0.01	<3m	<3m	N/A
13	8/11/2018 8:30	62.25	2.95	0.05	0.82	0.09	0.05	6m-1yr	3-6m	N/A
14	8/14/2018 14:30	0.5	0.05	0.10	0.05	0.02	0.02	<3m	<3m	N/A
15	8/17/2018 16:45	8.75	0.44	0.05	0.42	0.02	0.01	<3m	<3m	N/A
16	8/18/2018 16:00	6.75	0.1	0.01	0.07	0.02	0.01	<3m	<3m	N/A
17	8/19/2018 21:30	12.25	0.07	0.01	0.06	0.00	0.00	<3m	<3m	N/A
18	8/22/2018 6:45	8.75	0.4	0.05	0.35	0.02	0.01	<3m	<3m	N/A
19	9/6/2018 16:15	2.25	0.05	0.02	0.03	0.00	0.00	<3m	<3m	N/A
20	9/10/2018 16:45	19.5	1.38	0.07	0.25	0.06	0.03	<3m	<3m	N/A
21	9/12/2018 5:30	7.75	0.03	0.00	0.02	0.00	0.03	<3m	<3m	N/A
22	9/18/2018 1:45	12.75	1.6	0.13	1.05	0.07	0.03	1.5 yr	<3m	N/A
23	9/21/2018 7:15	4.75	0.04	0.01	0.03	0.00	0.00	<3m	<3m	N/A
24	9/22/2018 2:00	0.5	0.02	0.04	0.02	0.00	0.00	<3m	<3m	N/A
25	9/25/2018 11:15	13	1.52	0.12	0.73	0.06	0.03	6m	<3m	N/A
26	9/26/2018 22:15	2.25	0.37	0.16	0.27	0.02	0.04	<3m	<3m	N/A
27	9/28/2018 5:45	5.75	0.38	0.07	0.12	0.02	0.02	<3m	<3m	N/A
28	10/1/2018 14:45	37.25	0.72	0.02	0.15	0.02	0.02	<3m	<3m	N/A
29	10/7/2018 15:30	4.5	0.1	0.02	0.04	0.00	0.00	<3m	<3m	N/A
30	10/8/2018 17:00	2.25	0.02	0.01	0.01	0.00	0.00	<3m	<3m	N/A
31	10/11/2018 13:45	18.5	0.68	0.04	0.27	0.03	0.01	<3m	<3m	N/A
32	10/13/2018 7:45	4.25	0.12	0.03	0.04	0.01	0.02	<3m	<3m	N/A
33	10/15/2018 9:30	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
34	10/15/2018 23:15	1.5	0.07	0.05	0.04	0.00	0.00	<3m	<3m	N/A
35	10/21/2018 7:00	0.5	0.02	0.04	0.02	0.00	0.00	<3m	<3m	N/A

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
36	10/23/2018 13:00	5.5	0.38	0.07	0.22	0.02	0.01	<3m	<3m	N/A
37	10/24/2018 10:15	4.75	0.05	0.01	0.02	0.02	0.01	<3m	<3m	N/A
38	10/27/2018 6:30	25.75	1.96	0.08	0.35	0.08	0.04	<3m	3m	N/A
39	10/29/2018 4:15	9.25	0.6	0.06	0.36	0.03	0.05	<3m	<3m	N/A
40	11/2/2018 3:15	33.75	1.87	0.06	0.5	0.07	0.04	<3m	<3m	N/A
41	11/5/2018 18:00	26	1.21	0.05	0.18	0.05	0.03	<3m	<3m	N/A
42	11/9/2018 18:30	16	1.65	0.10	0.47	0.07	0.03	<3m	<3m	N/A
43	11/13/2018 1:15	22.25	1.23	0.06	0.2	0.05	0.03	<3m	<3m	N/A
44	11/15/2018 20:15	13.75	1.17	0.09	0.21	0.05	0.02	<3m	<3m	N/A
45	11/19/2018 2:45	38.5	0.66	0.02	0.09	0.02	0.01	<3m	<3m	N/A
46	11/21/2018 11:45	0.25	0.01	0.04	0.01	0.00	0.01	<3m	<3m	N/A
47	11/25/2018 1:30	10	0.73	0.07	0.35	0.03	0.02	<3m	<3m	N/A
48	11/26/2018 6:00	28	1.81	0.06	0.21	0.08	0.05	<3m	3m	N/A
49	12/2/2018 3:00	12	0.82	0.07	0.17	0.03	0.00	<3m	<3m	N/A
50	12/3/2018 3:15	5	0.02	0.00	0.01	0.03	0.02	<3m	<3m	N/A
51	12/16/2018 17:15	13.5	0.7	0.05	0.24	0.03	0.01	<3m	<3m	N/A
52	12/18/2018 2:15	0.25	0.01	0.04	0.01	0.00	0.01	<3m	<3m	N/A
53	12/21/2018 6:15	18.25	0.58	0.03	0.09	0.02	0.01	<3m	<3m	N/A
54	12/28/2018 9:00	10.25	0.28	0.03	0.11	0.01	0.01	<3m	<3m	N/A
55	12/31/2018 20:15	3.5	0.29	0.08	0.15	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	7/6/2018 10:30	1.75	0.35	0.20	0.25	0.01	0.01	<3m	<3m	N/A
2	7/11/2018 0:15	4.25	0.72	0.17	0.45	0.03	0.02	<3m	<3m	N/A
3	7/14/2018 23:00	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
4	7/17/2018 13:30	13	1.76	0.14	1.03	0.07	0.04	1.5 yr	<3m	N/A
5	7/22/2018 4:00	31.75	0.28	0.01	0.09	0.01	0.01	<3m	<3m	N/A
6	7/25/2018 13:45	12.75	0.08	0.01	0.03	0.00	0.00	<3m	<3m	N/A
7	7/26/2018 15:00	1.75	0.28	0.16	0.23	0.01	0.01	<3m	<3m	N/A
8	8/3/2018 12:45	0.5	0.68	1.36	0.68	0.03	0.01	3-6m	<3m	N/A
9	8/4/2018 9:45	4	1.32	0.33	0.97	0.08	0.04	1 yr	3m	N/A
10	8/8/2018 13:45	25.25	1.32	0.05	1.14	0.05	0.03	2 yr	<3m	N/A
11	8/11/2018 7:45	37	0.93	0.03	0.23	0.03	0.02	<3m	<3m	N/A
12	8/13/2018 15:45	6.25	0.36	0.06	0.27	0.02	0.02	<3m	<3m	N/A
13	8/17/2018 15:45	9.25	0.03	0.00	0.01	0.00	0.00	<3m	<3m	N/A
14	8/18/2018 14:15	10	0.35	0.04	0.12	0.02	0.01	<3m	<3m	N/A
15	8/22/2018 6:15	9.25	0.44	0.05	0.31	0.02	0.01	<3m	<3m	N/A
16	9/6/2018 15:30	3.75	0.31	0.08	0.25	0.01	0.01	<3m	<3m	N/A
17	9/10/2018 15:30	14.5	1.32	0.09	0.28	0.06	0.03	<3m	<3m	N/A
18	9/12/2018 1:45	27.25	1.29	0.05	0.52	0.05	0.04	<3m	<3m	N/A
19	9/18/2018 0:45	15	1.16	0.08	0.54	0.05	0.02	3m	<3m	N/A
20	9/19/2018 5:00	0.25	0.01	0.04	0.01	0.04	0.02	<3m	<3m	N/A
21	9/22/2018 2:00	1	0.09	0.09	0.09	0.00	0.00	<3m	<3m	N/A
22	9/25/2018 11:15	19.5	1.49	0.08	0.64	0.06	0.03	3-6m	<3m	N/A
23	9/26/2018 22:45	2.5	0.46	0.18	0.35	0.02	0.04	<3m	<3m	N/A
24	9/28/2018 5:45	5.25	0.54	0.10	0.33	0.02	0.02	<3m	<3m	N/A
25	9/29/2018 2:15	0.25	0.01	0.04	0.01	0.02	0.01	<3m	<3m	N/A
26	10/1/2018 16:45	38	0.94	0.02	0.24	0.03	0.02	<3m	<3m	N/A
27	10/7/2018 17:45	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
28	10/8/2018 15:30	2.25	0.02	0.01	0.01	0.00	0.00	<3m	<3m	N/A
29	10/11/2018 13:45	19.25	0.89	0.05	0.31	0.04	0.02	<3m	<3m	N/A
30	10/13/2018 7:00	5	0.16	0.03	0.04	0.01	0.02	<3m	<3m	N/A
31	10/15/2018 23:15	1.75	0.09	0.05	0.06	0.00	0.00	<3m	<3m	N/A
32	10/21/2018 7:00	0.5	0.02	0.04	0.02	0.00	0.00	<3m	<3m	N/A
33	10/23/2018 14:00	4.5	0.46	0.10	0.23	0.02	0.01	<3m	<3m	N/A
34	10/24/2018 9:15	6	0.05	0.01	0.02	0.02	0.01	<3m	<3m	N/A
35	10/27/2018 6:00	25.75	1.91	0.07	0.33	0.08	0.04	<3m	3m	N/A

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
36	10/29/2018 4:00	8.25	0.59	0.07	0.25	0.02	0.04	<3m	<3m	N/A
37	11/2/2018 3:15	1	0.11	0.11	0.11	0.00	0.00	<3m	<3m	N/A
38	11/2/2018 16:30	20.5	1.67	0.08	0.61	0.07	0.04	3-6m	<3m	N/A
39	11/5/2018 18:00	26.5	1.2	0.05	0.21	0.05	0.03	<3m	<3m	N/A
40	11/9/2018 18:30	17.25	1.8	0.10	0.45	0.08	0.04	<3m	3m	N/A
41	11/13/2018 1:00	13.5	0.98	0.07	0.14	0.04	0.02	<3m	<3m	N/A
42	11/16/2018 3:15	6.5	1.28	0.20	0.3	0.05	0.03	<3m	<3m	N/A
43	11/19/2018 3:45	38.75	0.55	0.01	0.08	0.02	0.01	<3m	<3m	N/A
44	11/25/2018 1:15	10.5	0.81	0.08	0.37	0.03	0.02	<3m	<3m	N/A
45	11/26/2018 17:00	17.25	1.61	0.09	0.2	0.07	0.04	<3m	<3m	N/A
46	12/2/2018 2:45	19	0.76	0.04	0.15	0.03	0.00	<3m	<3m	N/A
47	12/16/2018 11:30	17	0.73	0.04	0.2	0.03	0.02	<3m	<3m	N/A
48	12/21/2018 5:45	29.5	0.85	0.03	0.12	0.04	0.02	<3m	<3m	N/A
49	12/28/2018 7:15	11.75	0.35	0.03	0.1	0.01	0.01	<3m	<3m	N/A
50	12/31/2018 19:00	4.75	0.42	0.09	0.19	0.02	0.01	<3m	<3m	N/A

(2) 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	7/6/2018 10:30	1.75	0.37	0.21	0.27	0.02	0.01	<3m	<3m	N/A
2	7/11/2018 0:00	4.75	0.7	0.15	0.44	0.03	0.01	<3m	<3m	N/A
3	7/17/2018 13:30	14.75	2.01	0.14	0.93	0.08	0.04	1 yr	3m	N/A
4	7/22/2018 4:00	31.5	0.38	0.01	0.11	0.01	0.01	<3m	<3m	N/A
5	7/25/2018 13:45	13.25	0.12	0.01	0.03	0.01	0.00	<3m	<3m	N/A
6	7/26/2018 15:00	1.5	0.51	0.34	0.49	0.03	0.01	<3m	<3m	N/A
7	8/3/2018 12:45	0.5	0.43	0.86	0.43	0.02	0.01	<3m	<3m	N/A
8	8/4/2018 9:45	3.25	1.3	0.40	0.87	0.07	0.04	6m-1yr	<3m	N/A
9	8/5/2018 5:30	0.25	0.01	0.04	0.01	0.05	0.04	<3m	<3m	N/A
10	8/8/2018 13:30	25.5	0.85	0.03	0.58	0.03	0.02	3m	<3m	N/A
11	8/11/2018 7:45	37	0.96	0.03	0.52	0.04	0.02	<3m	<3m	N/A
12	8/13/2018 16:30	5	0.32	0.06	0.23	0.01	0.02	<3m	<3m	N/A
13	8/17/2018 15:45	9.25	0.06	0.01	0.04	0.00	0.00	<3m	<3m	N/A
14	8/18/2018 14:15	9.75	0.19	0.02	0.07	0.01	0.01	<3m	<3m	N/A
15	8/22/2018 6:15	9.25	0.42	0.05	0.31	0.02	0.01	<3m	<3m	N/A
16	9/6/2018 15:30	3	0.44	0.15	0.39	0.02	0.01	<3m	<3m	N/A
17	9/10/2018 16:15	13.25	1.32	0.10	0.27	0.06	0.03	<3m	<3m	N/A
18	9/12/2018 1:15	27.75	1.06	0.04	0.24	0.04	0.04	<3m	<3m	N/A
19	9/18/2018 0:00	15	1.04	0.07	0.49	0.04	0.02	<3m	<3m	N/A
20	9/19/2018 4:30	0.25	0.01	0.04	0.01	0.04	0.02	<3m	<3m	N/A
21	9/22/2018 2:00	1	0.11	0.11	0.11	0.00	0.00	<3m	<3m	N/A
22	9/25/2018 11:15	19.5	1.51	0.08	0.65	0.06	0.03	3-6m	<3m	N/A
23	9/26/2018 22:45	2.5	0.46	0.18	0.35	0.02	0.04	<3m	<3m	N/A
24	9/28/2018 5:45	5.25	0.54	0.10	0.33	0.02	0.02	<3m	<3m	N/A
25	9/29/2018 2:15	0.25	0.01	0.04	0.01	0.02	0.01	<3m	<3m	N/A
26	10/1/2018 16:45	38	0.94	0.02	0.24	0.03	0.02	<3m	<3m	N/A
27	10/7/2018 17:45	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
28	10/8/2018 15:30	2.25	0.02	0.01	0.01	0.00	0.00	<3m	<3m	N/A
29	10/11/2018 13:45	19.25	0.89	0.05	0.31	0.04	0.02	<3m	<3m	N/A
30	10/13/2018 7:00	5	0.16	0.03	0.04	0.01	0.02	<3m	<3m	N/A
31	10/15/2018 23:15	1.75	0.09	0.05	0.06	0.00	0.00	<3m	<3m	N/A
32	10/21/2018 7:00	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
33	10/23/2018 14:00	6.75	0.36	0.05	0.16	0.02	0.01	<3m	<3m	N/A
34	10/24/2018 10:30	2.25	0.04	0.02	0.03	0.02	0.01	<3m	<3m	N/A
35	10/27/2018 6:00	25.75	1.94	0.08	0.33	0.08	0.04	<3m	3m	N/A

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
36	10/29/2018 4:15	8	0.47	0.06	0.24	0.02	0.04	<3m	<3m	N/A
37	11/2/2018 3:15	31.25	1.82	0.06	0.59	0.07	0.04	3m	<3m	N/A
38	11/5/2018 18:00	26.5	1.18	0.04	0.2	0.05	0.02	<3m	<3m	N/A
39	11/9/2018 18:30	15.75	1.73	0.11	0.43	0.07	0.04	<3m	<3m	N/A
40	11/13/2018 0:45	12.75	1.03	0.08	0.16	0.04	0.02	<3m	<3m	N/A
41	11/16/2018 2:15	7.75	1.09	0.14	0.39	0.05	0.02	<3m	<3m	N/A
42	11/19/2018 4:00	38.25	0.53	0.01	0.08	0.02	0.01	<3m	<3m	N/A
43	11/25/2018 1:15	10.5	0.81	0.08	0.37	0.03	0.02	<3m	<3m	N/A
44	11/26/2018 17:00	17.25	1.61	0.09	0.2	0.07	0.04	<3m	<3m	N/A
45	12/2/2018 2:45	19	0.76	0.04	0.15	0.03	0.00	<3m	<3m	N/A
46	12/16/2018 11:30	17	0.73	0.04	0.2	0.03	0.02	<3m	<3m	N/A
47	12/21/2018 5:45	29.5	0.85	0.03	0.12	0.04	0.02	<3m	<3m	N/A
48	12/28/2018 7:15	11.75	0.35	0.03	0.1	0.01	0.01	<3m	<3m	N/A
49	12/31/2018 19:00	4.75	0.42	0.09	0.19	0.02	0.01	<3m	<3m	N/A

Rain Gauge 8: East Boston

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval [1]		
								1-hr	24-hr	48-hr
1	7/6/2018 10:30	1.75	0.37	0.21	0.33	0.02	0.01	<3m	<3m	N/A
2	7/11/2018 0:00	0.25	0.02	0.08	0.02	0.00	0.00	<3m	<3m	N/A
3	7/14/2018 21:45	5.5	0.29	0.05	0.23	0.01	0.01	<3m	<3m	N/A
4	7/17/2018 13:15	11.25	2.12	0.19	0.97	0.09	0.04	1 yr	3-6m	N/A
5	7/22/2018 4:00	31.75	0.3	0.01	0.07	0.01	0.01	<3m	<3m	N/A
6	7/25/2018 10:15	30.25	0.79	0.03	0.49	0.03	0.02	<3m	<3m	N/A
7	8/2/2018 18:45	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
8	8/3/2018 13:00	0.25	0.04	0.16	0.04	0.00	0.00	<3m	<3m	N/A
9	8/4/2018 9:45	2	0.59	0.30	0.49	0.03	0.01	<3m	<3m	N/A
10	8/8/2018 14:00	24.75	0.61	0.02	0.27	0.02	0.01	<3m	<3m	N/A
11	8/11/2018 8:00	38.25	2.23	0.06	0.76	0.09	0.05	6m-1yr	3-6m	N/A
12	8/13/2018 16:15	6.25	0.36	0.06	0.27	0.02	0.04	<3m	<3m	N/A
13	8/17/2018 16:15	10	0.33	0.03	0.3	0.01	0.01	<3m	<3m	N/A
14	8/18/2018 16:00	11.75	0.1	0.01	0.06	0.02	0.01	<3m	<3m	N/A
15	8/19/2018 21:30	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
16	8/22/2018 6:30	9	0.4	0.04	0.34	0.02	0.01	<3m	<3m	N/A
17	8/23/2018 4:45	0.25	0.01	0.04	0.01	0.02	0.01	<3m	<3m	N/A
18	9/6/2018 16:45	1.25	0.04	0.03	0.03	0.00	0.00	<3m	<3m	N/A
19	9/10/2018 16:45	13.25	1.3	0.10	0.23	0.05	0.03	<3m	<3m	N/A
20	9/12/2018 12:45	16.25	0.6	0.04	0.18	0.03	0.03	<3m	<3m	N/A
21	9/18/2018 1:45	12.75	1.41	0.11	0.9	0.06	0.03	1y	<3m	N/A
22	9/22/2018 2:00	0.5	0.02	0.04	0.02	0.00	0.00	<3m	<3m	N/A
23	9/25/2018 11:15	11.75	1.46	0.12	0.71	0.06	0.03	6m	<3m	N/A
24	9/26/2018 22:15	3.25	0.33	0.10	0.23	0.02	0.04	<3m	<3m	N/A
25	9/28/2018 5:45	5.75	0.34	0.06	0.12	0.01	0.01	<3m	<3m	N/A
26	10/1/2018 15:00	37	0.63	0.02	0.13	0.02	0.01	<3m	<3m	N/A
27	10/7/2018 15:15	4.5	0.09	0.02	0.04	0.00	0.00	<3m	<3m	N/A
28	10/8/2018 17:45	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
29	10/11/2018 13:30	18.75	0.68	0.04	0.27	0.03	0.01	<3m	<3m	N/A
30	10/13/2018 8:15	3.75	0.13	0.03	0.04	0.01	0.02	<3m	<3m	N/A
31	10/15/2018 9:30	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
32	10/15/2018 23:15	1.75	0.12	0.07	0.08	0.01	0.00	<3m	<3m	N/A
33	10/21/2018 7:00	0.5	0.02	0.04	0.02	0.00	0.00	<3m	<3m	N/A
34	10/23/2018 13:00	5.5	0.37	0.07	0.19	0.02	0.01	<3m	<3m	N/A
35	10/24/2018 11:00	4.25	0.05	0.01	0.02	0.02	0.01	<3m	<3m	N/A

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
36	10/27/2018 6:30	24.25	1.76	0.07	0.28	0.07	0.04	<3m	<3m	N/A
37	10/29/2018 3:30	10	0.56	0.06	0.3	0.02	0.04	<3m	<3m	N/A
38	11/2/2018 3:15	33.75	1.86	0.06	0.51	0.07	0.04	<3m	<3m	N/A
39	11/5/2018 18:00	26	1.19	0.05	0.16	0.05	0.02	<3m	<3m	N/A
40	11/9/2018 18:30	17	1.58	0.09	0.43	0.07	0.03	<3m	<3m	N/A
41	11/13/2018 1:30	12.5	1.19	0.10	0.19	0.05	0.02	<3m	<3m	N/A
42	11/15/2018 22:00	11.75	1.29	0.11	0.23	0.05	0.03	<3m	<3m	N/A
43	11/19/2018 2:30	39	0.71	0.02	0.09	0.02	0.01	<3m	<3m	N/A
44	11/25/2018 1:15	10.5	0.74	0.07	0.33	0.03	0.02	<3m	<3m	N/A
45	11/26/2018 7:45	22.5	1.62	0.07	0.19	0.07	0.04	<3m	<3m	N/A
46	12/2/2018 3:00	15.75	0.77	0.05	0.16	0.03	0.00	<3m	<3m	N/A
47	12/3/2018 6:45	0.25	0.01	0.04	0.01	0.02	0.02	<3m	<3m	N/A
48	12/16/2018 17:15	13.5	0.7	0.05	0.22	0.03	0.01	<3m	<3m	N/A
49	12/21/2018 6:00	18.5	0.59	0.03	0.1	0.02	0.01	<3m	<3m	N/A
50	12/28/2018 8:15	10.75	0.29	0.03	0.11	0.01	0.01	<3m	<3m	N/A
51	12/31/2018 19:15	4.5	0.33	0.07	0.17	0.02	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

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval [1]		
								1-hr	24-hr	48-hr
1	7/3/2018 21:15	5.75	0.18	0.03	0.17	0.01	0.00	<3m	<3m	N/A
2	7/6/2018 10:30	1.5	0.5	0.33	0.48	0.02	0.01	<3m	<3m	N/A
3	7/11/2018 0:45	12.25	0.41	0.03	0.19	0.02	0.01	<3m	<3m	N/A
4	7/16/2018 9:30	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
5	7/18/2018 7:15	3.75	0.19	0.05	0.1	0.01	0.00	<3m	<3m	N/A
6	7/22/2018 4:15	30.5	0.24	0.01	0.04	0.01	0.01	<3m	<3m	N/A
7	7/24/2018 10:00	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
8	7/25/2018 4:00	36.25	0.81	0.02	0.23	0.02	0.02	<3m	<3m	N/A
9	7/27/2018 5:15	0.25	0.01	0.04	0.01	0.01	0.02	<3m	<3m	N/A
10	8/3/2018 13:30	0.5	0.27	0.54	0.27	0.01	0.01	<3m	<3m	N/A
11	8/4/2018 9:30	1.75	0.45	0.26	0.34	0.03	0.02	<3m	<3m	N/A
12	8/8/2018 19:15	19	0.56	0.03	0.25	0.02	0.01	<3m	<3m	N/A
13	8/11/2018 7:30	41	1.33	0.03	0.73	0.05	0.03	6m	<3m	N/A
14	8/13/2018 17:00	5.75	0.27	0.05	0.2	0.01	0.01	<3m	<3m	N/A
15	8/14/2018 12:30	2	0.21	0.11	0.15	0.02	0.01	<3m	<3m	N/A
16	8/17/2018 16:45	30	0.65	0.02	0.32	0.03	0.01	<3m	<3m	N/A
17	8/19/2018 22:15	1.25	0.03	0.02	0.02	0.00	0.01	<3m	<3m	N/A
18	8/22/2018 6:30	8.5	0.78	0.09	0.68	0.03	0.02	3-6m	<3m	N/A
19	9/6/2018 16:00	2	0.06	0.03	0.03	0.00	0.00	<3m	<3m	N/A
20	9/10/2018 16:30	14	1.37	0.10	0.25	0.06	0.03	<3m	<3m	N/A
21	9/12/2018 6:30	22	0.46	0.02	0.18	0.02	0.03	<3m	<3m	N/A
22	9/16/2018 3:30	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
23	9/18/2018 0:30	12.75	1.84	0.14	1.12	0.08	0.04	2 yr	3m	N/A
24	9/19/2018 3:30	0.25	0.01	0.04	0.01	0.07	0.04	<3m	<3m	N/A
25	9/25/2018 8:00	15	1.48	0.10	0.29	0.06	0.03	<3m	<3m	N/A
26	9/26/2018 21:45	3.25	0.35	0.11	0.29	0.01	0.04	<3m	<3m	N/A
27	9/28/2018 4:30	9.25	0.32	0.03	0.15	0.01	0.01	<3m	<3m	N/A
28	9/29/2018 7:00	0.25	0.01	0.04	0.01	0.01	0.01	<3m	<3m	N/A
29	10/1/2018 15:00	41.75	0.76	0.02	0.2	0.03	0.02	<3m	<3m	N/A
30	10/7/2018 15:00	4.75	0.14	0.03	0.06	0.01	0.00	<3m	<3m	N/A
31	10/8/2018 17:45	4.25	0.02	0.00	0.01	0.00	0.00	<3m	<3m	N/A
32	10/11/2018 13:45	18.5	0.94	0.05	0.38	0.04	0.02	<3m	<3m	N/A
33	10/13/2018 7:00	4.75	0.13	0.03	0.05	0.01	0.02	<3m	<3m	N/A
34	10/14/2018 1:30	0.25	0.01	0.04	0.01	0.01	0.00	<3m	<3m	N/A
35	10/15/2018 6:15	18.75	0.13	0.01	0.06	0.01	0.00	<3m	<3m	N/A
36	10/21/2018 6:45	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
37	10/23/2018 16:45	1.25	0.14	0.11	0.13	0.01	0.00	<3m	<3m	N/A
38	10/24/2018 9:00	6.25	0.04	0.01	0.01	0.01	0.00	<3m	<3m	N/A
39	10/27/2018 6:30	25	1.49	0.06	0.21	0.06	0.03	<3m	<3m	N/A
40	10/29/2018 3:30	10.75	0.54	0.05	0.29	0.02	0.04	<3m	<3m	N/A
41	11/1/2018 9:15	0.5	0.02	0.04	0.02	0.00	0.00	<3m	<3m	N/A
42	11/2/2018 0:15	33.25	2.04	0.06	0.45	0.08	0.04	<3m	3m	N/A
43	11/5/2018 17:15	35.25	0.84	0.02	0.11	0.03	0.02	<3m	<3m	N/A
44	11/9/2018 19:00	15	1.38	0.09	0.38	0.06	0.03	<3m	<3m	N/A
45	11/13/2018 1:30	12.25	1.19	0.10	0.19	0.05	0.02	<3m	<3m	N/A
46	11/16/2018 3:30	7.25	1.15	0.16	0.38	0.05	0.02	<3m	<3m	N/A
47	11/19/2018 2:45	39.25	0.9	0.02	0.1	0.02	0.02	<3m	<3m	N/A
48	11/21/2018 9:15	0.25	0.03	0.12	0.03	0.01	0.01	<3m	<3m	N/A
49	11/25/2018 1:30	10	0.49	0.05	0.2	0.02	0.01	<3m	<3m	N/A
50	11/26/2018 9:15	25.25	1.77	0.07	0.19	0.07	0.04	<3m	<3m	N/A
51	12/2/2018 2:45	24.75	0.81	0.03	0.13	0.03	0.02	<3m	<3m	N/A
52	12/16/2018 12:15	20.5	0.68	0.03	0.21	0.03	0.01	<3m	<3m	N/A
53	12/21/2018 6:00	29.25	0.88	0.03	0.16	0.04	0.02	<3m	<3m	N/A
54	12/28/2018 6:45	12.25	0.36	0.03	0.12	0.02	0.01	<3m	<3m	N/A
55	12/31/2018 19:30	4.25	0.35	0.08	0.19	0.02	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 10: Hyde Park

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
1	7/6/2018 10:15	2.75	0.61	0.22	0.39	0.03	0.01	<3m	<3m	N/A
2	7/10/2018 23:45	4.75	0.56	0.12	0.37	0.02	0.01	<3m	<3m	N/A
3	7/17/2018 13:30	12.75	1.58	0.12	1.02	0.07	0.03	1.5 yr	<3m	N/A
4	7/22/2018 3:45	35	0.23	0.01	0.08	0.01	0.00	<3m	<3m	N/A
5	7/24/2018 9:30	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
6	7/25/2018 10:15	16.25	0.16	0.01	0.06	0.01	0.00	<3m	<3m	N/A
7	7/26/2018 14:45	13.5	0.41	0.03	0.38	0.02	0.01	<3m	<3m	N/A
8	8/3/2018 12:30	0.5	0.61	1.22	0.61	0.03	0.01	3-6m	<3m	N/A
9	8/4/2018 9:30	3.5	1.61	0.46	1.11	0.09	0.05	1.5 yr	3-6m	N/A
10	8/8/2018 13:30	16.75	0.38	0.02	0.1	0.02	0.01	<3m	<3m	N/A
11	8/11/2018 7:45	38.75	0.76	0.02	0.36	0.03	0.02	<3m	<3m	N/A
12	8/13/2018 16:30	12.5	0.17	0.01	0.1	0.01	0.01	<3m	<3m	N/A
13	8/17/2018 15:30	9.75	0.05	0.01	0.04	0.00	0.00	<3m	<3m	N/A
14	8/18/2018 14:15	9.75	0.3	0.03	0.18	0.01	0.01	<3m	<3m	N/A
15	8/19/2018 21:30	0.25	0.01	0.04	0.01	0.00	0.01	<3m	<3m	N/A
16	8/22/2018 6:15	9.75	0.45	0.05	0.3	0.02	0.01	<3m	<3m	N/A
17	9/6/2018 15:45	2	0.6	0.30	0.57	0.03	0.01	3m	<3m	N/A
18	9/10/2018 16:00	13.5	1.27	0.09	0.29	0.05	0.03	<3m	<3m	N/A
19	9/12/2018 1:30	27.25	1.02	0.04	0.22	0.04	0.04	<3m	<3m	N/A
20	9/16/2018 5:30	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
21	9/18/2018 0:30	14	1.29	0.09	0.52	0.05	0.03	<3m	<3m	N/A
22	9/19/2018 4:00	1.25	0.02	0.02	0.01	0.05	0.03	<3m	<3m	N/A
23	9/22/2018 2:00	4.75	0.1	0.02	0.09	0.00	0.00	<3m	<3m	N/A
24	9/25/2018 11:00	19.5	1.62	0.08	0.69	0.07	0.03	6m	<3m	N/A
25	9/26/2018 22:30	2.5	0.5	0.20	0.35	0.02	0.04	<3m	<3m	N/A
26	9/28/2018 5:30	5.75	0.58	0.10	0.31	0.02	0.02	<3m	<3m	N/A
27	9/29/2018 3:30	0.25	0.01	0.04	0.01	0.02	0.01	<3m	<3m	N/A
28	10/1/2018 16:45	35	1.05	0.03	0.27	0.04	0.02	<3m	<3m	N/A
29	10/7/2018 15:30	3.75	0.02	0.01	0.01	0.00	0.00	<3m	<3m	N/A
30	10/8/2018 16:15	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
31	10/11/2018 13:15	19.75	0.9	0.05	0.34	0.04	0.02	<3m	<3m	N/A
32	10/13/2018 7:00	5.25	0.17	0.03	0.05	0.01	0.02	<3m	<3m	N/A
33	10/15/2018 8:15	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
34	10/15/2018 23:15	3.75	0.12	0.03	0.09	0.01	0.00	<3m	<3m	N/A
35	10/17/2018 16:00	0.5	0.02	0.04	0.02	0.00	0.00	<3m	<3m	N/A

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
36	10/21/2018 7:00	0.5	0.02	0.04	0.02	0.00	0.00	<3m	<3m	N/A
37	10/23/2018 14:00	4.25	0.32	0.08	0.16	0.01	0.01	<3m	<3m	N/A
38	10/24/2018 9:45	3	0.02	0.01	0.01	0.01	0.01	<3m	<3m	N/A
39	10/27/2018 5:30	25.25	1.95	0.08	0.31	0.08	0.04	<3m	3m	N/A
40	11/2/2018 3:15	33.75	1.82	0.05	0.62	0.07	0.04	3-6m	<3m	N/A
41	11/5/2018 18:00	26.25	1.23	0.05	0.2	0.05	0.03	<3m	<3m	N/A
42	11/9/2018 18:15	16	1.56	0.10	0.42	0.07	0.03	<3m	<3m	N/A
43	11/13/2018 0:45	13	1.03	0.08	0.13	0.04	0.02	<3m	<3m	N/A
44	11/16/2018 3:15	6.5	1.15	0.18	0.37	0.05	0.02	<3m	<3m	N/A
45	11/19/2018 3:45	38.25	0.52	0.01	0.1	0.02	0.01	<3m	<3m	N/A
46	11/25/2018 1:15	10.5	0.8	0.08	0.34	0.03	0.02	<3m	<3m	N/A
47	11/26/2018 9:15	22.5	1.5	0.07	0.21	0.06	0.04	<3m	<3m	N/A
48	10/29/2018 3:15	9	0.54	0.06	0.26	0.02	0.04	<3m	<3m	N/A
49	12/2/2018 3:00	18.75	0.8	0.04	0.2	0.03	0.00	<3m	<3m	N/A
50	12/15/2018 7:00	0.5	0.02	0.04	0.02	0.00	0.00	<3m	<3m	N/A
51	12/16/2018 11:00	17.25	0.73	0.04	0.21	0.03	0.02	<3m	<3m	N/A
52	12/21/2018 5:30	29.75	0.99	0.03	0.16	0.04	0.02	<3m	<3m	N/A
53	12/28/2018 7:30	12	0.36	0.03	0.11	0.02	0.01	<3m	<3m	N/A
54	12/31/2018 19:45	4	0.43	0.11	0.18	0.02	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	7/3/2018 21:15	5.75	0.18	0.03	0.17	0.01	0.00	<3m	<3m	N/A
2	7/6/2018 10:30	1.5	0.5	0.33	0.48	0.02	0.01	<3m	<3m	N/A
3	7/11/2018 0:45	12.25	0.41	0.03	0.19	0.02	0.01	<3m	<3m	N/A
4	7/16/2018 9:30	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
5	7/18/2018 7:15	3.75	0.19	0.05	0.1	0.01	0.00	<3m	<3m	N/A
6	7/22/2018 4:15	30.5	0.24	0.01	0.04	0.01	0.01	<3m	<3m	N/A
7	7/24/2018 10:00	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
8	7/25/2018 4:00	36.25	0.81	0.02	0.23	0.02	0.02	<3m	<3m	N/A
9	7/27/2018 5:15	0.25	0.01	0.04	0.01	0.01	0.02	<3m	<3m	N/A
10	8/3/2018 13:30	0.5	0.27	0.54	0.27	0.01	0.01	<3m	<3m	N/A
11	8/4/2018 9:30	1.75	0.45	0.26	0.34	0.03	0.02	<3m	<3m	N/A
12	8/8/2018 19:15	19	0.56	0.03	0.25	0.02	0.01	<3m	<3m	N/A
13	8/11/2018 7:30	41	1.33	0.03	0.73	0.05	0.03	6m	<3m	N/A
14	8/13/2018 17:00	5.75	0.27	0.05	0.2	0.01	0.01	<3m	<3m	N/A
15	8/14/2018 12:30	2	0.21	0.11	0.15	0.02	0.01	<3m	<3m	N/A
16	8/17/2018 16:45	30	0.65	0.02	0.32	0.03	0.01	<3m	<3m	N/A
17	8/19/2018 22:15	1.25	0.03	0.02	0.02	0.00	0.01	<3m	<3m	N/A
18	8/22/2018 6:30	8.5	0.78	0.09	0.68	0.03	0.02	3-6m	<3m	N/A
19	9/6/2018 16:00	2	0.06	0.03	0.03	0.00	0.00	<3m	<3m	N/A
20	9/10/2018 16:30	14	1.37	0.10	0.25	0.06	0.03	<3m	<3m	N/A
21	9/12/2018 6:30	22	0.46	0.02	0.18	0.02	0.03	<3m	<3m	N/A
22	9/16/2018 3:30	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
23	9/18/2018 0:30	12.75	1.84	0.14	1.12	0.08	0.04	2 yr	3m	N/A
24	9/19/2018 3:30	0.25	0.01	0.04	0.01	0.07	0.04	<3m	<3m	N/A
25	9/25/2018 8:00	15	1.48	0.10	0.29	0.06	0.03	<3m	<3m	N/A
26	9/26/2018 21:45	3.25	0.35	0.11	0.29	0.01	0.04	<3m	<3m	N/A
27	9/28/2018 4:30	9.25	0.32	0.03	0.15	0.01	0.01	<3m	<3m	N/A
28	9/29/2018 7:00	0.25	0.01	0.04	0.01	0.01	0.01	<3m	<3m	N/A
29	10/1/2018 15:00	41.75	0.76	0.02	0.2	0.03	0.02	<3m	<3m	N/A
30	10/7/2018 15:00	4.75	0.14	0.03	0.06	0.01	0.00	<3m	<3m	N/A
31	10/8/2018 17:45	4.25	0.02	0.00	0.01	0.00	0.00	<3m	<3m	N/A
32	10/11/2018 13:45	18.5	0.94	0.05	0.38	0.04	0.02	<3m	<3m	N/A
33	10/13/2018 7:00	4.75	0.13	0.03	0.05	0.01	0.02	<3m	<3m	N/A
34	10/14/2018 1:30	0.25	0.01	0.04	0.01	0.01	0.00	<3m	<3m	N/A
35	10/15/2018 6:15	18.75	0.13	0.01	0.06	0.01	0.00	<3m	<3m	N/A
36	10/21/2018 6:45	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
37	10/23/2018 16:45	1.25	0.14	0.11	0.13	0.01	0.00	<3m	<3m	N/A
38	10/24/2018 9:00	6.25	0.04	0.01	0.01	0.01	0.01	<3m	<3m	N/A
39	10/27/2018 6:30	25	1.49	0.06	0.21	0.07	0.03	<3m	<3m	N/A
40	10/29/2018 3:30	10.75	0.54	0.05	0.29	0.03	0.04	<3m	<3m	N/A
41	11/1/2018 9:15	0.5	0.02	0.04	0.02	0.00	0.00	<3m	<3m	N/A
42	11/2/2018 0:15	33.25	2.04	0.06	0.45	0.08	0.04	<3m	3m	N/A
43	11/5/2018 17:15	35.25	0.84	0.02	0.11	0.03	0.02	<3m	<3m	N/A
44	11/9/2018 19:00	15	1.38	0.09	0.38	0.06	0.03	<3m	<3m	N/A
45	11/13/2018 1:30	12.25	1.19	0.10	0.19	0.05	0.02	<3m	<3m	N/A
46	11/16/2018 3:30	7.25	1.15	0.16	0.38	0.05	0.02	<3m	<3m	N/A
47	11/19/2018 2:45	39.25	0.9	0.02	0.1	0.02	0.02	<3m	<3m	N/A
48	11/21/2018 9:15	0.25	0.03	0.12	0.03	0.01	0.01	<3m	<3m	N/A
49	11/25/2018 1:30	10	0.49	0.05	0.2	0.02	0.01	<3m	<3m	N/A
50	11/26/2018 9:15	25.25	1.77	0.07	0.19	0.07	0.04	<3m	<3m	N/A
51	12/2/2018 2:45	24.75	0.81	0.03	0.13	0.03	0.02	<3m	<3m	N/A
52	12/16/2018 12:15	20.5	0.68	0.03	0.21	0.03	0.01	<3m	<3m	N/A
53	12/21/2018 6:00	29.25	0.88	0.03	0.16	0.04	0.02	<3m	<3m	N/A
54	12/28/2018 6:45	12.25	0.36	0.03	0.12	0.02	0.01	<3m	<3m	N/A
55	12/31/2018 19:30	4.25	0.35	0.08	0.19	0.02	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 12: Longwood

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval [(1)]		
								1-hr	24-hr	48-hr
1	7/6/2018 10:30	1.5	0.36	0.24	0.27	0.02	0.01	<3m	<3m	N/A
2	7/11/2018 0:00	2	0.1	0.05	0.09	0.00	0.00	<3m	<3m	N/A
3	7/14/2018 22:45	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
4	7/17/2018 13:15	13	1.79	0.14	0.83	0.07	0.04	6m-1yr	3m	N/A
5	7/22/2018 4:00	33	0.39	0.01	0.12	0.01	0.01	<3m	<3m	N/A
6	7/25/2018 13:45	26.5	0.67	0.03	0.36	0.02	0.01	<3m	<3m	N/A
7	8/2/2018 18:30	0.25	0.02	0.08	0.02	0.00	0.00	<3m	<3m	N/A
8	8/3/2018 12:45	0.5	0.15	0.30	0.15	0.01	0.00	<3m	<3m	N/A
9	8/4/2018 9:30	3.75	0.53	0.14	0.4	0.03	0.01	<3m	<3m	N/A
10	8/8/2018 13:45	16	0.55	0.03	0.23	0.02	0.01	<3m	<3m	N/A
11	8/11/2018 10:30	5	0.42	0.08	0.32	0.02	0.01	<3m	<3m	N/A
12	8/12/2018 4:00	17.5	1.59	0.09	1.07	0.08	0.04	1.5 yr	3m	N/A
13	8/13/2018 17:00	4	0.27	0.07	0.21	0.01	0.04	<3m	<3m	N/A
14	8/14/2018 12:30	0.25	0.16	0.64	0.16	0.02	0.01	<3m	<3m	N/A
15	8/17/2018 16:00	9	0.2	0.02	0.14	0.01	0.00	<3m	<3m	N/A
16	8/18/2018 15:45	7.5	0.15	0.02	0.07	0.01	0.01	<3m	<3m	N/A
17	8/19/2018 21:30	1.5	0.02	0.01	0.01	0.00	0.00	<3m	<3m	N/A
18	8/22/2018 6:45	8.75	0.4	0.05	0.35	0.02	0.01	<3m	<3m	N/A
19	9/6/2018 15:45	2	0.1	0.05	0.08	0.00	0.00	<3m	<3m	N/A
20	9/7/2018 7:15	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
21	9/10/2018 16:30	12.75	1.23	0.10	0.29	0.05	0.03	<3m	<3m	N/A
22	9/12/2018 1:45	27.25	0.65	0.02	0.25	0.03	0.03	<3m	<3m	N/A
23	9/18/2018 1:30	12.75	1.14	0.09	0.69	0.05	0.02	6m	<3m	N/A
24	9/22/2018 2:00	0.5	0.04	0.08	0.04	0.00	0.00	<3m	<3m	N/A
25	9/25/2018 11:15	12	1.64	0.14	0.7	0.07	0.03	6m	<3m	N/A
26	9/26/2018 22:15	2.25	0.29	0.13	0.21	0.01	0.04	<3m	<3m	N/A
27	9/28/2018 5:45	5.75	0.38	0.07	0.13	0.02	0.01	<3m	<3m	N/A
28	10/1/2018 16:00	35.75	0.62	0.02	0.14	0.02	0.01	<3m	<3m	N/A
29	10/7/2018 17:00	2	0.03	0.02	0.02	0.00	0.00	<3m	<3m	N/A
30	10/8/2018 17:00	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
31	10/11/2018 13:30	19.25	0.61	0.03	0.26	0.03	0.01	<3m	<3m	N/A
32	10/13/2018 8:15	3.5	0.12	0.03	0.04	0.01	0.02	<3m	<3m	N/A
33	10/15/2018 23:15	1.5	0.1	0.07	0.07	0.00	0.00	<3m	<3m	N/A
34	10/21/2018 7:00	0.5	0.02	0.04	0.02	0.00	0.00	<3m	<3m	N/A
35	10/23/2018 13:00	5	0.24	0.05	0.13	0.01	0.01	<3m	<3m	N/A

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
36	10/24/2018 9:15	3	0.04	0.01	0.02	0.01	0.01	<3m	<3m	N/A
37	10/27/2018 5:45	25	1.67	0.07	0.27	0.07	0.03	<3m	<3m	N/A
38	10/29/2018 4:00	8.75	0.78	0.09	0.34	0.03	0.04	<3m	<3m	N/A
39	11/1/2018 8:00	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
40	11/2/2018 3:15	35	1.9	0.05	0.47	0.07	0.04	<3m	3m	N/A
41	11/5/2018 17:45	26.25	1.12	0.04	0.17	0.04	0.02	<3m	<3m	N/A
42	11/9/2018 18:30	15.75	1.51	0.10	0.42	0.06	0.03	<3m	<3m	N/A
43	11/13/2018 1:00	12.75	1.14	0.09	0.17	0.05	0.02	<3m	<3m	N/A
44	11/16/2018 1:45	8	1.18	0.15	0.5	0.05	0.02	<3m	<3m	N/A
45	11/19/2018 2:30	40	0.59	0.01	0.09	0.02	0.01	<3m	<3m	N/A
46	11/25/2018 1:15	10.5	0.76	0.07	0.37	0.03	0.02	<3m	<3m	N/A
47	11/26/2018 9:45	21.5	1.62	0.08	0.2	0.07	0.04	<3m	<3m	N/A
48	12/2/2018 2:45	14	0.72	0.05	0.15	0.03	0.00	<3m	<3m	N/A
49	12/3/2018 7:45	0.25	0.01	0.04	0.01	0.02	0.02	<3m	<3m	N/A
50	12/16/2018 11:30	16.25	0.67	0.04	0.2	0.03	0.01	<3m	<3m	N/A
51	12/21/2018 5:45	18.75	0.8	0.04	0.13	0.03	0.02	<3m	<3m	N/A
52	12/28/2018 8:00	11	0.33	0.03	0.11	0.01	0.01	<3m	<3m	N/A
53	12/31/2018 19:45	4	0.4	0.10	0.18	0.02	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 13: Hayes Pump Station

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval [1]		
								1-hr	24-hr	48-hr
1	7/6/2018 10:45	1.25	0.23	0.18	0.22	0.01	0.00	<3m	<3m	N/A
2	7/14/2018 21:15	6.25	0.36	0.06	0.29	0.02	0.01	<3m	<3m	N/A
3	7/17/2018 12:45	8.5	1.76	0.21	1.03	0.07	0.04	1.5 yr	<3m	N/A
4	7/22/2018 4:30	32.25	0.47	0.01	0.16	0.02	0.01	<3m	<3m	N/A
5	7/25/2018 2:30	38.25	0.57	0.01	0.22	0.02	0.01	<3m	<3m	N/A
6	8/3/2018 13:30	0.75	0.1	0.13	0.1	0.00	0.00	<3m	<3m	N/A
7	8/4/2018 9:30	4	0.32	0.08	0.21	0.02	0.01	<3m	<3m	N/A
8	8/8/2018 19:30	18.75	0.21	0.01	0.09	0.01	0.00	<3m	<3m	N/A
9	8/11/2018 11:15	24.25	2.62	0.11	1.31	0.11	0.05	3 yr	6m-1yr	N/A
10	8/13/2018 17:30	6.5	0.2	0.03	0.1	0.01	0.04	<3m	<3m	N/A
11	8/14/2018 13:00	6.5	0.46	0.07	0.3	0.03	0.01	<3m	<3m	N/A
12	8/17/2018 17:30	23.75	0.74	0.03	0.55	0.03	0.02	3m	<3m	N/A
13	8/22/2018 7:15	8.25	0.95	0.12	0.61	0.04	0.02	3-6m	<3m	N/A
14	9/6/2018 16:15	2	0.08	0.04	0.05	0.00	0.00	<3m	<3m	N/A
15	9/10/2018 17:00	12	1.33	0.11	0.3	0.06	0.03	<3m	<3m	N/A
16	9/12/2018 8:30	27.75	0.4	0.01	0.24	0.02	0.03	<3m	<3m	N/A
17	9/18/2018 0:00	13.25	1.96	0.15	1.22	0.08	0.04	2 yr	3m	N/A
18	9/25/2018 11:45	11	1.26	0.11	0.42	0.05	0.03	<3m	<3m	N/A
19	9/26/2018 21:30	3.5	0.46	0.13	0.34	0.02	0.04	<3m	<3m	N/A
20	9/28/2018 7:00	4.25	0.1	0.02	0.05	0.00	0.01	<3m	<3m	N/A
21	10/2/2018 2:00	1.25	0.11	0.09	0.1	0.00	0.00	<3m	<3m	N/A
22	10/2/2018 17:00	8.75	0.31	0.04	0.18	0.02	0.01	<3m	<3m	N/A
23	10/11/2018 14:00	5.25	0.87	0.17	0.38	0.04	0.02	<3m	<3m	N/A
24	10/13/2018 7:45	4.25	0.11	0.03	0.05	0.00	0.02	<3m	<3m	N/A
25	10/15/2018 22:45	2	0.1	0.05	0.06	0.00	0.00	<3m	<3m	N/A
26	10/17/2018 15:45	0.25	0.02	0.08	0.02	0.00	0.00	<3m	<3m	N/A
27	10/21/2018 7:00	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
28	10/23/2018 17:30	0.5	0.23	0.46	0.23	0.01	0.00	<3m	<3m	N/A
29	10/24/2018 10:45	4.25	0.03	0.01	0.02	0.01	0.01	<3m	<3m	N/A
30	10/27/2018 6:45	25	1.27	0.05	0.19	0.05	0.03	<3m	<3m	N/A
31	10/29/2018 3:00	6.75	0.64	0.09	0.34	0.03	0.04	<3m	<3m	N/A
32	11/1/2018 9:00	0.75	0.04	0.05	0.04	0.00	0.00	<3m	<3m	N/A
33	11/2/2018 3:15	30.5	1.88	0.06	0.44	0.07	0.04	<3m	3m	N/A
34	11/5/2018 17:15	26.75	0.79	0.03	0.1	0.03	0.02	<3m	<3m	N/A

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
35	11/9/2018 19:15	15.5	1.31	0.08	0.35	0.05	0.03	<3m	<3m	N/A
36	11/13/2018 1:30	12.25	1.34	0.11	0.24	0.06	0.03	<3m	<3m	N/A
37	11/16/2018 5:00	10.5	1.28	0.12	0.31	0.05	0.03	<3m	<3m	N/A
38	11/19/2018 2:45	55.25	0.98	0.02	0.11	0.03	0.02	<3m	<3m	N/A
39	11/25/2018 1:30	61.25	2.38	0.04	0.22	0.08	0.05	<3m	3m	N/A
40	12/2/2018 3:15	13.75	0.76	0.06	0.11	0.03	0.00	<3m	<3m	N/A
41	12/16/2018 18:00	10.75	0.6	0.06	0.19	0.03	0.01	<3m	<3m	N/A
42	12/21/2018 6:15	18.5	0.67	0.04	0.16	0.03	0.01	<3m	<3m	N/A
43	12/28/2018 6:15	11.5	0.38	0.03	0.12	0.02	0.01	<3m	<3m	N/A
44	12/31/2018 19:15	4.5	0.3	0.07	0.13	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.

AECOM Imagine it. Delivered.

Rain Gauge 14: Roslindale

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
1	7/6/2018 10:15	2.75	0.5	0.18	0.35	0.02	0.01	<3m	<3m	N/A
2	7/11/2018 0:00	5.25	0.86	0.16	0.51	0.04	0.02	<3m	<3m	N/A
3	7/17/2018 13:30	13	2.13	0.16	1.08	0.09	0.04	1.5 yr	3-6m	N/A
4	7/22/2018 3:45	33.25	0.28	0.01	0.09	0.01	0.01	<3m	<3m	N/A
5	7/25/2018 13:45	26.75	0.81	0.03	0.5	0.03	0.02	<3m	<3m	N/A
6	8/3/2018 12:30	1.25	0.22	0.18	0.21	0.01	0.00	<3m	<3m	N/A
7	8/4/2018 9:30	3.5	0.93	0.27	0.58	0.05	0.02	3m	<3m	N/A
8	8/8/2018 13:30	25.25	1.38	0.05	0.72	0.06	0.03	6m	<3m	N/A
9	8/11/2018 7:30	41.75	0.98	0.02	0.44	0.04	0.02	<3m	<3m	N/A
10	8/13/2018 17:00	9.75	0.21	0.02	0.15	0.01	0.02	<3m	<3m	N/A
11	8/17/2018 15:45	9.25	0.12	0.01	0.09	0.01	0.00	<3m	<3m	N/A
12	8/18/2018 14:15	9.25	0.13	0.01	0.06	0.01	0.01	<3m	<3m	N/A
13	8/22/2018 6:15	9.25	0.47	0.05	0.34	0.02	0.01	<3m	<3m	N/A
14	9/6/2018 15:45	3.75	0.59	0.16	0.55	0.02	0.01	3m	<3m	N/A
15	9/10/2018 16:15	12.75	1.28	0.10	0.31	0.05	0.03	<3m	<3m	N/A
16	9/12/2018 1:30	27.5	0.91	0.03	0.24	0.04	0.03	<3m	<3m	N/A
17	9/18/2018 0:00	14.5	1.06	0.07	0.5	0.04	0.02	<3m	<3m	N/A
18	9/19/2018 4:00	1	0.02	0.02	0.02	0.04	0.02	<3m	<3m	N/A
19	9/22/2018 1:45	0.75	0.12	0.16	0.12	0.01	0.00	<3m	<3m	N/A
20	9/25/2018 11:00	19.5	1.82	0.09	0.9	0.08	0.04	1y	3m	N/A
21	9/26/2018 22:30	2.25	0.4	0.18	0.26	0.02	0.05	<3m	<3m	N/A
22	9/28/2018 5:30	7.75	0.51	0.07	0.26	0.02	0.02	<3m	<3m	N/A
23	10/1/2018 18:00	38	0.9	0.02	0.2	0.03	0.02	<3m	<3m	N/A
24	10/7/2018 19:00	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
25	10/8/2018 16:15	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
26	10/11/2018 13:15	19.5	0.87	0.04	0.31	0.04	0.02	<3m	<3m	N/A
27	10/13/2018 7:15	5	0.18	0.04	0.05	0.01	0.02	<3m	<3m	N/A
28	10/15/2018 23:15	1.5	0.12	0.08	0.1	0.01	0.00	<3m	<3m	N/A
29	10/18/2018 1:00	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
30	10/21/2018 6:45	0.75	0.03	0.04	0.03	0.00	0.00	<3m	<3m	N/A
31	10/23/2018 13:00	5.25	0.26	0.05	0.13	0.01	0.01	<3m	<3m	N/A
32	10/24/2018 9:45	3.25	0.03	0.01	0.02	0.01	0.01	<3m	<3m	N/A
33	10/27/2018 6:00	25	2.13	0.09	0.34	0.09	0.04	<3m	3-6m	N/A
34	10/29/2018 4:00	10.75	0.5	0.05	0.31	0.02	0.05	<3m	<3m	N/A
35	11/2/2018 3:15	33.75	1.78	0.05	0.51	0.07	0.04	<3m	<3m	N/A
36	11/5/2018 17:45	29.5	1.24	0.04	0.19	0.05	0.03	<3m	<3m	N/A

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
37	11/9/2018 18:15	16	1.65	0.10	0.45	0.07	0.03	<3m	<3m	N/A
38	11/13/2018 0:45	13	1.16	0.09	0.17	0.05	0.02	<3m	<3m	N/A
39	11/16/2018 3:30	6.25	1.19	0.19	0.35	0.05	0.02	<3m	<3m	N/A
40	11/19/2018 3:00	39.25	0.57	0.01	0.08	0.02	0.01	<3m	<3m	N/A
41	11/25/2018 1:15	10.5	0.84	0.08	0.37	0.04	0.02	<3m	<3m	N/A
42	11/26/2018 17:15	16.5	1.68	0.10	0.22	0.07	0.05	<3m	<3m	N/A
43	12/2/2018 2:45	19.75	0.79	0.04	0.17	0.03	0.00	<3m	<3m	N/A
44	12/15/2018 8:00	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
45	12/16/2018 11:00	17.25	0.75	0.04	0.23	0.03	0.02	<3m	<3m	N/A
46	12/21/2018 5:45	29.5	0.97	0.03	0.14	0.04	0.02	<3m	<3m	N/A
47	12/28/2018 7:30	23.25	0.37	0.02	0.1	0.02	0.01	<3m	<3m	N/A
48	12/31/2018 19:45	4	0.43	0.11	0.19	0.02	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	7/6/2018 10:30	1.75	0.32	0.18	0.22	0.01	0.00	<3m	<3m	N/A
2	7/11/2018 0:00	4.75	0.42	0.09	0.31	0.02	0.00	<3m	<3m	N/A
3	7/14/2018 21:15	1.75	0.02	0.01	0.01	0.00	0.00	<3m	<3m	N/A
4	7/17/2018 13:00	13.75	2.21	0.16	0.94	0.09	0.00	1 yr	3-6m	N/A
5	7/22/2018 4:00	33.5	0.42	0.01	0.13	0.01	0.00	<3m	<3m	N/A
6	7/25/2018 13:45	27	0.89	0.03	0.22	0.01	0.00	<3m	<3m	N/A
7	8/3/2018 12:45	2.25	0.17	0.08	0.16	0.01	0.00	<3m	<3m	N/A
8	8/4/2018 9:45	3.5	0.78	0.22	0.6	0.04	0.00	3m	<3m	N/A
9	8/8/2018 13:45	25.25	1.05	0.04	0.54	0.04	0.00	3m	<3m	N/A
10	8/11/2018 8:00	37.25	1.65	0.04	0.89	0.06	0.00	1y	<3m	N/A
11	8/13/2018 16:45	13.5	0.32	0.02	0.23	0.01	0.00	<3m	<3m	N/A
12	8/17/2018 15:45	9.5	0.15	0.02	0.09	0.01	0.00	<3m	<3m	N/A
13	8/18/2018 15:45	15.5	0.19	0.01	0.07	0.01	0.00	<3m	<3m	N/A
14	8/22/2018 6:30	9	0.46	0.05	0.35	0.02	0.00	<3m	<3m	N/A
15	9/6/2018 15:30	2.25	0.17	0.08	0.13	0.01	0.00	<3m	<3m	N/A
16	9/10/2018 16:15	12.75	1.3	0.10	0.29	0.05	0.03	<3m	<3m	N/A
17	9/12/2018 1:45	27	0.87	0.03	0.2	0.04	0.04	<3m	<3m	N/A
18	9/18/2018 0:15	14.25	1.13	0.08	0.56	0.05	0.02	3m	<3m	N/A
19	9/19/2018 4:15	0.25	0.01	0.04	0.01	0.05	0.02	<3m	<3m	N/A
20	9/22/2018 1:45	0.75	0.07	0.09	0.07	0.00	0.00	<3m	<3m	N/A
21	9/25/2018 10:45	19.75	1.64	0.08	0.79	0.07	0.03	6m-1yr	<3m	N/A
22	9/26/2018 22:15	2.5	0.43	0.17	0.28	0.02	0.04	<3m	<3m	N/A
23	9/28/2018 5:30	6.25	0.48	0.08	0.21	0.02	0.02	<3m	<3m	N/A
24	10/1/2018 16:30	43.5	0.82	0.02	0.19	0.03	0.02	<3m	<3m	N/A
25	10/8/2018 15:00	2	0.02	0.01	0.01	0.00	0.00	<3m	<3m	N/A
26	10/11/2018 13:30	19.25	0.8	0.04	0.3	0.03	0.02	<3m	<3m	N/A
27	10/13/2018 7:15	5.25	0.15	0.03	0.05	0.01	0.02	<3m	<3m	N/A
28	10/15/2018 23:15	1.75	0.15	0.09	0.12	0.01	0.00	<3m	<3m	N/A
29	10/21/2018 7:00	0.5	0.02	0.04	0.02	0.00	0.00	<3m	<3m	N/A
30	10/23/2018 13:00	5.25	0.34	0.06	0.17	0.01	0.01	<3m	<3m	N/A
31	10/24/2018 10:15	2.5	0.04	0.02	0.02	0.02	0.01	<3m	<3m	N/A
32	10/27/2018 6:00	25.5	1.94	0.08	0.32	0.08	0.04	<3m	3m	N/A
33	10/29/2018 4:15	8.5	0.5	0.06	0.33	0.02	0.05	<3m	<3m	N/A
34	11/1/2018 8:00	0.25	0.01	0.04	0.00	0.01	0.00	0.00	<3m	<3m
35	11/2/2018 3:15	1.25	0.12	0.10	0.01	0.11	0.01	0.00	<3m	<3m

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
36	11/2/2018 16:30	17.25	1.71	0.10	0.07	0.53	0.07	0.04	3m	<3m
37	11/5/2018 17:45	26.75	1.29	0.05	0.05	0.19	0.05	0.03	<3m	<3m
38	11/9/2018 18:30	19	1.71	0.09	0.07	0.48	0.07	0.04	<3m	<3m
39	11/13/2018 0:45	12.75	1.16	0.09	0.05	0.18	0.05	0.02	<3m	<3m
40	11/16/2018 2:45	7	1.25	0.18	0.05	0.35	0.05	0.03	<3m	<3m
41	11/19/2018 2:45	39.5	0.63	0.02	0.02	0.09	0.02	0.01	<3m	<3m
42	11/25/2018 1:15	10.5	0.81	0.08	0.03	0.37	0.03	0.02	<3m	<3m
43	11/26/2018 17:00	17.25	1.61	0.09	0.07	0.2	0.07	0.04	<3m	<3m
44	12/2/2018 2:45	19	0.76	0.04	0.15	0.03	0.00	<3m	<3m	N/A
45	12/16/2018 11:30	17	0.73	0.04	0.2	0.03	0.02	<3m	<3m	N/A
46	12/21/2018 5:45	29.5	0.85	0.03	0.12	0.04	0.02	<3m	<3m	N/A
47	12/28/2018 7:15	11.75	0.35	0.03	0.1	0.01	0.01	<3m	<3m	N/A
48	12/31/2018 19:00	4.75	0.42	0.09	0.19	0.02	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

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval [1]		
								1-hr	24-hr	48-hr
1	7/3/2018 19:30	2.5	0.03	0.01	0.02	0.00	0.00	<3m	<3m	N/A
2	7/6/2018 10:30	1.5	0.43	0.29	0.38	0.02	0.01	<3m	<3m	N/A
3	7/11/2018 0:00	0.25	0.03	0.12	0.03	0.00	0.00	<3m	<3m	N/A
4	7/14/2018 21:15	6	0.3	0.05	0.21	0.01	0.01	<3m	<3m	N/A
5	7/17/2018 13:00	13.25	2.27	0.17	0.99	0.09	0.05	1 yr	3-6m	N/A
6	7/22/2018 4:00	31.5	0.34	0.01	0.1	0.01	0.01	<3m	<3m	N/A
7	7/25/2018 23:00	17.5	0.65	0.04	0.53	0.03	0.01	3m	<3m	N/A
8	8/2/2018 18:30	0.25	0.1	0.40	0.1	0.00	0.00	<3m	<3m	N/A
9	8/3/2018 12:45	0.5	0.06	0.12	0.06	0.01	0.00	<3m	<3m	N/A
10	8/4/2018 9:30	4	0.6	0.15	0.47	0.03	0.02	<3m	<3m	N/A
11	8/8/2018 14:15	24.5	0.37	0.02	0.1	0.02	0.01	<3m	<3m	N/A
12	8/11/2018 10:30	35.75	2.18	0.06	1.06	0.08	0.05	1.5 yr	3m	N/A
13	8/13/2018 16:15	6.25	0.37	0.06	0.25	0.02	0.04	<3m	<3m	N/A
14	8/14/2018 12:45	2	0.07	0.04	0.04	0.02	0.01	<3m	<3m	N/A
15	8/17/2018 16:45	30.25	0.48	0.02	0.36	0.02	0.01	<3m	<3m	N/A
16	8/19/2018 22:45	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
17	8/22/2018 6:45	8.75	0.37	0.04	0.29	0.02	0.01	<3m	<3m	N/A
18	9/6/2018 16:00	2	0.05	0.03	0.03	0.00	0.00	<3m	<3m	N/A
19	9/10/2018 16:45	13.5	1.26	0.09	0.27	0.05	0.03	<3m	<3m	N/A
20	9/12/2018 2:15	26.75	0.53	0.02	0.18	0.02	0.03	<3m	<3m	N/A
21	9/18/2018 1:30	12.75	1.41	0.11	0.93	0.06	0.03	1 yr	<3m	N/A
22	9/22/2018 2:00	0.75	0.03	0.04	0.03	0.00	0.00	<3m	<3m	N/A
23	9/25/2018 11:15	12	1.59	0.13	0.71	0.07	0.03	6m	<3m	N/A
24	9/26/2018 22:15	2.25	0.34	0.15	0.26	0.02	0.04	<3m	<3m	N/A
25	9/28/2018 5:45	6	0.33	0.06	0.12	0.01	0.01	<3m	<3m	N/A
26	10/1/2018 15:45	36.25	0.62	0.02	0.14	0.02	0.01	<3m	<3m	N/A
27	10/7/2018 15:15	4.25	0.07	0.02	0.03	0.00	0.00	<3m	<3m	N/A
28	10/8/2018 17:30	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
29	10/11/2018 13:45	18.25	0.63	0.03	0.23	0.03	0.01	<3m	<3m	N/A
30	10/13/2018 8:15	3.75	0.13	0.03	0.04	0.01	0.02	<3m	<3m	N/A
31	10/15/2018 9:15	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
32	10/15/2018 23:15	1.5	0.15	0.10	0.11	0.01	0.00	<3m	<3m	N/A
33	10/21/2018 7:00	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
34	10/23/2018 13:00	5.5	0.37	0.07	0.21	0.02	0.01	<3m	<3m	N/A
35	10/24/2018 11:00	4.25	0.03	0.01	0.02	0.02	0.01	<3m	<3m	N/A

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
36	10/27/2018 6:30	24.75	1.41	0.06	0.24	0.06	0.03	<3m	<3m	N/A
37	10/29/2018 4:15	9.25	0.57	0.06	0.38	0.02	0.04	<3m	<3m	N/A
38	11/2/2018 3:15	33.75	1.82	0.05	0.15	0.07	0.04	<3m	<3m	N/A
39	11/5/2018 18:00	26	1.05	0.04	0.09	0.04	0.02	<3m	<3m	N/A
40	11/9/2018 18:30	15.75	1.37	0.09	0.12	0.06	0.03	<3m	<3m	N/A
41	11/13/2018 1:00	13	1.16	0.09	0.07	0.05	0.02	<3m	<3m	N/A
42	11/16/2018 1:45	8	1.17	0.15	0.09	0.05	0.02	<3m	<3m	N/A
43	11/19/2018 2:45	39	0.63	0.02	0.04	0.02	0.01	<3m	<3m	N/A
44	11/25/2018 1:15	10.25	0.65	0.06	0.09	0.03	0.01	<3m	<3m	N/A
45	11/26/2018 8:45	21.75	1.39	0.06	0.06	0.06	0.04	<3m	<3m	N/A
46	12/2/2018 3:00	13.75	0.77	0.06	0.05	0.03	0.00	<3m	<3m	N/A
47	12/3/2018 5:45	0.25	0.01	0.04	0.01	0.03	0.02	<3m	<3m	N/A
48	12/16/2018 17:15	12.25	0.59	0.05	0.08	0.03	0.01	<3m	<3m	N/A
49	12/21/2018 6:00	18.5	0.67	0.04	0.07	0.04	0.02	<3m	<3m	N/A
50	12/28/2018 7:45	11.25	0.3	0.03	0.04	0.01	0.01	<3m	<3m	N/A
51	12/31/2018 19:30	4.25	0.33	0.08	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.

AECOM Imagine it. Delivered.

Rain Gauge 17: Spot Pond

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
1	7/6/2018 10:45	2.5	0.22	0.09	0.19	0.01	0.00	<3m	<3m	N/A
2	7/14/2018 21:30	6	0.13	0.02	0.06	0.01	0.00	<3m	<3m	N/A
3	7/17/2018 13:00	13.75	1.92	0.14	0.95	0.08	0.04	1 yr	3m	N/A
4	7/22/2018 4:30	32.75	0.51	0.02	0.17	0.02	0.01	<3m	<3m	N/A
5	7/25/2018 14:00	26.5	0.5	0.02	0.21	0.02	0.01	<3m	<3m	N/A
6	8/4/2018 9:45	3.75	0.38	0.10	0.27	0.02	0.01	<3m	<3m	N/A
7	8/8/2018 19:30	19	0.25	0.01	0.08	0.01	0.01	<3m	<3m	N/A
8	8/11/2018 11:00	25	3.54	0.14	1.79	0.15	0.07	10 yr	2.5 yr	N/A
9	8/13/2018 2:00	0.25	0.01	0.04	0.01	0.10	0.07	<3m	3-6m	N/A
10	8/13/2018 17:15	31.75	1.19	0.04	0.64	0.05	0.06	3-6m	<3m	N/A
11	8/17/2018 17:15	23.75	0.43	0.02	0.25	0.02	0.01	<3m	<3m	N/A
12	8/19/2018 22:00	1.5	0.03	0.02	0.02	0.00	0.01	<3m	<3m	N/A
13	8/22/2018 7:00	8.5	0.6	0.07	0.5	0.03	0.01	<3m	<3m	N/A
14	9/6/2018 16:15	2	0.07	0.04	0.05	0.00	0.00	<3m	<3m	N/A
15	9/10/2018 16:30	12.75	1.48	0.12	0.28	0.06	0.03	<3m	<3m	N/A
16	9/12/2018 1:30	27	0.45	0.02	0.18	0.02	0.03	<3m	<3m	N/A
17	9/15/2018 0:45	0.25	0.01	0.04	0.01	0.00	0.01	<3m	<3m	N/A
18	9/16/2018 6:00	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
19	9/18/2018 0:15	13.75	1.72	0.13	1.01	0.07	0.04	1.5 yr	<3m	N/A
20	9/19/2018 5:30	0.25	0.01	0.04	0.01	0.06	0.04	<3m	<3m	N/A
21	9/25/2018 10:00	20.5	1.36	0.07	0.39	0.06	0.03	<3m	<3m	N/A
22	9/26/2018 21:45	3.5	0.34	0.10	0.25	0.02	0.04	<3m	<3m	N/A
23	9/28/2018 5:45	7	0.31	0.04	0.15	0.01	0.01	<3m	<3m	N/A
24	9/29/2018 3:00	0.25	0.01	0.04	0.01	0.01	0.01	<3m	<3m	N/A
25	10/1/2018 14:45	37.75	0.7	0.02	0.2	0.03	0.01	<3m	<3m	N/A
26	10/8/2018 15:30	3.75	0.02	0.01	0.01	0.00	0.00	<3m	<3m	N/A
27	10/10/2018 7:30	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
28	10/11/2018 14:00	17.75	0.73	0.04	0.27	0.03	0.02	<3m	<3m	N/A
29	10/13/2018 7:45	4.5	0.11	0.02	0.04	0.00	0.02	<3m	<3m	N/A
30	10/15/2018 12:15	13	0.09	0.01	0.04	0.00	0.00	<3m	<3m	N/A
31	10/21/2018 7:00	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
32	10/23/2018 15:30	2.75	0.18	0.07	0.12	0.01	0.00	<3m	<3m	N/A
33	10/24/2018 10:45	4.5	0.06	0.01	0.02	0.01	0.01	<3m	<3m	N/A
34	10/27/2018 6:45	24.5	1.65	0.07	0.27	0.07	0.03	<3m	<3m	N/A
35	10/29/2018 4:30	5.25	0.86	0.16	0.62	0.04	0.05	3-6m	<3m	N/A

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
36	11/1/2018 9:15	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
37	11/1/2018 22:30	35.25	1.87	0.05	0.4	0.07	0.04	<3m	<3m	N/A
38	11/5/2018 17:15	28	0.94	0.03	0.13	0.04	0.02	<3m	<3m	N/A
39	11/9/2018 19:15	15	1.4	0.09	0.38	0.06	0.03	<3m	<3m	N/A
40	11/13/2018 1:00	12.75	1.24	0.10	0.18	0.05	0.03	<3m	<3m	N/A
41	11/16/2018 4:15	6.25	1.34	0.21	0.4	0.06	0.03	<3m	<3m	N/A
42	11/19/2018 2:15	39.75	0.88	0.02	0.1	0.02	0.02	<3m	<3m	N/A
43	11/25/2018 1:30	10.25	0.62	0.06	0.3	0.03	0.01	<3m	<3m	N/A
44	11/26/2018 6:45	27.25	2.11	0.08	0.23	0.09	0.05	<3m	3-6m	N/A
45	12/2/2018 3:15	26.75	0.82	0.03	0.16	0.03	0.02	<3m	<3m	N/A
46	12/16/2018 17:45	15.5	0.71	0.05	0.19	0.02	0.01	<3m	<3m	N/A
47	12/21/2018 6:15	29.25	0.9	0.03	0.11	0.03	0.01	<3m	<3m	N/A
48	12/28/2018 6:30	13.5	0.36	0.03	0.11	0.01	0.01	<3m	<3m	N/A
49	12/31/2018 19:30	4.25	0.29	0.07	0.17	0.02	0.01	<3m	<3m	N/A

Rain Gauge 18: Union Park

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
1	7/3/2018 21:45	0.25	0.13	0.52	0.13	0.01	0.00	<3m	<3m	N/A
2	7/6/2018 10:30	1.75	0.39	0.22	0.3	0.02	0.01	<3m	<3m	N/A
3	7/11/2018 0:00	2.25	0.11	0.05	0.08	0.00	0.00	<3m	<3m	N/A
4	7/14/2018 21:15	1.75	0.05	0.03	0.04	0.00	0.00	<3m	<3m	N/A
5	7/17/2018 13:00	13.5	2	0.15	0.72	0.08	0.04	6m	3m	N/A
6	7/22/2018 4:00	31.75	0.31	0.01	0.07	0.01	0.01	<3m	<3m	N/A
7	7/25/2018 16:30	24	0.68	0.03	0.56	0.03	0.01	3m	<3m	N/A
8	8/3/2018 12:45	0.5	0.14	0.28	0.14	0.01	0.00	<3m	<3m	N/A
9	8/4/2018 9:45	3.25	0.71	0.22	0.58	0.04	0.02	3m	<3m	N/A
10	8/8/2018 13:45	16.25	0.96	0.06	0.69	0.04	0.02	6m	<3m	N/A
11	8/11/2018 8:00	7.25	0.43	0.06	0.29	0.02	0.01	<3m	<3m	N/A
12	8/12/2018 3:15	18	1.08	0.06	0.69	0.06	0.03	6m	<3m	N/A
13	8/13/2018 11:00	11	0.41	0.04	0.3	0.02	0.03	<3m	<3m	N/A
14	8/17/2018 16:00	9.25	0.34	0.04	0.21	0.01	0.01	<3m	<3m	N/A
15	8/18/2018 16:00	7.5	0.14	0.02	0.07	0.01	0.01	<3m	<3m	N/A
16	8/19/2018 21:30	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
17	8/22/2018 6:30	9	0.44	0.05	0.31	0.02	0.01	<3m	<3m	N/A
18	9/6/2018 16:30	2.75	0.14	0.05	0.11	0.01	0.00	<3m	<3m	N/A
19	9/10/2018 17:45	12.75	0.98	0.08	0.22	0.04	0.02	<3m	<3m	N/A
20	9/12/2018 3:00	27.25	0.55	0.02	0.18	0.02	0.03	<3m	<3m	N/A
21	9/18/2018 1:45	13.5	1.71	0.13	1.13	0.07	0.04	2 yr	<3m	N/A
22	9/22/2018 3:00	0.75	0.03	0.04	0.03	0.00	0.00	<3m	<3m	N/A
23	9/25/2018 10:30	21.75	1.31	0.06	0.47	0.05	0.03	<3m	<3m	N/A
24	9/27/2018 0:00	2.25	0.34	0.15	0.31	0.01	0.03	<3m	<3m	N/A
25	9/28/2018 5:45	7.75	0.34	0.04	0.14	0.01	0.01	<3m	<3m	N/A
26	10/1/2018 16:00	35.75	0.64	0.02	0.15	0.02	0.01	<3m	<3m	N/A
27	10/7/2018 15:30	4.25	0.09	0.02	0.04	0.00	0.00	<3m	<3m	N/A
28	10/8/2018 15:45	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
29	10/11/2018 13:30	19	0.72	0.04	0.29	0.03	0.02	<3m	<3m	N/A
30	10/13/2018 7:15	4.5	0.14	0.03	0.05	0.01	0.02	<3m	<3m	N/A
31	10/15/2018 9:30	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
32	10/15/2018 23:15	2	0.1	0.05	0.06	0.00	0.00	<3m	<3m	N/A
33	10/18/2018 1:15	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
34	10/21/2018 7:00	0.5	0.02	0.04	0.02	0.00	0.00	<3m	<3m	N/A
35	10/23/2018 13:00	5.5	0.27	0.05	0.13	0.01	0.01	<3m	<3m	N/A

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
36	10/24/2018 10:15	5	0.05	0.01	0.03	0.01	0.01	<3m	<3m	N/A
37	10/27/2018 6:15	24.75	1.87	0.08	0.31	0.07	0.03	<3m	<3m	N/A
38	10/29/2018 3:15	9.5	0.55	0.06	0.29	0.03	0.04	<3m	<3m	N/A
39	11/2/2018 3:00	1.25	0.13	0.10	0.12	0.01	0.00	<3m	<3m	N/A
40	11/2/2018 16:30	20.5	1.65	0.08	0.53	0.07	0.04	3m	<3m	N/A
41	11/5/2018 18:00	26.5	1.22	0.05	0.18	0.05	0.03	<3m	<3m	N/A
42	11/9/2018 18:30	15.75	1.63	0.10	0.44	0.07	0.03	<3m	<3m	N/A
43	11/13/2018 1:00	13	1.17	0.09	0.18	0.05	0.02	<3m	<3m	N/A
44	11/16/2018 0:45	14.5	1.42	0.10	0.33	0.06	0.03	<3m	<3m	N/A
45	11/19/2018 2:30	39.5	0.62	0.02	0.08	0.02	0.01	<3m	<3m	N/A
46	11/25/2018 1:15	10.25	0.78	0.08	0.33	0.03	0.02	<3m	<3m	N/A
47	11/26/2018 8:45	22	1.51	0.07	0.2	0.06	0.04	<3m	<3m	N/A
48	12/2/2018 3:00	12.5	0.74	0.06	0.15	0.03	0.00	<3m	<3m	N/A
49	12/16/2018 17:15	11.25	0.71	0.06	0.2	0.03	0.01	<3m	<3m	N/A
50	12/21/2018 6:00	30	0.7	0.02	0.11	0.03	0.01	<3m	<3m	N/A
51	12/28/2018 8:15	22	0.31	0.01	0.1	0.01	0.01	<3m	<3m	N/A
52	12/31/2018 19:15	4.5	0.39	0.09	0.18	0.02	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	7/6/2018 10:45	2	0.56	0.28	0.52	0.02	0.01	<3m	<3m	N/A
2	7/11/2018 0:00	0.5	0.02	0.04	0.02	0.00	0.00	<3m	<3m	N/A
3	7/14/2018 21:30	6.25	0.07	0.01	0.04	0.00	0.00	<3m	<3m	N/A
4	7/17/2018 13:15	17.25	2.03	0.12	0.67	0.08	0.04	3-6m	3m	N/A
5	7/22/2018 6:00	30.75	0.32	0.01	0.09	0.01	0.01	<3m	<3m	N/A
6	7/25/2018 3:00	37.75	0.75	0.02	0.5	0.03	0.02	<3m	<3m	N/A
7	8/2/2018 18:30	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
8	8/4/2018 9:45	2	0.45	0.23	0.32	0.02	0.01	<3m	<3m	N/A
9	8/8/2018 15:00	23.75	0.47	0.02	0.13	0.02	0.01	<3m	<3m	N/A
10	8/11/2018 10:45	38	1.87	0.05	0.78	0.07	0.04	6m-1yr	<3m	N/A
11	8/13/2018 17:15	4.75	0.31	0.07	0.25	0.02	0.02	<3m	<3m	N/A
12	8/14/2018 12:30	2.5	0.77	0.31	0.45	0.05	0.03	<3m	<3m	N/A
13	8/17/2018 16:45	9.75	0.15	0.02	0.09	0.01	0.00	<3m	<3m	N/A
14	8/18/2018 16:00	7.25	0.1	0.01	0.07	0.01	0.01	<3m	<3m	N/A
15	8/19/2018 22:30	1	0.02	0.02	0.02	0.00	0.00	<3m	<3m	N/A
16	8/22/2018 7:00	8.5	0.51	0.06	0.46	0.02	0.01	<3m	<3m	N/A
17	9/6/2018 15:30	2.5	0.11	0.04	0.08	0.00	0.00	<3m	<3m	N/A
18	9/10/2018 15:15	14.75	1.43	0.10	0.24	0.06	0.03	<3m	<3m	N/A
19	9/12/2018 2:15	26.5	0.79	0.03	0.32	0.03	0.04	<3m	<3m	N/A
20	9/18/2018 0:15	14	1.75	0.13	1.11	0.07	0.04	1.5 yr	<3m	N/A
21	9/22/2018 2:00	0.5	0.03	0.06	0.03	0.00	0.00	<3m	<3m	N/A
22	9/25/2018 9:00	21.75	1.61	0.07	0.46	0.07	0.03	<3m	<3m	N/A
23	9/26/2018 22:00	5.25	0.35	0.07	0.28	0.02	0.04	<3m	<3m	N/A
24	9/28/2018 5:00	7.25	0.4	0.06	0.18	0.02	0.02	<3m	<3m	N/A
25	10/1/2018 16:00	38.25	0.63	0.02	0.16	0.02	0.01	<3m	<3m	N/A
26	10/7/2018 16:15	4	0.08	0.02	0.03	0.00	0.00	<3m	<3m	N/A
27	10/8/2018 16:45	6	0.02	0.00	0.01	0.00	0.00	<3m	<3m	N/A
28	10/11/2018 15:00	23.25	0.68	0.03	0.3	0.03	0.01	<3m	<3m	N/A
29	10/13/2018 9:15	3.75	0.11	0.03	0.04	0.01	0.02	<3m	<3m	N/A
30	10/15/2018 9:45	16.5	0.1	0.01	0.04	0.00	0.00	<3m	<3m	N/A
31	10/18/2018 2:00	9.75	0.02	0.00	0.01	0.00	0.00	<3m	<3m	N/A
32	10/23/2018 16:30	3.5	0.26	0.07	0.17	0.01	0.01	<3m	<3m	N/A
33	10/24/2018 12:15	1.5	0.02	0.01	0.01	0.01	0.01	<3m	<3m	N/A
34	10/27/2018 7:30	25.75	1.15	0.04	0.17	0.05	0.02	<3m	<3m	N/A
35	10/29/2018 5:30	9	0.81	0.09	0.55	0.03	0.04	3m	<3m	N/A

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
36	11/2/2018 4:15	34	1.79	0.05	0.41	0.07	0.04	<3m	<3m	N/A
37	11/5/2018 16:45	35.75	0.89	0.02	0.14	0.03	0.02	<3m	<3m	N/A
38	11/9/2018 18:45	15.5	1.14	0.07	0.35	0.05	0.02	<3m	<3m	N/A
39	11/13/2018 1:15	22.5	1.11	0.05	0.17	0.05	0.02	<3m	<3m	N/A
40	11/15/2018 20:15	14.75	1.1	0.07	0.17	0.05	0.02	<3m	<3m	N/A
41	11/19/2018 2:30	39.25	0.64	0.02	0.11	0.02	0.01	<3m	<3m	N/A
42	11/25/2018 1:30	10	0.66	0.07	0.29	0.03	0.01	<3m	<3m	N/A
43	11/26/2018 9:15	26	1.41	0.05	0.17	0.06	0.04	<3m	<3m	N/A
44	12/2/2018 3:00	29.25	0.72	0.02	0.13	0.03	0.02	<3m	<3m	N/A
45	12/16/2018 12:00	18.25	0.52	0.03	0.16	0.02	0.01	<3m	<3m	N/A
46	12/21/2018 6:15	18.5	0.9	0.05	0.15	0.04	0.02	<3m	<3m	N/A
47	12/28/2018 14:00	0.75	0.03	0.04	0.03	0.00	0.00	<3m	<3m	N/A
48	12/31/2018 21:30	2.25	0.12	0.05	0.09	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	7/6/2018 10:30	1.75	0.27	0.15	0.24	0.01	0.01	<3m	<3m	N/A
2	7/10/2018 23:45	0.5	0.11	0.22	0.11	0.00	0.00	<3m	<3m	N/A
3	7/14/2018 22:30	0.5	0.02	0.04	0.02	0.00	0.00	<3m	<3m	N/A
4	7/17/2018 13:00	13.25	2.37	0.18	0.93	0.10	0.05	1 yr	6m	N/A
5	7/22/2018 4:30	33.75	0.46	0.01	0.1	0.01	0.01	<3m	<3m	N/A
6	7/24/2018 9:45	0.25	0.01	0.04	0.01	0.01	0.01	<3m	<3m	N/A
7	7/25/2018 13:15	27	0.92	0.03	0.3	0.03	0.02	<3m	<3m	N/A
8	8/2/2018 18:15	0.25	0.01	0.01	0.00	0.00	<3m	<3m	N/A	0.01
9	8/4/2018 9:30	4	0.48	0.32	0.02	0.01	<3m	<3m	N/A	0.32
10	8/8/2018 19:15	22.25	0.54	0.31	0.02	0.01	<3m	<3m	N/A	0.31
11	8/11/2018 9:45	6.25	1.12	0.85	0.05	0.02	6m-1yr	<3m	N/A	0.85
12	8/12/2018 6:45	16.25	0.1	0.07	0.05	0.03	<3m	<3m	N/A	0.07
13	8/13/2018 17:00	4	0.18	0.14	0.01	0.01	<3m	<3m	N/A	0.14
14	8/14/2018 11:45	2.75	0.25	0.22	0.02	0.01	<3m	<3m	N/A	0.22
15	8/17/2018 16:30	30.75	0.36	0.13	0.01	0.01	<3m	<3m	N/A	0.13
16	8/19/2018 22:30	1	0.03	0.03	0.00	0.01	<3m	<3m	N/A	0.03
17	8/22/2018 6:30	8.75	0.81	0.74	0.03	0.02	6m-1yr	<3m	N/A	0.74
18	8/23/2018 4:30	0.25	0.01	0.01	0.03	0.02	<3m	<3m	N/A	0.01
19	9/6/2018 15:30	2.5	0.11	0.04	0.08	0.00	0.00	<3m	<3m	N/A
20	9/10/2018 15:15	14.75	1.43	0.10	0.24	0.06	0.03	<3m	<3m	N/A
21	9/12/2018 2:15	26.5	0.79	0.03	0.32	0.03	0.04	<3m	<3m	N/A
22	9/18/2018 0:15	14	1.75	0.13	1.11	0.07	0.04	1.5 yr	<3m	N/A
23	9/22/2018 2:00	0.5	0.03	0.06	0.03	0.00	0.00	<3m	<3m	N/A
24	9/25/2018 9:00	21.75	1.61	0.07	0.46	0.07	0.03	<3m	<3m	N/A
25	9/26/2018 22:00	5.25	0.35	0.07	0.28	0.02	0.04	<3m	<3m	N/A
26	9/28/2018 5:00	7.25	0.4	0.06	0.18	0.02	0.02	<3m	<3m	N/A
27	10/1/2018 14:30	37.75	0.86	0.02	0.21	0.03	0.02	<3m	<3m	N/A
28	10/7/2018 18:15	2	0.06	0.03	0.05	0.00	0.00	<3m	<3m	N/A
29	10/8/2018 15:45	4.5	0.02	0.00	0.01	0.00	0.00	<3m	<3m	N/A
30	10/10/2018 5:30	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
31	10/11/2018 13:45	18.75	0.87	0.05	0.32	0.04	0.02	<3m	<3m	N/A
32	10/13/2018 8:00	3.75	0.12	0.03	0.04	0.01	0.02	<3m	<3m	N/A
33	10/14/2018 3:30	0.25	0.01	0.04	0.01	0.01	0.00	<3m	<3m	N/A
34	10/15/2018 8:30	1	0.02	0.02	0.02	0.00	0.00	<3m	<3m	N/A
35	10/15/2018 23:00	1.75	0.1	0.06	0.06	0.01	0.00	<3m	<3m	N/A
36	10/18/2018 0:45	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A

Event	Date & Start Time	Duration (hr)	Volume (in)	Average Intensity (in/hr)	Peak 1-hr Intensity (in/hr)	Peak 24-hr Intensity (in/hr)	Peak 48-hr Intensity (in/hr)	Storm Recurrence Interval (1)		
								1-hr	24-hr	48-hr
37	10/21/2018 5:45	1.75	0.03	0.02	0.02	0.00	0.00	<3m	<3m	N/A
38	10/23/2018 15:30	2.25	0.14	0.06	0.13	0.01	0.00	<3m	<3m	N/A
39	10/24/2018 9:30	3.25	0.04	0.01	0.34	0.03	0.02	<3m	<3m	N/A
40	10/27/2018 6:15	25.75	1.85	0.07	0.27	0.07	0.03	<3m	<3m	N/A
41	10/29/2018 3:00	10.25	0.82	0.08	0.34	0.78	0.04	<3m	<3m	N/A
42	11/1/2018 9:00	0.25	0.01	0.04	0.01	0.00	0.00	<3m	<3m	N/A
43	11/1/2018 23:15	37.75	2.18	0.06	0.48	0.08	0.05	<3m	3m	N/A
44	11/5/2018 16:30	36.75	1.06	0.03	0.14	0.04	0.02	<3m	<3m	N/A
45	11/9/2018 18:15	15.75	1.6	0.10	0.42	0.07	0.03	<3m	<3m	N/A
46	11/13/2018 1:00	12.5	1.26	0.10	0.22	0.05	0.03	<3m	<3m	N/A
47	11/16/2018 3:30	7.75	1.32	0.17	0.31	0.06	0.03	<3m	<3m	N/A
48	11/19/2018 1:45	40	0.85	0.02	0.14	0.02	0.02	<3m	<3m	N/A
49	11/21/2018 9:15	2.5	0.02	0.01	0.01	0.01	0.01	<3m	<3m	N/A
50	11/25/2018 1:15	10	0.69	0.07	0.31	0.03	0.01	<3m	<3m	N/A
51	11/26/2018 10:00	23.25	1.81	0.08	0.21	0.08	0.05	<3m	3m	N/A
52	12/2/2018 2:45	29.25	0.86	0.03	0.15	0.04	0.02	<3m	<3m	N/A
53	12/16/2018 11:45	18.25	0.73	0.04	0.21	0.03	0.02	<3m	<3m	N/A
54	12/21/2018 5:45	29.5	1.05	0.04	0.17	0.04	0.02	<3m	<3m	N/A
55	12/28/2018 5:45	13.5	0.4	0.03	0.13	0.02	0.01	<3m	<3m	N/A
56	12/31/2018 19:45	4	0.43	0.11	0.21	0.02	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.

Appendix C Rainfall Hyetographs

All hyetographs are plotted using 15-minute peak intensities.

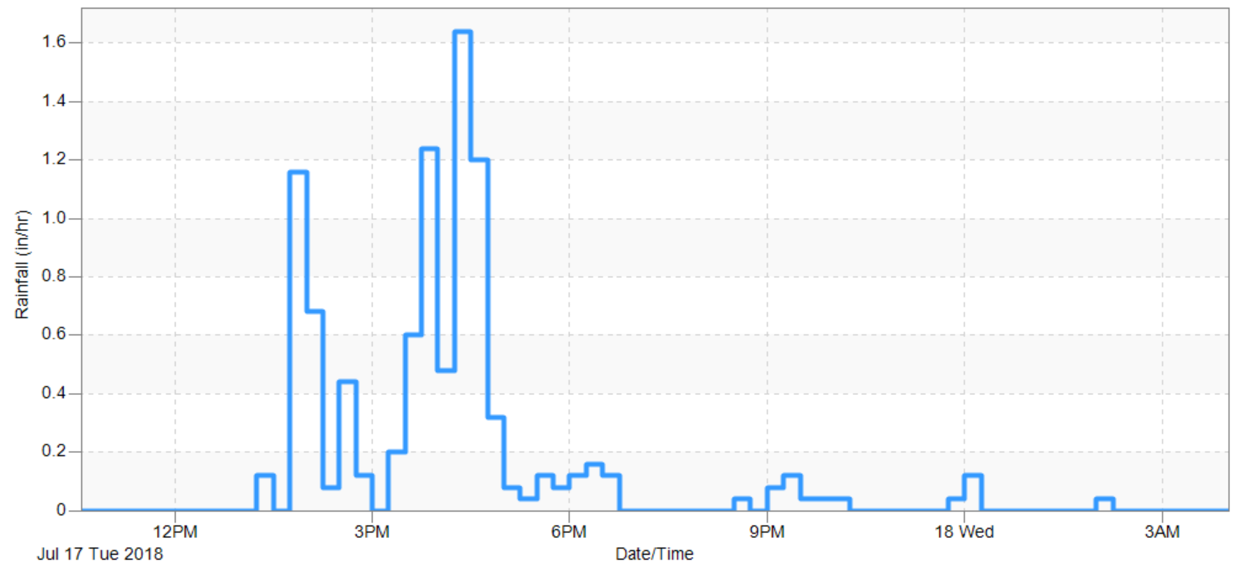


Figure 1. Ward Street July 17, 2018

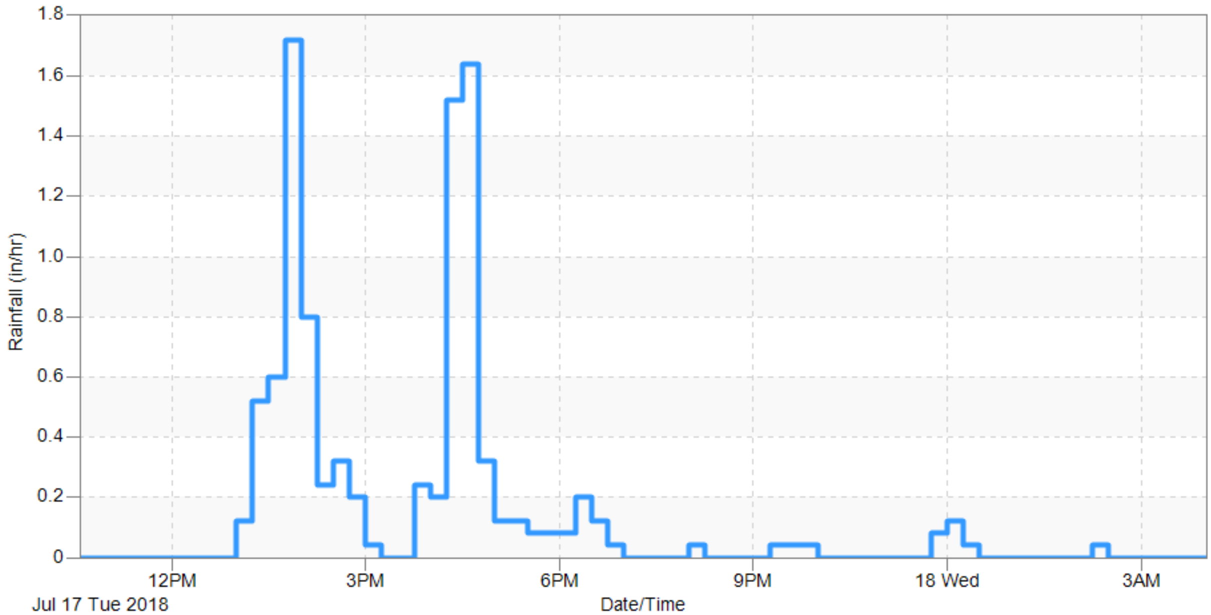


Figure 2. BO-DI-2 July 17, 2018

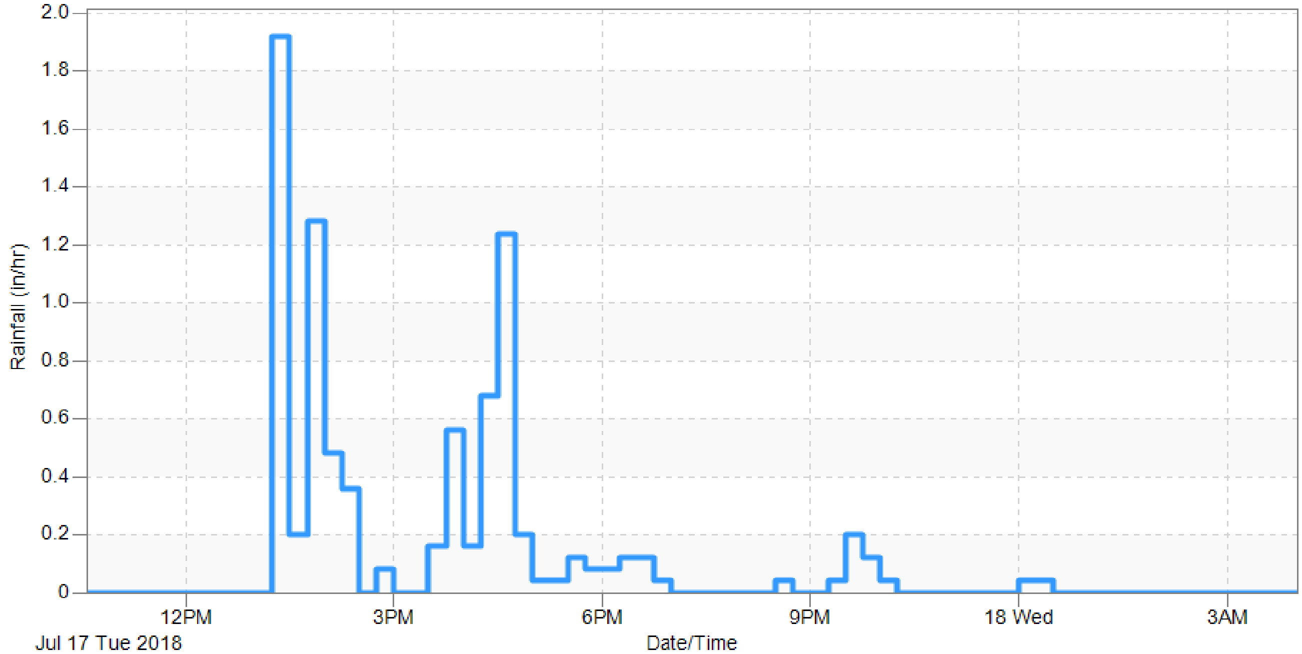


Figure 3. CH-BO-1 July 17, 2018

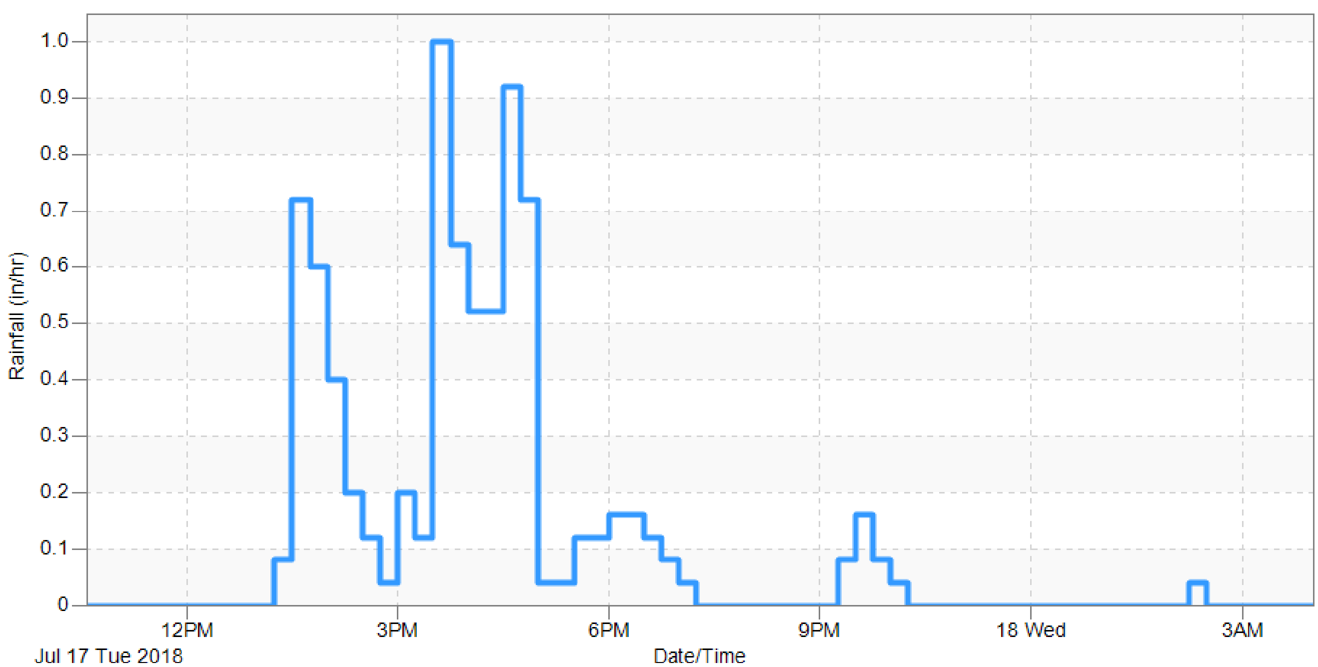


Figure 4. USGS Fresh Pond July 17, 2018

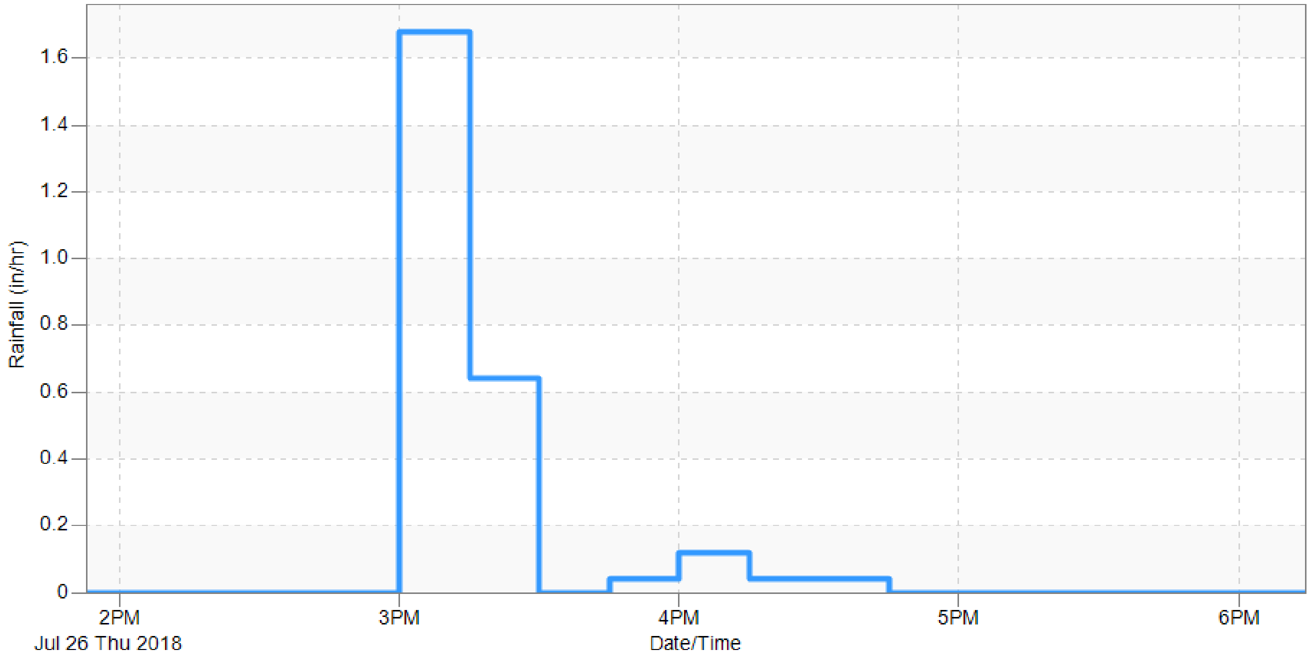


Figure 5. BO-DI-2 July 26, 2018

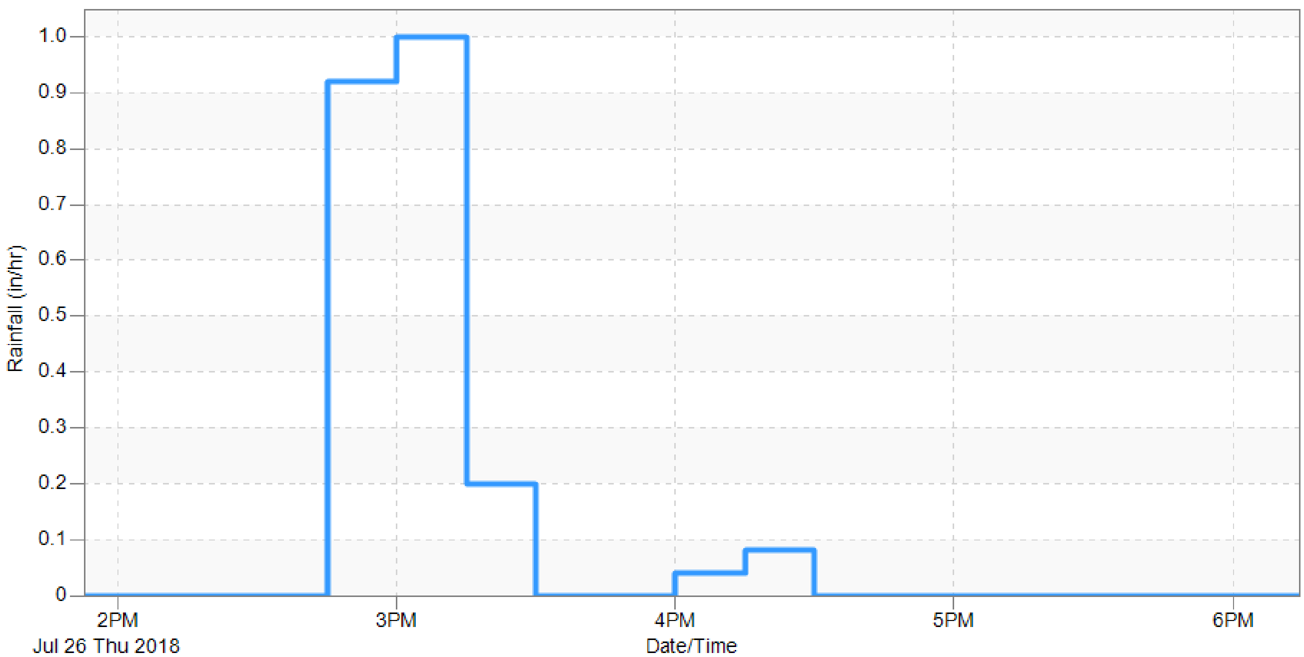


Figure 6. CH-BO-1 July 26, 2018

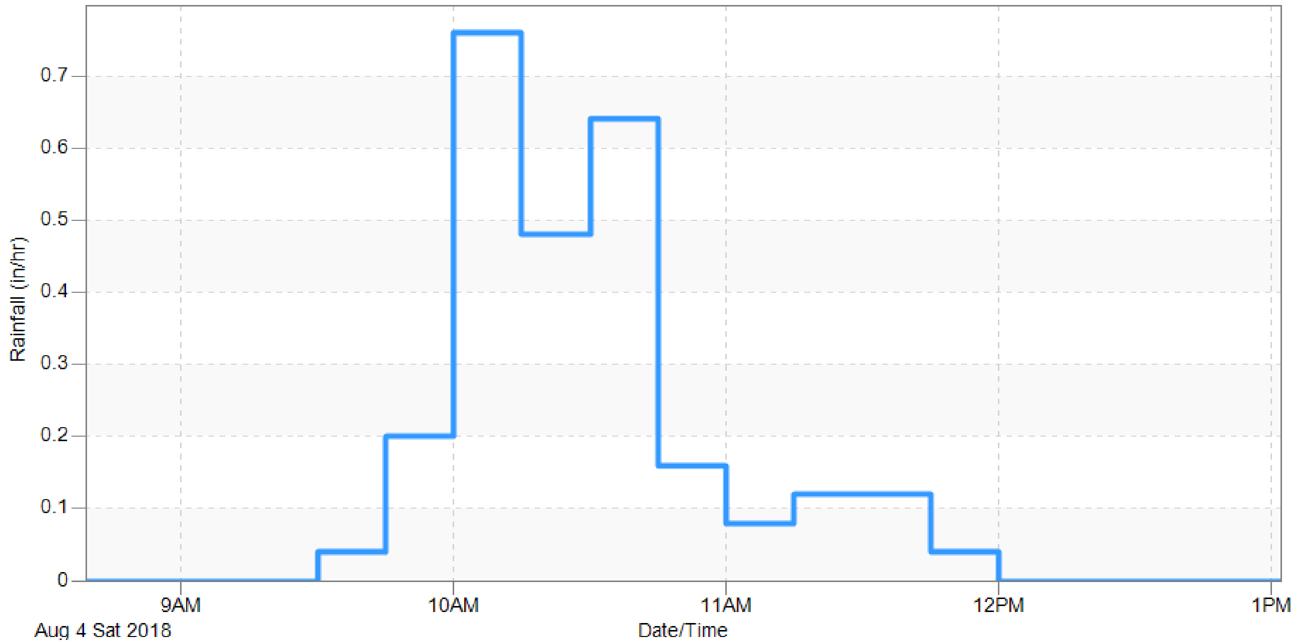


Figure 7. BO-DI-1 August 4, 2018

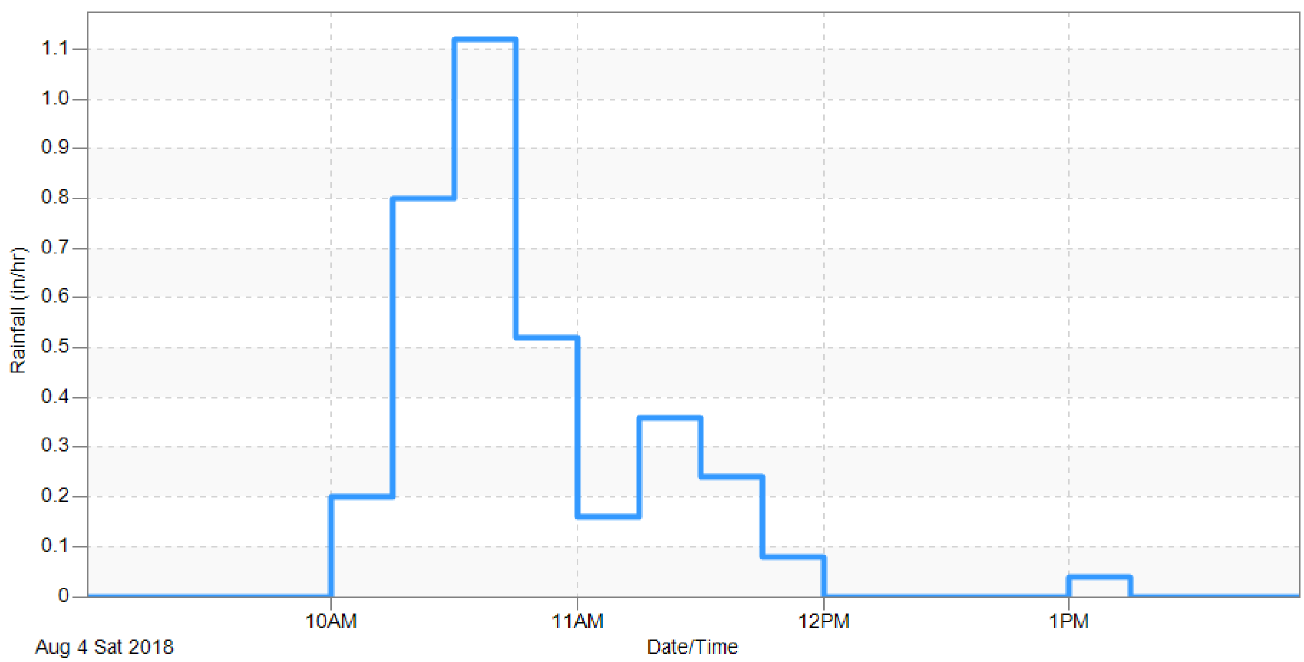


Figure 8. BO-DI-2 August 4, 2018

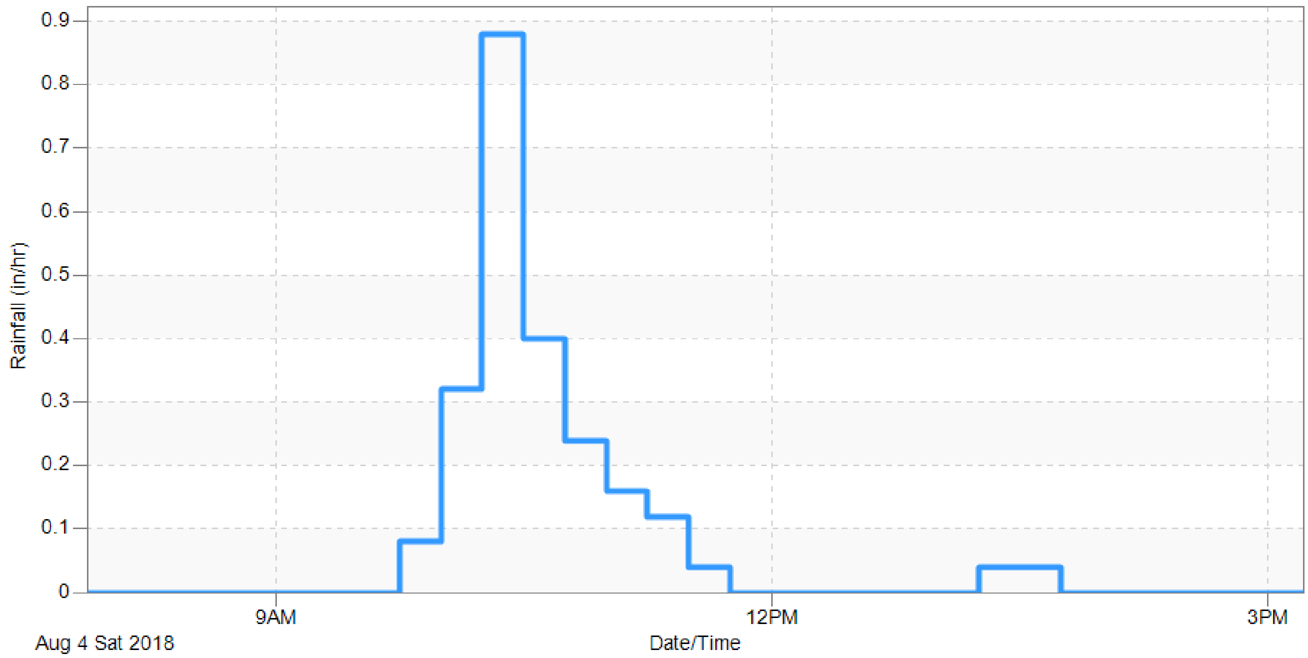


Figure 9. CH-BO-1 August 4, 2018

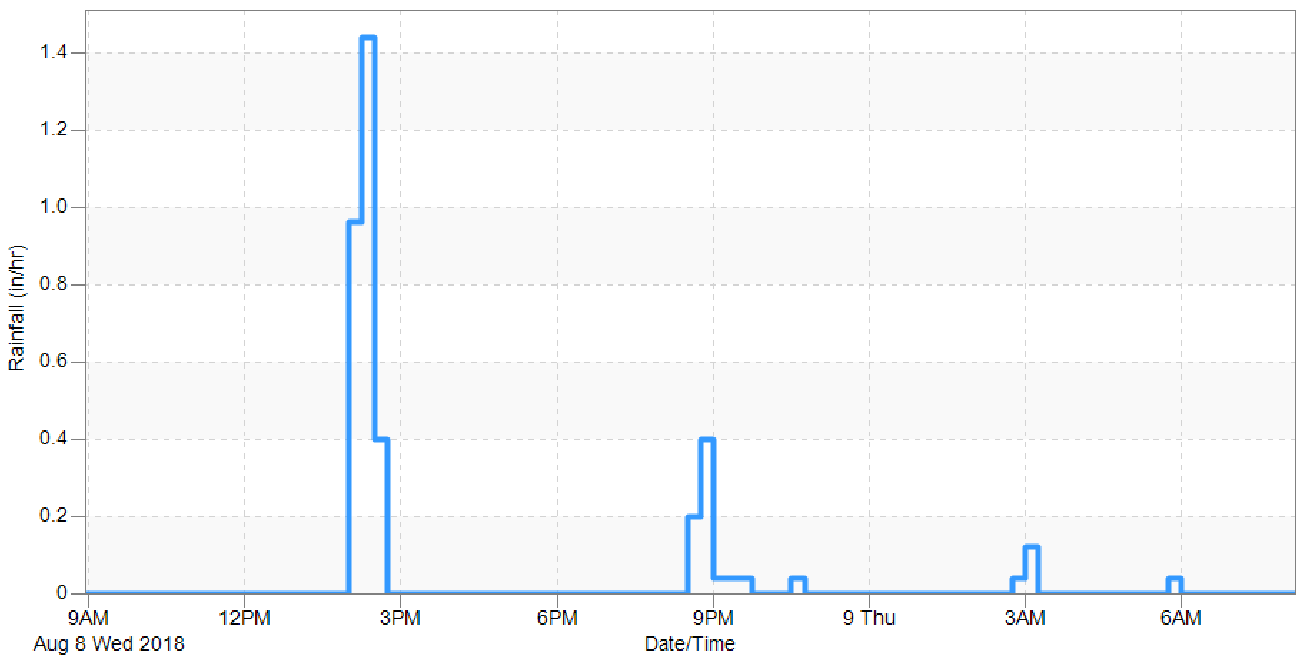


Figure 10. BO-DI-2 August 8, 2018

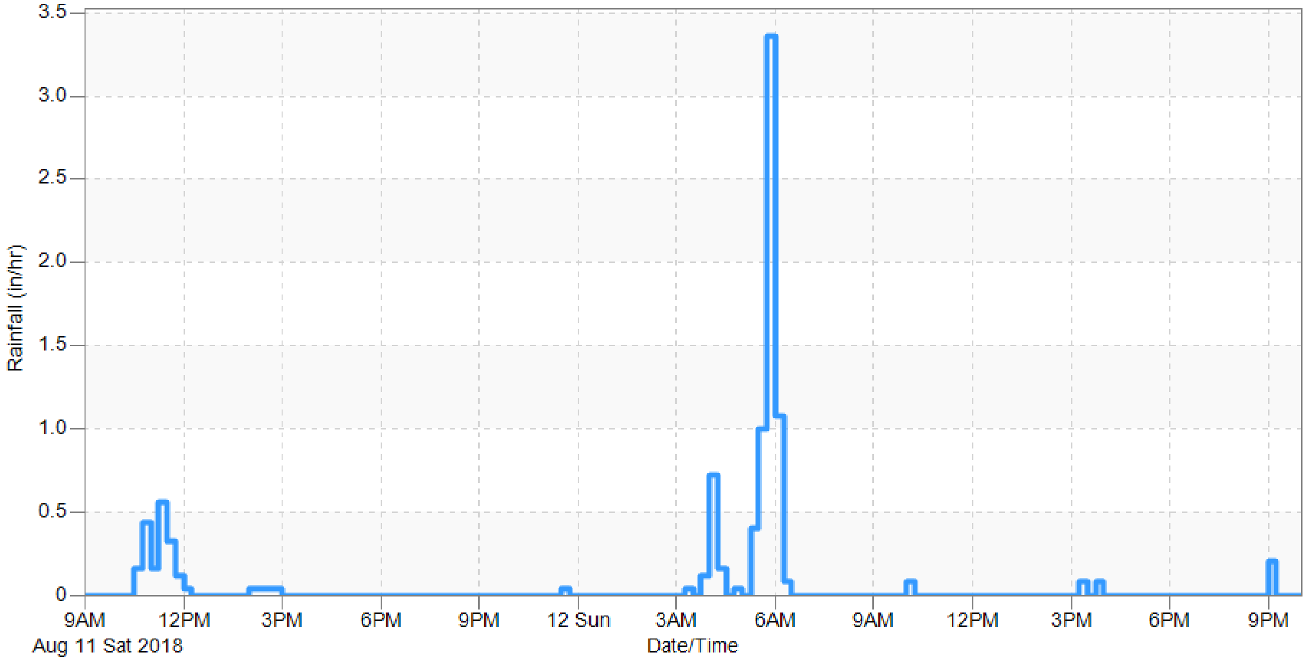


Figure 11. BO-DI-1 August 11, 2018

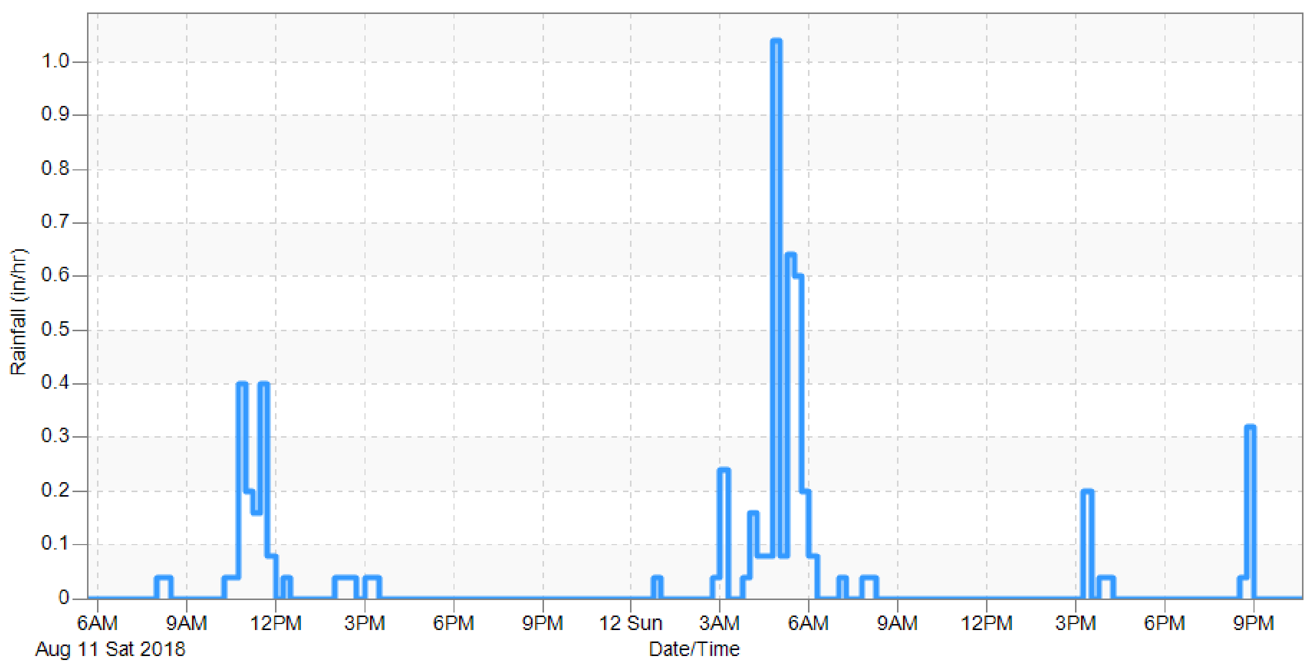


Figure 12. BO-DI-2 August 11, 2018

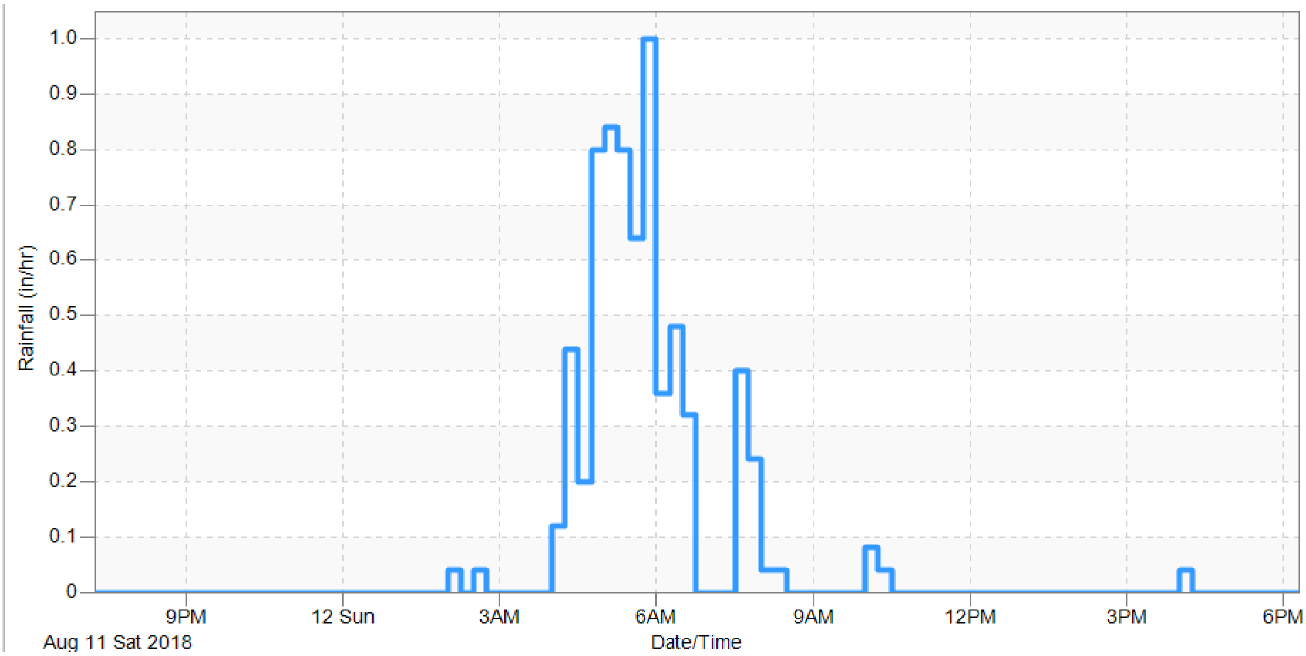


Figure 13. CH-BO-1 August 11, 2018

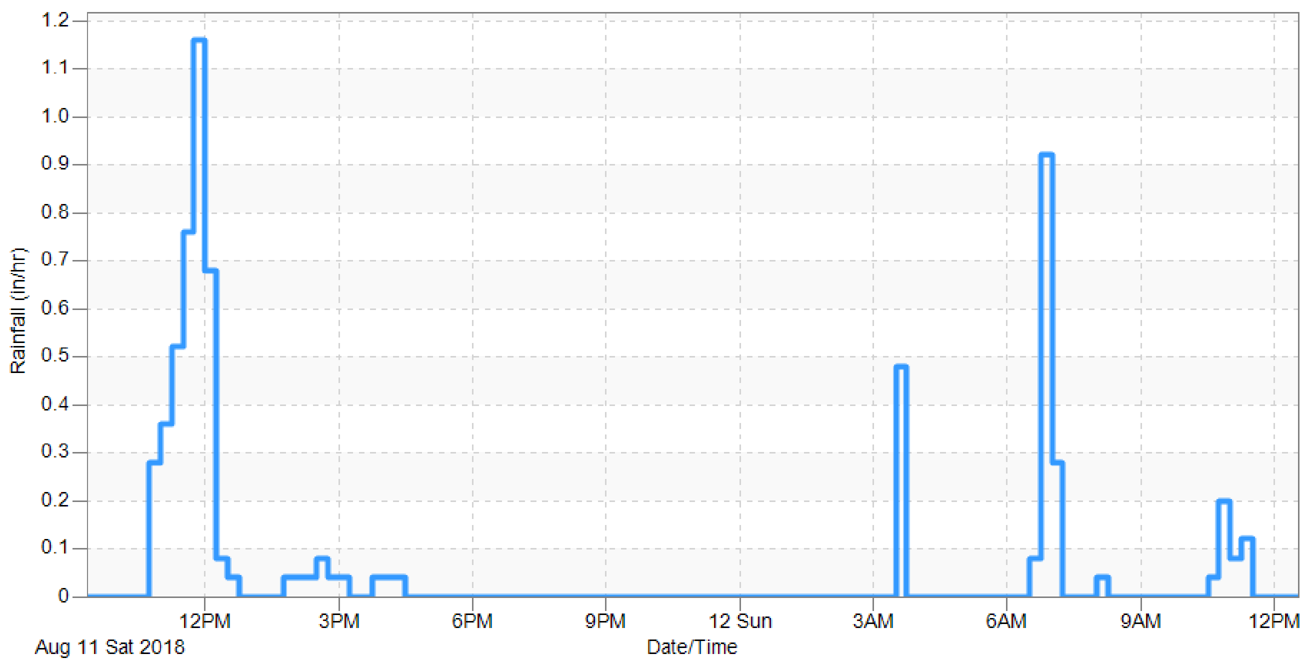


Figure 14. USGS Fresh Pond August 11, 2018

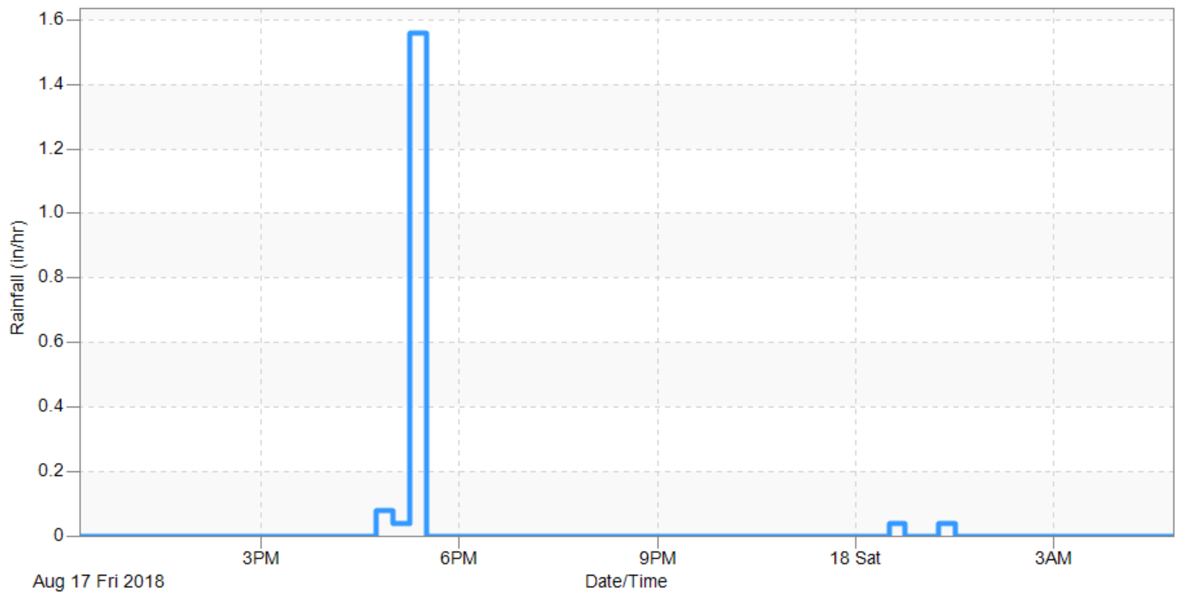


Figure 15. CH-BO-1 August 17, 2018

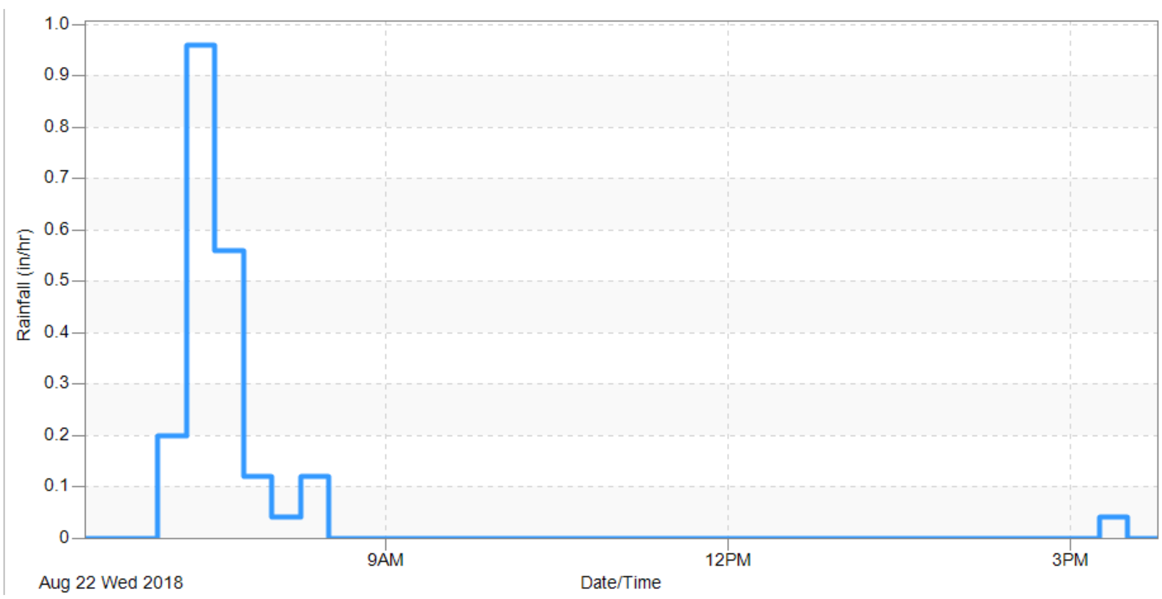


Figure 16. USGS Fresh Pond August 22, 2018

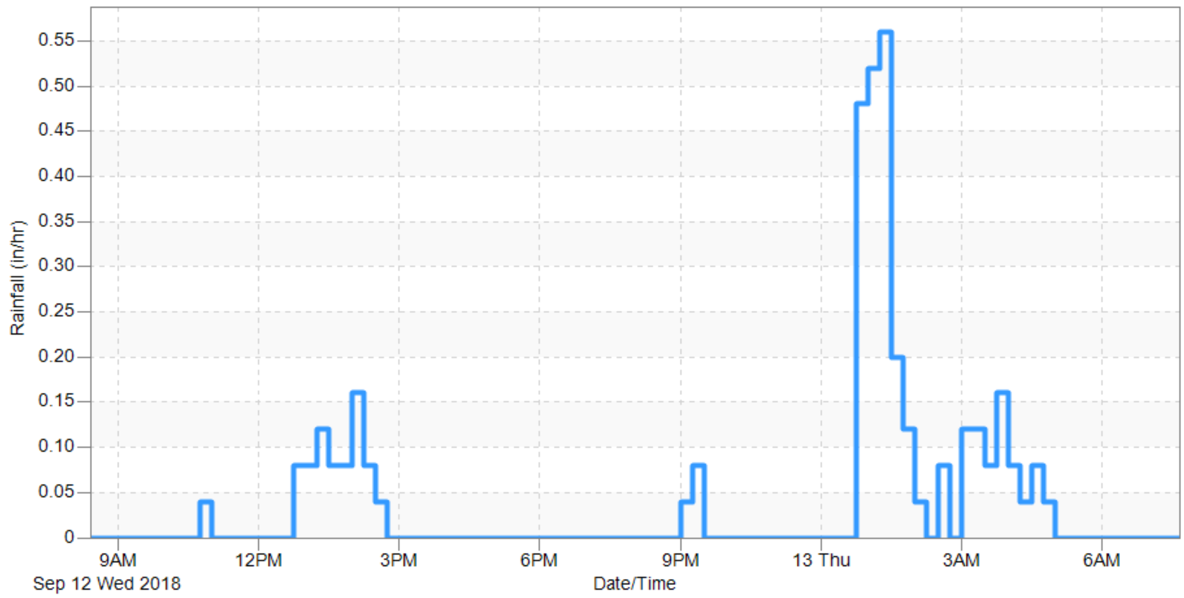


Figure 17. BO-DI-1 September 12, 2018

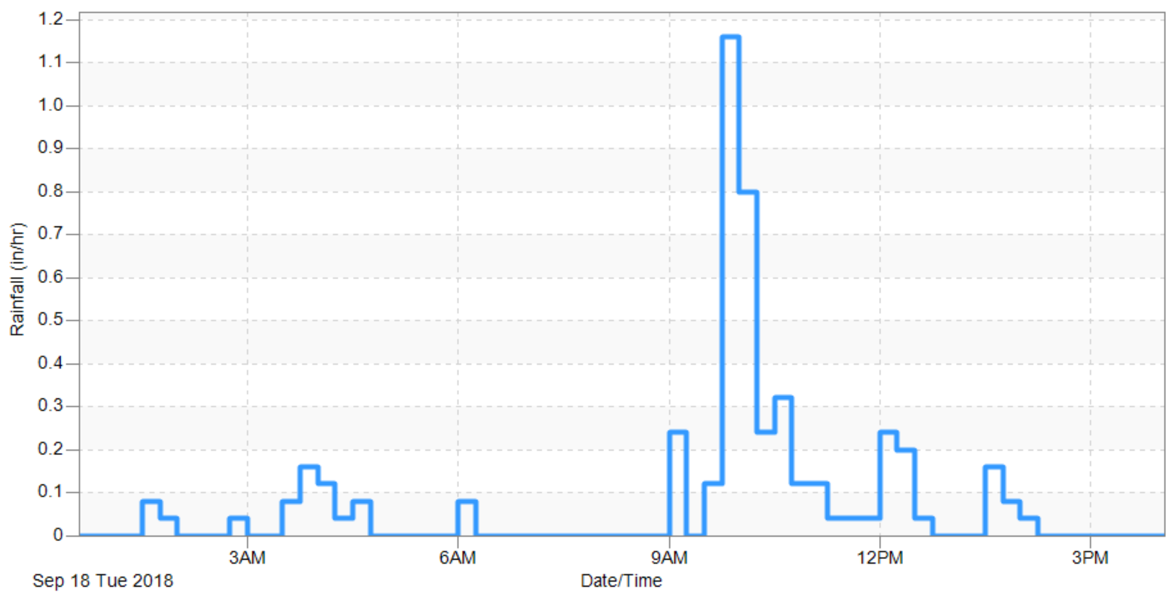


Figure 18. BO-DI-1 September 18, 2018

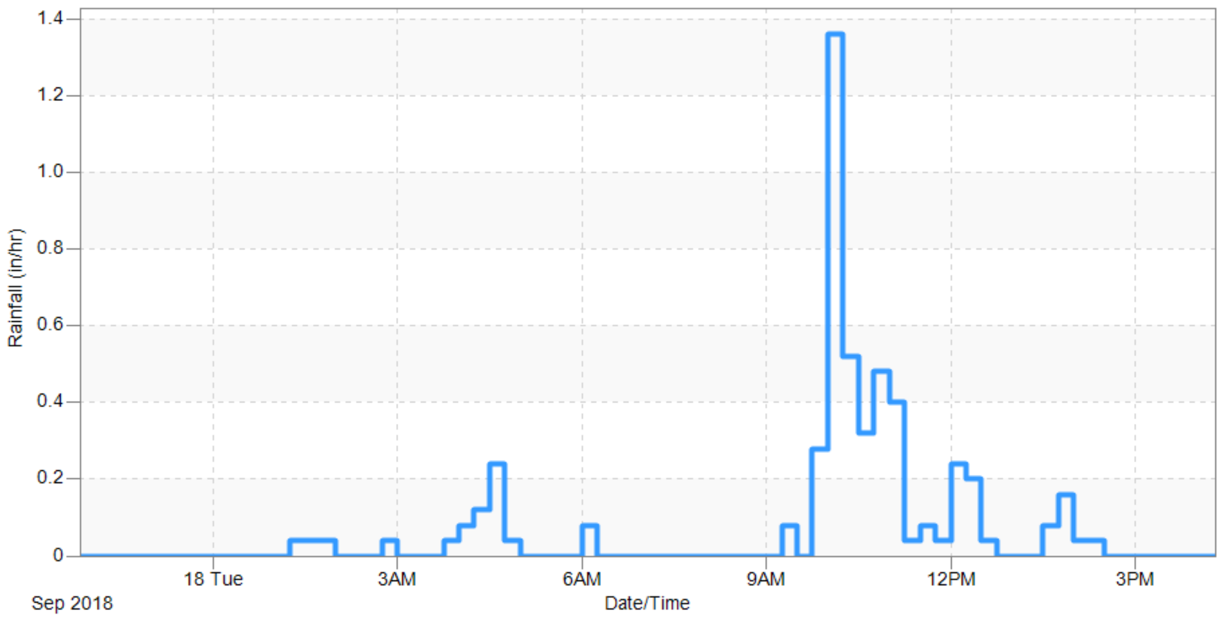


Figure 19. BO-DI-2 September 18, 2018

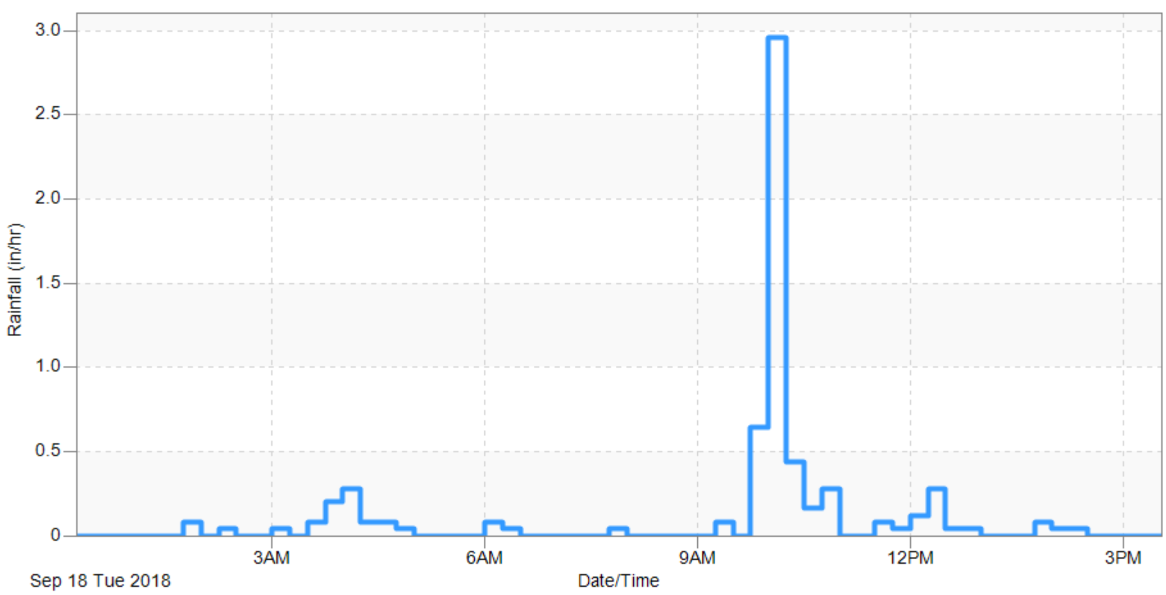


Figure 20. CH-BO-1 September 18, 2018

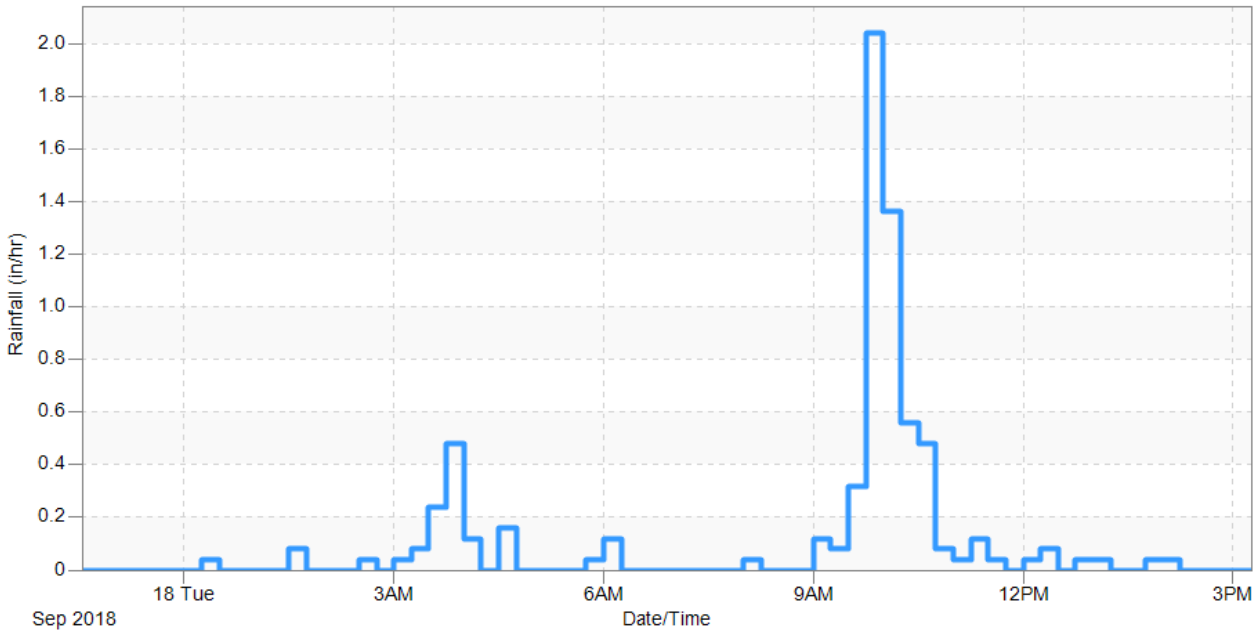


Figure 21. USGS Fresh Pond September 18, 2018

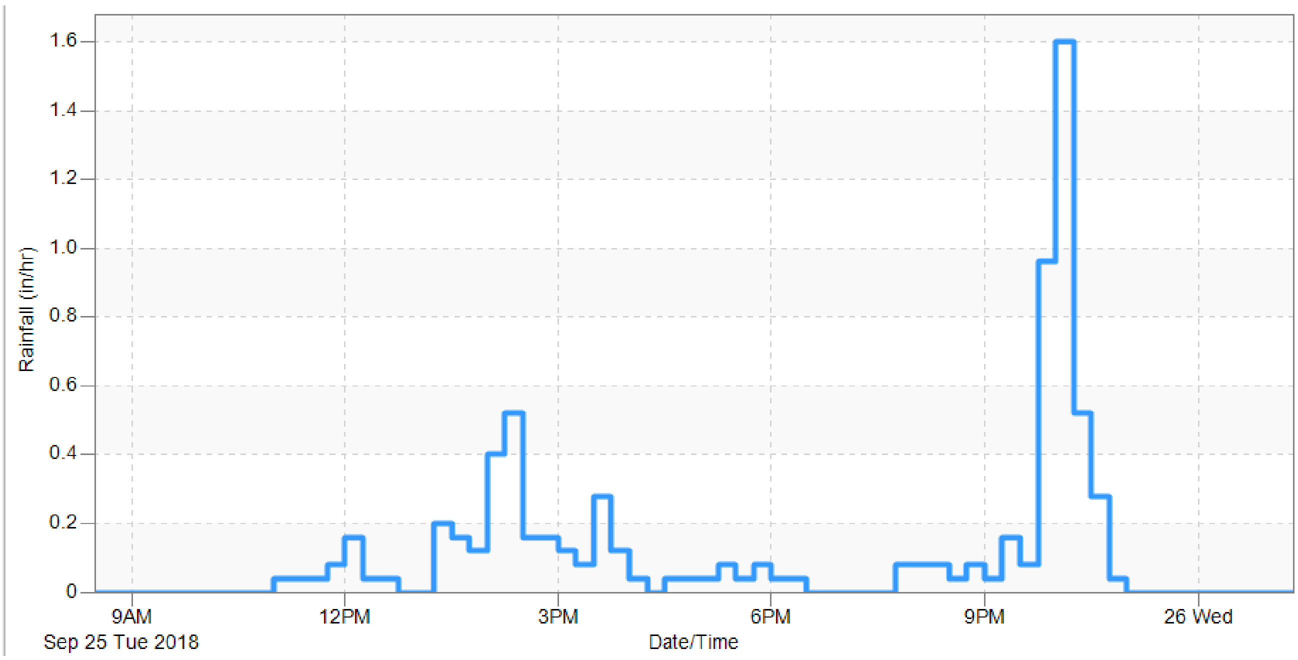


Figure 22. BO-DI-1 September 25, 2018

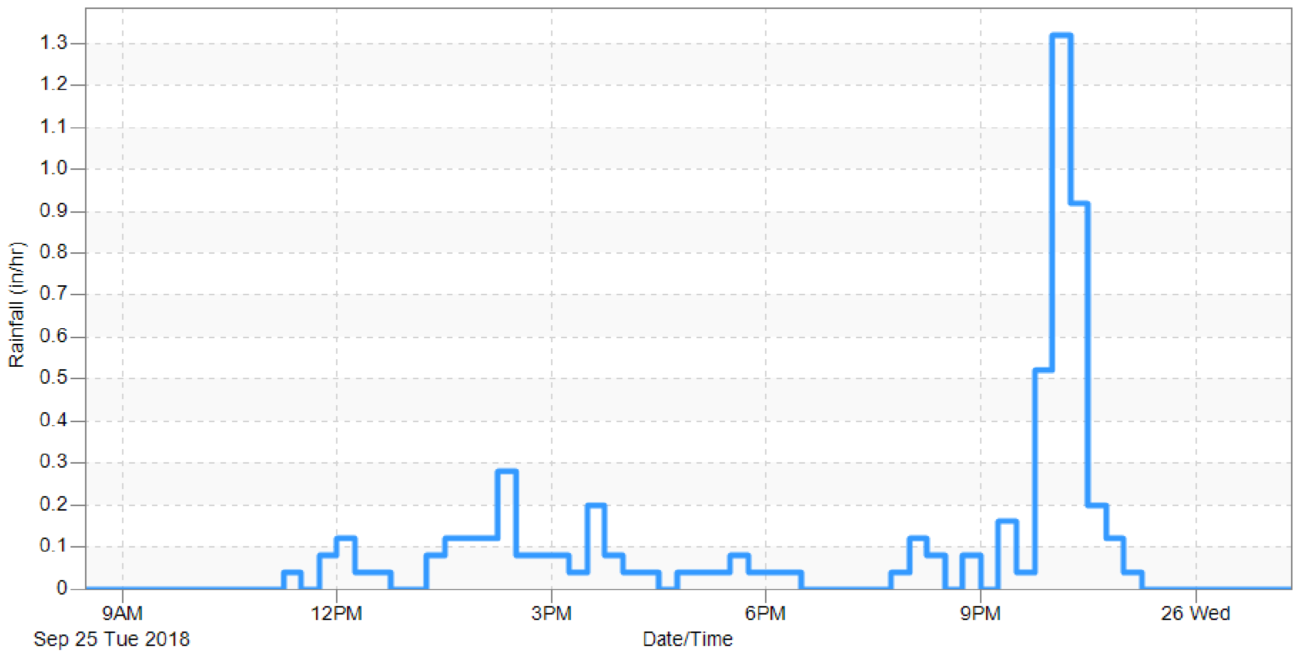


Figure 23. BO-DI-2 September 25, 2018

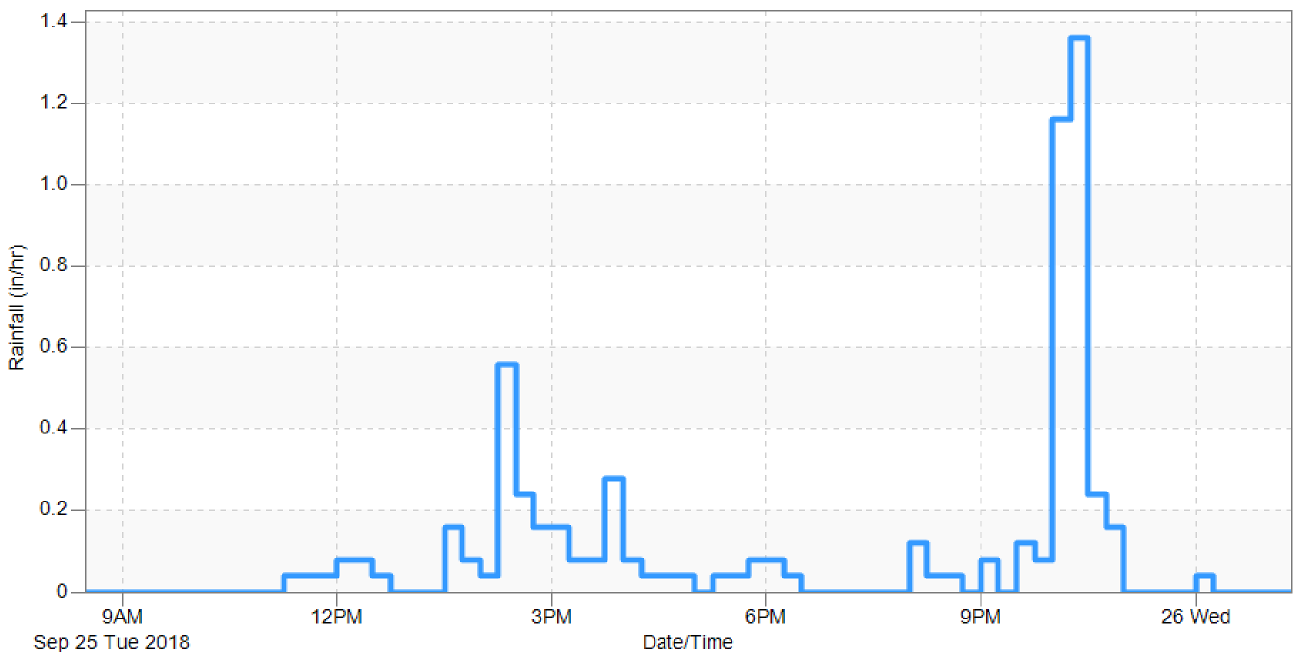


Figure 24. CH-BO-1 September 25, 2018

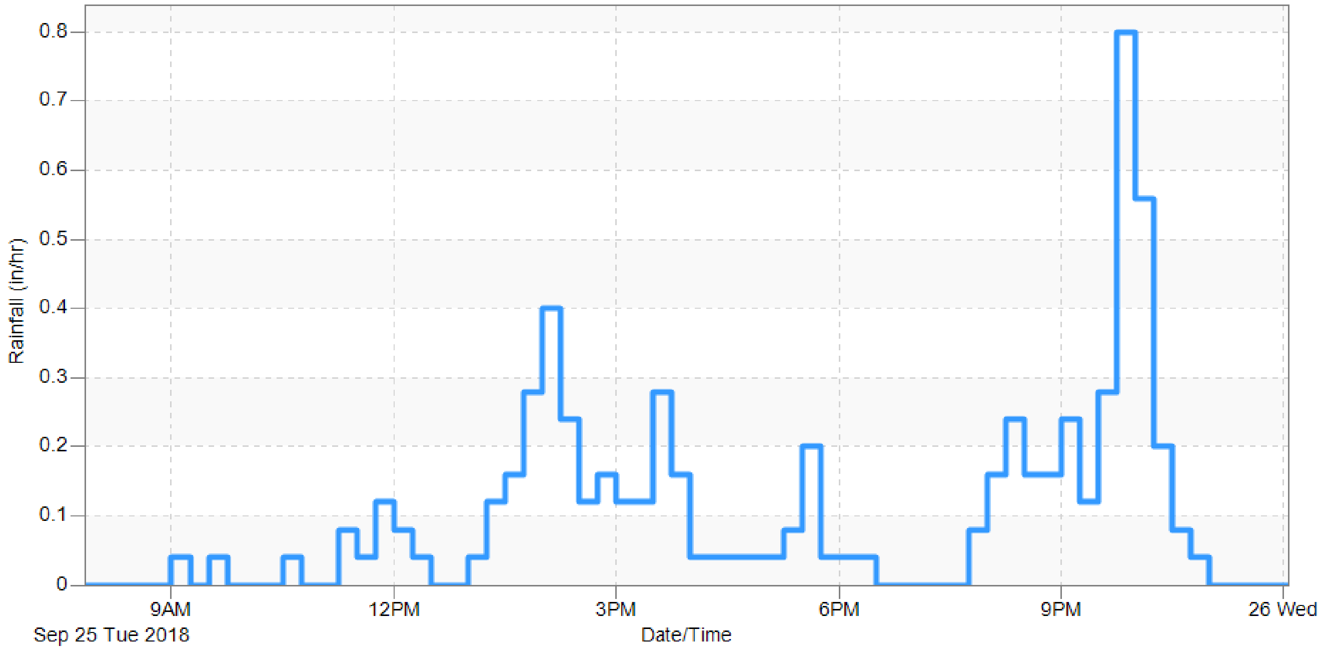


Figure 25. USGS Fresh Pond September 25, 2018

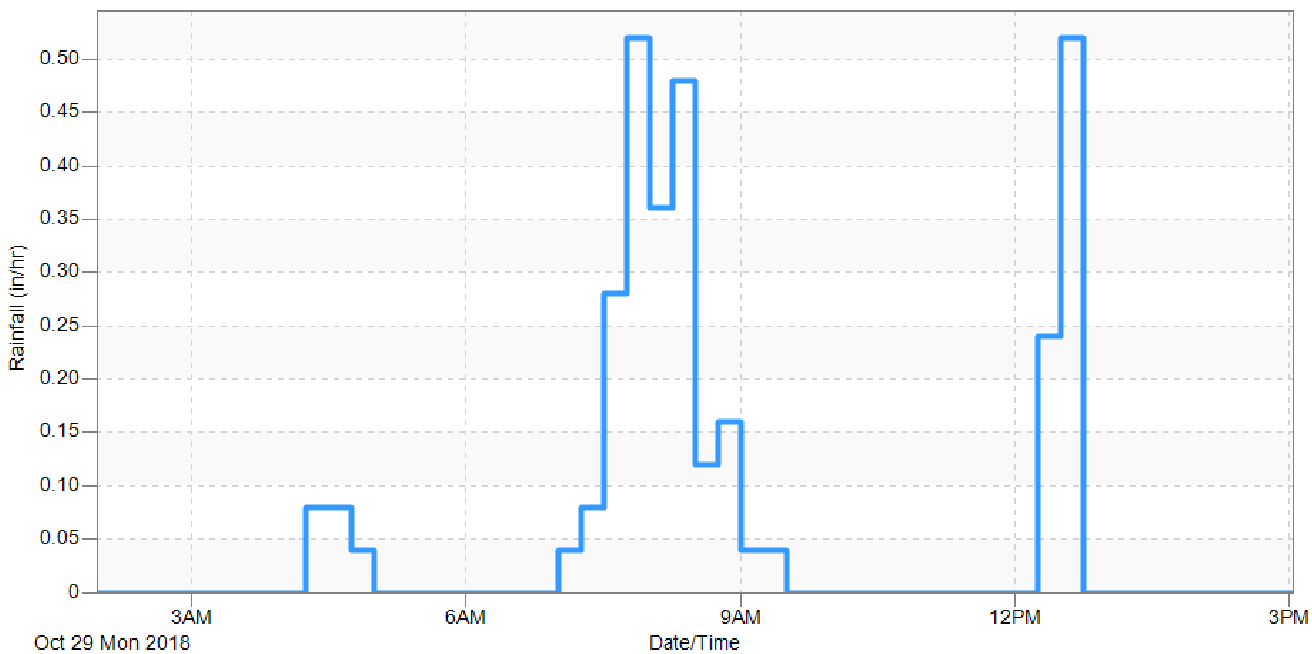


Figure 26. BO-DI-1 October 29, 2018

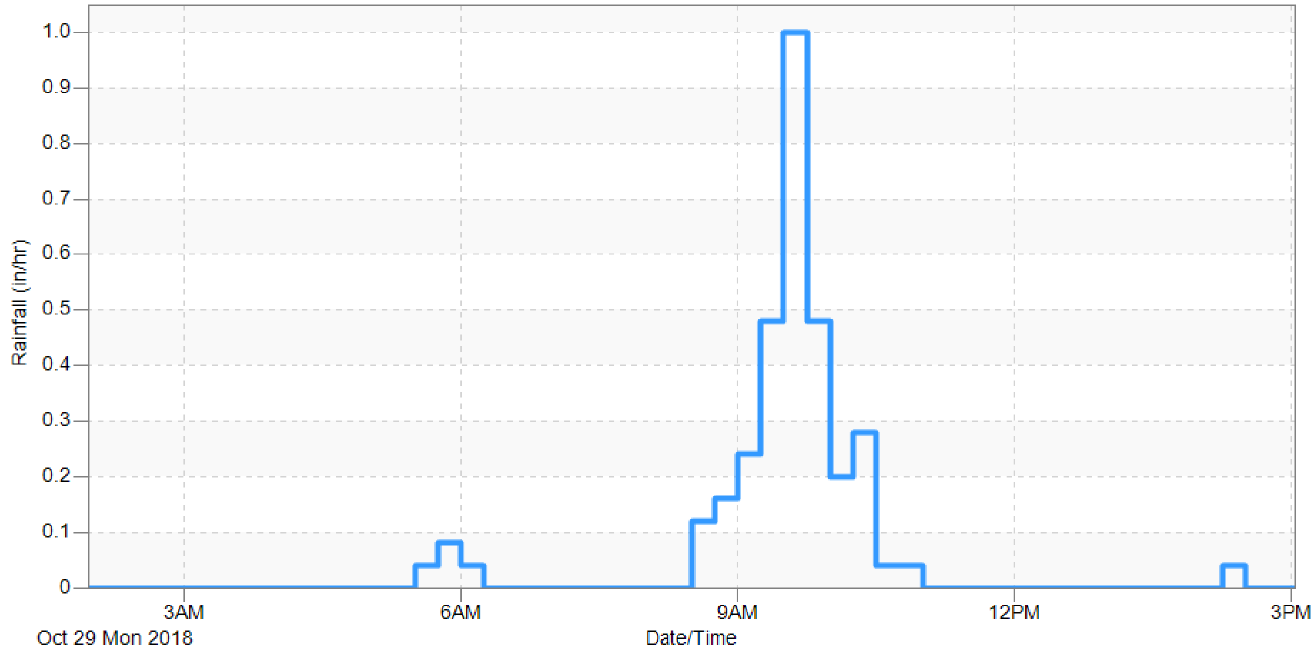


Figure 27. USGS Fresh Pond October 29, 2018

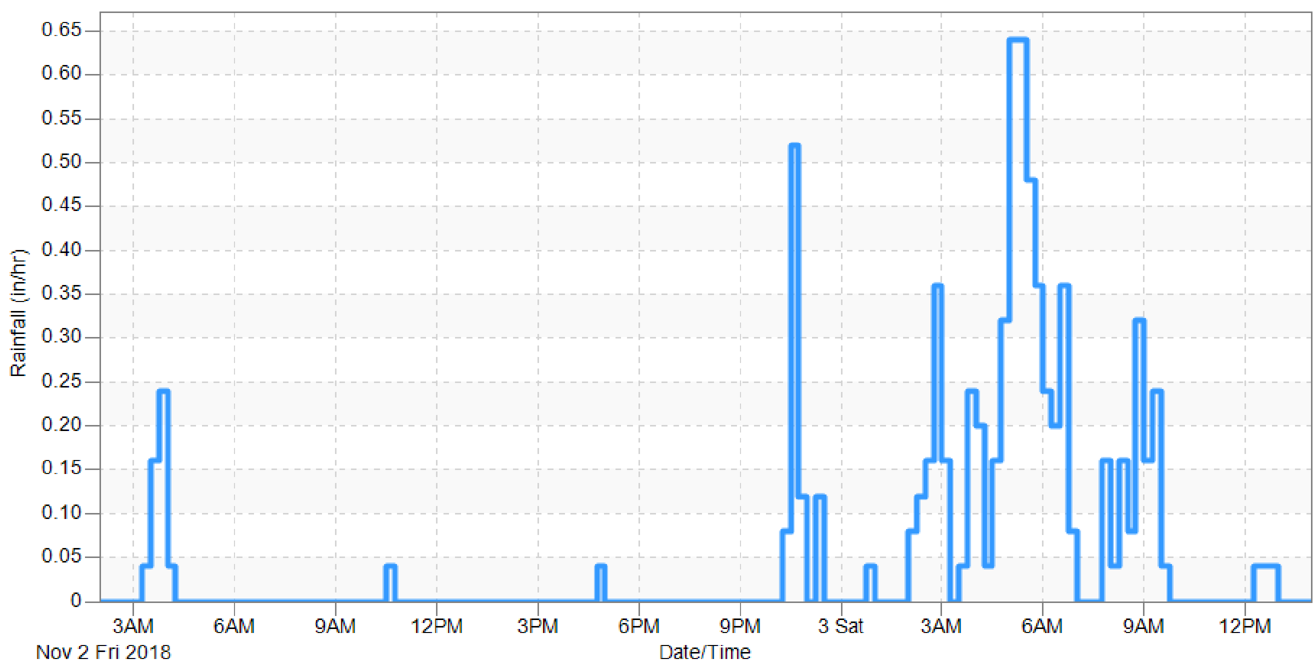


Figure 28. BO-DI-1 November 2, 2018

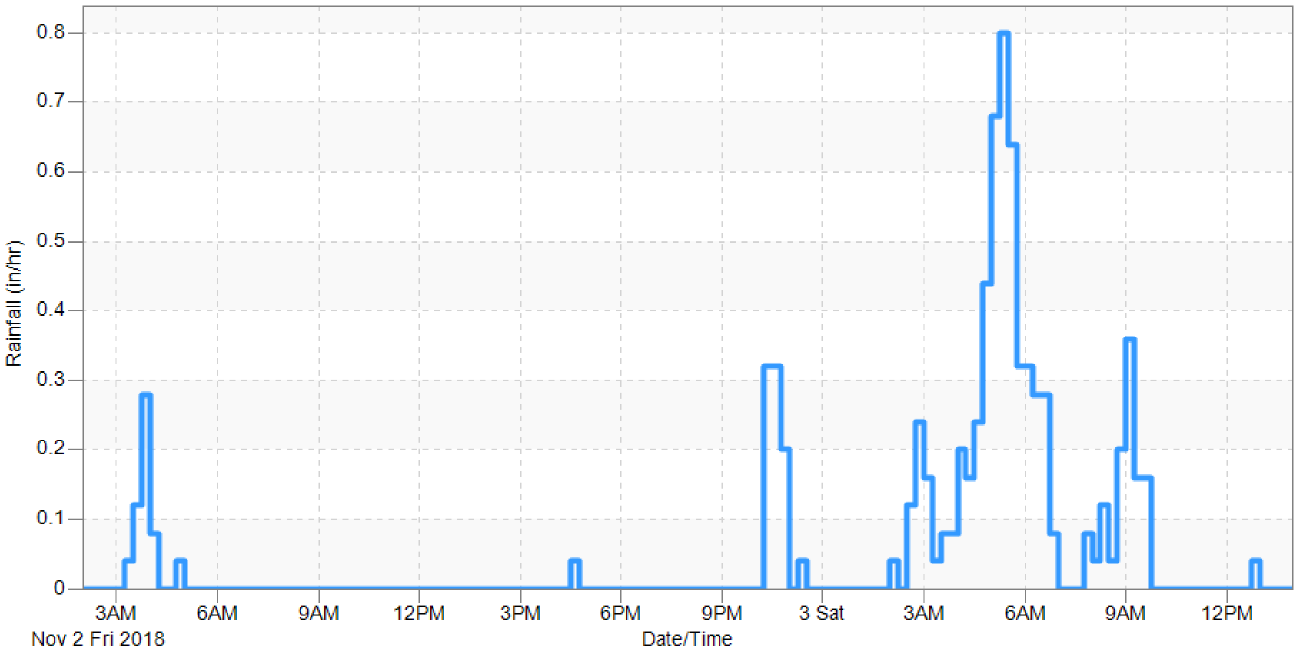


Figure 29. BO-DI-2 November 2, 2018

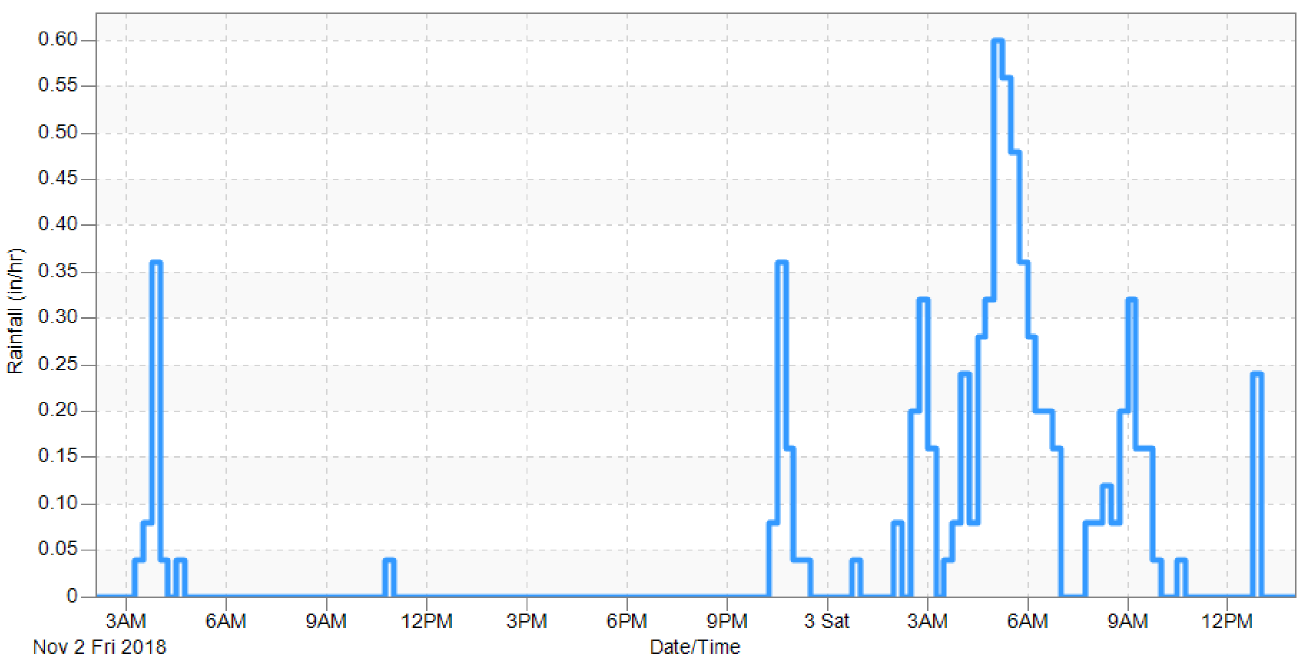


Figure 30. CH-BO-1 November 2, 2018

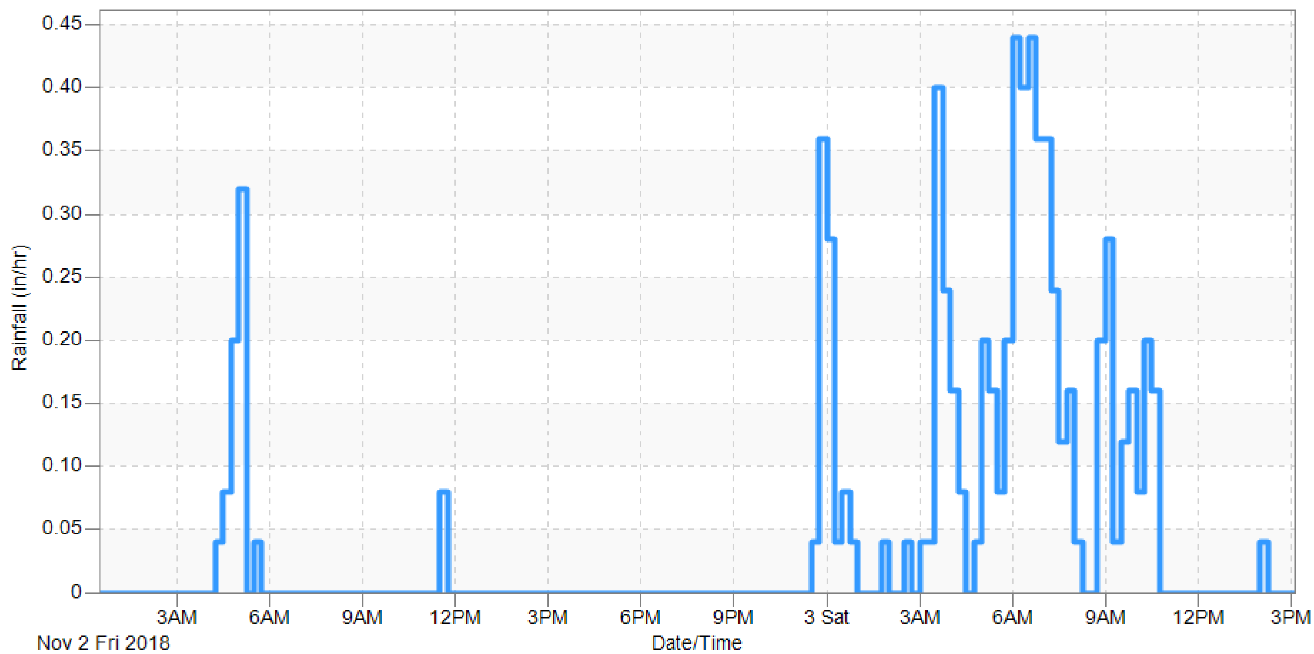


Figure 31. USGS Fresh Pond November 2, 2018

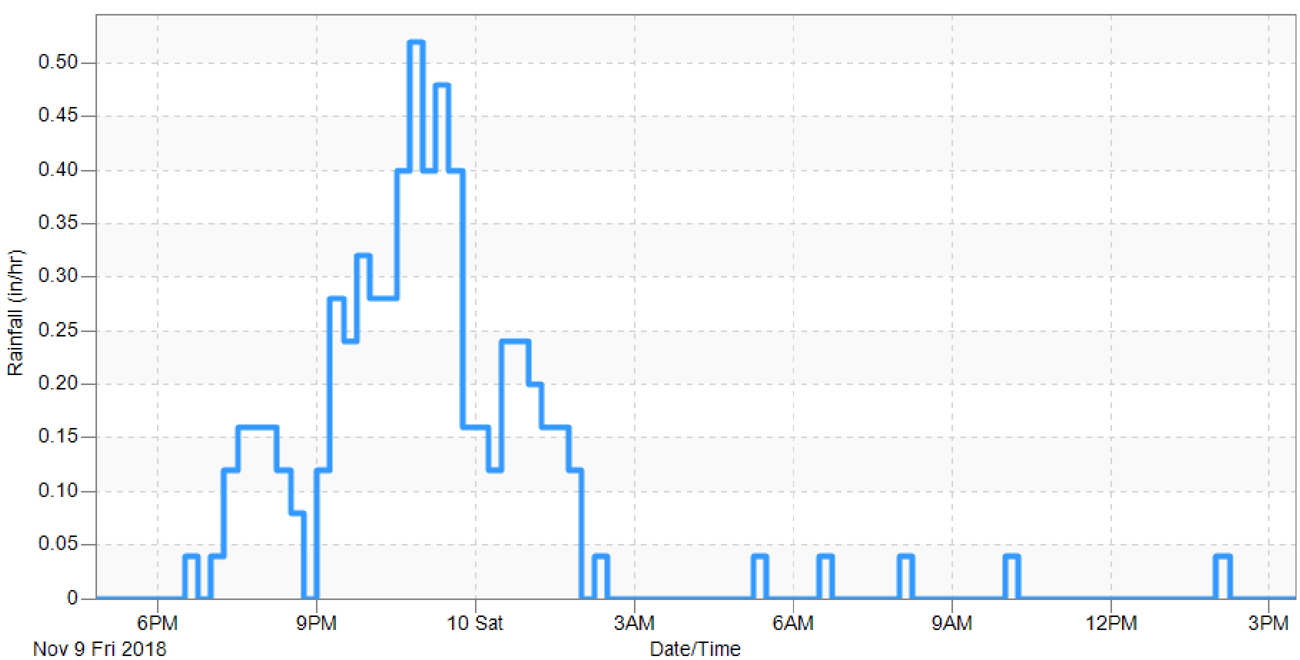


Figure 32. BO-DI-1 November 9, 2018

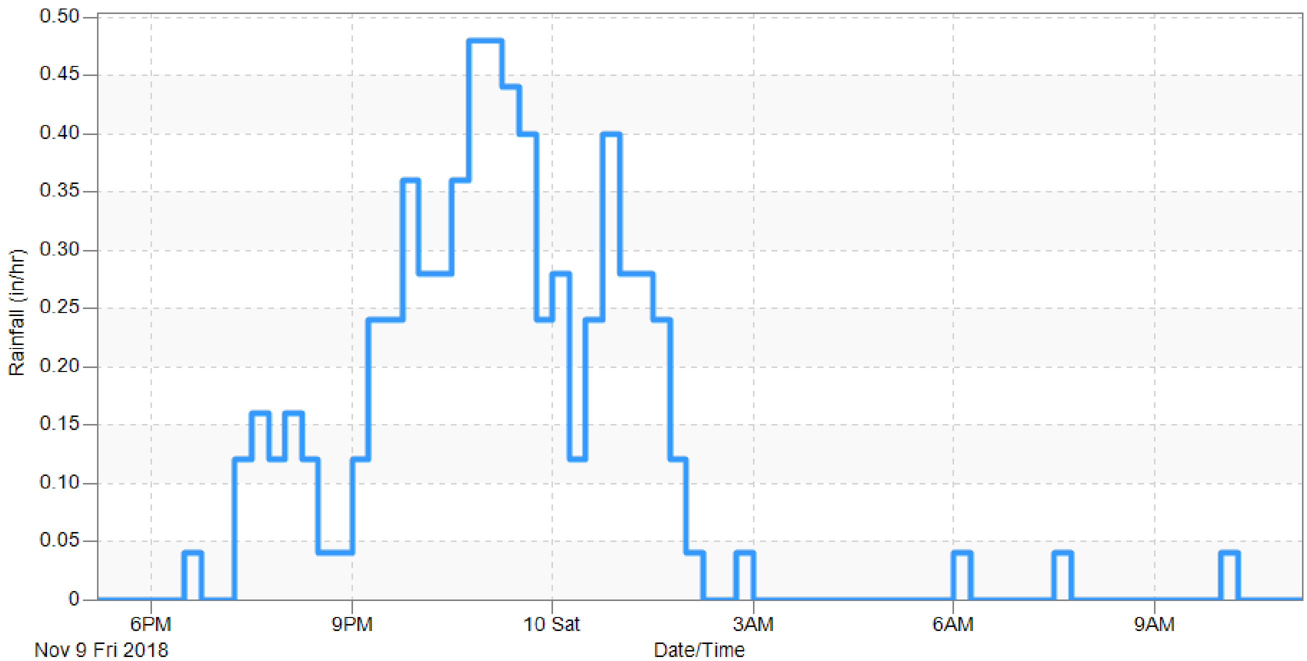


Figure 33. BO-DI-2 November 9, 2018

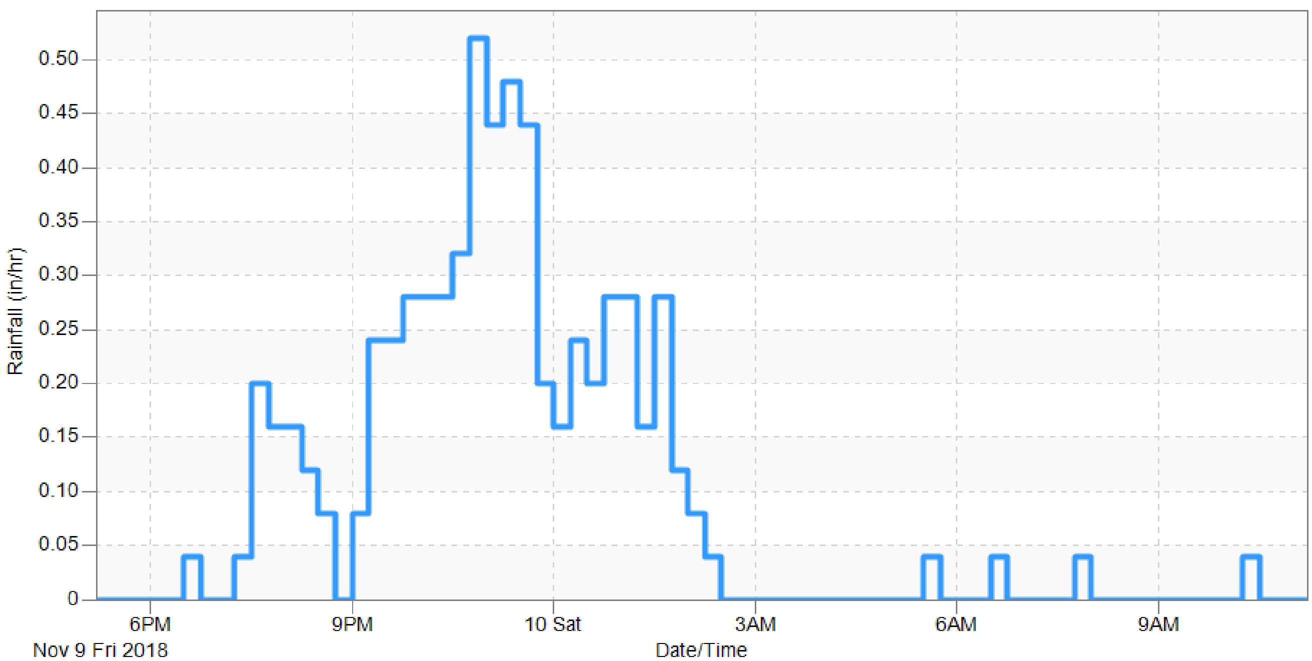
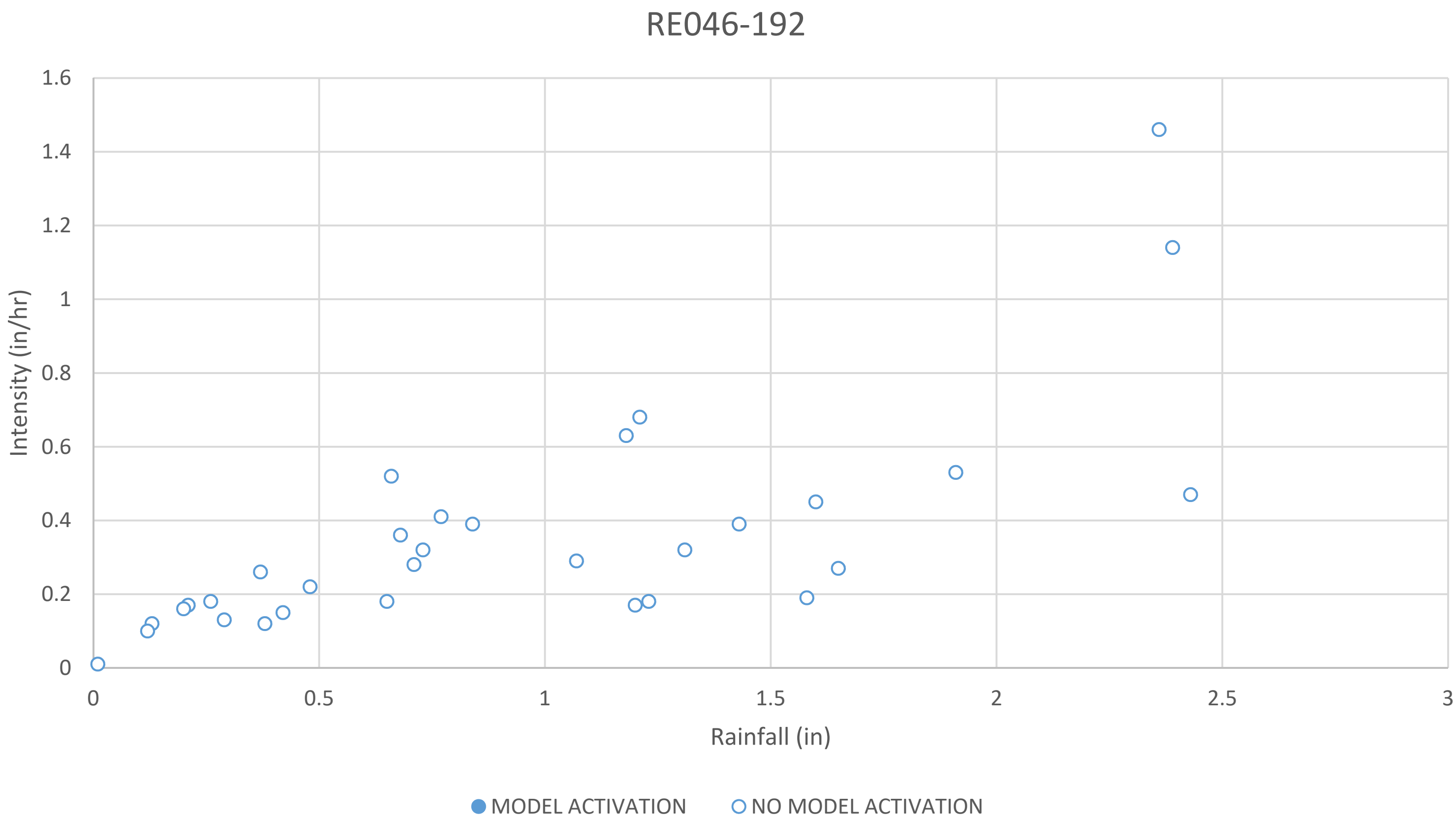


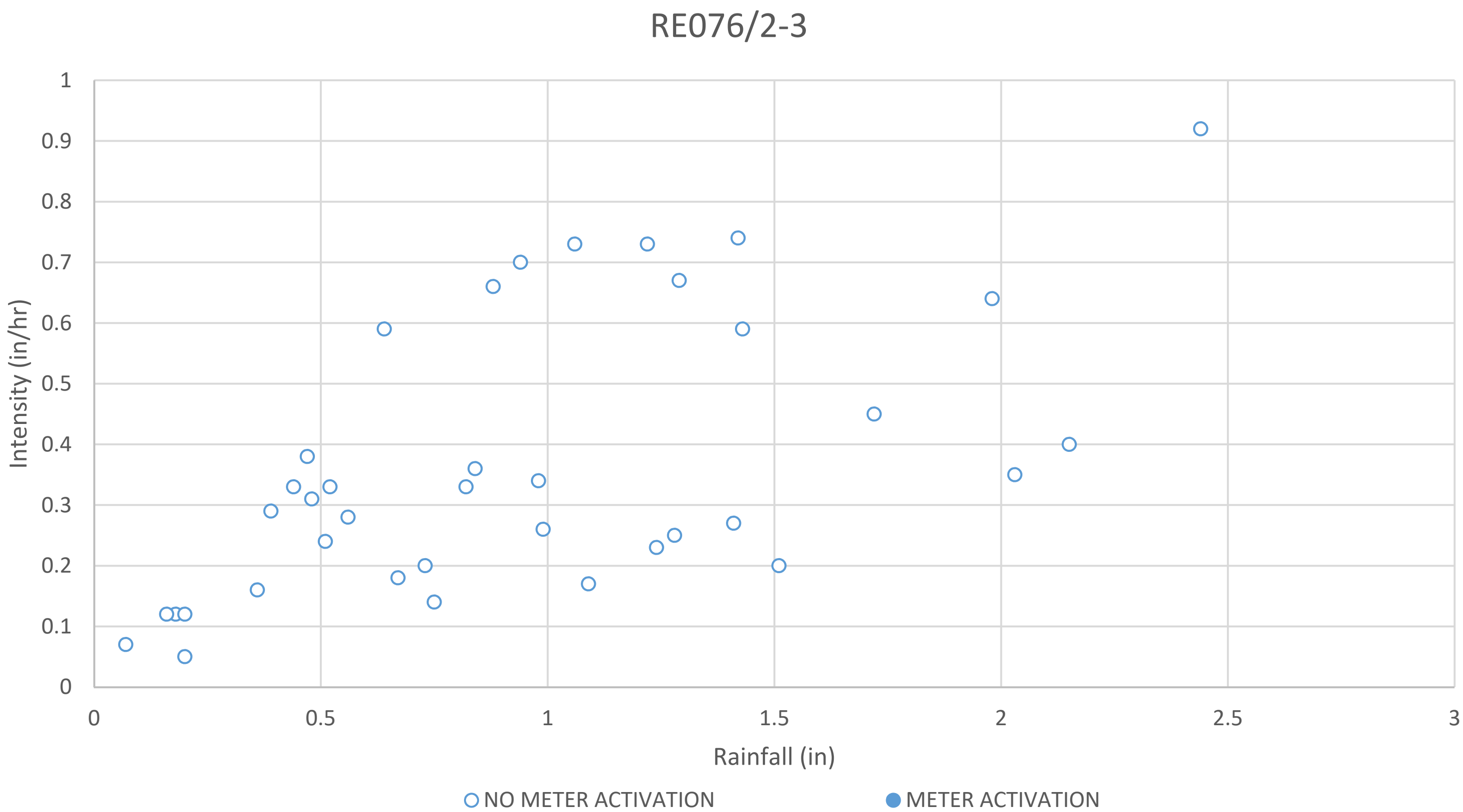
Figure 34. CH-BO-1 November 9, 2018

Appendix D Meter Data Scattergraphs

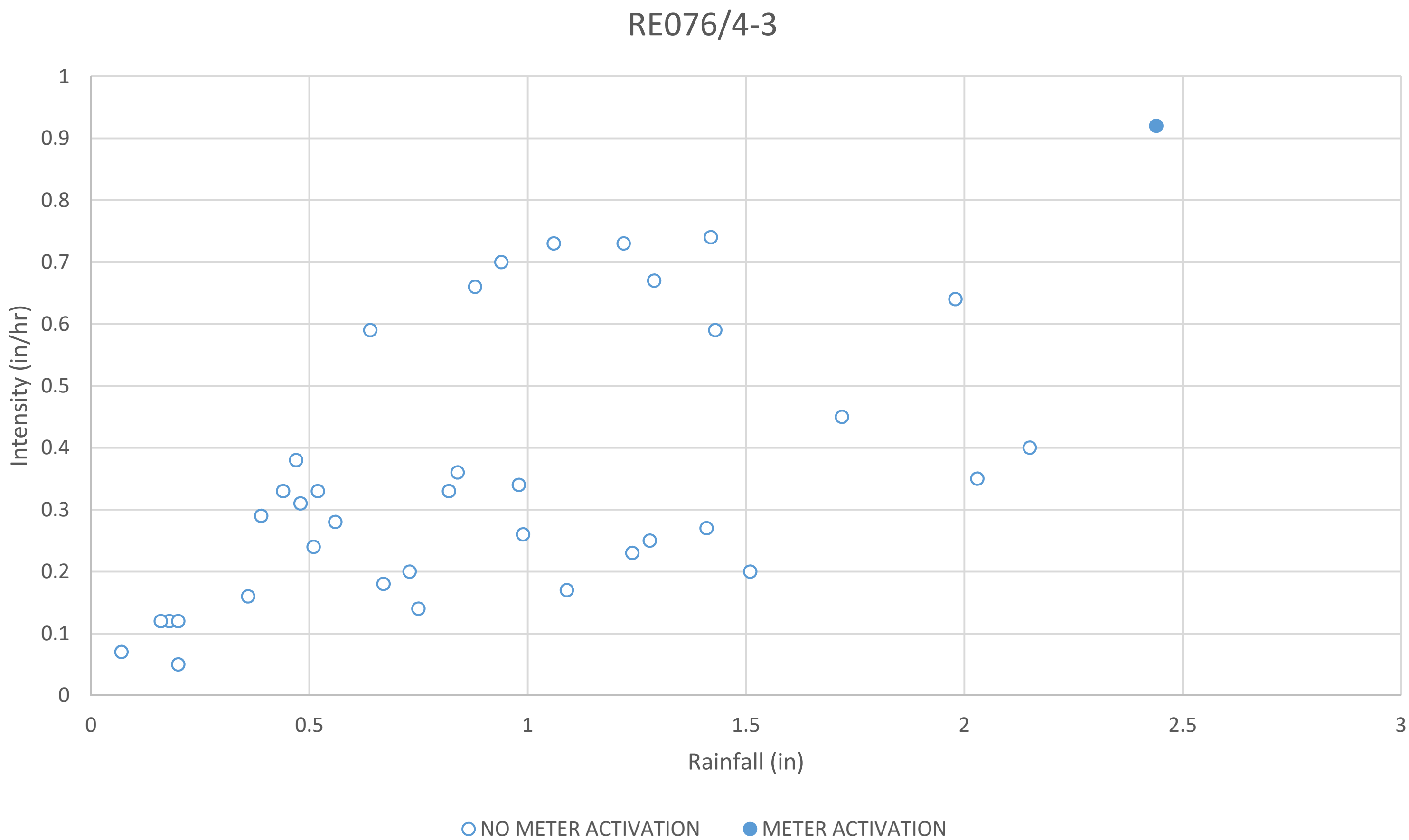
Outfall: MWR023
Regulator: RE046-192
Related Rain Gauge: 2



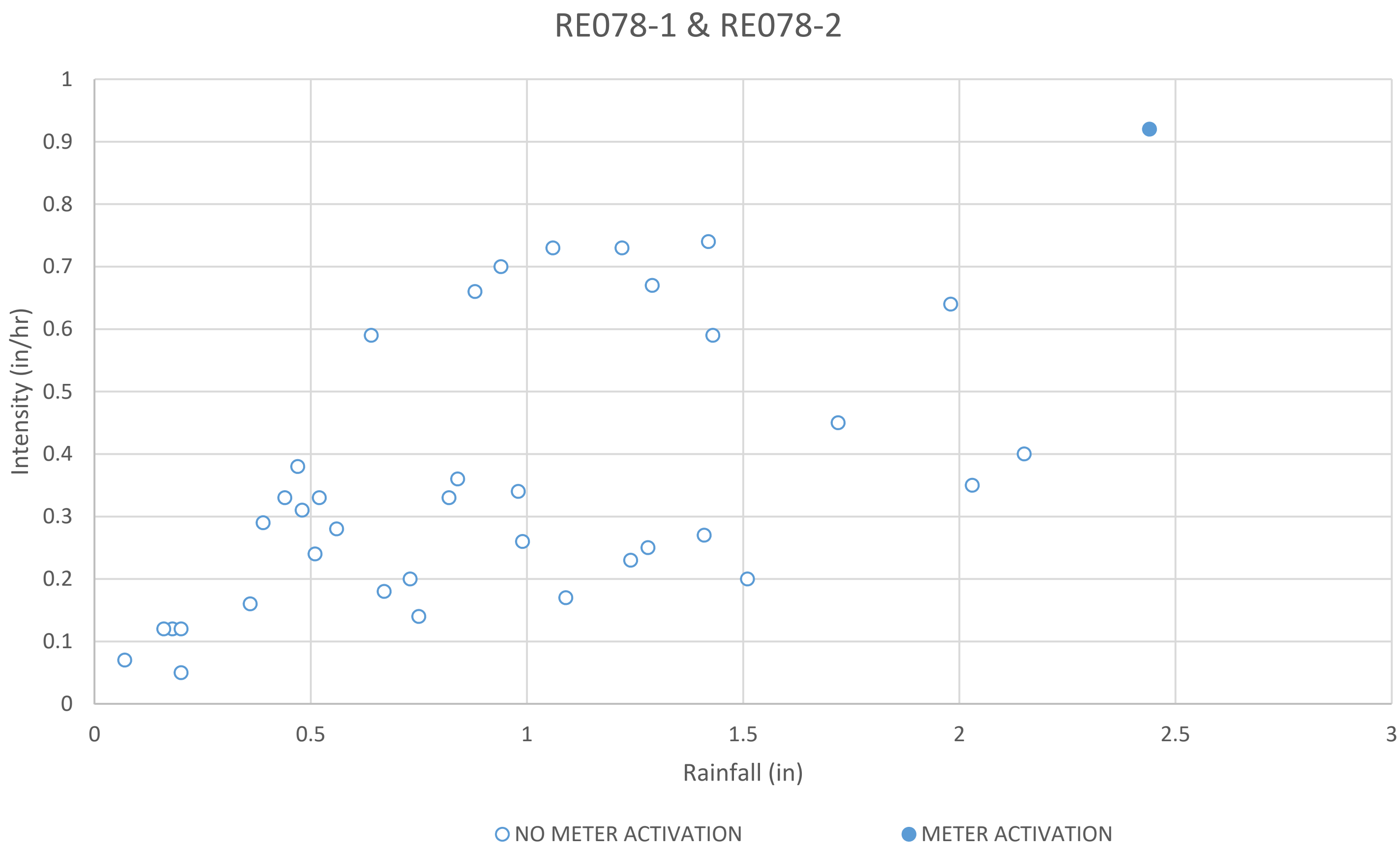
Outfall: BOS076
Regulator: RE076/2-3
Related Rain Gauge: 3



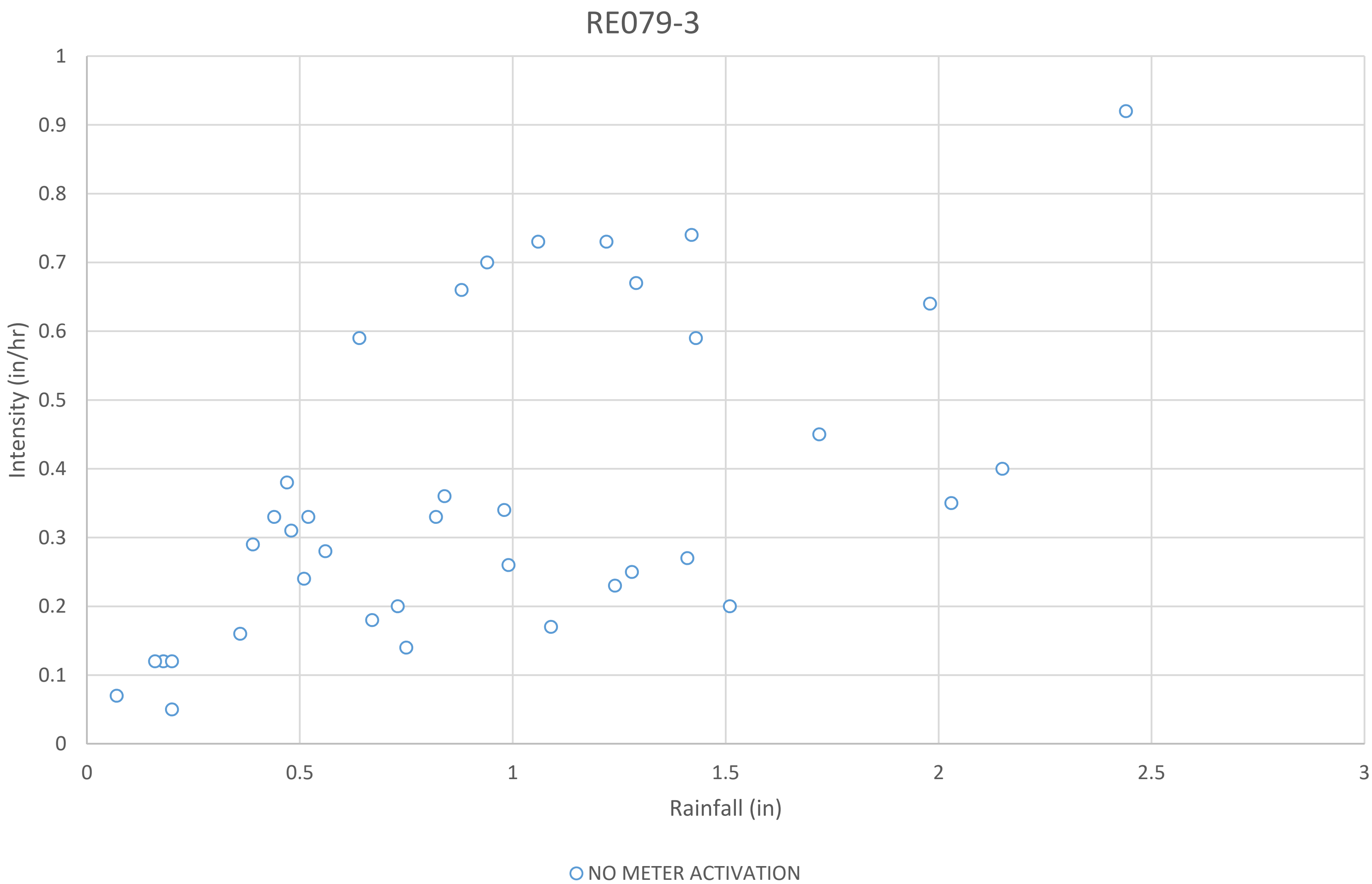
Outfall: BOS076
Regulator: RE076/4-3
Related Rain Gauge: 3



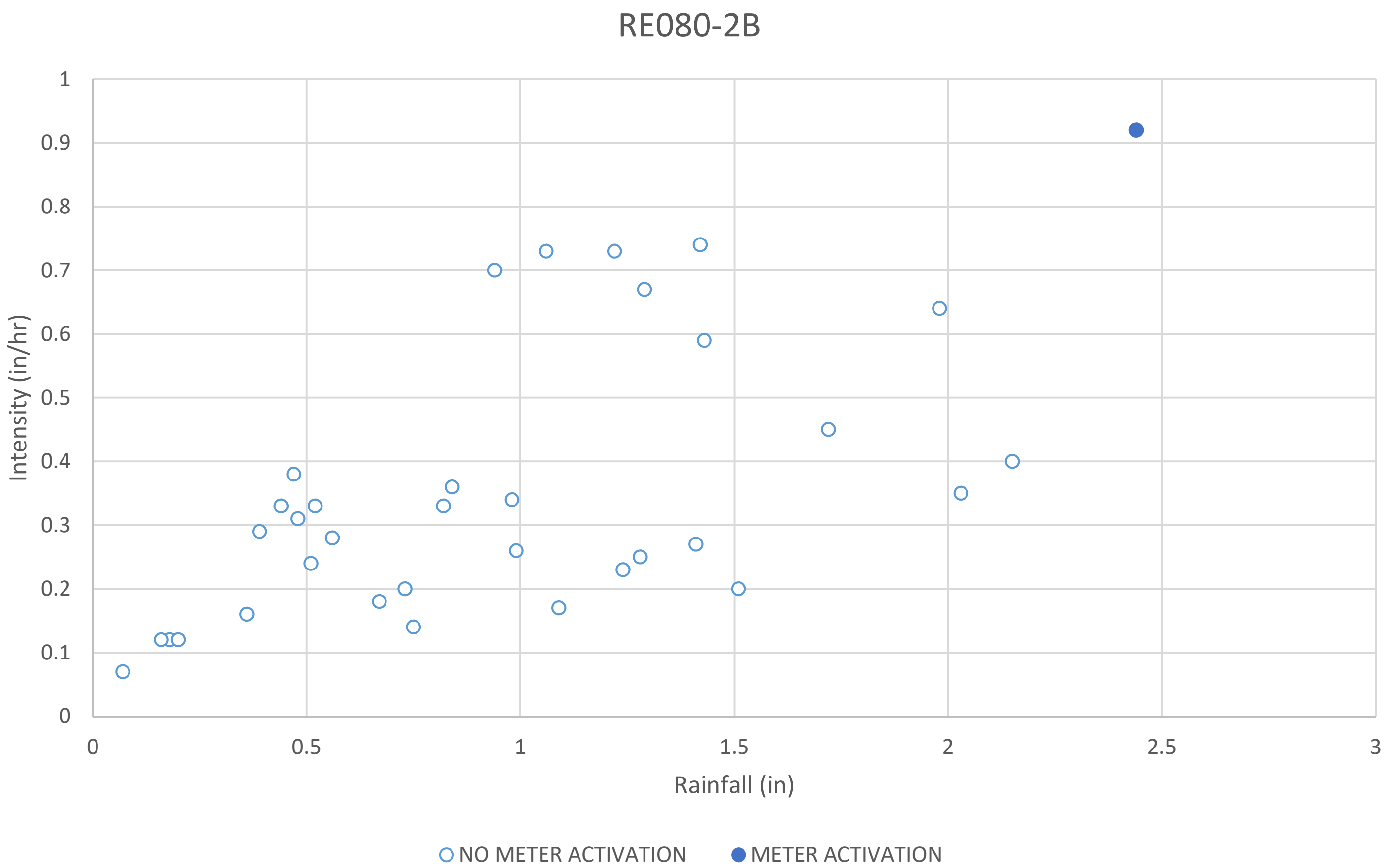
Outfall: BOS078
Regulator: RE078-1 & RE078-2
Related Rain Gauge: 3



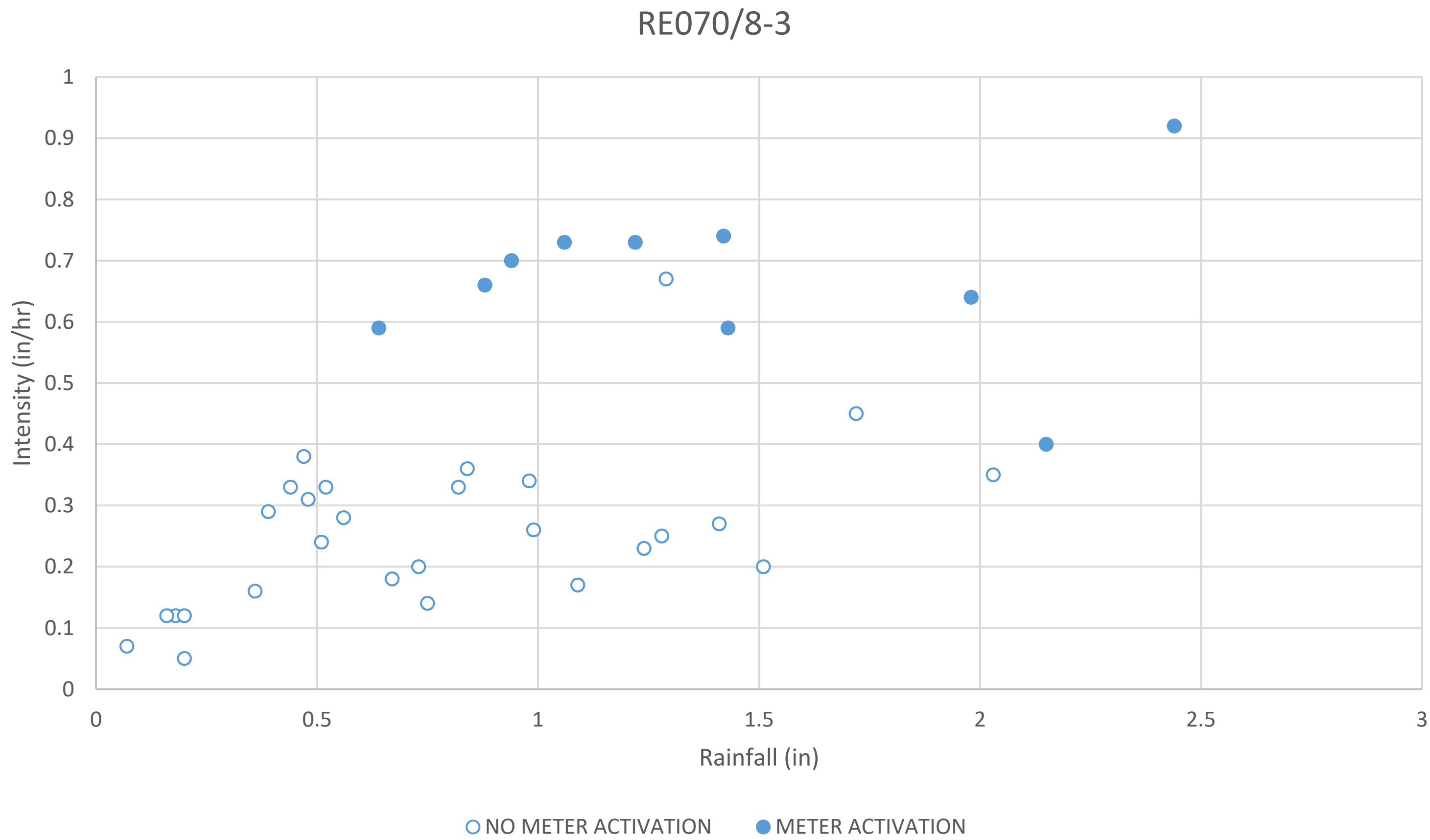
Outfall: BOS079
Regulator: RE079-3
Related Rain Gauge: 3



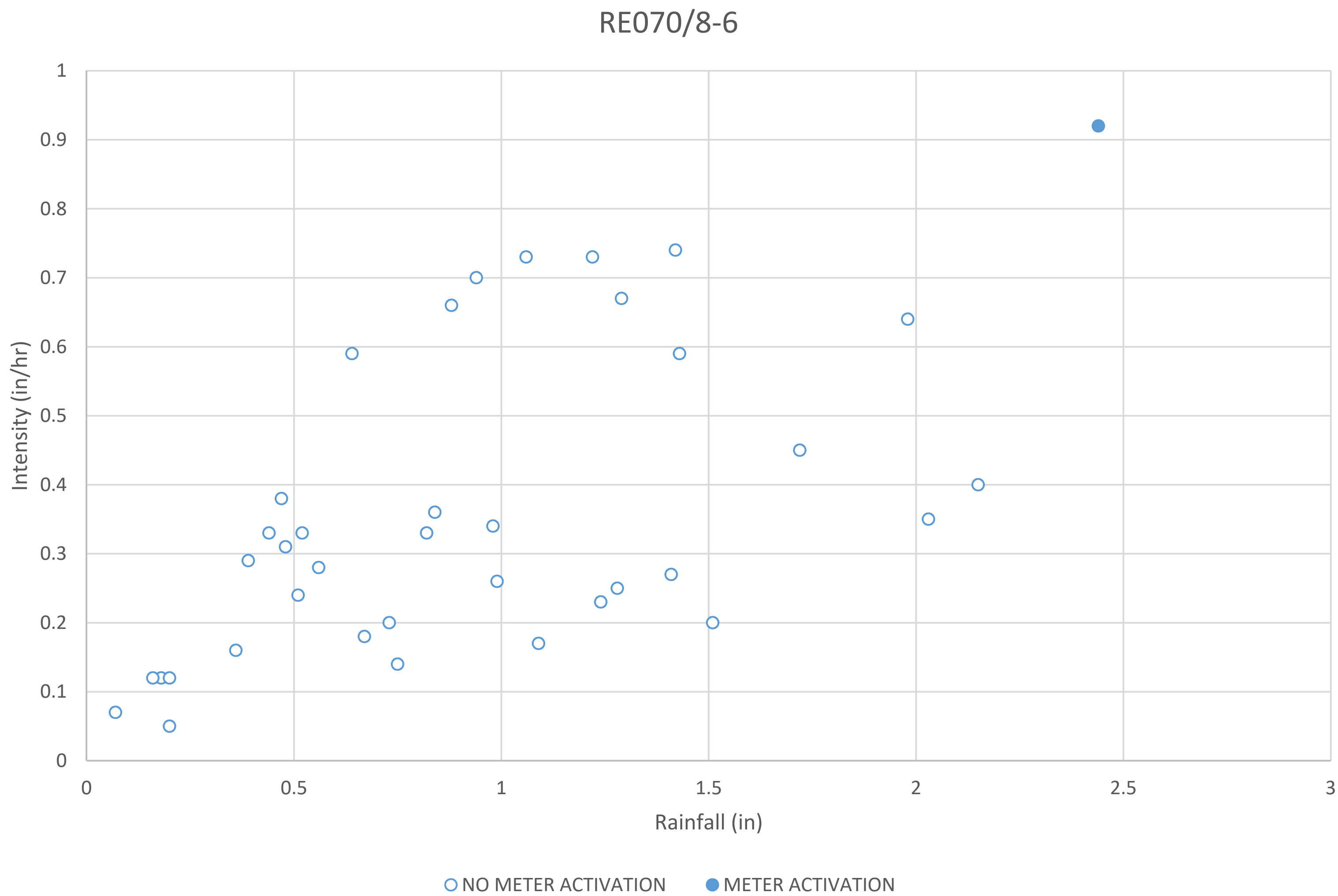
Outfall: BOS080
Regulator: RE080-2B
Related Rain Gauge: 3



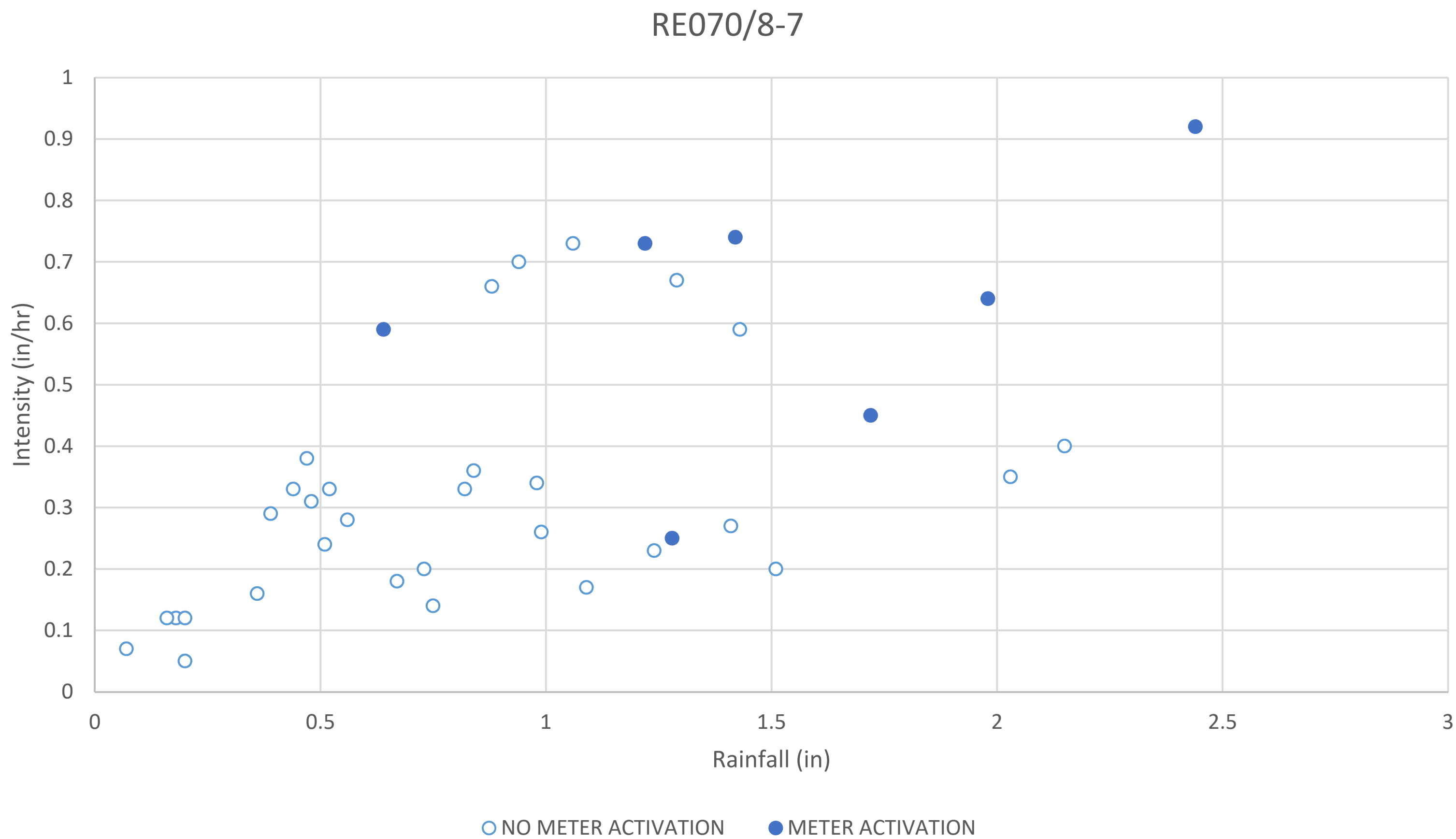
Outfall:BOS70/DBC
Regulator: RE070/8-3
Related Rain Gauge: 3



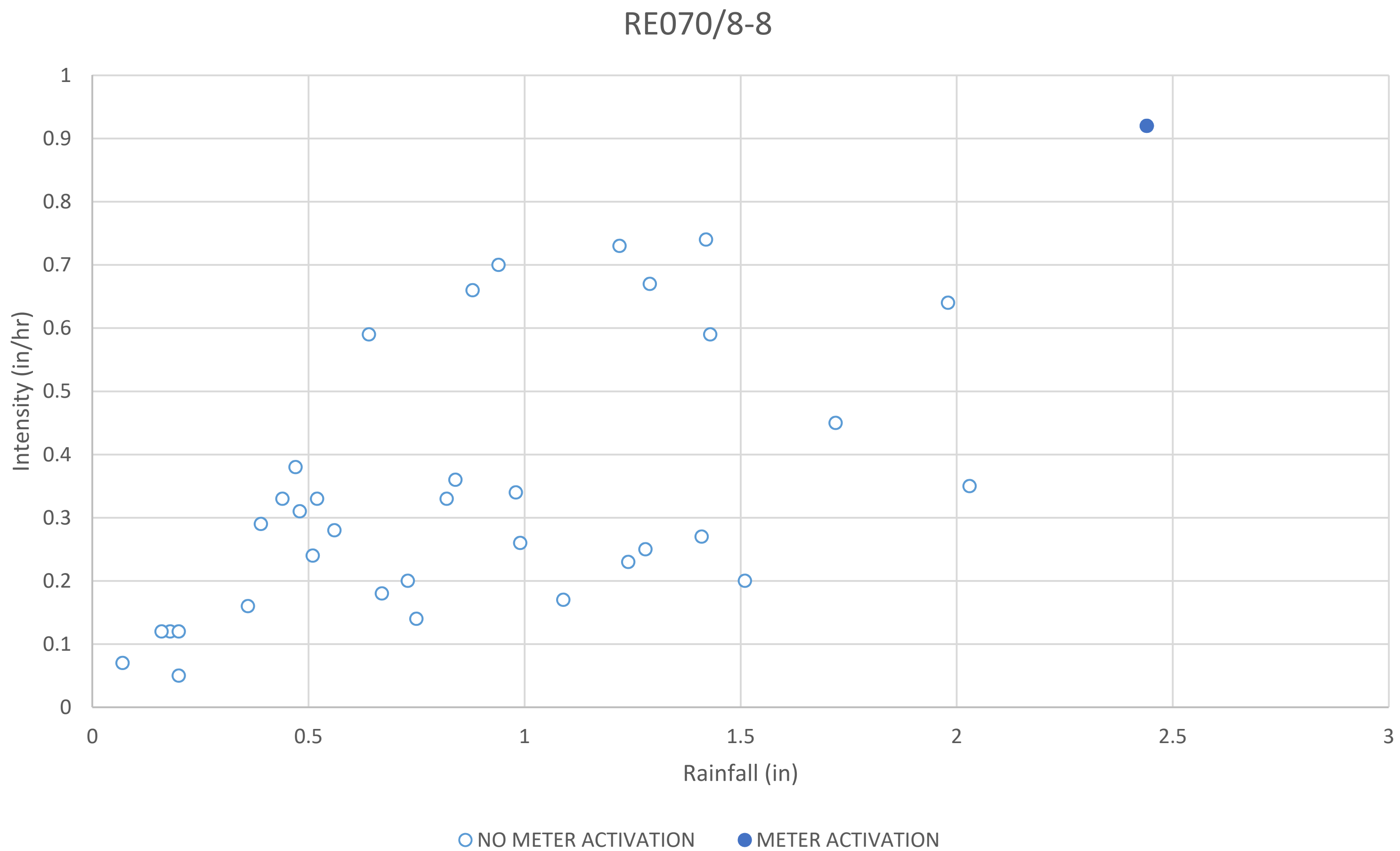
Outfall:BOS70/DBC
Regulator: RE070/8-6
Related Rain Gauge: 3



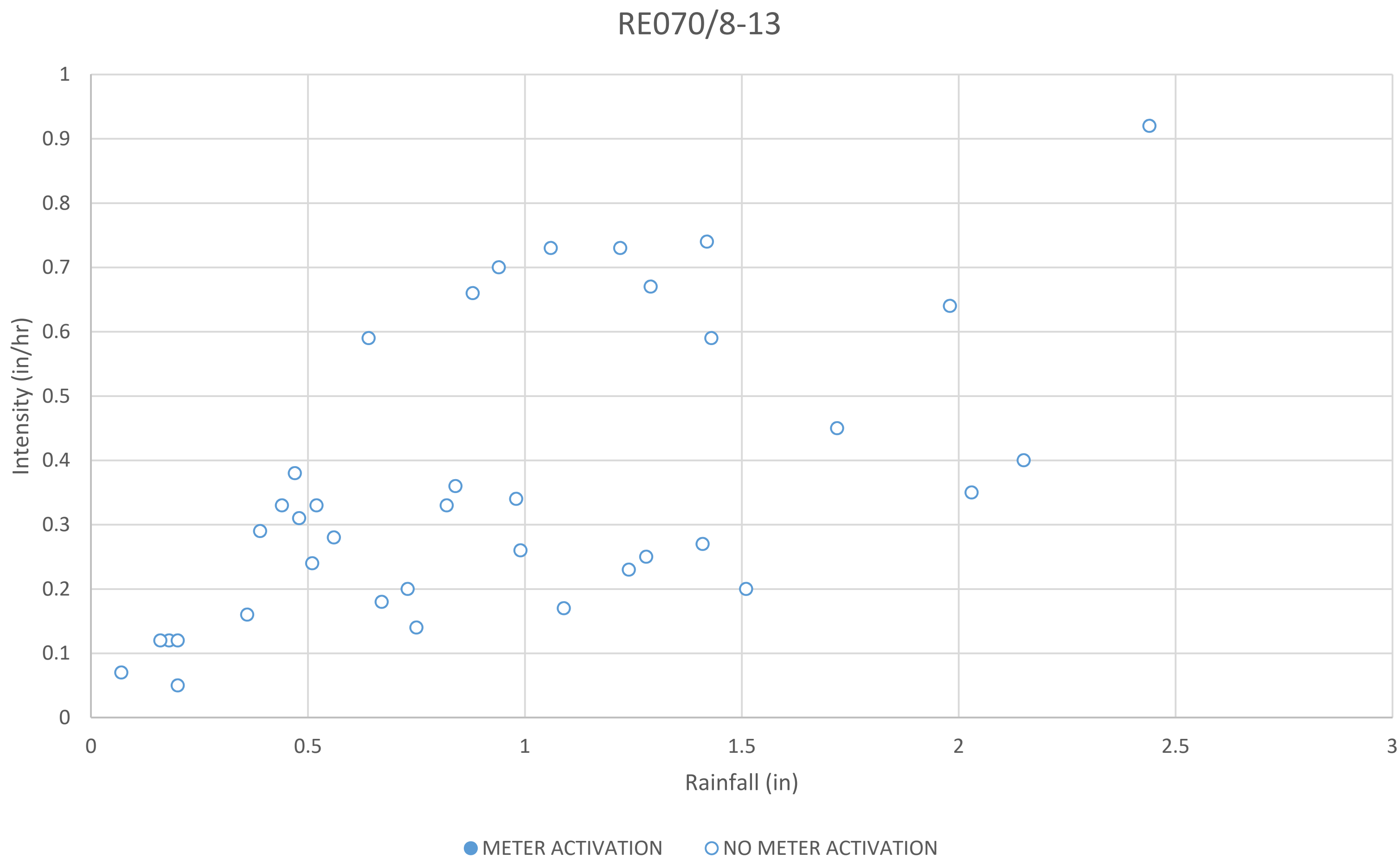
Outfall:BOS70/DBC
Regulator: RE070/8-7
Related Rain Gauge: 3



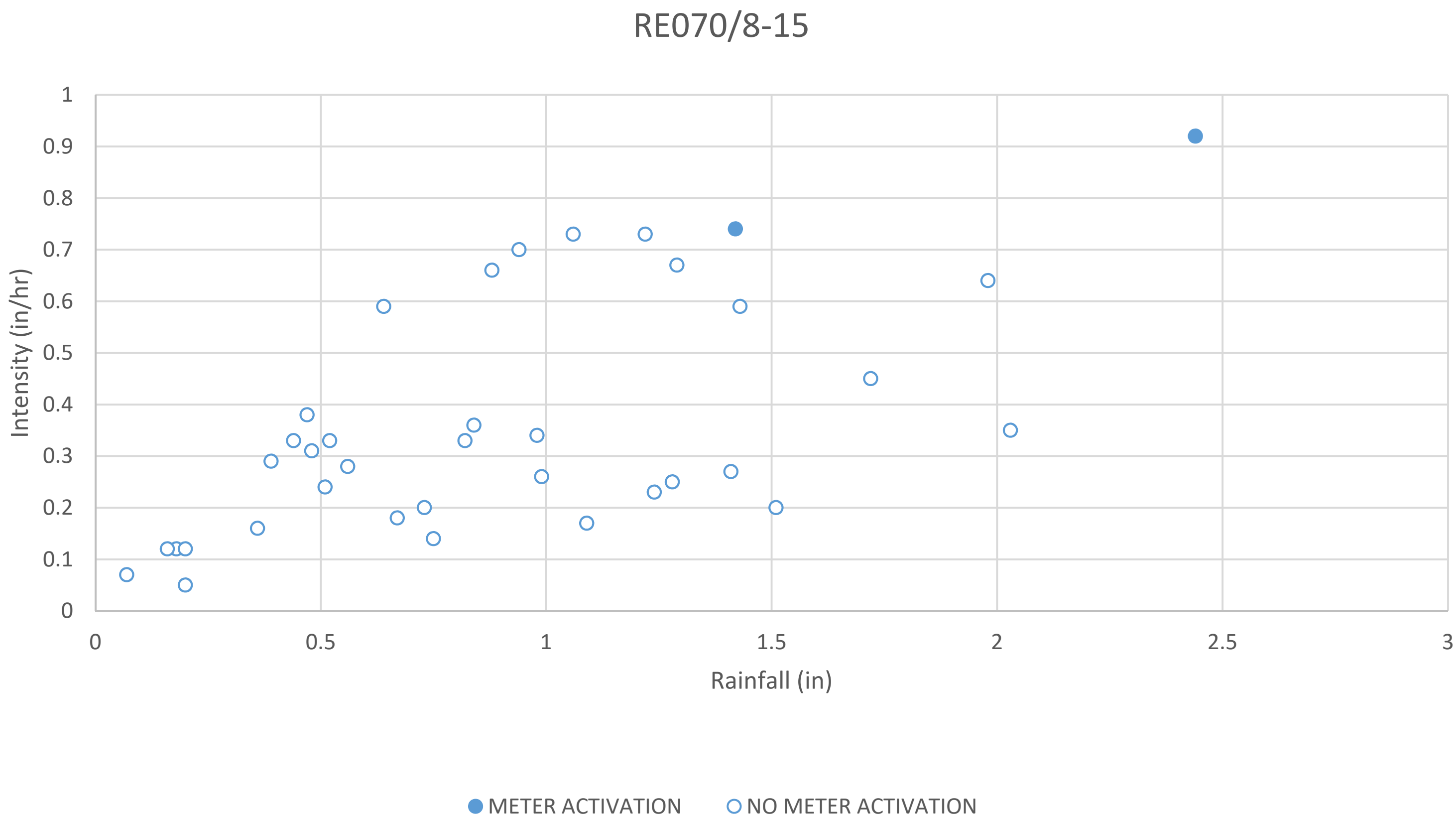
Outfall:BOS70/DBC
Regulator: RE070/8-8
Related Rain Gauge: 3



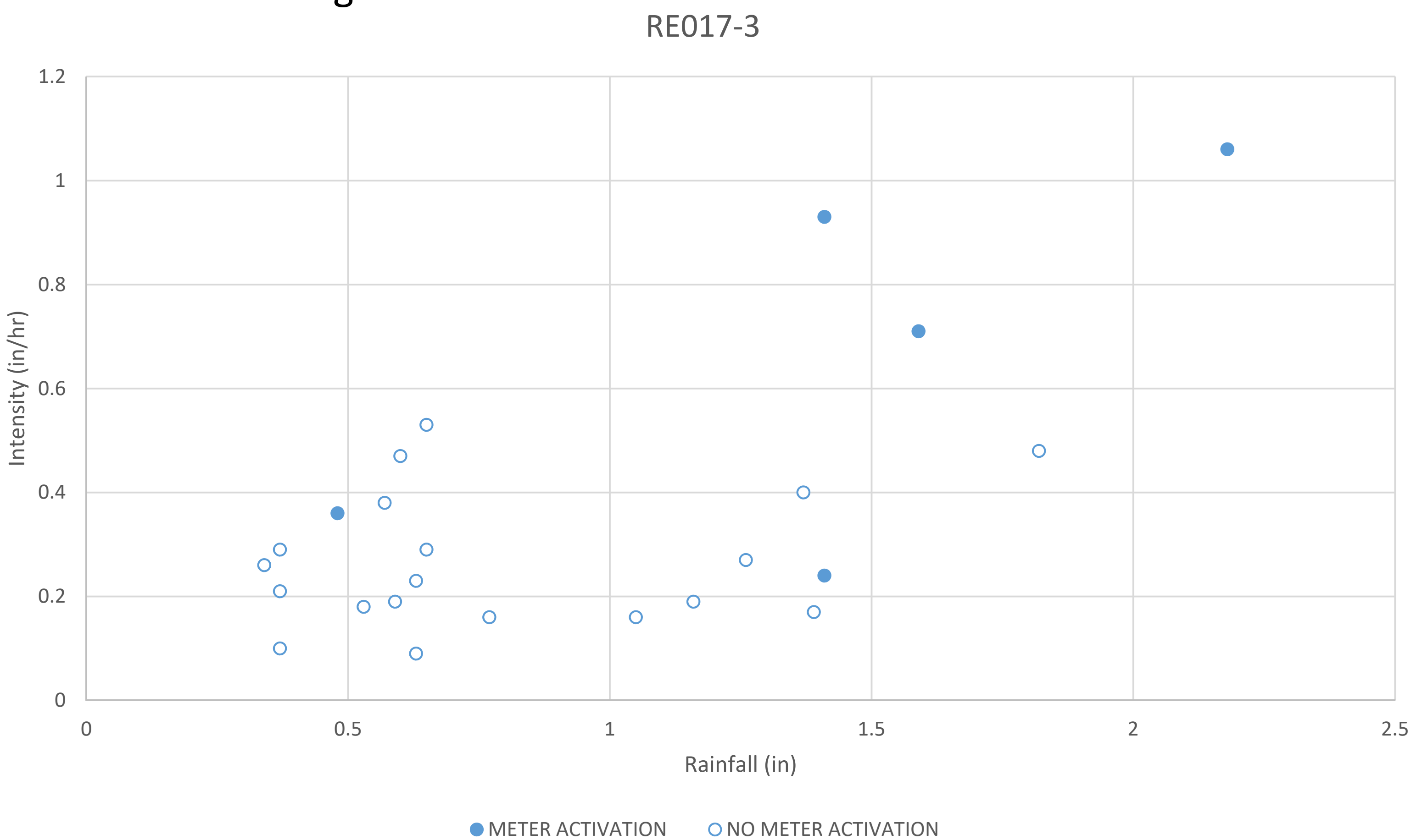
Outfall:BOS70/DBC
Regulator: RE070/8-13
Related Rain Gauge: 3



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

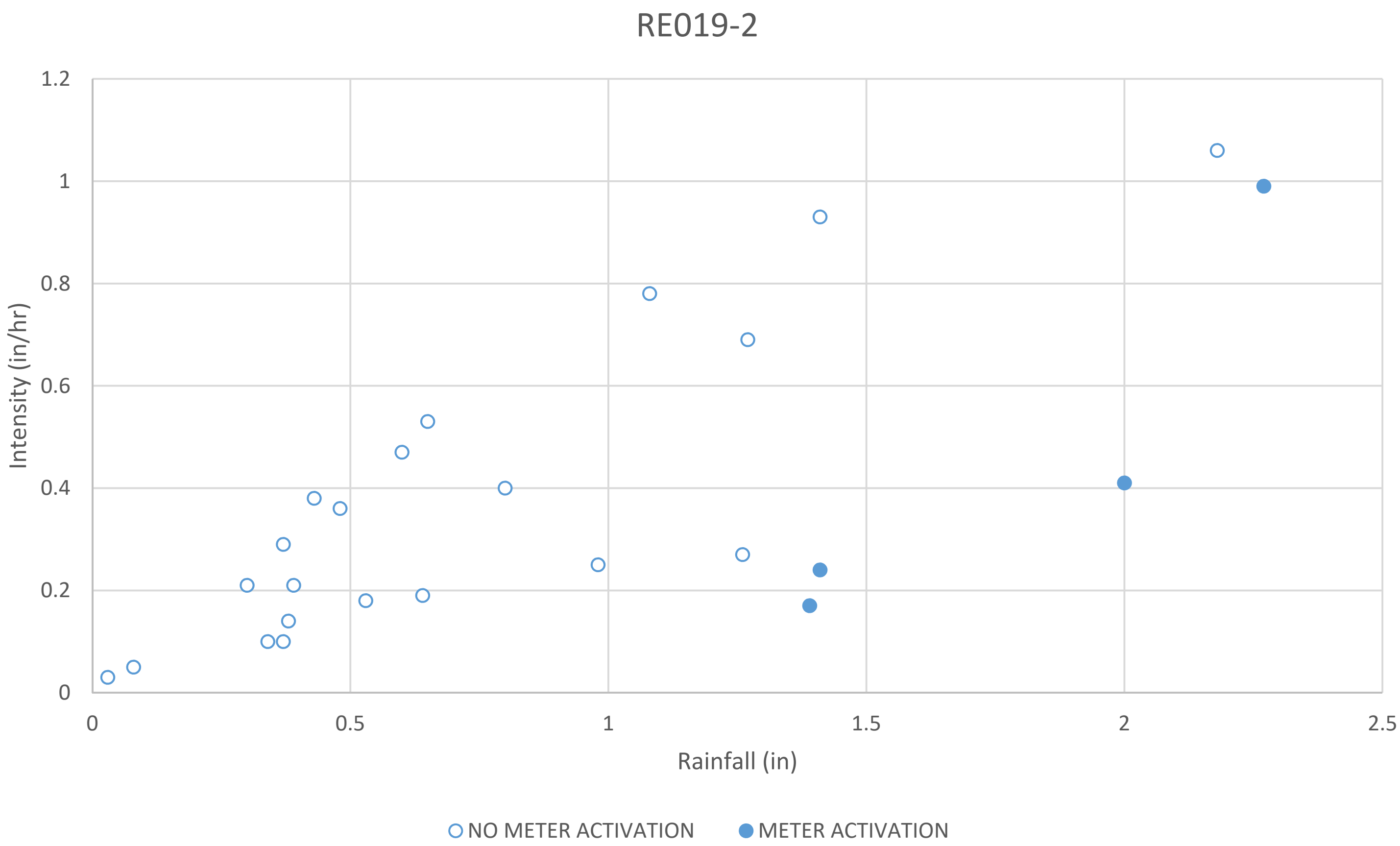


Outfall: BOS017
Regulator: RE017-3
Related Rain Gauge: 4

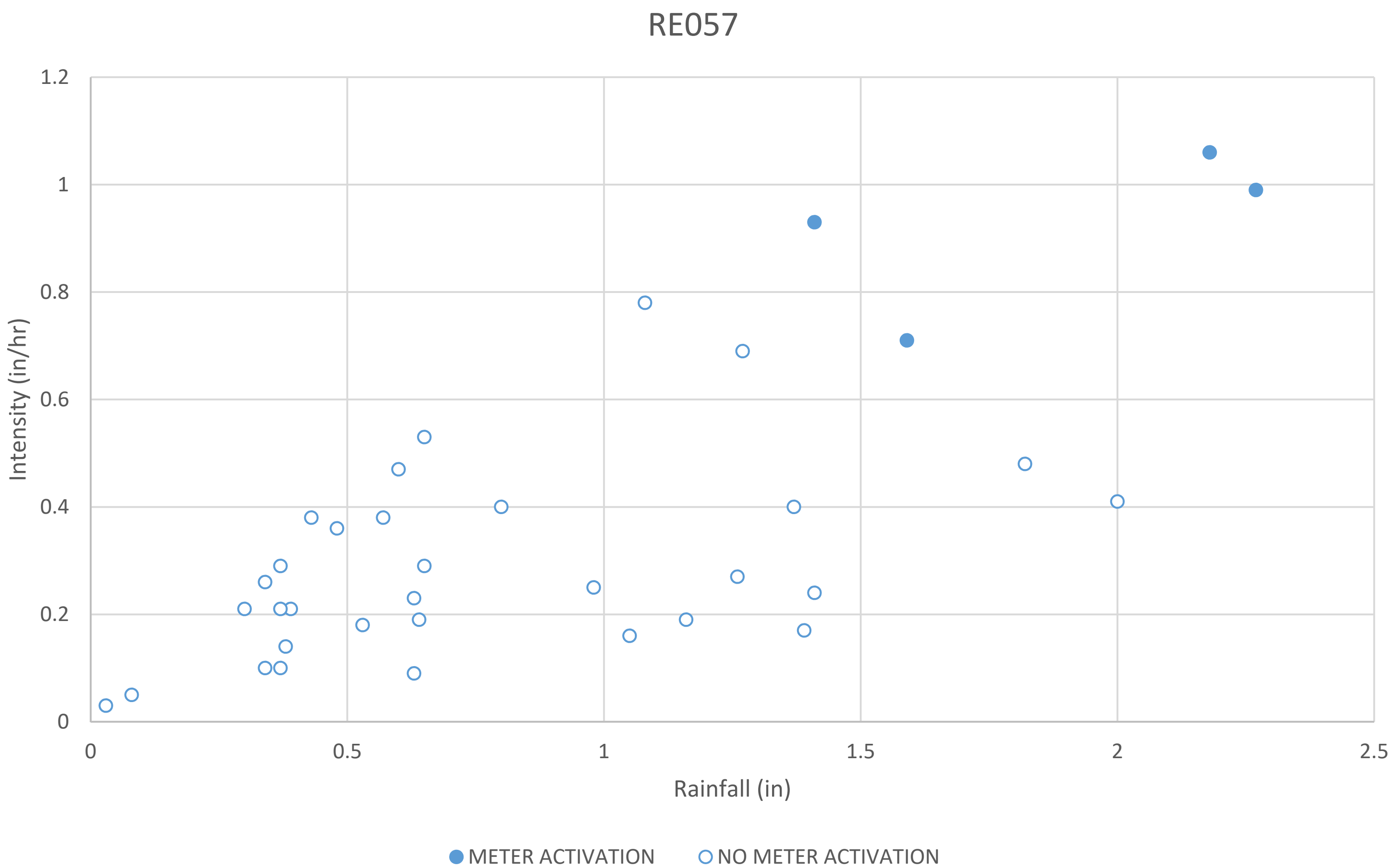


Does not include activations from April 15-July 18. After July 18 an inclinometer was added providing increased confidence in CSO activations

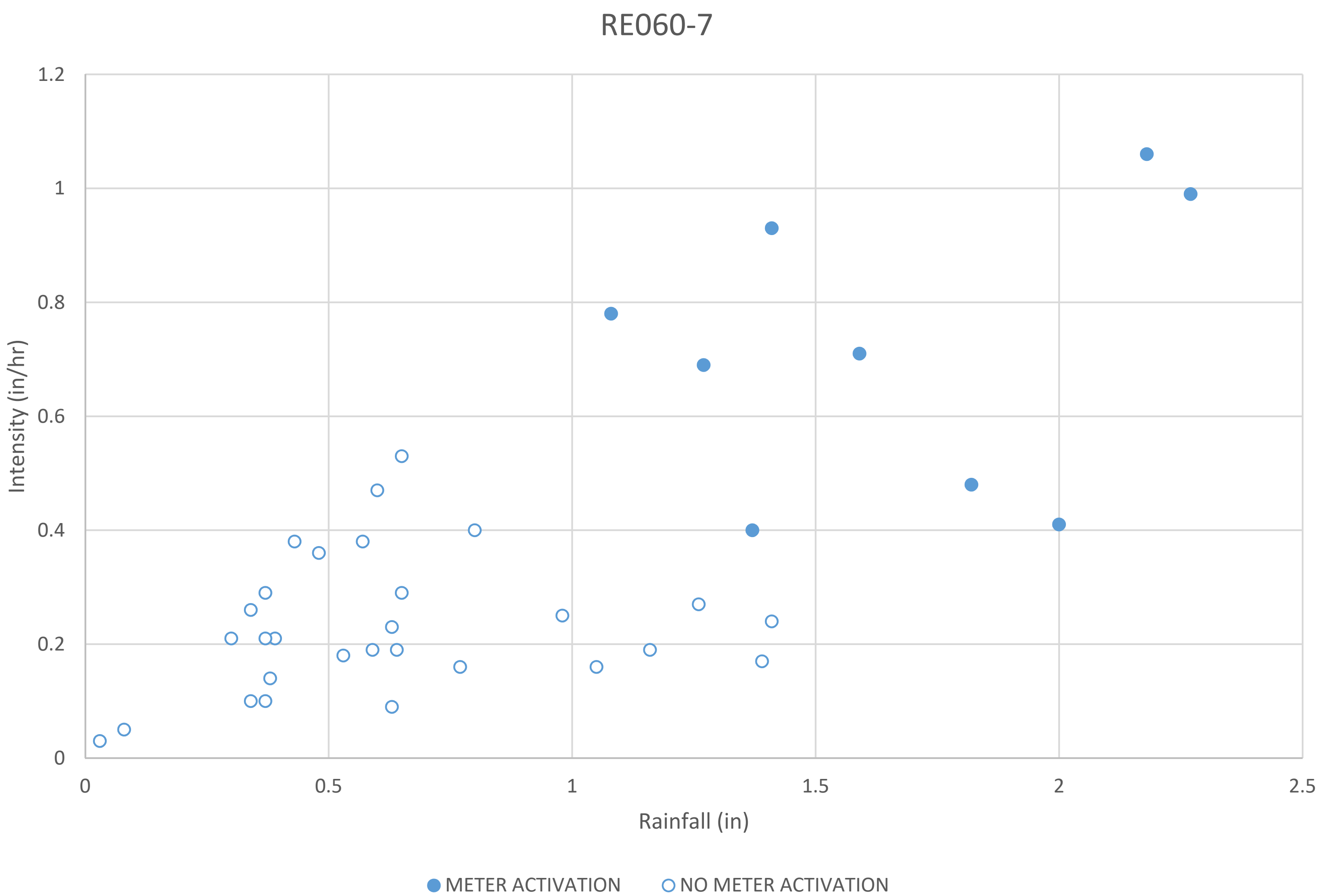
Outfall: BOS019
Regulator: RE019-2
Related Rain Gauge: 4



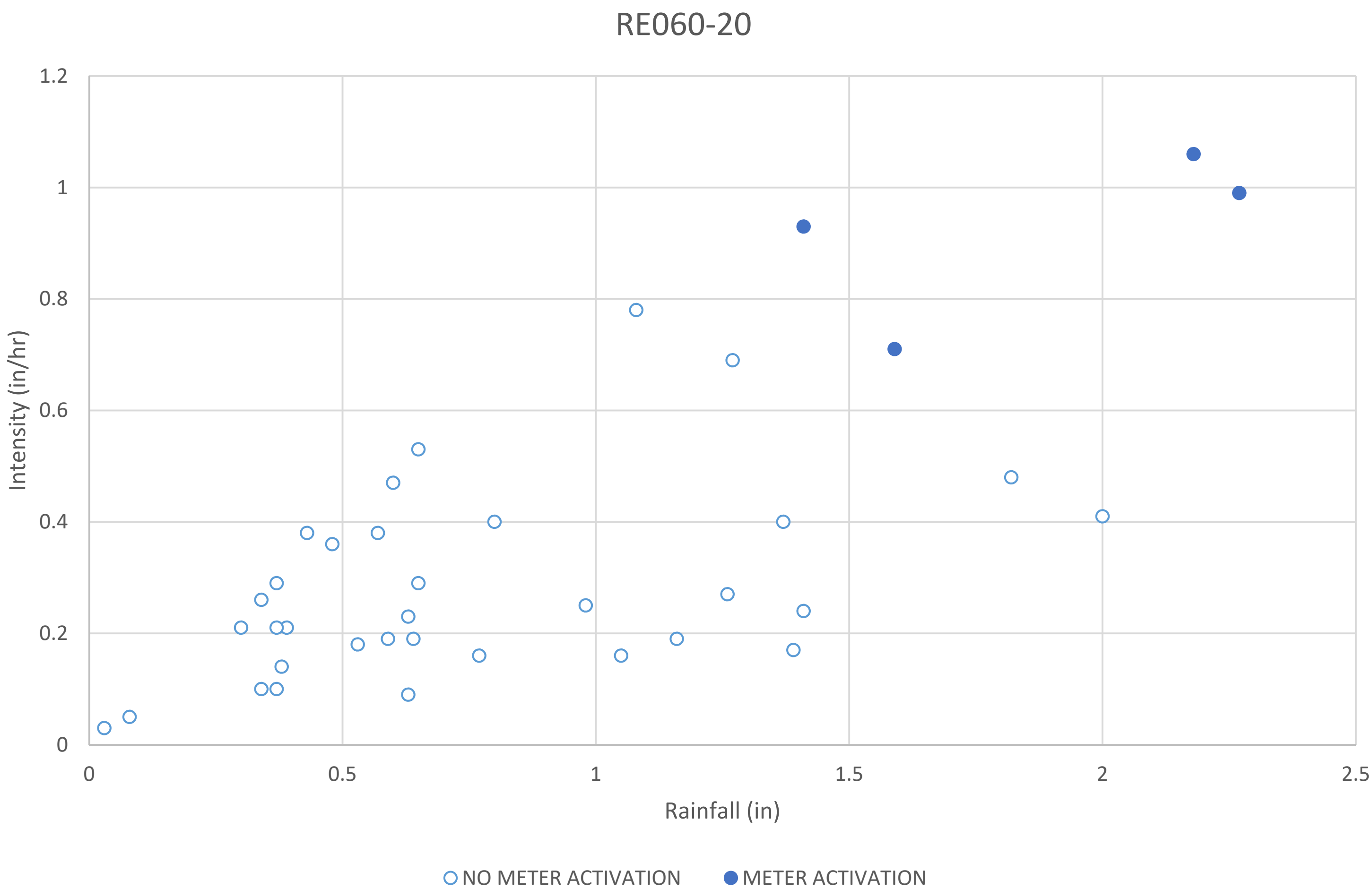
Outfall: BOS057
Regulator: RE057
Related Rain Gauge: 4



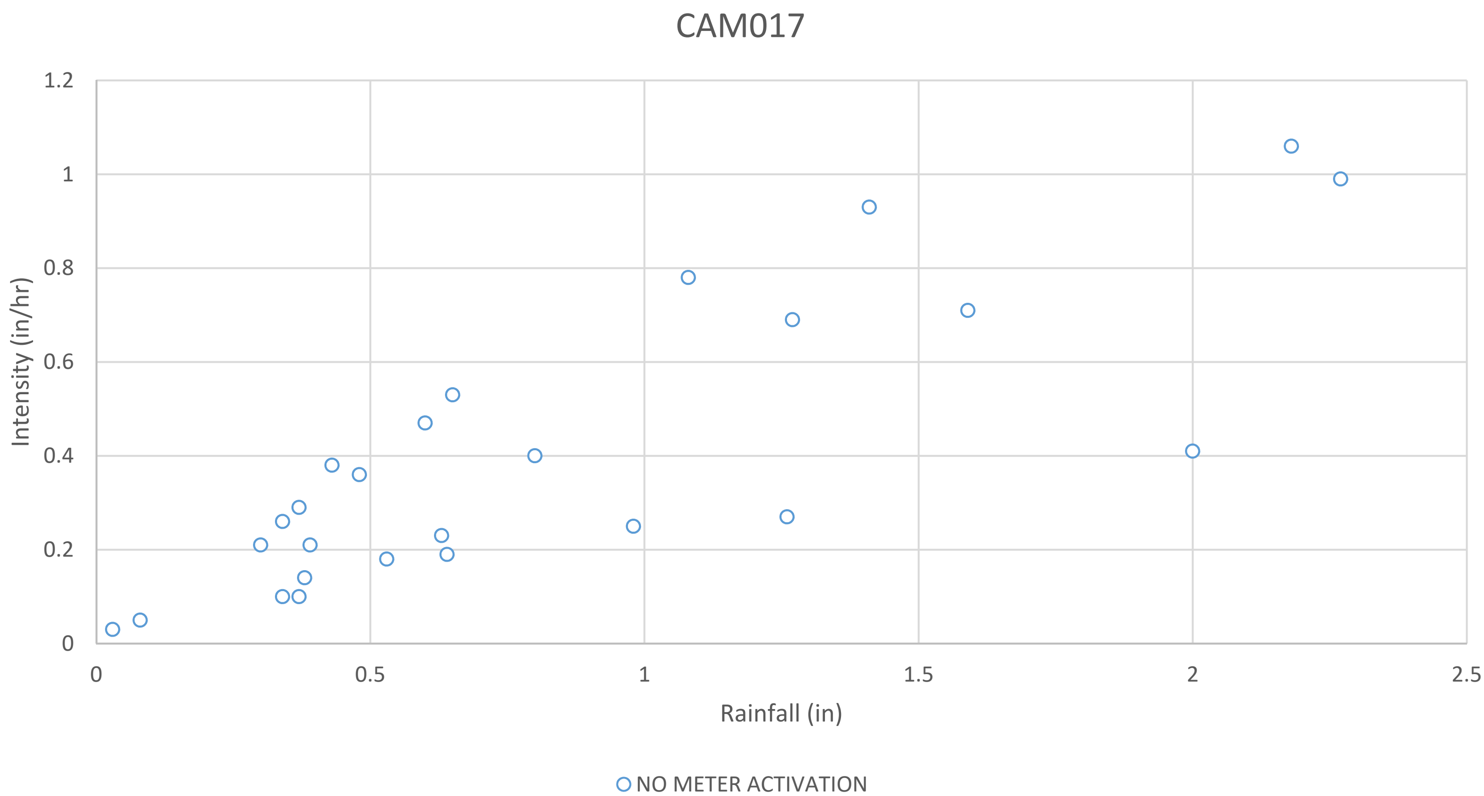
Outfall: BOS060
Regulator: RE060-7
Related Rain Gauge: 4



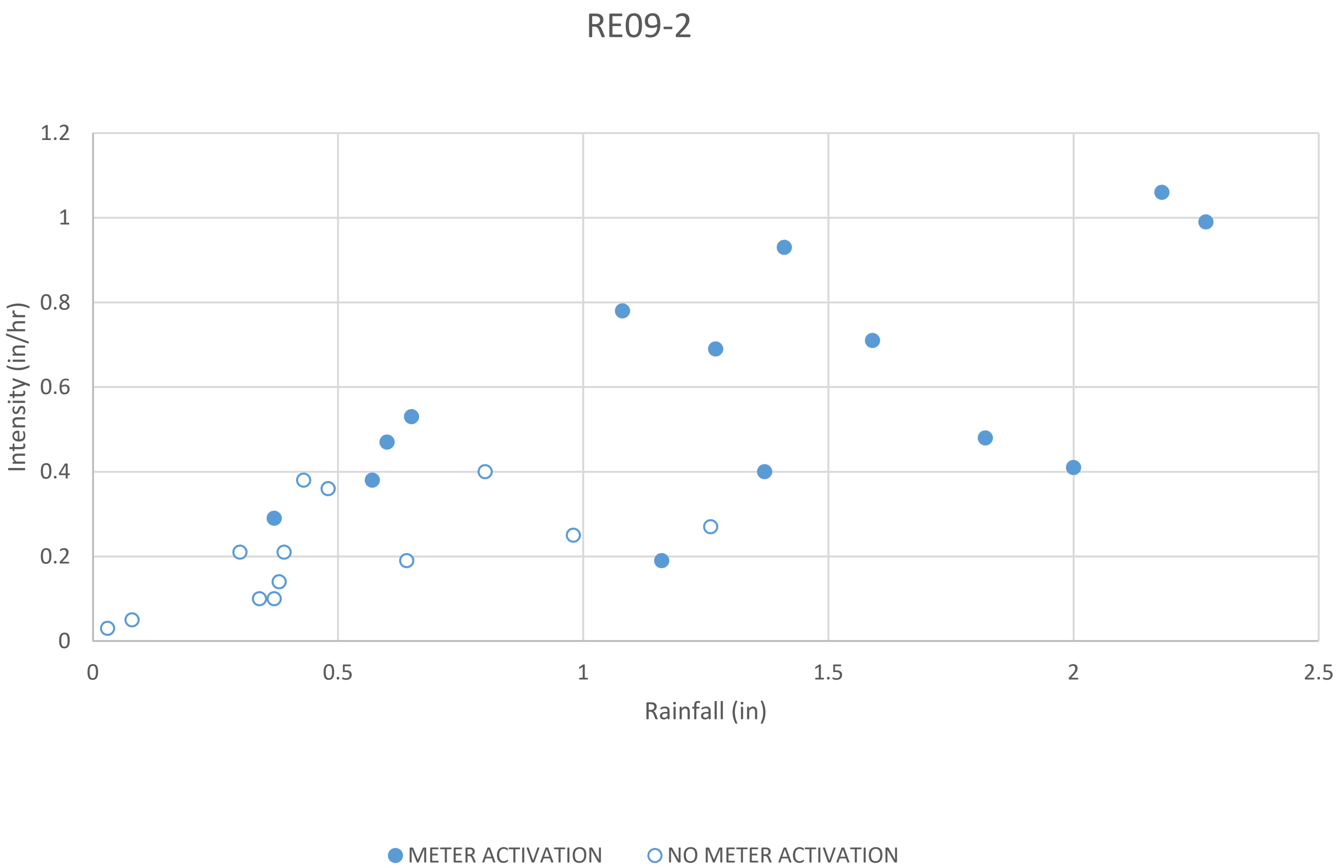
Outfall: BOS060
Regulator: RE060-20
Related Rain Gauge: 4



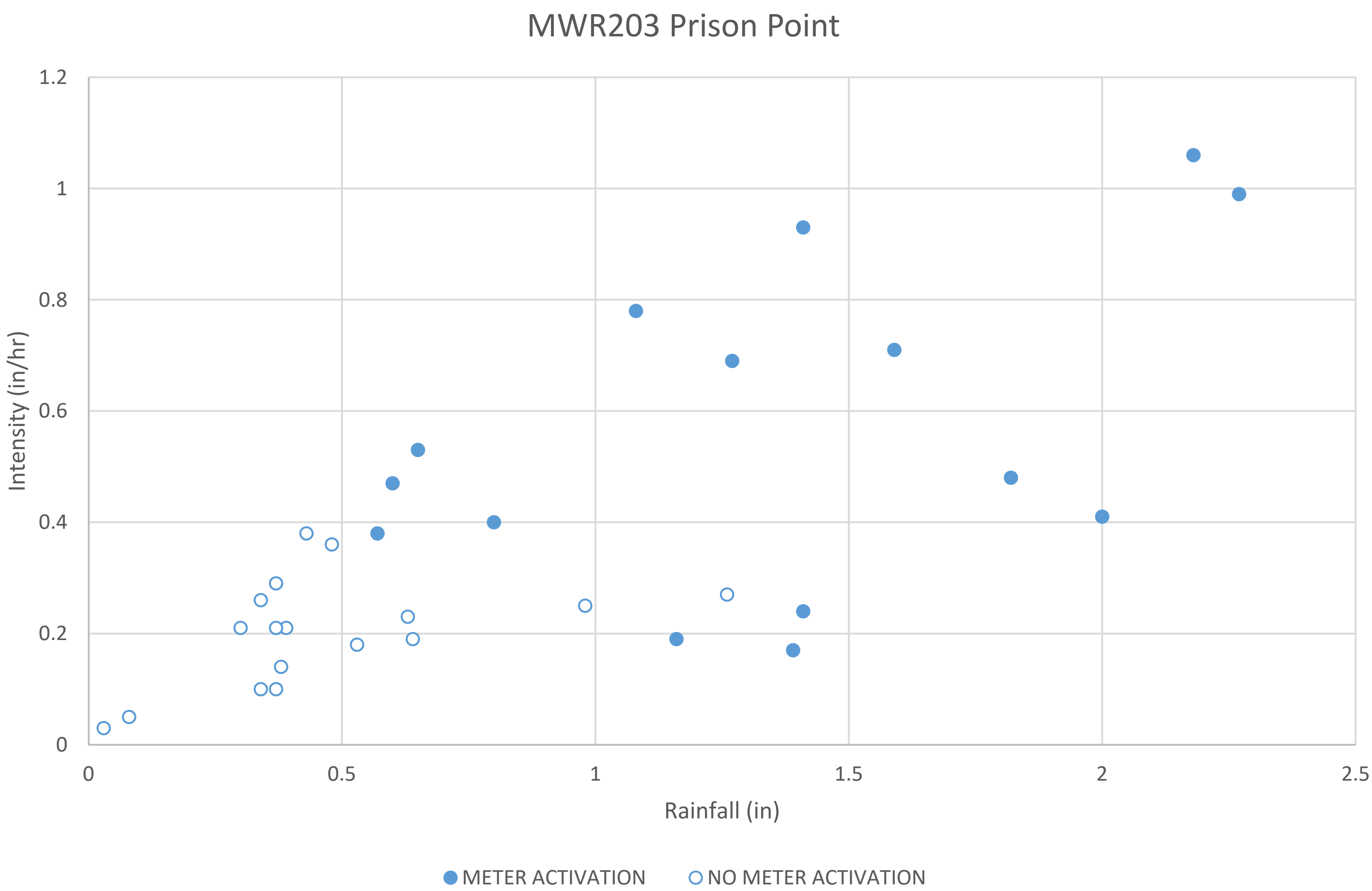
Outfall: CAM017
Regulator: CAM017
Related Rain Gauge: 4



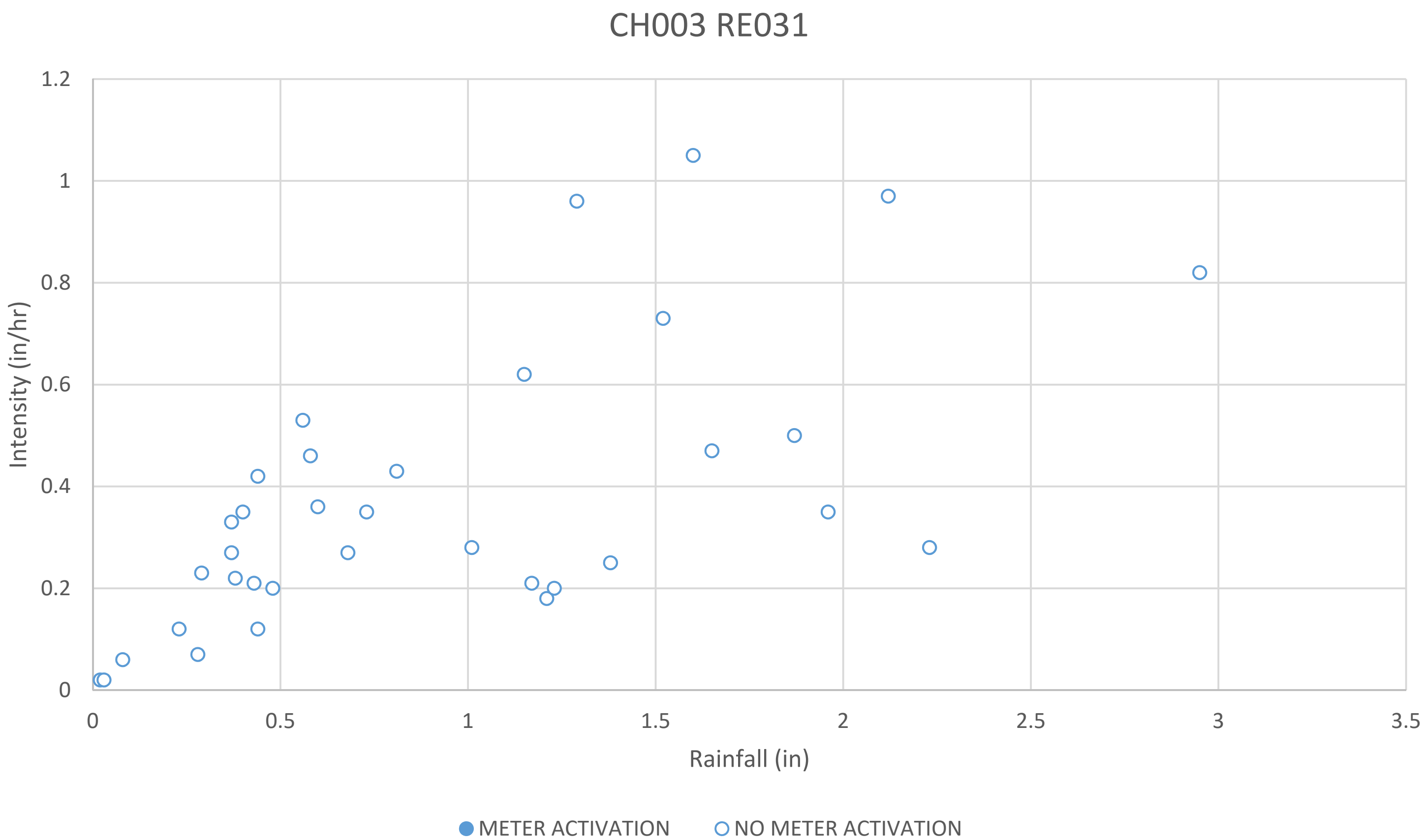
Outfall: BOS09
Regulator: RE0-2
Related Rain Gauge: 4



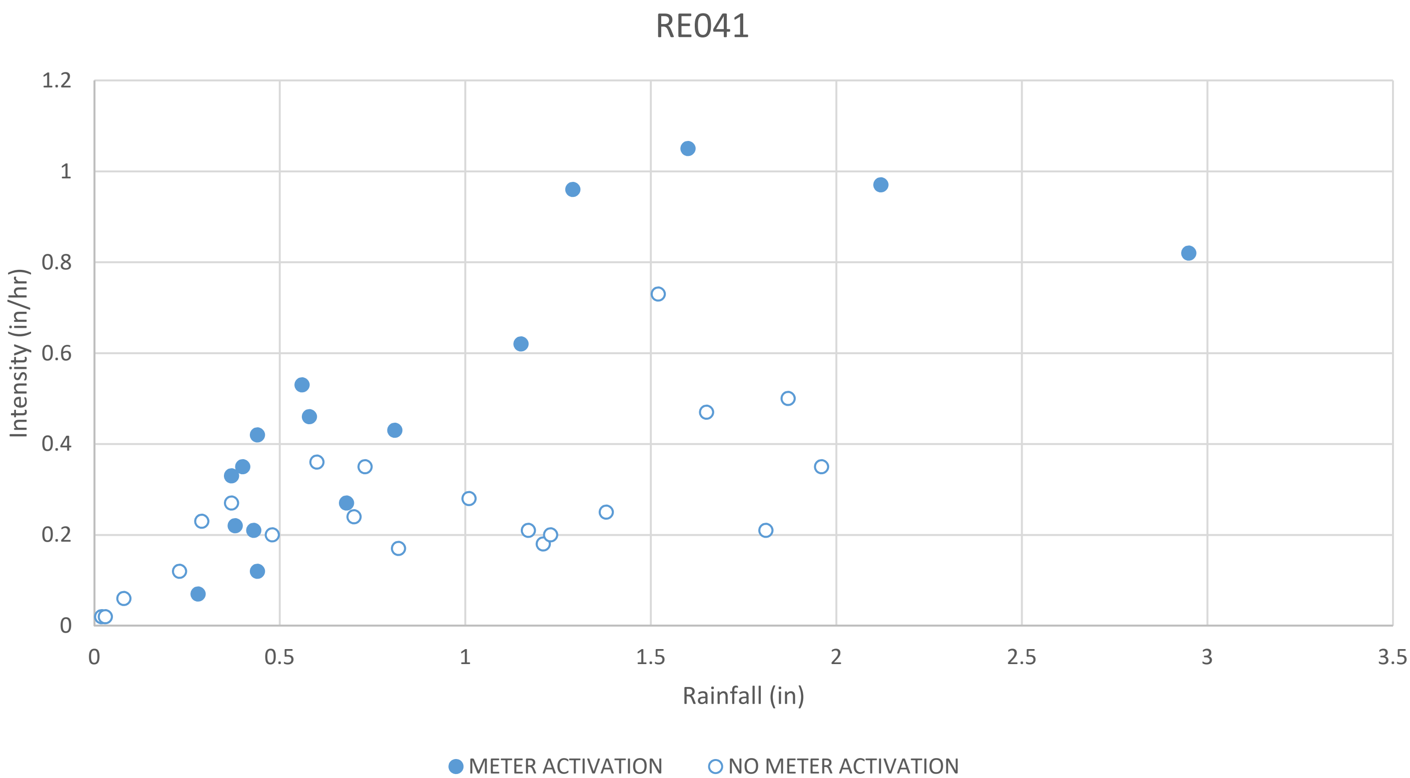
Outfall: MWR203
Regulator: Prison Point
Related Rain Gauge: 4



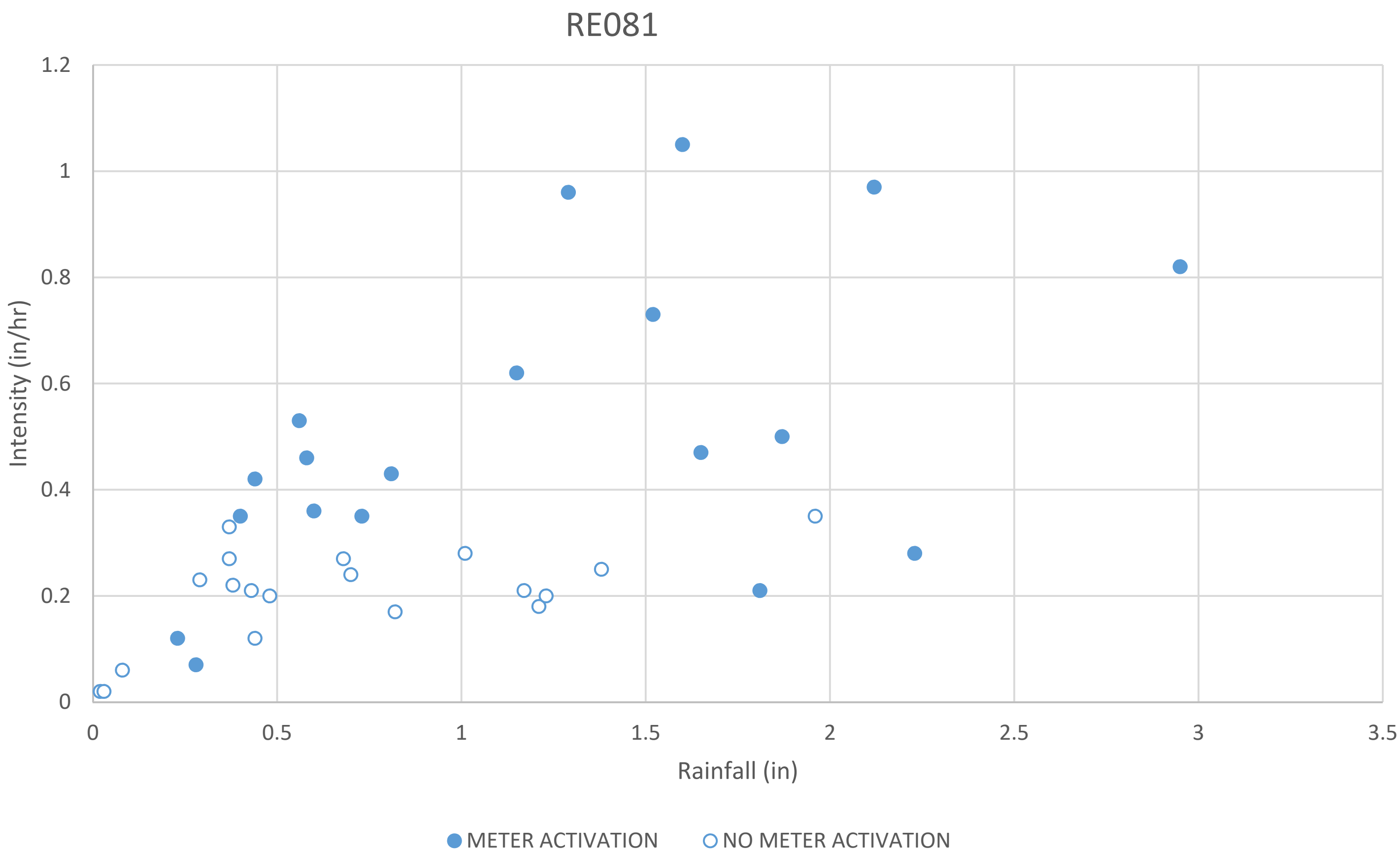
Outfall: CHE003
Regulator: RE031
Related Rain Gauge: 5



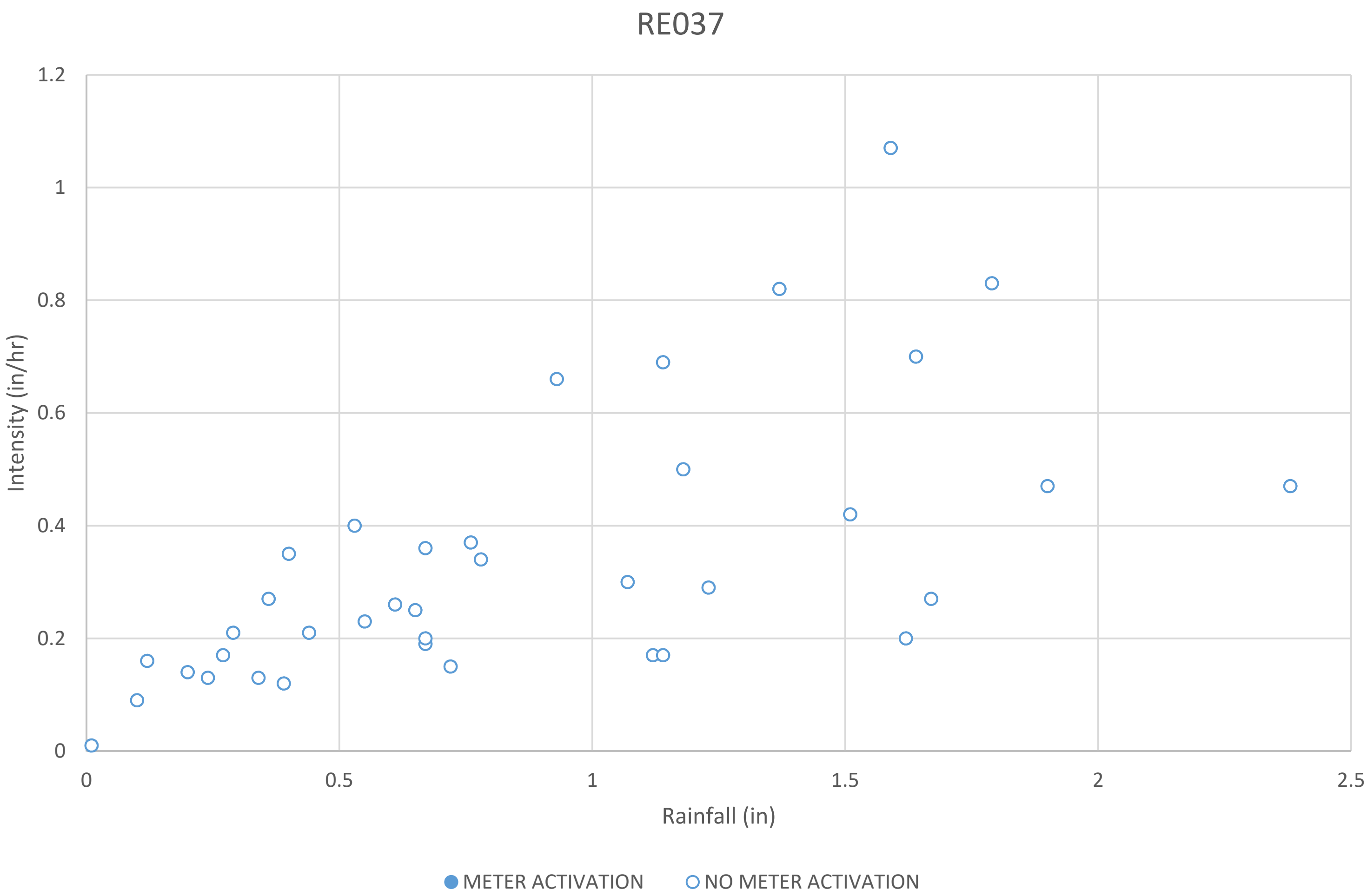
Outfall: CHE004
Regulator: RE041
Related Rain Gauge: 5



Outfall: CHE008
Regulator: RE081
Related Rain Gauge: 5



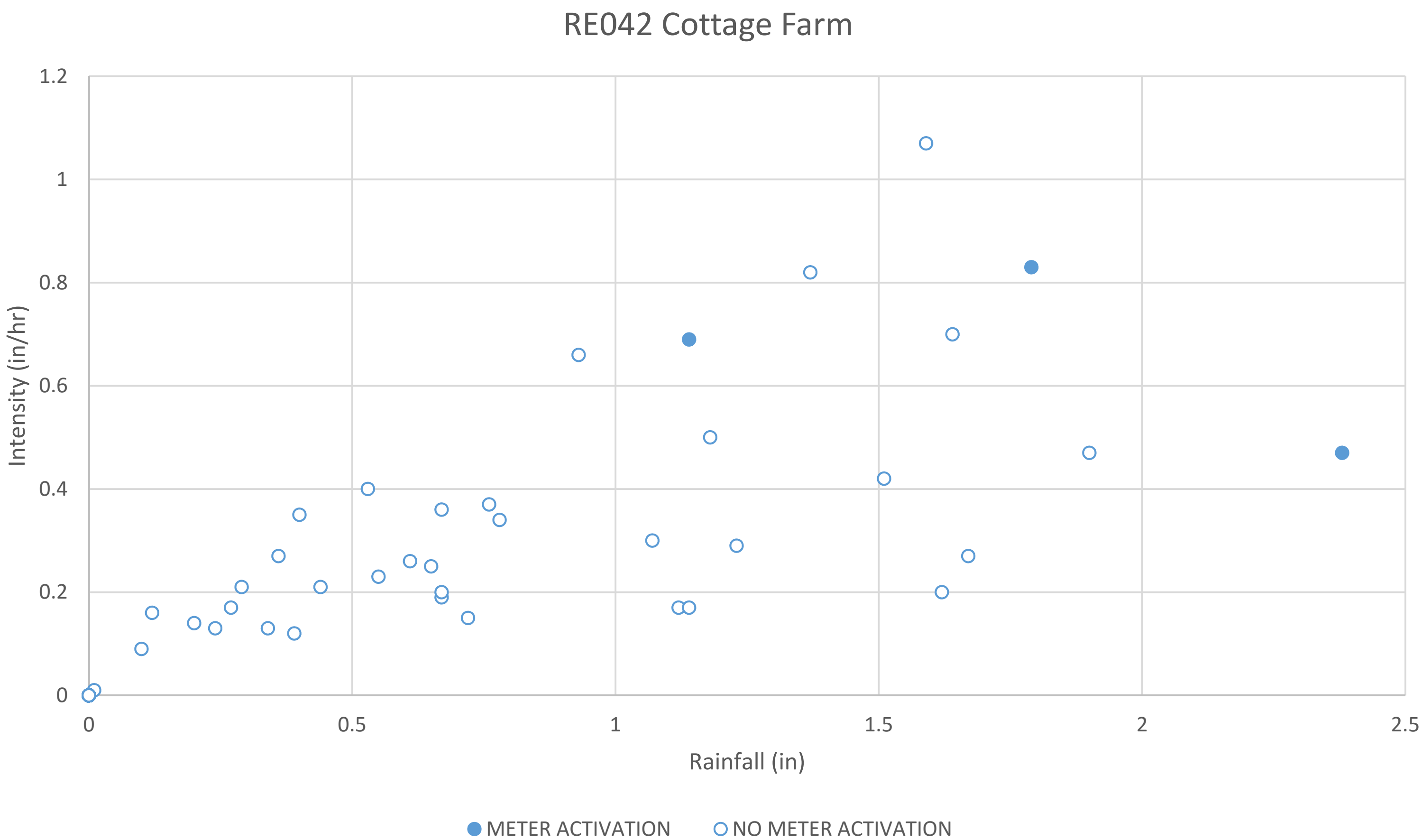
Outfall: MWR010
Regulator: RE037
Related Rain Gauge: 12



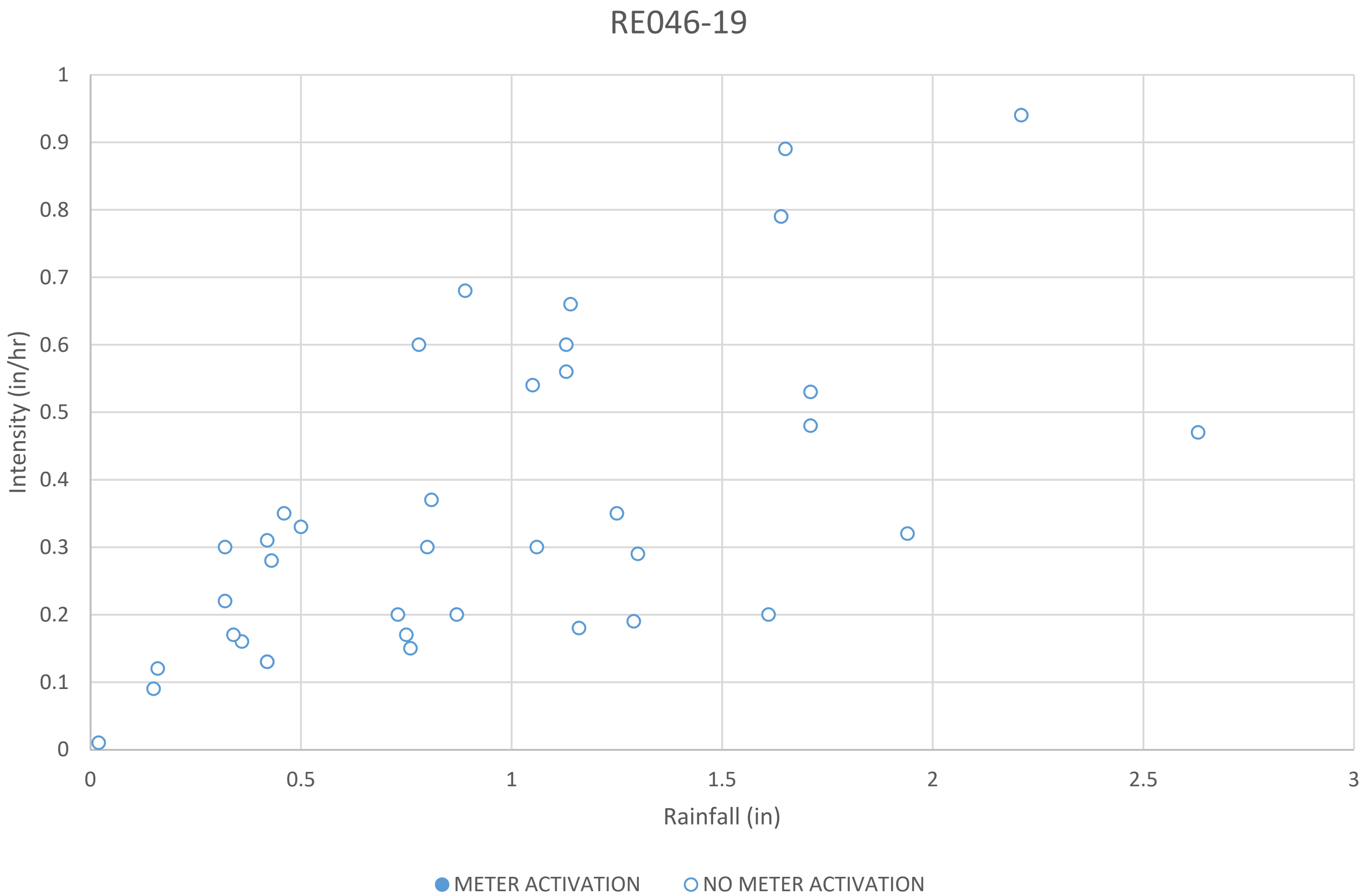
Outfall: MWR010
Regulator: RE036-9
Related Rain Gauge: 12

No scattergraph available for this location. Metering data not available until December, 2018

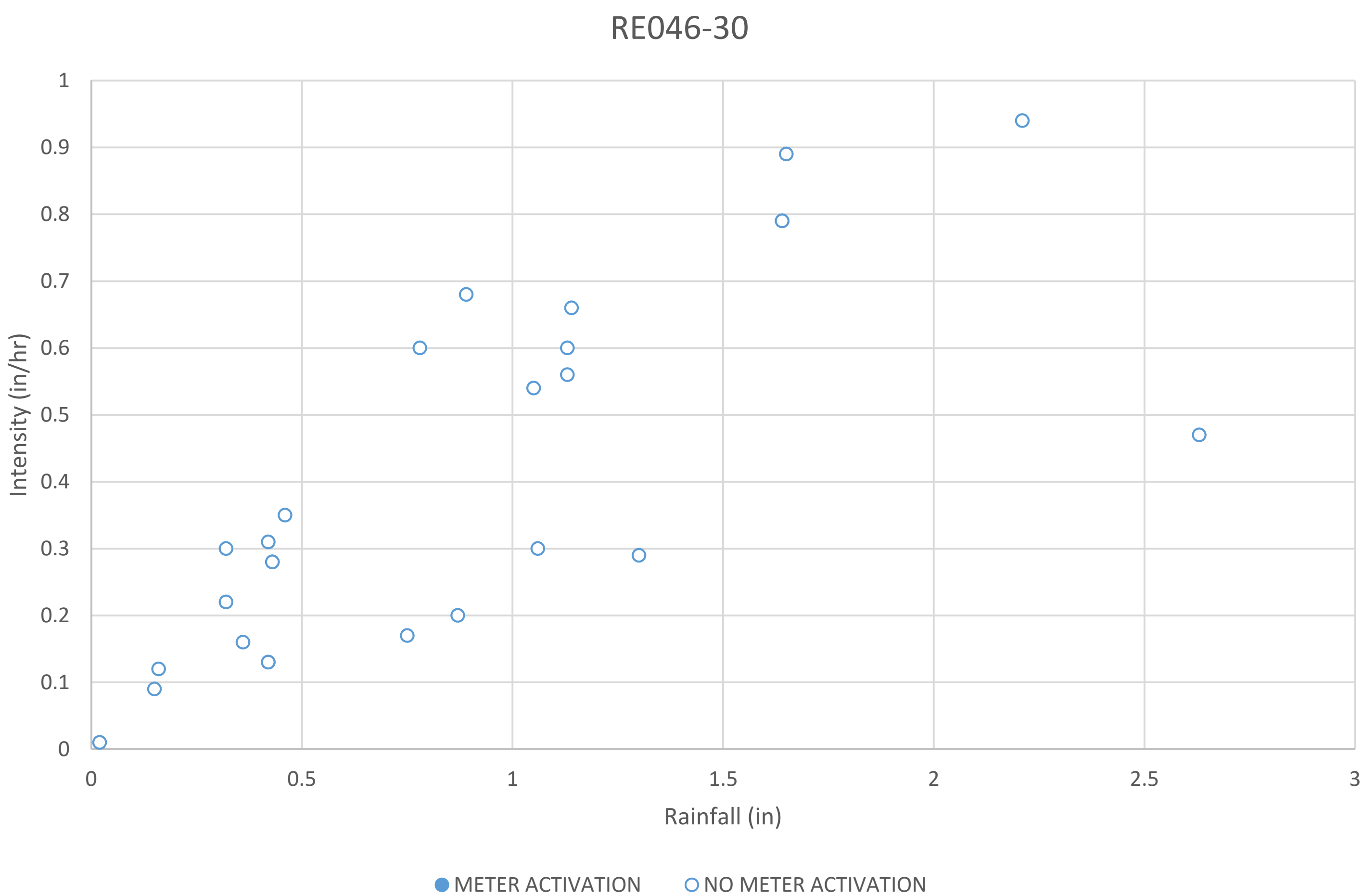
Outfall: MWR201 (Cottage Farm)
Regulator: RE042
Related Rain Gauge: 12



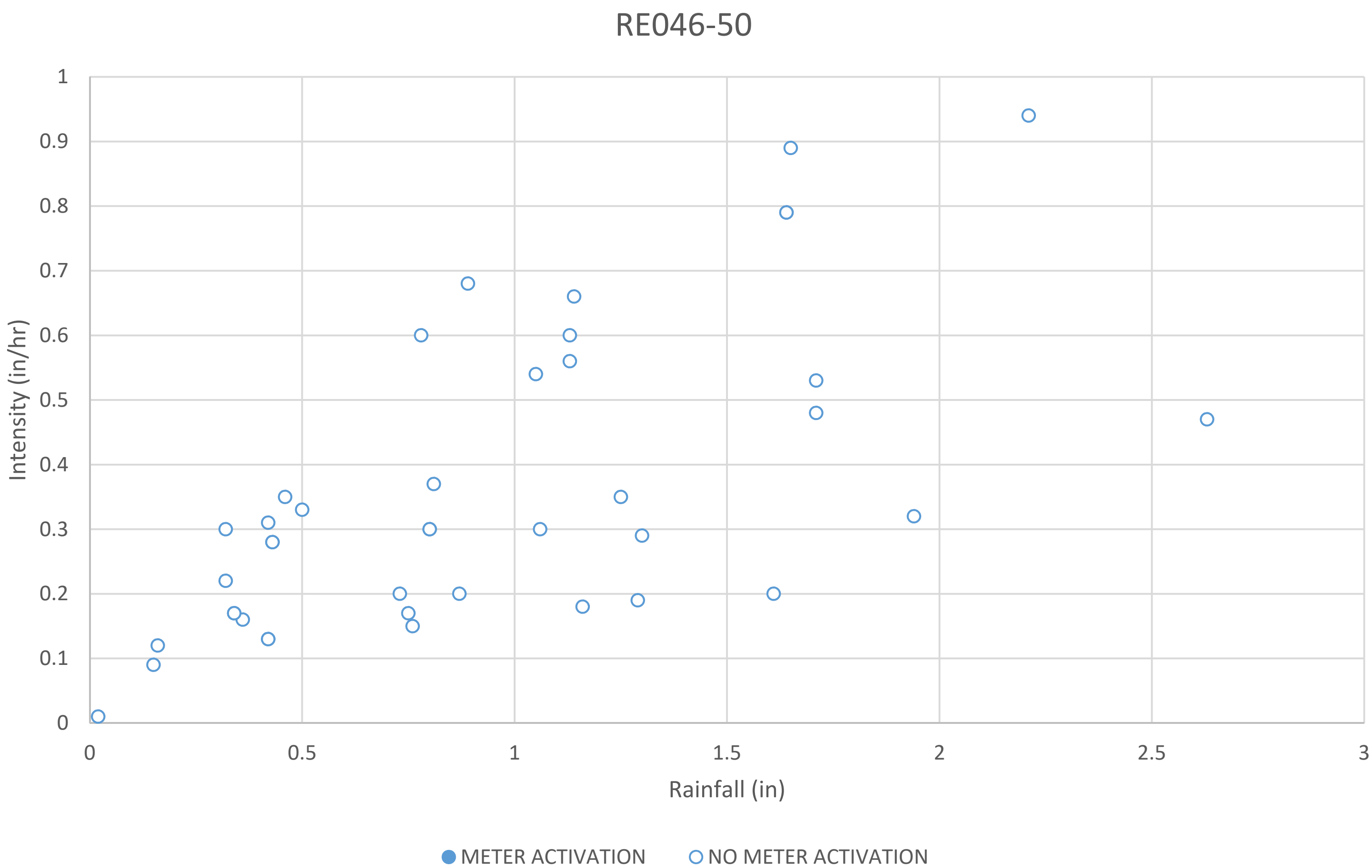
Outfall: MWR023
Regulator: RE046-19
Related Rain Gauge: 15



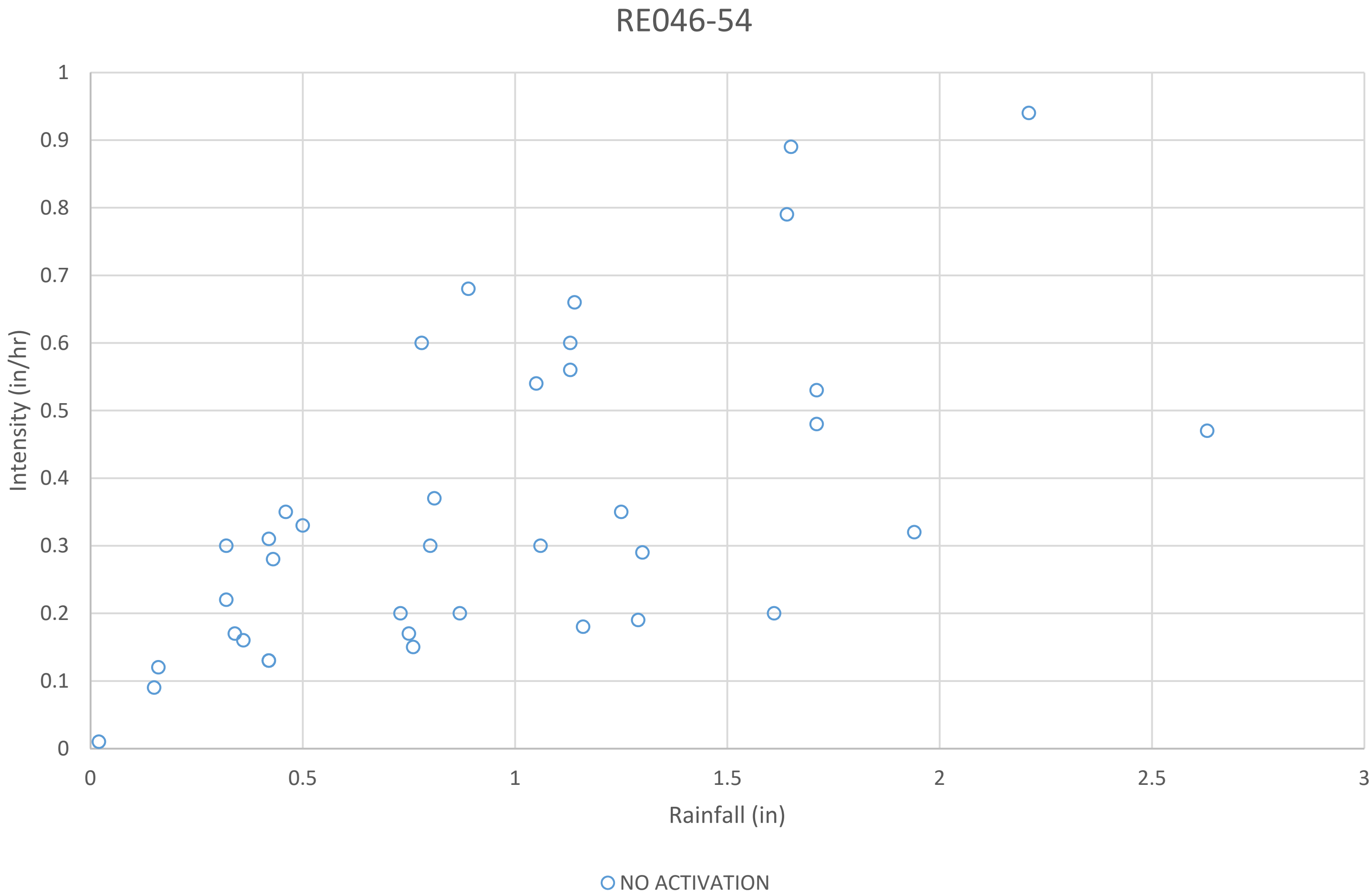
Outfall: MWR023
Regulator: RE046-30
Related Rain Gauge: 15



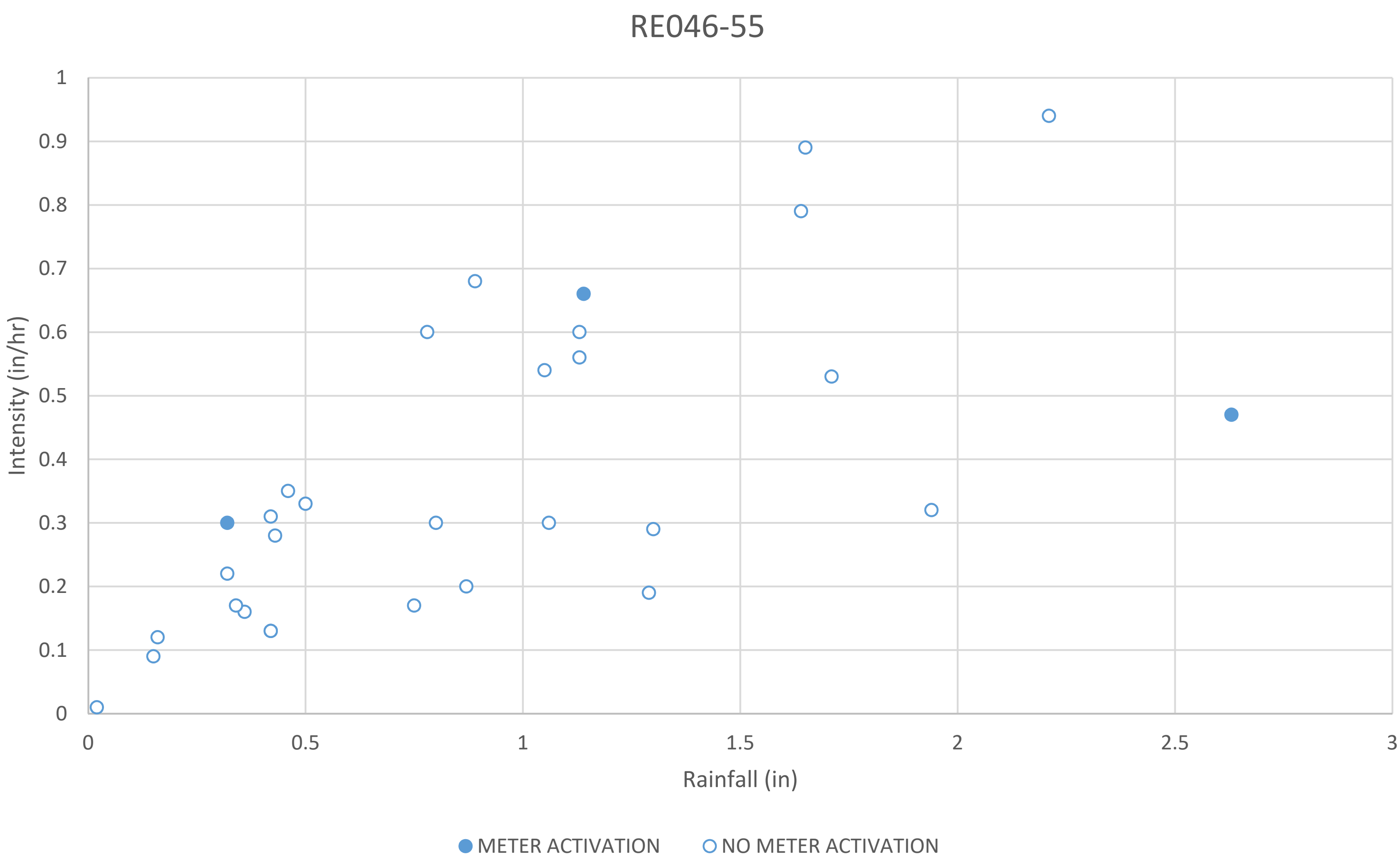
Outfall: MWR023
Regulator: RE046-50
Related Rain Gauge: 15



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

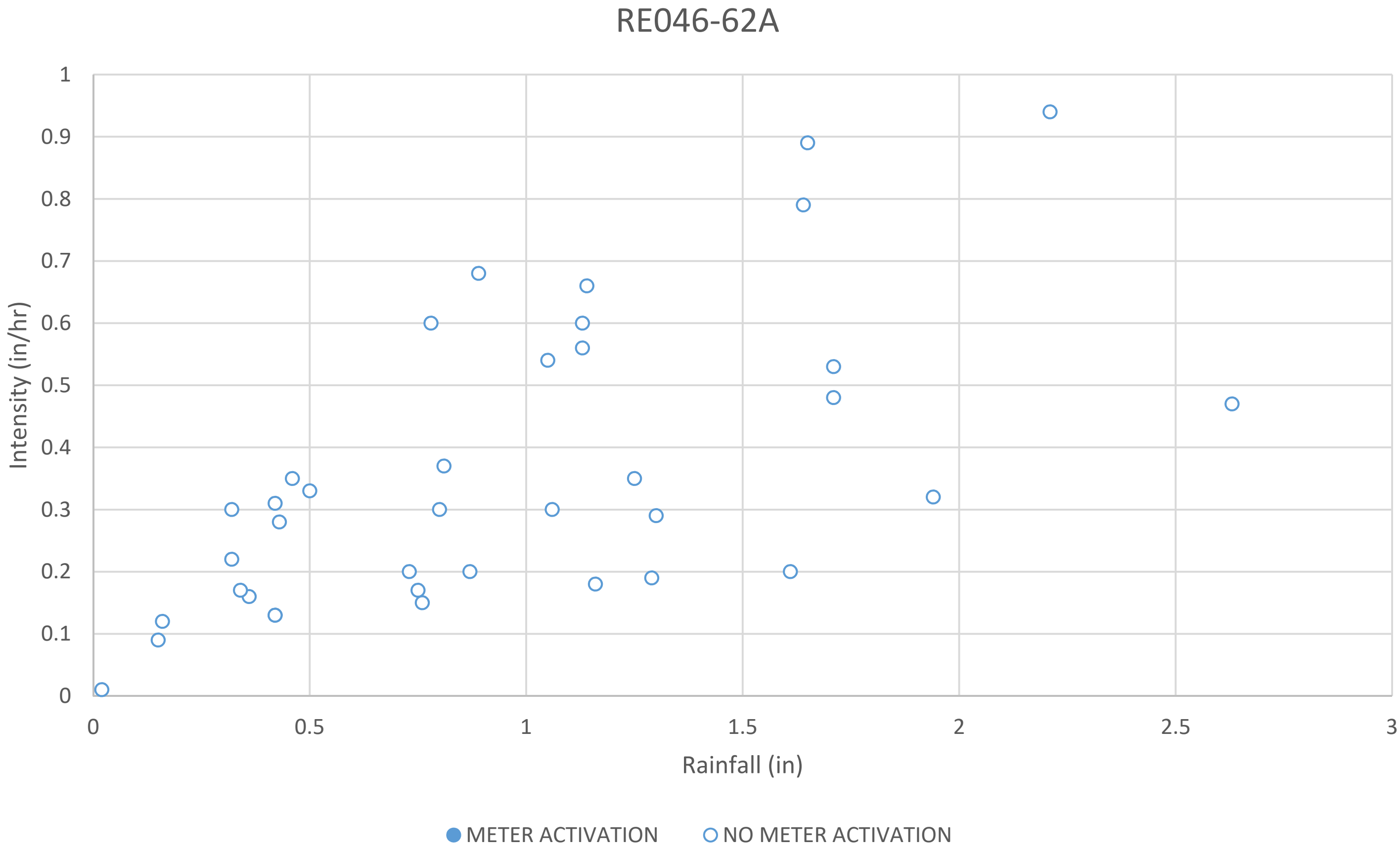


Outfall: MWR023
Regulator: RE046-55
Related Rain Gauge: 15

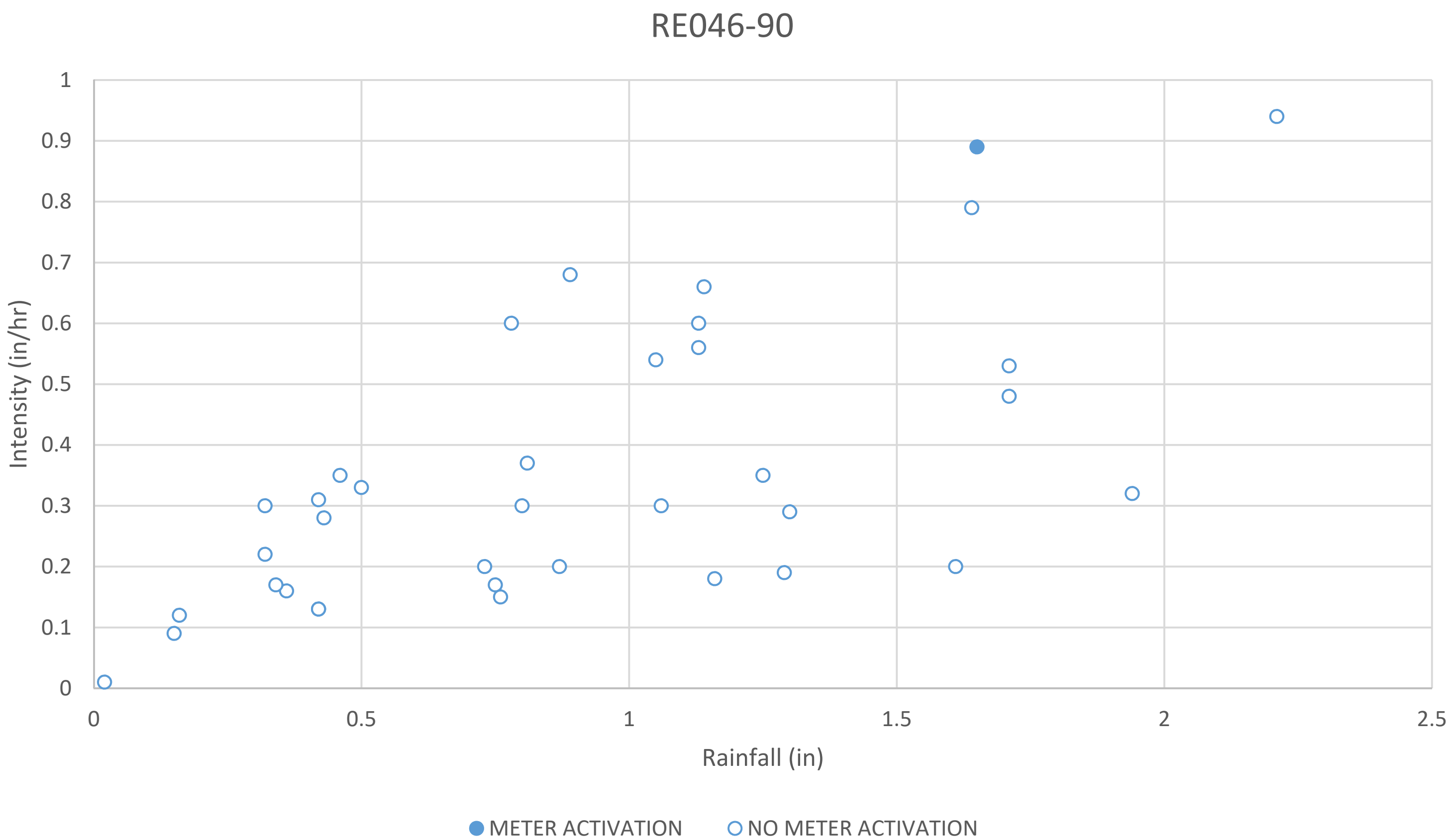


Blockage may have contributed to some activations prior to June 21, 2018.

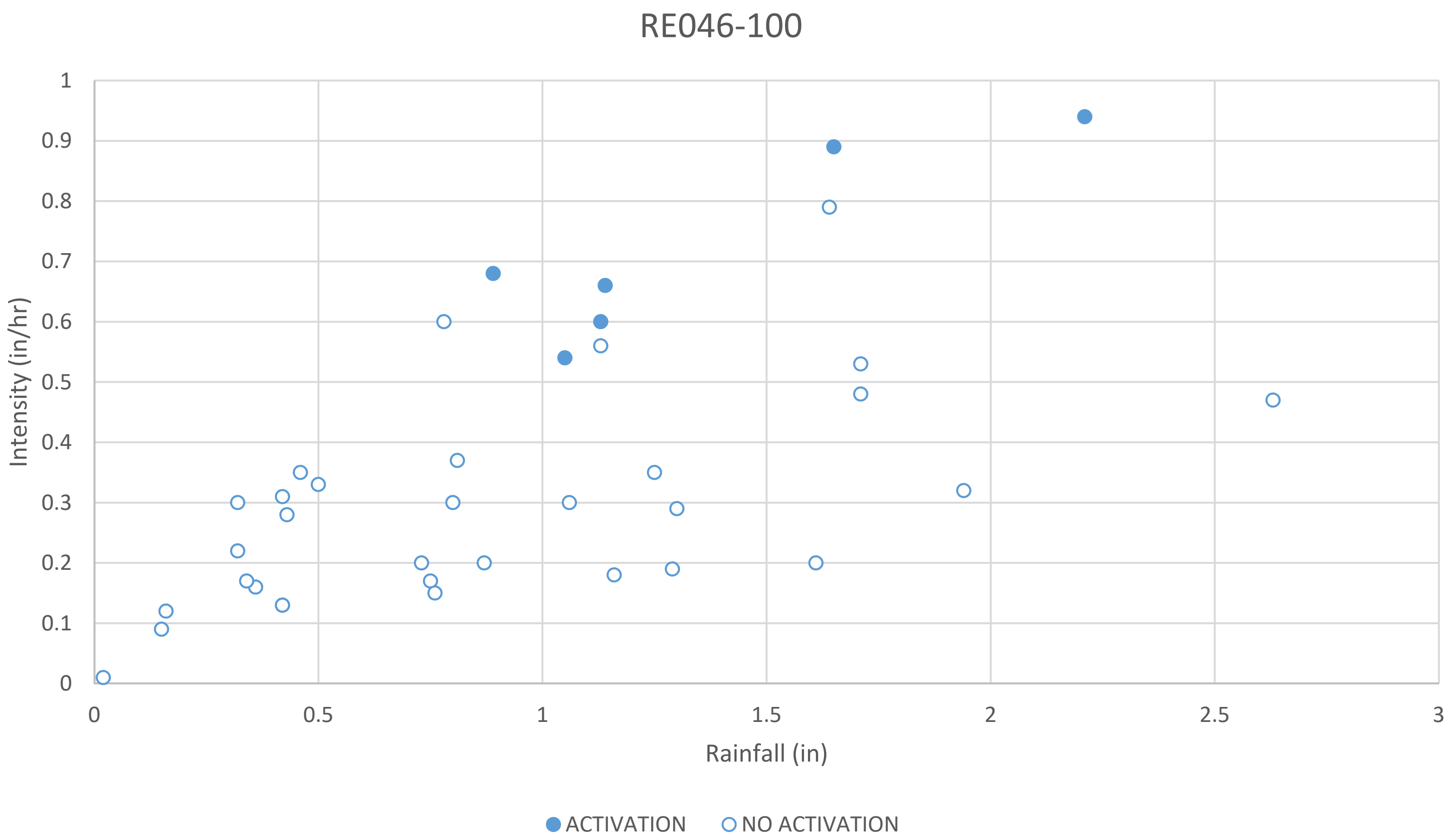
Outfall: MWR023
Regulator: RE046-62A
Related Rain Gauge: 15



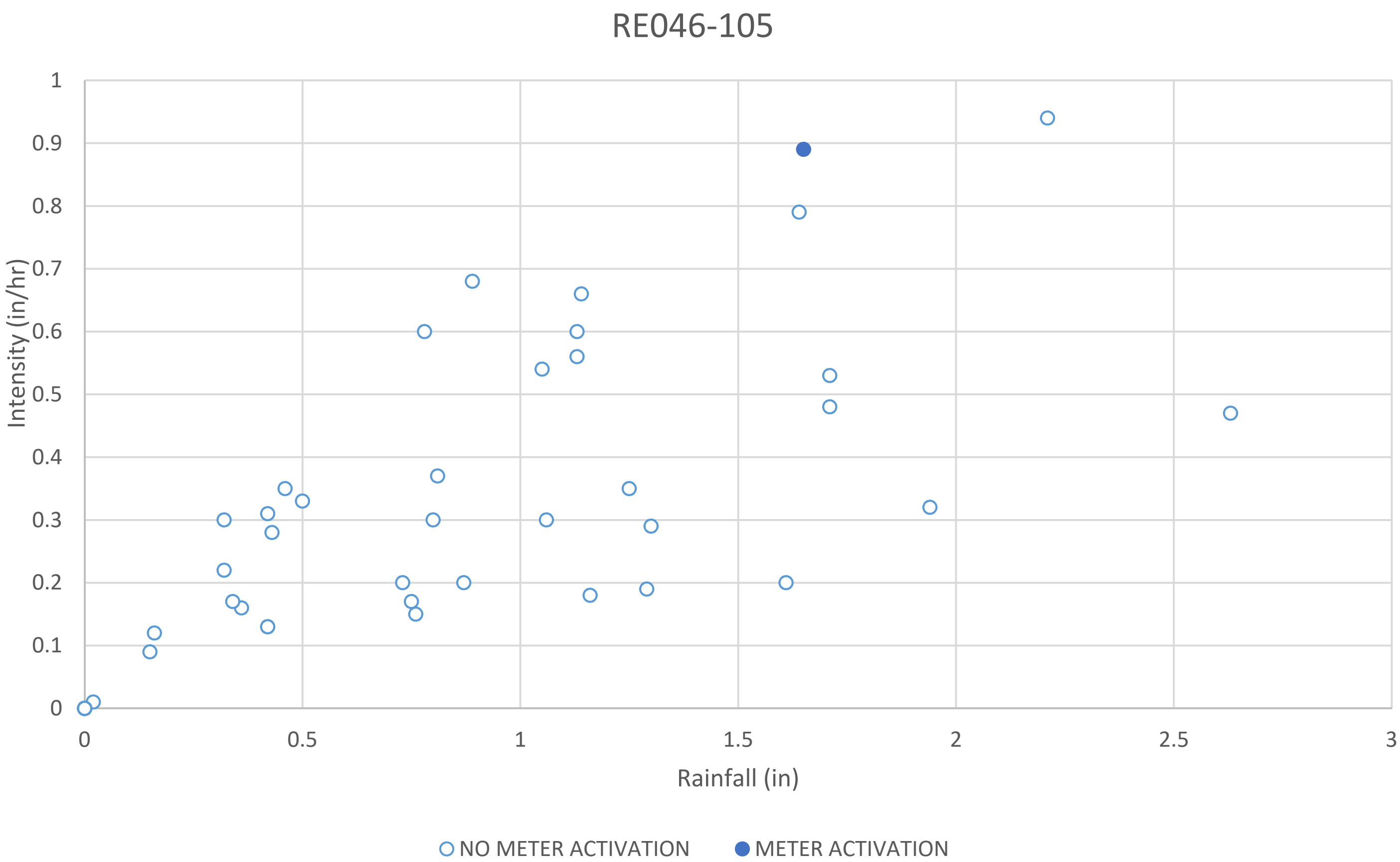
Outfall: MWR023
Regulator: RE046-90
Related Rain Gauge: 15



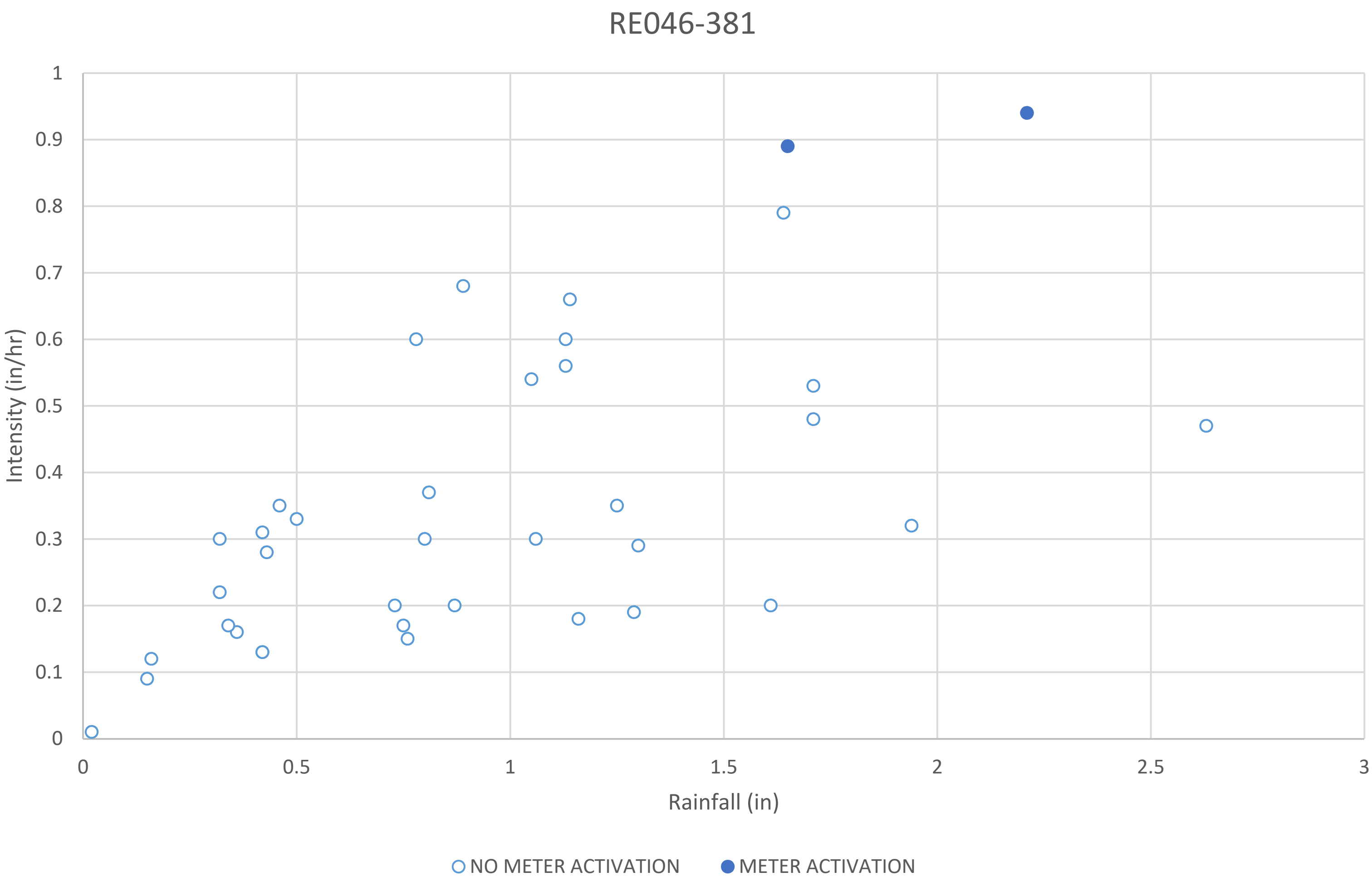
Outfall: MWR023
Regulator: RE046-100
Related Rain Gauge: 15



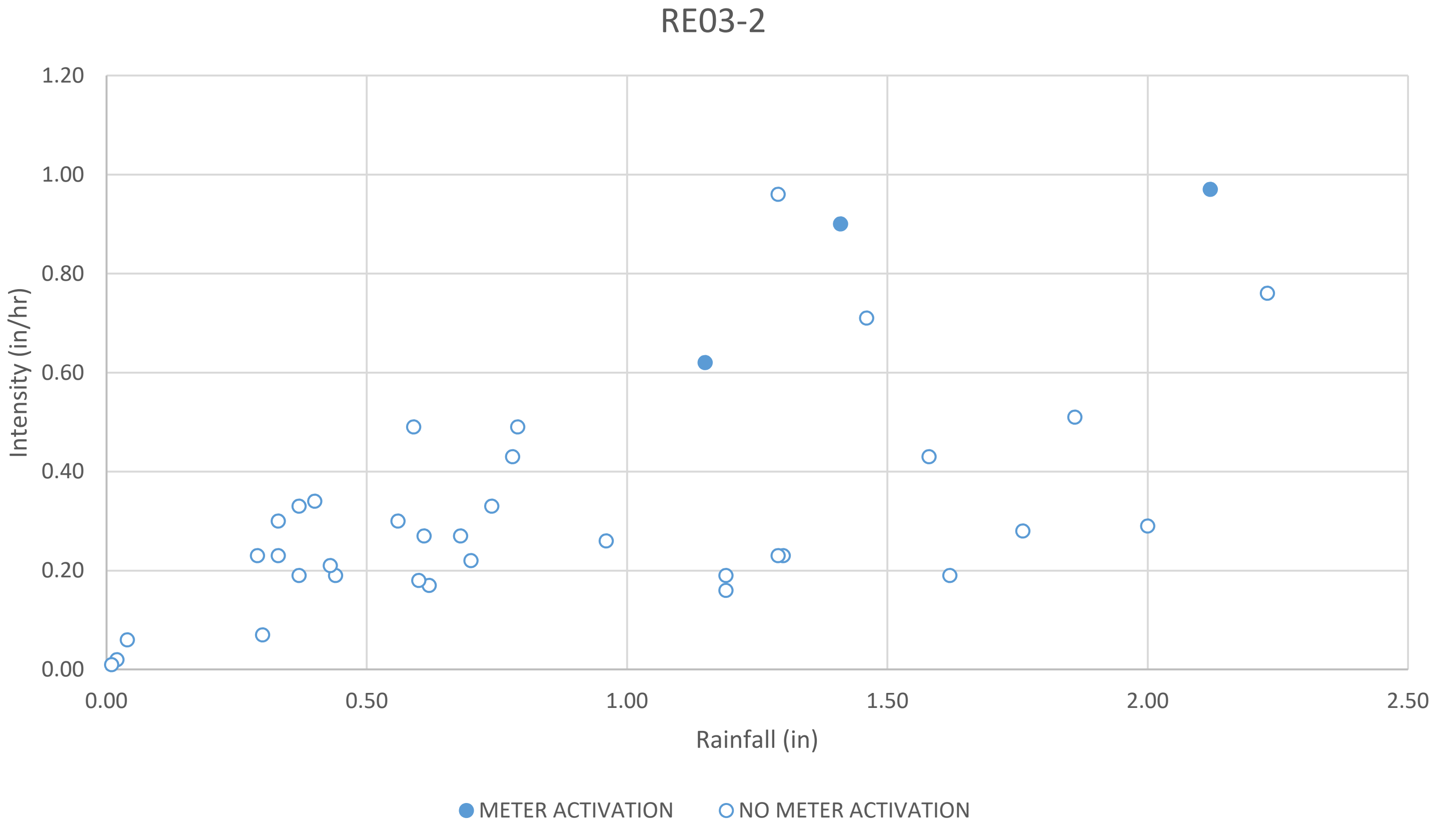
Outfall: MWR023
Regulator: RE046-105
Related Rain Gauge: 15



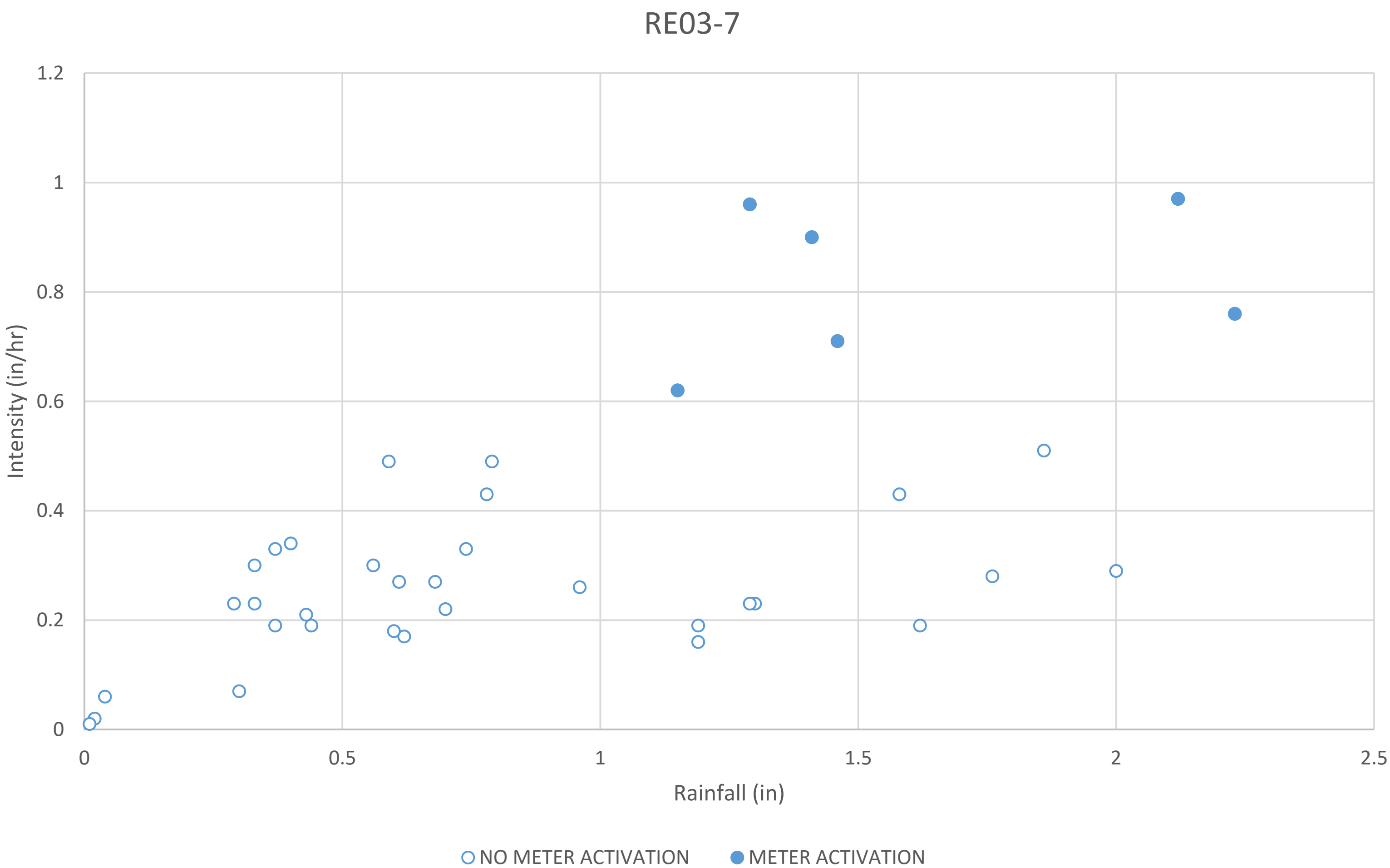
Outfall: MWR023
Regulator: RE046-381
Related Rain Gauge: 15



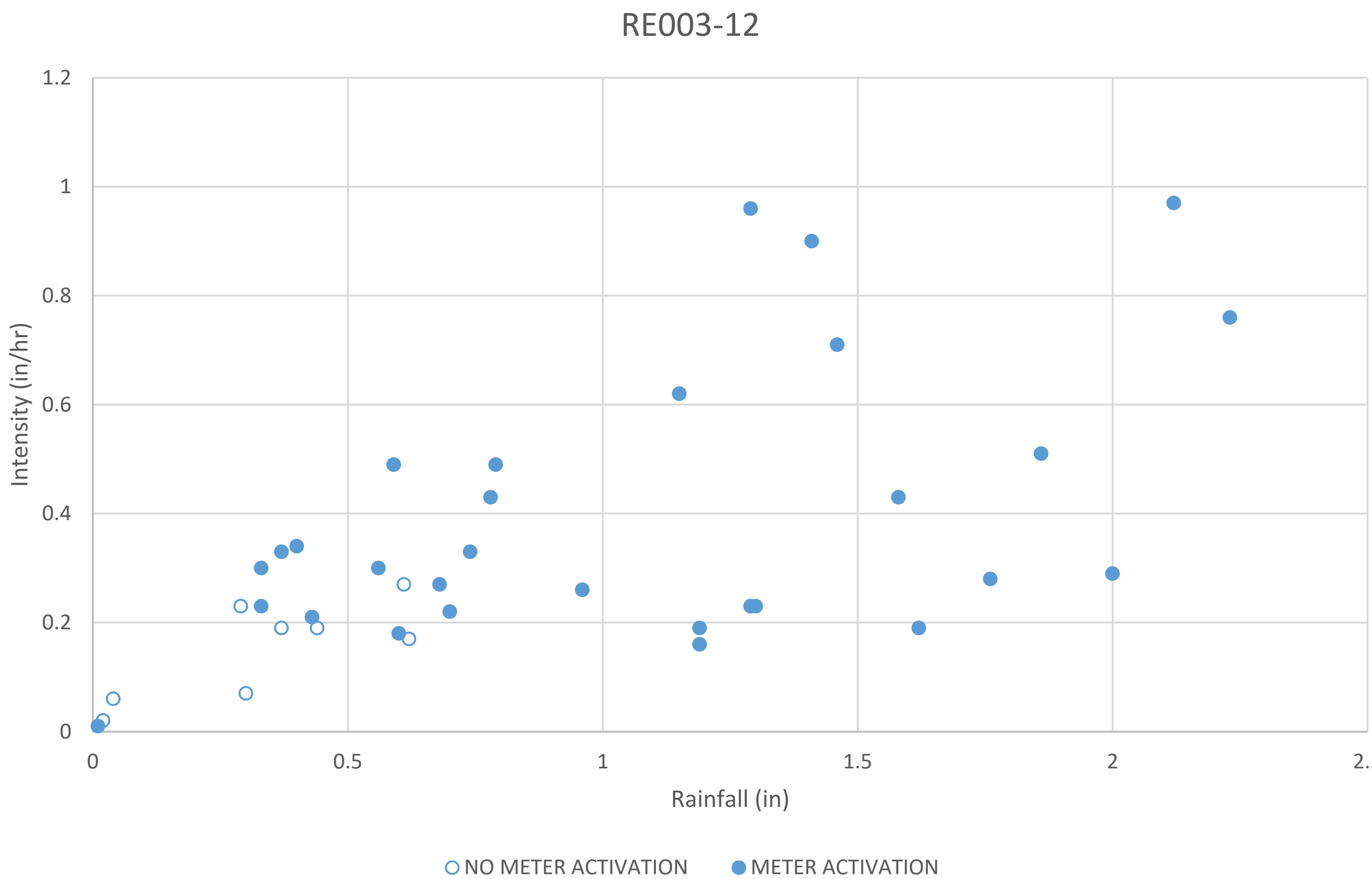
Outfall: BOS003
Regulator: RE03-2
Related Rain Gauge: 8



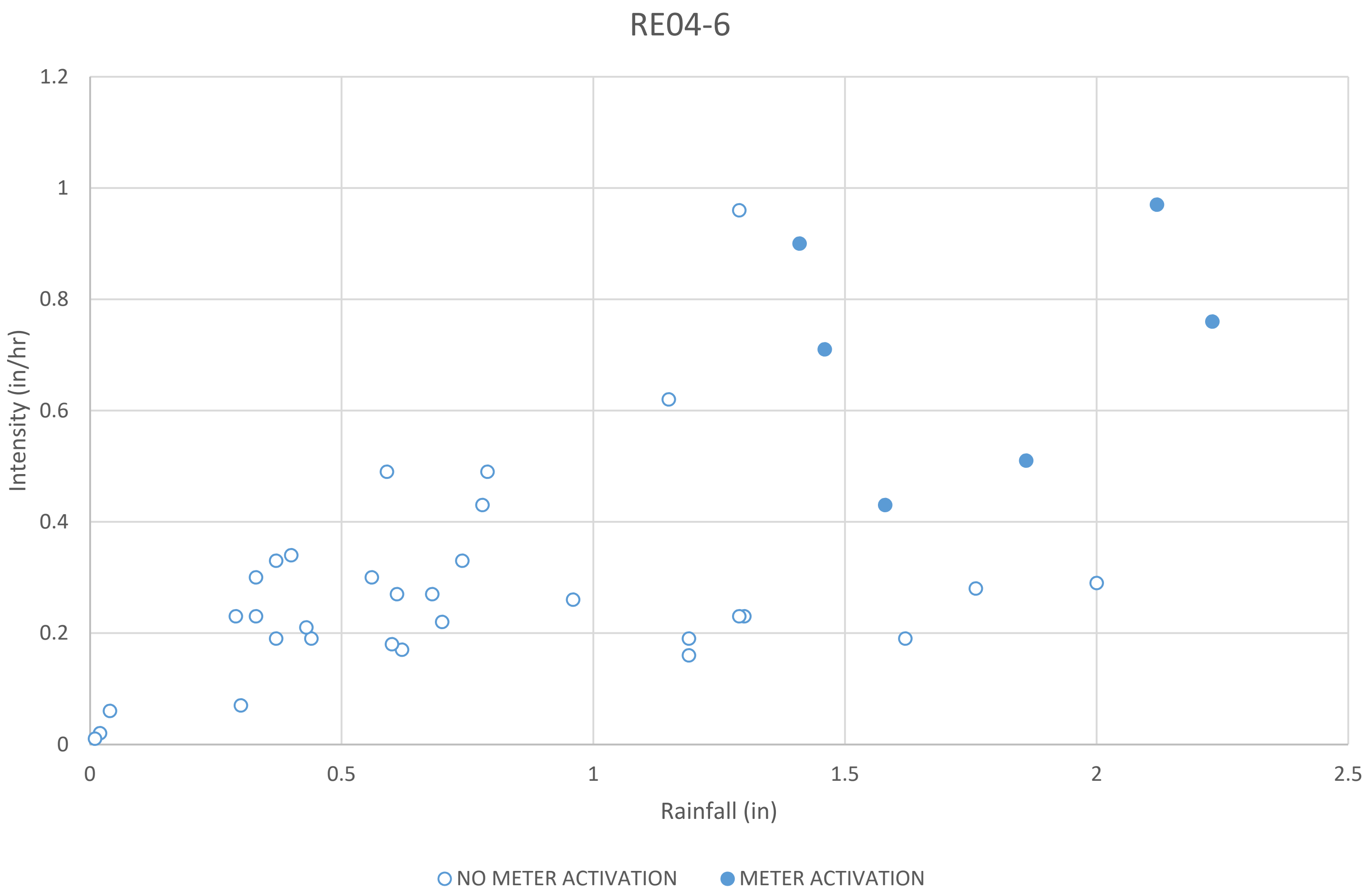
Outfall: BOS003
Regulator: RE03-7
Related Rain Gauge: 8



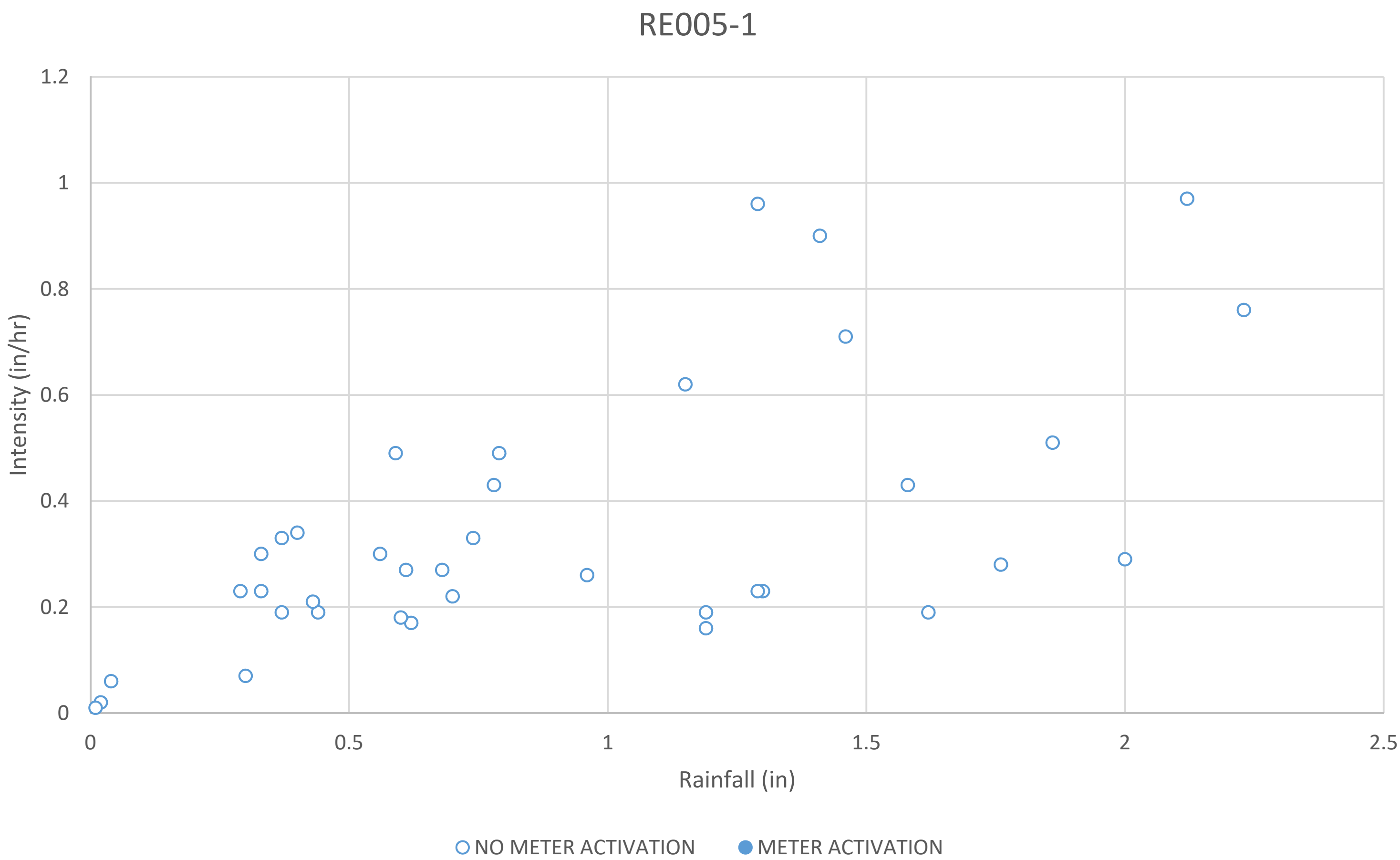
Outfall: BOS003
Regulator: RE03-12
Related Rain Gauge: 8



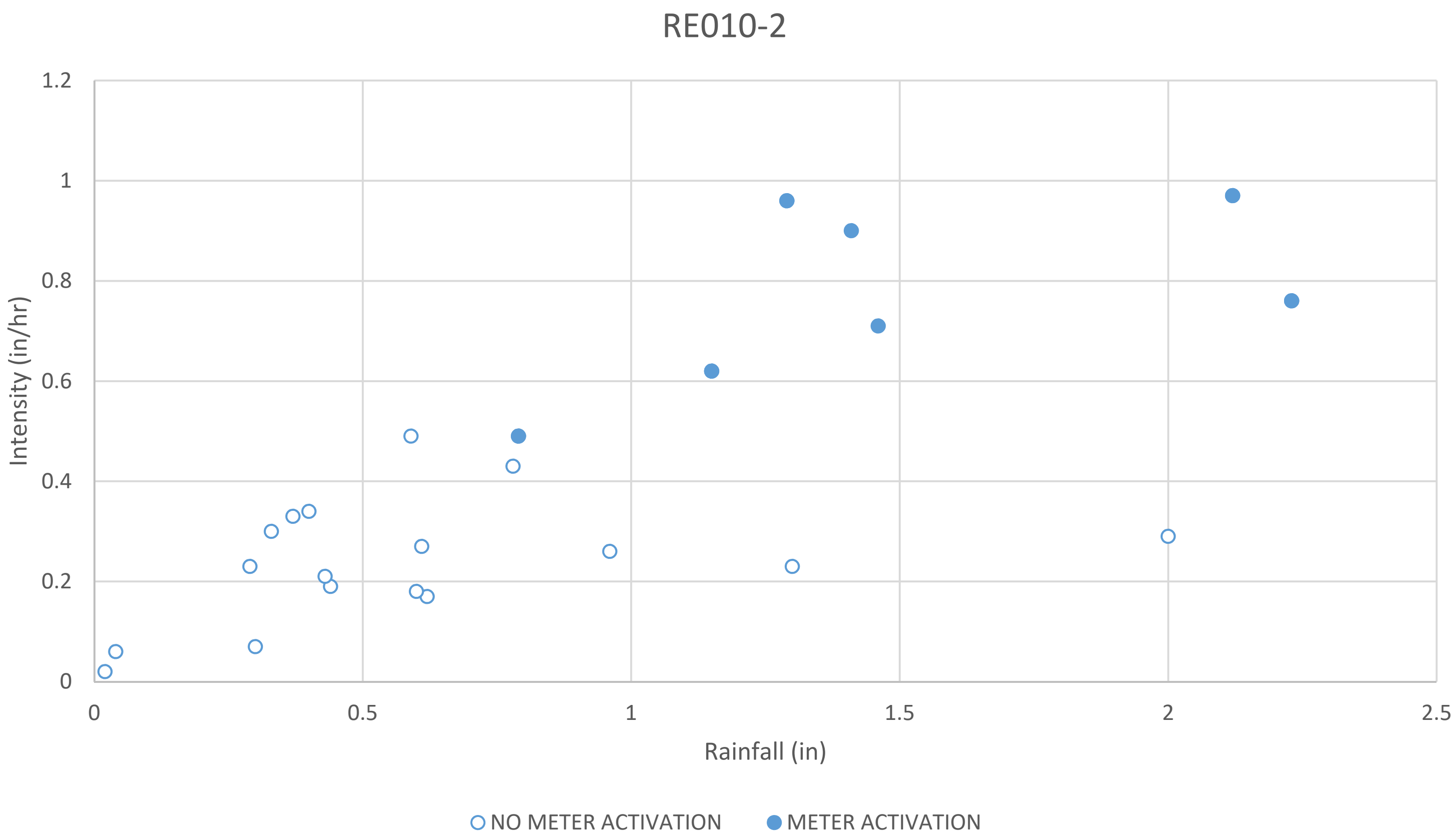
Outfall: BOS004
Regulator: RE04-6
Related Rain Gauge: 8



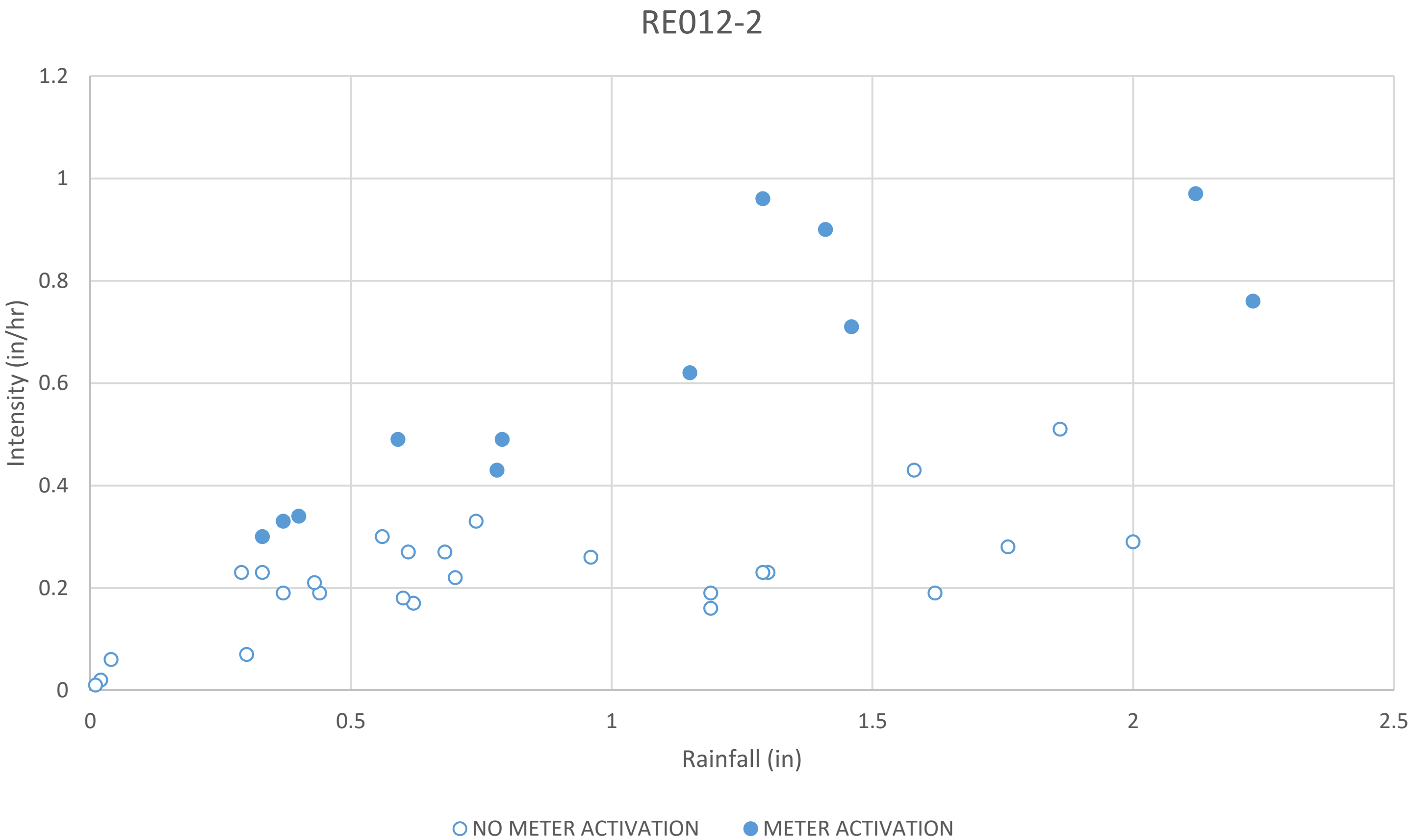
Outfall: BOS005
Regulator: RE05-1
Related Rain Gauge: 8



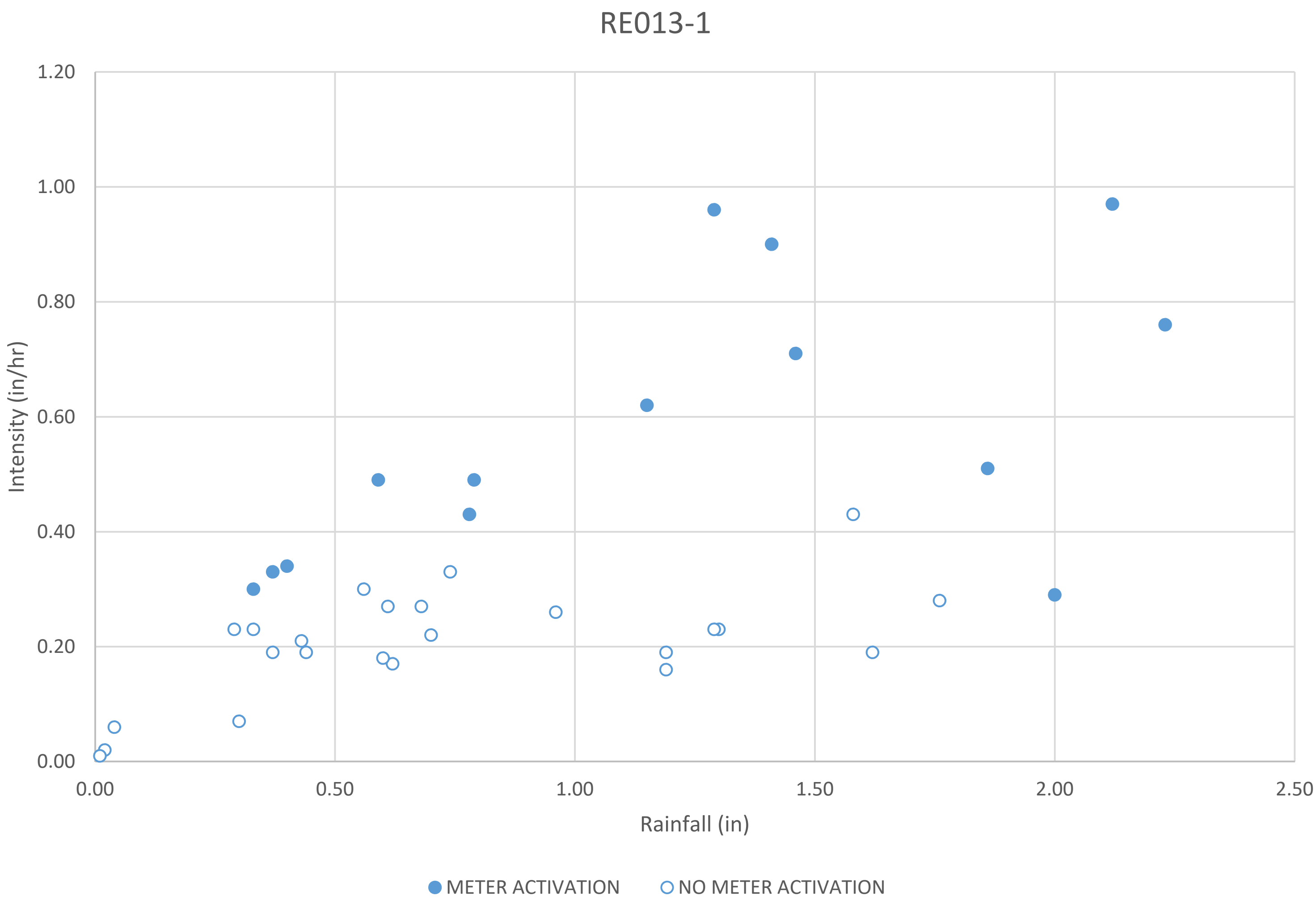
Outfall: BOS010
Regulator: RE010-2
Related Rain Gauge: 8



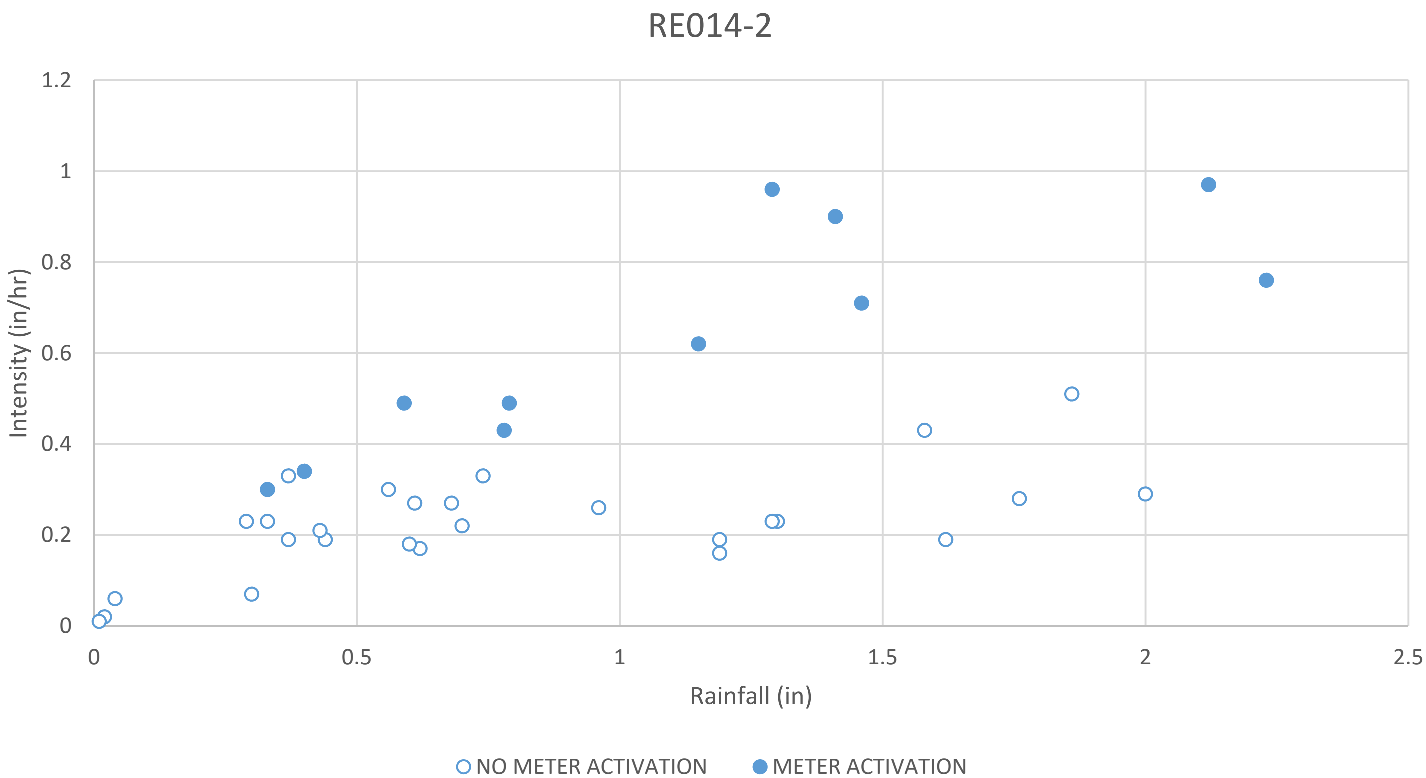
Outfall: BOS012
Regulator: RE012-2
Related Rain Gauge: 8



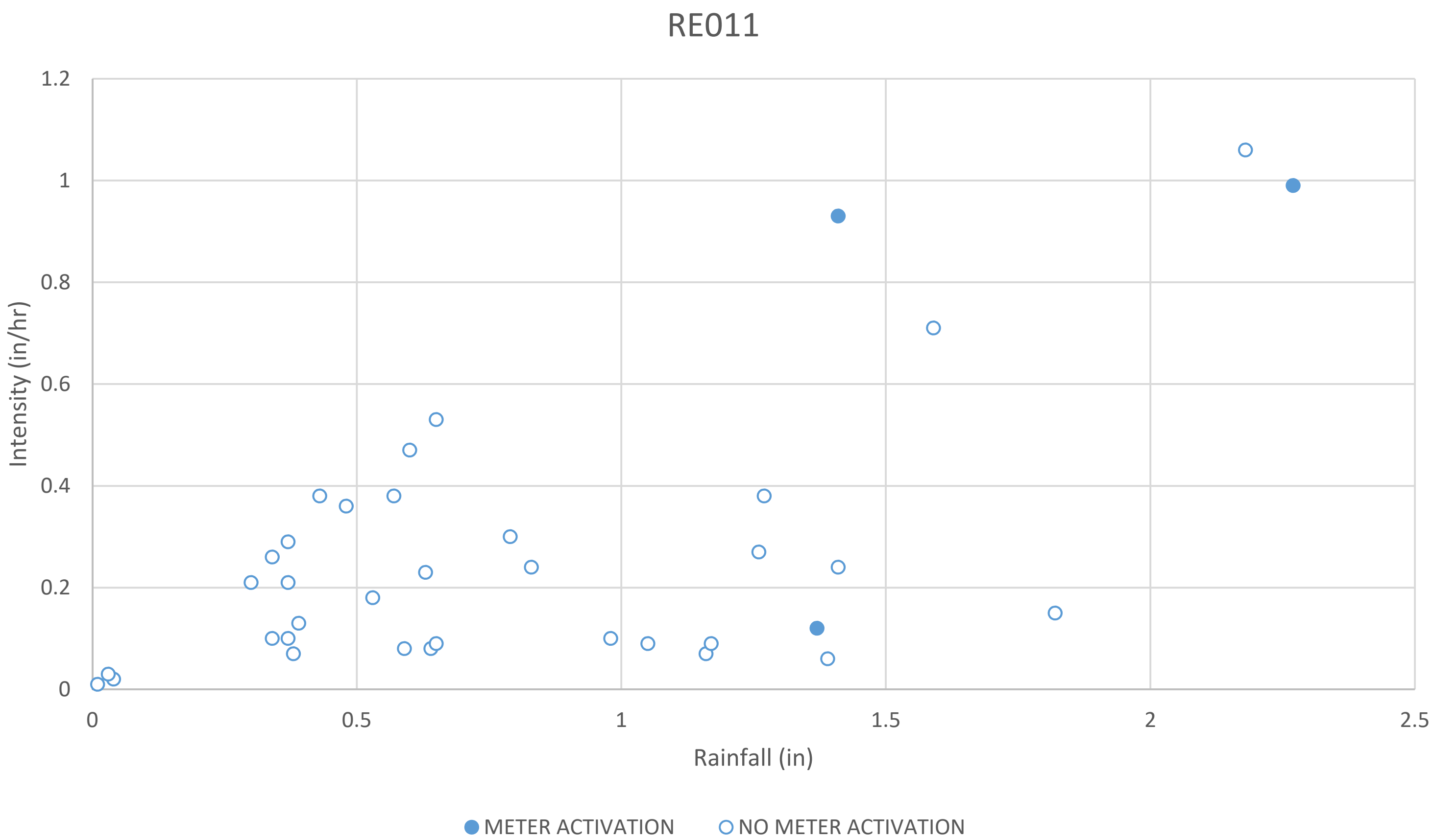
Outfall: BOS013
Regulator: RE013-1
Related Rain Gauge: 8



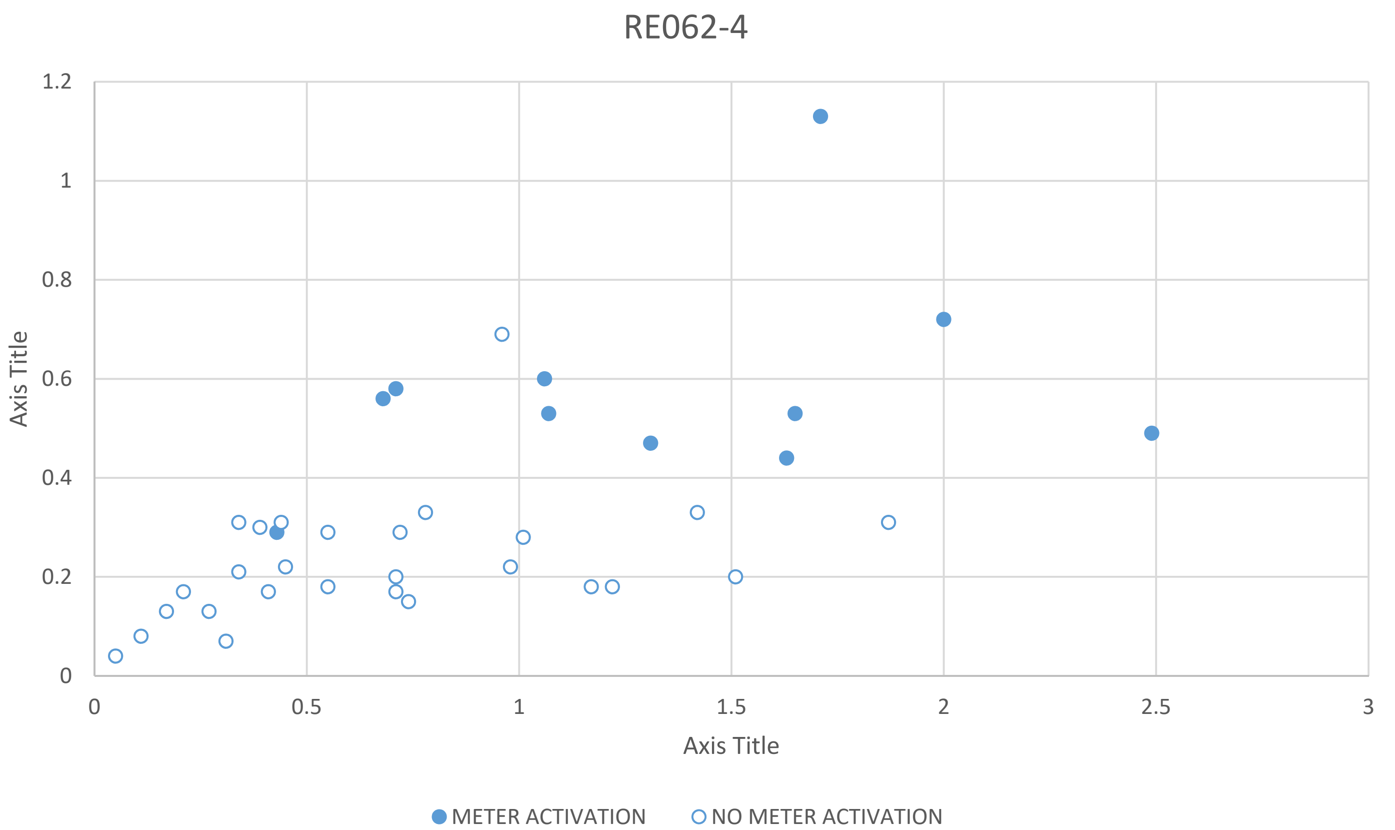
Outfall: BOS014
Regulator: RE014-2
Related Rain Gauge: 8



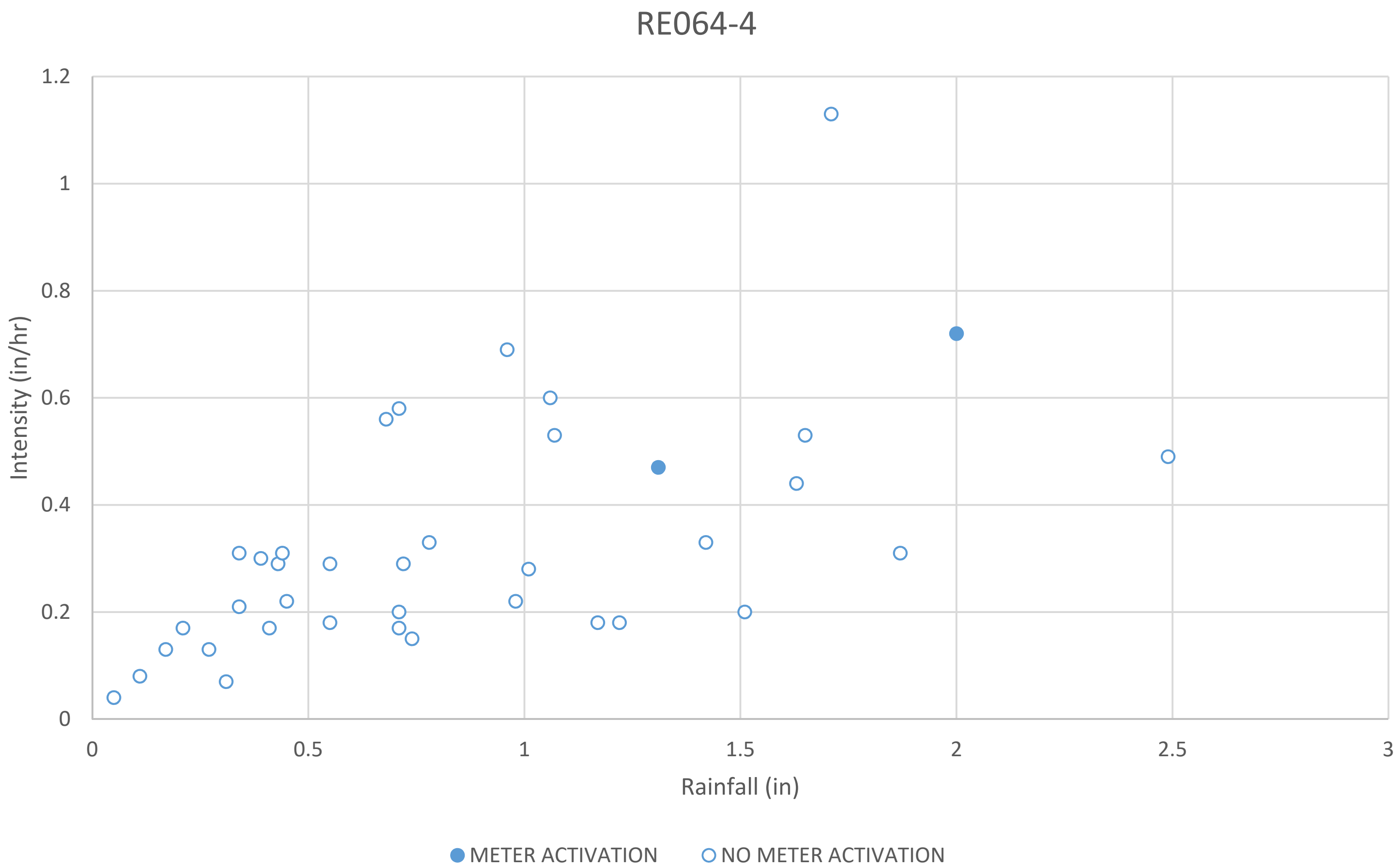
Outfall: CAM001
Regulator: RE011
Related Rain Gauge: 16



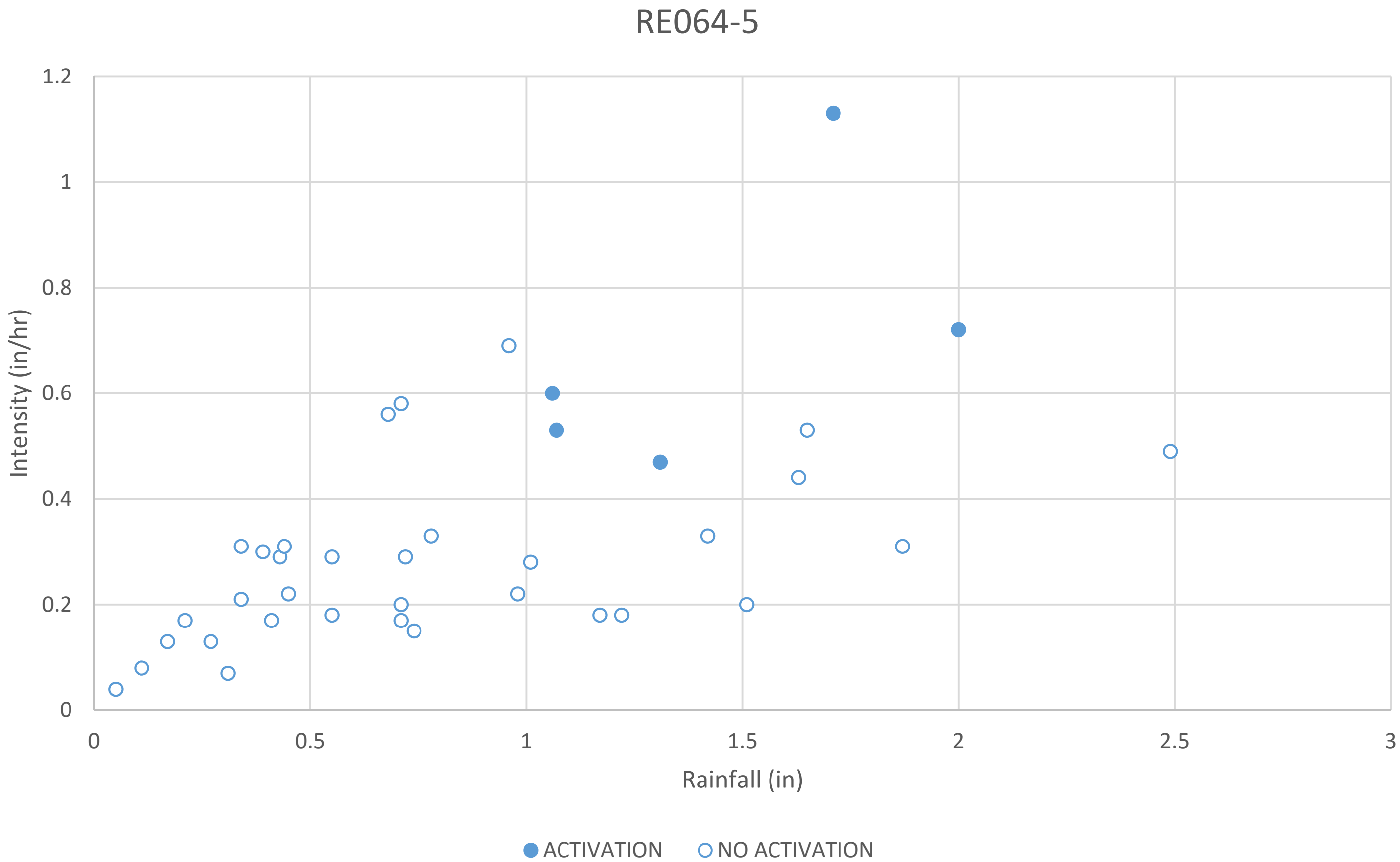
Outfall:BOS062
Regulator: RE62-4
Related Rain Gauge: 18



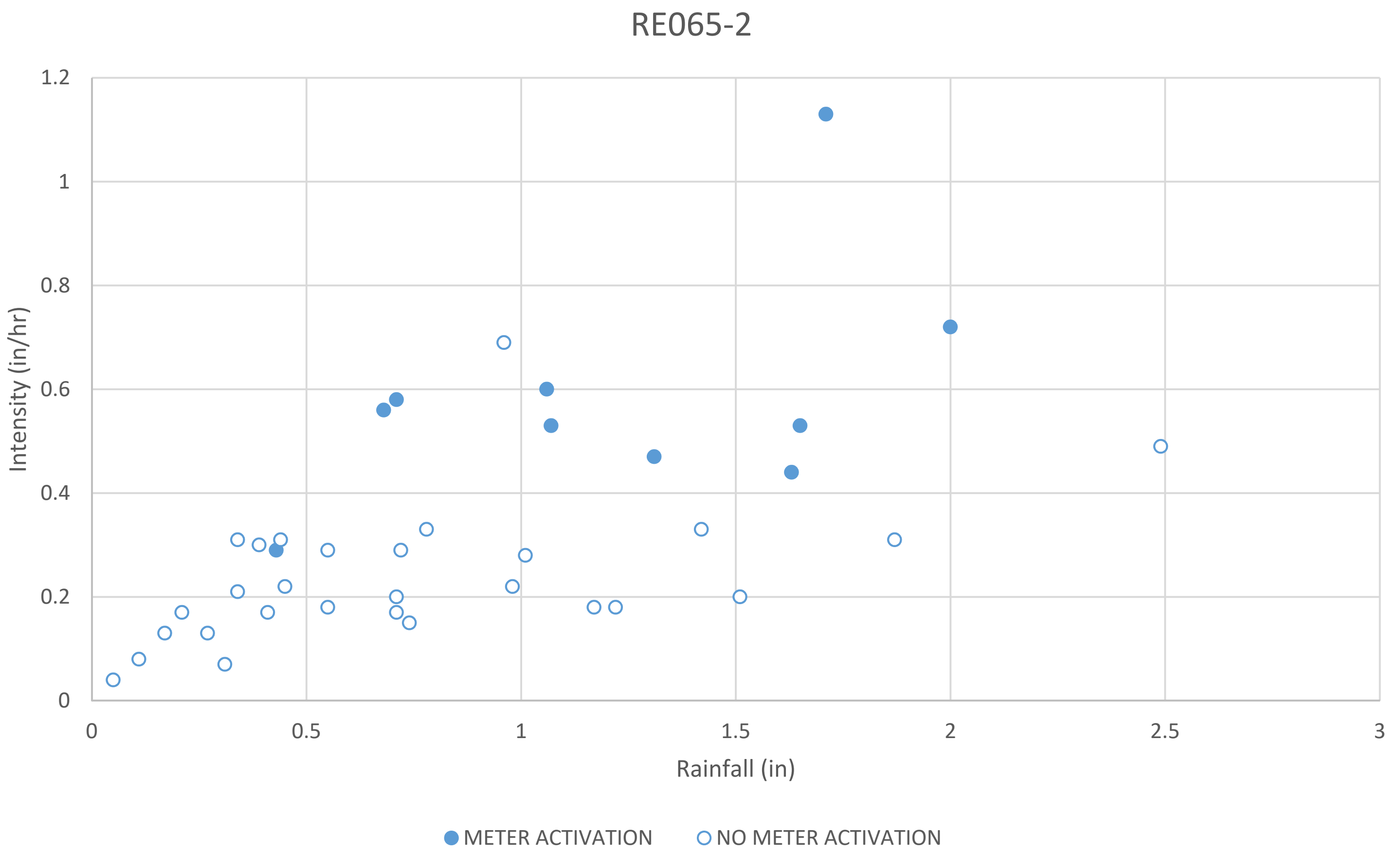
Outfall:BOS064
Regulator: RE64-4
Related Rain Gauge: 18



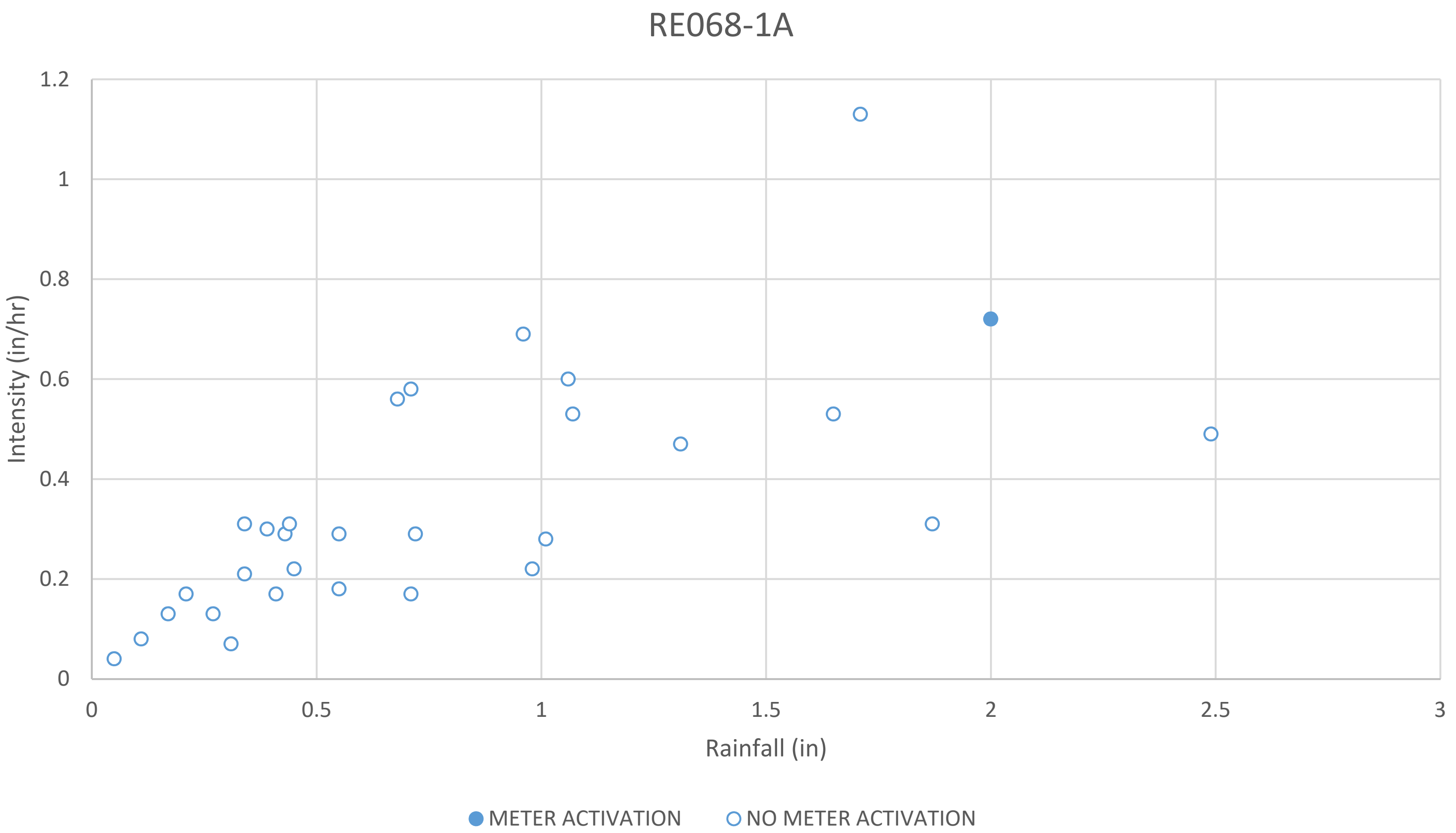
Outfall:BOS064
Regulator: RE64-5
Related Rain Gauge: 18



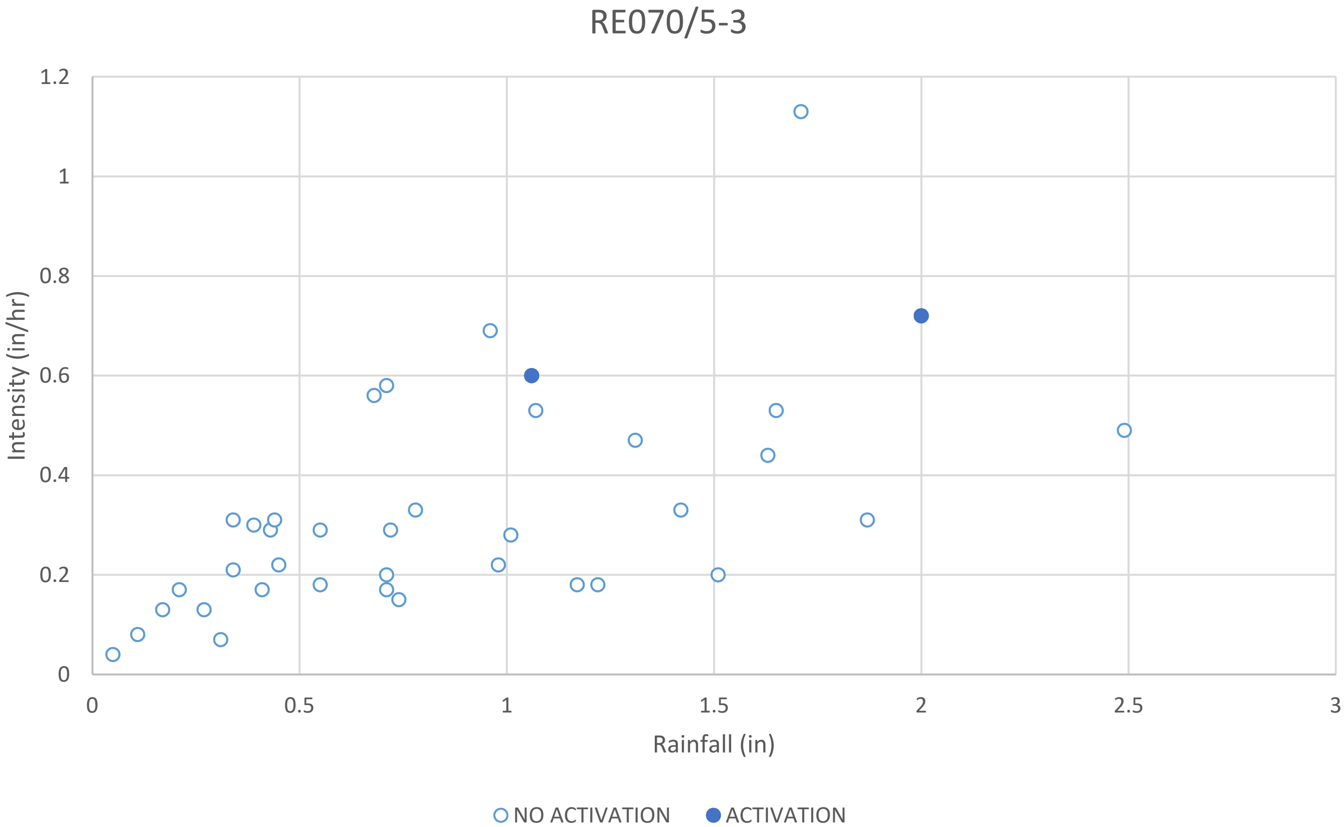
Outfall:BOS065
Regulator: RE65-2
Related Rain Gauge: 18



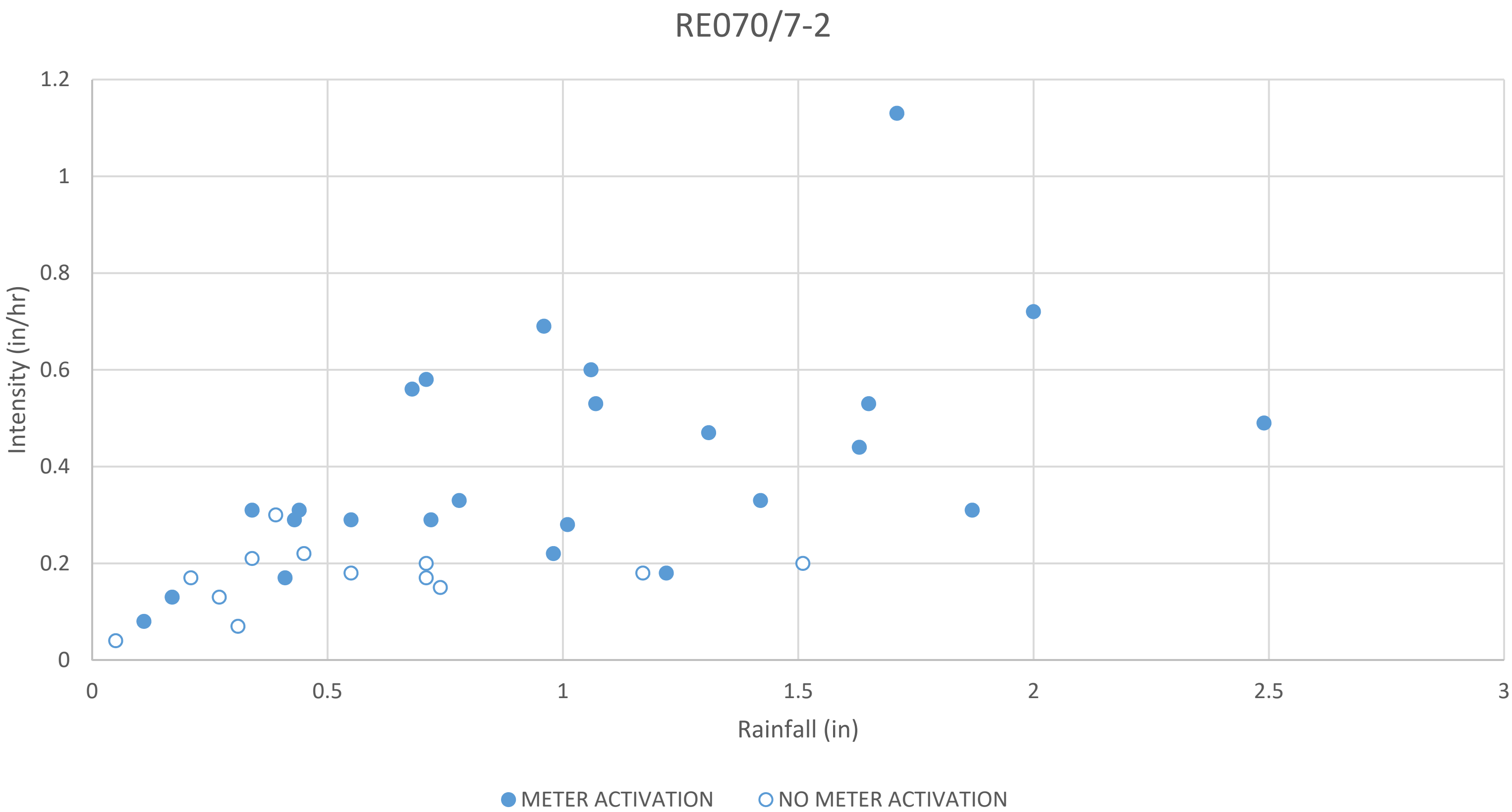
Outfall:BOS068
Regulator: RE68-1A
Related Rain Gauge: 18



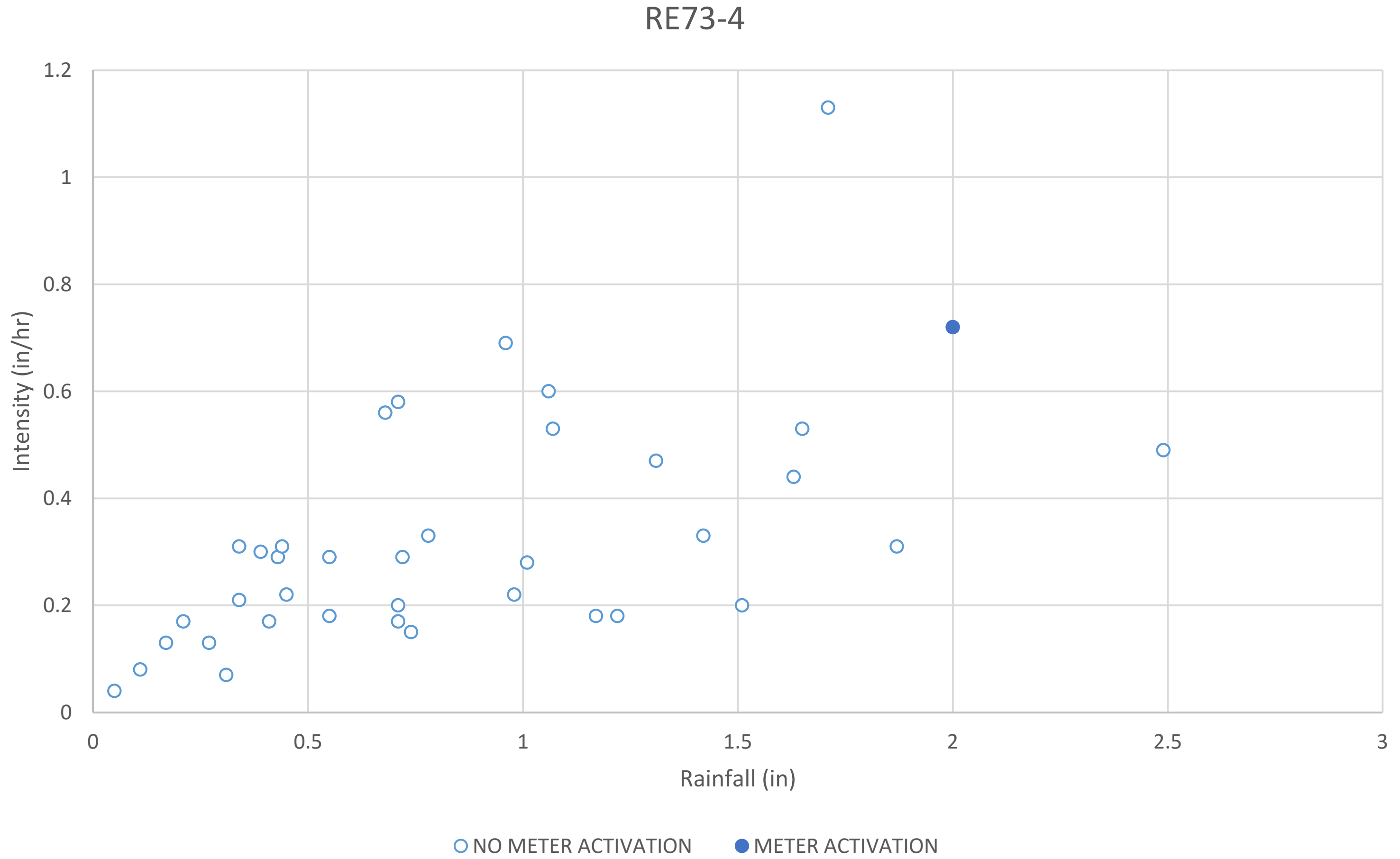
Outfall:BOS070/RRCC
Regulator: RE70/5-3
Related Rain Gauge: 18



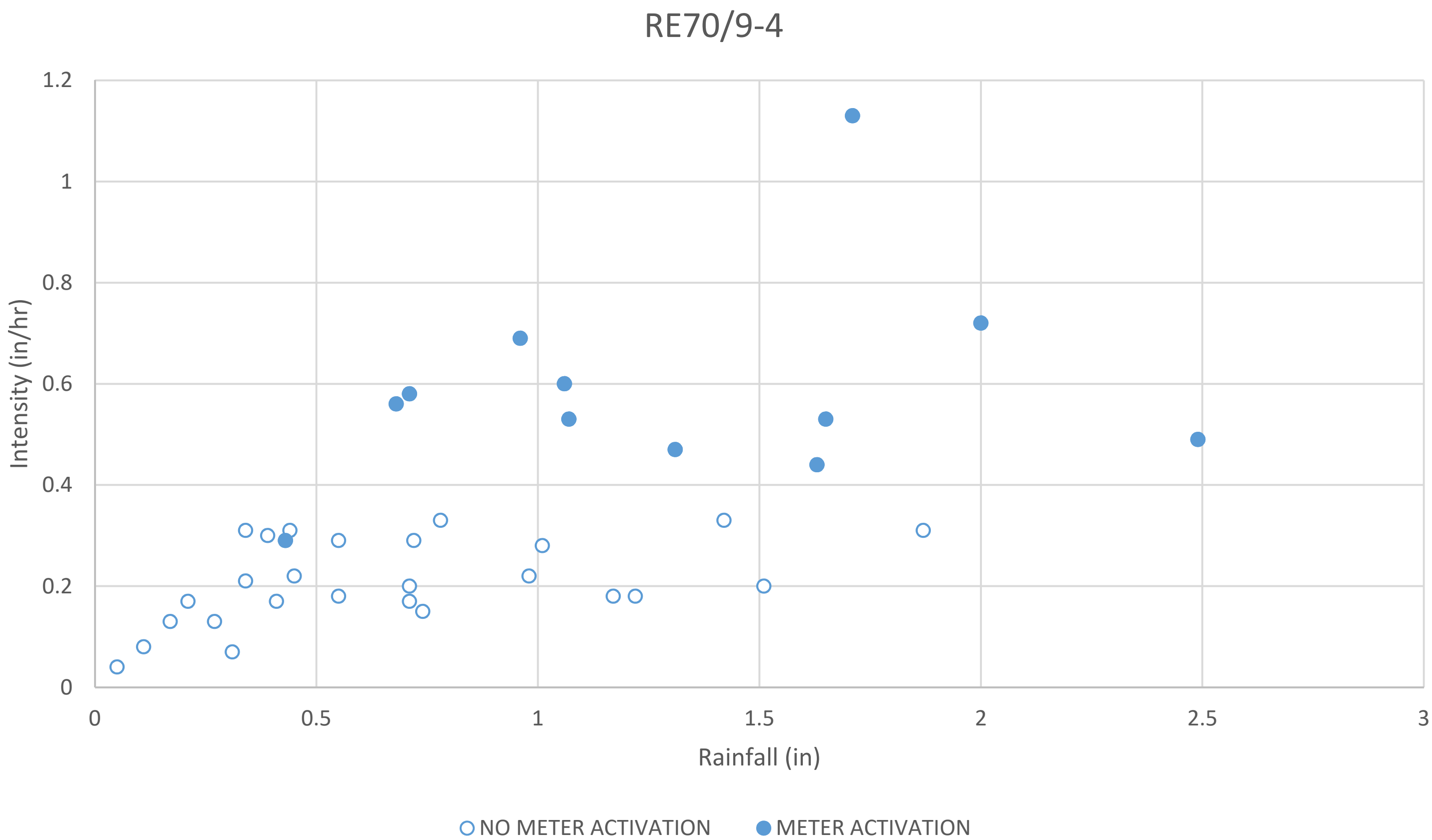
Outfall:BOS070/DBC
Regulator: RE70/7-2
Related Rain Gauge: 18



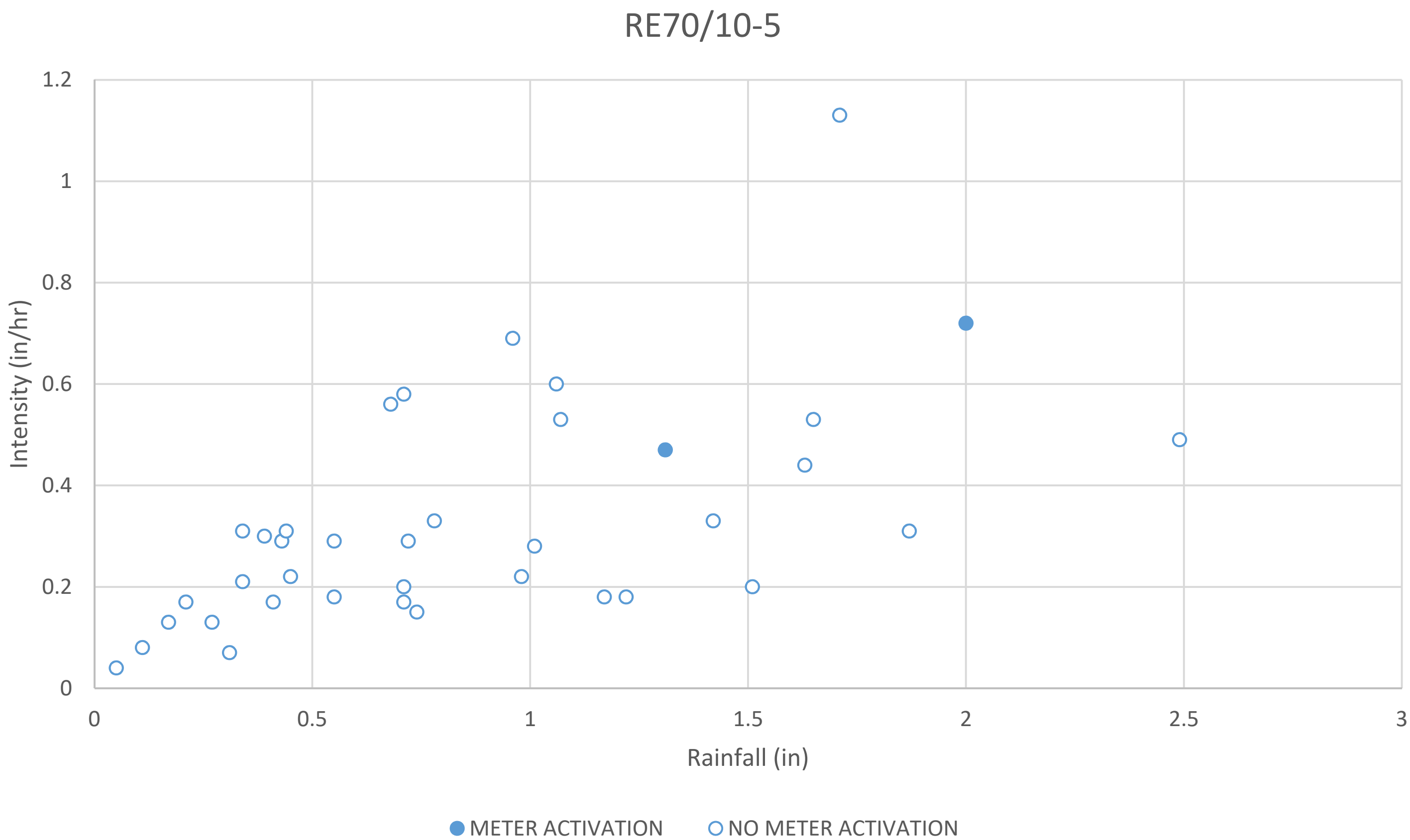
Outfall:BOS073
Regulator: RE073-4
Related Rain Gauge: 18



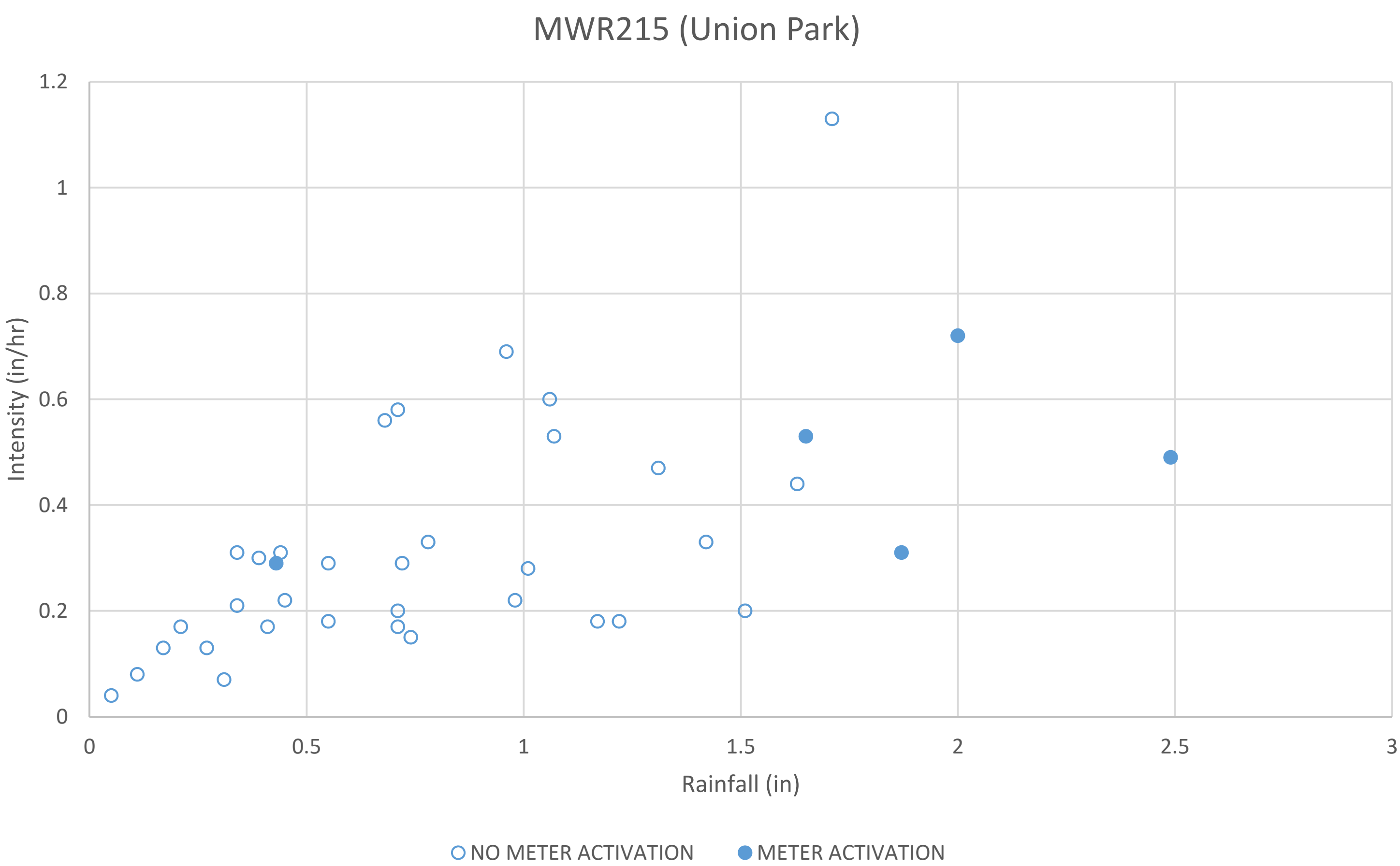
Outfall:BOS070/DBC
Regulator: RE70/9-4
Related Rain Gauge: 18



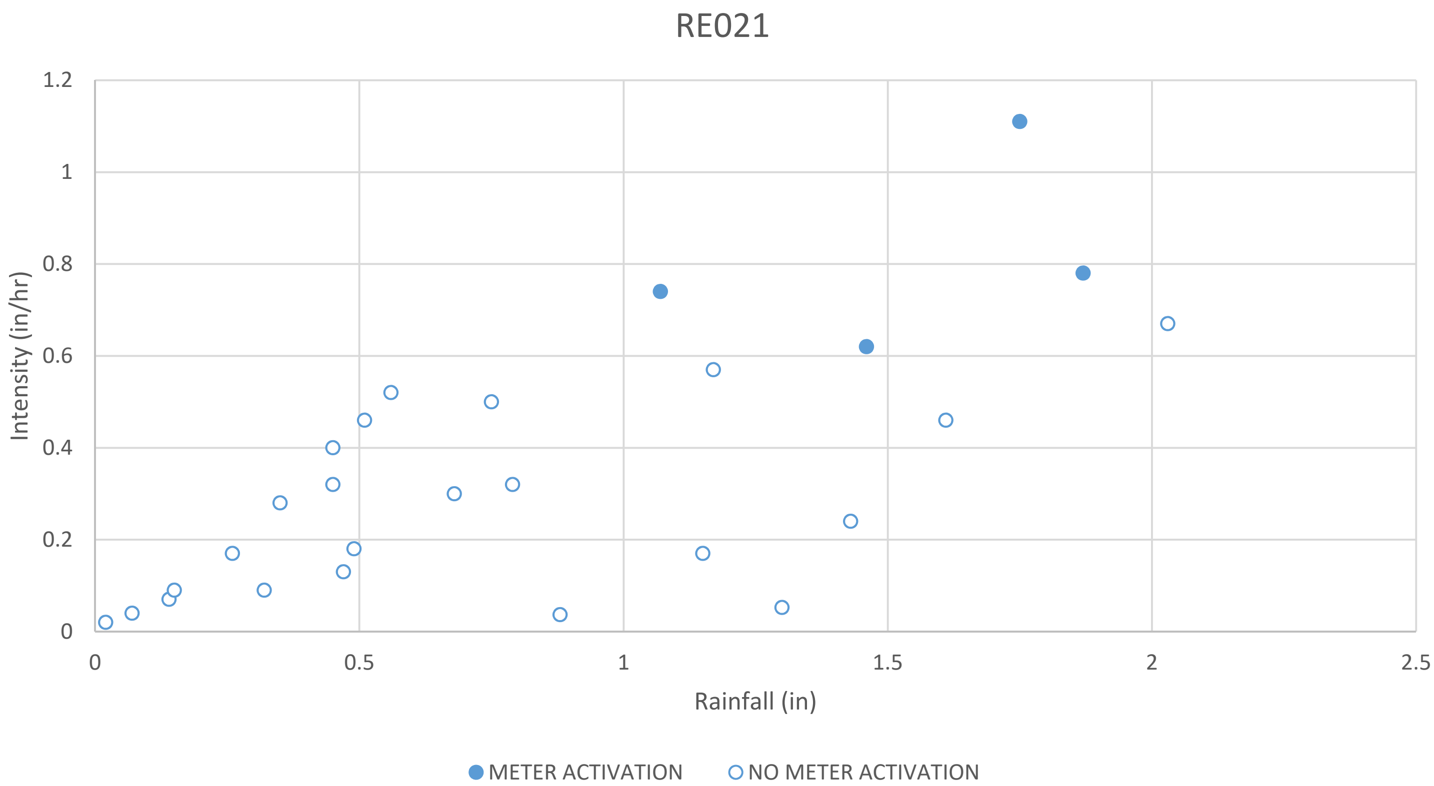
Outfall:BOS070/DBC
Regulator: RE70/10-5
Related Rain Gauge: 18



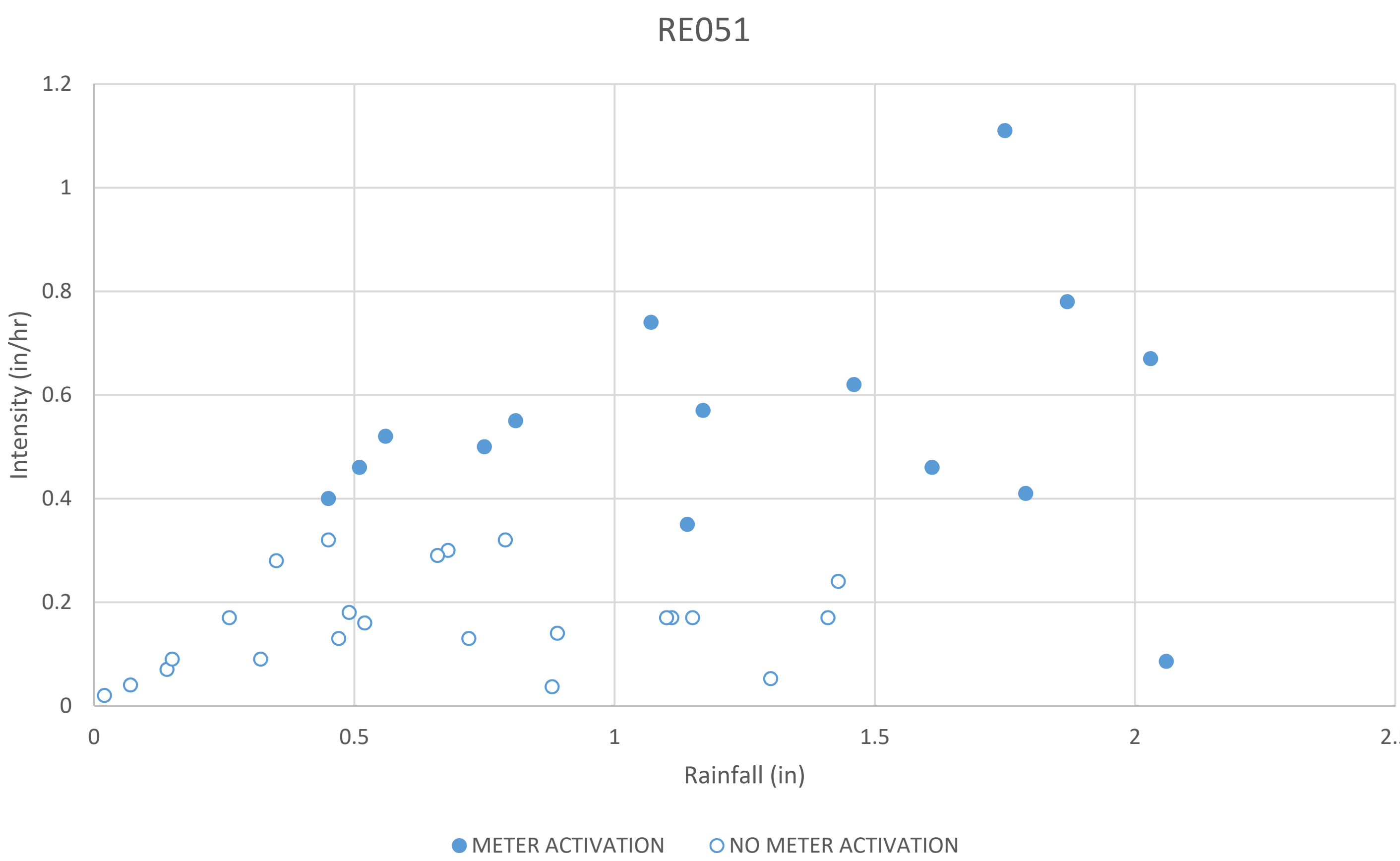
Outfall:MWR215 (Union Park)
Regulator: N/A
Related Rain Gauge: 18



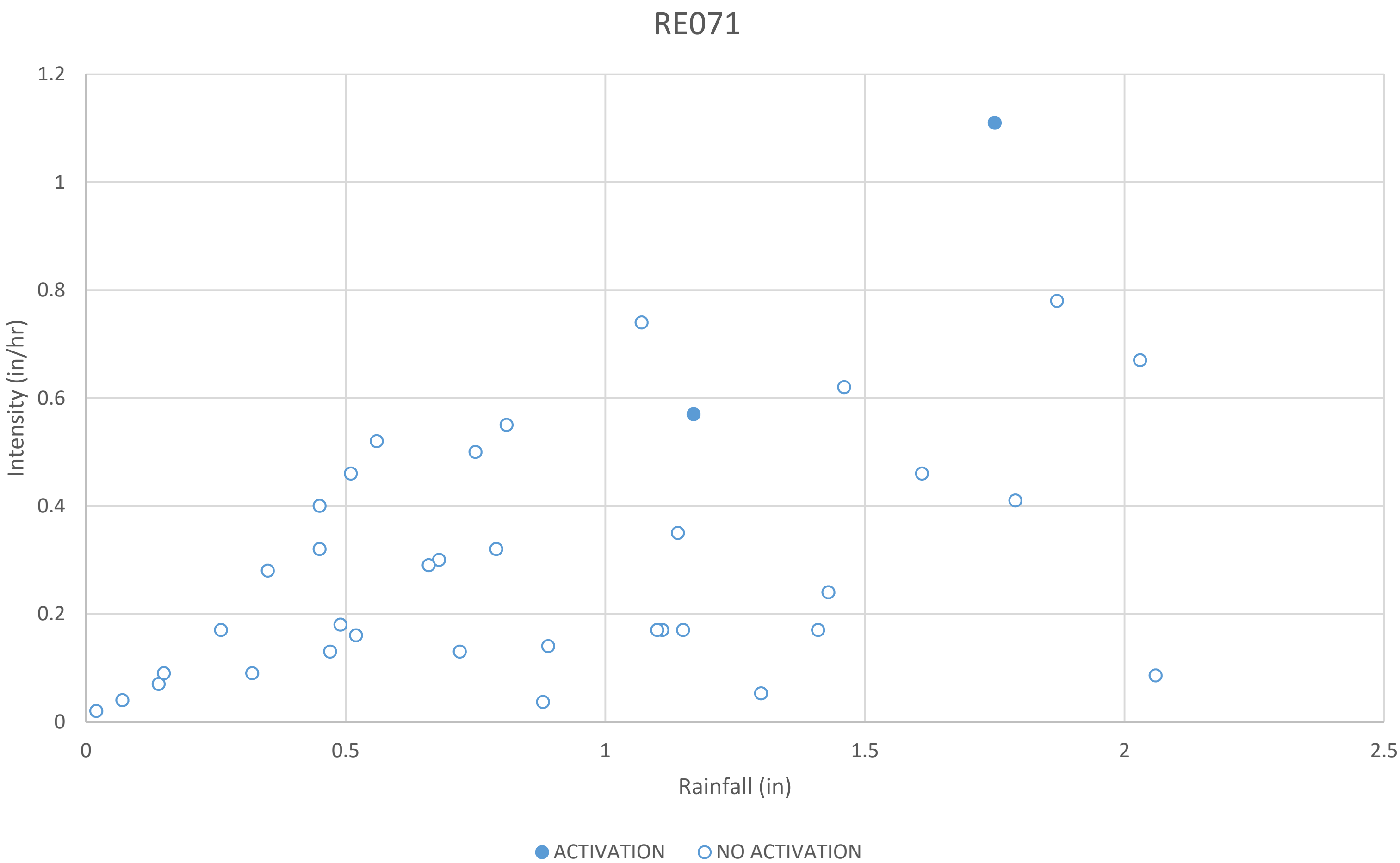
Outfall:CAM002
Regulator: RE021
Related Rain Gauge: 19



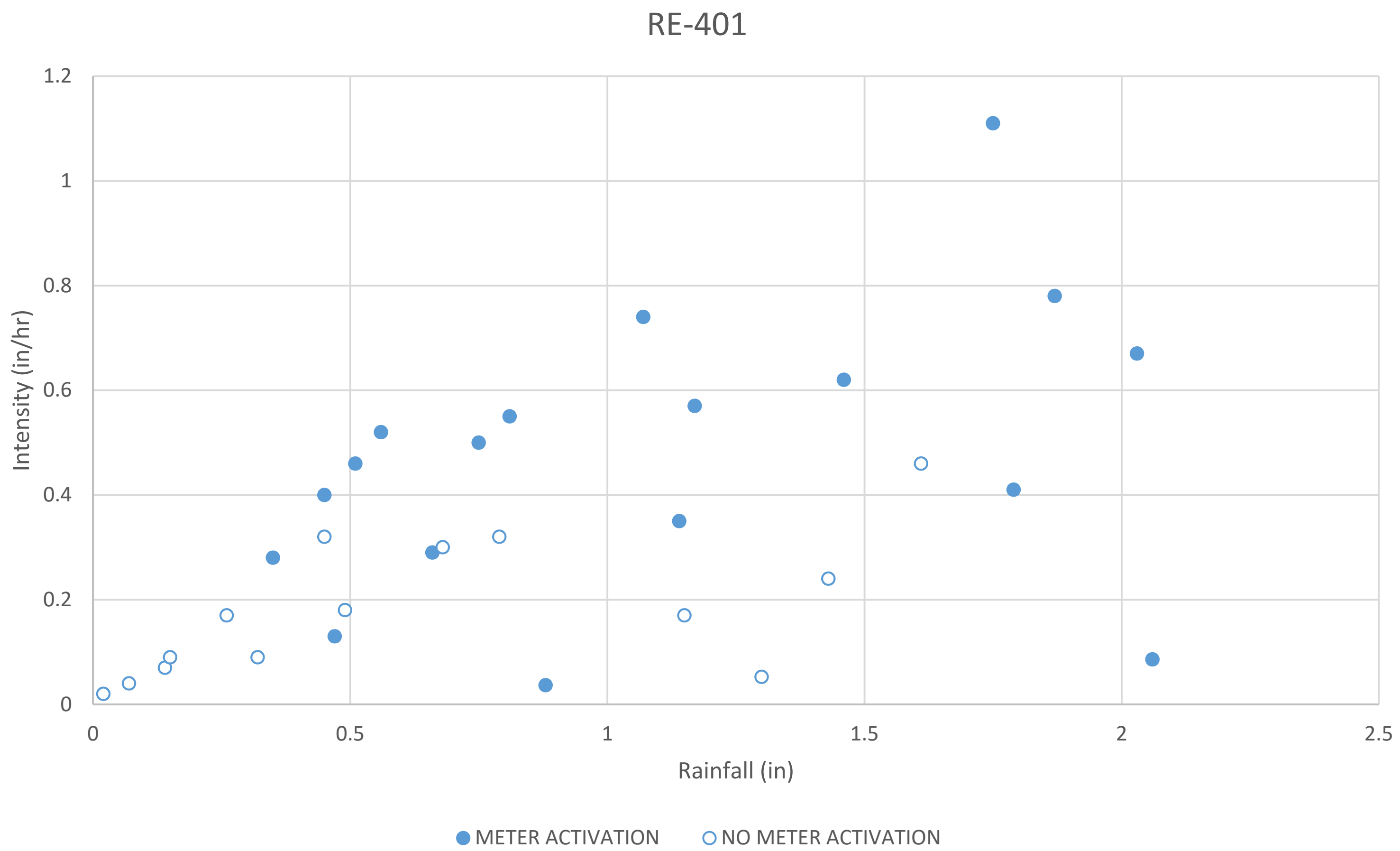
Outfall:CAM005
Regulator: RE051
Related Rain Gauge: 19



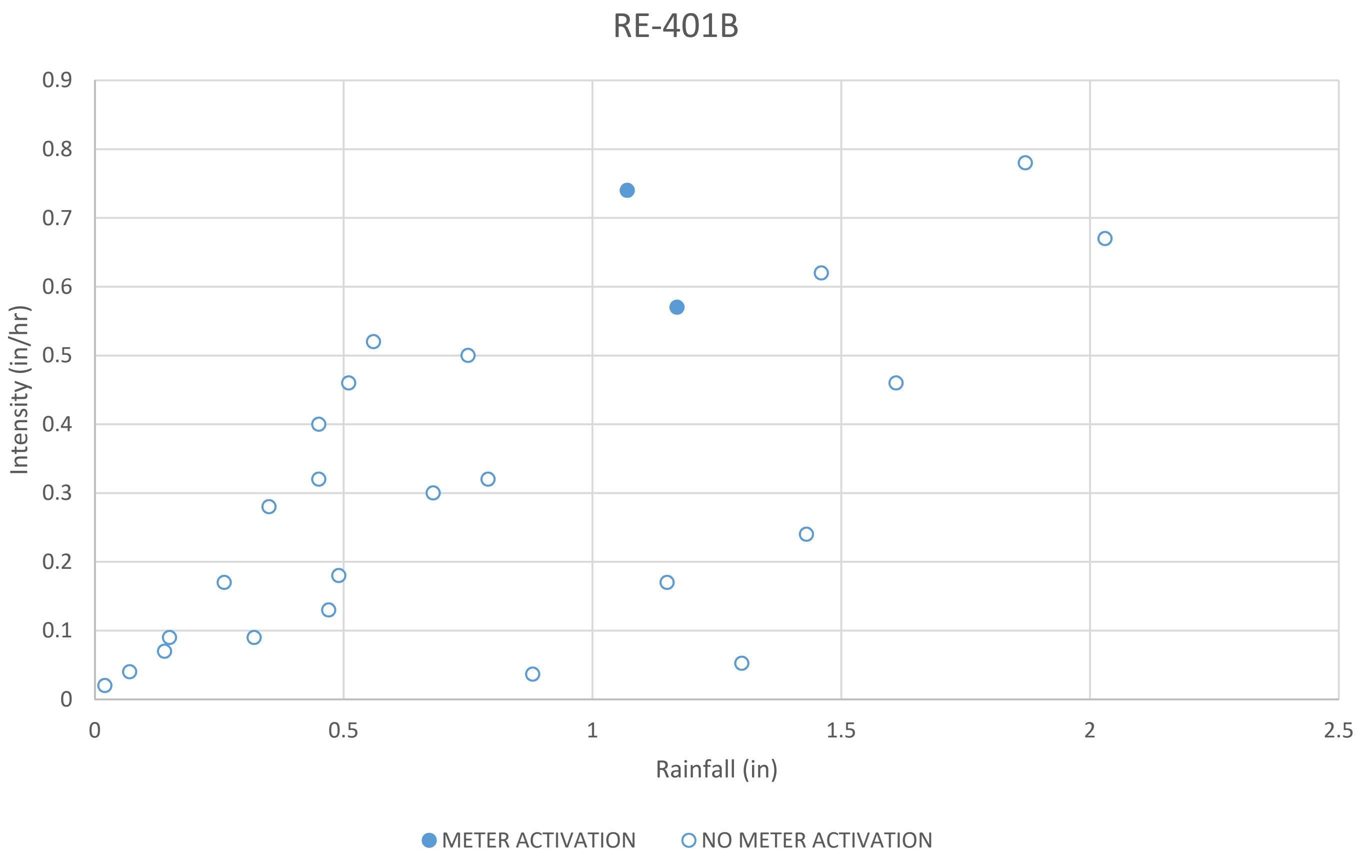
Outfall:CAM007
Regulator: RE071
Related Rain Gauge: 19



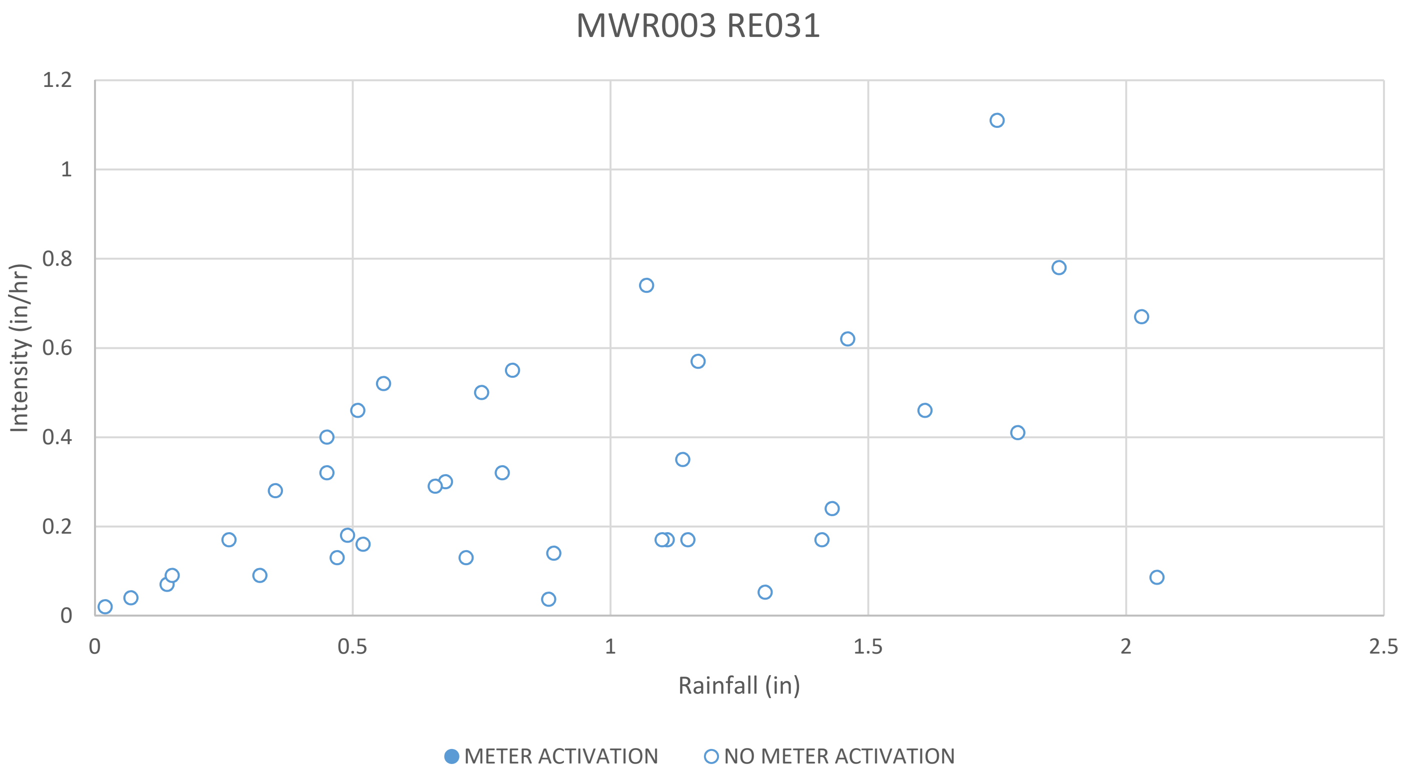
Outfall:CAM401a
Regulator: RE401
Related Rain Gauge: 19



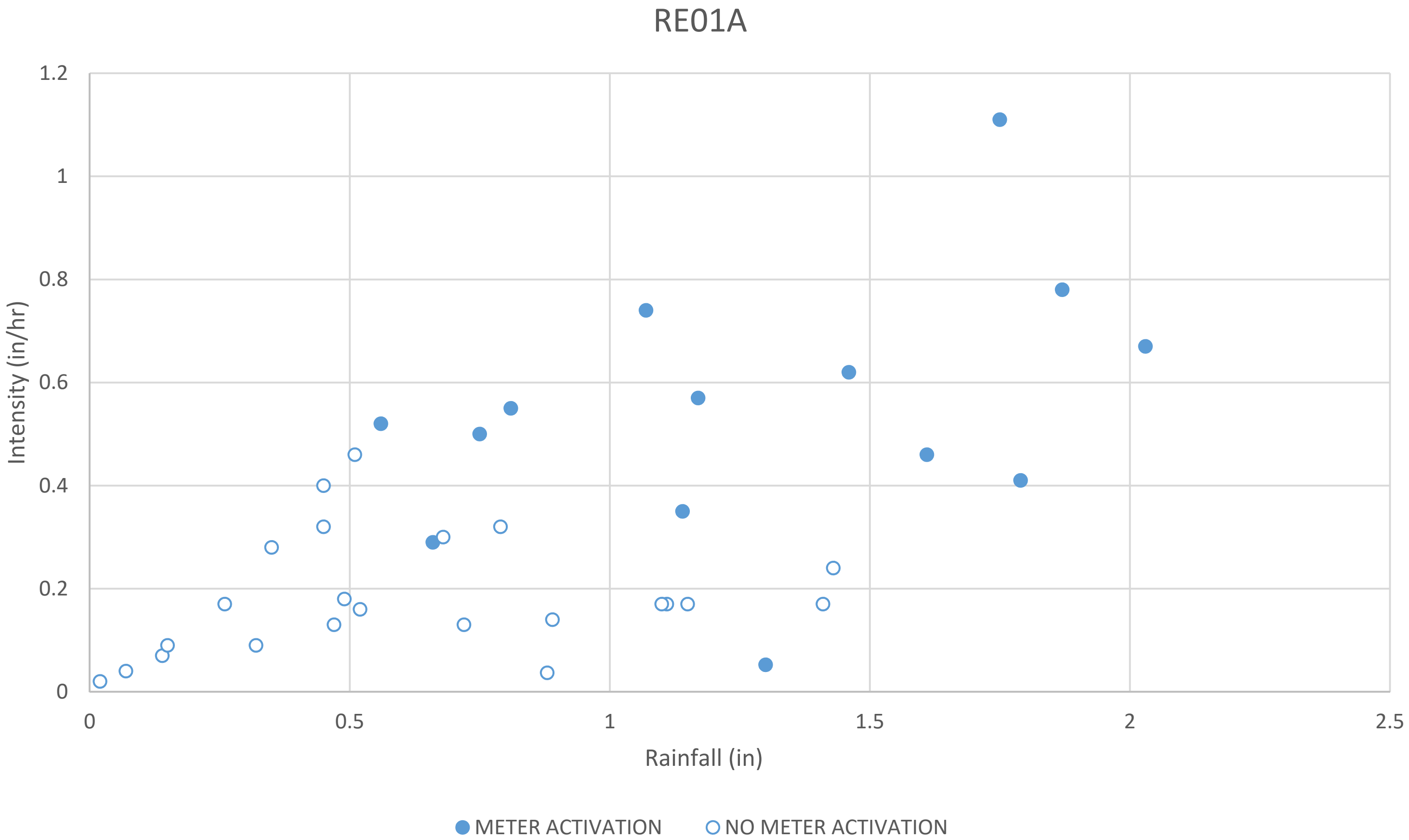
Outfall:CAM401B
Regulator: RE401B
Related Rain Gauge: 19



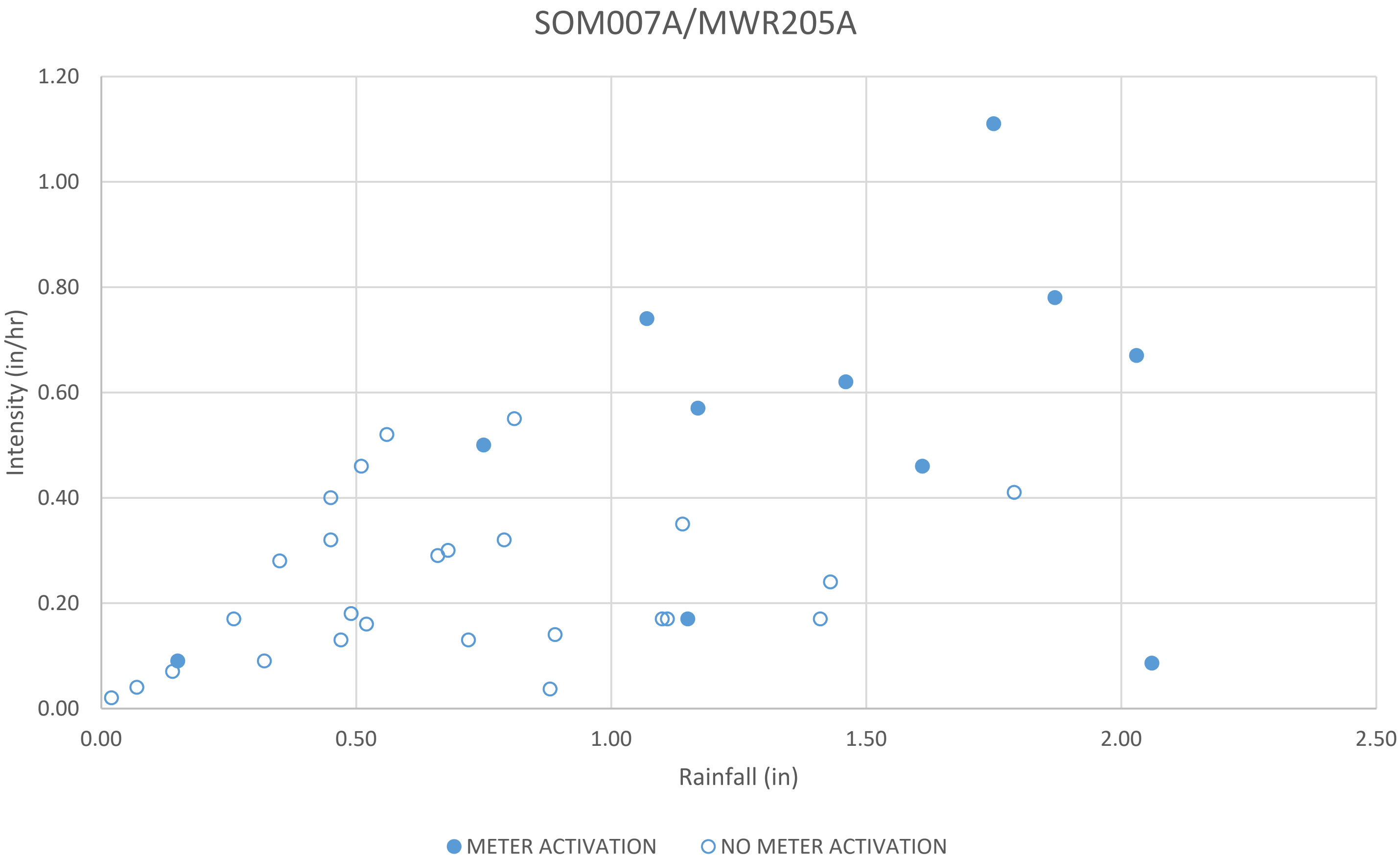
Outfall:MWR003
Regulator: RE031
Related Rain Gauge: 19



Outfall:SOM001A
Regulator: RE01A
Related Rain Gauge: 19



Outfall:SOM007A/MWR205A
Related Rain Gauge: 19



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