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Subject: CSO Discharge Estimates and Rainfall Analyses for Calendar Year 2017

Dear Mr. Brander and Mr. Borci:

Enclosed please find documentation of the Massachusetts Water Resources Authority's (MWRA) estimates of combined sewer overflow (CSO) discharges in its service area during calendar year 2017. MWRA is required to submit estimates of CSO activations and volumes for the previous calendar year for the Alewife Brook/Upper Mystic River and the Lower Charles River/Charles Basin in accordance with conditions in the Variance Extensions for the CSO Discharges to these waters, issued by the Massachusetts Department of Environmental Protection in 2016 pursuant to the Massachusetts Surface Water Quality Standards at 314 CMR 4.00. The Variance Extensions authorize limited CSO discharges to the Alewife Brook/Upper Mystic River and the Lower Charles River/Charles Basin in conjunction with National Pollution Discharge Elimination System (NPDES) permits MA0103284, MA0101982 and MA0101974 issued to MWRA, the City of Cambridge and the City of Somerville, respectively.

MWRA reports herewith its estimates of calendar year 2017 CSO activation frequency, total discharge duration and total discharge volume from each of the CSO outfalls addressed in MWRA's approved CSO Long-Term Control Plan (LTCP), including but not limited to the outfalls discharging to the Alewife Brook/Upper Mystic River and the Lower Charles River/Charles Basin. MWRA has also provided this information to its member communities with CSOs, including Boston Water and Sewer Commission (BWSC) and the cities of Cambridge, Chelsea and Somerville.

Table 10: Summary of 2017 and Typical Year Model Simulation Results, and Comparison to Typical Year Long-Term CSO Control Plan

Table 10, attached, presents estimated CSO activations, discharge duration and discharge volume at each CSO outfall during calendar year 2017. For most outfalls, MWRA developed the estimates using the MWRA InfoWorks sewer system model by simulating each of the rainfall events in 2017 with system conditions existing at the time of each storm and with storm-specific system operations. In support of these simulations, MWRA updated the model to account for new information and known changes to the system, including system improvements that were completed during the year, new meter data, and the results of field inspections. Each system change was incorporated into the 2017 rainfall simulations for subsequent storms, and all of the changes were incorporated into the 2017 Typical Year simulation, which represents end-of-year conditions. The most significant model updates for 2017 reflect the following new information. These and other model updates are also briefly listed at the bottom of Table 10.

- Modeled sediment depths in MWRA's Cambridge Branch Sewer sections 25-27, in Cambridge and Somerville, were revised, mostly by reducing sediment depths based on information from recent inspection. This had the effect of increasing modeled conveyance of flow to MWRA's DeLauri Pump Station and reducing predicted treated discharge volumes at the Prison Point CSO Facility and the Somerville Marginal CSO Facility, as shown in the table below. This model change also brought the model-predicted and facility-measured discharges at Prison Point closer together (see table on the following page).

Typical Year Discharges						
Facility	2016 Model		2017 Model		LTCP	
	Activations	Volume (MG)	Activations	Volume (MG)	Activations	Volume (MG)
Prison Point	18	276.0	17	237.8	17	243.0
Somerville-Marginal	22	71.7	22	67.3	39	60.6
DeLauri Pump Station	-	8,503	-	8,545	--	-

- Modeled configurations of BWSC sewers tributary to Outfall BOS070 (Fort Point Channel) were revised based on information provided by BWSC regarding its sewer separation work in these areas and the closing of regulator RE-070/6-1. These modifications changed the predicted discharges – increasing some, reducing others – at various regulators tributary to BOS070.

- In April 2017, BWSC raised the overflow weir at the sole remaining regulator (RE080-2B) tributary to Outfall BOS080 (Reserved Channel) by 15 inches, which significantly reduced CSO discharges from this outfall.

At the outfalls associated with MWRA's four CSO treatment facilities, the discharge estimates (activation frequency, duration and volume) presented in Table 10 for calendar year 2017 storms are from recorded measurements at the facilities, not model predictions. These outfalls are MWR201 (Cottage Farm), MWR203 (Prison Point), MWR205 (Somerville Marginal) and

MWR215 (Union Park). The activation frequencies and durations in Table 10 for outfalls SOM007A/MWR205A (Somerville-Marginal high tide relief), MWR003 (Alewife Brook) and BOS019 (Little Mystic Channel) are from data generated by MWRA depth sensors at the overflow weirs, but the estimated annual volumes at these three outfalls are from model predictions. The following table compares the recorded CSO measurements to the model predictions for these facility discharges for the storms in 2017 and for Typical rainfall under 2017 system conditions and the approved LTCP.

Comparison of MWRA CSO Discharge Measurements to Model Predictions								
Facility or Outfall	Measured in 2017		Model Predicted					
			2017 Storms		Typical Year/2017		Typical Year/LTCP	
	#	MG	#	MG	#	MG	#	MG
Cottage Farm	2	24.60	2	31.46	3	10.62	2	6.30
Prison Point	17	236.88	21	220.89	17	237.76	17	243.00
Somerville-Marginal	22	69.04	23	58.82	22	67.33	39	60.58
Union Park	5	18.15	11	33.81	11	33.81	17	71.37
SOM007A/MWR205A*	12	NM	2	2.20	2	1.82	3	3.48
MWR003*	1	NM	1	0.86	2	0.38	5	0.98
BOS019*	2	NM	2	0.46	1	0.21	2	0.58

** Discharge volume not measured (NM).

Table 10 also compares the results of the Typical Year simulation for end-of-year 2017 system conditions to the activation frequencies and annual volumes in the approved Long-Term Control Plan as defined in Exhibit B to the Second Stipulation of the United States and the Massachusetts Water Resources Authority on Responsibility and Legal Liability for Combined Sewer Overflow Control in the Federal District Court Order in the Boston Harbor Case as amended in May 2008. This comparison allows a tracking of progress towards meeting the long-term control levels.

Rainfall Analyses

Table 1: Comparison of Frequency of Rain Events within Selected Ranges of Total Rainfall, Typical Year Versus 2017

Table 2: Comparison of Storms with Greater than 2 Inches of Total Rainfall, Typical Year Versus 2017

Table 3: Comparison of Storms with Peak Intensities Greater than 0.40 Inch/Hour, Typical Year Versus 2017

Table 4: Top Ten Storms Contributing the Most CSO (Comparison of Model Predicted CSO Volumes for Storms in 2017 to Storms in the Typical Year)

Figure 1: Rainfall Intensity Comparison: 2017 Versus Typical Year

These rainfall comparisons were developed to be able to explain the magnitude of the estimated CSO discharges caused by 2017 rainfall relative to the model predicted discharges for the Typical Year with 2017 system conditions. These comparisons help to confirm that actual CSO discharges (and their associated impacts) are in line with the predictions that supported regulatory approvals of MWRA's LTCP. They also help to verify progress toward attainment of the long-term levels of control.

2017 Rainfall Close to the "Typical Year"

In 2017, Metropolitan Boston saw an end to the drought conditions of the previous few years. Generally, comparison of the metered and modeled discharge estimates for 2017 rainfall and the model predicted discharges for the Typical Year suggest that 2017 was close to the Typical Year. Measured or modeled CSO discharge frequencies in 2017 were similar to the model predictions of discharge frequencies for the Typical Year, suggesting closeness of the number of storms large enough to cause CSO activation. This is supported by the attached rainfall analyses. Table 1 shows approximately 14 storms with rainfall volume of greater than 1.0 inch for both 2017 and the Typical Year. Table 3 shows approximately 9 storms with greater than 0.4 inch/hour peak intensity for both 2017 and the Typical Year. Table 2 shows a larger number of Typical Year storms with rainfall volume greater than 2 inches, but rainfall volume has less influence on CSO than rainfall intensity. In addition, Figure 1 shows closeness of the peak rainfall intensity probability distributions of the rainfall events in 2017 as measured at three MWRA gauges and the rainfall events in the Typical Year.

Model predicted CSO discharge volume was slightly greater for the storms of 2017 (399 MG) than for the Typical Year (379 MG). This suggests that one or more of the largest storms in 2017 were larger (for CSO) than the storms in the Typical Year. Tables 2 and 3 show that certain rain gauges measured at least one storm in 2017 with recurrence interval of 2 years or greater. Table 4 shows that the estimated total CSO volume from the storm of October 29, 2017 (123 MG) is significantly greater than the estimated CSO volume from the largest storm in the Typical Year, September 23, 1992 (76.46 MG). Both the 2017 and Typical Year simulations that produced the results in Table 4 modeled 2017 system conditions.

Long-Term Levels of CSO Control and Performance Assessment

All 35 projects in MWRA's approved LTCP were complete and operational by December 2015. Other, continuing wastewater system improvements by MWRA and the CSO communities have the added benefit of improving upon the level of control. All four CSO communities (BWSC, Cambridge, Chelsea and Somerville) continue to pursue sewer separation in combined sewer areas and/or stormwater source controls, e.g., green infrastructure, that lower stormwater inflow to the sewer system. MWRA will continue to update its sewer system model to reflect the completion of these continuing efforts.

In compliance with the last two (of approximately 184) CSO control related milestones in the federal court schedule in the Boston Harbor Case, MWRA issued the notice to proceed in

November 2017 with a professional services contract for a 3-year post-construction monitoring program and CSO performance assessment intended to verify that remaining CSO discharges are consistent with the levels of control in the approved LTCP and court order. MWRA will submit a report on the results to EPA and DEP in December 2020 in compliance with Schedule Seven. The scope of work includes CSO inspections, overflow metering, hydraulic modeling, system performance assessments and water quality compliance assessment.

In March 2018, MWRA's contractor completed the inspections of more than 200 active or closed CSO regulators, and in April, the contractor completed the installation of overflow meters at 58 active or potentially active regulators. Most of the meters are scheduled to be in place and operational for at least two years, while some are expected to be removed once sufficient data are collected to confirm activation (or non-activation) frequencies and volumes over a range of large storms. MWRA intends to issue semi-annual progress reports, beginning in September 2018, that will include meter data, meter and model generated CSO discharge estimates, system performance assessment and progress updates for all of the key work activities, including receiving water quality data analyses.

Over the past several years, the CSO communities have installed meters to permanently monitor CSO overflows, in compliance with their NPDES permits, or to temporarily monitor overflows to evaluate the efficacy of overflow metering. MWRA recently coordinated closely with the communities to have access to the communities' raw data, CSO discharge estimates, and updated system conditions during the post-construction monitoring period. MWRA has included in the CSO performance assessment scope regular verification of MWRA and community meter data; validation of CSO discharge estimates from the data and from model simulations in part by correlating discharge estimates to rainfall and system hydraulic conditions; a recalibration of the model using verified field data for a range of storms; and comparisons of meter and model generated CSO discharges. While MWRA's InfoWorks model will be used to estimate Typical Year CSO discharges to verify attainment of LTCP levels, the metering program is intended in part to validate the model and its predictions.

Assessment of Typical Year Discharges to LTCP Levels of Control

Table 10 compares model predictions of Typical Year discharges for 2017 system conditions to the LTCP levels of control. The following provides brief evaluations where the model results indicate outfalls or system subareas may not be meeting LTCP levels. In addition to the following, the scope of MWRA's ongoing CSO performance assessment includes the identification and evaluation of physical and operational adjustments (e.g., raising of overflow weirs) that may enhance CSO control.

Outfall SOM01A (Alewife Brook): MWRA recently completed model runs to evaluate the size and hydraulic capacity of the connection between the City of Somerville's Tannery Brook Conduit and MWRA's Alewife Brook Conduit. From this information, and with input from the cities of Somerville and Cambridge, MWRA will make, and implement, a recommendation. Upgrade of the connection completed by MWRA in December 2013 added a 24-inch orifice plate that can be

upsized. The evaluations consider both the SOM01A CSO control benefits and the potential system impacts elsewhere, by increasing the connection size.

Charles River/Cottage Farm: The City of Cambridge's ongoing, long-term sewer separation work tributary to MWRA's North Charles Met and North Charles Relief sewers is predicted to further reduce CSO discharges at outfalls CAM005, CAM007 and MWR201 (Cottage Farm Facility), provided that the separated stormwater is able to be conveyed to the receiving water and not returned to the sewer system. One of the hurdles in being able to remove stormwater from the sewer system and convey flows to the receiving water is compliance with expected stormwater permit requirements relative to the Charles River Phosphorus TMDL.

East Boston: The 2017 Typical Year discharge predictions are higher than LTCP levels at a few of the East Boston outfalls, particularly BOS003 and BOS014. MWRA continues to coordinate with BWSC in investigating system conditions and potential localized system hydraulic restrictions, improving system characterization, and upgrading MWRA's model using data that will be collected from temporary meters installed by MWRA's CSO performance contractor at several regulators.

Chelsea Creek: MWRA recently installed additional meters to supplement the City of Chelsea's meters in the regulators at outfalls CHE004 and CHE008. As with the meter data that will be collected in other CSO areas, MWRA plans to use the additional data to validate meter-measured discharges, verify or improve model calibration, and better understand the hydraulic conditions within the regulators.

Should you have questions about MWRA's CSO discharge estimates or MWRA's continuing compliance efforts, please feel free to contact me, at 617-788-4359, or David Kubiak, at 617-570-5460.

Very truly yours,

David W. Coppes
Chief Operating Officer

Attachments

TABLE 10. SUMMARY OF 2017 AND TYPICAL YEAR MODEL SIMULATION RESULTS, AND COMPARISON TO TYPICAL YEAR LONG TERM CSO CONTROL PLAN

	2017 RAINFALL UNDER 2017 SYSTEM CONDITIONS			TYPICAL-YEAR RAINFALL UNDER 2017 SYSTEM CONDITIONS		TYPICAL-YEAR RAINFALL W/ LONG TERM CSO CONTROL PLAN	
Outfall	**Activation Frequency**	**Duration (hrs)**	**Volume (MG)**	**Activation Frequency**	**Volume (MG)**	**Activation Frequency**	**Volume (MG)**
ALEWIFE BROOK							
CAM001	1	1.41	0.05	1	0.02	5	0.19
CAM002	1	1.24	0.29	1	0.21	4	0.69
MWR003 [3]	1	0.50	0.86	2	0.38	5	0.98
CAM004	Closed	N/A	N/A	Closed	N/A	Closed	N/A
CAM400	Closed	N/A	N/A	Closed	N/A	Closed	N/A
CAM401A	1	1.49	0.55	2	0.44	5	1.61
CAM401B	2	2.19	0.29	2	0.18	7	2.15
SOM001A	2	2.98	3.02	5	3.90	3	1.67
SOM001	Closed	N/A	N/A	Closed	N/A	Closed	N/A
SOM002A	Closed	N/A	N/A	Closed	N/A	Closed	N/A
SOM003	Closed	N/A	N/A	Closed	N/A	Closed	N/A
SOM004	Closed	N/A	N/A	Closed	N/A	Closed	N/A
TOTAL		**9.80**	**5.05**		**5.12**		**7.29**
UPPER MYSTIC RIVER							
SOM007A/MWR205A [1]	12	13.35	2.20	2	1.82	3	3.48
SOM007	Closed	N/A	N/A	Closed	N/A	Closed	N/A
TOTAL		**13.35**	**2.20**		**1.82**		**3.48**
MYSTIC/CHELSEA CONFLUENCE							
MWR205 (Somerville Marginal Facility) [2]	22	83.65	69.04	22	67.33	39	60.58
BOS013	5	5.94	0.40	4	0.13	4	0.54
BOS014	5	6.65	2.12	4	0.45	0	0.00
BOS015	Closed	N/A	N/A	Closed	N/A	Closed	N/A
BOS017	0	0.00	0.00	0	0.00	1	0.02
CHE002	Closed	N/A	N/A	Closed	N/A	4	0.22
CHE003	0	0.00	0.00	0	0.00	3	0.04
CHE004	4	5.20	0.66	1	0.10	3	0.32
CHE008	8	19.93	4.35	7	1.83	0	0.00
TOTAL		**121.37**	**76.57**		**69.84**		**61.72**
UPPER INNER HARBOR							
BOS009	1	0.68	0.02	3	0.10	5	0.59
BOS010	5	5.64	1.00	6	0.46	4	0.72
BOS012	6	7.19	0.95	7	0.55	5	0.72
BOS019 [3]	2	14.82	0.46	1	0.21	2	0.58
BOS050	Closed	N/A	N/A	Closed	N/A	Closed	N/A
BOS052	Closed	N/A	N/A	Closed	N/A	Closed	N/A
BOS057	2	1.52	0.36	2	0.58	1	0.43
BOS058	Closed	N/A	N/A	Closed	N/A	Closed	N/A
BOS060	0	0.00	0.00	1	0.02	0	0.00
MWR203 (Prison Point) [4]	17	68.20	236.88	17	237.76	17	243.00
TOTAL		**98.05**	**239.67**		**239.67**		**246.04**
LOWER INNER HARBOR							
BOS003	17	50.40	19.50	18	11.80	4	2.87
BOS004	5	9.35	0.65	5	0.28	5	1.84
BOS005	0	0.00	0.00	0	0.00	1	0.01
BOS006 [5]	Closed	N/A	N/A	Closed	N/A	4	0.24
BOS007 [5]	Closed	N/A	N/A	Closed	N/A	6	1.05
TOTAL		**59.75**	**20.15**		**12.08**		**6.01**

TABLE 10. SUMMARY OF 2017 AND TYPICAL YEAR MODEL SIMULATION RESULTS, AND COMPARISON TO TYPICAL YEAR LONG TERM CSO CONTROL PLAN

	2017 RAINFALL UNDER 2017 SYSTEM CONDITIONS			TYPICAL-YEAR RAINFALL UNDER 2017 SYSTEM CONDITIONS		TYPICAL-YEAR RAINFALL W/ LONG TERM CSO CONTROL PLAN	
Outfall	**Activation Frequency**	**Duration (hrs)**	**Volume (MG)**	**Activation Frequency**	**Volume (MG)**	**Activation Frequency**	**Volume (MG)**
CONSTITUTION BEACH							
MWR207	Closed	N/A	N/A	Closed	N/A	Closed	N/A
TOTAL		**N/A**	**N/A**		**N/A**		**N/A**
FORT POINT CHANNEL							
BOS062	0	0.00	0.00	0	0.00	1	0.01
BOS064	1	1.00	0.04	1	0.02	0	0.00
BOS065	1	1.96	1.10	1	0.62	1	0.06
BOS068	0	0.00	0.00	0	0.00	0	0.00
BOS070							
BOS070/DBC	3	5.84	7.81	4	3.30	3	2.19
MWR215 (Union Park) [4]	5	15.32	18.15	11	33.81	17	71.37
BOS070/RCC	0	0.00	0.00	0	0.00	2	0.26
BOS072	Closed	N/A	N/A	Closed	N/A	0	0.00
BOS073	0	0.00	0.00	0	0.00	0	0.00
TOTAL		**24.13**	**27.10**		**37.74**		**73.89**
RESERVED CHANNEL							
BOS076	5	7.36	1.02	6	1.19	3	0.91
BOS078	1	0.71	0.05	0	0.00	3	0.28
BOS079	0	0.00	0.00	0	0.00	1	0.04
BOS080	1	1.21	0.08	3	0.08	3	0.25
TOTAL		**9.29**	**1.14**		**1.27**		**1.48**
NORTHERN DORCHESTER BAY							
BOS081	0	0.00	0.00	0	0.00	0 / 25 year	N/A
BOS082	0	0.00	0.00	0	0.00	0 / 25 year	N/A
BOS083 [6]	Closed	N/A	N/A	Closed	N/A	0 / 25 year	N/A
BOS084	0	0.00	0.00	0	0.00	0 / 25 year	N/A
BOS085	0	0.00	0.00	0	0.00	0 / 25 year	N/A
BOS086	0	0.00	0.00	0	0.00	0 / 25 year	N/A
BOS087	Closed	N/A	N/A	Closed	N/A	Closed	N/A
TOTAL		**0.00**	**0.00**		**0.00**		**0.00**
SOUTHERN DORCHESTER BAY							
BOS088/BOS089 (Fox Point)	Closed	N/A	N/A	Closed	N/A	Closed	N/A
BOS090 (Commercial Point)	Closed	N/A	N/A	Closed	N/A	Closed	N/A
TOTAL		**N/A**	**N/A**		**N/A**		**N/A**
UPPER CHARLES							
BOS032	Closed	N/A	N/A	Closed	N/A	Closed	N/A
BOS033	Closed	N/A	N/A	Closed	N/A	Closed	N/A
CAM005	1	4.49	1.66	3	1.36	3	0.84
CAM007	1	1.98	1.24	2	0.25	1	0.03
CAM009 [7]	Closed	N/A	N/A	Closed	N/A	2	0.01
CAM011 [7]	Closed	N/A	N/A	Closed	N/A	0	0.00
TOTAL		**6.47**	**2.90**		**1.62**		**0.88**

TABLE 10. SUMMARY OF 2017 AND TYPICAL YEAR MODEL SIMULATION RESULTS, AND COMPARISON TO TYPICAL YEAR LONG TERM CSO CONTROL PLAN

	2017 RAINFALL UNDER 2017 SYSTEM CONDITIONS			TYPICAL-YEAR RAINFALL UNDER 2017 SYSTEM CONDITIONS		TYPICAL-YEAR RAINFALL W/ LONG TERM CSO CONTROL PLAN	
Outfall	**Activation Frequency**	**Duration (hrs)**	**Volume (MG)**	**Activation Frequency**	**Volume (MG)**	**Activation Frequency**	**Volume (MG)**
LOWER CHARLES							
BOS028	Closed	N/A	N/A	Closed	N/A	Closed	N/A
BOS042	Closed	N/A	N/A	Closed	N/A	Closed	N/A
BOS049	Closed	N/A	N/A	Closed	N/A	Closed	N/A
CAM017	0	0.00	0.00	1	1.27	1	0.45
MWR010	0	0.00	0.00	0	0.00	0	0.00
MWR018	1	2.20	2.08	0	0.00	0	0.00
MWR019	1	1.23	0.22	0	0.00	0	0.00
MWR020	0	0.00	0.00	0	0.00	0	0.00
MWR021	Closed	N/A	N/A	Closed	N/A	Closed	N/A
MWR022	Closed	N/A	N/A	Closed	N/A	Closed	N/A
MWR201 (Cottage Farm) [4]	2	7.17	24.60	3	10.62	2	6.30
MWR023	0	0.00	0.00	1	0.02	2	0.13
SOM010	Closed	N/A	N/A	Closed	N/A	Closed	N/A
TOTAL		**10.60**	**26.89**		**11.91**		**6.88**
NEPONSET RIVER							
BOS093	Closed	N/A	N/A	Closed	N/A	Closed	N/A
BOS095	Closed	N/A	N/A	Closed	N/A	Closed	N/A
TOTAL		**N/A**	**N/A**		**N/A**		**N/A**
BACK BAY FENS							
BOS046 [8]	0	0.00	0.00	1	1.57	2	5.38
TOTAL		**0.00**	**0.00**		**1.57**		**5.38**
Total Treated			**349**		**350**		**381**
Total Untreated			**51**		**30**		**23**
GRAND TOTAL			**399**		**379**		**404**

(1) Includes portion of flow treated at Somerville Marginal facility and separate stormwater entering the Somerville Marginal Conduit (outfall) downstream of the facility. Activation frequency and volume for 2017 rainfall are from MWRA depth sensor measurements and MWRA model results, respectively.

(2) Volume represents all flow through the CSO treatment facility. Activation frequency and volume for 2017 rainfall are from MWRA facility records (measurements).

(3) Activation frequency and volume for 2017 rainfall are from MWRA depth sensor measurements and MWRA model results, respectively.

(4) Activation frequency and volume for 2017 rainfall are from MWRA facility records (measurements).

(5) BWSC has permanently closed outfalls BOS006 and BOS007 in East Boston as part of sewer separation and development plans in the tributary areas, although the outfalls were assumed to remain active in the long-term CSO control plan.

(6) CSO discharge at Outfall BOS083 was redirected to Outfall BOS084 as part of the construction of the North Dorchester Bay Storage Tunnel.

(7) The City of Cambridge closed outfalls CAM009 and CAM011 in November 2007, and continues to monitor upstream hydraulic effects.

(8) Volumes represent model predicted total discharge at outfall BOS046, including Stony Brook Conduit stormwater and CSO contributions.

Key 2017 Model Updates

Incorporated BWSC BOS070 sewer separation of tributary areas to CSO regulators RE070/5-2 and RE070/6-1.

Incorporated BWSC BOS070 CSO regulator RE070/6-1 closure.

Adjusted weir elevation after BWSC raised the weir elevation at BOS080 CSO regulator RE080-2B in April 2017.

Adjusted Cambridge Branch Sewer manhole rim elevations and incorporated sediment depth information using MWRA field measurements.

RAINFALL CHARACTERISTICS

TABLE 1. COMPARISON OF FREQUENCY OF RAIN EVENTS WITHIN SELECTED RANGES OF TOTAL RAINFALL, TYPICAL YEAR VERSUS 2017

Conditions	Total Rainfall (inches)	Total Number of Storms	Number of Storms by Volume				
			Volume < 0.25 inches	Volume 0.25 to 0.5 inches	Volume 0.5 to 1.0 inches	Volume 1.0 to 2.0 inches	Volume >= 2.0 inches
Typical Year	46.8	93	49	14	16	8	6
MWRA Rain Gauges							
Ward Street	44.10	100	58	13	14	12	3
Columbus Park	45.34	95	55	8	17	11	4
Chelsea Creek	46.31	101	63	11	10	13	4
HF-1C	39.90	98	57	13	15	11	2
RG-WF-1	38.32	100	58	15	13	12	2
BWSC Rain Gauges							
Allston	39.58	95	59	11	11	12	2
Dorchester - Adam Street	43.20	99	62	10	14	8	5
Charlestown	38.90	95	57	11	14	11	2
Roslindale	46.51	98	58	10	14	11	5
Union Park	41.40	99	60	12	14	10	3
USGS Rain Gauge							
Fresh Pond	39.52	101	61	14	13	11	2

TABLE 2. COMPARISON OF STORMS WITH GREATER THAN 2 INCHES OF TOTAL RAINFALL, TYPICAL YEAR VERSUS 2017

Rain Gauge	Date	Duration (hours)	Total Rainfall (inches)	Average Intensity (inch/hour)	Peak Intensity (inch/hour)	Storm Recurrence Interval (24-hour)
Typical Year	12/11/1992	50	3.89	0.08	0.20	1y
	8/15/1992	72	2.91	0.04	0.66	3m
	9/22/1992	23	2.76	0.12	0.65	1y
	11/21/1992	84	2.39	0.03	0.31	3m
	5/31/1992	30	2.24	0.07	0.37	3m-6m
	10/9/1992	65	2.04	0.03	0.42	<3m
Ward Street Headworks (BO-DI-1)	10/29/2017	16	3.18	0.20	0.76	2y
	3/31/2017	30.75	2.51	0.08	0.20	6m
	6/4/2017	58	2.14	0.04	0.24	<3m
Columbus Park Headworks (BO-DI-2)	3/31/2017	30.75	2.83	0.09	0.26	6m-1y
	6/16/2017	11.5	2.37	0.21	0.62	6m
	6/4/2017	57.5	2.35	0.04	0.24	<3m
	1/22/2017	63.5	2.00	0.03	0.23	3m
Chelsea Creek Headworks (CH-BO-1)	3/31/2017	30.75	2.88	0.09	0.21	1y
	10/29/2017	11.75	2.37	0.20	0.57	6m
	6/16/2017	12.75	2.34	0.18	0.69	6m
	1/22/2017	65.25	2.00	0.03	0.28	3m
Fresh Pond (from USGS)	10/29/2017	23.75	3.22	0.14	1.00	2y
	3/31/2017	31.25	2.17	0.07	0.19	3m-6m

TABLE 3. COMPARISON OF STORMS WITH PEAK INTENSITIES GREATER THAN 0.40 INCHES/HOUR, TYPICAL YEAR VERSUS 2017

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
Ward Street Headworks (BO-DI-1)	10/29/2017	16.00	3.18	0.20	0.76	6m-1y
	10/24/2017	46.00	1.94	0.04	0.68	3m-6m
	9/6/2017	18.00	1.30	0.07	0.54	<3m
	6/16/2017	12.50	1.89	0.15	0.52	<3m
	9/15/2017	3.00	0.54	0.18	0.46	<3m
	7/24/2017	13.75	1.37	0.10	0.44	<3m
Columbus Park Headworks (BO-DI-2)	8/2/2017	6.75	1.60	0.24	1.23	2y-5y
	9/6/2017	17.25	1.02	0.06	0.71	6m
	6/16/2017	11.50	2.37	0.21	0.62	3m-6m
	9/14/2017	0.50	0.61	1.22	0.61	3m-6m
	10/24/2017	46.50	1.76	0.04	0.51	<3m
	7/8/2017	2.75	0.62	0.23	0.48	<3m
	7/24/2017	15.50	1.70	0.11	0.48	<3m
	9/15/2017	10.00	0.69	0.07	0.47	<3m
	3/14/2017	11.50	1.66	0.14	0.44	<3m
	4/25/2017	37.75	1.77	0.05	0.40	<3m
Chelsea Creek Headworks (CH-BO-1)	7/12/2017	23.75	1.98	0.08	1.49	2y-5y
	9/30/2017	8.25	1.75	0.21	1.21	2y-5y
	8/2/2017	7.00	1.11	0.16	0.99	1y-2y
	7/18/2017	2.25	0.77	0.34	0.75	6m-1y
	6/16/2017	12.75	2.34	0.18	0.69	3m-6m
	9/6/2017	24.00	1.00	0.04	0.62	3m-6m
	10/29/2017	11.75	2.37	0.20	0.57	3m
	7/24/2017	18.75	1.61	0.09	0.53	<3m
	3/14/2017	12.00	1.71	0.14	0.52	<3m
	4/25/2017	37.25	1.81	0.05	0.41	<3m
	4/6/2017	12.00	1.56	0.13	0.40	<3m
Fresh Pond (from USGS)	10/29/2017	23.75	3.22	0.14	1.00	1y-2y
	7/12/2017	24.25	1.18	0.05	0.80	6m-1y
	9/15/2017	1.00	0.59	0.59	0.59	3m-6m
	7/18/2017	3.00	0.51	0.17	0.50	<3m
	6/16/2017	10.00	1.46	0.15	0.47	<3m
	5/25/2017	37.25	1.32	0.04	0.44	<3m
	9/14/2017	6.50	0.41	0.06	0.40	<3m

Table 4. Top Ten Storms Contributing the Most CSO

For 2017 Storms:

No.	Storm Event	CSO Volume By Storm		Cumulative CSO Volume	
		(MG)	% of Total CSO Discharged in 2017 (399 MG)	(MG)	% of Total CSO Discharged in 2017 (399 MG)
1	10/29/2017 Storm	122.93	30.8%	122.93	30.8%
2	6/16/2017 Storm	57.13	14.3%	180.06	45.1%
3	4/1/2017 Storm	38.64	9.7%	218.70	54.7%
4	7/24/2017 Storm	25.65	6.4%	244.34	61.2%
5	7/12/2017 Storm	25.45	6.4%	269.79	67.5%
6	1/24/2017 Storm	20.59	5.2%	290.39	72.7%
7	4/6/2017 Storm	16.51	4.1%	306.89	76.8%
8	9/7/2017 Storm	13.20	3.3%	320.10	80.1%
9	5/26/2017 Storm	11.28	2.8%	331.38	83.0%
10	10/25/2017 Storm	9.10	2.3%	340.48	85.2%

For the Typical Year Rainfall:

No.	Storm Event	CSO Volume By Storm		Cumulative CSO Volume	
		(MG)	% of Total CSO Discharged in Typical Year (379 MG)	(MG)	% of Total CSO Discharged in Typical Year (379 MG)
1	9/23/1992 Storm	76.46	20.2%	76.46	20.2%
2	12/11/1992 Storm	48.43	12.8%	124.90	32.9%
3	6/1/1992 Storm	43.31	11.4%	168.20	44.4%
4	10/23/1992 Storm	43.07	11.4%	211.27	55.7%
5	8/16/1992 Storm	34.91	9.2%	246.18	64.9%
6	11/23/1992 Storm	19.81	5.2%	266.00	70.1%
7	5/2/1992 Storm	18.66	4.9%	284.66	75.1%
8	8/11/1992 Storm	15.46	4.1%	300.11	79.1%
9	9/3/1992 Storm	12.63	3.3%	312.74	82.5%
10	6/6/1992 Storm	11.89	3.1%	324.63	85.6%

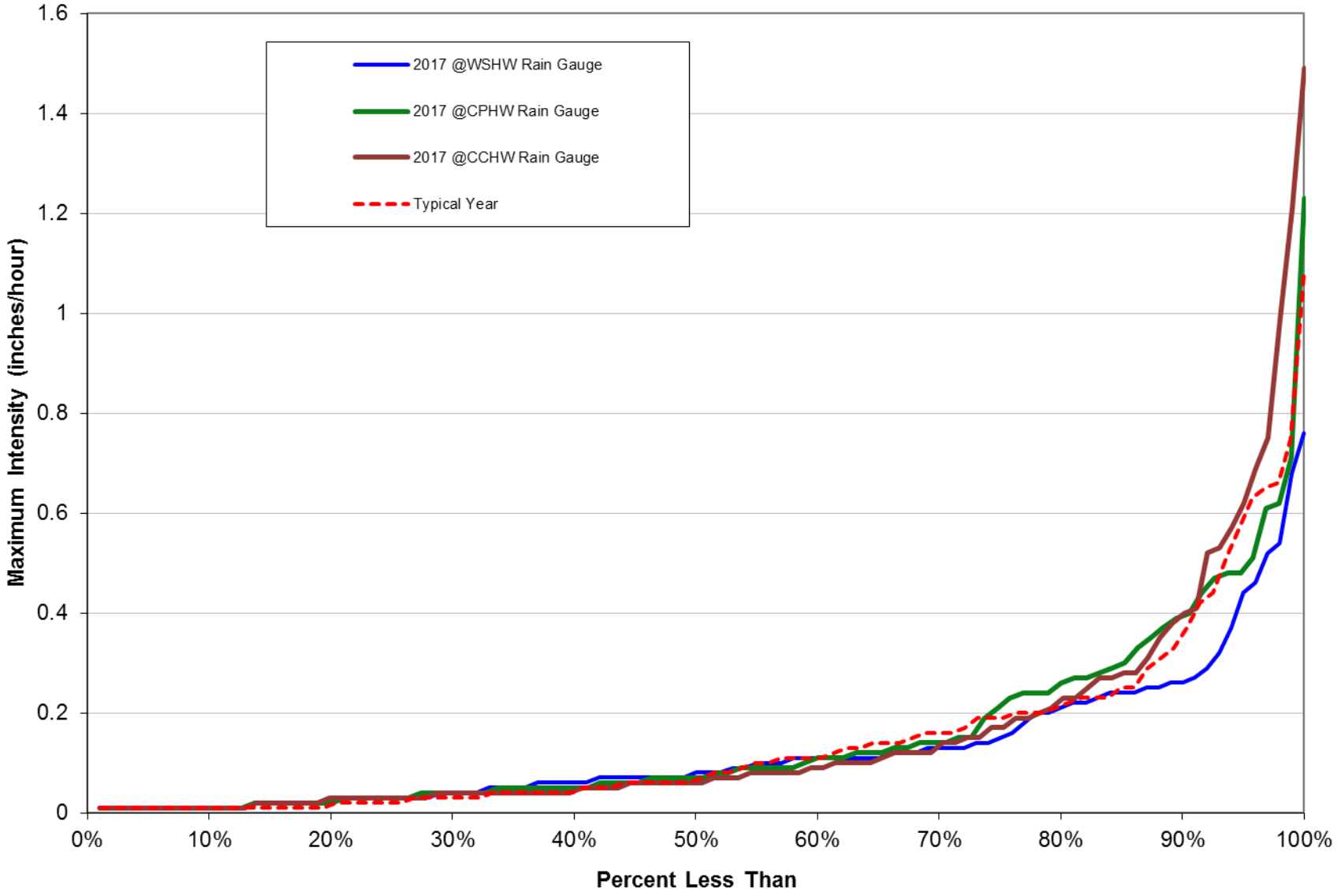

FIGURE 1. RAINFALL INTENSITY COMPARISON: 2017 VS. TYPICAL YEAR