



# Haverhill

Robert E. Ward, Deputy DPW Director  
Water/Wastewater Division  
Phone: 978-374-2382 Fax: 978-521-4083  
[rward@haverhillwater.com](mailto:rward@haverhillwater.com)

April 24, 2018

Ms. Joy Hilton  
Enforcement Officer  
Water Technical Unit  
U.S. Environmental Protection Agency, Region 1  
5 Post Office Square, Suite 100  
Boston, MA 02109-3912

Subject: City of Haverhill, MA NPDES Permit #MA 0101621  
Consent Decree (Civil Action No. 16-11698-IT)  
Combined Sewer Overflow Annual Report 2017

Dear Ms. Hilton:

In accordance with Part I.D.3 of the City of Haverhill's NPDES Permit and the Consent Decree item VII.M.51, we are providing this annual report for the 2017 calendar year.

Enclosed is the certification statement required by paragraph 99 of the Consent Decree.

If you require additional information, please call me at (978) 374-2382.

Sincerely,

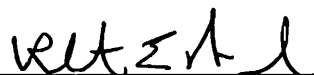
Robert E. Ward  
Deputy DPW Director

Enclosure(s)

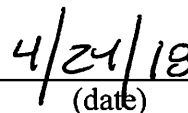
cc: Chief, Environmental Enforcement Section, U.S. DOJ  
Susan Poswistilo, U.S. Attorney, MA District  
Michael Wagner, USEPA, [wagner.michael@epa.gov](mailto:wagner.michael@epa.gov)  
Kevin Brander, DEP, [kevin.brander@state.ma.us](mailto:kevin.brander@state.ma.us)  
I. Andrew Goldberg, MA Assistant Attorney General, [andy.goldberg@state.ma.us](mailto:andy.goldberg@state.ma.us)  
Mayor James J. Fiorentini, City of Haverhill, [mayor@cityofhaverhill.com](mailto:mayor@cityofhaverhill.com)  
William Cox, City Solicitor, [billcoxlaw@aol.com](mailto:billcoxlaw@aol.com)  
Michael Leon, Nutter, McClennen & Fish LLP, [MLeon@nutter.com](mailto:MLeon@nutter.com)  
Mike Stankovich, DPW Director, [mstankovich@cityofhaverhill.com](mailto:mstankovich@cityofhaverhill.com)  
Paul Jessel, Wastewater, [pjessel@haverhillwater.com](mailto:pjessel@haverhillwater.com)  
Fred Haffty, WWTP Facility Manager, [fhaffty@haverhillwater.com](mailto:fhaffty@haverhillwater.com)

### Certification Statement

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.



Robert E. Ward  
Deputy DPW Director  
City of Haverhill

  
(date)



**City of Haverhill**

**Department of Public Works**

**Wastewater Division**

**Annual Combined Sewer Overflow Report**

**Calendar Year 2017**

**NPDES Permit No. MA 0101621**

## **Purpose**

This report was prepared in accordance with Part I, Section D (3) of National Pollutant Discharge Elimination System (NPDES) Permit No. MA 0101621 issued to the City of Haverhill with an effective date of February 1, 2008. The permit authorizes the City to discharge excess stormwater/wastewater from twenty (20) combined sewer outfalls located along the Merrimack and Little Rivers. The report also satisfies the requirements of Item VII.M.51 of the Consent Decree (Civil Action No. 16-11698-IT) between the United States, Commonwealth of Massachusetts, and the City of Haverhill.

As required by the NPDES permit and the Consent Decree, this report includes:

- Information related to each combined sewer overflow (CSO) event for each outfall including date and time the overflow started and stopped, the volume of the overflow for each event, the amount of precipitation associated with each overflow event, the total volume discharged from each outfall for the year, and the total volume discharged for the year
- Daily precipitation information including total precipitation, peak intensity, and average intensity.
- Certification that monthly inspections were completed
- Information related to the Nine Minimum Controls

## **CSO Regulators/Structures**

Of the original twenty (20) CSO outfalls and twenty-three (23) CSO regulators identified in the NPDES permit, the City has closed eleven (11) CSO regulator/outfalls and one (1) regulator (separately identified), as follows:

- Bates Bridge (001)
- Boardman Street (010)
- Fire Station (016)
- Little River North (021D, regulator)
- Little River South (02IE)
- Railroad Bridge (022)
- 266 River Street (023)
- Beach Street (025)
- Front Street (031)
- South Prospect Street (033)
- South Main Street (035)
- Ferry Street (036)

The City discovered four (4) CSO regulator/outfalls after the 2008 permit was issued including the Marginal Pump Station, Bethany Avenue, Chestnut Street, and South Webster Street CSOs. The city has already closed the Marginal Pump Station CSO; however, the other three remain open and are now inspected and monitored as part of the CSO program. The City also had to re-open the Emerson Street outfall (021B) as part of its flood control program, which is discussed later in this report.

Currently, Haverhill has fifteen (15) open CSO regulators/structures that are connected to thirteen (13) outfalls. Of the thirteen (13), five (5) outfalls discharge to the Little River, and eight (8) outfalls discharge to the Merrimack River. Figure 1 shows the outfall locations. Two sets of two regulators share an outfall: Broadway and High Street regulators share the High Street (038) outfall and Winter Street/Hale Street and Winter Street regulators share the Winter Street (021H) outfall.

Five of the CSO regulator structures also function as flood structures (Broadway, High Street, Emerson Street, Winter Street and Winter Street/Hale Street). There are sluice gates within the structures to provide system flood protection and emergency relief to the collection system under extreme high river flood conditions. Each sluice gate remains fully open unless the city is under a river flood condition. Although the Broadway, High Street, and Emerson Street regulators are open, they rarely activate under typical storm conditions.

Table 1 lists Haverhill's open CSO outfalls and regulators, and identifies which are part of the flood control system. In addition, this table shows the city's approach to CSO discharge monitoring, which is discussed later in this report. The three (3) newly identified CSO outfalls have not been assigned an NPDES permit number but the city uses the identification number below to help track the CSO activations.

**Table 1 CSO Outfalls and Regulators**

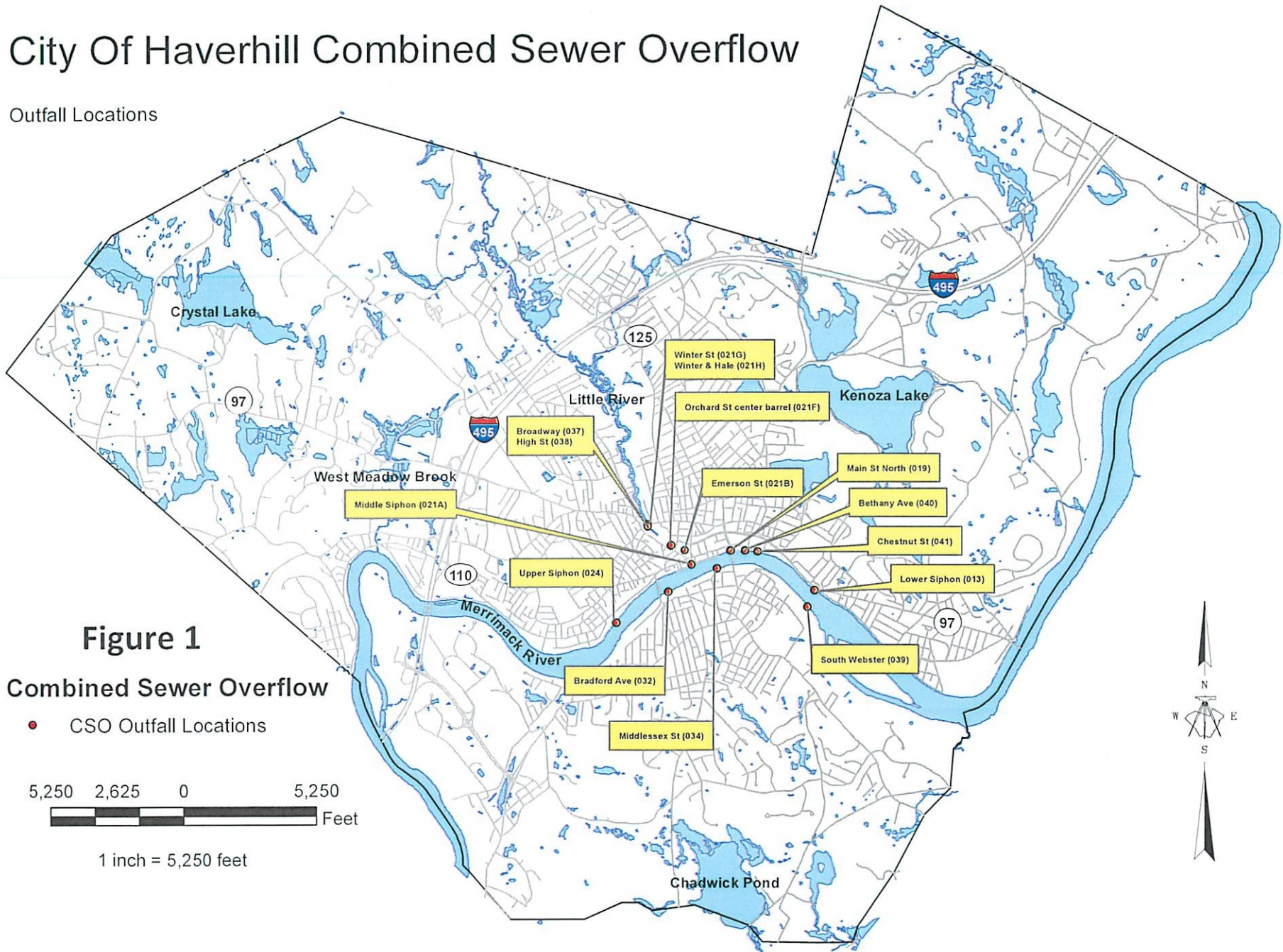
NPDES ID	CSO Outfall Name	CSO Regulators (if more than 1)	CSO Monitoring and Volume Estimating Approach
<b>Lower Siphon CSOs</b>			
(019)	Main Street North		D at Weir/D&V in Outfall
(013)	Lower Siphon		Depth/Sluice Gate Opening-Orifice Equation
(040)	Bethany Avenue		D at Weir/D&V in Outfall
(041)	Chestnut Street		D at Weir/D&V in Outfall
<b>Middle Siphon CSOs</b>			
(038)	High Street	Broadway (037) (F)	Depth at Weir
		High Street (038) (F)	Depth at Weir
(021B)	Emerson Street (F)		Depth at Weir
(021H)	Winter Street	Winter Street (021G) (F)	D at Weir/D&V in Outfall
		Winter Street/Hale Street (021H) (F)	Depth at Weir
(021F)	Center Barrel – Orchard Street		D at Weir/D&V in Outfall
(021A)	Middle Siphon		D at Weir/D&V in Outfall
<b>Upper Siphon CSOs</b>			
(024)	Upper Siphon		Depth/Sluice Gate Opening-Orifice Equation
<b>Bradford Interceptor CSOs</b>			
(032)	Bradford Avenue		D at Weir/D&V in Outfall
(034)	Middlesex Street		Depth at Weir
(039)	South Webster		D at Weir/D&V in Outfall

NOTE: (F) = indicates CSO regulators used in the flood protection system.  
 CSO Monitoring Approach is discussed in text:  
 (D&V) = depth and velocity meter;  
 (D) = depth only)



# City Of Haverhill Combined Sewer Overflow

Outfall Locations



This map was produced from The City of Haverhill's Geographic Information System.  
The City of Haverhill expressly disclaims any liability that may result from the use of this map.

## **CSO Discharge Monitoring**

Since 2014, each of the city's fifteen (15) CSO regulators has been monitored by a depth measuring device at the weir and/or a depth/velocity meter in the CSO outfall pipe, as indicated in Table 1. All CSO regulators were monitored by a depth gauge located at the CSO weir (some are ultrasonic meters and some have both ultrasonic and transducer gauge). Most of the CSO regulators also have a depth/velocity gauge in the CSO outfall (measuring the depth and velocity of the CSO flow through the outfall pipe).

The flow metering equipment is maintained by a contractor, Flow Assessment Services (FAS), who also reports the CSO activations and flow/volumes estimates on a website accessible to the city. The subcontractor is responsible for analysis of the meter information to make sure good flow data is collected.

CSO flow computations at the CSO weir are estimated using a depth of flow over a weir calculation. The depth/velocity gauges utilize an area-velocity equation to estimate flow in the outfall pipe. In some cases, the depth/velocity meters could not be installed on the outfall pipe because flow measurements were hydraulically affected by river backwater conditions and/or downstream backwater gates (gravity flap gates).

During a storm event, low flow or turbulent conditions may adversely affect one or the other flow estimating locations. For example, there may be storm flow over the weir that is measurable, but the depth of flow in the pipe is not significant enough to be adequately measured by the depth/velocity gauge in the outfall pipe (especially at the start of the storm or during small storm events). Accordingly, FAS utilizes all measurements to formulate good flow estimations for the city.

The Upper and Lower Siphon CSO regulators used to be monitored by similar equipment since they had weirs in front of the CSO outfall pipes (upstream of the backwater gates). However, in early 2017, the city completed construction of the Wet Weather Maximization and CSO Structure Modification project, which was recommended in the 2011 Phase II LTCP. The regulators at the Upper and Lower Siphons were modified by installing modulating sluice gates.

As of the beginning of 2017, CSO discharges at the Upper and Lower Siphon are monitored by city-maintained depth gauges as part of the system improvements completed for the Wet Weather Maximization and CSO Structure Modifications project. Under this project, the existing weirs at both locations were removed and a set of two modulating sluice gates were installed on each CSO outfall opening. The purpose of these improvements is to allow the city to store wet weather flow in the interceptor pipes upstream of each CSO regulator. Now the CSOs are only activated by automated or remote controls when the CSO discharge gates are opened.

Flow estimates at Upper and Lower Siphon are now calculated by the city based on an orifice equation that reflects the typically surcharged (but variable) CSO gate opening. Each regulator has depth measurement devices (radar units) that record the depths in the influent sewer, downstream of the CSO gates (river conditions), and downstream of the flow inlet gate to the siphons (to evaluate the backwater condition of the Bradford Interceptor).

FAS was asked to reconsider the possibility of monitoring the CSO discharges at each of the regulators for backup data to confirm the orifice equations. However, upon review, FAS indicated that the downstream outfall hydraulic conditions at each structure prohibited the installation of gauges that could obtain reasonable and accurate information downstream of the CSO outfall gates.

These hydraulic complexities included a steeply sloped and curved discharge chute in the Upper Siphon discharge chamber, an existing gravity backflow gate at Lower Siphon (that could result in flow variability), and frequently submerged outfall pipes at both structures (due to tides and high river level conditions). In addition, the typically submerged outfall conditions would make it difficult to verify the meter against existing flow conditions. Thus, looking at the potential variabilities of flow, turbulence, and frequent submerged conditions, FAS's opinion was that they couldn't readily provide accurate CSO flow rates on the discharge side of the outfall gates.

Working with CDM Smith, the city developed appropriate computations to calculate flow through the variable orifice sluice gate openings. These equations will be used to calculate the volume of CSO discharged by storm event at the Upper and Lower Siphon CSO Structures beginning with 2017.

## 2017 CSO Outfall Activation Statistics

Activation frequency and flow characteristics are measured by the meters as discussed above. FAS sends the city monthly and yearly flow data, including volume, from the meters that it maintains (all except for Upper and Lower Siphon CSO regulator meters). For the Upper and Lower Siphon, the city uses the data downloaded from the SCADA system to calculate CSO volume. Table 2 summarizes the total volume discharged and number of activations for each CSO outfall for 2017.

Table 2  
CSO Summary by Regulator

NPDES #	CSO Regulator	Number of Activations	Total Vol (gallons)
(013)	Lower Siphon	2	6,029,683
(019)	Main Street North	1	10,900
(021A)	Middle Siphon	13	6,302,168
(021B)	Emerson Street	2	46,661
(021F)	Center Barrel Orchard Street	32	6,574,749
(021G)	Winter Street	10	226,446
(021H)	Winter Street and Hale Street	22	2,566,104
(024)	Upper Siphon	6	4,388,656
(032)	Bradford Avenue	7	443,638
(034)	Middlesex Street	20	2,444,243
(037)	Broadway	2	2,035
(038)	High Street	3	4,162
(039)	South Webster Street	18	218,305
(040)	Bethany Avenue	25	1,276,596
(041)	Chestnut Street	17	230,953
		Total	30,765,299

Appendix A includes a summary of the CSO activations on an event basis and Appendix B provides a comprehensive summary of the individual CSO regulator activation start and stop times and the rainfall characteristics for each storm event in 2017.

In Appendix A, the city has noted the instances where the downstream CSO notification may not have included all appropriate information because of communication and gauge issues between the city and FAS. In some cases, FAS did not report individual CSO activations to the city right after a storm event but identified that the regulator activated later during its internal data trends analysis (completed during its monthly reports). This error was identified in August 2017, and after August 25, 2017, FAS adjusted



its activation alarms to present more accurate data to the city. In other cases, activations were noted by FAS but this information was inadvertently left off the CSO notification. Finally, for several instances, the city apparently reported CSO activations that did not actually occur, which was confirmed after the metering subcontractor evaluated the regulator data in the monthly reports.

It is also important to note that the city was refining its real-time control instrumentation during 2017 at the Upper and Lower Siphon CSO regulators. In some cases, the control system set points were raised too high and caused excessive surcharge in the system (which created SSOs reported at the Upper Siphon on 6/27/2017, 7/18/2017, 8/23/2017, and 9/6/2017). In other cases, the city turned to manual operation of the system (to avoid suspected excessive surcharge) and may have inadvertently left the CSO gates open longer than necessary.

Another example of system fine-tuning occurred during the October 29-30, 2017 storm event. In this event, the city was not able to operate all the pumps at the Main Influent Pumping Station (due to inoperable electronic motor drives that were subsequently fixed). This was a significant storm event that resulted in a rapid system wet weather response at the Lower Siphon CSO regulator. As this is the most downstream CSO regulator that protects the overall system, and Wastewater Treatment Facility (WWTF) pumping capacity was temporarily restricted, the Collection System Supervisor manually operated the CSO gates, overriding automated control. This manual condition may have resulted in CSO activation longer than necessary. The city has reviewed the conditions that occurred during this storm event and has instituted procedures to minimize CSO durations for the Upper and Lower Siphons.

## **2017 Precipitation**

Rain data is collected at the City of Haverhill WWTF using a RainWise, Inc., rain gage. Precipitation is measured in 15-minute intervals to within 0.01 inches. NetStorm, a CDM Smith sponsored software, utilizes the rain gauge information and to develop rainfall statistics per storm event. NetStorm data was used to develop the data shown in the tables in Appendices A and B. Appendix C summarizes precipitation during 2017 for each day, including total rainfall (expressed in inches), peak intensity (highest 15-minute sample multiplied by four to convert to inches per hour), and average intensity. It should be noted that some storm durations last longer than one day; for an example, the storm on 6/4/2017 lasted for 56.25 hours. The city received 44.19 inches of rainfall for calendar year 2017. Haverhill typically receives an average annual rainfall amount of 42.91 inches. For calendar year 2017, 0.08 inches per hour was the lowest peak rainfall intensity that resulted in a CSO activation, primarily at the Center Barrel CSO.

## **Haverhill's CSO Program Progress**

The following is a summary of City's progress on its CSO abatement program over the last 20 years.

- In August 2002, a Final Phase I CSO Long Term Control Plan (FLTCP) was submitted to the USEPA and the Massachusetts Department of Environmental Protection (MassDEP). The recommended plan included improvements to increase treatment capacity at the WWTF, influent pump station upgrades to handle additional wet weather flow, and regulator modifications to the Bradford side CSOs on the south bank of the Merrimack River.
- The benefits of the Phase I CSO Abatement Program improvements included a modeled reduction of annual CSO volume from 70 million to 30 million gallons and an increase of the percent capture of wet weather flow from 92 to 97 percent. These improvements were all implemented by 2006 and cost \$22 million.

- In July 2011, the city's Phase II CSO LTCP was submitted to the USEPA and MassDEP. Based on EPA and MassDEP comments, the city revised its Phase II CSO Long Term Control Plan (LTCP) and submitted it to the EPA and MassDEP in June 2013. The plan documented the effectiveness of Phase I CSO controls and improvements, and recommended a plan to continue to address the remaining CSOs. The revised plan included the permanent closure of thirteen (13) CSOs, raising of weirs at three (3) CSO regulators, and implementation of the Wet Weather System Maximization/ CSO Structure Modifications project which included CSO regulator modifications, a new CSO sewer, and installation of a real-time automated flow system to further increase CSO discharge control. These system improvements were complete in early 2017. The improvements are expected to reduce annual CSO volume to approximately 20 million gallons, eliminate or reduce the frequency of CSOs from a number of outfalls, and increase the percent capture of wet weather flow to about 98 percent. The cost of the Phase II program was \$12 million.
- In February 2017, the city completed and submitted an Integrated Final LTCP, an updated implementation program that encompassed Capacity Maintenance Operation Management (CMOM) for the collection system; a Wastewater Comprehensive Plant Evaluation (CPE); Infiltration Inflow Assessment (I/I); Green Infrastructure; and an updated LTCP based on a SWMM model that was calibrated to include refinement of the combined and separate catchment acreage.

As noted above, in March 2017, the City accepted as “substantially” complete the Wet Weather Maximization and CSO Structure Modifications. These improvements converted a passive, no control, CSO discharge system to dynamic control, whereby CSOs at the Upper and Lower Siphons are actively controlled using a real-time instrumentation control system. The principal components are:

The principle control strategy is to maximize flow from the Middle Siphon CSO regulator into the Middle Siphon and Bradford Interceptor to reduce CSOs at this regulator. This is achieved by diverting flow away from the Bradford Interceptor at both the Upper and Lower Siphon CSO regulators and storing this flow in the respective upstream interceptor pipes during storm events.

Since March 2017, the city has made and continues to make numerous adjustments to the instrumentation and control logic of the real-time control system (based on real storm event results) to balance maximize storage of wet weather flow and to avoid excessive surcharge in the interceptor pipe systems. With each instrumentation modification, the city has experimented with subsequent storms to examine the wet weather flow capture potential. Review of system conditions during the 2017 storm events has guided the city to establish a “Summer” operating mode, based on the typical summer thunderstorms that have high rainfall intensities. These higher intensities rainfalls cause the dry weather level to reach its maximum level very quickly; therefore, the city has modified its operations to reflect these rapidly unfolding conditions to protect the overall system.

As discussed above, the city continues to fine-tune the control set points by reviewing system performances after storm events to develop control strategy that will prevent CSO discharge to the maximum extent possible.

## **Nine Minimum Controls**

Haverhill continues to implement all aspects of its nine minimum control (NMC) program submitted to the EPA in 1996.

### **1. Proper operation and regular maintenance programs for the sewer system and CSO outfalls**

The city continues to use its Computerized Maintenance Management System (CMMS) MaintStar to track and manage the maintenance of their combined sewer system including inspection and cleaning of sewers, drains, pumping stations, CSO regulators and outfalls. Collection system inspection and cleaning is periodically done by outside contractors for the city. Sewer segments with frequent problems are added to a list in CMMS to receive more frequent maintenance by the city's crew.

The city inspects its largest sewer pumping stations (pumping rate greater than 100,000 gallons per day) daily (on weekdays) and once per week for the remaining sewer pumping stations. The city completes preventive maintenance quarterly at each of the stations. Cleaning and maintenance of the interceptor system and siphons is performed on an as-needed basis. Collection system personnel perform monthly inspections of the CSO regulators and outfall. In addition, CSO regulators are monitored by flow meters that notify wastewater managers when an activation occurs. If an activation notice is received during dry weather, collection system operators are dispatched to investigate immediately.

The city's existing inspection and maintenance programs appear to be adequate to minimize CSO discharges and there are no planned revisions to this program over the next reporting period.

### **2. Maximize the use of the collection system for storage**

The city's CSO regulators are controlled by weirs at most of the CSO regulators and by automatically controlled sluice gates at the Upper and Lower Siphon CSO structures.

Weirs at the regulators have also been raised periodically to reduce CSO discharges based on revisions to the LTCPs. The city has closed eleven CSO regulators/outfalls and one regulator, which effectively increases the use of the collection system for wet weather storage. No weirs were raised or CSO sealed in 2017 but the city expects to raise the Middle Siphon CSO weir in Fiscal Year 2018.

The automated real-time control system (instrumentation, depth monitoring, and modulated flow control gates operated by automated programming) installed at the Upper and Lower Siphon CSO structures is designed to utilize the interceptor storage upstream of each regulator structure to allow more flow from the Middle CSO to be conveyed to the Bradford Interceptor, and ultimately to the WWTF, to maximize the use of interceptor storage for wet weather flows and to reduce CSO discharges.

The city will continue to fine-tune this real-time flow control system to maximize the use of the interceptor piping system for wet weather storage.

### **3. Review and modification of pretreatment requirements to ensure the CSO impacts are minimized**

The purpose of the Industrial Pretreatment Program (IPP) is to help minimize impacts of discharges in the combined sewer system from non-domestic sources during wet weather events. The city engaged a consultant and hired a new IPP Coordinator to review and implement an enhanced IPP program in 2017. The IPP monitors significant industrial users (SIU) that discharge to the city's sewer system. The city's sewer use regulations prohibit any discharge to the collection system that may be detrimental to the wastewater treatment process or to the receiving water. These regulations establish limits for the amount of pollutant loads that can be discharged to the sewer system. All industrial discharges to the city's sewer system are required to adhere to the requirements of the city's IPP program. Inspections of these dischargers is performed by city staff and an outside consultant.

The city will continue to enhance the implementation and enforcement of this program over the next reporting period. No significant changes to the IPP program are expected.

#### **4. Maximization of flow to the publicly owned treatment works (POTW) for treatment**

The city has implemented many measures to maximize flow to the WWTF, including raising weirs and adding CSO control gates that will allow real time control to minimize CSO discharge. In addition, in 2006, the city increased the wet weather treatment capacity at the WWTF by increasing its influent pumping capacity and adding a secondary bypass pipe to allow for primary treatment and disinfection of wet weather flow. In 2016, the city also modified the Bradford Avenue CSO and the Middle Siphon Inlet Structure to improve the flow capacity into its interceptor system to maximize flow the WWTF.

In 2017, a Comprehensive Plant Evaluation (CPE) was completed that reviewed and assessed all of the process, equipment, and infrastructure needs at the plant to keep the facility running reliably and to maximize treatment levels of the flow conveyed to the WWTF. These facility improvements were prioritized and an implementation plan was established to complete these improvements.

#### **5. Elimination of overflows during dry weather**

Overflows from the CSO discharge outfalls are prohibited under the NPDES permit. The city's CSO regulators are monitored to ensure that there are no known dry weather overflows (DWOs). Flow meters in the regulators notify wastewater managers when an activation occurs. If an activation notice is received during dry weather, collection system operators are dispatched to investigate.

There were no Dry Weather Overflow discharges from the CSO regulators in 2017.

#### **6. Control of solid material and floatable material in CSOs**

Under the Wet Weather System Maximization/CSO Structure Modifications project, the city is maximizing its capture of wet weather flow for eventual treatment at the WWTF, which maximizes floatables control. The city has also raised weirs to capture more wet weather flow, and floatables in the first flush, during storm events. As part of the Integrated (Final Long-Term CSO Control Plan) FLTCP, CDM Smith evaluated other potential solids and floatables controls options that could be implemented at the CSO regulators.

It was determined that there are no easy and cost-effective approaches to capturing solids and floatables at the city's CSO regulators for a variety of reasons including the constrained space within the regulators to install new screens, trash racks, or baffles, the lack of available land (most of the outfalls are situated directly on the river with no reasonable room for inline screens along the outfall pipe), and river/flow conditions that would preclude outfall technologies (like booms or netting systems).

The city relies on regular cleaning of catch basins and street sweeping near CSO regulators as a preventive measure for the reduction of floatables to its combined system and receiving waters. The city is also considering increasing the frequency of catch basin cleaning and street sweeping to improve its floatables capture.

There are no expected changes to this NMC.

## **7. Pollution prevention programs to reduce contaminants in CSOs**

Haverhill has adopted city ordinances that prohibit litter and debris from being deposited on the street and within the watershed area. The city also performs regular cleaning of catch basins and street sweeping near CSO regulators as a preventive measure for the reduction of pollutants into the combined system. Finally, the city has an IPP program and is developing an enhanced fat, oil, and grease (FOG) control program that will help to minimize the amount of pollutants in the city CSO discharges.

In the 2017 Integrated LTCP, the city identified enhancements that could be implemented to improve its street sweeping and catch basin cleaning programs that could increase the frequency of system-wide cleaning. The city will begin to implement this plan in the next reporting period.

## **8. Public notification to ensure that the public receives adequate notification of CSO occurrences and CSO impacts**

Each of the CSO regulators and outfalls has signage that identifies the CSO outfall. Within 24-hours of a CSO occurrence, an email notification is sent to downstream communities, local Board of Health, harbor master, and local drinking water authorities. Appendix D includes the current list of those that are notified within 24-hours of a CSO occurrence.

The city's Public Notification Program, (required by the NMC) consists of public education about CSO discharges and their impacts. "Real-Time" notification of the receiving water impacts or use restrictions during the activation of the CSO discharge is not feasible (due to its transient and intermittent occurrences). Accordingly, the city relies on a general education program and the city's official web site to keep the public aware of the possible health risks.

The address below is the City's CSO web site:

[http://www.haverhillma.gov/departments/public\\_works\\_department/water\\_wastewater/wastewater/wastewater\\_collection\\_system/combined\\_sewer\\_overflows\\_\(cso\)/index.php](http://www.haverhillma.gov/departments/public_works_department/water_wastewater/wastewater/wastewater_collection_system/combined_sewer_overflows_(cso)/index.php)

## **9. Monitoring to effectively characterize CSO impacts and the efficiency of CSO controls**

In 2014, the city contracted with a flow metering subcontractor, to install and maintain depth and depth/velocity meters at each of its CSO regulators. These gauges monitor overflow activations and measure CSO flow rates and volumes. The results of the 2017 monitoring program are discussed above.

End of Report



## Appendix A

Appendix A  
Haverhill MA  
Summary of CSO Regulator Activations for 2017

Activation by Storm Events (2017)				Lower Siphon	Main Street North	Middle Siphon	Emerson Street	Center Barrel Orchard Street	Winter Street (Duncan Street)	Winter Street and Hale Street	Upper Siphon	Bradford Avenue	Middlesex Street	Broadway Diversional	High Street Diversional	South Webster	Bethany Avenue	Chestnut Street	
Date	Total Rainfall (in)	Peak Rainfall (in/hr)	Max Flow WWTF (mgd)																
				13	19	021A	021B	021F	021G	021H	24	32	34	37	38	39	40	41	TOTAL
01/03/2017	0.8	0.24						19,679											19,679
02/25/2017	0.3	0.68	56					92,745		8,397			5,686			4,452	27,386		138,666
03/27/2017	0.68	0.24	59					242,002											242,002
04/04/2017	0.77	0.28	56					131,405		211							6,511		138,127
04/06/2017	1.05	0.40	70			15,389		806,223		34,338			11,496			6,180	15,870		889,496
04/21/2017	0.79	0.24	52					2,156											2,156
05/02/2017	0.36	0.44	63					199,724		24,035			12,902			2,072	25,167	2,550	266,450
05/05/2017	1.03	0.60	64					254,267		21,552			12,045			4,243	31,173	1,169	324,449
05/14/2017	1.29	0.32	62					70,209											70,209
05/26/2017	0.87	0.52	61					183,211		9,865			17,599			2,037	17,378	270	230,360
06/05/2017	0.83	0.52	53					189,356									3,855		193,211
06/06/2017	1.48	0.20	65					283,874											283,874
06/16/2017	1.08	0.36	65					1,179,792		30,247			585			445	3,550	23	1,214,642
06/17/2017	0.47	0.40	65					474,876		8,339			11,734				25,829	1,070	521,848
06/23/2017	0.1	0.16	43					4,173									4,109		8,282
06/27/2017	0.63	0.60	63			85,306		175,867	18,525	191,809			52,771				113,135	13,160	650,573
06/30/2017	0.77	1.44	65			80,628		68,112	6,451	63,316		26,643	63,403			8,578	67,018	12,115	396,264
07/01/2017																			0
07/11/2017	0.15	0.16	47														4,415		4,415
07/18/2017	0.58	1.92	65			207,873		121,167	17,896	118,781	148,530	104,292	390,064			17,164	94,949	21,285	1,242,001
07/24/2017	0.98	0.32	63					86,512											86,512
08/18/2017	0.5	0.80	59			258,442		161,429	15,051	122,243		2,481	68,201			13,051	77,470	11,537	729,905
08/23/2017	0.56	0.84	62			811,385	6,617	408,982	86,996	548,691	1,099,427	56,363	247,680	490	445	22,170	182,089	33,102	3,504,437
09/03/2017	0.63	0.36	62					9,491									7,152		16,643
09/06/2017	1.23	1.84	61		10,900	1,170,085	40,044	295,036	49,858	594,536	801,267	210,225	698,821	1,545	3,343	34,429	212,516	48,684	4,171,289
09/07/2017	0.81	0.80	65			286,593		130,055	8,507	198,906	508,462	1,815	89,493			11,940	71,420	18,071	1,325,262
09/15/2017	0.52	1.00	65	802,666		699,840		206,012	12,074	334,625	1,164,076	41,819	137,245		374	16,554	191,938	43,829	3,651,052
10/09/2017	0.59	0.80	50			78,630		57,720	9,653	83,754			53,090			12,949	39,408	12,404	347,608
10/25/2017	0.8	0.40	46					41,929											41,929
10/26/2017	0.74	0.60	43					40,463		12,948			20,314			12,886	34,532	5,356	126,499
10/29/2017	1.03	0.44	44			418,570		181,296		1,455			66,831			850			669,002
10/30/2017	1.41	0.64	49	5,227,017		2,180,400		340,052		118,896	666,894		463,447			37,240	128	2,546	9,036,620
11/19/2017	0.33	0.40	50			9,027		62,822	1,435	37,600			20,836			11,065	19,396	3,782	165,963
11/22/2017	0.72	0.20	59					6,388											6,388
12/06/2017	0.46	0.24	62					47,724		1,560							202		49,486
		Volume TOTALS		6,029,683	10,900	6,302,168	46,661	6,574,749	226,446	2,566,104	4,388,656	443,638	2,444,243	2,035	4,162	218,305	1,276,596	230,953	30,765,299

Number of Activations for the Year	2	1	13	2	32	10	22	6	7	20	2	3	18	25	17
Downstream Notification originally noted that this CSO discharged but FAS did not show a discharge.															
CSO volume for FAS but no downstream notification that this CSO discharged. FAS confirmed on 8/25/17 that notificatons were not sent for these CSO activations and sensors have subsequently been reset to provide better alarm															
CSO activation (volume) that was reported to city but not included on Downstream Notification.															

NOTE: 021D, 021E, and 021M Eliminated in 2016

## Appendix B

# Appendix B: CSO Flow Meter Summary

NPDES #	NPDES Description	CSO Start	CSO End	Total Vol (gals.) Event	CSO Duration (hr.)	Rain Total (in.)	Peak Hour Depth Intensity (in./hr.)	Storm Duration (hr.)	Daily Avg. Intensity (in./hr.)
(021F)	Orchard Street Center Barrel	01/03/17 20:50:00	01/03/17 21:10:00	19,679	0.33	0.08	0.08	20.25	0.04
<b>STORM TOTALS:</b>				<b>19,679</b>					
(040)	Bethany Avenue	02/25/17 21:55:00	02/25/17 22:00:00	27,386	0.08	0.30	0.68	3.75	0.08
(021F)	Orchard Street Center Barrel	02/25/17 21:55:00	02/25/17 22:30:00	92,745	0.58	0.30	0.68	3.75	0.08
(034)	Middlesex Street	02/25/17 22:00:00	02/25/17 22:00:00	5,686	0.08	0.30	0.68	3.75	0.08
(039)	South Webster Street	02/25/17 22:00:00	02/25/17 22:15:00	4,452	0.25	0.30	0.68	3.75	0.08
(021H)	Winter Street and Hale Street	02/25/17 22:05:00	02/25/17 22:10:00	8,397	0.08	0.30	0.68	3.75	0.08
<b>STORM TOTALS:</b>				<b>138,666</b>					
(021F)	Orchard Street Center Barrel	03/27/17 10:15:00	03/27/17 11:55:00	242,002	1.67	0.68	0.24	7.50	0.09
<b>STORM TOTALS:</b>				<b>242,002</b>					
(040)	Bethany Avenue	04/04/17 22:00:00	04/04/17 22:00:00	6,511	0.08	0.77	0.28	19.75	0.04
(021F)	Orchard Street Center Barrel	04/04/17 22:00:00	04/04/17 23:15:00	131,405	1.25	0.77	0.28	19.75	0.04
(021H)	Winter Street and Hale Street	04/04/17 22:10:00	04/04/17 22:10:00	211	0.08	0.77	0.28	19.75	0.04
<b>STORM TOTALS:</b>				<b>138,127</b>					
(021F)	Orchard Street Center Barrel	04/06/17 10:50:00	04/06/17 20:30:00	806,223	9.67	1.05	0.40	11.75	0.09
(040)	Bethany Avenue	04/06/17 13:35:00	04/06/17 19:05:00	15,870	5.50	1.05	0.40	11.75	0.09
(021H)	Winter Street and Hale Street	04/06/17 13:40:00	04/06/17 19:20:00	34,338	5.67	1.05	0.40	11.75	0.09
(034)	Middlesex Street	04/06/17 18:45:00	04/06/17 19:05:00	11,496	0.33	1.05	0.40	11.75	0.09
(039)	South Webster Street	04/06/17 18:45:00	04/06/17 19:20:00	6,180	0.58	1.05	0.40	11.75	0.09
(021A)	Middle Siphon	04/06/17 19:10:00	04/06/17 19:30:00	15,389	0.33	1.05	0.40	11.75	0.09
<b>STORM TOTALS:</b>				<b>889,496</b>					
(021F)	Orchard Street Center Barrel	04/21/17 20:20:00	04/21/17 20:25:00	2,156	0.08	0.78	0.24	26.25	0.03
<b>STORM TOTALS:</b>				<b>2,156</b>					
(040)	Bethany Avenue	05/02/17 03:05:00	05/02/17 03:45:00	25,167	0.67	0.36	0.44	8.25	0.04
(021F)	Orchard Street Center Barrel	05/02/17 03:20:00	05/05/17 15:55:00	199,724	84.58	0.36	0.44	8.25	0.04
(034)	Middlesex Street	05/02/17 03:45:00	05/02/17 03:45:00	12,902	0.08	0.36	0.44	8.25	0.04
(041)	Chestnut Street	05/02/17 03:45:00	05/02/17 03:45:00	2,550	0.08	0.36	0.44	8.25	0.04
(039)	South Webster Street	05/02/17 03:45:00	05/02/17 03:50:00	2,072	0.08	0.36	0.44	8.25	0.04
(021H)	Winter Street and Hale Street	05/02/17 03:45:00	05/02/17 04:00:00	24,035	0.25	0.36	0.44	8.25	0.04
<b>STORM TOTALS:</b>				<b>266,451</b>					
(040)	Bethany Avenue	05/05/17 16:00:00	05/05/17 17:05:00	31,173	1.08	1.03	0.60	36.00	0.03
(021F)	Orchard Street Center Barrel	05/05/17 16:00:00	05/05/17 17:45:00	254,267	1.75	1.03	0.60	36.00	0.03
(041)	Chestnut Street	05/05/17 16:50:00	05/05/17 16:55:00	1,169	0.08	1.03	0.60	36.00	0.03
(034)	Middlesex Street	05/05/17 16:50:00	05/05/17 17:00:00	12,045	0.17	1.03	0.60	36.00	0.03
(039)	South Webster Street	05/05/17 16:55:00	05/05/17 17:10:00	4,243	0.25	1.03	0.60	36.00	0.03
(021H)	Winter Street and Hale Street	05/05/17 16:55:00	05/05/17 17:15:00	21,552	0.33	1.03	0.60	36.00	0.03
<b>STORM TOTALS:</b>				<b>324,449</b>					
(021F)	Orchard Street Center Barrel	05/14/17 04:25:00	05/14/17 06:05:00	70,209	1.67	1.29	0.32	34.75	0.04
<b>STORM TOTALS:</b>				<b>70,209</b>					
(021F)	Orchard Street Center Barrel	05/26/17 00:45:00	05/26/17 03:40:00	183,211	2.92	1.08	0.04	25.25	0.04
(021H)	Winter Street and Hale Street	05/26/17 00:55:00	05/26/17 01:20:00	9,865	0.42	1.08	0.04	25.25	0.04
(041)	Chestnut Street	05/26/17 01:05:00	05/26/17 01:05:00	270	0.08	1.08	0.04	25.25	0.04
(034)	Middlesex Street	05/26/17 01:05:00	05/26/17 01:10:00	17,599	0.08	1.08	0.04	25.25	0.04
(040)	Bethany Avenue	05/26/17 01:05:00	05/26/17 01:10:00	17,378	0.08	1.08	0.04	25.25	0.04
(039)	South Webster Street	05/26/17 01:05:00	05/26/17 01:15:00	2,037	0.17	1.08	0.04	25.25	0.04
<b>STORM TOTALS:</b>				<b>230,359</b>					
(040)	Bethany Avenue	06/05/17 01:55:00	06/05/17 01:55:00	3,855	0.08	2.33	0.36	56.25	0.04
(021F)	Orchard Street Center Barrel	06/05/17 02:00:00	06/05/17 23:35:00	189,356	21.58	2.33	0.36	56.25	0.04
<b>STORM TOTALS:</b>				<b>193,211</b>					

## Appendix B: CSO Flow Meter Summary

NPDES #	NPDES Description	CSO Start	CSO End	Total Vol (gals.) Event	CSO Duration (hr.)	Rain Total (in.)	Peak Hour Depth Intensity (in./hr.)	Storm Duration (hr.)	Daily Avg. Intensity (in./hr.)
(021F)	Orchard Street Center Barrel	06/06/17 12:50:00	06/06/17 15:10:00	283,874	2.33	2.33	0.36	56.25	0.04
<b>STORM TOTALS:</b>				<b>283,874</b>					
(021F)	Orchard Street Center Barrel	06/16/17 16:40:00	06/16/17 23:10:00	1,179,792	6.50	1.55	0.40	11.75	0.13
(021H)	Winter Street and Hale Street	06/16/17 21:55:00	06/16/17 22:20:00	30,247	0.42	1.55	0.40	11.75	0.13
(040)	Bethany Avenue	06/16/17 22:05:00	06/16/17 22:05:00	3,550	0.08	1.55	0.40	11.75	0.13
(041)	Chestnut Street	06/16/17 22:05:00	06/16/17 22:05:00	23	0.08	1.55	0.40	11.75	0.13
(039)	South Webster Street	06/16/17 22:10:00	06/16/17 22:55:00	445	0.75	1.55	0.40	11.75	0.13
(034)	Middlesex Street	06/16/17 22:45:00	06/16/17 22:45:00	585	0.08	1.55	0.40	11.75	0.13
<b>STORM TOTALS:</b>				<b>1,214,641</b>					
(040)	Bethany Avenue	06/17/17 01:40:00	06/17/17 02:00:00	25,829	0.33	1.55	0.40	11.75	0.13
(041)	Chestnut Street	06/17/17 01:45:00	06/17/17 02:00:00	1,070	0.25	1.55	0.40	11.75	0.13
(021H)	Winter Street and Hale Street	06/17/17 01:45:00	06/17/17 02:05:00	8,339	0.33	1.55	0.40	11.75	0.13
(021F)	Orchard Street Center Barrel	06/17/17 01:45:00	06/17/17 02:15:00	474,876	0.50	1.55	0.40	11.75	0.13
(034)	Middlesex Street	06/17/17 01:55:00	06/17/17 02:00:00	11,734	0.08	1.55	0.40	11.75	0.13
<b>STORM TOTALS:</b>				<b>521,848</b>					
(040)	Bethany Avenue	06/23/17 13:35:00	06/23/17 13:35:00	4,109	0.08	0.10	0.16	1.00	0.10
(021F)	Orchard Street Center Barrel	06/23/17 13:45:00	06/23/17 13:50:00	4,173	0.08	0.10	0.16	1.00	0.10
<b>STORM TOTALS:</b>				<b>8,283</b>					
(041)	Chestnut Street	06/27/17 13:55:00	06/27/17 14:20:00	13,160	0.42	0.63	0.60	3.00	0.21
(034)	Middlesex Street	06/27/17 13:55:00	06/27/17 16:20:00	52,771	2.42	0.63	0.60	3.00	0.21
(040)	Bethany Avenue	06/27/17 13:55:00	06/27/17 16:20:00	113,135	2.42	0.63	0.60	3.00	0.21
(021G)	Winter Street	06/27/17 14:00:00	06/27/17 14:20:00	18,525	0.33	0.63	0.60	3.00	0.21
(021H)	Winter Street and Hale Street	06/27/17 14:00:00	06/27/17 15:50:00	191,809	1.83	0.63	0.60	3.00	0.21
(021F)	Orchard Street Center Barrel	06/27/17 14:00:00	06/27/17 16:40:00	175,867	2.67	0.63	0.60	3.00	0.21
(021A)	Middle Siphon	06/27/17 14:05:00	06/27/17 14:30:00	85,306	0.42	0.63	0.60	3.00	0.21
<b>STORM TOTALS:</b>				<b>650,573</b>					
(021F)	Orchard Street Center Barrel	06/30/17 18:50:00	06/30/17 19:45:00	68,112	0.92	0.77	1.44	5.25	0.15
(021G)	Winter Street	06/30/17 19:20:00	06/30/17 19:25:00	6,451	0.08	0.77	1.44	5.25	0.15
(034)	Middlesex Street	06/30/17 19:20:00	06/30/17 19:30:00	63,403	0.17	0.77	1.44	5.25	0.15
(040)	Bethany Avenue	06/30/17 19:20:00	06/30/17 19:30:00	67,018	0.17	0.77	1.44	5.25	0.15
(041)	Chestnut Street	06/30/17 19:20:00	06/30/17 19:30:00	12,115	0.17	0.77	1.44	5.25	0.15
((032))	Bradford Avenue	06/30/17 19:25:00	06/30/17 19:25:00	26,643	0.08	0.77	1.44	5.25	0.15
(021A)	Middle Siphon	06/30/17 19:25:00	06/30/17 19:35:00	80,628	0.17	0.77	1.44	5.25	0.15
(021H)	Winter Street and Hale Street	06/30/17 19:25:00	06/30/17 19:35:00	63,316	0.17	0.77	1.44	5.25	0.15
(039)	South Webster Street	06/30/17 19:25:00	06/30/17 19:35:00	8,578	0.17	0.77	1.44	5.25	0.15
<b>STORM TOTALS:</b>				<b>396,263</b>					
(040)	Bethany Avenue	07/11/17 09:00:00	07/11/17 09:00:00	4,415	0.08	0.15	0.16	9.00	0.02
<b>STORM TOTALS:</b>				<b>4,415</b>					
(021G)	Winter Street	07/18/17 15:45:00	07/18/17 15:50:00	17,896	0.08	0.58	1.92	3.75	0.15
(040)	Bethany Avenue	07/18/17 15:45:00	07/18/17 15:55:00	94,949	0.17	0.58	1.92	3.75	0.15
(041)	Chestnut Street	07/18/17 15:45:00	07/18/17 15:55:00	21,285	0.17	0.58	1.92	3.75	0.15
(021H)	Winter Street and Hale Street	07/18/17 15:45:00	07/18/17 16:05:00	118,781	0.33	0.58	1.92	3.75	0.15
(034)	Middlesex Street	07/18/17 15:45:00	07/18/17 16:05:00	390,064	0.33	0.58	1.92	3.75	0.15
(021F)	Orchard Street Center Barrel	07/18/17 15:45:00	07/18/17 16:10:00	121,167	0.42	0.58	1.92	3.75	0.15
(021A)	Middle Siphon	07/18/17 15:45:00	07/18/17 16:15:00	207,873	0.50	0.58	1.92	3.75	0.15
(039)	South Webster Street	07/18/17 15:50:00	07/18/17 16:10:00	17,164	0.33	0.58	1.92	3.75	0.15
(032)	Bradford Avenue	07/18/17 16:50:00	07/18/17 17:00:00	104,292	0.17	0.58	1.92	3.75	0.15
(024)	Upper Siphon	07/18/17 04:55:00	07/18/17 05:20:00	148,530	0.42	0.58	1.92	3.75	0.15
<b>STORM TOTALS:</b>				<b>1,242,002</b>					



## Appendix B: CSO Flow Meter Summary

NPDES #	NPDES Description	CSO Start	CSO End	Total Vol (gals.) Event	CSO Duration (hr.)	Rain Total (in.)	Peak Hour Depth Intensity (in./hr.)	Storm Duration (hr.)	Daily Avg. Intensity (in./hr.)
(021F)	Orchard Street Center Barrel	07/24/17 11:55:00	07/24/17 14:30:00	86,512	2.58	0.98	0.32	24.00	0.04
<b>STORM TOTALS:</b>				<b>86,512</b>					
(021F)	Orchard Street Center Barrel	08/18/17 11:25:00	08/18/17 12:05:00	161,429	0.67	0.50	0.80	4.75	0.11
(040)	Bethany Avenue	08/18/17 11:25:00	08/18/17 11:45:00	77,470	0.33	0.50	0.80	4.75	0.11
(041)	Chestnut Street	08/18/17 11:25:00	08/18/17 11:45:00	11,537	0.33	0.50	0.80	4.75	0.11
(021H)	Winter Street and Hale Street	08/18/17 11:30:00	08/18/17 11:55:00	122,243	0.42	0.50	0.80	4.75	0.11
(021A)	Middle Siphon	08/18/17 11:35:00	08/18/17 12:10:00	258,442	0.58	0.50	0.80	4.75	0.11
(021G)	Winter Street	08/18/17 11:35:00	08/18/17 11:40:00	15,051	0.08	0.50	0.80	4.75	0.11
(032)	Bradford Avenue	08/18/17 11:35:00	08/18/17 11:35:00	2,481	0.08	0.50	0.80	4.75	0.11
(034)	Middlesex Street	08/18/17 11:35:00	08/18/17 11:50:00	68,201	0.25	0.50	0.80	4.75	0.11
(039)	South Webster Street	08/18/17 11:35:00	08/18/17 11:50:00	13,051	0.25	0.50	0.80	4.75	0.11
<b>STORM TOTALS:</b>				<b>729,904</b>					
021G	Winter Street	08/23/17 00:05:00	08/23/17 00:30:00	86,996	0.42	0.55	0.84	1.75	0.31
(034)	Middlesex Street	08/23/17 00:05:00	08/23/17 00:40:00	247,680	0.58	0.55	0.84	1.75	0.31
(040)	Bethany Avenue	08/23/17 00:05:00	08/23/17 00:25:00	182,089	0.33	0.55	0.84	1.75	0.31
(041)	Chestnut Street	08/23/17 00:05:00	08/23/17 00:30:00	33,102	0.42	0.55	0.84	1.75	0.31
(021A)	Middle Siphon	08/23/17 00:10:00	08/23/17 01:05:00	811,385	0.92	0.55	0.84	1.75	0.31
(021H)	Winter Street and Hale Street	08/23/17 00:10:00	08/23/17 00:50:00	548,691	0.67	0.55	0.84	1.75	0.31
(032)	Bradford Avenue	08/23/17 00:10:00	08/23/17 00:30:00	56,363	0.33	0.55	0.84	1.75	0.31
(039)	South Webster Street	08/23/17 00:10:00	08/23/17 00:40:00	22,170	0.50	0.55	0.84	1.75	0.31
(021F)	Orchard Street Center Barrel	08/23/17 00:15:00	08/23/17 01:00:00	408,982	0.75	0.55	0.84	1.75	0.31
(038)	High Street	08/23/17 00:20:00	08/23/17 00:20:00	445	0.08	0.55	0.84	1.75	0.31
(021B)	Emerson Street	08/23/17 00:25:00	08/23/17 00:25:00	6,617	0.08	0.55	0.84	1.75	0.31
(037)	Broadway	08/23/17 00:25:00	08/23/17 00:25:00	490	0.08	0.55	0.84	1.75	0.31
(024)	Upper Siphon	8/23/2017 1:20	08/23/17 2:20	1,099,427	1.00	0.55	0.84	1.75	0.31
<b>STORM TOTALS:</b>				<b>3,504,437</b>					
(021F)	Orchard Street Center Barrel	09/03/17 16:55:00	09/03/17 17:10:00	9,491	0.25	0.63	0.36	8.25	0.08
(040)	Bethany Avenue	09/03/17 17:00:00	09/03/17 17:00:00	7,152	0.08	0.63	0.36	8.25	0.08
<b>STORM TOTALS:</b>				<b>16,643</b>					
(021F)	Orchard Street Center Barrel	09/06/17 08:25:00	09/06/17 11:35:00	295,036	3.17	1.97	1.84	20.00	0.10
(021G)	Winter Street	09/06/17 08:25:00	09/06/17 11:05:00	49,858	2.67	1.97	1.84	20.00	0.10
(021H)	Winter Street and Hale Street	09/06/17 08:25:00	09/06/17 11:25:00	594,536	3.00	1.97	1.84	20.00	0.10
(040)	Bethany Avenue	09/06/17 08:25:00	09/06/17 08:35:00	212,516	0.17	1.97	1.84	20.00	0.10
(041)	Chestnut Street	09/06/17 08:25:00	09/06/17 11:05:00	48,684	2.67	1.97	1.84	20.00	0.10
(021A)	Middle Siphon	09/06/17 08:30:00	09/06/17 11:50:00	1,170,085	3.33	1.97	1.84	20.00	0.10
(034)	Middlesex Street	09/06/17 08:30:00	09/06/17 11:30:00	698,821	3.00	1.97	1.84	20.00	0.10
(039)	South Webster Street	09/06/17 08:30:00	09/06/17 11:20:00	34,429	2.83	1.97	1.84	20.00	0.10
(032)	Bradford Avenue	09/06/17 10:50:00	09/06/17 11:10:00	210,225	0.33	1.97	1.84	20.00	0.10
(021B)	Emerson Street	09/06/17 10:55:00	09/06/17 11:00:00	40,044	0.08	1.97	1.84	20.00	0.10
(038)	High Street	09/06/17 10:55:00	09/06/17 10:55:00	3,343	0.08	1.97	1.84	20.00	0.10
(019)	Main Street North	09/06/17 11:00:00	09/06/17 11:05:00	10,900	0.08	1.97	1.84	20.00	0.10
(037)	Broadway	09/06/17 11:00:00	09/06/17 11:00:00	1,545	0.08	1.97	1.84	20.00	0.10
(024)	Upper Siphon	09/06/17 11:50:00	09/06/17 12:15:00	801,267	0.42	1.97	1.84	20.00	0.10
<b>STORM TOTALS:</b>				<b>4,171,290</b>					

# Appendix B: CSO Flow Meter Summary

NPDES #	NPDES Description	CSO Start	CSO End	Total Vol (gals.) Event	CSO Duration (hr.)	Rain Total (in.)	Peak Hour Depth Intensity (in./hr.)	Storm Duration (hr.)	Daily Avg. Intensity (in./hr.)
(021F)	Orchard Street Center Barrel	09/07/17 00:50:00	09/07/17 02:00:00	130,055	1.17	0.07	0.20	3.25	0.02
(021H)	Winter Street and Hale Street	09/07/17 00:50:00	09/07/17 01:45:00	198,906	0.92	0.07	0.20	3.25	0.02
(034)	Middlesex Street	09/07/17 00:50:00	09/07/17 01:40:00	89,493	0.83	0.07	0.20	3.25	0.02
(040)	Bethany Avenue	09/07/17 00:50:00	09/07/17 01:35:00	71,420	0.75	0.07	0.20	3.25	0.02
(041)	Chestnut Street	09/07/17 00:50:00	09/07/17 01:35:00	18,071	0.75	0.07	0.20	3.25	0.02
(021A)	Middle Siphon	09/07/17 00:55:00	09/07/17 02:00:00	286,593	1.08	0.07	0.20	3.25	0.02
(021G)	Winter Street	09/07/17 00:55:00	09/07/17 01:30:00	8,507	0.58	0.07	0.20	3.25	0.02
(039)	South Webster Street	09/07/17 00:55:00	09/07/17 01:40:00	11,940	0.75	0.07	0.20	3.25	0.02
(032)	Bradford Avenue	09/07/17 01:30:00	09/07/17 01:35:00	1,815	0.08	0.07	0.20	3.25	0.02
(024)	Upper Siphon	09/07/17 02:30:00	09/07/17 02:35:00	508,462	0.08	0.07	0.20	3.25	0.02
<b>STORM TOTALS:</b>				<b>1,325,263</b>					
(040)	Bethany Avenue	09/15/17 15:50:00	09/15/17 16:35:00	191,938	0.75	0.49	1.00	2.00	0.25
(021F)	Orchard Street Center Barrel	09/15/17 16:00:00	09/15/17 17:05:00	206,012	1.08	0.49	1.00	2.00	0.25
(021H)	Winter Street and Hale Street	09/15/17 16:00:00	09/15/17 16:50:00	334,625	0.83	0.49	1.00	2.00	0.25
021G	Winter Street	09/15/17 16:10:00	09/15/17 16:20:00	12,074	0.17	0.49	1.00	2.00	0.25
(021A)	Middle Siphon	09/15/17 16:10:00	09/15/17 17:10:00	699,840	1.00	0.49	1.00	2.00	0.25
(041)	Chestnut Street	09/15/17 16:10:00	09/15/17 16:35:00	43,829	0.42	0.49	1.00	2.00	0.25
(034)	Middlesex Street	09/15/17 16:15:00	09/15/17 16:45:00	137,245	0.50	0.49	1.00	2.00	0.25
(032)	Bradford Avenue	09/15/17 16:20:00	09/15/17 16:30:00	41,819	0.17	0.49	1.00	2.00	0.25
(039)	South Webster Street	09/15/17 16:20:00	09/15/17 16:45:00	16,554	0.42	0.49	1.00	2.00	0.25
038	High Street	09/15/17 16:20:00	09/15/17 16:20:00	374	0.08	0.49	1.00	2.00	0.25
(013)	Lower Siphon	09/15/17 17:30:00	09/15/17 17:40:00	802,666	0.17	0.49	1.00	2.00	0.25
(024)	Upper Siphon	09/15/17 05:10:00	09/15/17 05:35:00	1,164,076	0.12	0.49	1.00	2.00	0.25
<b>STORM TOTALS:</b>				<b>3,651,052</b>					
021G	Winter Street	10/09/17 09:30:00	10/09/17 09:35:00	9,653	0.08	0.59	0.80	12.75	0.05
(041)	Chestnut Street	10/09/17 09:35:00	10/09/17 09:40:00	12,404	0.08	0.59	0.80	12.75	0.05
(034)	Middlesex Street	10/09/17 09:35:00	10/09/17 09:45:00	53,090	0.17	0.59	0.80	12.75	0.05
(040)	Bethany Avenue	10/09/17 09:35:00	10/09/17 09:45:00	39,408	0.17	0.59	0.80	12.75	0.05
(021H)	Winter Street and Hale Street	10/09/17 09:35:00	10/09/17 09:50:00	83,754	0.25	0.59	0.80	12.75	0.05
(021A)	Middle Siphon	10/09/17 09:35:00	10/09/17 09:55:00	78,630	0.33	0.59	0.80	12.75	0.05
(039)	South Webster Street	10/09/17 09:35:00	10/09/17 09:55:00	12,949	0.33	0.59	0.80	12.75	0.05
(021F)	Orchard Street Center Barrel	10/09/17 09:30:00	10/09/17 10:00:00	57,720	0.50	0.59	0.80	12.75	0.05
<b>STORM TOTALS:</b>				<b>347,608</b>					
(021F)	Orchard Street Center Barrel	10/25/17 02:45:00	10/25/17 07:20:00	41,929	4.58	1.54	0.60	42	0.04
<b>STORM TOTALS:</b>				<b>41,929</b>					
(034)	Middlesex Street	10/26/17 14:35:00	10/26/17 14:40:00	20,314	0.08	1.54	0.60	42	0.04
(040)	Bethany Avenue	10/26/17 14:30:00	10/26/17 14:40:00	34,532	0.17	1.54	0.60	42	0.04
(041)	Chestnut Street	10/26/17 14:30:00	10/26/17 14:40:00	5,356	0.17	1.54	0.60	42	0.04
(039)	South Webster Street	10/26/17 14:30:00	10/26/17 14:45:00	12,886	0.25	1.54	0.60	42	0.04
(021H)	Winter Street and Hale Street	10/26/17 14:40:00	10/26/17 14:50:00	12,948	0.17	1.54	0.60	42	0.04
(021F)	Orchard Street Center Barrel	10/26/17 14:35:00	10/26/17 14:55:00	40,463	0.33	1.54	0.60	42	0.04
<b>STORM TOTALS:</b>				<b>126,499</b>					
(021A)	Middle Siphon	10/29/17 22:00:00	10/29/17 23:55:00	418,570	1.92	2.44	0.64	23.75	0.10
(021F)	Orchard Street Center Barrel	10/29/17 20:55:00	10/29/17 23:55:00	181,296	3.00	2.44	0.64	23.75	0.10
(021H)	Winter Street and Hale Street	10/29/17 23:55:00	10/29/17 23:55:00	1,455	0.08	2.44	0.64	23.75	0.10
(034)	Middlesex Street	10/29/17 23:05:00	10/29/17 23:55:00	66,831	0.83	2.44	0.64	23.75	0.10
(039)	South Webster Street	10/29/17 23:55:00	10/29/17 23:55:00	850	0.08	2.44	0.64	23.75	0.10
<b>STORM TOTALS:</b>				<b>669,002</b>					

# Appendix B: CSO Flow Meter Summary

NPDES #	NPDES Description	CSO Start	CSO End	Total Vol (gals.) Event	CSO Duration (hr.)	Rain Total (in.)	Peak Hour Depth Intensity (in./hr.)	Storm Duration (hr.)	Daily Avg. Intensity (in./hr.)
(040)	Bethany Avenue	10/30/17 02:50:00	10/30/17 02:50:00	128	0.08	2.44	0.64	23.75	0.10
(041)	Chestnut Street	10/30/17 00:45:00	10/30/17 02:50:00	2,546	2.08	2.44	0.64	23.75	0.10
(021H)	Winter Street and Hale Street	10/30/17 00:00:00	10/30/17 03:20:00	118,896	3.33	2.44	0.64	23.75	0.10
(039)	South Webster Street	10/30/17 00:00:00	10/30/17 03:20:00	37,240	3.33	2.44	0.64	23.75	0.10
(021F)	Orchard Street Center Barrel	10/30/17 00:00:00	10/30/17 04:05:00	340,052	4.08	2.44	0.64	23.75	0.10
(034)	Middlesex Street	10/30/17 00:00:00	10/30/17 04:30:00	463,447	4.50	2.44	0.64	23.75	0.10
(021A)	Middle Siphon	10/30/17 00:00:00	10/30/17 04:50:00	2,180,400	4.83	2.44	0.64	23.75	0.10
(013)	Lower Siphon	10/30/17 00:45:00	10/30/17 02:50:00	3,267,240	4.42	2.44	0.64	23.75	0.10
(013)	Lower Siphon	10/30/17 3:20	10/30/17 04:10:00	1,959,776	4.42	2.44	0.64	23.75	0.10
(024)	Upper Siphon	10/30/17 12:25:00	10/30/17 04:15:00	666,894	3.83	2.44	0.64	23.75	0.10
<b>STORM TOTALS:</b>				<b>9,036,620</b>					
(021G)	Winter Street	11/19/17 10:45:00	11/19/17 10:45:00	1,435	0.08	0.40	0.40	15.50	0.03
(040)	Bethany Avenue	11/19/17 10:45:00	11/19/17 10:50:00	19,396	0.08	0.40	0.40	15.50	0.03
(041)	Chestnut Street	11/19/17 10:50:00	11/19/17 10:50:00	3,782	0.08	0.40	0.40	15.50	0.03
(021A)	Middle Siphon	11/19/17 10:50:00	11/19/17 10:55:00	9,027	0.08	0.40	0.40	15.50	0.03
(021H)	Winter Street and Hale Street	11/19/17 10:45:00	11/19/17 11:00:00	37,600	0.25	0.40	0.40	15.50	0.03
(034)	Middlesex Street	11/19/17 10:50:00	11/19/17 11:00:00	20,836	0.17	0.40	0.40	15.50	0.03
(039)	South Webster Street	11/19/17 10:50:00	11/19/17 11:05:00	11,065	0.25	0.40	0.40	15.50	0.03
(021F)	Orchard Street Center Barrel	11/19/17 10:45:00	11/19/17 11:10:00	62,822	0.42	0.40	0.40	15.50	0.03
<b>STORM TOTALS:</b>				<b>165,964</b>					
(021F)	Orchard Street Center Barrel	11/22/17 12:05:00	11/22/17 12:20:00	6,388	0.25	0.72	0.20	9.00	0.08
<b>STORM TOTALS:</b>				<b>6,388</b>					
(021F)	Orchard Street Center Barrel	12/6/2017 0:55	12/6/17 0:55	47,724	0.00	0.50	0.24	13.00	0.04
(021H)	Winter Street and Hale Street	12/06/17 00:35:00	12/06/17 00:40:00	1,560	0.08	0.50	0.24	13.00	0.04
(040)	Bethany Avenue	12/06/17 00:30:00	12/06/17 00:30:00	202	0.08	0.50	0.24	13.00	0.04
<b>STORM TOTALS:</b>				<b>49,486</b>					
<b>2017 GRAND TOTAL</b>								<b>30,765,300</b>	

## Appendix C

Appendix C  
Calendar Year 2017 Rainfall Data

Start Date	Rain Total (in.)	Peak Hour Depth Intensity (in./hr.)	Duration (hours)	Daily Avg. Intensity (in./hr.)
01/01/2017	0.10	0.08	2.75	0.04
01/03/2017	0.80	0.24	20.25	0.04
01/06/2017	0.02	0.04	1.25	0.02
01/08/2017	0.19	0.01	14.50	0.01
01/11/2017	0.24	0.12	9.50	0.03
01/12/2017	0.11	0.08	7.00	0.02
01/18/2017	0.62	0.12	1.25	0.50
01/24/2017	1.57	0.32	51.00	0.03
02/01/2017	0.06	0.04	4.50	0.01
02/07/2017	0.51	0.16	13.75	0.04
02/08/2017	0.08	0.12	1.00	0.08
02/09/2017	0.55	0.16	11.50	0.05
02/11/2017	0.07	0.04	9.75	0.01
02/13/2017	0.80	0.12	19.75	0.04
02/16/2017	0.47	0.16	12.00	0.04
02/25/2017	0.30	0.68	3.75	0.08
03/08/2017	0.15	0.08	21.00	0.01
03/10/2017	0.06	0.12	2.50	0.02
03/14/2017	2.04	0.32	16.00	0.13
03/24/2017	0.06	0.08	1.25	0.05
03/25/2017	0.32	0.12	12.25	0.03
03/27/2017	0.68	0.24	7.50	0.09
03/29/2017	0.63	0.16	13.25	0.05
04/01/2017	2.05	0.24	16.00	0.13
04/04/2017	0.77	0.28	19.75	0.04
04/06/2017	1.05	0.40	11.75	0.09
04/07/2017	0.01	0.04	0.25	0.04
04/12/2017	0.20	0.12	2.25	0.09
04/15/2017	0.02	0.08	0.25	0.08
04/19/2017	0.09	0.08	3.25	0.03
04/21/2017	0.79	0.24	26.50	0.03
04/25/2017	1.22	0.24	24.50	0.05
04/26/2017	0.02	0.04	1.00	0.02
04/28/2017	0.01	0.04	0.25	0.04
04/30/2017	0.02	0.04	2.75	0.01
05/02/2017	0.36	0.44	8.25	0.04
05/05/2017	1.03	0.60	36.00	0.03
05/14/2017	1.29	0.32	34.75	0.04
05/19/2017	0.04	0.04	1.75	0.02
05/22/2017	0.04	0.04	3.75	0.01
05/23/2017	0.19	0.12	8.50	0.02
05/25/2017	0.23	0.08	13.00	0.02
05/26/2017	0.87	0.52	0.50	1.74
05/27/2017	0.01	0.04	0.25	0.04



Appendix C  
Calendar Year 2017 Rainfall Data

Start Date	Rain Total (in.)	Peak Hour Depth Intensity (in./hr.)	Duration (hours)	Daily Avg. Intensity (in./hr.)
05/29/2017	0.04	0.04	2.50	0.02
05/31/2017	0.01	0.04	0.25	0.04
06/01/2017	0.09	0.16	5.00	0.02
06/04/2017	0.02	0.08	0.25	0.08
06/05/2017	0.83	0.52	24.00	0.03
06/06/2017	1.48	0.20	29.75	0.05
06/16/2017	1.08	0.36	8.00	0.14
06/17/2017	0.47	0.40	4.00	0.12
06/19/2017	0.23	0.68	2.25	0.10
06/20/2017	0.05	0.04	1.75	0.03
06/23/2017	0.10	0.16	1.00	0.10
06/24/2017	0.06	0.08	0.75	0.08
06/25/2017	0.16	0.16	2.50	0.06
06/27/2017	0.63	0.60	3.00	0.21
06/30/2017	0.77	1.44	5.25	0.15
07/07/2017	0.23	0.08	5.75	0.04
07/08/2017	0.02	0.04	5.25	0.004
07/11/2017	0.15	0.16	9.00	0.02
07/12/2017	0.15	0.20	9.00	0.02
07/13/2017	0.08	0.08	2.00	0.04
07/15/2017	0.06	0.16	3.50	0.02
07/18/2017	0.58	1.92	3.75	0.15
07/20/2017	0.03	0.08	0.50	0.06
07/21/2017	0.01	0.04	0.25	0.04
07/24/2017	0.98	0.32	24.00	0.04
07/27/2017	0.01	0.04	0.25	0.04
08/02/2017	0.10	0.08	5.25	0.02
08/03/2017	0.01	0.04	0.25	0.04
08/05/2017	0.07	0.16	0.5	0.14
08/08/2017	0.04	0.04	7	0.01
08/12/2017	0.06	0.04	4.75	0.01
08/18/2017	0.50	0.80	4.75	0.11
08/23/2017	0.56	0.84	2	0.28
08/30/2017	0.05	0.04	2.25	0.02
09/03/2017	0.63	0.36	8.25	0.08
09/06/2017	1.23	1.84	14	0.09
09/07/2017	0.81	0.80	7.75	0.10
09/14/2017	0.10	0.16	1	0.10
09/15/2017	0.52	1.00	2.5	0.21
09/16/2017	0.01	0.04	0.25	0.04
09/19/2017	0.10	0.20	6.75	0.01
09/20/2017	0.12	0.08	6.5	0.02
09/22/2017	0.14	0.16	7	0.02
09/30/2017	0.71	0.32	5.75	0.12

Appendix C  
Calendar Year 2017 Rainfall Data

Start Date	Rain Total (in.)	Peak Hour Depth Intensity (in./hr.)	Duration (hours)	Daily Avg. Intensity (in./hr.)
10/06/2017	0.01	0.04	0.25	0.04
10/08/2017	0.10	0.12	1.5	0.07
10/09/2017	0.59	0.80	12.75	0.05
10/16/2017	0.01	0.04	0.25	0.04
10/24/2017	0.25	0.52	4	0.06
10/25/2017	0.80	0.40	24	0.03
10/26/2017	0.74	0.60	15.5	0.05
10/29/2017	1.03	0.44	11.25	0.09
10/30/2017	1.41	0.64	12	0.12
11/06/2017	0.11	0.20	4.75	0.02
11/08/2017	0.03	0.04	1.5	0.02
11/13/2017	0.17	0.12	4	0.04
11/16/2017	0.39	0.16	8	0.05
11/18/2017	0.07	0.08	1.00	0.07
11/19/2017	0.33	0.40	13.50	0.02
11/22/2017	0.72	0.20	9	0.08
12/01/2017	0.08	0.08	2.75	0.03
12/05/2017	0.04	0.04	5.00	0.01
12/06/2017	0.46	0.24	8.00	0.06
12/10/2017	0.51	0.08	10.75	0.05
12/12/2017	0.21	0.08	10.5	0.02
12/22/2017	0.27	0.08	12.75	0.02
12/23/2017	0.54	0.16	13.25	0.04
12/25/2017	0.50	0.12	9	0.06

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## Appendix D

## Appendix D Downstream Notification List

First Name	Last Name	Job Title	Company	Address	City	Business Phone	E-mail
Gary	Field	Assistant Chief Operator	Amesbury	19 Merrimack Street	Amesbury, MA 01913	978-388-1912	<a href="mailto:fieldg@amesburyma.gov">fieldg@amesburyma.gov</a>
Jack	Morris	Regional Health Director	Amesbury	9 School Street	Amesbury, MA 01913	978-388-8134 x 752	<a href="mailto:morrisj@amesburyma.gov">morrisj@amesburyma.gov</a>
Jeffrey	Mason	Water System Manager	Amesbury	62 Friends Street	Amesbury, MA 01913	978-388-0853	<a href="mailto:masonj@amesburyma.gov">masonj@amesburyma.gov</a>
Robert	Desmarais	Director Public Works	Amesbury	62 Friends Street	Amesbury, MA 01913	978-388-8127	<a href="mailto:rob@amesburyma.gov">rob@amesburyma.gov</a>
John	Sokol	Flow Assessment	Contractor	19 Harvey Road, Unit 22	Bedford, NH 03110	603-656-9799	<a href="mailto:jsokol@flowassessment.com">jsokol@flowassessment.com</a>
Joy	Hilton	Engineer, Water Technical Unit	EPA	5 Post Office Square, Suite 100	Boston, MA 02109-3912	617-918-1877	<a href="mailto:hilton.joy@epa.gov">hilton.joy@epa.gov</a>
Lori	Bentsen	Administrative Assistant Board of Health	Groveland	183 Main Street	Groveland, MA 01834	978-556-7210	<a href="mailto:lbentsen@grovelandma.com">lbentsen@grovelandma.com</a>
Tom	Cusick	Superintendent	Groveland Water Dept	183 Main Street	Groveland, MA 01834	978-556-7200 x219	<a href="mailto:Tcusick@grovelandma.com">Tcusick@grovelandma.com</a>
John	D'Aoust	Water Facility Manager	Haverhill	131 Amesbury Road	Haverhill, MA 01830	978-374-2385	<a href="mailto:jdaoust@haverhillwater.com">jdaoust@haverhillwater.com</a>
Bonnie	Dufresne	Board of Health	Haverhill	4 Summer street	Haverhill, MA 01830	978-374-2325	<a href="mailto:bdufresne@cityofhaverhill.com">bdufresne@cityofhaverhill.com</a>
Mike	Vets	Harbor Master	Haverhill	72 Coffin Avenue	Haverhill, MA 01830	978-372-8477	<a href="mailto:vetsm@comcast.net">vetsm@comcast.net</a>
Mike	Stankovich	DPW Director	Haverhill	500 Primrose Street	Haverhill, MA 01830	978-374-2360	<a href="mailto:mstankovich@cityofhaverhill.com">mstankovich@cityofhaverhill.com</a>
Carrie	Prescott	IPP Coordinator	Haverhill	40 South Porter Street	Haverhill, MA 01835	978-374-2382	<a href="mailto:cprescott@haverhillwater.com">cprescott@haverhillwater.com</a>
David	Shaw	Senior Collection System operator	Haverhill	40 South Porter Street	Haverhill, MA 01835	978-374-2382	<a href="mailto:dshaw@haverhillwater.com">dshaw@haverhillwater.com</a>
Fred	Haffty	Wastewater Facility Manager	Haverhill	40 South Porter Street	Haverhill, MA 01835	978-374-2382	<a href="mailto:fhaffty@haverhillwater.com">fhaffty@haverhillwater.com</a>
Paul	Jessel	Collection System Supervisor	Haverhill	40 South Porter Street	Haverhill, MA 01835	978-374-2382	<a href="mailto:piessel@haverhillwater.com">piessel@haverhillwater.com</a>
Robert	Ward	Deputy DPW Director	Haverhill	40 South Porter Street	Haverhill, MA 01835	978-374-2382	<a href="mailto:rward@haverhillwater.com">rward@haverhillwater.com</a>
Rusty	Russell	Merrimack Rivershed Council	Lawrence	60 Island Street, Suite 211-E	Lawrence, MA 01840	978-655-4742	<a href="mailto:rrussell@merrimack.org">rrussell@merrimack.org</a>
James	Drake	Project Manager	CDM Smith	670 N. Commercial St, Rm 201	Manchester, NH 03101	603-222-8336	<a href="mailto:DrakeJS@cdmsmith.com">DrakeJS@cdmsmith.com</a>
Berni	Angelo	Administrative Assistant Board of Health	Merrimac	4 School Street	Merrimac, MA 01860	978-346-4066	<a href="mailto:BOH@townofmerrimac.com">BOH@townofmerrimac.com</a>
Eileen	Hurley	Board of Health	Merrimac	2 School Street	Merrimac, MA 01860	978-804-9537	<a href="mailto:healthagent@townofmerrimac.com">healthagent@townofmerrimac.com</a>
Gary	Tuck	Water Foreman	Merrimac	2-8 School Street	Merrimac, MA 01860	978-346-8417	<a href="mailto:gtuck@townofmerrimac.com">gtuck@townofmerrimac.com</a>
Mike	Buzzell	Wastewater Chief Operator	Merrimac	50 Federal Way	Merrimac, MA 01860	978-346-7857	<a href="mailto:btmwwtf@comcast.net">btmwwtf@comcast.net</a>
Robert	Sinibaldi	DPW Director	Merrimac	4 School Street	Merrimac, MA 01860	978-346-0612	<a href="mailto:dpwdir@townofmerrimac.com">dpwdir@townofmerrimac.com</a>
Deborah	Rogers	Board of Health	Newbury	12 Kent Way, Suite 200	Newbury, MA 01951	978-465-862 x316	<a href="mailto:boardofhealth@townofnewbury.org">boardofhealth@townofnewbury.org</a>
David	Roach	Newbury Shell Fish Purification	Newburyport	84 82nd Street, Plum Island Point	Newburyport, MA 01950	978-465-3553	<a href="mailto:dave.roach@state.ma.us">dave.roach@state.ma.us</a>
Donna	Holaday	Mayor	Newburyport	60 Pleasant Street	Newburyport, MA 01950	978-465-4413	<a href="mailto:DHoladay@CityofNewburyport.com">DHoladay@CityofNewburyport.com</a>
Frank	Giacalone	Director of Public Health	Newburyport	60 Pleasant Street	Newburyport, MA 01950	978-465-4410	<a href="mailto:fgiacalone@cityofnewburyport.com">fgiacalone@cityofnewburyport.com</a>
Jeff	Kennedy	Senior Marine Fisheries Biologists	Newburyport	30 Emerson Avenue	Gloucester, MA 01930	978-282-0308 x165	<a href="mailto:jeff.kennedy@state.ma.us">jeff.kennedy@state.ma.us</a>
Anthony	Furnari	Wastewater Chief Operator	Newburyport	157 Water Street	Newburyport, MA 01950	978-465-4464 x1702	<a href="mailto:jdugan@CityofNewburyport.com">jdugan@CityofNewburyport.com</a>
Paul	Hogg	Harbor Master	Newburyport	PO Box 550	Newburyport, MA 01950	978-462-3746	<a href="mailto:phogg@cityofnewburyport.com">phogg@cityofnewburyport.com</a>
Thomas	Smolski	Water Superintendent	Newburyport	7 Spring Lane	Newburyport, MA 01950	978-465-4466	<a href="mailto:Tsmolski@cityofnewburyport.com">Tsmolski@cityofnewburyport.com</a>
Senior	Biologist	Marine Fisheries	Newburyport	30 Emerson Avenue	Gloucester, MA 01930	978-282-0308 x165	<a href="mailto:shellfish.newburyport@state.ma.us">shellfish.newburyport@state.ma.us</a>
Jamie	Tuccolo	Collection System Superintendent	Newburyport	16 A Perry Way	Newburyport, MA, 01950	978-490-0018	<a href="mailto:JTuccolo@CityofNewburyport.com">JTuccolo@CityofNewburyport.com</a>
Cheri	Cousens <sup>1</sup>	Executive Director	GLSD	240 Charles Street	North Andover, MA 01845	978-685-1612	<a href="mailto:ccousens@glsd.org">ccousens@glsd.org</a>
Thomas	Connors <sup>1</sup>	Chairman	GLSD	240 Charles Street	North Andover, MA 01845	978-685-1612	<a href="mailto:tmconnors@aol.com">tmconnors@aol.com</a>
John	Morris	Board of Health	Salisbury	P.O. Box 5072	Salisbury, MA 01952	978-462-3430	<a href="mailto:imorris@salisburyma.gov">imorris@salisburyma.gov</a>
Jeff	Ingalls	Chief Operator	Salisbury	P.O. Box 5221	Salisbury, MA 01952	978-465-4058	<a href="mailto:wwtp@salisburyma.gov">wwtp@salisburyma.gov</a>
Lisa	DeMeo	Director of Public Works	Salisbury	39 Lafayette Road	Salisbury, MA 01952	978-463-656	<a href="mailto:ldemeo@salisburyma.gov">ldemeo@salisburyma.gov</a>
Ray	Pike	Harbor Master	Salisbury	5 Beach Road	Salisbury, MA 01952	978-499-0740	<a href="mailto:harbormaster@salisburyma.gov">harbormaster@salisburyma.gov</a>
Paul	Sevigny	Health Agent	West Newbury	381 Main Street	West Newbury, MA 01985	978-363-1100 ext 19	<a href="mailto:psevigny@town.west-newbury.ma.us">psevigny@town.west-newbury.ma.us</a>
Kevin	Brander	Municipal Services/Wastewater Section	MDEP	205B Lowell Street	Wilmington, MA 01887	978-694-3236	<a href="mailto:Kevin.Brande@state.ma.us">Kevin.Brande@state.ma.us</a>
Nihar	Mohanty	DEP NERO	MASSDEP	205B Lowell Street	Wilmington, MA 01887	978-694-3237	<a href="mailto:nihar.mohanty@state.ma.us">nihar.mohanty@state.ma.us</a>

<sup>1</sup> Added in 2018