Summary of CSO Receiving Water Quality Monitoring in Upper Mystic River/Alewife Brook and Charles River, 2013

Massachusetts Water Resources Authority

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Summary of CSO Receiving Water Quality Monitoring in Upper Mystic River/Alewife Brook and Charles River, 2013

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1 Introduction

This report summarizes data collected as part of the Massachusetts Water Resources Authority (MWRA) combined sewer overflow (CSO) receiving water monitoring program, and is produced in accordance with the variance for CSO discharges to Lower Charles River/Charles Basin and the variance for CSO discharges to the Alewife Brook/Upper Mystic River. The goal of this monitoring is to identify the water quality impacts of CSO flows on water bodies.

During the 2013 calendar year, MWRA continued to implement its Long Term CSO Control Plan, which was developed to address CSO discharges from all CSOs hydraulically connected to the MWRA sewer system and member communities. This monitoring summary provides an assessment of water quality in the Charles and Mystic Rivers, which are affected by CSO projects implemented as part of this plan.

In 2013, the Massachusetts Department of Environmental Protection (MADEP) extended the Variance for CSO discharges to the Lower Charles River/Charles Basin issued to MWRA, Boston Water and Sewer Commission (BWSC) and the City of Cambridge respectively by three years, to October 1, 2016. MADEP also extended the Variance for CSO discharges to the Alewife Brook/Upper Mystic River issued to MWRA, the City of Cambridge and the City of Somerville respectively by three years, to September 1, 2016.

Under the agreement on the Long Term Control Plan (the “LTCP”) reached by EPA, MADEP and MWRA in March 2006, MADEP agreed to issue a series of three-year variance extensions through 2020, and MWRA agreed to implement the approved LTCP by 2015 and verify system performance and the levels of control at all CSO outfalls by 2020. At that time, DEP will consider issuing long-term water quality standards determinations based on the verified performance of the LTCP and other conditions affecting the water quality and uses of these water bodies.

Conditions in the recent variance extensions require MWRA to implement the LTCP in compliance with federal court schedule milestones (“Schedule Seven”) and require MWRA and the municipalities to continue to implement the Nine Minimum Controls of EPA’s National CSO Control Policy. Conditions in the variance extensions also require all of the CSO permittees to report estimated CSO discharge frequencies and volumes from their respective outfalls to these receiving waters on an annual basis. MWRA is also required to continue receiving water quality monitoring to assess impacts of CSO discharges.

CSO control progress in 2013 as it relates to the Charles River and Alewife Brook/Mystic River includes the following:

- The Town of Brookline completed the Brookline sewer separation project in April 2013, ahead of the July 2013 milestone in the court schedule. The project removed large volumes of stormwater from the Brookline and MWRA sewer systems and redirected the stormwater flows through CSO Outfall MWR010 to the Charles River Basin. The project involved the installation of large sanitary sewers in Beacon, St. Mary’s, and Monmouth Streets and the conversion of existing combined sewers to
storm drains. Several new connections were also created between the separated Brookline system and MWRA’s Charles River Valley Sewer and South Charles Relief Sewer. The project has reduced treated CSO discharges to the Charles River at MWRA’s Cottage Farm facility: model simulations performed by MWRA to support its annual reporting requirement show that the Brookline sewer separation project has reduced Typical Year CSO discharges from Cottage Farm from 7 activations and 27.2 million gallons to 5 activations and 18.7 million gallons, a 31% annual volume reduction. Sewer separation programs by the City of Cambridge are expected to further lower the Cottage Farm discharges. This sewer separation project also resulted in the closing of a BWSC CSO regulator that contributed to CSO discharges at Outfall MWR010 and likely further reduced already infrequent overflows from MWRA’s Charles River Valley Sewer to Outfall MWR010.

- Cambridge achieved substantial completion and beneficial use of the CAM004 stormwater outfall and wetland basin project in April 2013, in compliance with Schedule Seven. The wetland basin is intended to mitigate water quality and flooding impacts to the Little River and Alewife Brook of planned sewer separation in upstream areas along and surrounding Huron and Concord Avenues. The stormwater outfall and wetland basin will provide detention and wetlands treatment to the separated stormwater flows prior to discharge to the Little River as stormwater is removed from the Cambridge and MWRA sewer systems.

- The City of Cambridge also attained 70% completion of the first of three major construction contracts for the CAM004 Sewer Separation project (Contract 8A), commenced the second contract (8B) and advertised the third contract (9) for construction bids (Cambridge commenced Contract 9 in February 2014). This project is intended to close Outfall CAM004 and lower CSO discharges at other outfalls to Alewife Brook and is the CSO abatement centerpiece of MWRA’s Alewife Brook CSO control plan. Cambridge expects to complete the project by December 2015 in compliance with Schedule Seven.

- MWRA achieved substantial completion of the construction contract for the Interceptor Connection Relief and Floatables Control at Outfall SOM01A project in December 2013, ahead of the June 2014 milestone in Schedule Seven. The project provides for floatables control at Outfall SOM01A, which discharges into Alewife Brook, and allows for an increase in the capacity of the connection from Somerville’s Tannery Brook Conduit to MWRA’s interceptor, lowering CSO discharges at SOM01A once the CAM004 sewer separation project is complete in 2015.

- MWRA attained 100% design of its Control Gate and Floatables Control at Outfall MWR003 and MWRA Rindge Avenue Siphon Relief project in December 2013 and plans to issue the notice to proceed with construction by August 2014, in compliance with Schedule Seven. The project is the last of six projects in MWRA’s CSO control plan for Alewife Brook and the last of the 35 projects in the LTCP to move into construction. The project will improve sewer system performance, contribute to CSO reductions along Alewife Brook, and provide floatables control and sewer system relief at Outfall MWR003 in extreme storms in part to compensate for the closing of nearby Outfall CAM004 with completion of the CAM004 sewer separation project in December 2015.
As of the end of 2013, 37 CSOs have been closed or effectively closed in Boston Harbor and its tributaries; 47 CSOs remained active.¹ In the Charles, nine CSOs remained active and ten have been closed. In the Alewife Brook, seven CSOs remained active, six have been closed. In the Mystic River, one treated CSO (Somerville Marginal) remains active, discharging at two locations depending on tide (MWR205A upstream of the Amelia Earhart dam and MWR205 in the marine river mouth). BOS017 also discharges at the river mouth.

System-wide, average annual CSO discharge has been reduced from 3.3 billion gallons in 1988 to 463 million gallons as of the end of 2013, an 86% reduction, with 90% of current discharge volume receiving treatment at MWRA’s four CSO treatment facilities. Other MWRA system improvements since the 1990s have also reduced the frequency and volume of CSO flows over the period of the monitoring program and have resulted in increased treatment of remaining flows. Figure 1-1 shows the estimated CSO flow reduction system-wide since 1988, and Figure 1-2 shows the CSO flow reduction by receiving water. For purposes of this report, receiving water quality data from 2008 to the present is considered representative of current conditions.

Figure 1-1. Estimated CSO flow reductions, 1988 – 2016.
Source: MWRA CSO Annual Progress Report 2013 (March 2014)

¹ SOM002 and SOM006 were closed prior to the approval of the Long Term Control Plan and are included in this total. SOM009 discharges to the system upstream of other outfalls and is not included in the overall count. CAM009 and 011 are also included, which are temporarily closed, pending the results of a long-term hydraulic assessment by the City of Cambridge. CSO discharges at BOS-081, -082, -084, -085 and -086 are effectively eliminated, with a 25-year storm level of control.
Rainfall volumes at various locations in the MWRA service area appear in Table 1-1. The table summarizes the frequency of rain events within selected ranges of total rainfall for 2013. 2013 rainfall totals are very close to the Typical Year predictions, suggesting that rainfall in 2013 was representative in terms of the effect of rainfall on system performance. Compared to 2012, there were approximately the same total number of storms, but more storms in the 0.25 to 0.5 inch category and fewer storms in the higher rainfall categories. (Refer to Tables 3-3 and Table 4-3 for CSO discharge estimates for the Charles and Mystic, respectively.)

Table 1-1. Comparison of rain event frequency by rainfall volume, 2013 rainfall vs. typical year.

<table>
<thead>
<tr>
<th></th>
<th>Total Rainfall (in.)</th>
<th>Total Number of Storms</th>
<th>Number of storms, by rainfall volume</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>&lt;0.25 inches</td>
</tr>
<tr>
<td>Typical Year</td>
<td>46.8</td>
<td>93</td>
<td>49</td>
</tr>
<tr>
<td>2013 Ward St. Headworks</td>
<td>42.9</td>
<td>91</td>
<td>46</td>
</tr>
<tr>
<td>2013 Columbus Park Headworks</td>
<td>43.37</td>
<td>97</td>
<td>54</td>
</tr>
<tr>
<td>2013 BWSC Charlestown</td>
<td>35.52</td>
<td>94</td>
<td>57</td>
</tr>
<tr>
<td>2013 Fresh Pond (USGS)</td>
<td>33.89</td>
<td>95</td>
<td>60</td>
</tr>
</tbody>
</table>

Source: MWRA CSO Discharge Estimates and Rainfall Analyses for Calendar Year 2013, Table 1.
1.1 Overview of the monitoring program
MWRA’s CSO receiving water quality monitoring program has been ongoing since 1989, with most sampling locations continuously monitored since 1991. All harbor and tributary areas impacted by CSOs in Boston, Chelsea, Cambridge, and Somerville are included in the monitoring program. For most sampling locations included in this report, at least 20 samples have been collected each year.

1.2 Organization and purpose of the report
Chapter 2 presents the materials and methods used in monitoring. Chapters 3 and 4 of this report discuss the results of the CSO receiving water quality monitoring program in the Charles River and Mystic River/Alewife Brook. Water quality parameters examined for each region include: bacterial indicators (E. coli, Enterococcus and fecal coliform), dissolved oxygen, water clarity (Secchi depth, total suspended solids), nutrients (phosphate, ammonium, nitrate/nitrite) and chlorophyll.

The purpose of the report is to summarize 2013 water quality in the Charles and Alewife Brook/Mystic River. The report compares sampling results to water quality standards, and shows spatial and temporal variations in water quality, and differences between wet and dry weather. Data from the previous five monitoring years are analyzed together for representativeness, and data for 2013 for bacterial and physical parameters are also shown separately.

2 Materials and Methods

2.1 Field and laboratory methods

2.1.1 Selection of sampling locations
Some sampling locations were chosen for their proximity to CSO discharges and others were chosen to provide representative water quality measurements for a given area. Complete lists of stations including descriptions for the Charles and Mystic River/Alewife Brook appear in Section 3.1 and 4.1, respectively.

2.1.2 Sampling schedules
Approximately 20 station visits or more were made to each location each year, within two separate monitoring projects. Eutrophication monitoring is conducted once monthly year-round at a subset of river locations, and includes nutrient, chlorophyll, TSS, bacteria, and physical measurements. CSO receiving monitoring includes bacteria sampling and physical measurements that are collected between April and December of each year, in weekly rotations for each region. Sampling is random with respect to weather; however efforts were made to collect additional samples during wet weather, if an inadequate number of station visits occurred following rainfall events by mid-year.

2.1.3 Sample collection
At all locations, water samples and water quality measurements were collected near-surface (approximately 0.1 meters below surface). Surface samples were collected by grab into rinsed sample containers. Bottom samples were collected at locations with a water depth greater than 3 meters, using a Kemmerer sampler or
alpha bottle at 0.5 meters above the sediment surface. Bottom water quality measurements (physical measurements such as dissolved oxygen, temperature, and salinity) were made at most locations regardless of depth, but some upstream locations are too shallow for separate bottom readings. Separate sampling containers were used for bacteria, nutrient, and TSS analyses.

2.1.4 Field measurements
Field measurements were made with different instruments over the course of the monitoring program. Table 2-1 lists the instruments used and the variables measured.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Instruments used</th>
</tr>
</thead>
<tbody>
<tr>
<td>dissolved oxygen, turbidity, pH</td>
<td>Hydrolab Datasonde 5 (2006 - 2008)</td>
</tr>
<tr>
<td></td>
<td>YSI6600, YSI6820 (2009 - 2013)</td>
</tr>
<tr>
<td></td>
<td>YSI 600XL for temperature, conductivity, dissolved oxygen (1999 – 2013)</td>
</tr>
<tr>
<td>Secchi Depth</td>
<td>Wildco 8-inch limnological Secchi disk (upstream of dams)</td>
</tr>
<tr>
<td></td>
<td>Wildco 8-inch oceanographic Secchi disk (marine waters)</td>
</tr>
</tbody>
</table>

2.1.5 Rainfall measurements
Rainfall measurements were taken from the National Weather Service (NWS) rain gauge located at Logan Airport in East Boston, as this was considered the most representative location for the entire monitoring area. Results from the gauge are reported in one-day intervals. Data are downloaded from the NWS website and stored in MWRA’s Environmental Monitoring & Measurement System (EM&MS) database.

2.1.6 Laboratory analyses
Samples were analyzed at the MWRA Central Laboratory. For enumeration of bacteria, nutrients, and TSS, MWRA Department of Laboratory Services Standard Operating Procedures is followed.

Detailed laboratory methods with quality assurance and quality control procedures are described in the Central Laboratory Standard Operating Procedure (MWRA 2008).

Table 2-2 lists the analytes measured and methods used in the monitoring program. MWRA discontinued *E. coli* monitoring at marine locations due to methodological concerns with the use of the Colilert method for marine samples, replacing *E. coli* with fecal coliform.
Table 2-2. Laboratory measurements.

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Method</th>
</tr>
</thead>
</table>
| Enterococcus     | Standard Methods 9230C 2c, membrane filtration (for samples collected 1996 – 2003)  
                   | EPA Method 1600 (for samples collected 1999 – 2006, some 2007)          
                   | Enterolert (for samples collected 2008 – 2013)                         |
| E. coli          | Modified EPA 1103.1, membrane filtration (for samples collected 2000 – 2006)  
                   | Colilert (for samples collected 2007 - 2013)                           |
| Fecal coliform   | Standard Methods 9222D, membrane filtration                            |
| Total suspended solids | Clesceri et al. (1998, Method 2540D), using nucleopore filters        |
| Total phosphorus | TP and/or TDP: Solarzano and Sharp (1980a); PP: Solarzano and Sharp (1980a),  
                   | Whatman G/F                                                             |
| Phosphate        | Murphy and Riley (1962), modified as in Clesceri et al (1998, Method 4500-P F)  
                   | Skalar SANplus autoanalyzer, Whatman G/F filters                       |
| Total Nitrogen   | TN and/or TDN: Solarzano and Sharp (1980b), Whatman G/F filters; PN: Perkin Elmer  
                   | CHN analyzer, Whatman G/F                                              |
                   | Skalar SANplus autoanalyzer, Whatman G/F filters                       |
| Nitrate+nitrite  | Bendshneider and Robinson (1952), modified as in Clesceri et al (1998, Method 4500-  
                   | NO3 F), Skalar SANplus autoanalyzer, Whatman G/F filters              |
| Chlorophyll a    | Acid-corrected (Holm Hansen 1965) as described in EPA (1992). Sequoia Turner  
                   | Model 450 fluorometer, GF/F filters                                      |

2.2  Data analysis

Descriptive Analyses. Indicator bacteria counts are typically log-normally distributed, and therefore a proper measure of central tendency for these data is the geometric mean. Geometric means and their associated 95% confidence intervals were calculated for the measurements made at each station over the sampling period.

Many results are plotted as percentile plots, as shown in Figure 2-1. These plots present a frequency distribution of a group of measurements. Each box comprises measurements from a single beach or sampling location. Values are shown in Figure 2-1 for the 10th, 25th, 50th, 75th, and 90th percentiles. Single measurements beyond these ranges (outliers) are displayed as dots.

Figure 2-1. Percentile distributions indicated on percentile plots
Box plots display the range and central tendencies of the data allow for easy comparison of the results among stations. The 50\textsuperscript{th} percentile (median) is equivalent to the geometric mean, assuming the data are log-normally distributed.

2.3 Water Quality Standards used in this report

Standards are shown in Table 2-6, and include standards and guidelines from the Massachusetts Department of Environmental Protection (MADEP), Environmental Protection Agency (EPA), Massachusetts Department of Public Health (MADPH), and the Massachusetts Division of Marine Fisheries (MADMF). The MADEP standard for Class SB waters (fishable swimmable) are based on \textit{E. coli} and/or \textit{Enterococcus} counts for freshwater, and \textit{Enterococcus} counts for marine waters, following a USEPA recommendation for \textit{Enterococcus} in marine waters (USEPA 1986). The Massachusetts Department of Public Health issued regulations for beach management based on the USEPA criteria. MADMF uses fecal coliform to monitor shellfish growing waters.
<table>
<thead>
<tr>
<th>Designated Use/Standard</th>
<th>Parameter</th>
<th>Support</th>
</tr>
</thead>
</table>
| Inland waters, Class B, warm water fishery Massachusetts waters, MADEP | Dissolved Oxygen | ≥ 5.0 mg/l  
≥ 60% saturation unless background conditions lower |
|                         | Temperature | ≤ 28.3°C (83°F) |
|                         | pH         | 6.5 to 8.3 S.U. |
| Coastal/marine waters, Class SB Massachusetts waters, MADEP | Dissolved Oxygen | ≥ 5.0 mg/L  
≥ 60% saturation unless background conditions lower |
|                         | Temperature | < 26.7°C (80°F) |
|                         | pH         | 6.5 to 8.5 S.U. |
| Primary contact recreation (designated swimming area), MADPH, MADEP | Enterococcus | Single sample limit 61 counts/100 ml (freshwater), 104 counts/100 ml (marine); geometric mean 33 counts/100 ml (freshwater), 35 counts/100 ml (marine) |
| Freshwater primary contact recreation (designated swimming area), MADPH, MADEP | E. coli | Single sample limit 235 counts/100 ml (freshwater only); geometric mean 126 counts/100 ml (freshwater only) |
| Former standard, primary contact recreation, MADEP (pre-2007) | Fecal coliform | Geometric mean ≤ 200 counts/100 ml, no more than 10% of samples above 400 counts/100 ml |
| Restricted shellfishing, MADMF | Fecal coliform | Geometric mean ≤ 88 counts/100 ml |
| Primary contact recreation, MADEP, aesthetics -- transparency | Secchi disk depth | ≥ 1.2 meters (4 feet) at public bathing beaches and lakes |

1 All receiving water areas discussed in this report are either Class B or SB according to MADEP standards current as of January 2007 (except for Mystic River mouth, which is SB_{CSO}. SB_{CSO} has the same water quality standards as SB except CSOs are present).

From MADEP 2007:

**Inland Water Class B:** These waters are designated as a habitat for fish, other aquatic life, and wildlife, and for primary and secondary contact recreation. Where designated they shall be suitable as a source of water supply with appropriate treatment. They shall be suitable for irrigation and other agricultural uses and for compatible industrial cooling and process uses. These waters shall have consistently good aesthetic value.

**Coastal and Marine Class SB:** These waters are designated as a habitat for fish, other aquatic life, and wildlife, and for primary and secondary contact recreation. In approved areas they shall be suitable for shellfish harvesting with depuration (Restricted Shellfishing Areas). These waters shall have consistently good aesthetic value.
3 Results: Charles River

3.1 Sampling area

MWRA’s sampling area in the Charles River includes the river segment from the Watertown Dam in Watertown downstream to the New Charles River Dam in Boston, near the river mouth. This area, for purposes of this report called the Charles Basin, is freshwater and designated Class B with a variance for Combined Sewer Overflows by MADEP (the variance was extended in October 2013). The river segment is approximately 10.3 km (8.6 mi) long. The New Charles River Dam and locks limit river flow and tidal exchange at the river mouth.

MWRA monitoring locations are primarily located midstream, bracketing CSO outfalls. Locations were also selected near to or downstream of outfalls where accessible by boat: at the Stony Brook outlet and CSO (MWR023), Faneuil Brook outlet and CSO that has since been closed (BOS032, closed in 1997), and downstream of the Cottage Farm CSO outfall diffusers (MWR201).

For purposes of this report, MWRA’s monitoring area in the lower Charles is divided into three smaller reaches. Table 3-1 describes the reaches, sampling locations and CSOs within each reach. Sampling locations and CSOs appear in Figure 3-1.

Figure 3-1. Map of MWRA Charles River sampling locations.
Table 3-1. MWRA monitoring locations, Charles River Basin.

<table>
<thead>
<tr>
<th>Reach</th>
<th>Description of Reach</th>
<th>Sampling location</th>
<th>Location Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Basin</td>
<td>Watertown Dam in Watertown, downstream to Magazine Beach (near BU Bridge) in Cambridge</td>
<td>012, Watertown</td>
<td>Watertown Dam at footbridge (upstream of all CSOs)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>001, Newton</td>
<td>Downstream of Newton Yacht Club (upstream of all CSOs)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>144, Allston</td>
<td>Faneuil Brook outlet (at BOS032, closed 11/97)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>002, Allston</td>
<td>Downstream of Beacon St. Bridge (downstream of BOS033, closed 10/96)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>003, Cambridge</td>
<td>Downstream of Eliot Bridge, Cambridge side (at CAM005)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>004, Cambridge/Allston</td>
<td>Between River St. and Western Ave. bridges</td>
</tr>
<tr>
<td></td>
<td></td>
<td>005, Cambridge</td>
<td>10 m off of Magazine Beach</td>
</tr>
<tr>
<td>Mid-Basin</td>
<td>BU Bridge on Boston/Cambridge line to downstream of Longfellow Bridge</td>
<td>006, Cambridge/Boston</td>
<td>BU Bridge, downstream side (downstream of MWR201)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>007, Cambridge</td>
<td>MIT Boathouse, Cambridge side</td>
</tr>
<tr>
<td></td>
<td></td>
<td>145, Boston</td>
<td>Stony Brook outlet, Boston side (at MWR203)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>008, Cambridge/Boston</td>
<td>Mass. Ave Bridge, downstream side (downstream of MWR203, MWR018)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>009, Cambridge/Boston</td>
<td>Longfellow Bridge, upstream side (downstream of MWR201, closed 3/00)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>010, Boston</td>
<td>Longfellow Bridge, downstream side (downstream of MWR202, closed 3/00)</td>
</tr>
<tr>
<td>Lower Basin</td>
<td>Science Museum to North Station railroad bridge, near Charlestown.</td>
<td>166, Boston</td>
<td>Science Museum, upstream of old dam (downstream of all lower basin CSOs)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>011, Boston</td>
<td>Between Science Museum and New Charles Dam/locks (downstream of all Charles CSOs)</td>
</tr>
</tbody>
</table>

Sampling locations are midstream unless otherwise noted.

3.2 Pollution sources

Known pollution sources to the Charles River are shown in Table 3-2, which include nine active CSOs. MWRA’s Cottage Farm CSO treatment facility, located upstream of the BU Bridge, screens, chlorinates and dechlorinates CSO flow before discharge and is the only source of treated CSO discharge to the river. (MWRA’s Prison Point CSO facility, located near the Charles River mouth, has its discharge point on the Boston Harbor side of the New Charles Dam.) With increases in sewer system capacity, the number of
activations at Cottage Farm has decreased over the last two decades – from more than 20 activations in the late 1990s to 3 activations in 2013. The Stony Brook/Muddy River outlet near Kenmore Square is a source of contaminated brook flow and stormwater flows to the basin area, however CSO discharge volumes to the Stony Brook have been reduced in recent years due to sewer separation by Boston Water and Sewer Commission (BWSC) in the mid-2000s.

Table 3-3 shows the MWRA model simulation results for CSOs affecting the Charles River Basin in calendar year 2013. Actual CSO volumes and activation frequency are available for the Cottage Farm CSO facility, while the remaining results are estimated using model data.

The receiving water program is designed to capture water quality in all weather conditions. Table 3-4 summarizes the proportion of samples collected in dry, damp, and wet weather, which indicate a slightly higher proportion of samples collected in rainy conditions than prior years.

<table>
<thead>
<tr>
<th>Table 3-2. Charles River Basin pollution sources.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Source</strong></td>
</tr>
<tr>
<td>CSOs (untreated)</td>
</tr>
<tr>
<td>CAM009 closed 11/07 CAM011 closed 11/07 BOS032 closed 11/97 BOS033 closed 10/96</td>
</tr>
<tr>
<td>CSO treatment facility (settling and detention; screened, chlorinated and dechlorinated CSO discharge)</td>
</tr>
<tr>
<td>Storm drains</td>
</tr>
<tr>
<td>Upstream inputs (elevated bacteria counts upstream)</td>
</tr>
<tr>
<td>Dry weather inputs (elevated bacteria counts in dry weather)</td>
</tr>
<tr>
<td>Tributary brook or stream flow</td>
</tr>
</tbody>
</table>
Table 3-3. Charles River Basin CSO activations, results of MWRA model simulations and facility records for 2013 system conditions and 2013 rainfall.1

<table>
<thead>
<tr>
<th>CSO Outfall</th>
<th>Activation Frequency</th>
<th>Total Discharge Duration (hr)</th>
<th>Total Discharge Volume (million gallons)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Upper Charles</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAM005</td>
<td>1</td>
<td>2.22</td>
<td>0.66</td>
</tr>
<tr>
<td>CAM007</td>
<td>1</td>
<td>2.22</td>
<td>0.63</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td>4.44</td>
<td>1.29</td>
</tr>
<tr>
<td><strong>Back Bay Fens (Muddy River)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BOS046</td>
<td>2</td>
<td>18.89</td>
<td>13.07</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td>18.89</td>
<td>13.07</td>
</tr>
<tr>
<td><strong>Lower Charles</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAM017</td>
<td>1</td>
<td>0.97</td>
<td>0.21</td>
</tr>
<tr>
<td>MWR010</td>
<td>0</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>MWR018</td>
<td>1</td>
<td>1.95</td>
<td>1.07</td>
</tr>
<tr>
<td>MWR019</td>
<td>0</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>MWR020</td>
<td>0</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>MWR201 (Cottage Farm Facility)</td>
<td>3</td>
<td>11.24</td>
<td>30.26</td>
</tr>
<tr>
<td>MWR023 (Stony Brook)</td>
<td>2</td>
<td>1.80</td>
<td>0.08</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td>15.96</td>
<td>31.61</td>
</tr>
</tbody>
</table>

1 Activation frequency and volume are from MWRA model results, except where noted.
2 Activation frequency and volume are from MWRA facility records (measurements).
3 47.3 million gallons of 49.3 million gallons – or 96% – of total annual CSO discharge to the Lower Charles is treated.

Table 3-4. Charles River sample collection by rainfall condition.

<table>
<thead>
<tr>
<th>Sampling period</th>
<th>Dry1</th>
<th>Damp1</th>
<th>Wet1</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>31%</td>
<td>34%</td>
<td>35%</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>790 samples</td>
<td>878 samples</td>
<td>893 samples</td>
<td>2561 samples</td>
</tr>
<tr>
<td>2008 - 2012</td>
<td>32%</td>
<td>28%</td>
<td>41%</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>220 samples</td>
<td>190 samples</td>
<td>279 samples</td>
<td>689 samples</td>
</tr>
<tr>
<td>2013</td>
<td>34%</td>
<td>28%</td>
<td>41%</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>790 samples</td>
<td>190 samples</td>
<td>279 samples</td>
<td>689 samples</td>
</tr>
</tbody>
</table>

1 Dry: no rainfall for previous 3 days; Wet: at least 0.5 inches in previous 2 days; damp is everything in between. Sampling is random with respect to weather, though if needed wet weather sampling is added late in the year to maintain a representative annual sample.

3.3 Summary of water quality, 2009-2013

A detailed summary of water quality results collected during the last five years is shown in Table 3-5.
Table 3-5. Summary of water quality, Charles River Basin 2009 - 2013.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Upper Basin</th>
<th>Mid-Basin</th>
<th>Lower Basin</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Parameter</strong></td>
<td><strong>MA DEP Water Quality Guideline or Standard</strong></td>
<td><strong>Mean ± SD</strong></td>
<td><strong>% meeting guideline</strong></td>
</tr>
<tr>
<td>Surface Temperature (°C)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Summer</td>
<td>&lt;28.3</td>
<td>21 ± 4.9</td>
<td>97.8</td>
</tr>
<tr>
<td>Winter</td>
<td></td>
<td>5.1 ± 5.1</td>
<td>100.0</td>
</tr>
<tr>
<td>Bottom water dissolved oxygen (mg/L)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Summer</td>
<td>5.0</td>
<td>8.1 ± 1.6</td>
<td>97.5</td>
</tr>
<tr>
<td>Winter</td>
<td>5.0</td>
<td>13.4 ± 1.9</td>
<td>100.0</td>
</tr>
<tr>
<td>pH (S.U.)</td>
<td></td>
<td>6.5-8.3</td>
<td>7.4 ± 0.3</td>
</tr>
<tr>
<td>Total Suspended Solids (mg/L)</td>
<td></td>
<td>NS</td>
<td>4.3 ± 5.5</td>
</tr>
<tr>
<td>Water clarity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secchi depth (m)</td>
<td></td>
<td>NS</td>
<td>1.1 ± 0.3</td>
</tr>
<tr>
<td>Turbidity (NTU)</td>
<td></td>
<td>NS</td>
<td>6.5 ± 3.4</td>
</tr>
</tbody>
</table>
Table 3-5. Summary of water quality, Charles River Basin 2009 - 2013, continued.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>MA DEP Water Quality Guideline or Standard</th>
<th>Upper Basin</th>
<th></th>
<th>Mid- Basin</th>
<th></th>
<th>Lower Basin</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MA DEP Water Quality Guideline or Standard</td>
<td>Mean ± SD</td>
<td>% meeting guideline</td>
<td>Range</td>
<td>n</td>
<td>Mean ± SD</td>
<td>% meeting guideline</td>
</tr>
<tr>
<td>Bacteria (col/100mL)²</td>
<td>E. coli 200 / 400³</td>
<td>147 (134-161)</td>
<td>88.3</td>
<td>0 - 2400</td>
<td>877</td>
<td>61 (55-68)</td>
<td>73.4</td>
</tr>
<tr>
<td></td>
<td>Enterococcus 126 / 235³⁴</td>
<td>12 (10-14)</td>
<td>91.1</td>
<td>0 - 5790</td>
<td>879</td>
<td>6 (5-7)</td>
<td>80.9</td>
</tr>
<tr>
<td>Nutrients (μmol/L)</td>
<td>Phosphate NS</td>
<td>0.74 ± 0.38</td>
<td>-</td>
<td>0.01 - 2.46</td>
<td>130</td>
<td>ND</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Ammonium NS</td>
<td>4.1 ± 3.3</td>
<td>-</td>
<td>0.4 - 25.5</td>
<td>130</td>
<td>ND</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Nitrate+nitrite NS</td>
<td>42.5 ± 18.8</td>
<td>-</td>
<td>7.9 - 92.1</td>
<td>130</td>
<td>ND</td>
<td>-</td>
</tr>
<tr>
<td>Algae (μg/L)</td>
<td>Chlorophyll NS</td>
<td>4.1 ± 4.3</td>
<td>100.0</td>
<td>0.4 - 22.7</td>
<td>130</td>
<td>ND</td>
<td>ND</td>
</tr>
</tbody>
</table>

NS: no standard or guideline. ND: No data.

¹Summer (June-September), Winter (December-March).
²For bacterial data, 95% confidence intervals are provided in lieu of standard deviations. “Mean” = geometric mean for bacteria data.
³First number is the all samples geometric mean limit - compare to the “Mean±SD” column; the second number is the single sample limit - compare to the “% meeting guideline” column.
⁴E. coli or Enterococcus is an acceptable indicator for Massachusetts Department of Public Health, EPA, and MADEP to assess suitability for swimming in freshwater.
⁵NOAA guideline.
⁶Median and standard error of the median are shown for pH, not arithmetic mean and standard deviation.
3.4 Trends in water quality, 2013

This section provides an analysis of trends for water quality parameters measured in the lower Charles in the 2013 monitoring year.

3.4.1 Physical measurements

Temperature. Summer water temperatures for 2013 are shown for each sampling location in the top graph in Figure 3-2. Surface temperatures are relatively consistent upstream to downstream, particularly upstream of the lower basin. Bottom-water temperatures are consistently lower in the deeper waters downstream, particularly Station 009 (upstream of the Longfellow Bridge), where water depth exceeds 6 meters (20 to 23 feet). Station 166 is collected in a shallow location in the basin near the Science Museum, where differences in surface and bottom temperatures are small. Locations upstream of Station 004 (upstream of the Eliot Bridge in Cambridge) are relatively shallow, with depths ranging from 1 to 3 meters.

Dissolved Oxygen. The spatial trend in dissolved oxygen (DO) is shown in the center graph of Figure 3-2. Average surface and bottom DO does meet the State standard of 5.0 mg/L at most locations in the Lower Charles, but mean bottom water DO failed to meet the standard at deeper water locations downstream, including stations 007, 009, 010 and 011. Stratification due to salt water intrusion through the river locks during the summer months—as well as cooler bottom temperatures—results in extremely low bottom-water dissolved oxygen in the lower basin area near the Longfellow Bridge. Station 166, downstream of the lower basin, is collected at a relatively shallow near-shore location and does not reflect the low DO levels of deeper water in the lower basin.

Water clarity. Water clarity is indicated by Secchi disk depth. Summer Secchi results (measured June through September) are shown for individual sampling locations in the bottom graph in Figure 3-2. Station 12 at the Watertown Dam is too shallow for Secchi measurements but is typically clear to the river bottom. All locations in the Lower Charles have relatively consistent measurements, with Secchi depths at or near the standard of 1.2 meters.
Figure 3-2. Summer temperature, dissolved oxygen and Secchi depth, Charles River Basin, 2013.
Dashed lines are State standards or guideline (maximum for temperature, minima for DO and Secchi).
No Secchi data are available for Station 012 because of shallow depth; the site is typically visible to bottom.
3.4.2 Nutrients, TSS and chlorophyll

Monthly means for total nitrogen, ammonium, nitrate/nitrite, total phosphorus, phosphate, total suspended solids, and chlorophyll \( a \) at the upstream (012) and downstream (166) locations in the lower Charles are shown in Figure 3-3 and Figure 3-4, respectively. 2013 averages are plotted with the average of the previous five years (2008 – 2012) for comparison.

Seasonal signals are most evident with nitrate+nitrite, total phosphorus/phosphate, and chlorophyll \( a \). While the two locations show similar concentrations for most parameters, there are differences between the two stations for chlorophyll \( a \). Historically, Station 012 has the highest chlorophyll concentrations in spring, whereas the Lower Basin has highest concentrations in late summer. In 2013 chlorophyll at both locations was below the 5-year average for the late spring and summer months, particularly at the Science Museum location, though slightly above average for late fall.

Trends for the 2013 monitoring year are similar to the 2008 – 2012 averages for most parameters, though phosphate, TSS, and chlorophyll showed some differences for 2013. As in 2012, TSS concentrations were generally lower than the 5-year average. Phosphate concentrations were also below the 5-year average at the Lower Basin location near the Science Museum—as in 2012, nearly half the historical concentrations—but concentrations were about average upstream at the Watertown dam.
Figure 3-3. Monthly average nutrients, TSS and Chlorophyll 2008 – 2013, Station 012, Watertown Dam.

Error bars are ± 1 SD.
Figure 3-4. Monthly average nutrients, TSS and Chlorophyll 2008 – 2013, Station 166, Science Museum. Error bars are ± 1 SD.
3.4.3 Bacterial water quality

Figure 3-5 shows the current bacterial water quality at each location sampled in the Charles for 2013, for dry, damp, and wet weather. Upstream reaches generally have more elevated bacteria counts than downstream locations, though this trend is less pronounced in 2013 than in past years, with a slight but continuing improvement in conditions at Watertown Dam.

Annual geometric means for each location for 2008 - 2013 appear in Table 3-6. Geometric means for 2013 are shown in a separate column from the five-year means. If confidence intervals for the two periods overlap, this indicates no statistically significant difference between the two means ($\alpha = 0.95$). Without exception, 2013 bacterial concentrations at all locations are lower than the 5-year mean. This is particularly notable as a slightly higher proportion of samples were collected in wet weather in 2013 as compared to earlier years.

The top graph in Figure 3-5 shows percentile plots of *Enterococcus* counts arranged from upstream to downstream locations for 2013 (note log scale). The bottom graph in Figure 3-5 shows percentile plots of *E. coli* counts arranged from upstream to downstream locations for 2013. Generally, *E. coli* shows the same spatial trend as *Enterococcus*, with more elevated bacteria counts upstream relative to downstream locations. Locations downstream of the BU Bridge in Cambridge met geometric mean standards for both bacterial indicators in dry weather. Upstream locations met geometric mean standards in both weather conditions, with the exception of stations 012, 001 and 005 in wet weather, the same pattern as 2012. Annual geometric means shown in Table 3-6 met the *Enterococcus* geometric mean standard, and all but stations 001, 144, and 006 met the *E. coli* standard, again a pattern similar to 2012.

Figure 3-6 shows the impact of rainfall on the three Lower Charles reaches on *Enterococcus* densities, along with results for individual locations near CSO outfalls. Bacterial concentrations in light rainfall, damp and dry conditions met the geometric mean standard in all three reaches, failing to meet the standard during heavy rain.

The change in *Enterococcus* concentrations since 1989 in the Upper Charles Basin (upstream of CSO influences) and the lower Charles (including the Mid- and Lower-Basin locations) appear in Figure 3-7 and Figure 3-8. Results are grouped by phases of the Long Term CSO Plan improvements and include the geometric mean counts in each rainfall condition. These figures show change over time in both regions, with statistically significant improvement in water quality in the latest phase. Upper Basin shows improvement in both dry and wet conditions but meets the geometric mean swimming standard only in dry weather. The most pronounced change is in the lower Charles, which meets the geometric mean swimming standard in all conditions. The greatest improvement in bacterial water quality since the early 1990s has been in dry weather, followed by heavy rain conditions.
Figure 3-5. Indicator bacteria concentrations, Charles River Basin, 2013. Dotted lines show MADEP Enterococcus and E. coli standard. Dry: no rainfall for previous 3 days; Wet: at least 0.5 inches in previous 2 days; damp is everything in between.

<table>
<thead>
<tr>
<th>Station</th>
<th>Location</th>
<th>Surface or Bottom</th>
<th>Number of samples</th>
<th>Enterococcus (95% CI)</th>
<th>E. coli (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>2008–’12 2013</td>
<td>DEP limit: 33 counts/100 mL</td>
<td>DEP limit: 126 counts/100 mL</td>
</tr>
<tr>
<td>012</td>
<td>Newtown/Watertown, footbridge upstream of Watertown Dam</td>
<td>S</td>
<td>126 27</td>
<td>28 (19-39) 19 (8-43)</td>
<td>173 (141-211) 116 (77-176)</td>
</tr>
<tr>
<td>001</td>
<td>Newton, near Nonantum Rd., rear of DCR skating rink</td>
<td>S</td>
<td>99 24</td>
<td>29 (20-43) 12 (6-25)</td>
<td>274 (227-330) 204 (145-287)</td>
</tr>
<tr>
<td>144</td>
<td>Brighton, downstream of N. Beacon St. bridge, Faneuil Brook outlet, BOS-032 (closed 1999)</td>
<td>S</td>
<td>94 25</td>
<td>31 (21-47) 10 (5-22)</td>
<td>307 (232-408) 168 (106-267)</td>
</tr>
<tr>
<td>002</td>
<td>Allston, downstream of Arsenal Street bridge, BOS-033</td>
<td>S</td>
<td>93 24</td>
<td>21 (13-32) 3 (1-7)</td>
<td>221 (178-275) 94 (57-156)</td>
</tr>
<tr>
<td>003</td>
<td>Allston/Cambridge, midstream, near Mt. Auburn Street, between CAM-005 and CAM-006</td>
<td>S</td>
<td>95 24</td>
<td>16 (10-24) 4 (2-9)</td>
<td>213 (168-271) 103 (62-171)</td>
</tr>
<tr>
<td>004</td>
<td>Allston/Cambridge, midstream, between River Street and Western Avenue bridges</td>
<td>S</td>
<td>99 24</td>
<td>7 (4-11) 2 (1-6)</td>
<td>90 (65-125) 45 (23-87)</td>
</tr>
<tr>
<td>005</td>
<td>Cambridge, near Magazine Beach, upstream of Cottage Farm</td>
<td>S</td>
<td>201 49</td>
<td>8 (6-11) 5 (2-10)</td>
<td>109 (88-136) 98 (61-157)</td>
</tr>
<tr>
<td>006</td>
<td>Cambridge/Boston, midstream, downstream of Cottage Farm, BU bridge</td>
<td>S</td>
<td>106 24</td>
<td>13 (8-19) 3 (1-8)</td>
<td>182 (139-238) 141 (96-208)</td>
</tr>
<tr>
<td>007</td>
<td>Cambridge, near Memorial Dr., MIT Boathouse</td>
<td>S</td>
<td>106 24</td>
<td>7 (4-10) 2 (1-6)</td>
<td>112 (82-154) 49 (23-106)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
<td>106 24</td>
<td>16 (10-24) 4 (1-10)</td>
<td>183 (134-250) 71 (32-159)</td>
</tr>
<tr>
<td>145</td>
<td>Boston (Charlesgate), Muddy River/Stony Brook outlet</td>
<td>S</td>
<td>107 25</td>
<td>16 (10-24) 6 (2-16)</td>
<td>218 (155-307) 100 (46-218)</td>
</tr>
<tr>
<td>008</td>
<td>Cambridge/Boston, midstream, downstream of Harvard Bridge</td>
<td>S</td>
<td>106 24</td>
<td>6 (4-9) 2 (0-4)</td>
<td>104 (73-148) 41 (19-86)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
<td>106 24</td>
<td>10 (7-15) 2 (1-5)</td>
<td>155 (112-214) 45 (21-93)</td>
</tr>
<tr>
<td>009</td>
<td>Cambridge/Boston, midstream, upstream of Longfellow Bridge near Community Sailing</td>
<td>S</td>
<td>106 24</td>
<td>3 (2-5) 1 (0-3)</td>
<td>59 (43-82) 20 (10-40)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
<td>106 24</td>
<td>1 (0-1) 2 (1-4)</td>
<td>13 (9-19) 3 (1-5)</td>
</tr>
<tr>
<td>010</td>
<td>Boston, downstream of Longfellow Bridge, MWR-022</td>
<td>S</td>
<td>106 24</td>
<td>2 (1-4) 1 (0-2)</td>
<td>40 (28-58) 15 (6-34)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
<td>106 24</td>
<td>3 (2-4) 1 (0-3)</td>
<td>28 (19-41) 10 (5-20)</td>
</tr>
<tr>
<td>166</td>
<td>Boston, old Charles River dam, rear of Science Museum</td>
<td>S</td>
<td>132 26</td>
<td>4 (3-6) 1 (0-3)</td>
<td>91 (69-120) 39 (23-67)</td>
</tr>
<tr>
<td>011</td>
<td>Boston, upstream of river locks (New Charles River Dam) and I-93, near Nashua St.</td>
<td>S</td>
<td>106 24</td>
<td>3 (2-4) 2 (1-3)</td>
<td>40 (30-55) 24 (14-40)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
<td>106 24</td>
<td>8 (6-12) 9 (4-16)</td>
<td>44 (32-59) 21 (10-44)</td>
</tr>
</tbody>
</table>

1Geometric mean limit for Enterococcus is 35 counts/100 mL in marine water, 33 counts/100 mL in freshwater. The E. coli limit is 126 counts/100 mL.
Figure 3-6. *Enterococcus* by rainfall condition, Charles Basin, 2013.

Dotted line shows MADEP standard of 33 counts/100 mL. Rainfall is NOAA rainfall from Logan airport. “Dry”: no rainfall for previous 3 days; “Heavy”: more than 0.5 inches in previous 3 days; “Damp” and/or rain distant in time: any rain < 0.15 inches at least two or three days previous to sampling and/or 0.1 inches in previous day; “Light rain”: between 0.1 and 0.5 inches in previous day and/or between 0.15 and 0.5 in two previous days.
Figure 3-7. *Enterococcus* over time, Upper Charles Basin (upstream of CSOs) by phase of Long Term CSO Plan and rainfall condition.

Dotted line shows State standard. Data includes results for stations 012, 001, 002, 003. Rainfall is NOAA rainfall from Logan airport. “Dry”: no rainfall for previous 3 days; “Heavy”: more than 0.5 inches in previous 3 days; “Damp” and/or rain distant in time: any rain < 0.15 inches at least two or three days previous to sampling and/or 0.1 inches in previous day; “Light rain”: between 0.1 and 0.5 inches in previous day and/or between 0.15 and 0.5 in two previous days.

Figure 3-8. *Enterococcus* over time, Lower Charles Basin by phase of Long Term CSO Plan and rainfall condition.

Dotted line shows State standard. Data includes results for all stations downstream of Western Ave (Station 004). Rainfall is NOAA rainfall from Logan airport. “Dry”: no rainfall for previous 3 days; “Heavy”: more than 0.5 inches in previous 3 days; “Damp” and/or rain distant in time: any rain < 0.15 inches at least two or three days previous to sampling and/or 0.1 inches in previous day; “Light rain”: between 0.1 and 0.5 inches in previous day and/or between 0.15 and 0.5 in two previous days.
3.5 **Summary of Charles River Water Quality**

2013 bacterial water quality in the Charles was generally consistent or better than five-year historical averages, with most individual locations meeting geometric mean standards for *E. coli* and *Enterococcus*, and individual locations in the Lower Basin having geometric mean bacteria counts below the five-year mean. In heavy rain conditions 2013 was consistent with past years, with the Mid-Basin and Lower Basin meeting geometric mean standards.

Spatially, water quality was for the most part consistent with prior years, with more elevated concentrations at upstream locations (upstream of most CSOs), improving as the river widens and slows in the Lower Basin and approaches the New Charles Dam.

Bottom-water dissolved oxygen met standards in the Upper Charles Basin, but failed to meet standards in the lower Charles Basin, a pattern consistent with prior years. Seawater entering through the Charles locks in summer contributes to stratification of the basin, limiting exchange with surface waters and at least partially explains the lower bottom DO.

Nutrients and chlorophyll exhibited seasonal signals but matched long term averages overall. The exceptions were below-average summer chlorophyll and phosphate concentrations in the Lower Charles but near to average at the Watertown Dam.
4 Results: Mystic River and Alewife Brook

4.1 Sampling area

Monitoring results of the Mystic River are divided into four reaches. Table 4-1 describes the reaches and the sampling locations within each reach. Locations are shown on the map in Figure 4-1.

4.2 Pollution sources

Known pollution sources to the Mystic River/Alewife Brook are shown in Table 4-2 and consist of stormwater, upstream inputs and CSOs. Nine CSOs are located in Cambridge and Somerville, including seven active CSOs in Alewife Brook, and one treated CSO in the Lower Mystic basin (Somerville Marginal CSO, MWR205A/SOM007A), which discharges screened and dechlorinated flow only during an activation occurring at high tide. At low tide, the Somerville Marginal CSO (MWR205) discharges downstream of the Amelia Earhart dam, screening and chlorinating CSO flow before discharge. It is the only source of treated CSO discharge to the Mystic River. For calendar year 2013, Somerville Marginal 205A/SOM007A had five discharge events, and Somerville Marginal 205 had 19 activations resulting in discharge below the dam.

Table 4-3 shows the MWRA model simulation results for CSOs affecting the Mystic River and Alewife Brook in calendar year 2013. Metered CSO volumes and activation frequency are available for the Somerville Marginal CSO facility, while the remaining results are estimated using model results.
Table 4-4 summarizes the proportion of samples collected in dry, damp, and wet weather between 2008 and 2013.

Table 4-1. MWRA monitoring locations, Mystic River and Alewife Brook.

<table>
<thead>
<tr>
<th>Reach</th>
<th>Description of Reach</th>
<th>Sampling location</th>
<th>Location Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Alewife Brook</strong></td>
<td>Tributary to Mystic River. From confluence at Little River in Cambridge/Arlington to</td>
<td>174, Cambridge/Arlington</td>
<td>Little River, upstream of Rt. 2 and off ramp to Alewife T station. Upstream of all CSOs.</td>
</tr>
<tr>
<td>(Class B/Variance,</td>
<td>confluence with Mystic River in Arlington/Somerville</td>
<td>074, Cambridge/Arlington</td>
<td>Downstream of CAM001A, CAM004, MWR003</td>
</tr>
<tr>
<td>warm water fishery)</td>
<td></td>
<td>172, Cambridge/Arlington</td>
<td>Downstream of CAM001, CAM002, CAM400, CAM401B, SOM001A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>070, Arlington/Somerville</td>
<td>Mystic Valley Parkway bridge. Downstream of all Alewife CSOs</td>
</tr>
<tr>
<td><strong>Upper Mystic River</strong></td>
<td>Downstream of Lower Mystic Lake in Arlington/Medford to Route 28 bridge in Medford</td>
<td>083, Arlington/Medford</td>
<td>Upstream of confluence of Mystic River and Alewife Brook</td>
</tr>
<tr>
<td>(Class B/Variance,</td>
<td></td>
<td>057, Medford</td>
<td>Confluence of Mystic River and Alewife Brook</td>
</tr>
<tr>
<td>warm water fishery)</td>
<td></td>
<td>066, Medford</td>
<td>Boston Ave bridge, downstream side</td>
</tr>
<tr>
<td></td>
<td></td>
<td>056, Medford</td>
<td>Upstream of I-93 bridge, near Medford Square off ramp</td>
</tr>
<tr>
<td><strong>Lower Mystic River basin</strong></td>
<td>Route 28 bridge in Medford to Amelia Earhart Dam in Somerville/Everett</td>
<td>177, Medford</td>
<td>Downstream of Rt. 16 bridge</td>
</tr>
<tr>
<td>(Class B/Variance,</td>
<td></td>
<td>067, Medford</td>
<td>Rt. 28 bridge, downstream side, near Somerville Marginal MWR205A outfall</td>
</tr>
<tr>
<td>warm water fishery)</td>
<td></td>
<td>176, Medford/Everett</td>
<td>Malden River, upstream of Rt. 16 bridge</td>
</tr>
<tr>
<td></td>
<td></td>
<td>059, Somerville/Everett</td>
<td>Confluence of Mystic and Malden Rivers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>167, Somerville/Everett</td>
<td>Amelia Earhart Dam, upstream side</td>
</tr>
<tr>
<td><strong>Mystic River mouth</strong></td>
<td>Downstream of Amelia Earhart Dam in Somerville/Everett to Tobin Bridge, Chelsea R.</td>
<td>052, Somerville</td>
<td>Downstream of Amelia Earhart dam, near Somerville Marginal CSO facility outfall (MWR205)</td>
</tr>
<tr>
<td>(Class SB/CSO, marine)</td>
<td>confluence in Chelsea/East Boston</td>
<td>069, Charlestown</td>
<td>Rear of Schrafft’s Center at BOS-017 outfall</td>
</tr>
<tr>
<td></td>
<td></td>
<td>137, Charlestown/Everett</td>
<td>Upstream of Tobin Bridge near confluence of Mystic, Chelsea Rivers and upper inner harbor</td>
</tr>
</tbody>
</table>

Sampling locations are midstream unless otherwise noted.
Table 4-2. Mystic River/Alewife Brook pollution sources.

<table>
<thead>
<tr>
<th>Source</th>
<th>Alewife Brook</th>
<th>Upper Mystic River</th>
<th>Lower Mystic Basin</th>
<th>Mystic River mouth</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSOs (untreated)</td>
<td>4 active, 5 closed</td>
<td>2 closed</td>
<td>None</td>
<td>1 active BOS017</td>
</tr>
<tr>
<td>CAM401A, MWR003, CAM001, CAM002, CAM401B, SOM001A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAM004 to be closed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAM400 closed 3/11</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SOM001 closed 12/96</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SOM002 closed 1994</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SOM002A closed 8/95</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SOM003 closed 8/95</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SOM004 closed 12/95</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SOM006 closed 12/96</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SOM007 closed 12/96</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CSO treatment facility</td>
<td>No</td>
<td>No</td>
<td>Yes Somerville Marginal (MWR205A/SOM007A, high tide only) Activated 5 times in 2013</td>
<td>Yes Somerville Marginal (MWR205) Activated 19 times in 2013</td>
</tr>
<tr>
<td>(screened, chlorinated and dechlorinated CSO discharge)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storm drains</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Upstream inputs (elevated bacteria counts upstream)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Dry weather inputs (elevated bacteria counts in dry weather)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Tributary brook or stream flow</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Table 4-3. Mystic River/Alewife Brook CSO activations, results of MWRA model simulations and facility records for 2013 system conditions and 2013 rainfall.1

<table>
<thead>
<tr>
<th>CSO Outfall</th>
<th>Activation Frequency</th>
<th>Total Discharge Duration (hr)</th>
<th>Total Discharge Volume (Million Gallons)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Alewife Brook</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAM001</td>
<td>0</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>CAM002</td>
<td>1</td>
<td>0.73</td>
<td>0.06</td>
</tr>
<tr>
<td>MWR003</td>
<td>2</td>
<td>2.20</td>
<td>0.43</td>
</tr>
<tr>
<td>CAM004</td>
<td>6</td>
<td>8.99</td>
<td>1.87</td>
</tr>
<tr>
<td>CAM401A</td>
<td>2</td>
<td>2.43</td>
<td>0.43</td>
</tr>
<tr>
<td>CAM401B</td>
<td>8</td>
<td>12.56</td>
<td>1.05</td>
</tr>
<tr>
<td>SOM001A</td>
<td>2</td>
<td>2.49</td>
<td>1.59</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td>29.41</td>
<td>5.43</td>
</tr>
<tr>
<td><strong>Mystic River (upstream of dam)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SOM007A/MWR205A (Somerville Marginal, high tide discharge only)2</td>
<td>5</td>
<td>4.56</td>
<td>9.75</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td>4.56</td>
<td>9.75</td>
</tr>
<tr>
<td><strong>Mystic River mouth (downstream of dam, marine outfalls)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MWR205 (Somerville Marginal Facility)3</td>
<td>19</td>
<td>87.35</td>
<td>64.46</td>
</tr>
<tr>
<td>BOS017</td>
<td>0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td>87.35</td>
<td>64.46</td>
</tr>
</tbody>
</table>

1Activation frequency and volume are from MWRA model results, except where noted.
2Activation frequency and volume are from MWRA depth sensor measurement and MWRA model results, respectively.
3Activation frequency and volume are from MWRA facility records (measurements).
4Treated discharge.

Table 4-4. Mystic River/Alewife Brook sample collection by rainfall condition.

<table>
<thead>
<tr>
<th>Sampling period</th>
<th>Dry(^1)</th>
<th>Damp(^1)</th>
<th>Wet(^1)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008-2012</td>
<td>31% 928 samples</td>
<td>32% 958 samples</td>
<td>36% 1077 samples</td>
<td>100% 2963 samples</td>
</tr>
<tr>
<td>2013</td>
<td>32% 292 samples</td>
<td>32% 286 samples</td>
<td>36% 322 samples</td>
<td>100% 900 samples</td>
</tr>
</tbody>
</table>

\(^1\) Dry: no rainfall for previous 3 days; Wet: at least 0.5 inches in previous 2 days; Damp is everything in between. Sampling is random with respect to weather, though if needed wet weather sampling is added late in the year to maintain a representative annual sample of wet weather.
4.3 Summary of water quality, 2009-2013

A detailed summary of water quality results collected from the last five years is shown in Table 4-5.
Table 4-5. Summary of water quality, Mystic River/Alewife Brook 2009 - 2013.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Water Quality Guideline or Standard</th>
<th>Alewife Brook</th>
<th>Upper Mystic</th>
<th>Lower Mystic Basin</th>
<th>Malden River</th>
<th>Mystic Mouth</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ± SD % meeting guideline Range n</td>
<td>Mean ± SD % meeting guideline Range n</td>
<td>Mean ± SD % meeting guideline Range n</td>
<td>Mean ± SD % meeting guideline Range n</td>
<td>Mean ± SD % meeting guideline Range n</td>
<td>Mean ± SD % meeting guideline Range n</td>
</tr>
<tr>
<td>Surface Temperature (°C)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Summer</td>
<td>&lt;28.3</td>
<td>18.2 ± 4 99.8</td>
<td>6.6 - 28.4 417</td>
<td>20.4 ± 4.1 99.2</td>
<td>8.3 - 28.5 524</td>
<td>20.2 ± 4.2 99.3</td>
</tr>
<tr>
<td>Winter</td>
<td>4 ± 2</td>
<td>100.0</td>
<td>0.8 - 9.3 36</td>
<td>2.5 ± 1.9 100.0</td>
<td>0.4 - 8.1 61</td>
<td>3.3 ± 2.3 100.0</td>
</tr>
<tr>
<td>Bottom water dissolved oxygen (mg/L)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Summer</td>
<td>5.0</td>
<td>5.1 ± 2.3 51.9</td>
<td>0 - 15.1 414</td>
<td>7 ± 1.7 89.7</td>
<td>0.4 - 10.9 522</td>
<td>7.2 ± 2.4 82.8</td>
</tr>
<tr>
<td>Winter</td>
<td>5.0</td>
<td>11.4 ± 1.2 100.0</td>
<td>8.9 - 13.9 36</td>
<td>12.2 ± 0.9 100.0</td>
<td>10 - 14.6 59</td>
<td>11.9 ± 1.9 100.0</td>
</tr>
<tr>
<td>pH (S.U.)</td>
<td>6.5-8.3 (8.5 marine)</td>
<td>7.3 ± 0.3 99.5</td>
<td>6.7 - 9 638</td>
<td>7.5 ± 0.4 96.5</td>
<td>6.8 - 9 810</td>
<td>7.5 ± 0.6 93.0</td>
</tr>
<tr>
<td>Water clarity</td>
<td>Total Suspended Solids (mg/L)</td>
<td>NS ND - ND 0</td>
<td>5.2 ± 5.4 -</td>
<td>0.2 - 44.3 198</td>
<td>6.3 ± 4.3 -</td>
<td>0.6 - 30.1 120</td>
</tr>
<tr>
<td>Secchi depth (m)</td>
<td>NS 0.5 ± 0.2 - 0.2 - 1 38</td>
<td>1.3 ± 0.4 -</td>
<td>0.6 - 3.2 102</td>
<td>1 ± 0.2 -</td>
<td>0.4 - 1.9 275</td>
<td>1 ± 0.3 -</td>
</tr>
<tr>
<td>Turbidity (NTU)</td>
<td>NS 13.6 ± 7.1 - 3.5 - 34.7 141</td>
<td>5.8 ± 3.5 -</td>
<td>0.5 - 19.4 591</td>
<td>8.2 ± 4.9 -</td>
<td>0.3 - 44.2 724</td>
<td>9.8 ± 7.6 -</td>
</tr>
</tbody>
</table>
### Table 4-5. Summary of water quality, Mystic River/Alewife Brook 2009 - 2013, continued.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Water Quality Guideline or Standard</th>
<th>Alewive Brook</th>
<th>Upper Mystic</th>
<th>Lower Mystic Basin</th>
<th>Malden River</th>
<th>Mystic Mouth</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ± SD</td>
<td>% meeting guideline</td>
<td>Range</td>
<td>n</td>
<td>Mean ± SD</td>
<td>% meeting guideline</td>
</tr>
<tr>
<td><strong>Fecal coliform</strong></td>
<td>200 / 400</td>
<td>671 (481-936)</td>
<td>2.6</td>
<td>82 - 63000</td>
<td>196</td>
<td>742 (662-832)</td>
</tr>
<tr>
<td><strong>E. coli</strong></td>
<td>126 / 235</td>
<td>742 (662-832)</td>
<td>78.2</td>
<td>0 - 50400</td>
<td>568</td>
<td>131 (114-150)</td>
</tr>
<tr>
<td><strong>Enterococcus</strong></td>
<td>33 / 61</td>
<td>238 (204-277)</td>
<td>76.4</td>
<td>0 - 45700</td>
<td>568</td>
<td>26 (21-31)</td>
</tr>
<tr>
<td><strong>Phosphate</strong></td>
<td>NS</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>0</td>
<td>0.53 ± 0.68</td>
</tr>
<tr>
<td><strong>Ammonium</strong></td>
<td>NS</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>0</td>
<td>14.2 ± 12</td>
</tr>
<tr>
<td><strong>Nitrate+nitrite</strong></td>
<td>NS</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>0</td>
<td>55.8 ± 30.6</td>
</tr>
<tr>
<td><strong>Chlorophyll a</strong></td>
<td>25</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>0</td>
<td>9.1 ± 6.5</td>
</tr>
</tbody>
</table>

NS: no standard or guideline. ND: No data.

1Summer (June-September), Winter (December-March).
2For bacterial data, 95% confidence intervals are provided in lieu of standard deviations.
3First number is the all samples geometric mean limit - compare to the "Mean±SD" column; the second number is the single sample limit - compare to the "% meeting guideline" column. For marine locations, fecal coliform replaced E. coli in marine waters in 2007 for methodological reasons.
4E. coli or Enterococcus are acceptable indicators for Massachusetts Department of Public Health and MADEP to assess suitability for swimming in fresh water.
5NOAA guideline.
6Median and standard error of the median are shown for pH, not arithmetic mean and standard deviation.
4.4 **Trends in water quality, 2013**

This section reports spatial trends for water quality parameters measured in the Mystic River/Alewife Brook in 2013.

4.4.1 **Physical measurements**

**Temperature.** Summer mean temperatures for 2013 are shown for each sampling location in the uppermost graph of Figure 4-2. Surface and bottom temperatures are similar, except in the downstream reach, on the marine side of the dam, where water depth is greater and harbor temperatures are lower.

**Dissolved Oxygen.** Dissolved oxygen is shown in the center graph of Figure 4-2. Mean surface and dissolved oxygen concentrations meet the State standard of 5.0 mg/L at all locations except for the lower Alewife Brook, and bottom water concentrations meet except in portions of Alewife Brook, and the lower Mystic River downstream of the Route 16 bridge (Station 177 and 067), Malden River (Station 176) and upstream of the Amelia Earhart dam (Station 167). Of any location in the Alewife and Mystic, bottom-water dissolved oxygen is typically lowest at the Malden River location (Station 176). Unlike the Charles River, there is little evidence of stratification due to saltwater intrusion in the lower portion of the Mystic.

**Water clarity.** Water clarity is indicated by Secchi disk depth, which appears for each sampling location in the bottom graph of Figure 4-2. Water clarity for all but the Mystic River mouth is poor, with nearly all stations upstream of the Dam failing to meet the guideline of 1.2 meters except for Station 056 and Station 166 in Medford, which typically meet water clarity limits (Alewife Brook and several upper Mystic locations are too shallow to measure Secchi depth, usually the river bottom is visible at these locations). Clarity on the marine side of the Amelia Earhart dam improves substantially at the marine portion of the river mouth.
Figure 4-2. Summer temperature, dissolved oxygen, and Secchi depth, Mystic River, 2013.
Dashed lines are State standards or guideline (maximum for temperature, minima for DO and Secchi).
Brook locations are typically too shallow for measurements in the summer months.
4.4.2 Nutrients, TSS and chlorophyll

Figures 4-3 through 4-6 show monthly average total nitrogen, ammonium, nitrate+nitrite, total phosphorus, orthophosphate, total suspended solids, and chlorophyll \( a \) at the upstream Mystic locations (083 upstream of Alewife Brook and 066 at Boston Ave.), downstream (167 at Amelia Earhart Dam) and river mouth (137).

As biological activity increases during the summer months, ammonium and phosphate show relatively strong seasonal effects. Station 167, immediately upstream of the dam, is more eutrophic than either upstream or at the mouth of the river. Chlorophyll concentrations at Station 167 are typically more than double the concentrations of upstream locations, though summer chlorophyll was below average in 2013, as it was in downstream reach of the Lower Charles, suggesting a regional pattern. Monthly average chlorophyll upstream of the Mystic basin is most elevated in the spring as compared to later in the season, while concentrations are highest in late summer downstream of the basin.

In winter months, when biological nutrient uptake is low, ammonium concentrations in the upper Mystic are more than double the concentration in the Charles Basin. Nutrient concentrations on the marine side of the dam are generally much lower than upstream, particularly for nitrogen, chlorophyll, and total suspended solids. In general, 2013 results were similar to the 5-year average for nutrient parameters, with the exception of chlorophyll and phosphate concentrations, which were slightly lower than average during the summer and early fall.
Figure 4-3. Monthly average nutrients, TSS and Chlorophyll 2008 – 2013, Station 083 (Mystic upstream of Alewife Br.)

Error bars are ± 1 SD. Note different scale for nitrate+nitrite, phosphate, chlorophyll and TSS than for Figures 4-5 and 4-6.
Figure 4-4. Monthly average nutrients, TSS and Chlorophyll 2008 – 2013, Station 066 (Boston Ave.)

Error bars are ± 1 SD. Note different scales than Figures 4-3, 4-5 and 4-6 for most parameters.
Figure 4-5. Monthly average nutrients, TSS and Chlorophyll 2008 – 2013, Station 167 (Amelia Earhart Dam (upstream/freshwater)).

Error bars are ± 1 SD. Note different scales than Figures 4-3, 4-4 and 4-6 for most parameters.
Figure 4-6. Monthly average nutrients, TSS and Chlorophyll 2008 – 2013, Station 137 Mystic River mouth (marine).
Error bars are ± 1 SD. Note different scales than Figures 4-3, 4-4 and 4-5 for most parameters.
4.4.3 Bacterial water quality

Figure 4-7 shows the current bacterial water quality at each location sampled in the Mystic River and Alewife Brook for 2013 for dry, damp, and wet weather. Water quality is relatively consistent downstream of the Mystic/Alewife confluence, with the majority of stations meeting bacterial standards in dry weather.

Geometric means for each indicator for 2008 - 2013 appear in Table 4-6. Consistent with recent years, annual geometric means meet standards for all locations in 2013 except for Alewife Brook, but are somewhat higher than the five-year averages for both Enterococcus and E. coli. Alewife Brook geometric means were substantially higher in 2013 compared to the five year historical average.

The uppermost graph in Figure 4-7 shows percentile plots of Enterococcus counts for each location, arranged from upstream to downstream for 2013. The center graph shows percentile plots of E. coli and the bottom graph fecal coliform, which is monitored in the marine portion of the Mystic River in place of E. coli.

E. coli shows a similar trend to Enterococcus, with Mystic basin locations generally meeting the geometric mean limit of 126 counts/100 mL in dry weather but not in wet conditions. As shown in Table 4-6, E. coli at most Mystic mainstem locations remained relatively consistent with the 5-year averages, with geometric means well within the standard. The geometric mean bacteria at Station 056, upstream of the I-93 bridge, improved substantially in 2013. The geometric mean for Station 052 (Somerville Marginal outfall MWR205) meets the former fecal coliform standard of 200 counts/100 mL and the Enterococcus standard of 35 counts/100 mL. Geometric means at Station 052 are elevated in heavy rain but meet standards in dry and damp weather. Further upstream in the Alewife, all locations consistently fail to meet standards in both dry and wet weather, though conditions improve in the river mainstem, moving downstream to the river mouth.

The spatial and temporal change in Enterococcus concentrations in Alewife Brook and the Mystic River appear in Figure 4-8 through Figure 4-10. Figure 4-8 shows the impact of rainfall on the three river reaches on Enterococcus densities, along with the change at locations near CSO outfalls. With the exception of Alewife Brook, the Mystic River reaches meet Enterococcus standards in dry, damp and light rainfall conditions, but fail to meet standards in heavy rain. In the Alewife, all locations, even the Little River location upstream of CSOs, fail to meet standards in all rainfall conditions, suggesting persistent contamination problems in the entire length of the Brook. The CSO downstream of the Mystic Basin, Somerville Marginal Outfall 20,5 does meet standards in dry, damp, and light rainfall conditions but not in heavy rain.

Results in Figures 4-9 and 4-10 are grouped by phases of the Long Term CSO Plan improvements and include the geometric mean counts in each rainfall condition. Enterococcus results show little change over time in the Mystic River in dry and wet weather since the early 1990’s, with slight improvements in dry and damp weather.
Figure 4-7. Indicator bacteria concentrations, Mystic River/Alewife Brook, 2013.

Dotted lines show MADEP Enterococcus and E. coli standard and former fecal coliform standard. E. coli testing was discontinued in 2007 in marine waters for methodological reasons. Dry: no rainfall for previous 3 days; Wet: at least 0.5 inches in previous 2 days; damp is everything in between.
<table>
<thead>
<tr>
<th>Station</th>
<th>Location</th>
<th>Surface or Bottom</th>
<th>Number of samples</th>
<th>Enterococcus (95% CI) counts/100 mL</th>
<th>E. coli (95% CI) counts/100 mL</th>
</tr>
</thead>
<tbody>
<tr>
<td>174</td>
<td>Cambridge, Little River, upstream of Rt. 2 and off ramp to Alewife T station</td>
<td>S</td>
<td>133</td>
<td>31</td>
<td>160 (113-226)</td>
</tr>
<tr>
<td>074</td>
<td>Cambridge, Little River, at off ramp to Alewife T station</td>
<td>S</td>
<td>133</td>
<td>31</td>
<td>102 (72-146)</td>
</tr>
<tr>
<td>172</td>
<td>Arlington, Alewife Brook, upstream of Massachusetts Ave bridge, midchannel</td>
<td>S</td>
<td>133</td>
<td>31</td>
<td>210 (157-282)</td>
</tr>
<tr>
<td>070</td>
<td>Arlington, Alewife Brook, off Mystic Valley Parkway bridge</td>
<td>S</td>
<td>133</td>
<td>31</td>
<td>275 (212-358)</td>
</tr>
<tr>
<td>083</td>
<td>Medford, upstream of confluence of Mystic River and Alewife Brook</td>
<td>S</td>
<td>232</td>
<td>47</td>
<td>17 (13-23)</td>
</tr>
<tr>
<td>057</td>
<td>Medford, confluence of Mystic River and Alewife Brook</td>
<td>S</td>
<td>108</td>
<td>20</td>
<td>31 (22-45)</td>
</tr>
<tr>
<td>066</td>
<td>Medford, Mystic River, Boston Ave bridge</td>
<td>S</td>
<td>140</td>
<td>26</td>
<td>46 (33-66)</td>
</tr>
<tr>
<td>056</td>
<td>Medford, Mystic River, upstream of I-93 bridge</td>
<td>S</td>
<td>106</td>
<td>21</td>
<td>18 (12-27)</td>
</tr>
<tr>
<td>177</td>
<td>Medford, Downstream of Rt. 16 bridge, mid-channel</td>
<td>S</td>
<td>140</td>
<td>25</td>
<td>27 (19-40)</td>
</tr>
<tr>
<td>067</td>
<td>Medford, Mystic River, Rt. 28 bridge</td>
<td>S</td>
<td>108</td>
<td>21</td>
<td>27 (19-40)</td>
</tr>
<tr>
<td>059</td>
<td>Everett, confluence of Mystic and Malden Rivers</td>
<td>S</td>
<td>105</td>
<td>21</td>
<td>3 (2-5)</td>
</tr>
<tr>
<td>176</td>
<td>Malden River, upstream of Rt. 16 bridge</td>
<td>S</td>
<td>107</td>
<td>21</td>
<td>9 (5-15)</td>
</tr>
<tr>
<td>167</td>
<td>Medford, Mystic River, upstream side of Amelia Earhart Dam</td>
<td>S</td>
<td>126</td>
<td>25</td>
<td>6 (4-8)</td>
</tr>
<tr>
<td>052</td>
<td>Somerville, Mystic River, near Somerville Marginal CSO facility (MWR205) – marine</td>
<td>S</td>
<td>133</td>
<td>25</td>
<td>15 (10-23)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
<td>69</td>
<td>12</td>
<td>3 (2-5)</td>
</tr>
<tr>
<td>069</td>
<td>Charlestown, near Schrafft’s Center at BOS-017 outfall - marine</td>
<td>S</td>
<td>133</td>
<td>25</td>
<td>7 (4-11)</td>
</tr>
<tr>
<td>137</td>
<td>Mystic River, upstream of Tobin Bridge – marine/Inner Harbor</td>
<td>S</td>
<td>22</td>
<td>10</td>
<td>2 (0-4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
<td>113</td>
<td>24</td>
<td>5 (3-8)</td>
</tr>
</tbody>
</table>

1Results in italics are fecal coliform, not E. coli. E. coli testing was discontinued in 2007 in marine waters for methodological reasons. Geometric mean limit for Enterococcus is 35 counts/100 mL in marine water, 33 counts/100 mL in freshwater. The E. coli limit is 126 counts/100 mL.
**Figure 4-8. Enterococcus by rainfall condition, Mystic River/Alewife Brook, 2013.**

Dotted line shows State standard of 33 counts/100 mL for freshwater. Rainfall is NOAA rainfall from Logan airport. “Dry”: no rainfall for previous 3 days; “Heavy”: more than 0.5 inches in previous 3 days; “Damp” and/or rain distant in time: any rain < 0.15 inches at least two or three days previous to sampling and/or 0.1 inches in previous day; “Light rain”: between 0.1 and 0.5 inches in previous day and/or between 0.15 and 0.5 in two previous days.
Figure 4-9. Enterococcus over time, Alewife Brook by phase of Long Term CSO Plan and rainfall condition.

Dotted line shows State standard. Data includes results for stations 174, 172, 074 and 070. Rainfall is NOAA rainfall from Logan airport. “Dry”: no rainfall for previous 3 days; “Heavy”: more than 0.5 inches in previous 3 days; “Damp” and/or rain distant in time: any rain < 0.15 inches at least two or three days previous to sampling and/or 0.1 inches in previous day; “Light rain”: between 0.1 and 0.5 inches in previous day and/or between 0.15 and 0.5 in two previous days.

Figure 4-10. Enterococcus over time, Mystic River by phase of Long Term CSO Plan and rainfall condition.

Dotted line shows State standard. Data includes results for all Mystic River stations excepting Alewife Brook. Rainfall is NOAA rainfall from Logan airport. “Dry”: no rainfall for previous 3 days; “Heavy”: more than 0.5 inches in previous 3 days; “Damp” and/or rain distant in time: any rain < 0.15 inches at least two or three days previous to sampling and/or 0.1 inches in previous day; “Light rain”: between 0.1 and 0.5 inches in previous day and/or between 0.15 and 0.5 in two previous days.
4.5 Summary of Mystic River/Alewife Brook water quality

In 2013, water quality conditions generally met clarity and dissolved oxygen standards downstream of the Alewife, in the river mainstem and at the river mouth, though bottom-water dissolved oxygen concentrations were lower than normal at some lower Mystic locations. The Alewife Brook did not meet standards for bottom-water dissolved oxygen or water clarity.

Overall, bacteria concentrations in the Mystic River met standards for much of the upper and lower Mystic Basin and Mystic River mouth in dry weather, damp and light rain, but failed to meet limits in heavy rain and in all conditions in the Alewife Brook, which had an increase in bacterial concentrations compared to past years, particularly at the most upstream location, in the Little River, upstream of all Alewife CSOs.

With the exception of the Alewife, most locations in the Mystic River did meet Enterococcus geometric mean limits overall. While the Alewife did not meet Enterococcus or E. coli standards in dry or wet weather, conditions in the mainstem downstream of the Alewife/Mystic confluence suggest a limited influence of Alewife Brook on bacterial water quality in the river mainstem.

With the exception of occasionally elevated upstream chlorophyll concentrations, 2013 nutrient parameters were largely similar to previous years, with monthly concentrations near long term averages. As in past years, the area upstream of the Amelia Earhart dam near Malden River confluence was the most eutrophic, with consistently elevated chlorophyll $a$ and low dissolved oxygen relative to upstream locations, and the most pronounced changes in seasonal nitrogen concentrations.
REFERENCES


MADEP. 1996. Massachusetts surface water quality standards. Massachusetts Department of Environmental Protection, Division of Water Pollution Control, Technical Services Branch. Westborough, MA (Revision of 314 CMR 4.00, effective January, 2008).


MWRA. 2009. (DCN 5000.0). Department of Laboratory Services Quality Assurance Management Plan, Revision 3.0. Massachusetts Water Resources Authority, Boston, MA.


MWRA 2013. Letter dated April 30 to USEPA and MA DEP regarding CSO Discharge Estimates and Rainfall Analyses for Calendar Year 2011. Massachusetts Water Resources Authority, Boston, MA.


APPENDICES

Appendix I
Mystic River, percent compliance with *Enterococcus* single sample limit by river segment

Appendix II
2013 raw data, laboratory analyses

Appendix III
2013 raw data, physical profile results
Mystic River: *Enterococcus* by river segment
Geometric means and percent of samples meeting State swimming standards, 2011-2013

**Dots are sampling locations. State swimming standards for Enterococcus: single sample limit is 61 cfu/100 mL in freshwater, 104 cfu/100 mL in marine water. Rainfall: Heavy Rain is at least 0.5 inches of rain in previous 48 hours; Light Rain is between 0.1 and 0.5 inches of rainfall in previous 48 hours.**
APPENDIX II
2013 raw data for laboratory results.

Non-detected results have been converted to detection limit for all results except for bacteria, which are converted to 0.
APPENDIX III
2013 raw data for physical profile results.