Summary of CSO Receiving Water Quality Monitoring in Upper Mystic River/Alewife Brook and Charles River, 2007

Massachusetts Water Resources Authority

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Summary of CSO Receiving Water Quality Monitoring in Upper Mystic River/Alewife Brook and Charles River, 2007

Prepared by:

Kelly Coughlin
Environmental Quality Department, Operations Division
Massachusetts Water Resources Authority
100 First Avenue, Boston, MA 02129

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1 Introduction

This report presents a summary of data collected as part of MWRA's ongoing combined sewer overflow (CSO) receiving water monitoring program. The goal of this monitoring is to identify the water quality impacts of CSO flows on water bodies.

During the 2007 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 its 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.

2007 Developments. In 2007, Massachusetts Department of Environmental Protection (MADEP) extended the CSO Variances for the Charles River issued to MWRA, BWSC and the City of Cambridge by three years, to October 1, 2010. MADEP also extended the CSO Variances for the Alewife Brook/Upper Mystic River issued to MWRA, the City of Cambridge and the City of Somerville by three years, to September 1, 2010.

Under the agreement on the Long-Term Control Plan reached by EPA, MADEP and MWRA in March 2006, MADEP agreed to issue a series of three-year variance extensions until 2020, and MWRA agreed to implement the revised Long-Term Control Plan by 2015 and verify the predicted performance of the plan 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 Long-Term Control Plan and other conditions affecting the water quality and uses of these water bodies.

Conditions in the recent variance extensions require MWRA to implement the Long-Term Control Plan and require MWRA and the municipalities to continue to implement the Nine Minimum Controls of EPA's National CSO Control Policy. MWRA is also required to continue its water quality sampling program, and all of the CSO permittees are required to report estimated CSO discharge frequency and volume from their respective outfalls to these receiving waters on an annual basis.

2007 CSO progress as it relates to the Alewife Brook/Mystic River and Charles River include the following:

- In March 2007, MWRA completed construction of the $14.3 million BOS019 CSO Storage Conduit in Charlestown. The storage conduit captures up to 670,000 gallons of CSO, reducing the average annual number of discharges at outfall BOS019, which outlets to the Little Mystic Channel, from 13 to 2 and reducing total annual discharge volume at this outfall by 86%, from 4.4 million gallons to 0.6 million gallons. In the 15-month period from March 31, 2007 through June 30, 2008, CSO has entered the facility during 28 storms, and 6.8 million gallons of overflow that previously would have discharged to Little Mystic Channel was captured during these events and pumped back to the collection system after the storms for transport to the Deer Island treatment plant. Only during two of these storms, on April 16, 2007, and February 13, 2008, did the overflow exceed the storage capacity of the conduit and cause a discharge of the net flow to the Little Mystic Channel.

- On March 30, 2007, MWRA submitted its report on the optimization study of the Prison Point CSO Facility to EPA and DEP. In the report, MWRA recommended a set of wet weather operational improvements predicted to reduce the number of treated discharges to the Inner Harbor near the Charles River mouth from 30 to 17 in a typical rainfall year and reduce the facility's average annual discharge volume from 335 million gallons to 250 million gallons. MWRA continues to implement the operational strategies and track the improved performance of the facility.

- MWRA, BWSC and the Town of Brookline continued to make substantial progress to implement the set of new projects that were added to the Long-Term Control Plan by the agreement with EPA and DEP of March 2006, to further reduce CSO discharges to the Charles River. MWRA received the 100% design plans and specifications for the $3.8 million Cottage Farm Brookline Connection and Inflow Controls project. MWRA also procured design services for the $2.0 million Charles River Interceptor Gate Controls/Additional Interceptor Connections project.

- The Town of Brookline and BWSC completed field investigations, preliminary design plans and related reports for the Brookline Sewer Separation project and the Bulfinch Triangle Sewer Separation project, respectively. These projects are intended to improve upon the substantial reduction in pollutant loadings to the Charles River already achieved through major CSO related investments by MWRA, BWSC, Brookline and Cambridge.

- In November 2007, the City of Cambridge installed floatables control at CSO outfalls CAM007 and CAM017 and closed CSO outfalls CAM009 and CAM011 on the Charles River.

As of the end of 2007, 27 CSOs have been closed in the Boston Harbor and its tributaries since the early 1990s, 57 CSOs remain active. In the Charles, ten CSOs remain active and nine have been closed (most recently CAM009 and CAM011). In the Alewife Brook, eight CSOs remain active, five have been closed. In the Mystic River one treated CSO (Somerville Marginal) remains active in the Lower Mystic, discharging at two locations depending on tide (MWR205A upstream of the Amelia Earhart dam and MWR205 in the marine river mouth).

System-wide, average annual CSO discharge has been reduced by 2.7 billion gallons since 1988, an 81% reduction. Other system improvements since the 1990s have also reduced the frequency and volume of CSO flows over the period of the monitoring program and has resulted in increased treatment of remaining flows. These improvements include increased pumping capacity at Deer Island Treatment Plant; improvements to MWRA's pumping and interceptor systems; completion of nine minimum controls; and completion of system optimization projects. Figure 1-1 shows the estimated CSO flow reduction system-wide since 1987, and Figure 1-2 shows the CSO flow reduction by receiving water. For purposes of this report, receiving water quality data from 1998 to the present is considered representative of current conditions.

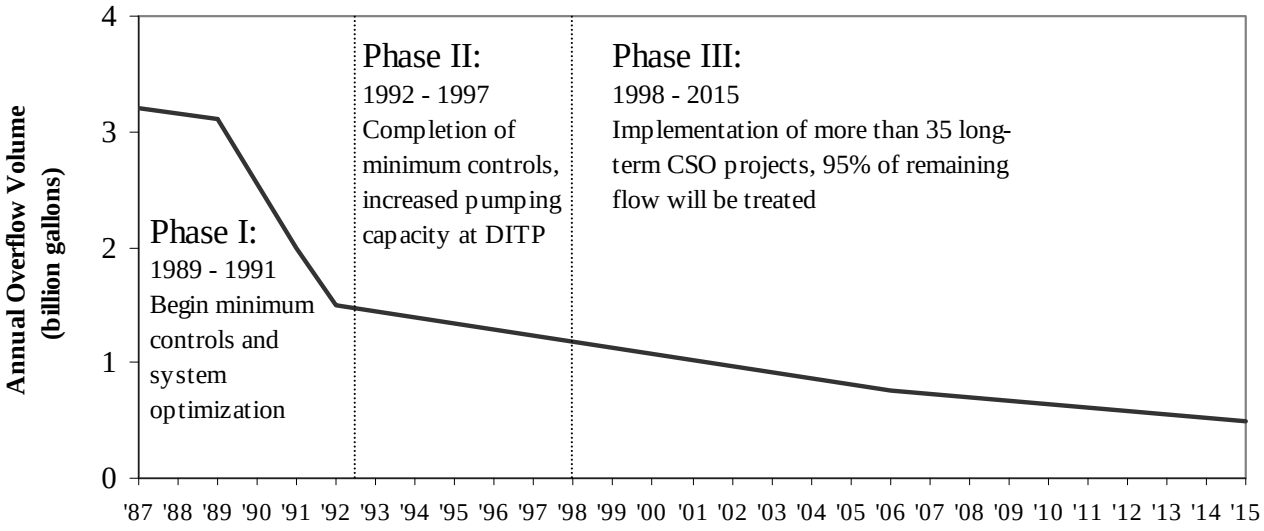

Figure 1-1. Estimated CSO flow reductions, 1987 – 2015.

Source: MWRA CSO Annual Progress Report 2007

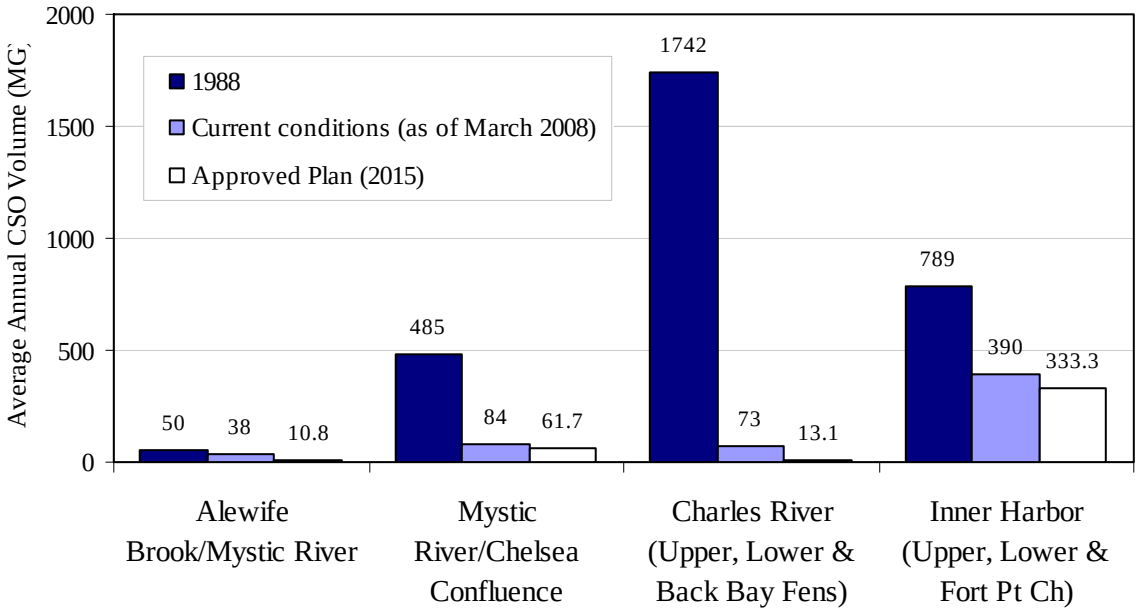

Figure 1-2. CSO Typical Year Discharge Volumes for 1988, Current, and Approved Long Term Control Plan model estimates

Source: MWRA CSO Annual Progress Report 2007

1.1 Overview of the monitoring program

MWRA's CSO receiving water quality monitoring program has been ongoing since 1989. 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 for at least six years.

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* and *Enterococcus*), dissolved oxygen, water clarity (Secchi depth, total suspended solids), nutrients (phosphate, ammonium, nitrate/nitrite) and chlorophyll.

The purpose of the report is to summarize 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 1998 – 2007 are analyzed together, and data for 2007 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. A complete list of stations, with descriptions for the Charles and Mystic River/Alewife Brook appear in Section 3.1 and 4.1, respectively.

2.1.2 Sampling schedule

Approximately 20 station visits or more were made to each location each year. Sampling was 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. In some cases, stations with known contamination problems were specifically targeted for wet weather sampling.

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, directly into rinsed sample containers. Bottom samples were collected with a Kemmerer sampler at 0.5 meters above the sediment surface at locations deeper than approximately 4 meters. Beginning in 2000, bottom water quality measurements were made at most locations regardless of depth. 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 2-1. Field measurements.

Variable	Instruments used
Temperature, conductivity/salinity, dissolved oxygen, turbidity, pH	YSI model 3800 Water Quality Logger (1994 - 2001) Hydrolab Datasonde 4 (1997-2007) Hydrolab Datasonde 5 (2003 - 2007) YSI 600XL for temperature, conductivity, dissolved oxygen (1999 – 2007)
Secchi Depth	Wildco 8-inch limnological secchi disk (upstream of dams) Wildco 8-inch oceanographic secchi disk (marine waters)

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 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 2006).

Table 2-2 lists the analytes measured and methods used in the monitoring program.

Table 2-2. Laboratory measurements.

Analyte	Method
Enterococcus	Standard Methods 9230C 2c, membrane filtration (for samples collected 1996 – 1998) EPA Method 1600 (for samples collected 1999–2006, some 2007) Enterolert (for samples collected 2007)
E. coli (measured from 2001 – 2007)	Modified EPA 1103.1, membrane filtration (for samples collected 2000–2006) Colilert (for samples collected 2007)
Fecal coliform (limited measurements after 2001)	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 GF/F
Phosphate	Murphy and Riley (1962), modified as in Clesceri et al (1998, Method 4500-P F) Skalar SAN^{plus} autoanalyzer, Whatman GF/F filters
Total Nitrogen	TN and/or TDN: Solarzano and Sharp (1980b), Whatman G/F filters; PN: Perkin Elmer CHN analyzer, Whatman GF/F
Ammonium	Fiore and O'Brien (1962), modified as in Clesceri et al (1998, Method 4500-NH3 H), Skalar SAN^{plus} autoanalyzer, Whatman GF/F filters
Nitrate+nitrite	Bendshneider and Robinson (1952), modified as in Clesceri et al (1998, Method 4500-NO3 F), Skalar SAN^{plus} autoanalyzer, Whatman GF/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.

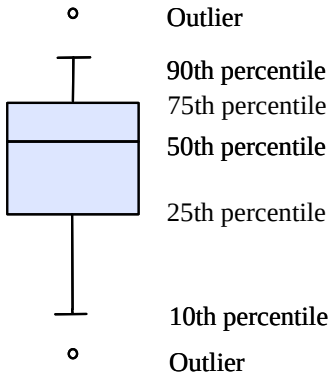

Figure 2-1. Percentile distributions indicated on percentile plots

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 10^{th}, 25^{th}, 50^{th}, 75^{th}, and 90^{th} percentiles. Single measurements beyond these ranges (outliers) are displayed as dots.

The plots display the range and central tendencies of the data to be seen and allow for easy comparison of the results among stations. Since part of the Massachusetts standard is a percentile, these plots are particularly appropriate (see Section 2.3 for a description of these guidelines). The 50^{th} percentile or 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). As of January 2008, the MADEP standard for Class SB waters (fishable swimmable) are based on *E. coli* and/or *Enterococcus* counts for freshwater, and *Enterococcus* counts for marine waters, following a USEPA recommendation for *Enterococcus* in marine waters (USEPA 1986). The Massachusetts Department of Public Health has issued regulations for beach management based on the USEPA criteria. The Massachusetts Division of Marine Fisheries continues to use fecal coliform counts to assess suitability for shellfish growing waters.

Table 2-3. Water quality standards for Class B and Class SB waters[1].

Designated Use/Standard	Parameter	Support
Inland waters, Class B, warm water fishery Massachusetts waters, MADEP	Dissolved Oxygen	≥ 5.0 mg/l ≥ 60% saturation unless background conditions lower
	Temperature	≤ 28.3ºC (83ºF)
	pH	6.0 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	< 26.7ºC (80ºF)
	pH	6.5 to 8.5 S.U.
Primary contact recreation (designated swimming area), EPA and MADPH guidelines and, as of 2007, primary contact recreation, Massachusetts MADEP	*Enterococcus*	Single sample limit 61colonies/100 ml (freshwater), 104 colonies/100 ml (marine); geometric mean 33 colonies/100 ml (freshwater), 35 colonies/100 ml (marine)
Freshwater primary contact recreation (designated swimming area), EPA and MADPH guidelines; and, as of 2007, primary contact recreation, Massachusetts MADEP	*E. coli*	Single sample limit 235 colonies/100 ml (freshwater only); geometric mean 126 colonies/100 ml (freshwater only)
Prior to 2007, primary contact recreation, Massachusetts MADEP	Fecal coliform	Geometric mean ≤ 200 colonies/100 ml, no more than 10% of samples above 400 colonies/100 ml
Restricted shellfishing, Massachusetts MADMF	Fecal coliform	Geometric mean ≤ 88 colonies/100 ml

[1] All receiving water areas discussed in this report are either Class B or SB according to MADEP standards current as of January 2007.

From MADEP 1996:

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 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 2007). The river segment is approximately 10.3 km (8.6 mi) long. The New Charles 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 Stony Brook outlet and CSO (MWR023), Faneuil Brook outlet and CSO (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.

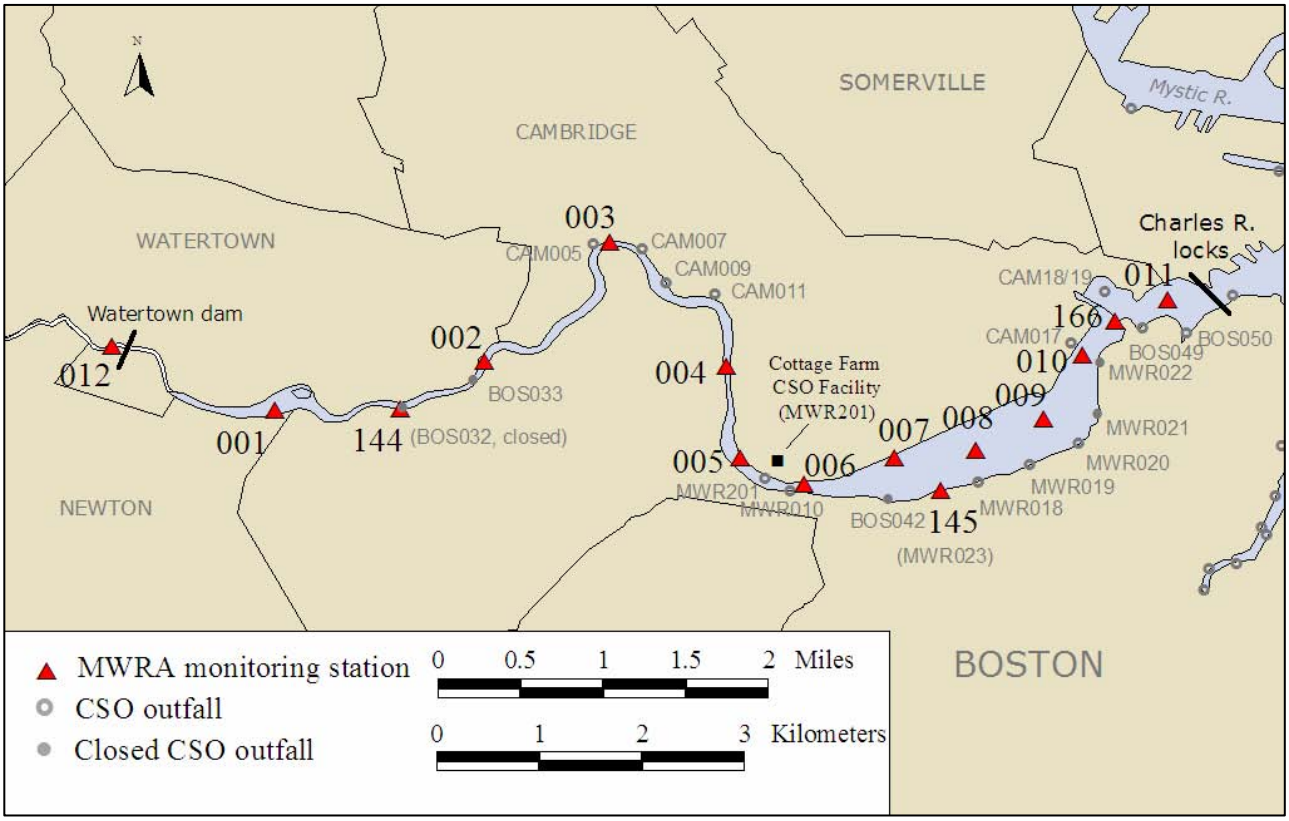

Figure 3-1. Map of MWRA Charles River sampling locations

Table 3-1. MWRA monitoring locations, Charles River Basin.

Reach	Description of Reach	Sampling location	Location Description
Upper Basin (Class B/ Variance, warm water fishery)	Watertown dam in Watertown, downstream to Magazine Beach (near BU Bridge) in Cambridge	012, Watertown	Watertown Dam at footbridge (upstream of all CSOs)
		001, Newton	Downstream of Newton Yacht Club (upstream of all CSOs)
		144, Allston	Faneuil Brook outlet (at BOS032, closed 11/97)
		002, Allston	Downstream of Beacon St. bridge (downstream of BOS033, closed 10/96)
		003, Cambridge	Downstream of Eliot Bridge, Cambridge side (at CAM005)
		004, Cambridge/Allston	Between River St. and Western Ave. bridges
		005, Cambridge	10 m off of Magazine Beach
Mid-Basin (Class B/Variance, warm water fishery)	BU Bridge on Boston/Cambridge line to downstream of Longfellow Bridge	006, Cambridge/Boston	BU Bridge, downstream side (downstream of MWR201)
		007, Cambridge	MIT Boathouse, Cambridge side
		145, Boston	Stony Brook outlet, Boston side (at MWR203)
		008, Cambridge/Boston	Mass. Ave bridge, downstream side (downstream of MWR203, MWR018)
		009, Cambridge/Boston	Longfellow Bridge, upstream side (downstream of MWR021, closed 3/00)
		010, Boston	Longfellow Bridge, downstream side (downstream of MWR022, closed 3/00)
Lower Basin (Class B/Variance, warm water fishery)	Science Museum to North Station railroad bridge, near Charlestown.	166, Boston	Science Museum, upstream of old dam (downstream of all lower basin CSOs)
		011, Boston	Between Science Museum and New Charles Dam/locks (downstream of all Charles CSOs)

Sampling locations are midstream unless otherwise noted. Sampling at stations 002, 003, and 004 was restored after a hiatus from 2002 - 2005.

3.2 Pollution sources

Known pollution sources to the Charles River are shown in Table 3-2. Contamination upstream of the Watertown Dam has been evident since MWRA's monitoring program began in 1989, though conditions have improved since the mid-1990s. 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. With increases in sewer system capacity, the number of activations at Cottage Farm has significantly decreased in recent years – from 26 activations in 1996 to 3 activations for calendar year 2007. The Stony Brook/Muddy River outlet near Kenmore Square is a source of contaminated brook flow and stormwater flows to the basin area. In 2006, BWSC completed the Stony Brook sewer separation project at a cost of $45.1 million, reducing annual CSO discharge volumes to the Stony Brook by 99.7%. In November 2007, the city of Cambridge closed CAM009 and CAM011 (between monitoring stations 003 and 004).

The receiving water program is designed to capture water quality representative of all rainfall conditions. Table 3-3 summarizes the proportion of samples collected in dry, damp, and wet weather for 1998-2007.

Table 3-2. Charles River Basin pollution sources.

Source	Upper Basin	Mid-Basin	Lower Basin
CSOs (untreated)	2 active, 4 closed CAM005, CAM007 CAM009 closed 11/07 CAM011 closed 11/07 BOS032 closed 11/97 BOS033 closed 10/96	6 active, 3 closed MWR010, MWR023, MWR018, MWR019, MWR20, CAM017 BOS042 closed 5/96 MWR021 closed 3/00 MWR022 closed 3/00	1 active BOS049 (to be closed)
CSO treatment facility (settling and detention; screened, chlorinated and dechlorinated CSO discharge)	No	Yes Cottage Farm (MWR201) Activated 6 times in 2007	No
Storm drains	Yes	Yes	Yes
Upstream inputs (elevated bacteria counts upstream)	Yes	Yes	Yes
Dry weather inputs (elevated bacteria counts in dry weather)	Yes	Yes	Yes
Tributary brook or stream flow	Yes	Yes	Yes

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

Sampling period	Dry[1]	Damp[1]	Wet[1]	Total
1998 - 2006	29.5% 1125 samples	28.7% 1094 samples	41.8% 1595 samples	100% 3814 samples
2007	32.9% 118 samples	21.4% 77 samples	45.7% 164 samples	100% 359 samples

[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, 1998-2007

A detailed summary of water quality results collected from 1998 through 2007 is shown in Table 3-4.

Table 3-4. Summary of water quality, Charles River Basin 1998 – 2007.

Parameter		MA DEP Water Quality Guideline or Standard	Upper Basin				Mid-Basin				Lower Basin			
			Mean ± SD	% meeting guideline	Range	n	Mean ± SD	% meeting guideline	Range	n	Mean ± SD	% meeting guideline	Range	n
Surface Temperature (°C)[1]	Summer	<28.3	20.9 ± 4.5	99.2	7.2 - 29.3	1257	21 ± 4.1	98.7	8.8 - 29.8	1517	21.6 ± 4.4	94.4	11.2 - 30.2	623
	Winter		2.8 ± 3.1	100.0	-1.1 - 15.6	179	ND	ND	ND	0	3.4 ± 2.8	100.0	-1.5 - 13.7	166
Bottom water dissolved oxygen (mg/L)[1]	Summer	5.0	7.4 ± 1.8	92.0	0.2 - 13.6	1231	5.7 ± 3.1	68.4	0 - 12.7	1478	6.8 ± 2.4	80.0	0.3 - 13.1	615
	Winter	5.0	13.5 ± 1.4	100.0	5.5 - 16.1	178	ND	ND	ND	0	12.6 ± 0.9	100.0	10.1 - 15.8	164
pH (S.U.)		6.5-8.3	7.2 ± 0.4	96.1	5.3 - 9.2	1937	7.3 ± 0.5	92.7	6 - 9.5	2269	7.4 ± 0.6	90.4	5.1 - 9.5	1055
Water clarity	Total Suspended Solids (mg/L)	NS	4.9 ± 2.9	-	0.5 - 19.3	376	ND	-	ND	0	4.4 ± 2.2	-	0.7 - 14.4	371
	Secchi depth (m)	NS	0.9 ± 0.3	-	0.3 - 2.1	654	1 ± 0.3	-	0.3 - 6	1277	1.2 ± 0.3	-	0.4 - 2.2	244
	Turbidity (NTU)	NS	6 ± 4.7	-	0 - 36.1	1071	7.6 ± 5.3	-	0 - 42.5	1595	4.3 ± 4.3	-	0 - 45.2	654

Table 3-4. Summary of water quality, Charles River Basin 1998 – 2007, continued.

Parameter		MA DEP Water Quality Guideline or Standard	Upper Basin				Mid- Basin				Lower Basin			
			Mean ± SD	% meeting guideline	Range	n	Mean ± SD	% meeting guideline	Range	n	Mean ± SD	% meeting guideline	Range	n
Bacteria (col/100mL)[2]	Fecal coliform (1998 – 2000)	200 / 400[3]	228 (203-257)	48.0	0 - 158000	688	80 (71-90)	57.2	0 - 43300	876	49 (42-58)	68.3	0 - 18200	407
	E. coli (2001- 2007)	126 / 235[3,4]	178 (158-201)	43.7	0 - 12300	692	64 (57-71)	71.0	0 - 34400	1256	42 (36-49)	79.9	0 - 10500	453
	Enterococcus (1998- 2007)	33 / 61[3]	62 (55-70)	38.9	0 - 17600	1372	14 (13-15)	69.3	0 - 9200	2123	11 (10-13)	75.1	0 - 8900	856
Nutrients (µmol/L)	Phosphate	NS	0.74 ± 0.44	-	0.11 - 3.01	375	ND	-	ND	0	0.71 ± 0.52	-	0.04 - 3.63	365
	Ammonium	NS	5.7 ± 4.4	-	0.2 - 42.9	376	ND	-	ND	0	8.9 ± 6.8	-	0 - 32.1	366
	Nitrate+nitrite	NS	39.5 ± 20.5	-	0 - 116	374	ND	-	ND	0	36.1 ± 20.9	-	0 - 107.1	364
Algae (µg/L)	Chlorophyll	25[5]	7.2 ± 7.1	95.6	0.5 - 37.6	362	ND	-	ND	0	15.8 ± 16.3	80.2	0.7 - 112	353

NS: no standard or guideline. ND: No data. [1]: Summer (June-September), Winter (December-March).

[2]: For bacterial data, 95% confidence intervals are provided in lieu of standard deviations. Fecal coliform is no longer used as an indicator of suitability for primary recreation. Most recent results for 2000-2001 are shown for comparison.

[3]: First 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 fecal coliform, MADEP had an additional limit in that more than 90% of single samples must meet the single sample limit of 400 colonies/100mL.

[4]: *E. coli* or *Enterococcus* is an acceptable indicator for Massachusetts Department of Public Health, EPA, and MADEP to assess suitability for swimming in freshwater.

[5]: NOAA guideline.

3.4 Trends in water quality, 2007

This section provides an analysis of spatial trends for water quality parameters measured in the lower Charles in the 2007 monitoring year.

3.4.1 Physical measurements

Temperature. Summer mean temperatures for 2007 are shown for each sampling location in the top graph in Figure 3-2. Temperature profiles are relatively consistent upstream to downstream, with bottom-water temperatures relatively low in the deepest stations, 009 and 010, where depths average 6 to 7 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 slight.

Dissolved Oxygen. The spatial trend in dissolved oxygen (DO) in the Charles Basin differs for surface and bottom waters, shown in the center graph of Figure 3-2. Mean surface DO meets the State standard of 5.0 mg/L at all locations at the surface, but mean bottom water DO consistently fails to meet meets the standard at most Mid- and Lower-Basin locations. 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 (Stations 009 and 010). Station 166, downstream of the lower basin, is collected at a relatively shallow near-shore location and does not reflect the low levels of deeper water. Station 011 has the highest bottom water salinity of any of the locations (data not shown), but does have slightly higher dissolved oxygen levels than basin locations located further upstream – likely reflecting the influence of more highly oxygenated ocean water infiltrating the New Charles Dam.

Water clarity. Water clarity is indicated by Secchi disk depth. Summer (June through September) Secchi results shown for individual sampling locations in the bottom graph in Figure 3-2. (Because of its shoreline location, Secchi disk depths are not measured at Station 166). In general, there is a pattern of increasing water clarity from upstream to downstream. Most Secchi depths average approximately 1.0 meter in the summer months, which fails to meet the State guideline of 1.2 meters.

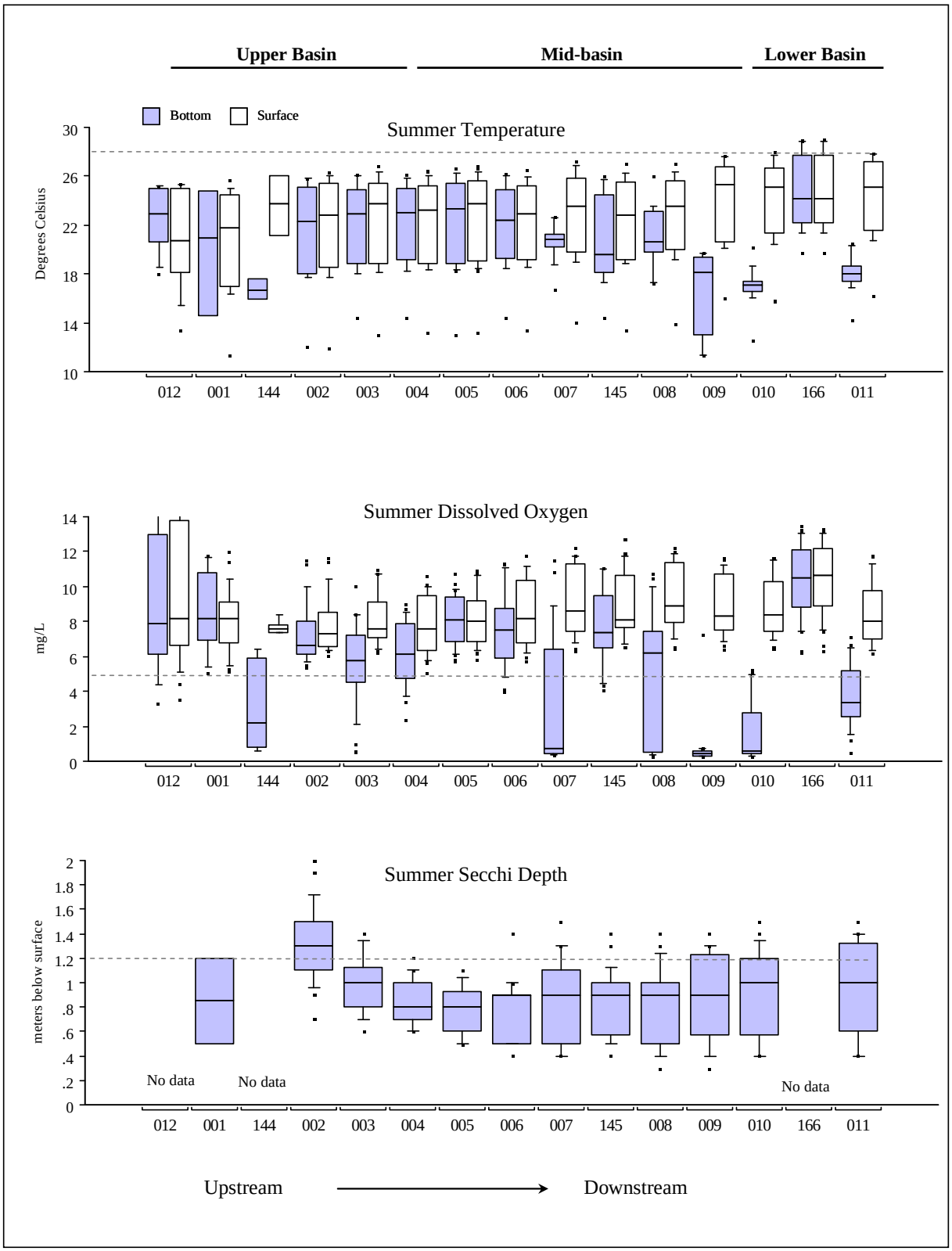

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Figure 3-2. Summer temperature, dissolved oxygen, and Secchi depth, Charles River Basin, 2007.

Dashed lines are State standards. No Secchi data is available for Station 012 because it is too shallow.

3.4.2 Nutrients, TSS and chlorophyll

Monthly averages for total nitrogen, ammonium, nitrate/nitrite, total phosphorus, phosphate, total suspended solids, and chlorophyll *a* at the upstream (166) and downstream (012) locations in the lower Charles are shown in Figure 3-3 and Figure 3-4, respectively. Nutrient monitoring began in 1997, immediately-+- prior to the latest phase of the CSO plan used in this report. There is no evidence of a trend in nutrient or clarity measures since monitoring began.

However, in the shorter term, results do show strong seasonal trends. 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 marked differences between the two stations for ammonium, total suspended solids and chlorophyll *a*. Total suspended solids increases in the spring months at Station 012, but there is a less dramatic increase downstream of the lower basin at Station 166.

Trends for the 2007 monitoring year are similar to the 1998-2006 averages, although chlorophyll *a* and total suspended solids at Watertown Dam (Station 012) were lower than average. The Science Museum location (Station 166) had below average concentrations for ammonium for the year, but an increase in total phosphorus, total nitrogen, and total suspended solids in early autumn.

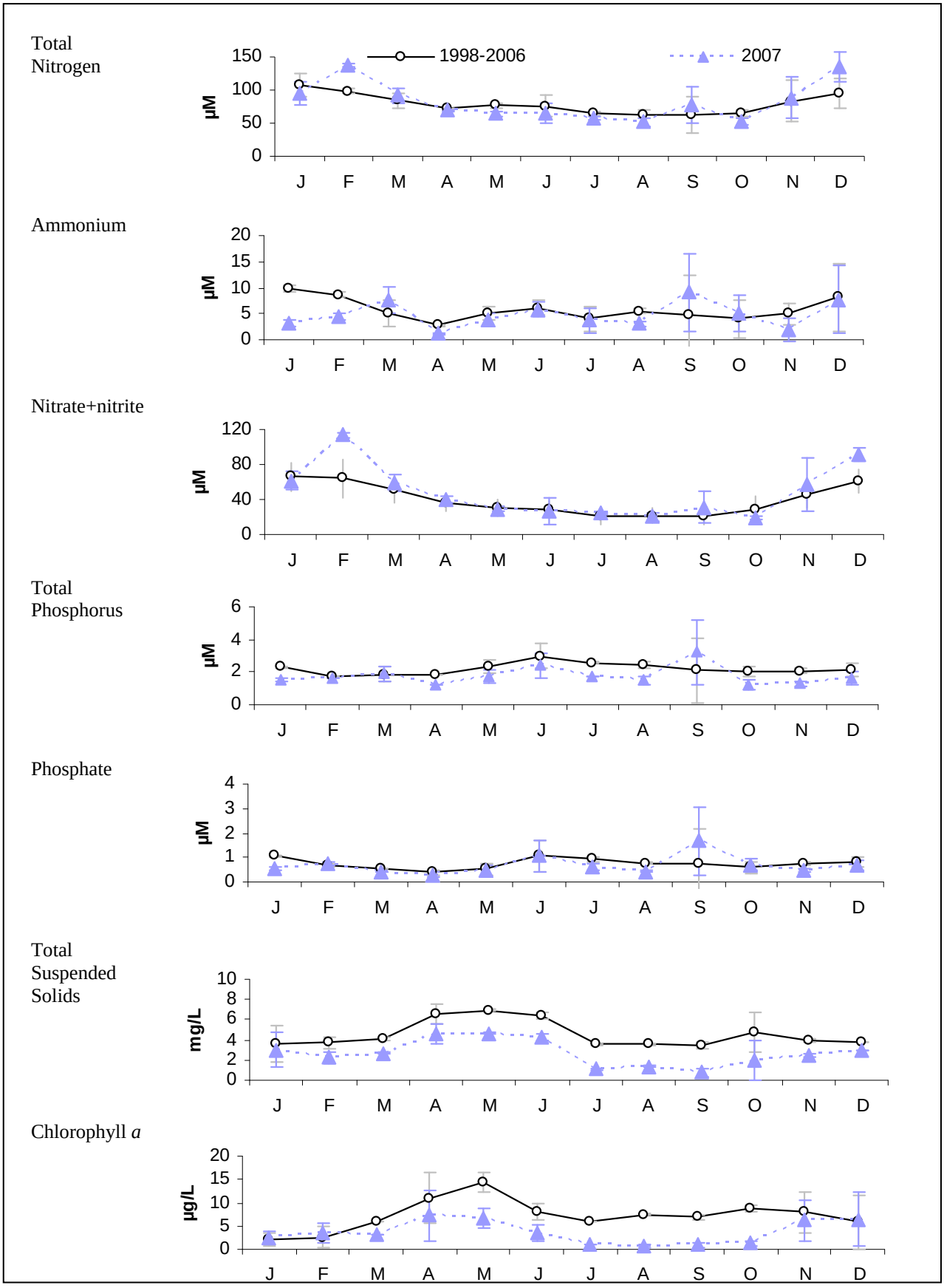

Figure 3-3. Monthly average nutrients, TSS and Chlorophyll 1998 – 2007, Station 012, Watertown Dam.

Error bars are 95% confidence intervals.

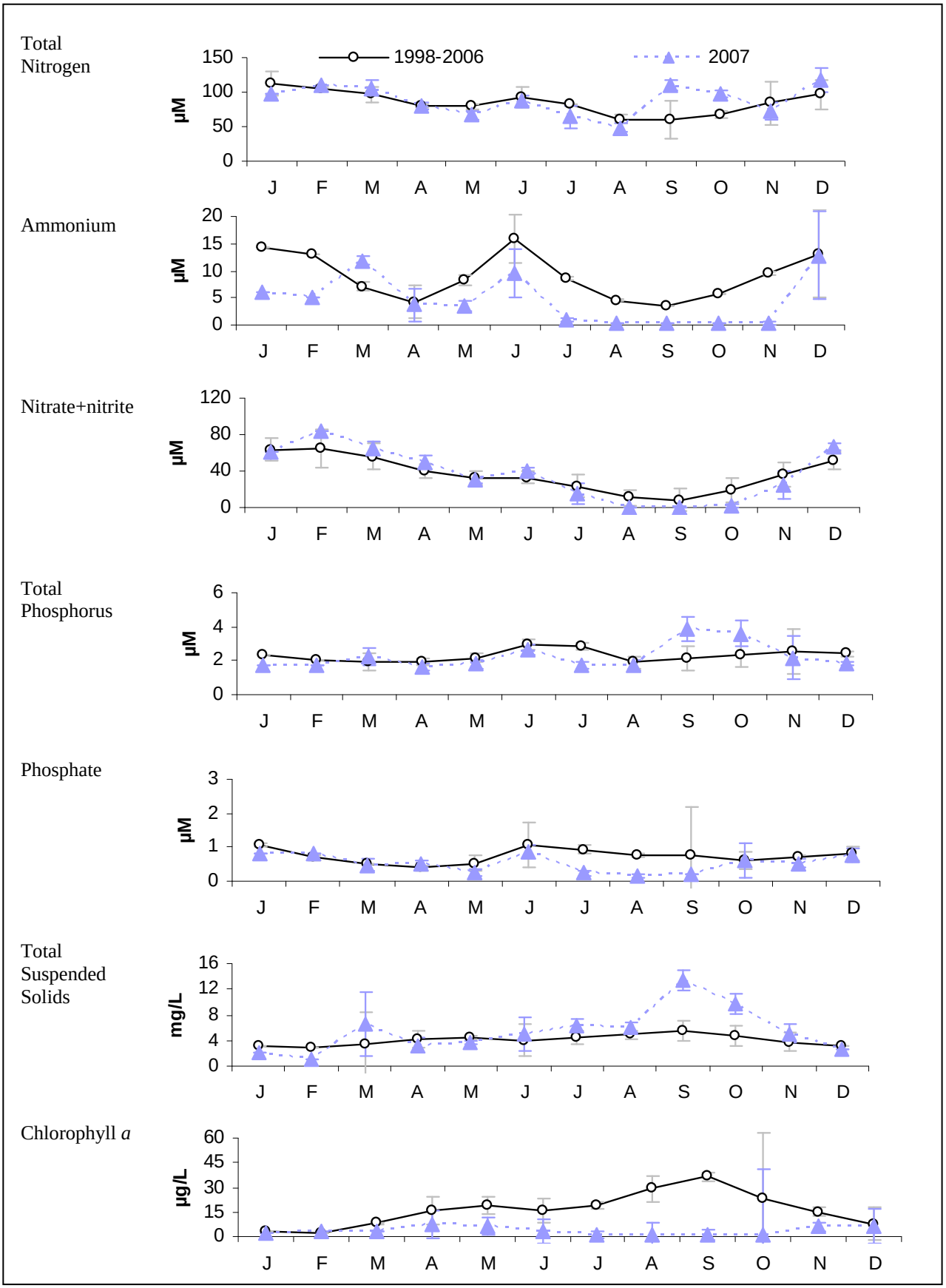

Figure 3-4. Monthly average nutrients, TSS and Chlorophyll 1998 – 2007, Station 166, Science Museum.

Error bars are 95% confidence intervals.

3.4.3 Bacterial water quality

Figure 3-5 shows the current bacterial water quality at each location sampled in the Charles for 2007. Bacterial water quality in the Charles varies upstream to downstream, with upstream reaches generally having generally more elevated bacteria counts than downstream locations.

Geometric means for each location for 1998 – 2007 appear in Table 3-5. Geometric means for 2007 are shown in a separate column from 1998-2006 results. If confidence intervals for the two periods overlap, this indicates no statistically significant difference between the two means.

Enterococcus. The uppermost graph in Figure 3-5 shows percentile plots of *Enterococcus* counts arranged from upstream to downstream locations for 2007. Figure 3-6 shows the impact of rainfall on the three river reaches on *Enterococcus* densities, along with the change at locations near CSO outfalls. All reaches show a similar pattern, with wet weather mean counts generally higher than in dry weather. Bacterial water quality of the most upstream locations in the Upper Basin (upstream of CSOs) improved markedly in 2007, indicating reduced impacts of non-CSO sources of contamination.

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, particularly in the latest phase (1998 – 2007, $p < 0.0001$, ANOVA, analysis not shown). The Upper Basin shows improvement in both dry and wet conditions but does not yet consistently meet the geometric mean swimming standard. When all results from 1998 onwards are included, however, results for 2007 look promising. For the 1998-2007 period, the most pronounced change is in the lower Charles, which meets the geometric mean swimming standard in all but heavy rain. Since the mid-1990s, the greatest improvement in bacterial water quality was in light and heavy rain, with less improvement in dry and damp conditions.

E. coli. The center graph in Figure 3-5 shows percentile plots of *Enterococcus* counts arranged from upstream to downstream locations for 2007. Generally, *E. coli* shows the same trend as *Enterococcus*, however geometric mean *E. coli* for most locations are near the swimming standard of 126 colonies/100 mL, compared to *Enterococcus* geometric means, which are well within the swimming standard for *Enterococcus*.

Fecal coliform. Fecal coliform monitoring was reduced, replaced with *E. coli* beginning in mid-2001. No fecal coliform samples were collected in 2007 so results for 2001-2002 are shown only for comparison. Fecal coliform appears in the bottom graph in Figure 3-5.

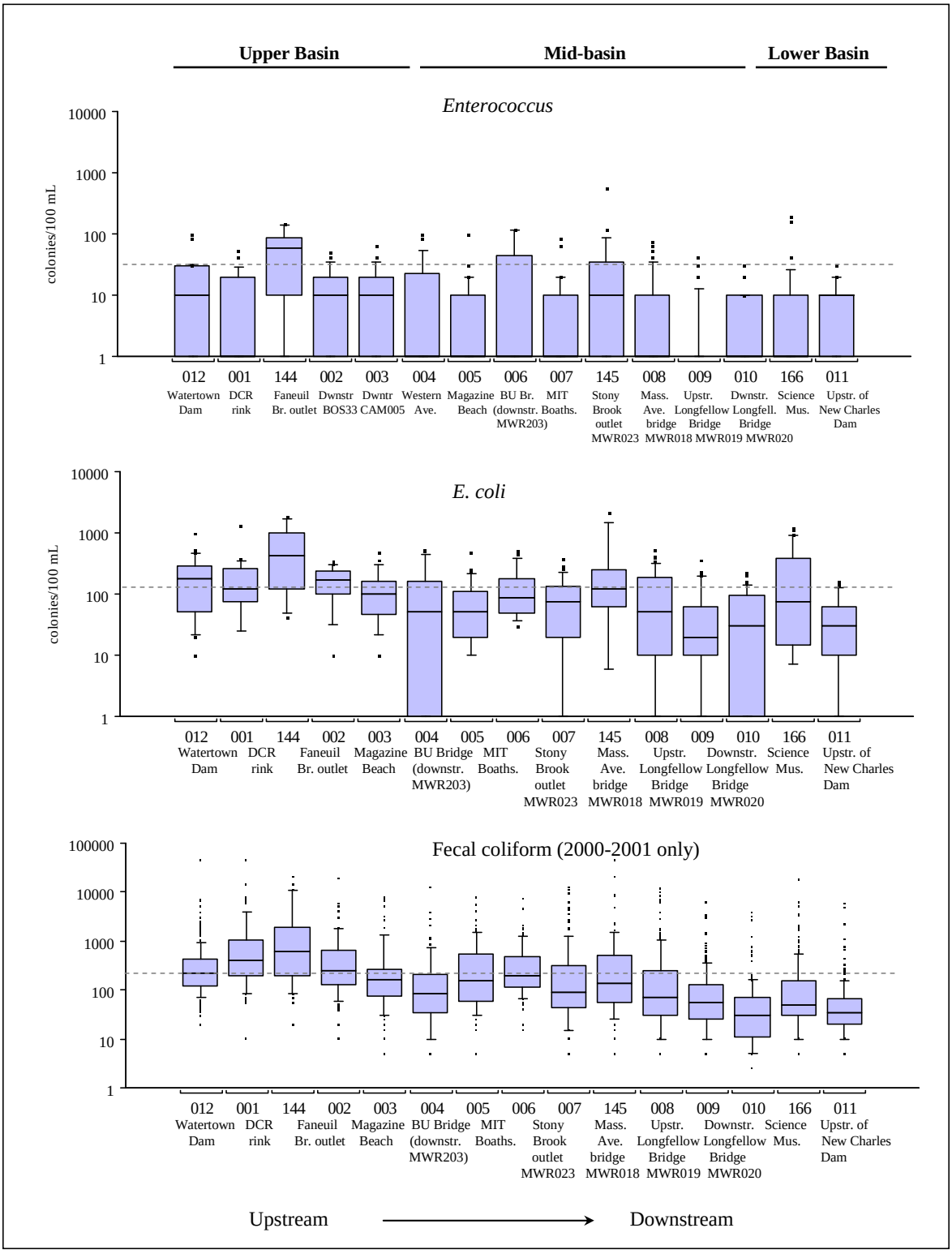

Figure 3-5. Indicator bacteria concentrations, Charles River Basin, 2007.

Dotted lines show MADEP *Enterococcus* and *E. coli* standard. Fecal coliform has been phased out from the monitoring program, replaced by *E. coli*, 2000-2001 results are shown with the former standard.

Table 3-5. Geometric mean indicator bacteria, Charles River Basin, 1998 – 2007.

Station	Location	Surface or Bottom	Number of samples[1]	*Enterococcus* (95% CI)		*E. coli* (95% CI)	
				1998 – 2006	2007	2002 - 2006	2007
012	Newtown/Watertown, footbridge upstream of Watertown Dam	S	396/26 172/29	122 (105-142)	7 (4-14)	189 (155-230)	133 (86-204)
001	Newton, near Nonantum Rd., rear of DCR skating rink	S	145/21 63/21	191 (137-265)	3 (1-8)	447 (321-624)	94 (45-196)
144	Brighton, downstream of N. Beacon St. bridge, Faneuil Brook outlet, BOS-032 (closed 1999)	S	67/6 33/6	307 (189-496)	26 (5-118)	328 (127-846)	341 (113-1027)
002	Allston, downstream of Arsenal Street bridge, BOS-033	S	111/21 26/21	87 (62-122)	4 (1-9)	272 (172-430)	131 (89-193)
003	Allston/Cambridge, midstream, near Mt. Auburn Street, between CAM-005 and CAM-006	S	111/21 26/21	49 (34-72)	5 (2-11)	226 (153-334)	74 (41-131)
004	Allston/Cambridge, midstream, between River Street and Western Avenue bridges	S	111/21 26/21	22 (14-33)	3 (1-8)	130 (81-209)	23 (7-68)
005	Cambridge, near Magazine Beach, upstream of Cottage Farm	S	233/21 149/21	38 (29-49)	2 (1-5)	181 (144-227)	44 (26-75)
006	Cambridge/Boston, midstream, downstream of Cottage Farm, BU bridge	S	192/21 106/21	18 (13-24)	5 (2-13)	256 (204-323)	84 (48-147)
007	Cambridge, near Memorial Dr., MIT Boathouse	S	191/21/104/21	17 (12-24)	2 (1-5)	120 (89-163)	29 (11-75)
		B	190/21/103/21	39 (28-53)	3 (1-6)	178 (132-242)	69 (47-101)
145	Boston (Charlesgate), Muddy River/Stony Brook outlet	S	191/21/104/21	40 (29-56)	10 (4-23)	233 (170-320)	100 (38-261)
008	Cambridge/Boston, midstream, downstream of Harvard Bridge	S	191/21/104/21	13 (9-18)	3 (1-7)	75 (54-105)	39 (16-89)
		B	190/21/103/21	23 (17-32)	2 (0-4)	138 (104-183)	33 (13-79)
009	Cambridge/Boston, midstream, upstream of Longfellow Bridge near Community Sailing	S	193/21/106/21	8 (5-10)	1 (0-3)	53 (40-72)	28 (11-66)
		B	191/21/105/21	10 (7-13)	1 (0-2)	14 (10-21)	10 (5-19)
010	Boston, downstream of Longfellow Bridge, MWR-022	S	192/21/106/21	6 (4-9)	2 (1-4)	41 (30-57)	19 (7-50)
		B	192/21/105/21	5 (4-7)	2 (1-4)	9 (6-13)	12 (5-26)
166	Boston, old Charles River dam, rear of Science Museum	S	394/36/166/32	14 (11-18)	2 (1-4)	51 (38-68)	64 (31-130)
011	Boston, upstream of river locks (New Charles River Dam) and I-93, near Nashua St.	S	194/21/107/21	9 (7-11)	1 (0-3)	39 (30-51)	22 (12-40)
		B	194/21/106/21	16 (13-20)	8 (4-14)	37 (29-49)	23 (11-45)

[1]N values for *Enterococcus* and *E. coli* for the 1998-2006 and 2007 periods, respectively.
Fecal coliform sampling was discontinued in 2001 and results are not included in the table.

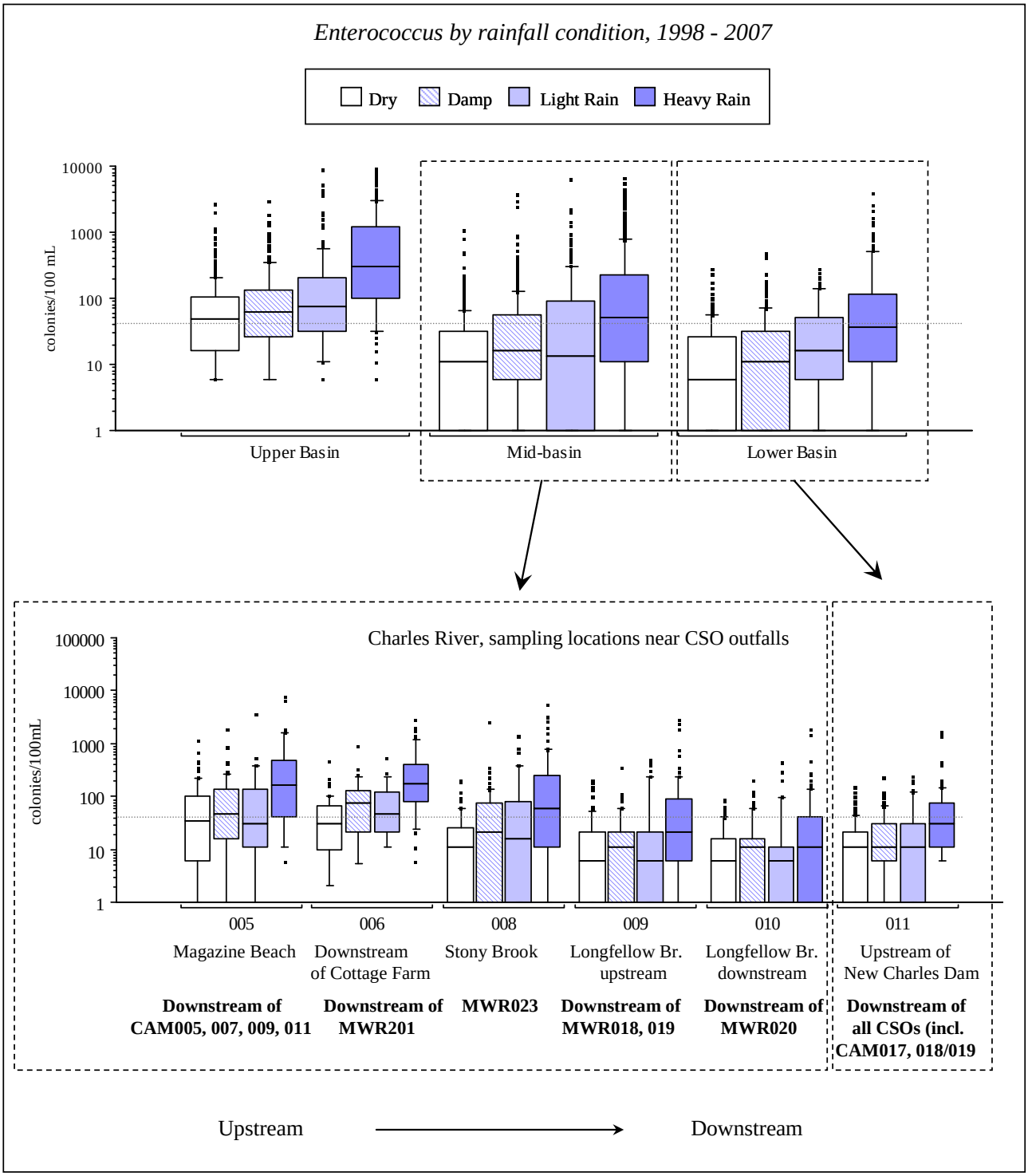

Figure 3-6. *Enterococcus* by rainfall condition, Charles Basin, 1998 - 2007.

Dotted line shows MADEP standard of 33 colonies/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.

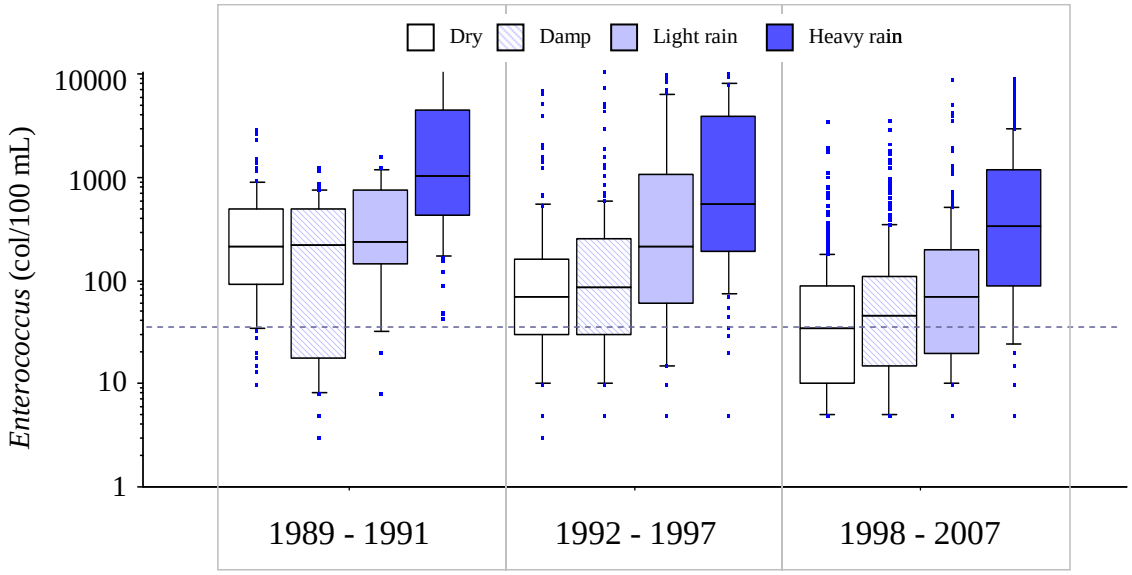

Figure 3-7. *Enterococcus* over time, Upper Charles Basin (upstream of CSOs) by phase of Long Term CSO Plan and rainfall condition.

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.

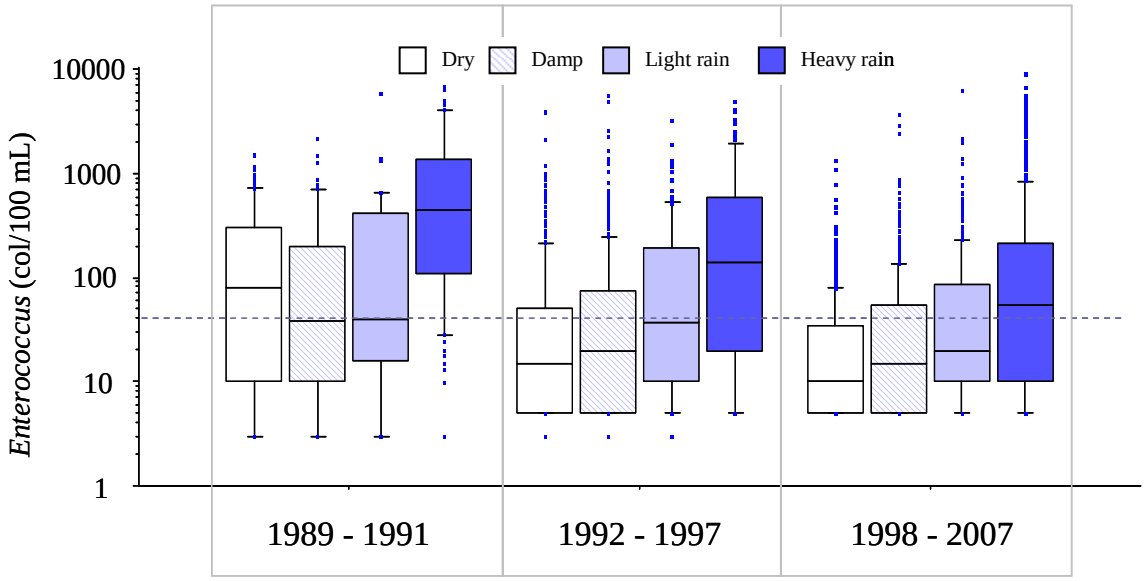

Figure 3-8. *Enterococcus* over time, Lower Charles Basin by phase of Long Term CSO Plan and rainfall condition.

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

Bacterial water quality in the Charles is poorer at upstream locations (upstream of CSOs), and improves as the river widens and slows in the Lower Basin and approaches the New Charles Dam. However, 2007 results show a significant improvement in Upper Basin bacterial water quality in particular, and an improvement in Mid-Basin as well, though this change is not statistically significant. Bottom-water dissolved oxygen worsens considerably in the lower Charles Basin. As in previous years, the lower basin locations were stratified in summer, resulting in relatively low bottom water temperatures and extremely low bottom water dissolved oxygen. Seawater continues to enter through the Charles locks in summer, contributing to stratification of the basin, limiting exchange with surface waters.

Nutrients and chlorophyll exhibited strong seasonal and spatial signals, with chlorophyll *a* and ammonium more elevated downstream than upstream in summer months, and total suspended solids more elevated upstream than downstream in spring months. Total nitrogen and total phosphorus are similar in both upstream and downstream locations. Chlorophyll *a* concentrations were lower on average at both locations in 2007, and ammonium concentrations were lower at the Watertown Dam for much of the year.

4 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.

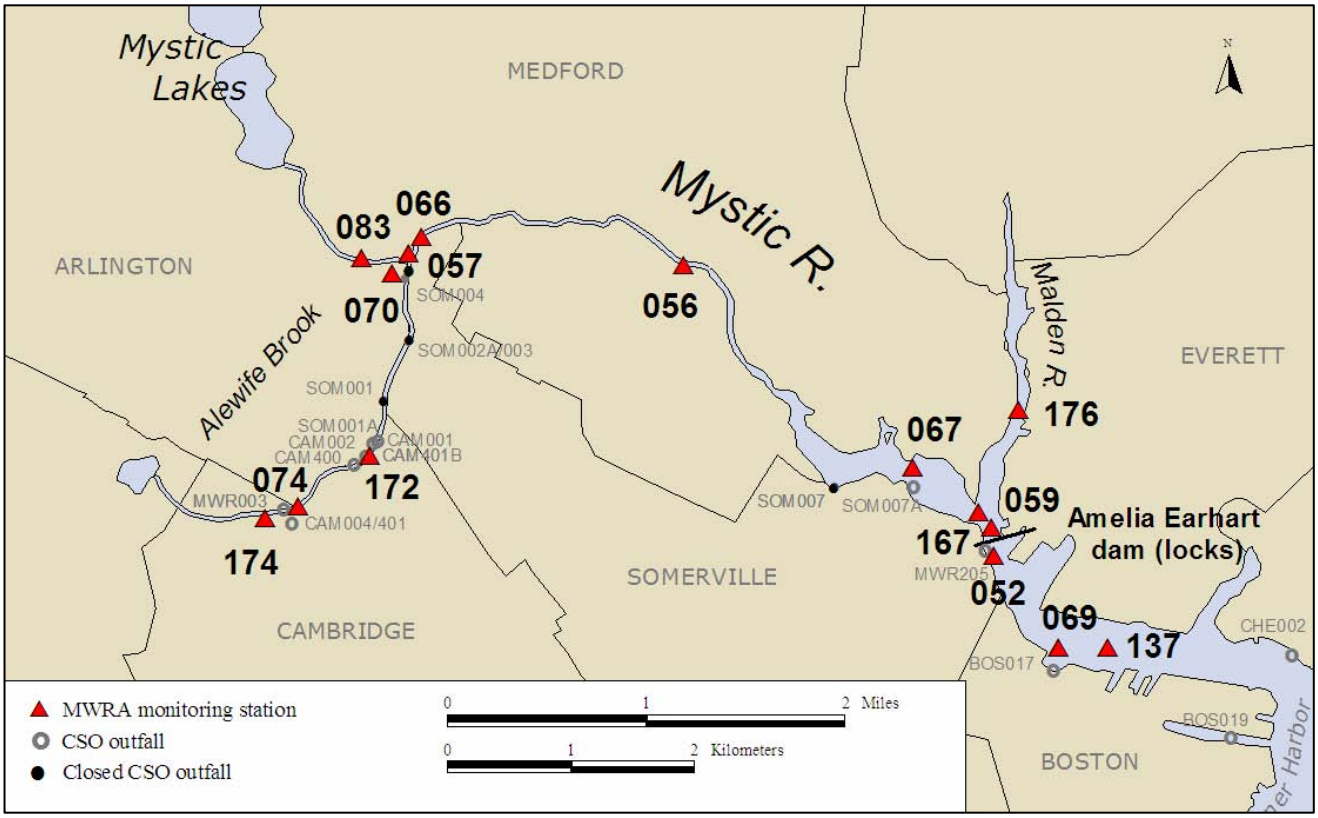

Figure 4-1. Map of Mystic River sampling locations.

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 eight active CSOs in Alewife Brook, and one treated CSO in the Lower Mystic basin (Somerville Marginal CSO, MWR205A/SOM007A), which discharges only during an activation 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 2007, Somerville Marginal 205A/SOM007A had six discharge events, and Somerville Marginal 205 had 15 activations resulting in discharge. The Alewife Brook is the primary source of contaminated flow to the lower Mystic River, in both dry and wet weather.

Table 4-3 summarizes the proportion of samples collected in dry, damp, and wet weather between 1998 and 2007.

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

Reach	Description of Reach	Sampling location	Location Description
Alewife Brook (Class B/Variance, warm water fishery)	Tributary to Mystic River. From confluence at Little River in Cambridge/Arlington to confluence with Mystic River in Arlington/Somerville	174, Cambridge/Arlington	Little River, upstream of Rt. 2 and off ramp to Alewife T station. Upstream of all CSOs.
		074, Cambridge/Arlington	Downstream of CAM001A, CAM004, MWR003
		172, Cambridge/Arlington	Downstream of CAM001, CAM002, CAM400, CAM401B, SOM001A
		070, Arlington/Somerville	Mystic Valley Parkway bridge. Downstream of all Alewife CSOs
Upper Mystic River (Class B/Variance, warm water fishery)	Downstream of Lower Mystic Lake in Arlington/Medford to Route 28 bridge in Medford	083, Arlington/Medford	Upstream of confluence of Mystic River and Alewife Brook
		057, Medford	Confluence of Mystic River and Alewife Brook
		066, Medford	Boston Ave bridge, downstream side
		056, Medford	Upstream of I-93 bridge, near Medford Square off ramp
Lower Mystic River basin (Class B/Variance, warm water fishery)	Route 28 bridge in Medford to Amelia Earhart Dam in Somerville/Everett	177, Medford	Downstream of Rt. 16 bridge
		067, Medford	Rt. 28 bridge, downstream side, near Somerville Marginal MWR205A outfall
		176, Medford/Everett	Malden River, upstream of Rt. 16 bridge
		059, Somerville/Everett	Confluence of Mystic and Malden Rivers
		167, Somerville/Everett	Amelia Earhart Dam, upstream side
Mystic River mouth (Class SB/CSO, marine)	Downstream of Amelia Earhart Dam in Somerville/Everett to Tobin Bridge, Chelsea R. confluence in Chelsea/East Boston	052, Somerville	Downstream of Amelia Earhart dam, near Somerville Marginal CSO facility outfall (MWR205)
		137, Charlestown/Everett	Upstream of Tobin Bridge near confluence of Mystic, Chelsea Rivers and upper inner harbor

Sampling locations are midstream unless otherwise noted.

Table 4-2. Mystic River/Alewife Brook pollution sources.

Source	Alewife Brook	Upper Mystic River	Lower Mystic Basin	Mystic River mouth
CSOs (untreated)	8 active, 5 closed CAM401A, MWR003, CAM001, CAM401B, CAM002, SOM001A *CAM004, CAM400 to be closed* SOM001 closed 12/96 SOM002 closed 1994 SOM002A closed 8/95 SOM003 closed 8/95 SOM004 closed 12/95	2 closed SOM006 closed 12/96 SOM007 closed 12/96	None	1 active BOS017
CSO treatment facility (screened, chlorinated and dechlorinated CSO discharge)	No	No	Yes Somerville Marginal (MWR205A/SOM007A, high tide only) Activated 6 times in 2007	Yes Somerville Marginal (MWR205) Activated 15 times in 2007
Storm drains	Yes	Yes	Yes	Yes
Upstream inputs (elevated bacteria counts upstream)	Yes	Yes	Yes	Yes
Dry weather inputs (elevated bacteria counts in dry weather)	Yes	Yes	Yes	Yes
Tributary brook or stream flow	Yes	Yes	Yes	Yes

Table 4-3. Mystic River/Alewife Brook sample collection by rainfall condition.

Sampling period	Dry[1]	Damp[1]	Wet[1]	Total
1998-2006	32.7% 1176 samples	29.6% 1063 samples	37.7% 1357 samples	100% 3596 samples
2007	43.2% 165 samples	20.7% 79 samples	36.1% 138 samples	100% 382 samples

[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.

4.3 Summary of water quality, 1998-2007

A detailed summary of water quality results collected from 1998 through 2007 is shown in Table 4-4.

Table 4-4. Summary of water quality, Mystic River/Alewife Brook 1998 – 2007.

Parameter		Water Quality Guideline or Standard	Alewife Brook				Upper Mystic				Lower Mystic Basin				Malden River				Mystic Mouth			
			Mean ± SD	% meeting guideline	Range	n	Mean ± SD	% meeting guideline	Range	n	Mean ± SD	% meeting guideline	Range	n	Mean ± SD	% meeting guideline	Range	n	Mean ± SD	% meeting guideline	Range	n
Surface Temperature (°C)[1]	Summer	<28.3	18.4 ± 4.1	100.0	6.3 - 26.4	542	20.5 ± 4.4	99.7	7.2 - 28.4	1059	20.3 ± 4.4	100.0	8.1 - 27.8	977	20.4 ± 4	98.8	9 - 29.5	163	17 ± 2.7	100.0	9.5 - 24.8	576
	Winter		4.8 ± 1.8	100.0	1.7 - 8.1	32	3 ± 2	100.0	-0.6 - 9.5	143	4 ± 2.4	100.0	-0.3 - 14.3	171	ND	ND	ND	0	3.5 ± 2	100.0	-0.7 - 8.5	111
Bottom water dissolved oxygen (mg/L)[1]	Summer	5.0	4.8 ± 1.8	45.6	1.2 - 10.2	537	6.7 ± 1.5	88.7	0.1 - 11.7	1051	7.7 ± 2.6	86.2	0.1 - 14.7	970	5.3 ± 4	58.4	0 - 14.1	161	6.5 ± 1.1	93.8	3.5 - 10.7	564
	Winter	5.0	10.3 ± 1.1	100.0	7.6 - 12	32	11.6 ± 1.4	99.3	4.1 - 14.4	142	11.5 ± 1.4	100.0	5 - 14.7	167	ND	ND	ND	0	10 ± 1	100.0	7.5 - 13.7	111
pH (S.U.)		6.5-8.3	7.1 ± 0.3	96.3	5.9 - 8.8	765	7.4 ± 0.4	96.0	5.4 - 8.9	1542	7.6 ± 0.7	78.2	5 - 11.3	1527	7.5 ± 0.7	84.8	6 - 9.7	211	7.7 ± 0.3	98.0	5.2 - 9.5	937
Water clarity	Total Suspended Solids (mg/L)	NS	ND	-	ND	0	5.6 ± 3.4	-	0.2 - 26.7	395	8.1 ± 3.9	-	0.5 - 26.3	342	ND	-	ND	0	4 ± 5.8	-	0.2 - 115	582
	Secchi depth (m)	NS	0.5 ± 0.2	-	0.2 - 1	69	1.2 ± 0.6	-	0.1 - 4	351	0.7 ± 0.2	-	0.2 - 2.5	433	0.8 ± 0.2	-	0.4 - 1.8	94	2.3 ± 0.9	-	0.3 - 5.5	462
	Turbidity (NTU)	NS	10.6 ± 8	-	0 - 58.5	309	6.2 ± 4.8	-	0 - 42	984	11 ± 6.7	-	0 - 52	870	10.8 ± 6.4	-	1.8 - 49	167	4.8 ± 5.5	-	0 - 59.9	610

Table 4-4. Summary of water quality, Mystic River/Alewife Brook 1998 – 2007, continued.

Parameter		Water Quality Guideline or Standard	Alewife Brook				Upper Mystic				Lower Mystic Basin				Malden River				Mystic Mouth			
			Mean ± SD	% meeting guideline	Range	n	Mean ± SD	% meeting guideline	Range	n	Mean ± SD	% meeting guideline	Range	n	Mean ± SD	% meeting guideline	Range	n	Mean ± SD	% meeting guideline	Range	n
Bacteria (col/100mL)[2]	Fecal coliform (1998 – 2002)	200 / 400[3]	1210 (1067-1372)	16.9	0 - 156000	437	190 (167-216)	73.9	0 - 95100	536	70 (61-82)	89.2	0 - 30400	499	115 (54-244)	70.8	0 - 2800	24	38 (31-47)	83.7	0 - 252000	582
	E. coli (2001- 2007)	126 / 235[3,4]	643 (583-710)	16.6	0 - 146000	585	90 (79-103)	74.4	0 - 42200	710	36 (30-42)	84.8	0 - 12400	547	54 (37-78)	79.3	0 - 10800	116	24 (19-31)	82.4	0 - 180000	476
	Enterococcus (1998- 2007)	33 / 61[3]	397 (358-440)	9.7	0 - 24800	893	53 (47-60)	54.3	0 - 18500	1090	9 (8-11)	82.2	0 - 16600	915	21 (14-32)	73.5	0 - 9000	117	7 (6-8)	84.2	0 - 58800	1017
Nutrients (µmol/L)	Phosphate	NS	ND	-	ND	0	0.4 ± 0.27	-	0.01 - 1.96	393	0.3 ± 0.22	-	0.01 - 1.53	341	ND	-	ND	0	1.02 ± 0.46	-	0 - 2.52	584
	Ammonium	NS	ND	-	ND	0	16.2 ± 13.6	-	0 - 60.8	393	12.9 ± 13.4	-	0.1 - 51.8	341	ND	-	ND	0	6.8 ± 5.9	-	0 - 27.8	584
	Nitrate+nitrite	NS	ND	-	ND	0	49.8 ± 26.2	-	0.3 - 177.9	392	36.3 ± 26.7	-	0 - 168.6	339	ND	-	ND	0	7.1 ± 7.2	-	0.1 - 62.4	581
Algae (µg/L)	Chlorophyll *a*	25[5]	ND	ND	ND	0	11.9 ± 8.4	91.6	0.2 - 56.8	394	29.8 ± 21.9	48.3	1.8 - 131	327	ND	ND	ND	0	3.9 ± 5.2	99.0	0.2 - 49.6	590

NS: no standard or guideline. ND: No data. [1]: Summer (June-September), Winter (December-March).

[2]: For bacterial data, 95% confidence intervals are provided in lieu of standard deviations.

[3]: First 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 fecal coliform, until 2007, MADEP had an additional limit in that more than 90% of single samples must meet the single sample limit of 400 colonies/100mL.

[4]: *E. coli* or *Enterococcus* are acceptable indicators for Massachusetts Department of Public Health and MADEP to assess suitability for swimming in freshwater.

[5]: NOAA guideline.

4.4 Trends in water quality, 2007

This section reports spatial trends for water quality parameters measured in the Mystic River in the 2007 monitoring year.

4.4.1 Physical measurements

Temperature. Summer mean temperatures for 2007 are shown for each sampling location in the top graph of Figure 4-2. Temperatures are lowest in the Alewife Brook and at the river mouth, where the river meets Boston Harbor. Surface and bottom temperatures are similar, except in the downstream reach near the dam where the river deepens, with depths averaging more than 6 meters (19 feet).

Dissolved Oxygen. The spatial trend in dissolved oxygen in the Mystic Basin is similar for surface and bottom waters, except in the most downstream Lower Basin/Malden River locations, shown in the center graph of Figure 4-2. Mean surface and bottom dissolved oxygen are well above the State standard of 5.0 mg/L in much of the river, but fail to meet the standard in the downstream bottom-water portions of Alewife Brook, Malden River, and upstream of the Amelia Earhart dam. Bottom-water dissolved oxygen is lowest at the Malden River location, Station 176.

Unlike the Charles River, there is little evidence of stratification in the lower portion of the Mystic due to saltwater intrusion. The elevated summer surface DO values indicate eutrophic conditions in this area of the river. MWRA sampling crews routinely report significant algae blooms in this area in midsummer. The relatively good DO values (and lower chlorophyll *a* values, see Figure 4-3) at nearby upstream locations in the Mystic Basin implicate the Malden River as a source of eutrophication in the area immediately upstream of the Amelia Earhart Dam (station 059 is at the confluence of the Malden and Mystic Rivers and conditions show the influence of both tributaries).

Water clarity. Water clarity is indicated by Secchi disk depth; shown for individual sampling locations in the bottom graph of Figure 4-2. In general water clarity is poor, with nearly all stations failing to meet the guideline of 1.2 meters. (Alewife Brook is too shallow to collect Secchi depth readings.) Clarity downstream of the Amelia Earhart dam improves markedly as the river flows are diluted by Boston Harbor water.

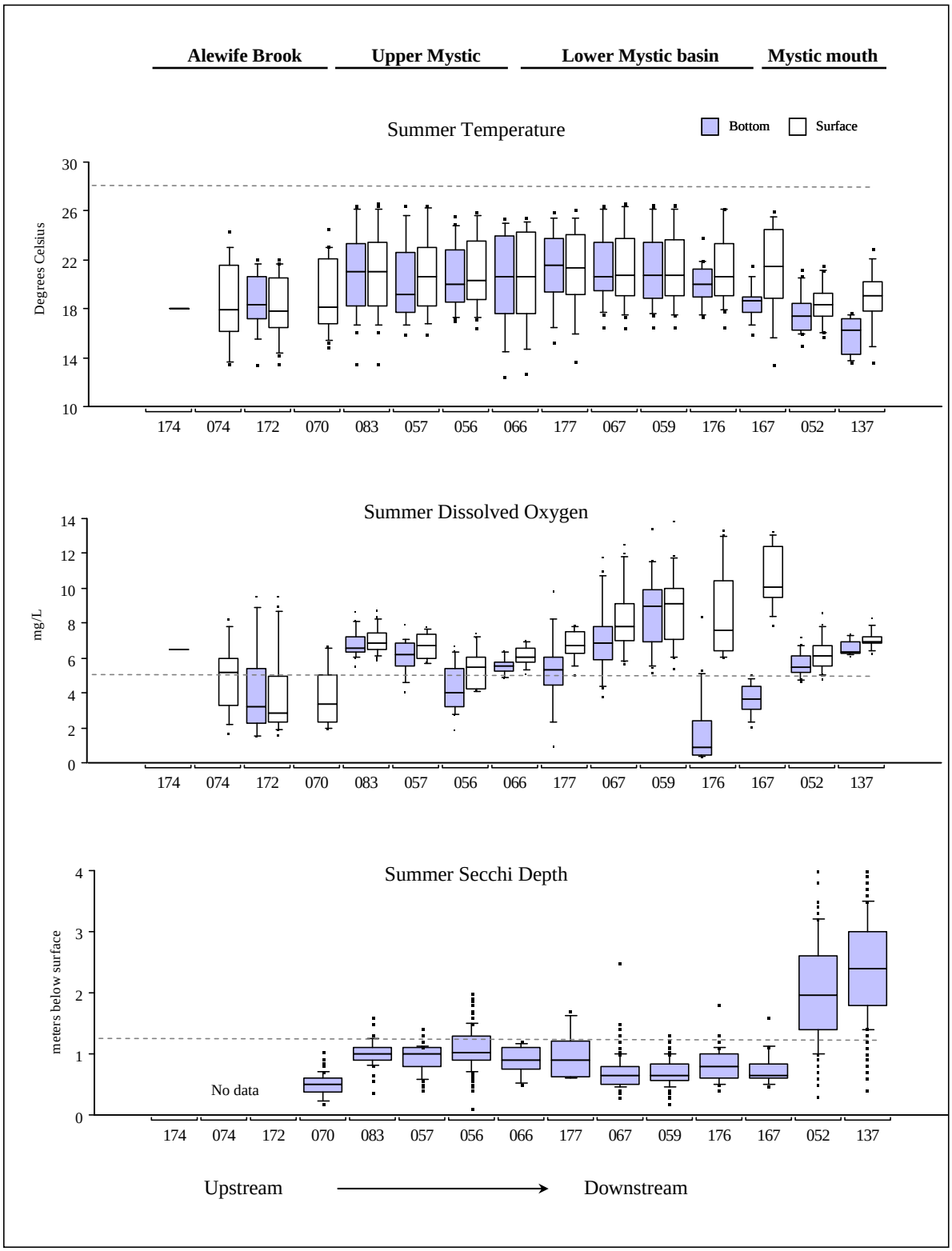

Figure 4-2. Summer temperature, dissolved oxygen, and Secchi depth, Lower Mystic, 2007.

Dashed lines are State standards. Fewer results are available for the upper Alewife Brook because upstream locations are often too shallow for measurements in the summer months.

4.4.2 Nutrients, TSS and chlorophyll

Monthly average total nitrogen, ammonium, nitrate/nitrite, total phosphorus, orthophosphate, total suspended solids, and chlorophyll *a* at the upstream (066), downstream (167) and river mouth (137) locations are shown in Figure 4-3, Figure 4-4, and Figure 4-5, respectively. These results show strong seasonal trends. The nitrogen parameters drop substantially in summer months, and chlorophyll *a* and TSS increase. Station 167, immediately upstream of the dam, is more eutrophic than either upstream or at the mouth of the river, with increases in chlorophyll *a* in the warm weather months. 2007 results were near 1998-2006 averages for most nutrient parameters, with the exception of below-average TSS and chlorophyll *a* at the upstream location near Boston Ave. (166).

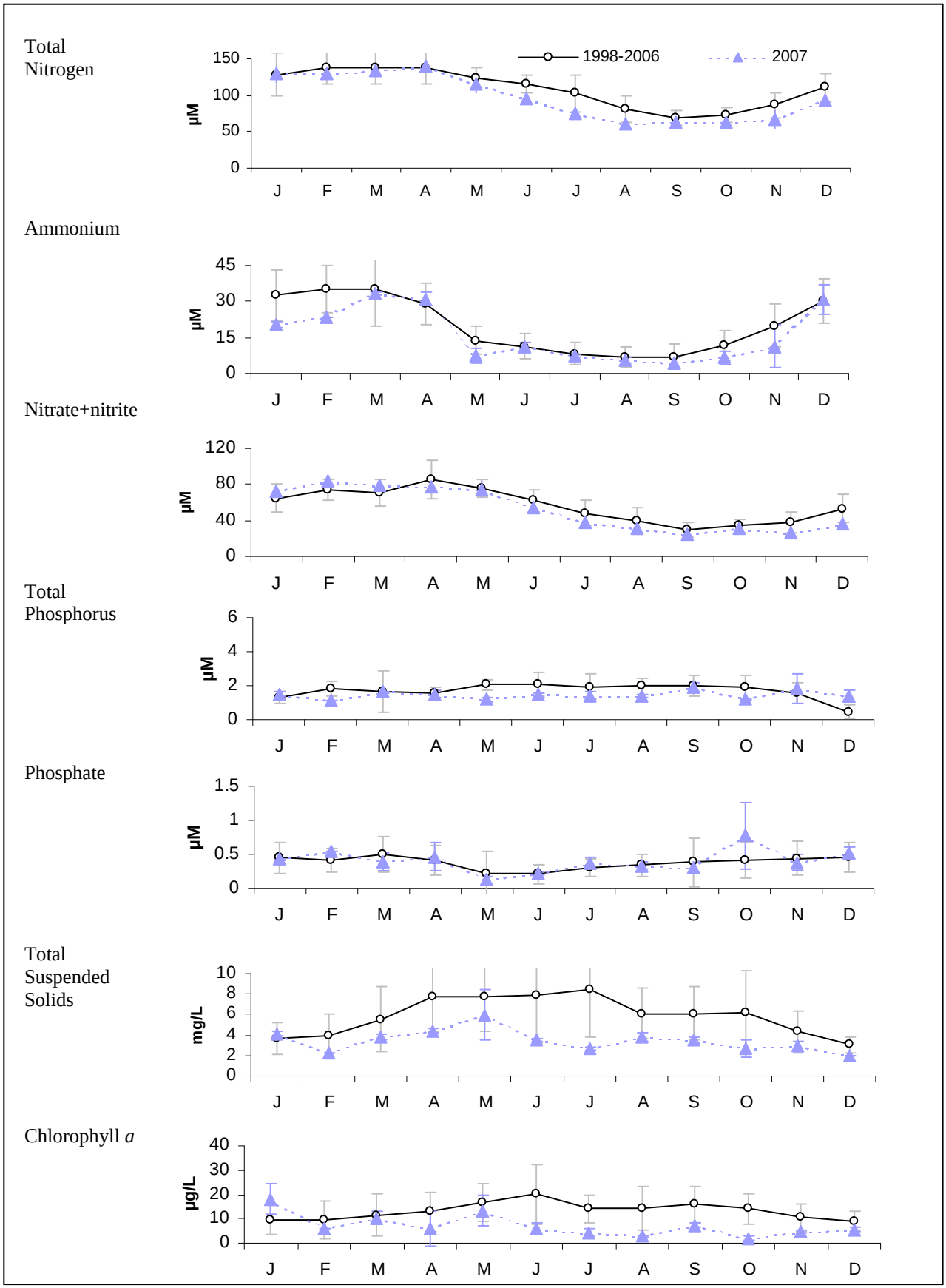

Figure 4-3. Monthly average nutrients, TSS and Chlorophyll 1998 – 2007, Station 066 (Boston Ave.)

Error bars are 95% confidence intervals.

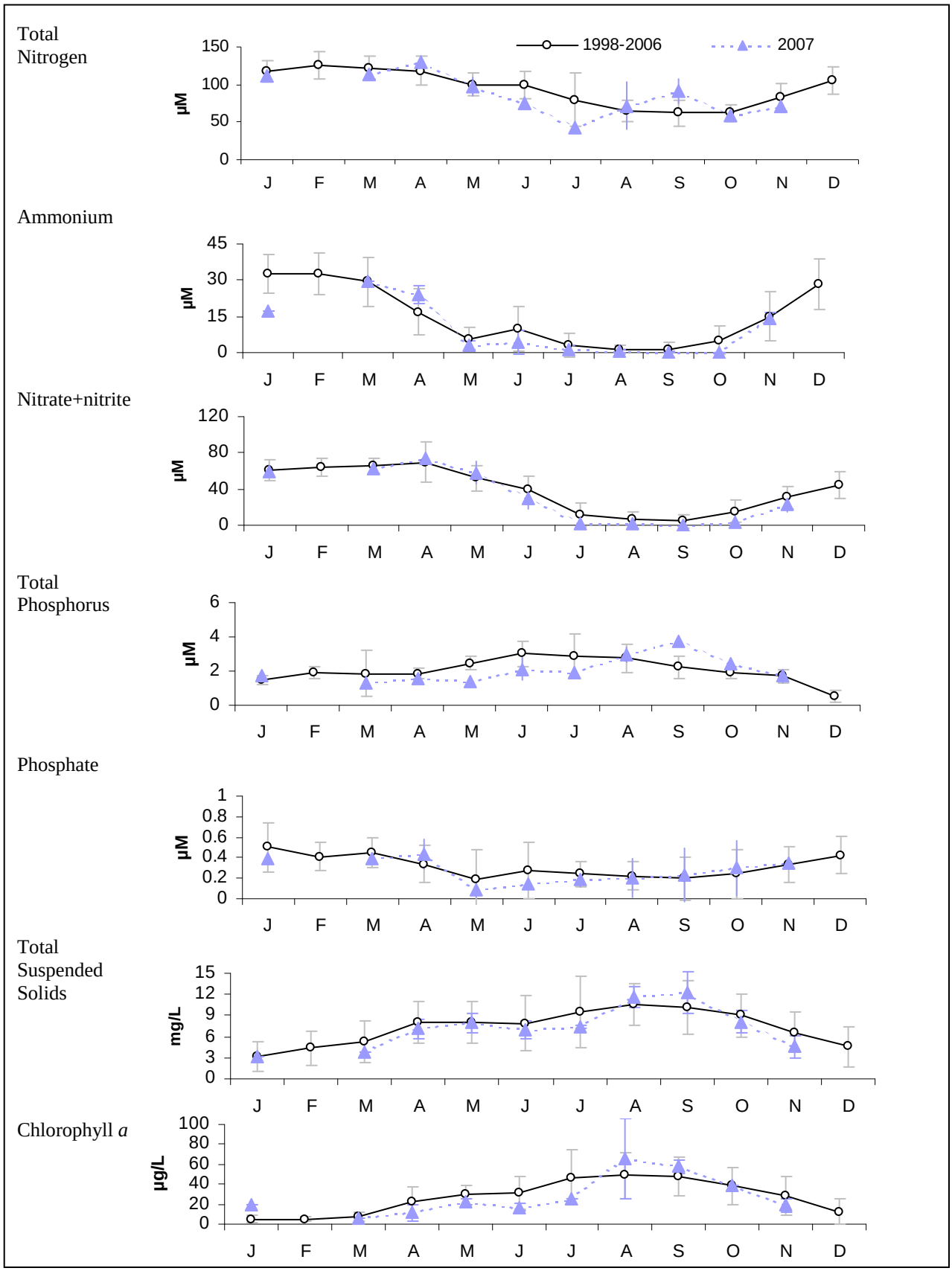

Figure 4-4. Monthly average nutrients, TSS and Chlorophyll 1998 – 2007, Station 167 (Amelia Earhart Dam (upstream/freshwater)).

Error bars are 95% confidence intervals.

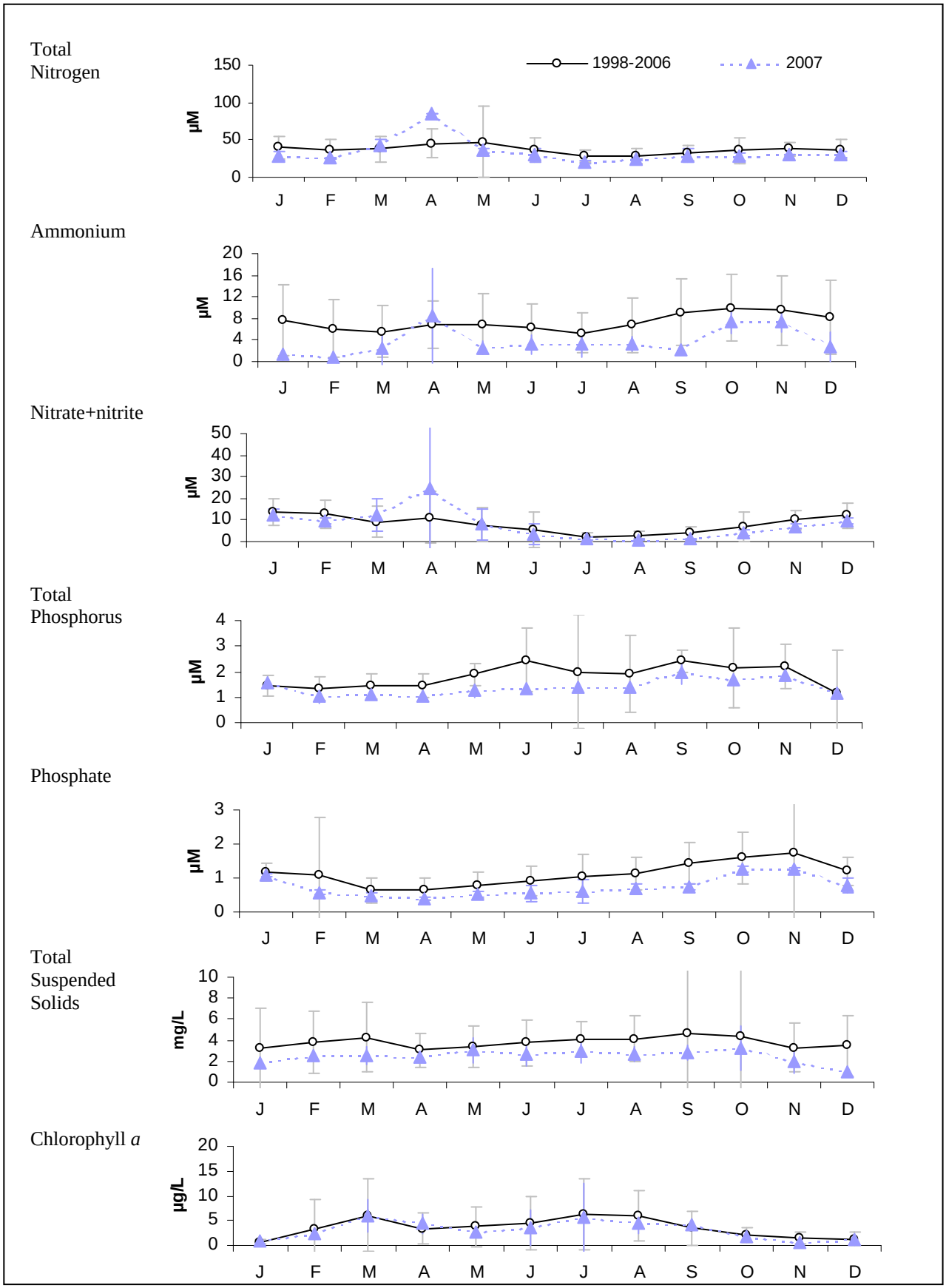

Figure 4-5. Monthly average nutrients, TSS and Chlorophyll 1998 – 2007, Station 137 Mystic River mouth (marine).

Error bars are 95% confidence intervals.

4.4.3 Bacterial water quality

Figure 4-6 shows the current bacterial water quality at each location sampled in the Mystic River and Alewife Brook for 2007. Alewife Brook has the highest bacteria counts, and counts gradually decrease downstream to the river mouth.

Geometric means for each indicator for all locations for 1998 – 2007 appear in Table 4-5.

Enterococcus. The uppermost graph in Figure 4-6 shows percentile plots of *Enterococcus* counts for each location, arranged from upstream to downstream for 2007. Figure 4-7 shows the impact of rainfall on the three river reaches on *Enterococcus* densities, along with the change at locations near CSO outfalls. For the 1998-2007 period (with results for all years combined), Alewife Brook locations consistently fail to meet standards, in both dry and wet weather, though conditions improve dramatically moving downstream to the river mouth. However, 2007 geometric means for the Alewife decreased significantly, and all Mystic River locations met *Enterococcus* swimming standards.

Figure 4-7 indicates little change in water quality from the most upstream location in the Alewife (upstream of all CSOs) to the most downstream location near Mystic Valley Parkway in both wet and dry weather, indicating the influence of non-CSO, dry weather sources of contamination. Following heavy rain, the highest counts in the Alewife are found at the two downstream locations.

The change in *Enterococcus* concentrations since 1989 in Alewife Brook and the Mystic River appear in Figure 4-8 and Figure 4-9. 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 little change over time in either the Alewife or the Mystic River in dry and wet weather since the early 1990's. However, Mystic River locations do generally meet geometric mean limits in dry and light rainfall conditions.

E. coli. The center graph in Figure 4-6 shows percentile plots of *Enterococcus* counts arranged from upstream to downstream locations for 2007. *E. coli* shows a similar trend to *Enterococcus,* with the exception of Alewife Brook, locations generally meet the geometric mean limit of 126 colonies/100 mL.

Fecal coliform. Fecal coliform monitoring was reduced and replaced with *E. coli* beginning in mid-2001. No fecal coliform samples were collected in 2007 so results for 2001-2002 are shown only for comparison. Fecal coliform appears in the bottom graph in Figure 4-6.

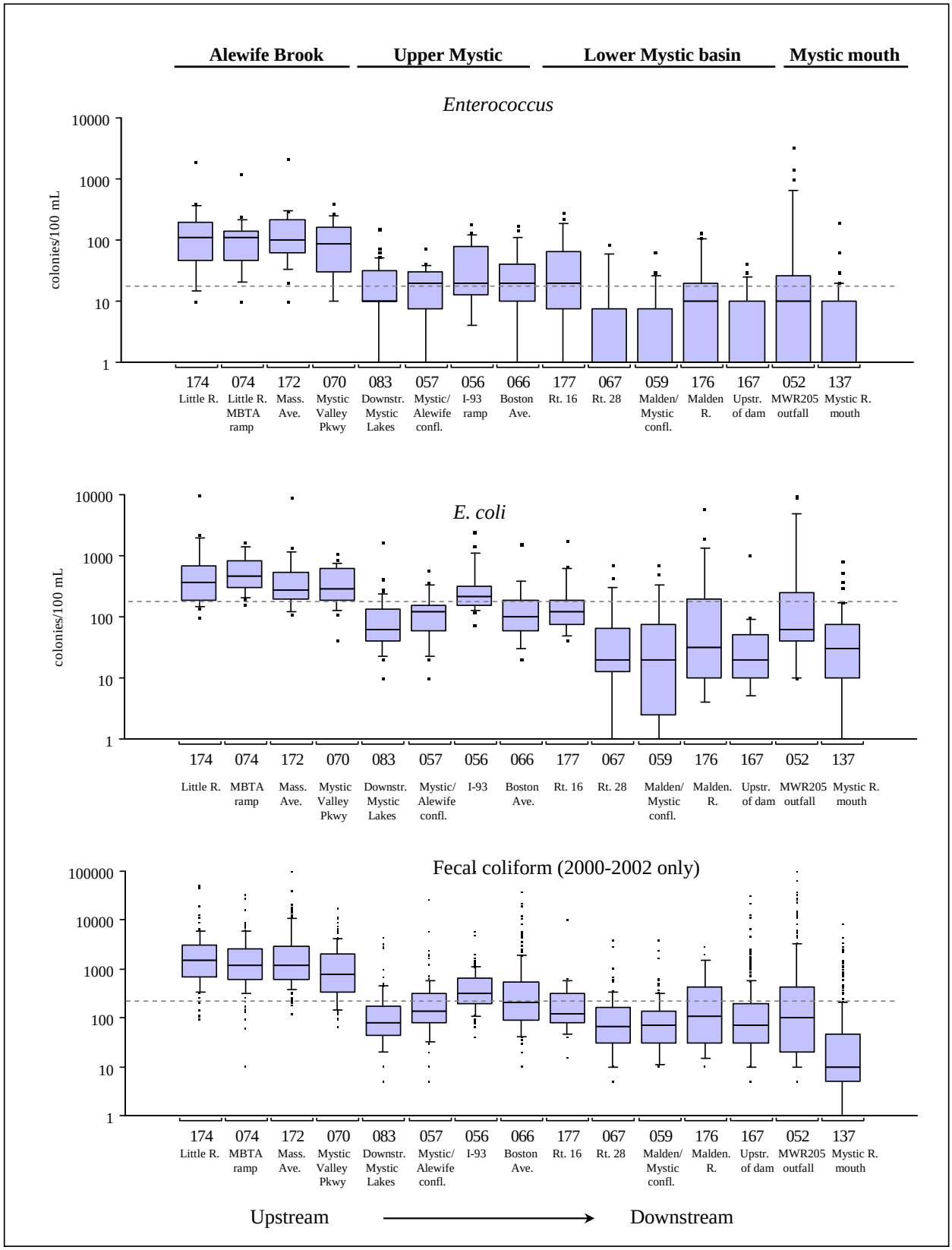

Figure 4-6. Indicator bacteria concentrations, Mystic River/Alewife Brook, 2007.

Dotted lines show EPA geometric mean guideline and MADEP fecal coliform standard.
Fecal coliform has been phased out from the monitoring program, replaced by *E. coli*, 2000-2002 results are shown.

Table 4-5. Geometric mean indicator bacteria, Mystic River, 1998 – 2007.

Station	Location	Surface or Bottom	Number of samples[1]	*Enterococcus* (95% CI)		*E. coli* (95% CI)	
				1998 - 2006	2007	1998 - 2006	2007
174	Cambridge, Little River, upstream of Rt. 2 and offramp to Alewife T station	S	182/20 113/20	461 (369-575)	97 (56-168)	701 (574-857)	430 (263-701)
074	Cambridge, Little River, at offramp to Alewife T station	S	204/20 135/20	392 (317-484)	74 (40-138)	688 (561-844)	536 (352-814)
172	Arlington, Alewife Brook, upstream of Massachusetts Ave bridge, midchannel	S	204/118/119 /19	563 (471-673)	10 (6-17)	769 (630-939)	349 (228-534)
070	Arlington, Alewife Brook, off Mystic Valley Parkway bridge	S	221/21 136/21	457 (366-570)	61 (33-112)	644 (502-827)	306 (219-429)
083	Medford, upstream of confluence of Mystic River and Alewife Brook	S	217/21 132/38	48 (37-62)	10 (6-17)	60 (47-77)	64 (41-98)
057	Medford, confluence of Mystic River and Alewife Brook	S	172/17 112/17	62 (48-80)	11 (5-23)	88 (66-116)	101 (63-162)
056	Medford, Mystic River, upstream of I-93 bridge	S	180/19 95/19	60 (46-80)	23 (12-45)	255 (190-342)	266 (183-387)
066	Medford, Mystic River, Boston Ave bridge	S	316/25 164/25	111 (92-134)	14 (7-27)	139 (106-182)	110 (71-170)
177	Medford, Downstream of Rt. 16 bridge, mid-channel	S	107/21 106/21	31 (21-45)	16 (7-37)	94 (69-129)	141 (94-210)
067	Medford, Mystic River, Rt. 28 bridge	S	165/19 97/19	8 (5-10)	1 (0-4)	29 (20-41)	22 (9-50)
059	Everett, confluence of Mystic and Malden Rivers	S	187/19 98/19	11 (8-13)	1 (0-3)	27 (19-38)	18 (6-47)
176	Malden River, upstream of Rt. 16 bridge	S	96/23 96/19	26 (16-41)	6 (2-15)	56 (38-83)	43 (15-117)
167	Medford, Mystic River, upstream side of Amelia Earhart Dam	S	358/20 148/20	11 (8-13)	1 (0-3)	24 (17-35)	22 (11-45)
052	Somerville, Mystic River, near Somerville Marginal CSO facility (MWR205)	S	256/21 128/20	29 (21-41)	15 (4-49)	134 (80-224)	251 (101-624)
		B	186/11 101/11	12 (9-15)	3 (0-9)	31 (21-46)	29 (18-44)
137	Mystic River, upstream of Tobin Bridge	S	294/23 132/23	6 (5-8)	3 (1-7)	23 (16-33)	59 (33-105)
		B	289/23 132/23	1 (1-2)	1 (0-2)	2 (1-3)	6 (3-14)

[1]N values for *Enterococcus* and *E. coli* for the 1998-2006 and 2007 periods, respectively.
Fecal coliform sampling was discontinued in 2001 and results are not included in the table.

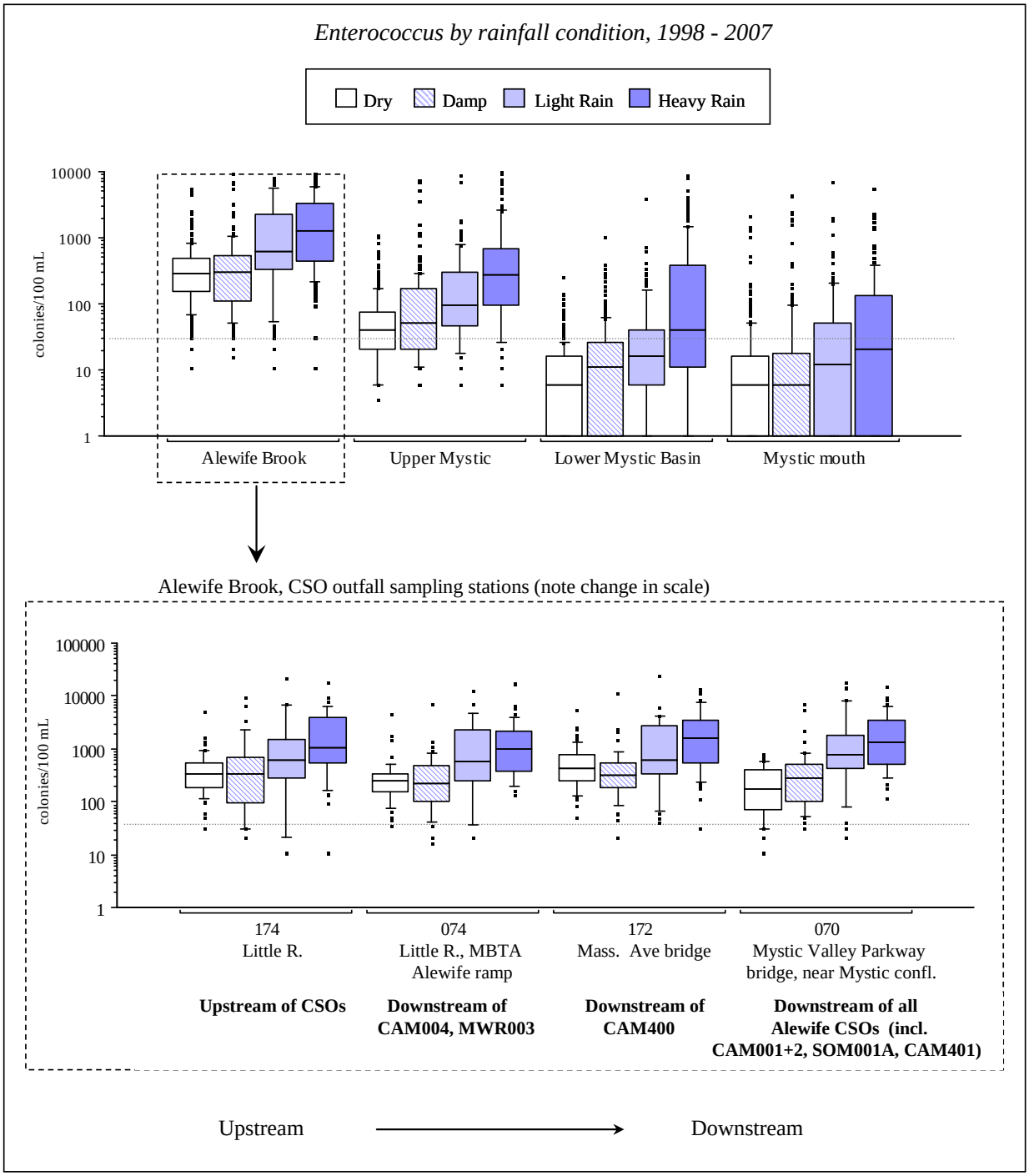

Figure 4-7. *Enterococcus* by rainfall condition, Mystic River/Alewife Brook, 1998 - 2007.

Dotted line shows State standard. 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.

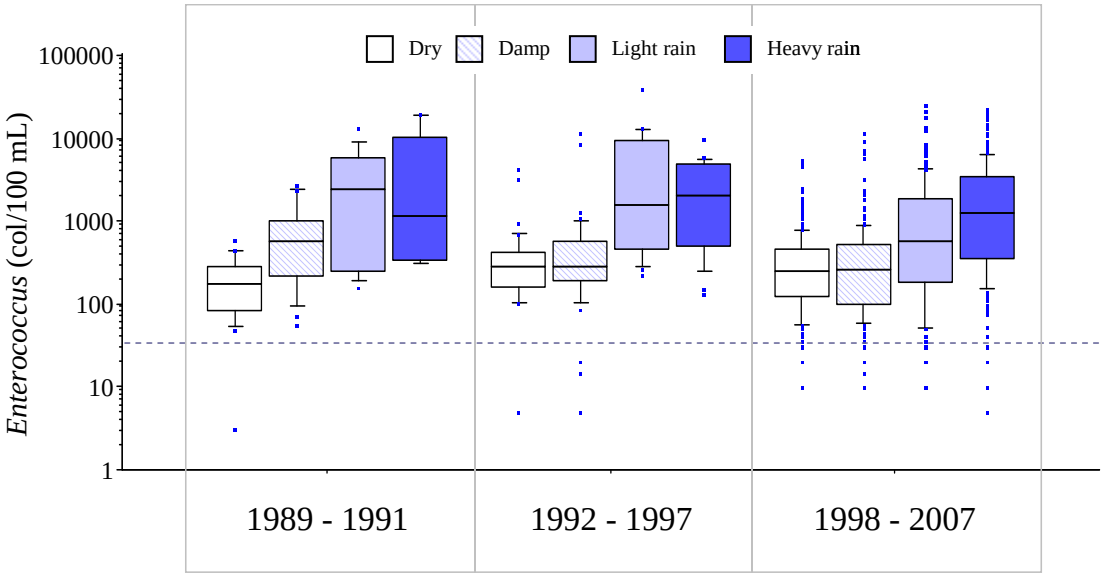

Figure 4-8. *Enterococcus* over time, Alewife Brook by phase of Long Term CSO Plan and rainfall condition.

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.

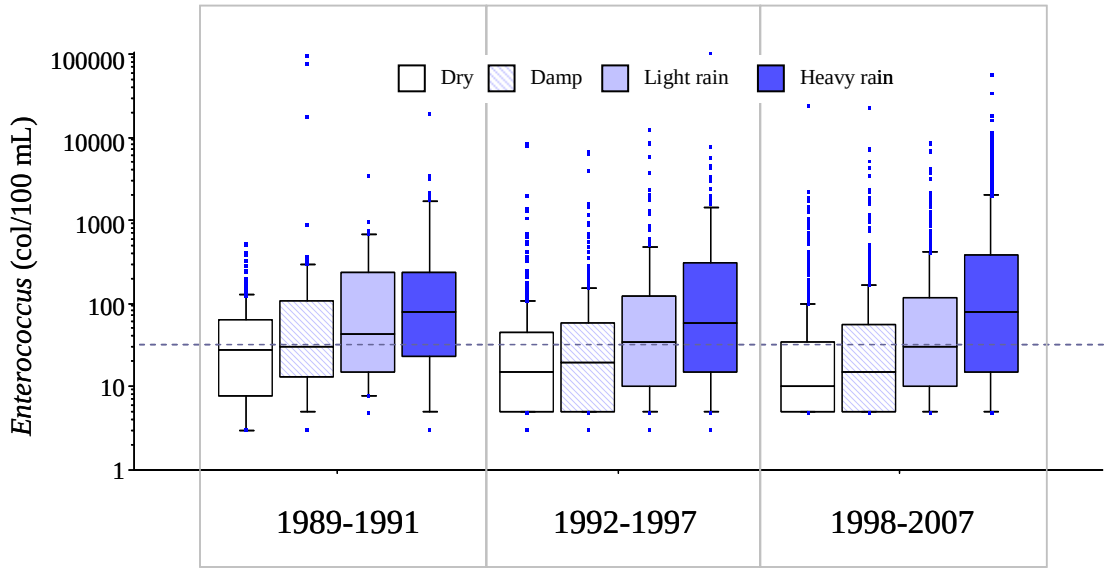

Figure 4-9. *Enterococcus* over time, Mystic River by phase of Long Term CSO Plan and rainfall condition.

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

Water quality in the Mystic River generally meets water quality standards for much of the Lower Mystic Basin and Mystic River mouth, but fails to meet limits in the Upper Mystic, Alewife Brook and Malden River. Bacterial counts in the Alewife for the 1998-2007 period fail to meet standards, even in dry weather without CSO-related impacts, and water clarity and dissolved oxygen also remain poor in this area. However, 2007 results indicate significant improvement in bacterial water quality compared to 1998-2006, particularly in the Alewife. Geometric mean limits were still not met in the Alewife but all locations in the Mystic River did meet *Enterococcus* geometric mean limits, and most locations met *E. coli* geometric mean limits.

Wet weather continues to adversely impact all locations in the Mystic River and Alewife Brook, with the highest bacteria counts occurring after heavy rain. However, in the lower portion of the River geometric mean bacteria counts are well within standards; in 2007, all locations met the *Enterococcus* single sample limit of 104 colonies/100 mL downstream of Alewife Brook.

Like the Charles River, nutrients and chlorophyll show strong seasonal fluctuations. 2007 nutrient results were similar to previous years, though the Upper Mystic location (Station 066) had below average concentrations for total suspended solids and chlorophyll *a*. Locations near the Amelia Earhart dam and Malden River confluence were the most eutrophic, having the highest chlorophyll *a* and lowest dissolved oxygen, and pronounced changes in seasonal nitrogen concentrations.

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Massachusetts Water Resources Authority
Charlestown Navy Yard
100 First Avenue
Boston, MA 02129
(617) 242-6000
http://www.mwra.state.ma.us