# Combined work/quality assurance project plan

*for*

# Combined Sewer Overflow Receiving Water Monitoring and Nutrient Effects Monitoring in the Lower Charles River Basin

**Massachusetts Water Resources Authority**

**Environmental Quality Department**
**Report ENQUAD 2005-13**

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# Combined Work/Quality Assurance Project Plan

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# Combined Sewer Overflow Receiving Water Monitoring and Nutrient Effects Monitoring in the Lower Charles River Basin

prepared by


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## 1.0 PROJECT NAME

Combined Sewer Overflow Receiving Water Monitoring and
Nutrient Effects Monitoring in Charles River

## 2.0 PROJECT REQUESTED BY

Massachusetts Department of Environmental Protection

## 3.0 DATE OF REQUEST

October 24, 2002

## 4.0 DATE OF PROJECT INITIATION

April 1, 2000

## 5.0 PROJECT MANAGEMENT

Dr. Andrea Rex, Director, Environmental Quality Department
Dr. David Taylor, Project Manager, Environmental Quality
Ms. Kelly Coughlin, Harbor monitoring coordinator, Environmental Quality
Dr. Michael Delaney, Director, Department of Laboratory Services
Ms. Laura Ducott, Microbiology Laboratory Supervisor
Ms. Stephanie Moura, Project Manager, Planning

## 6.0 QUALITY ASSURANCE MANAGEMENT

Dr. William Andruchow, Quality Assurance Manager, Central Laboratory
Ms. Wendy Leo, Project Manager EM & MS Database

## 7.0. PROJECT DESCRIPTION

### 7.1 Objectives and Scope

Combined sewer overflows (CSOs) have been a significant source of wet weather pollution to the Lower Charles River. Over the next decade, both small-scale projects and major construction efforts by MWRA and the CSO communities will significantly reduce untreated CSO discharges (MWRA 1994). This report describes planned MWRA water quality monitoring efforts in the Lower Charles River. The purpose of this monitoring is to measure water quality and assess CSO impacts on these water bodies; the plan is written to comply with the Final Variance for the MWRA CSO-Control Plan for the Lower Charles River Basin. The water quality monitoring will enable MWRA to assess the impacts of CSO discharges and to track the environmental effects of pollution abatement projects.

The Lower Charles River Basin monitoring is a component of a larger monitoring program that MWRA began in 1989 (Rex 1991, 1993). Data have been gathered over the past 10 years to measure the effect of CSOs on Boston Harbor and its tributary rivers, to satisfy MWRA's NPDES permit requirements, to relate bacteria counts in the water to rainfall, and to measure changes in water quality over time as CSO remediation plans are effected. Related monitoring focuses on other waterbodies affected by CSOs: the Inner Harbor, Northern and Southern Dorchester Bay, the Mystic River, and the Neponset River. The CSO monitoring program measures the effects of CSO discharges by focusing on the bacterial pollution in the water column, with intensive monitoring of bacterial indicators. Sampling stations are located near and distant from CSOs, with an attempt to "bracket" active CSOs. Samples are collected during both wet and dry weather.

**7.2 Data Usage**

Data from the Harbor-wide water quality monitoring are presented monthly and quarterly in MWRA=s report on performance measures, are presented in the annual State of the Harbor report (Rex and Connor 1997, Rex 2000 and Rex et al 2002), and are available on the MWRA web site (http://www.mwra.com). The data will be used to track the recovery of the Harbor following completion of the Boston Harbor Project and the CSO Plan. Beyond these local uses, the data are of general scientific interest as a record of the effects of a major pollution abatement effort in an important urban river and estuary system.

Data from the CSO receiving water monitoring are provided to state and federal regulatory agencies, and to the Boston Water and Sewer Commission (BWSC 1995, 1996, 1997, 2001) as part of required monitoring to measure the effects of these wet-weather discharges on the receiving waters. These data will also used by MWRA to track the progress of CSO remediation efforts, and to detect sources of sewage pollution. Past monitoring data from this program have been used in CSO facilities planning efforts (Leo et al. 1994) particularly in calibrating models predicting bacteria counts in the Harbor. The data will continue to be used for similar purposes by MWRA and its consultants. The data are also used by MWRA in advanced statistical analyses (Gong, et al. 1996, 1998) to determine if the relationship between rainfall and bacteria pollution in the Harbor and rivers is changing as a result of pollution abatement projects.

## 7.3 Rationale and Design

### 7.3.1 Combined Sewer Overflow Receiving Water Monitoring

There are twelve active CSOs in the Charles River which are hydraulically connected to the MWRA wastewater system. The water quality sampling described in this plan is relatively intensive both spatially and temporally. Samples are collected for two consecutive days per week, on an every-three-week cycle from April through December, unless the river is impassable because of freezing. In addition, samples are collected at two locations biweekly for nutrient effects and bacteria monitoring year-round.

7.3.1.1 Criteria for Selection of Sampling Locations

Figure 1 shows the location of CSOs and sampling stations in Charles River. Sampling stations are located as far upstream as the Watertown dam and downstream to the Charles River locks at the river mouth, with all sites located midstream and/or near CSOs outfalls. Table 1 lists the sampling locations.

7.3.1.2 Sampling Locations

The sampling locations for Charles River CSO Receiving Water monitoring are shown in Figure 1. Table 1 gives the location descriptions for these stations.

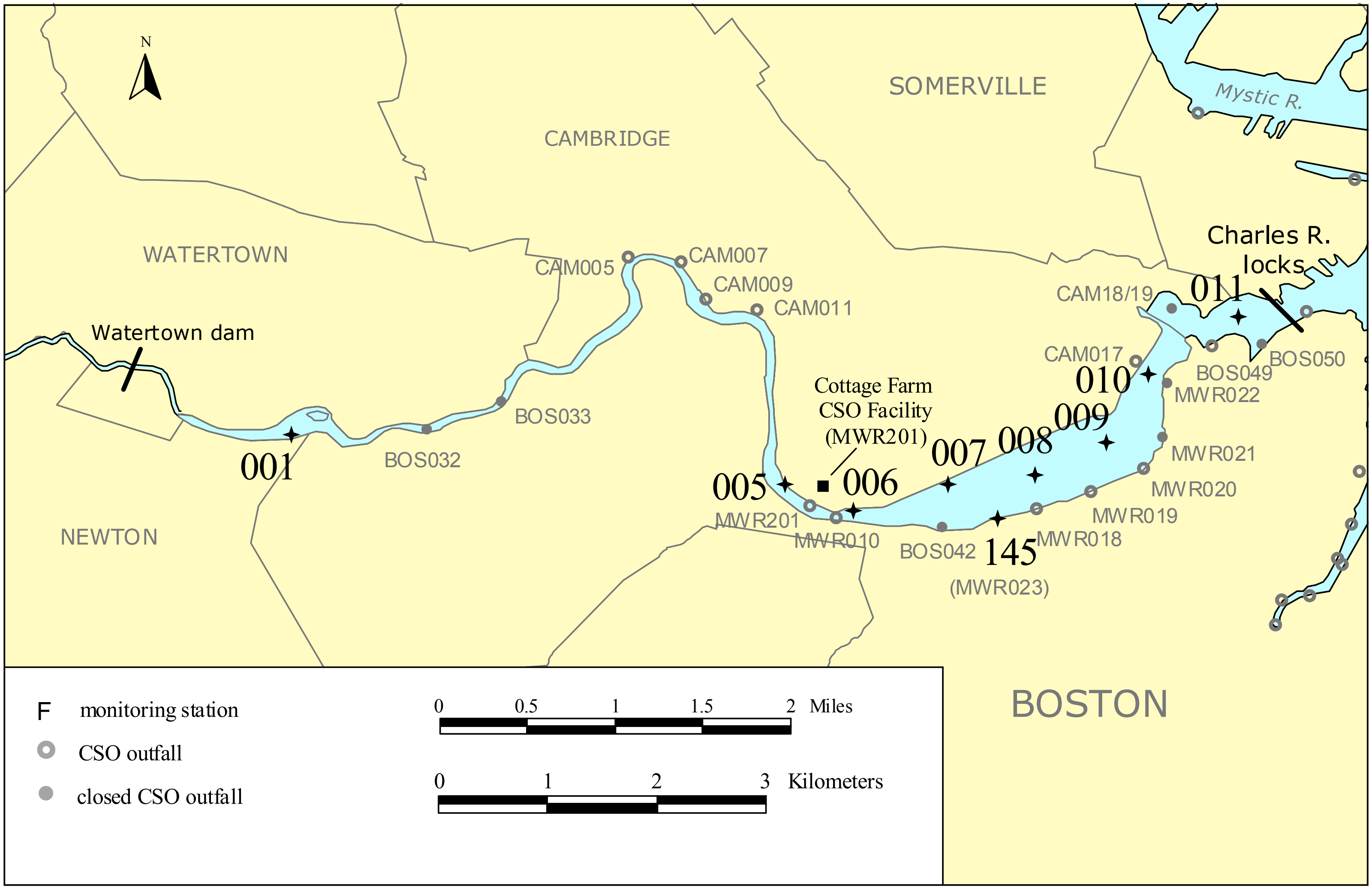


**FIGURE 1. Sampling locations for Charles River CSO Receiving Water Monitoring**

**Table 1. List of Sampling Locations for Charles River CSO Receiving Water Monitoring**

| Site No. | Description (nearest CSO influence) | Latitude (N) | Longitude (W) | Depth Sampled S = Surface B = Bottom |
|---|---|---|---|---|
| 001 | Brighton, rear of MDC skating rink, downstream of Newton Yacht Club | 42° 21.55 | 71° 10.21 | S |
| 005 | Cambridge, upstream of Cottage Farm CSO, near Magazine Beach | 42° 21.30 | 71° 06.93 | S |
| 006 | Cambridge, downstream of Cottage Farm CSO near BU boathouse | 42° 21.15 | 71° 06.51 | S |
| 007 | Cambridge, near MIT boathouse | 42° 21.30 | 71° 05.81 | S+B |
| 008 | Cambridge/Boston, downstream of Harvard Bridge | 42° 21.27 | 71° 05.37 | S+B |
| 009 | Boston, between Harvard and Longfellow Bridges | 42° 21.34 | 71° 05.27 | S+B |
| 010 | Boston, downstream of Longfellow Bridge | 42° 21.83 | 71° 04.49 | S+B |
| 011 | Boston, downstream of old Charles River dam | 42° 22.10 | 71° 04.02 | S+B |

7.3.1.3 <u>Sample Collection and Parameters Measured</u>

Standard water quality measurements are made in the field with portable instruments; water samples for bacteria analysis are collect into sterile sample containers, stored on ice and transported to the laboratory for analysis as rapidly as possible. Tables 2, 3 and 4 describe the monitoring parameters and sampling schedule for the Charles. The sampling schedule is random with respect to weather. Because approximately 20 surveys will be conducted per year, it is expected that sampling will occur under both wet and dry conditions over the course of the sampling period.

**Table 2. Monitoring Parameters for CSO Receiving Water Monitoring: Field Measurements**

| Parameter | Instrument | Units |
|---|---|---|
| Temperature | Hydrolab Datasonde 4 sonde and Surveyor 4 data logger, or YSI 600XL monitoring system | °C |
| Dissolved oxygen | | mg/l,<br>% saturation |
| Salinity | | PSU |
| Conductivity | | millisiemens/cm |
| Turbidity | | NTU |
| pH | | pH units |
| Secchi depth | Black and White 8≅ diameter limnological disk | meters |
| Transmissivity | WetLabs C-Star transmissometer | percent transmittance |

**Table 3. Monitoring Parameters for CSO Receiving Water Monitoring: Laboratory Measurements**

| Parameter LIMS Test Code | Sample Container | Preservation | Analysis Method | Holding Time | Units |
|---|---|---|---|---|---|
| *E. coli*<br>ECOLAQMMT | Sterile 250-ml LDPE bottle | Cooler <10°C | modified EPA 1103.1 | 6 hours | #/100 ml |
| *Enterococcus*<br>EC24AQMFL | | | EPA1600 | | |

**Table 4. Frequency and Number of Samples Collected for Charles River CSO Receiving Water Quality**

| Study, LIMS Code | Survey Frequency | Sites per Survey | No. of surveys | Total planned samples per year |
|---|---|---|---|---|
| CSO Receiving Water Quality<br>CSO-RW | 2 surveys/week, every three weeks,<br>April-December | 12 | 20 | 340 |

### 7.3.2 Nutrient Effects Monitoring

This program focuses on eutrophication (nutrient enrichment) parameters. Boston Harbor receives estimated total N and P loadings from combined terrestrial sources of 130 $g/m^2/y$ plus atmospheric sources of 20 $g/m^2/y$ (Alber and Chan 1994)Xhigh compared to other bays and estuaries in the US. Almost all of these nutrientsX90% of N and 95% of P—are from MWRA wastewater treatment facilities. These discharges are of sufficient magnitude to significantly elevate concentrations of dissolved inorganic nitrogen and chlorophyll *a* in the Harbor=s water column, and to lower the dissolved oxygen concentrations in the bottom waters of the Harbor (Adams et al. 1992, Hydroqual 1995). Wastewater loadings of nutrient and solids to the Harbor have been decreasing since 1991, when MWRA stopped sludge discharges to the Harbor. From January 1995 through July 1996, a new more efficient primary treatment facility was phased in, and in August 1997 MWRA began phasing in secondary treatment. In July 1998, the Nut Island (South System) treatment plant was decommissioned, and flows diverted to Deer Island. In September 2000, secondary treated effluent was diverted from the Harbor to Massachusetts Bay through a 9.5-mile outfall tunnel.

The water quality monitoring described here will provide data to measure the present state of eutrophication in the Charles River, and help provide data to measure the present state of the Charles River, Boston Harbor and ultimately Massachusetts Bay. The purpose is to measure the eutrophication status of the major rivers tributary to the Harbor (the Mystic and the Neponset will also be sampled) and to improve the estimates of loadings of nutrients and solids to the Harbor. Sampling takes place year round, every two weeks.

7.3.2.1 <u>Criteria for Selection of Sampling Locations</u>

Very few measurements of eutrophication parameters have previously been recorded in rivers tributary to the Harbor. Two sites will be monitored in the Charles, which bracket the CSO area. One site is just upstream of the river locks at the Science Museum and represents loads to the Harbor. A site just downstream of the Watertown dam will indicate the effects of upstream sources These sites were chosen because they are accessible by foot in winter, when access by boat is limited.

7.3.2.2 Sampling Locations

The sampling locations for Charles River nutrient effects monitoring are shown in Figure 2. Table 5 gives the location descriptions for these stations.

**Table 5. Sampling Locations for Charles River Nutrient Effects Monitoring**

| Site No. | Description | Latitude (N) | Longitude (W) | Sample Depth |
|---|---|---|---|---|
| 012 | Charles River at Watertown dam | 42° 21.90 | 71° 11.41 | Surface |
| 166 | Charles River at Science Park, old Charles River dam | 42° 21.97 | 71° 04.21 | Surface |

7.3.2.3 Sample Collection and Parameters Measured

Stations 012 and 166 are accessed on foot, and can be sampled even when the rivers are not navigable due to ice. A Kemmerer sampler is used to collect water samples, and the samples are stored on ice and transported back to the laboratory. Table 6 lists parameters measured in the field, Table 7 lists parameters measured in the laboratory.

**Table 6. Monitoring Parameters for Charles River Nutrient Effects Monitoring: Field Measurements**

| Parameter | Instrument | Units |
|---|---|---|
| Temperature | Hydrolab Datasonde 4 and Surveyor 4 data logger, or YSI 600XL monitoring system | °C |
| Dissolved oxygen | | mg/l, % saturation |
| Salinity | | PSU |
| Conductivity | | millisiemens/cm |
| Turbidity | | NTU |
| pH | | pH units |
| Transmissivity | WetLabs C-Star Transmissometer | percent transmittance (pct) |

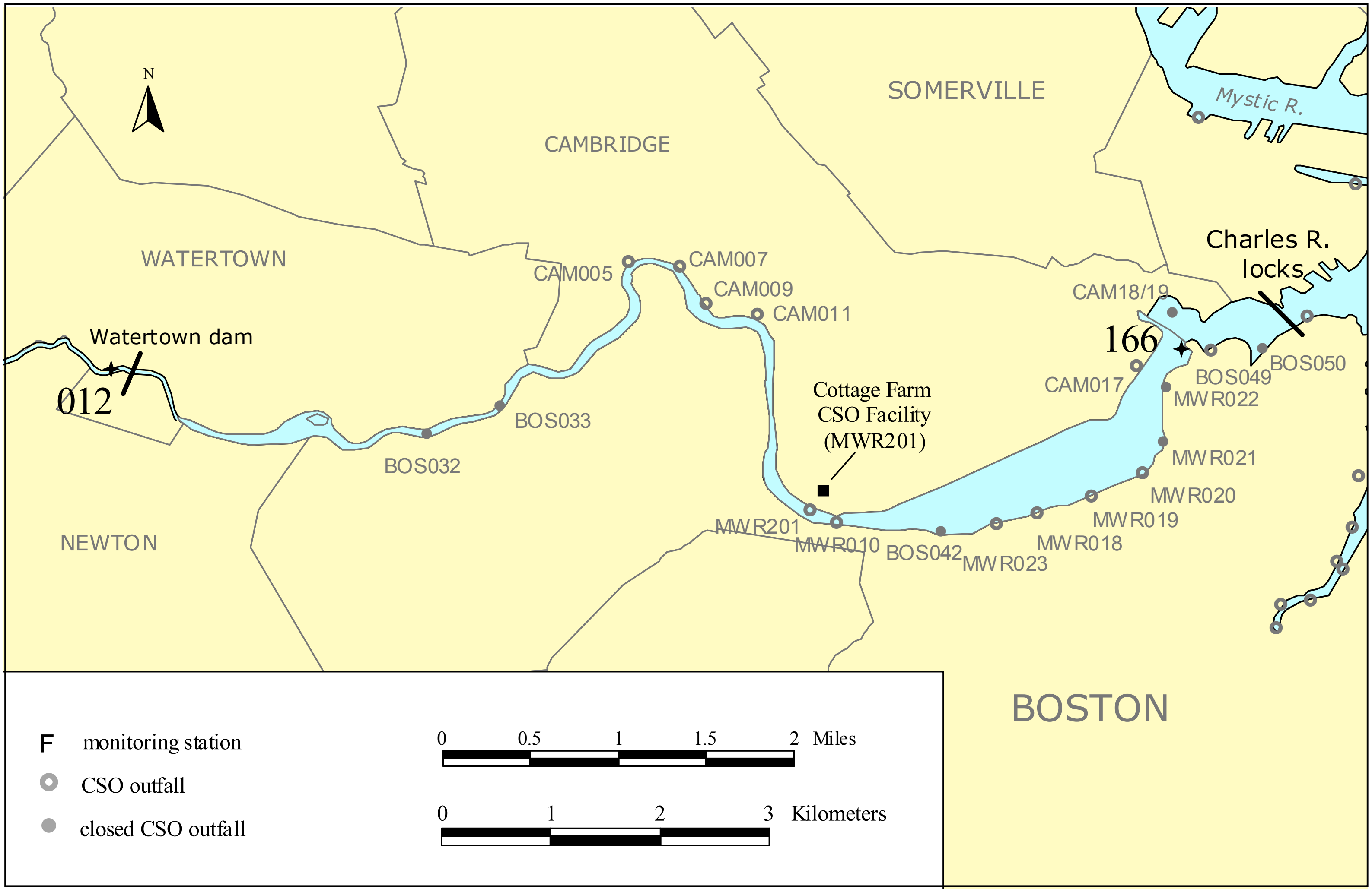


**FIGURE 2. Sampling locations for Charles River Nutrient Effects Monitoring**

**Table 7. Monitoring Parameters for Charles River Nutrient Effects: Laboratory Analyses**

| Parameter LIMS code | Sample Container | Preservation | Analysis Method | Holding Time | Units |
|---|---|---|---|---|---|
| *E. coli* ECOLAQMMT | Sterile 250-ml LDPE bottle | Cooler <10°C | modified EPA 1103.1 | 6 hours | #/100 ml |
| *Enterococcus* ECOCAQMFL | | | EPA1600 | | |
| Total suspended solids TSS-SWGRV | 1-L wide-mouth translucent LDPE bottles | | EPA 160.2 | 7 days | mg/l |
| Total nitrogen TN--SWAAN | 1-L amber wide-mouth HDPE bottle | | Valderrama, 1981 unfiltered | 6 hours | µmol/l |
| Nitrate/Nitrite NO32SWAAN | | | EPA 353.2 | | |
| Ammonium NH3--SWAAN | | | EPA 350.2 | | |
| Total phosphorous TP--SWAAN | 1-L amber wide-mouth HDPE bottle | Cooler <10°C | Valderrama, 1981 unfiltered | 6 hours | µmol/l |
| Orthophosphate | | | EPA 365.1 | | |
| Chlorophyll *a* CHLASWFLU | 1-L amber wide-mouth HDPE bottle | Cooler <10°C | Modified EPA 445.0 | 6 hours | µg/l |
| Phaeophytin PHAESWFLU | | | | | |

**Table 8. Frequency and Number of Samples Collected for Charles River Nutrient Effects Monitoring**

| Survey Frequency | Sites per Survey | Total Samples per year |
|---|---|---|
| Bi-weekly, year round | 2 | 76 |

## 8.0 PROJECT FISCAL INFORMATION

This project is funded through MWRA=s FY Current Expense Budget.

## 9.0 SCHEDULE

Nutrient effects samples will be collected biweekly January through December. Laboratory analyses are completed and entered into the LIMS system within ten days, depending on the test performed.

CSO receiving water samples will be collected April 1 through December 31, two consecutive days every three weeks. Laboratory analyses are completed and entered into the LIMS system within five days.

The schedule is subject to change depending on weather and other extenuating circumstances; however a minimum of 20 surveys will be conducted per year.

## 10.0 PROJECT ORGANIZATION AND RESPONSIBILITY

Dr. Andrea Rex, (617) 788-4708, Director of Environmental Quality, and is the Principal Investigator for the CSO and Harbor Outfall Monitoring activities.

Dr. David Taylor, (617) 788-4748, Project Manager, is the Principal Investigator for the Nutrient Effects monitoring.

Ms. Kelly Coughlin, (617) 788-4717, Biologist, is responsible for coordinating receiving water quality monitoring activities and managing data acquisition, review and storage.

Dr. Michael Delaney, (617) 660-7801, is Director of Laboratory Services, and has overall responsibility for managing laboratory operations.

Dr. William Andruchow (617) 660-7804, is the Quality Assurance manager for the Department of Laboratory Services, and is responsible for the development of SOPs for laboratory analyses.

Ms. Wendy Leo (617) 788-4743, is the Quality Assurance manager for the Environmental Monitoring and Management Oracle database.

Ms. Laura Ducott (617) 660-7832, is Supervisor of the Microbiology Laboratory in the Department of Laboratory Services. She has overall responsibility for overseeing sample collection and analyses of samples for fecal coliform, *E. coli,* and *Enterococcus*, and has responsibility for managing the field work.

Ms. Stephanie Moura (617) 788-4399 is Project Manager in the Planning Department, coordinating MWRA's CSO Variance reporting activities.

# 11.0 DATA QUALITY REQUIREMENTS AND ASSESSMENTS

## 11.1 Data Management QA/QC

MWRA will own, process, and manage the field and laboratory data. MWRA will store the data in its Oracle database.

## 11.2 Key Personnel

**Table 9. Key personnel in data management and data processing**

| Department | Function | Name |
|---|---|---|
| Laboratory Services | Approves and enters Central Lab results into LIMS | Laura Ducott, Keary Berger |
| ENQUAD | Reviews and uploads all lab and field data into EM&MS | Kelly Coughlin |
| Metering and Monitoring, Operations Support | Collects rainfall data/loads data into EM&MS | Rod Pineros/Kelly Coughlin |

## 11.3 Data Management

The MWRA Central Laboratory will analyze samples, and enter the data into the Laboratory Information Management System (LIMS) for validation and QA/QC. MWRA ENQUAD will upload the data from LIMS into its Environmental Monitoring and Management System (EM&MS) database for warehousing and subsequent distribution to data analysts. EM&MS is an Oracle relational database available to MWRA users on a DEC Alpha server via the MWRA internal network. Data are stored in Oracle in normalized relational tables that allow users to retrieve data using such tools as Oracle Browser, Microsoft Access, ArcView and Arc/Info GIS.

MWRA rainfall data will be downloaded from the rain gauges, checked, and placed on an internal MWRA network drive by MWRA's Operations Support Program of its Field Operations Department. ENQUAD will then upload the data to the EM&MS Oracle database for warehousing and subsequent distribution to ENQUAD data analysts and other users.

## 11.4 Measures to Ensure Data Quality, Procedures for Identifying and Correcting Data Errors

The MWRA Department of Laboratory Services will enter data into the LIMS system using existing QA/QC procedures specified by the Laboratory Quality Assurance Management Plan. MWRA ENQUAD will transfer only checked and validated LIMS data into the EM&MS Oracle database. Data quality for rainfall information will be maintained by the MWRA's Operations Support Department, which will provide calibration and maintenance of the rain gauges, and will check the data to ensure reliability of measurements.

**11.5 Information Security**

The security of MWRA Central Laboratory data in LIMS is maintained through the Data Anomaly Investigation Request (DAIR) process, which requires all potential changes to data (*e.g*., error correction, entry of missing data) to go through a process of step-by-step review and approval by the Laboratory Quality Assurance Manager, and documentation of all changes. Users of LIMS data access the data through views, and cannot modify data in the database.

The EM&MS version of the data will be a copy of the approved LIMS data and will not be modified without approval from the Principal Investigators and the Central Laboratory's Quality Assurance Manager. Data integrity in the EM&MS database will be maintained through the use of established database constraints. Any changes made in the EM&MS database will be recorded in database documentation and data notebooks. Data users will access the EM&MS Database through Oracle Browser views, which do not enable users to modify the data in the database.

Rain gauge data will be maintained by the Monitoring and Metering Department in a read-only format that cannot be modified. Any changes to this data in EM&MS will be checked with the Operations Support data manager.

**11.6 Documentation of the Data Set, Data Elements, and Methodologies Residing in the Proposed Information Management System**

Sampling data will be documented in the LIMS audit trail and the DAIR process. Data entered into the EM&MS system will be documented in the Oracle database structure. When ENQUAD distributes data to users from EM&MS, it will provide documentation stored in the database structure, such as: collection procedures, laboratory method reference, sample handling, sample analysis, measurement accuracy and precision, appropriate uses of data, potential and known problems with the data.

### 11.7 Frequency of the Data Collection as Added to the Information System

Data will be entered into EM&MS after being approved in the LIMS system. MWRA rain gauge data will be entered into EM&MS after being posted on the MWRA internal network (approximately once a week).

### 11.8 Information Comparisons

The MWRA EM&MS Oracle database facilitates data comparison through the use of established information management and relational database design principles. Because of this design, the data can be linked to the MWRA geographic information system, exported in a variety of standard spreadsheet and text formats for use by others, and accessed with a range of standard data query software. Currently, field, laboratory and rainfall data in the EM&MS database are used by MWRA and outside users (*e.g.*, researchers, agencies, consultants, students, watershed associations, communities) to assess the health of Massachusetts coastal waters and compare data from other studies.

## 12.0 SAMPLING AND LABORATORY PROCEDURES

Sampling and laboratory procedures will be carried out as documented in MWRA's Standard Operating Procedures, listed in the Appendix "List of Approved SOPs." The MWRA Central Laboratory is a Massachusetts Department of Environmental Protection Certified Laboratory.

## 13.0 SAMPLE CUSTODY PROCEDURES

Internal chain of custody forms and sample bottle labels are generated by the Central Laboratory. Samples are collected by MWRA Laboratory personnel and checked in upon return to the Laboratory, as described in the Central Laboratory's Standard Operating Procedures.

## 14.0 CALIBRATION PROCEDURES AND PREVENTIVE MAINTENANCE

Field and laboratory instruments are calibrated and maintained according to the Central Laboratory's Standard Operating Procedures.

## 15.0 DOCUMENTATION, DATA REDUCTION AND REPORTING

All data, including rainfall and tide data, will be loaded into MWRA's Oracle database. The database structure for these data already exists, and contains 10 years of monitoring results. Data analysis will include, as appropriate, measures of central tendency (*e.g.* geometric means of bacteria indicators, means of dissolved oxygen concentration, etc.) of different variables under varying weather conditions, and an appropriate representation of the frequency distribution of the data, such as percentile box plots. Regression analyses and/or non-parametric analyses will be used to develop simple models that predict when and how much rainfall results in violations of water quality standards, and how long the effects on water quality persist.

## 16.0 DATA VALIDATION

The Central Laboratory's data reduction, validation, and reporting procedures are documented in section 7.0 of its Quality Assurance Management Plan. Data validation consists of a three level review process: **Level 1** - the Analyst Review, **Level 2** - Validation, **Level 3** - Approval. The Review, Validation, and Approval processes are employed to ensure conformity with the requirements of the QAMP, and with client data quality requirements. Reported results must be traceable. Traceability is the characteristic of data that allows a final result to be verified by review of its associated documentation. All laboratory results for a given sample must be traceable throughout the entire analytical process applied to the sample. Traceability is maintained through LIMS (which stores all of the pertinent data associated with the sample) and by the utilization of various logbooks (preparation, analytical, and instrumental), instrument raw data printouts, electronic files, and spreadsheets.

## 17.0 PERFORMANCE AND SYSTEMS AUDITS

The Department of Laboratory Services' audit procedures are documented in section 9.0 of its Quality Assurance Management Plan. A **performance audit** provides a quantitative assessment of the analytical measurement process. It provides a direct and independent, point-in-time evaluation of the accuracy of the various measurement systems and methods. This is accomplished by challenging each analytical system (method/procedure) with an accepted reference standard for the analyte(s) of interest. The Laboratory annually participates in Performance Efficiency (PE) studies and bi-annually in the Water Pollution (WP) Performance Efficiency studies. Acceptable performance on these PE samples is required for NPDES self-monitoring analyses and Massachusetts DEP Certification, respectively. In addition, internally administered performance evaluation samples may be submitted to the laboratory sections on a random, as required, basis and for those analytes not present in the WP samples.

A **systems audit** is a review of laboratory operations to verify that the laboratory has the necessary facilities, equipment, staff and procedures in place to generate acceptable data. It represents a subjective evaluation of the strengths and weaknesses of the Laboratory and identifies areas that need improvement. Systems audits are performed quarterly by the QA Specialist.

## 18.0 CORRECTIVE ACTION

The Central Laboratory's corrective action procedures are documented in Section 11.0 of its Quality Assurance Management Plan (QAMP). The occurrence of a practice or incident that is inconsistent with the established quality assurance and quality control procedures of the laboratory must be formally addressed with a corrective action response. Any laboratory employee may, and is encouraged to, request corrective actions when necessary.

Section 11.0 of the QAMP details the situations that require corrective action, and how corrective actions are initiated, investigated, resolved and documented to ensure a complete and systematic response to each corrective action request.

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