Commonwealth of Massachusetts
Executive Office of Energy & Environmental Affairs

Department of Environmental Protection
Central Regional Office • 8 New Bond Street, Worcester MA 01606 • 508-792-7650

Charles D. Baker
Governor

Karyn E. Polito
Lieutenant Governor

Kathleen A. Theoharides
Secretary

Martin Suuberg
Commissioner

Bacterial Monitoring
General Quality Assurance Project Plan (QAPP)

CN 521.0: January 28, 2020

For Bacterial Monitoring of Inland and Coastal Waters of the Commonwealth of Massachusetts

Meghan E. Selby, Water Quality Planning Grants Coordinator ..... Date

Suzanne Flint, Quality Assurance Officer ..... Date

Richard Chase, Data Project Manager ..... Date

HOW TO USE THIS GENERAL QAPP

A Quality Assurance Project Plan (QAPP) describes the quality control elements to be implemented for a monitoring project for the data collected to be of sufficient and documented quality to meet the project needs. This Bacterial Monitoring General QAPP (hereinafter termed the "general QAPP") is intended to serve organizations participating in the Massachusetts Department of Environmental Protection's (MassDEP) Water Quality Monitoring Grant Program with the goal of increasing the amount of bacteria data available for MassDEP's use in the assessment of primary and secondary contact recreational uses in surface waters of the Commonwealth. The QAPP is designed to be adopted as-is in conjunction with development of a Sampling and Analysis Plan (SAP) detailing the program- and project-specific components of the sample collection and analyses. A template SAP and example field and Standard Operating Procedures (SOPs) are provided at: https://www.mass.gov/guides/water-quality-monitoring-for-volunteers.

This Bacterial Monitoring General QAPP is designed to provide consistent, basic quality assurance procedures for all grantees with the aim of producing scientifically-sound, legally-defensible data. The goals of individual monitoring projects may be different from DEP's goals and should be identified in each organization's Sampling and Analysis Plan (SAP). Organizations electing to follow this QAPP must also prepare and submit an SAP which describes the specifics of their monitoring project and defines any differences from this QAPP. Unless otherwise specified in an approved SAP, organizations will collect and analyze samples as described in this QAPP and DEP's referenced Standard Operating Procedures (SOPs).

Color Key:

Requirement: specifies the general QAPP requirement.

SAP content: denotes content required in the project Sampling and Analysis Plan (SAP).

Individual organizations adopting this General QAPP must follow these steps:

1) Carefully review the General QAPP for its contents and to ensure that your program can meet its requirements. If your project varies from these requirements or uses methods not covered by this General QAPP, you may submit a full project QAPP for DEP review/approval or, for minor changes, highlight the specific differences in the required SAP.
2) Complete and sign the "Bacterial Monitoring General QAPP Adoption Form" in Appendix 1.
3) Complete a Sampling and Analysis Plan (SAP) with your program details (template provided).
4) Submit your QAPP package for review and approval before the start of sampling. The QAPP package should include:
    a. General QAPP Adoption Form
    b. Project Sampling and Analysis Plan
    c. all associated field and lab Standard Operating Procedures (SOPs)
    d. example project forms (bottle label, Chain of Custody, field forms, lab forms)

Please note: recipients of Monitoring Grants must have the QAPP Adoption Form and an approved SAP signed by the grantee and the appropriate MassDEP agency representatives *before* proceeding with project implementation.

Additional guidance on developing projects, quality assurance, and writing a full QAPP is available:

- MassDEP https://www.mass.gov/guides/water-quality-monitoring-for-volunteers
- Massachusetts Water Watch Partnership: https://www.umass.edu/mwwp/resources/qa.html
- EPA Citizen Science: https://www.epa.gov/citizen-science/quality-assurance-handbook-and-guidance-documents-citizen-science-projects

Planning/Timing: In general, program planning (including QAPP adoption/development and drafting the Sampling and Analysis Plan) should begin approximately five to six months before the anticipated start of field work. QAPPs and SAPs must be approved before the start of sampling (MassDEP can generally review a QAPP/SAP submission within 30 days, but allow additional time for revisions.)

QAPP Format: This General QAPP follows the format and guidance recommended in "EPA Requirements for Quality Assurance Project Plans" EPA QA/R-5. March 2001. Downloaded from: https://www.epa.gov/sites/production/files/2016-06/documents/r5-final_0.pdf

Acknowledgements
This General QAPP was prepared in support of bacterial monitoring projects funded by grants from MassDEP's Water Quality Monitoring Grant Program. Reviewers of the QAPP included Richard Chase and Megan Selby, Massachusetts Department of Environmental Protection (MassDEP). Prepared by: Suzanne Flint, MassDEP.

Version
Last updated 1/28/2020.

Disclaimer
Reference to trade names, commercial products and manufacturers in this General QAPP does not constitute endorsement by EEA and/or MassDEP.

GROUP A: PROJECT MANAGEMENT

A3. Distribution List

This QAPP shall be posted on the MassDEP's public-facing website at https://www.mass.gov/guides/water-quality-monitoring-for-volunteers. Projects funded through MassDEP's Water Quality Monitoring Grants will receive electronic notification of the document and subsequent revisions. The official signed document will be on file at the MassDEP Watershed Planning Program offices at 8 New Bond Street, Worcester, MA. The QA Officer may make revisions to this plan, which shall be approved by the signatories in section A1 above. MassDEP is not responsible for the control of reprinted copies from the web sites or photo copies of the original plan. It is the responsibility of the reader to ensure that they are using the most current general QAPP.

The General Bacterial Monitoring QAPP, signed QAPP Adoption Form (Appendix 1), and approved Program SAP must be distributed to major project participants, e.g.:

- Project Manager
- Project Monitoring Program Coordinator
- Project Field Coordinator
- Project Lab Coordinator
- Project QA Officer
- Project Technical Advisory Committee
- Contract analytical lab(s) manager/director

In addition, the signed QAPP Adoption Form and the approved Program SAP must be distributed to:

- MassDEP Quality Assurance Officer, Suzanne Flint, suzanne.flint@mass.gov
- MassDEP Water Quality Planning Grants Coordinator, meghan.selby@mass.gov

A4. Project/Task Organization

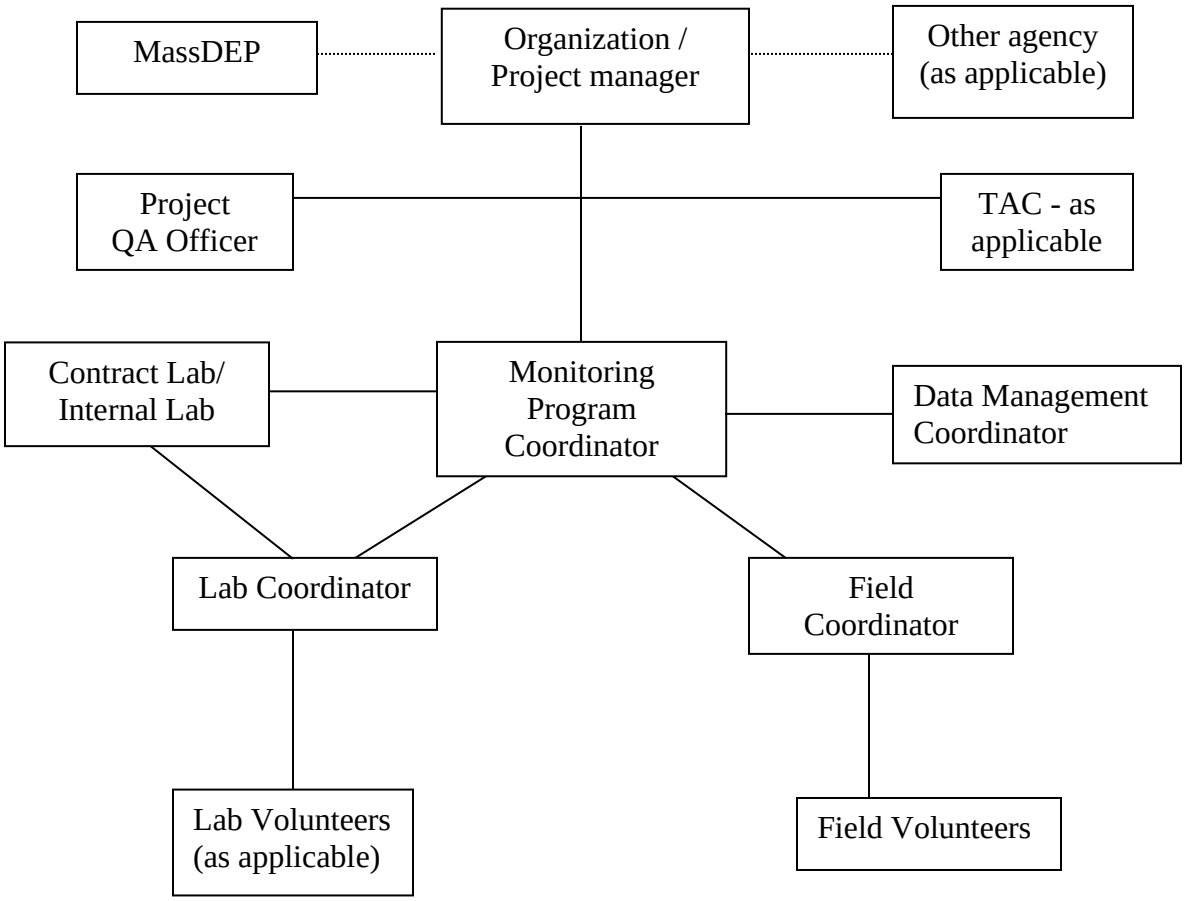
Requirement: The project must have an organized structure for effective communication and completion of tasks.

Table 1: Project Organization (typical roles):

Name(s)	Project Title/Responsibility
Specify in Project SAP	**Project Manager** – Oversees all aspects of project that incorporate the monitoring program including: fiscal management, project objectives, data uses, reporting, program changes, etc.
Specify in Project SAP	**Technical Advisory Committee** – Program oversight and advice.
Specify in Project SAP	**Monitoring Program Coordinator** – Volunteer recruitment and training, coordination with TAC (as applicable). Adopts the General QAPP and develops the Program SAP. Manages data, conducts initial QA/QC, and produces final monitoring report.
Specify in Project SAP	**Lab Coordinator** – Oversees laboratory analysis and QC and/or arranges with contract lab(s) to perform analyses according to QAPP. Ensures correct analysis and QC procedures are used, holding times are met, and adequate documentation is provided.
Specify in Project SAP	**Field Coordinator** – Responsible for training and supervising volunteers in field work; ensures field forms are properly filled out, samples and forms are transported to laboratories as needed; and works with project coordinators and QA Officer to ensure QA compliance.
Specify in Project SAP	**Data Management Coordinator (if separate from Monitoring Program Coordinator)** – Maintains the data systems for the program, performs/oversees data entry, and checks entries for accuracy against field and lab forms.
Specify in Project SAP	**Project QA Officer** – Ensures that all project QA/QC procedures are followed. ***Note:*** Because of a *potential conflict of interest*, this person should not fill the roles of Monitoring Program Coordinator, Field or Lab Coordinator. However, this person may be involved in writing the QAPP.
Specify in Project SAP	**Volunteers** – Conduct sampling, perform field analyses, and assist in laboratory analyses and/or data entry.
Specify in Project SAP	**Contract Analytical Lab Manager(s)/Director(s) -** Responsible for analytical procedures performed under contract (or other arrangement) with monitoring organization.
Meghan Selby	**MassDEP Water Quality Planning Grant Coordinator** – Oversees grant administration and ensures reporting requirements are met.
Suzanne Flint	**MassDEP Quality Assurance Officer** – Reads QA reports, reviews the Project SAPs, confers with program QA officer on ***quality control*** issues that arise during a monitoring program.
Richard Chase	**MassDEP Technical Reviewer** – Reviews and approves General Bacterial Monitoring QAPP.

Figure 1: Typical Organizational Chart

Lines between boxes indicate who communicates directly with whom.



A5. Problem Definition/Background

Requirement: must document background knowledge, the need for the proposed work, and defined objectives.

Water quality and biological data, including bacterial data, form the basis for assessing surface water quality in accordance with the requirements set forth in §305(b) and §303(d) of the federal Clean Water Act. Use-attainment determinations (e.g. whether a waterbody is clean enough for swimming and boating) are made for each waterbody for which adequate data and information are available. However, with more than 3,000 lakes and ponds and 12,000 miles of streams and rivers in the state, MassDEP's Watershed Planning Program (WPP) can sample only a fraction of these surface waters in any given year.

Therefore, in addition to the data collected by its own staff, WPP also considers reliable data from other state and federal agencies, local governments, volunteer organizations, and other sources ("external data") in making water quality assessments. MassDEP's aim in offering funding for bacterial sampling by non-DEP groups is to increase the amount of reliable indicator data available for making assessments (specific bacteria analytes are sampled as surrogates and indicators of the relative potential for pathogenic organisms to be present). In addition to water body health assessments, data also may be used for Total Maximum Daily Load (TMDL) programs, municipal infrastructure improvements, Clean Water Act Section §319 projects, MA Wetlands Restoration Program projects, and to advise local-level decision makers and inform the public on the condition of local waters. For more information on MassDEP's water quality assessment process, see DEP's 2018 Consolidated Assessment and Listing Methodology *Guidance* at: https://www.mass.gov/service-details/water-quality-assessments

SAP content: describe project-specific objectives, relevant background information and how the data will be used.

A6. Project/Task Description

This Bacterial Monitoring General QAPP covers grab sampling (by wading or using a sample collector such as a sampling pole) for *E. coli* and/or enterococci to evaluate health risks associated with recreation. Note that both *E. coli* and enterococci can be bacterial indicators for fresh water (*E. coli* is preferred). Enterococci is the preferred indicator for marine or brackish waters. Fecal coliform bacteria are the indicator for shellfishing areas. Analytical methods covered here include:

- SM 9223B, EPA 1603 (for *E. coli*)
- SM 9223B, EPA 1600, and ASTM D6503-99 (for enterococci).
- SM 9221 (C, E) (for Fecal coliform)

Each organization's SAP will define their monitoring goals, describe specifics of where and when samples (including frequency) will be collected, by whom (and how samplers will be trained and supervised), which analytes will be collected, how samples will be analyzed, and a timetable for the monitoring program (see example in Table 3).

In general, sites should be selected to reflect representative average conditions in a water body – at least one site per river reach, lake, or wetland. Lake sampling is typically done at a beach or from the shoreline. Analysis can be conducted "in-house" (e.g., SM9223B by Colilert system) or by a contract lab using any of the listed analysis methods.

Samples should be collected bi-weekly (every other week) for all non-bathing waters during the contact season (June 1st to September 30th (preferred) or April 1st to October 15th). These frequencies are designed to ensure that an adequate number of valid samples are collected within the 90-day averaging period to determine criteria evaluations. Time of day for sampling is flexible within required hold-times (6 hours from sample collect to delivery to the lab; a total of 8 hours between sampling and start of analysis). Sampling can be regularly scheduled (rain or shine), although dry weather sampling (e.g., no or < 0.25 inches antecedent rainfall in prior 72 hours) is preferred and significant storm events should be avoided. In tidal areas, the tide cycle influence must be taken into account when planning sampling (aiming to sample on an ebb tide) and conducting impact assessments.

Data may be compared to current state water quality standards (https://www.mass.gov/doc/314-cmr-400-surface-water-quality-standards/download).

Table 2: Massachusetts Water Quality Standards (as of 1/2/2020)

Type/Class	Indicator	Criteria
FRESHWATER		
Class A Public Water Supply	Fecal Coliform	• 20 cfu/100 ml in all samples in any six-month period
	Total Coliform	• 100 cfu/100 ml in 90% of samples in any six-month period
Bathing beaches in bathing season	*E. coli*	• geometric mean of 126 cfu/100ml in most recent 5 samples, and • 235 cfu/100ml in any single sample
	Enterococci	• geometric mean of 33 cfu/100ml in most recent 5 samples, and • 61 cfu/100ml in any single sample
Class A and B waters and all bathing beaches during non-bathing season	*E. coli*	• geometric mean of 126 cfu/100 ml of all samples within 6-month period, and • 235 cfu/100 ml in any single sample
	Enterococci	• 33 cfu/100 ml typically based on a minimum of five samples, and • 61 cfu/100 ml in any single sample
Class C	*E. coli*	• 630 cfu/100 ml typically based on a min. of five samples, and • 1260 cfu/100 ml in 10% of samples
COASTAL AND MARINE		
Class SA shellfishing	Fecal Coliform	• geometric mean of 14 MPN/100 ml, and • 28 MPN/100 ml in 10% of samples
Class SB shellfishing	Fecal Coliform	• median or geometric mean of 88 MPN/100 ml, and • 260 MPN/100 ml in 10% of samples
Bathing beaches during bathing season	Enterococci	• geometric mean of 35 cfu/100 ml of five most recent samples within a bathing season, and • 104 cfu/100ml in any single sample
Class SA and SB waters and bathing beaches during non-bathing season	Enterococci	• geometric mean of 35 cfu/100ml of all samples in the most recent 6 months typically based on five samples, and • 104 cfu/100ml in any single sample
Class SC	Enterococci	• geometric mean of 175 cfu/100ml in all samples in the most recent six months, typically based 5 most recent samples, and • 350 cfu/100 ml in 10% of samples

The Project Monitoring Coordinator will develop findings and conclusions, which can be incorporated into a study report for dissemination to the QAPP distribution list, the local press, and other stakeholders via paper or electronic media. Provisional results may also be disseminated as needed throughout the

sampling season via web sites, press announcements, or at informational kiosks at public water access locations, etc.

All grantees must submit data before November 15 after each sampling season. Data can be submitted to MassDEP through WPP's data portal; submission guidelines are here: https://www.mass.gov/guides/external-data-submittals-to-the-watershed-planning-program.

Alternatively, data can be submitted to EPA's WQX system (https://www.epa.gov/waterdata/water-quality-data-wqx). Providing data to the WQX database makes the data available to the public via the national Water Quality Portal (WQP). The WQP is a cooperative service sponsored by the United States Geological Survey (USGS), the Environmental Protection Agency (EPA), and the National Water Quality Monitoring Council (NWQMC). For access to the user's guide see this link: https://www.waterqualitydata.us. MassDEP staff can access external water quality data submitted through the National WQP.

If submitting via the WQX/WQP (and not via DEP's data portal), notification of data uploads must be sent to WQData.Submit@mass.gov. Please include:

- the MassDEP Data Integrity Form
- any QC data that is part of the project but not uploaded to WQX.

SAP content: Grantees should specify which method they plan to use for data submittal.

Annual Task Calendar

This represents a typical revolving calendar. Some tasks may continue into the following year.

SAP content: Project-specific timetables must be included in project SAPs.

Table 3: Typical Project Schedule

Activity	J	F	M	A	M	J	J	A	S	O	N	D
Develop monitoring objectives and study design with Technical Advisory Committee		**X**										
Review the General QAPP		**X**										
Develop project-specific SAP		**X**	**X**									
Submit QAPP Adoption Form and SAP to Mass DEP for approval		**X**	**X**	**X**								
Equipment inventory, purchase, inspection, and testing			**X**	**X**	**X**							
Field training for samplers			**X**	**X**	**X**	**X**						
Lab training sessions (in-house analyses)				**X**	**X**							
Sampling surveys				**X**	**X**	**X**	**X**	**X**	**X**	**X**		
Data entry					**X**	**X**	**X**	**X**	**X**	**X**	**X**	
Data review and validation					**X**	**X**	**X**	**X**	**X**	**X**	**X**	
Field audit(s)					**X**	**X**	**X**	**X**	**X**	**X**		
Lab audit(s)					**X**	**X**	**X**	**X**	**X**			
Assess and interpret findings									**X**	**X**	**X**	
Report results and findings										**X**	**X**	**X**
Submit final data to MassDEP or upload to WQX											**X**	

A7. Data Quality Objectives (DQOs)

Requirement: Clear and achievable ***data quality objectives*** for each parameter to be measured in the project.

For water quality data to inform decision making it is critical that the quality of the results themselves be assessed in order to understand the sampling error and the error of the measurements themselves. Organizations are responsible for collecting, analyzing, and reporting the QC data needed for determining whether their data quality objectives are met. When data is submitted, MassDEP reviews this QC information (among other things) to assign data quality scores and assess whether data is of sufficient quality to be used in assessments (see Appendix III for a description of the data review process).

Taken together, ***precision***, ***accuracy***, ***representativeness***, ***completeness***, and ***comparability*** comprise the major data quality indicators used to assess the quality of the program's data. Typical QC samples are listed in Table 4 and data quality objectives (DQOs) for each of these indicators are listed in Table 5. (Additional discussion of data quality objectives can be found in the resources listed above on page 4).

- **Precision** is the ability of a measurement to consistently be reproduced. Repeated measurements (e.g. duplicates) are usually used to determine precision. **Field duplicates** should be taken for at least 10% of samples (or once per sampling event whichever is more frequent). **Laboratory splits or duplicates** are used to evaluate laboratory precision. Consult with any contract lab to determine their split frequency. For projects doing in-house bacterial analysis, laboratory splits should be done for at least 10% of samples (a larger volume field sample should be taken to allow laboratory splits to be conducted).

- **Accuracy** is the degree of confidence in a measurement. The smaller the difference between the measurement of a parameter and its "true" or expected value, the more accurate the measurement. Accuracy for water quality monitoring is usually estimated using laboratory QC data (**blank results**, **known** QC samples, etc.).

- **Representativeness** is how well the collected data depict the true system. Most sampling sites are selected to be representative of the waterbody (or in the case of hotspot monitoring, of the pollution source of interest). Sample collection timing and frequency is selected to capture data that are representative of target conditions (e.g. a range of water levels, weather, seasons, etc.). How the project sampling site selection and collection timing to be representative of the system should be described the project SAP.

- **Comparability** is the extent to which data from one data set can be compared directly to another data set. Comparability can be assured by using **known protocols** and **documenting methods**, analysis, sampling sites, times and dates, sample storage and transfer, as well as laboratories and identification specialists used so that future surveys can produce comparable data by following similar procedures.

- **Completeness** is the amount of data that must be collected to achieve the project goals. At least 80% of the anticipated number of samples are typically collected, analyzed and determined to meet data quality objectives for the project to be considered fully successful. A report detailing the number of anticipated samples, number of valid results, and percent completion (number of valid samples / number of anticipated samples) for each parameter is typically produced.

Detection Limits are defined in several different ways. See Appendix II for definitions of level of quantitation, lower level of detection, and instrument, method, practical quantitation and reporting detection limits.

Table 4: Typical QC sample types and uses

QC Sample Type	Description / Recommended Frequency	Indicator of
Field Blank	A "clean" sterile sample, produced in the field, used to detect contamination during the sampling process (sampling, transport, and lab analysis). Typically taken by taking sterile water into the field and transferring it to a sample bottle under field conditions. Frequency: 10% of samples or once per sampling event (whichever is more frequent).	Accuracy
Equipment or rinse blank	Field equipment blanks are only necessary if water samples are collected in another sampling device and transferred into the sample container. A field equipment blank uses sterile water rinsed through the sampling devices to detect cross-contamination between sites. A field equipment blank is collected and transferred in the same manner as the stream water sample. Frequency: 10% of samples or once per sampling event (whichever is more frequent).	Accuracy
Known samples	For bacterial testing, known samples (e.g. *E. coli* and *Pseudomonas aeruginosa* as positive and negative controls) can be purchased and analyzed alongside field samples. Frequency: once per new batch of reagents for in-house analysis; once per laboratory analysis batch (see manufacturer's instructions).	Accuracy
Split sample	Sample that is divided equally into two or more sample containers and analyzed. E.g. a 290-ml sample is split into two 120-ml samples in the lab and analyzed as separate samples. Splitting can be done in the field (field split) or in the lab (lab split). Field splits can be sent to separate labs to assess inter-lab precision. Frequency: 10% of laboratory samples.	Lab precision
Field duplicate sample	Two samples taken at the same time (one immediately after the other), at the same site, and analyzed by the same lab using the same methods. Duplicates can be used to detect both the natural variability in the environment and that caused by field sampling methods. Frequency: 10% of samples or once per sampling event (whichever is more frequent).	Field precision

Table 5: Data Quality Objectives (DQOs) for Bacterial Samples

Parameter	Units	Accuracy	Precision (RPD) (Field and Laboratory)	Approx. Expected Range
E. coli, enterococci, Fecal coliform	Colonies or CFU/100 ml *or* MPN/100 ml	Blanks and negatives show no colonies, ***positives*** show colonies	For log_{10} transformed field duplicate or laboratory split data: <30% RPD (<50 CFU/ 100mls) <20% RPD (50-500 CFU) <10 % RPD (500-5000 CFU) < 5% RPD (>5000 CFU)	0-1,000,000

SAP content: note any proposed alternate or project-specific DQOs.

A8. Training Requirements

Requirement: Instruction in all aspects of project data collection and management shall be provided to participants

All members of the project team are required to attend training appropriate to the type of monitoring they will conduct. The Monitoring Coordinator shall ensure that volunteers receive appropriate training by organizing and conducting workshops (securing the services of expert trainers as needed) and/or arranging for volunteers to be trained at workshops held by other qualified personnel or organizations. Volunteers failing to attend required training sessions and/or not meeting expectations shall not participate in data collection under this General QAPP.

The Monitoring Coordinator enters training data into the project database and records the following information: subject matter, training course title, type of training materials, date and agenda, name and qualification of trainers, and names of participants trained.

SAP content: describe project-specific training.

A9. Documentation and Records

Requirement: Documentation and record-keeping for all project activities related to data collection and data quality shall be implemented for the duration of the project.

Table 6: Documents and Document Retention (typical)

Project documents should be retained consistent with Massachusetts state polices on document retention or at least six years after the project becomes inactive.

Document Name / Description	Storage Location	Storage Time
General Bacterial Sampling Quality Assurance Project Plan (QAPP) QAPP project description and assurance procedures.	MassDEP electronic files (copy to organization's files)	Indefinite
General Bacterial Sampling QAPP Adoption Form (signed)	Organization's office (copy to MassDEP)	6 years
Sampling Analysis Plan- specific sampling information for each organization's activities.	Organization's office (copy to MassDEP)	6 years
Water Quality Monitoring Guidebook- Methods manual for volunteers detailing field methods	Organization's office	6 years
Training Records	Organization's office	6 years
Equipment Notebooks - records of quality control checks, calibrations and maintenance.	Organization's office	6 years
Field Data Sheets - Field forms containing sampling meta data and raw field data.	Organization's office	6 years
Chain of Custody Records accompanies samples from collection to laboratories. Sample collectors, all individuals who take custody of the samples, and laboratory intake will sign COC forms. Information included: sample ID, date, time, type of sample, and sampler's names.	Organization's office	6 years
Sample Labels will be placed on all sample containers, and will include the site name, date, time, location, type of sample, and sampler's name.	Organization's office	Temporary
Final Reports and QC Summary Reports – Summarizing project data and findings. Summarizing all QC data available for a project during the dates relevant to the data submittal.	Organization's office	6 years
External Data submitted to MassDEP by organization for review, reformatting and upload into External Database	MassDEP electronic files	Indefinite

SAP content: population Table 4 in the SAP with project-specific details.

GROUP B: DATA GENERATION AND ACQUISITION

B1. Sampling Process Design

Requirement: explain the thought process behind the sampling plan; provide detailed information regarding the "what, when, how, where and why"; address safety issues

SAP content: The sampling design (i.e. parameters, number and location of sampling sites, sampling time of day, frequency, and season) should be selected to meet the monitoring objectives as described in the project SAP. Bacterial samples should be collected bi-weekly (every other week) during the contact season (June 1st to September 30th (preferred) or April 1st to October 15th). Any specific environmental

conditions, ambient, summer base flow, runoff events, etc. needed to answer the organization's specific monitoring question should be identified in their SAP.

Stations must be located so samples and other data can be collected that are representative of the conditions being monitored according to project objectives. In practice, this means that stream stations should be located on relatively straight runs, away from obvious eddies or backwaters, far enough from major obstructions that prevent adequate mixing, and far enough downstream of tributary or other inputs to ensure complete mixing before samples are collected. Lake stations should be located far enough into open water to avoid obvious near-shore influences and outside of confined embayments unless near-shore or embayment conditions are of primary interest. In lakes of complex morphometry, multiple sampling stations may be required to collect representative data. Beach sites should be representative of the recreational use area. Other site location considerations include: ease of access, safety, and permission.

Project-specific design shall be described in a project-specific SAP. The SAP must include:

- the *logic* for selecting their sampling design (locations, sampling time, frequency)
- a list of monitoring locations including: site ID, site name, water body, short description, and GPS coordinates (Table in SAP)
- map of the sampling locations
- photographs of sampling sites are recommended
- identify how sites will be accessed
- identify the total number of sites
- what parameters will be measured at each site
- when (time of year/day, environmental conditions, etc.).

Sampling Safety. Personal safety shall be a primary consideration in all activities, including selection of sampling sites, dates, and training programs. Safety procedures shall include, but not be limited to:

- No sampling shall occur when personal safety is thought to be compromised.
- The Monitoring Coordinator and Field Coordinator shall confer before each sampling event to decide whether adverse weather or other conditions pose a threat to safety and will cancel/postpone sampling when necessary.
- Communication plan in case of cancellation/postponement should be specified in the SAP.
- Sampling shall take place in teams of two or more.
- Samplers shall wear life vests when sampling from boats or wading in waters under difficult conditions.
- Samplers shall wear proper clothing to protect against the elements as applicable, especially footwear and raingear.

IMPORTANT! When sampling in rivers, samplers shall estimate flow conditions and avoid sampling when river depth (in feet) times velocity (feet per second) are equal to 5 or greater (e.g. 1.5 foot depth * 4 feet/second velocity = 6 = unsafe conditions!).

B2. Sampling Method Requirements

Requirement: All sample collections shall follow specific ***Standard Operating Procedures (SOPs)***

All sample collections shall follow project-specific ***Standard Operating Procedures (SOPs)***, as contained or referenced in a project-specific Sampling and Analysis Plan.

It is recommended that pre-sampling coordination with a laboratory take place to ensure that proposed sample collection procedures (found in the SOPs) meet the needs of the chosen laboratory.

General sampling method for bacterial samples: Place upright, capped sample bottle under the surface of the water about six inches. Do not rinse bottle. Slowly uncap and let it fill to capacity under the water. With hands away from the bottle opening, bring the bottle up and out of the water, pour sufficient water to leave approximately 1/2 inch air space in the bottle. Cap bottle and tighten. Care should be taken to avoid loss of any dichlorination reagent inside the sample container. Latex gloves should be worn when sampling in waters suspected of contamination.

Table 7: General Sample Collection Methods[1]

Sample Type/ Device	Parameter(s)	Container Type(s) and Preparation	Minimum Sample Quantity [2]	Sample Preservation	Maximum Holding Time
▪ Manual grab sample ▪ "Pole" sample ▪ Basket sample	▪ *E. coli* bacteria ▪ Enterococci ▪ Fecal coliform	▪ 120-ml sterile bottle (new-sealed or autoclave-sealed)	120 ml per analyte	▪ Sodium thiosulfate if chlorine residual suspected ▪ Refrigerate on ice to <4°C	▪ Transport to lab within six hours ▪ Analyze within 8 hours of collection

1) This table highlights field sampling specifications that should be contained in project-specific SOPs in greater detail.

2) Coordinate with lab regarding sample volume requirements and other issues

B3. Sample Handling and Custody Requirements

Requirement: document procedures used to label, transport, store and track custody of samples

Sample container labels should be attached to dry bottles (before delivery to the field) with the following information: Site ID#, sample type, date and time, preservation (if any), name of sampler, name of organization conducting sampling. All sample containers will be labeled before delivery to the field samplers.

In the field, the samplers should check the pre-labeled information against the chain of custody form, add their initials and time of collection to the bottle label, and record the time of collection on the chain of custody form. Samples should be put immediately on ice in a cooler (i.e. <4°C in the dark).

Transport temperature: Each cooler should be supplied with a clearly labeled "temperature blank," a sample bottle with distilled water that is placed in the cooler at the start of the sampling. Using a temperature blank allows the cooler temperature to be checked on arrival at the lab and avoids the possibility of thermometer breakage from being placed directly in the cooler or sample contamination by checking the temperature of a real sample. All samples must be delivered to the lab for analysis within 6 hours of collection.

Chain of Custody forms will be used to record time of collection and all transport and storage information. Completed Chain of Custody forms are permanently archived at the organization's office.

SAP content: note any differences.

B4. Analytical Methods Requirements

Requirement: identify analytical methods used in the project; must be based on standardized laboratory methods that are specifically referenced in the SAP

The submitted SAP shall include Standard Operating Procedures (SOPs) written by the laboratory for all methods used. These SOPs may reference a published method (e.g. SM 4500 P), but citing a method alone is not sufficient. Method detection and reporting limits must be ascertained for each analyte from the lab being employed.

Table 8: Bacteria Analytical Methods

Parameter	Method #	Source of Method	MDL [1]	Special Considerations
E. coli	EPA 1603 (Modified mTEC)	EPA	5 CFU/100 mL	preferred indicator for fresh waters
	SM 9213-D (mTEC)	Standard Methods, 21st	1 CFU/ 100 mL	
	SM 9223-B (enzyme substrate, Colilert™)	Standard Methods, 21st	1 MPN/100 mL	
Enterococci	EPA 1600 (Membrane Filtration)	EPA	5 CFU/ 100 mL	preferred indicator for marine and brackish waters
	SM 9230-B, SM 9230-C	Standard Methods, 21st	lower reporting limit <10 MPN/100 mL	
	ASTM D6503-99 (enzyme substrate)	ASTM	1 MPN/100 mL	
	SM 9223-B (Enterolert™)	Standard Methods, 21st	1 MPN/100 mL	
Fecal coliform	SM9221-C, E	Standard Methods, 21st	lower reporting limit <10 MPN/100 mL	Preferred indicator for shellfishing areas
	SM 9222-D	Standard Methods, 21st	< 10 CFU/100 mL	

1) MDLs may vary from those proposed in the General QAPP. Consult your laboratory and include the appropriate MDL in the project SAP.

B5. Quality Control Requirements

Requirement: the project shall include sufficient quality control measures to assess general data quality issues, as well as specific data quality objectives

Field Audit of Volunteers
One or more trainers from among the Project Coordinator, QA Officer, or Field Coordinator will accompany each field crew on a sampling session once a season. Trainers will observe sampling activities and check sampling techniques and field data sheets for accuracy. Trainers will submit brief written reports of audits to the Project Coordinator for review and storage.

Field QC Checks
At least one field duplicate and one field blank will be submitted for every ten samples collected or for each sampling day, whichever is more frequent. For projects collecting only 1-2 samples per sampling survey, all parameters must be duplicated on their first sampling expedition. After the first duplicate, then duplicates should be collected at a rate of one every ten samples or at least once every 2 months, whichever generates more duplicates.

Blanks and duplicates should be submitted "blind" to the laboratory (i.e. the sample label and number should not identify the sample as a QC sample or indicate where it was taken).

SAP content: project-specific procedures for taking ambient **field blank** QC samples and **field duplicate QC** samples shall be stated in the project SAP or SOPs.

Laboratory QC
One lab duplicate will be analyzed for every 10 samples or once/sampling day (whichever is greater). The lab will split a sample (field samplers will have to collect a larger-volume sample for splitting) and analyze both subsamples.

When using SM9223B with the IDEXX Colilert™ system, reagents will be tested with IDEXX Quanti-Cult™ culture at the start and end of the monitoring year. Incubator temperatures will be checked at the beginning and end of each incubation and recorded in a log book kept with the incubator along with date, time and who completed the check the equipment.

Any contract lab's QC protocols shall be discussed with the lab prior to sampling to ensure acceptability. Organizations should request that the laboratory report include, in addition to sample results, results of laboratory QC for duplicates, spikes, and blanks.

QC Calculations
The following indicators will be calculated and recorded with the associated data: relative percent difference (RPD) between field duplicates, RPDs between laboratory duplicates, results of positive and negative known samples, field and laboratory blank results, and % completeness.

Because of the relatively high natural variability of bacterial data, Relative Percent Difference (RPD) for bacterial samples is usually calculated as the absolute value of the difference in *log base 10* result between the two duplicates divided by the mean of the duplicates ×100:

=ABS(LOG10(A)-LOG10(B))/AVERAGE(LOG10(A),LOG10(B))*100

Where A = original result, B = duplicate or split result

Completeness is the ratio of the number of valid sample results to the total number of samples analyzed with a specific matrix and/or analysis. At the end of each sampling season, the percent completeness will be calculated by the following equation:

=COUNT(valid measurements)/COUNT(planned measurements)*100

Corrective Actions
If measurements are determined to be out of QC acceptance range those measurements will be flagged "qualified" and/or may be excluded from reports. Corrective actions may include: repeat sampling when feasible, recalibration of instruments, and retraining of water quality samplers.

SAP content: note specific corrective actions to be taken in project.

Documenting QC Results
All QC results for water quality measurements will be recorded in the project database. Instrument calibration records will be recorded and stored in Excel spreadsheets.

Quality control tests described here must be followed and the results of these QC tests reported with the submitted data.

B6 and B7. Instrument/Equipment Inspection, Calibration and Frequency

Requirement: All instruments shall be calibrated and maintained at a pre-determined frequency to ensure instrument accuracy and precision

Maintenance shall occur as needed. Records of equipment inspection, maintenance, repair and replacement shall be kept in a logbook. In addition to following a manufacturer's recommendations, project-specific SOPs for instrument maintenance shall be followed.

Table 9: Typical Instrument/Equipment Inspection, Testing Procedures

Equipment Type	Inspection Frequency	Type Inspection	Maintenance, Corrective Action
Autoclave (bacterial analysis)	Weekly	Inspect and clean as needed. Spore check is run with a batch to ensure the autoclave is reaching proper temperature and pressure	Clean, lubricate surfaces; maintain water surfaces according to user's manual.
Sample prep equipment (e.g., sealer for Colilert® bacteria method)	Prior to each sampling	Visual inspection, clean, and maintain according to manufacturer's recommendations.	Take apart and clean
Incubator (bacteria analysis)	Prior to each sampling	Check temperature with max/min electronic thermometer (traceable to NIST)	Spare batteries, electrolyte
NIST Traceable Thermometer	Annually	Check thermometer reading at 0°C and room temperature against another thermometer	Send for certified re-calibration when >0.5°C difference
Life Preservers (PFDs)	Before each use	Visual for integrity	Keep spares
Cooler	Before each sampling date	Cleanness	Replace
Waders	Before each sampling date and whenever leaving a body of water	Visual inspection for damage, presence of plant or animal material on waders	Patch or replace

SAP content: note any differences.

B8. Inspection & Acceptance Requirements for Supplies

Requirement: procurement, inspection and acceptance of sampling, analytical and ancillary project supplies shall occur in a consistent, timely manner. (Supplies are generally considered things that are "used up."

Table 10:Typical Supplies Inspection, Acceptance Procedures

Supplies	Inspection Frequency	Type of Inspection	Available Parts	Maintenance
IDEXX reagents	With each new batch	Visual inspection of quantity and expiration date	Spare, fresh reagents	Storage according to manufacturer's recommendations. Annual replacement at beginning of sampling season
Quanti-Tray	Before each laboratory batch	Visual inspection for damage and cleanliness	Spare trays	NA
Sterile water	Before each use	Visual inspection for cleanliness	Spare water	NA
Field and Lab sample sheets	Before each sampling date	Visual	Additional copies	NA
Sample Bottles	Before each sampling date	Integrity, cleanness, verified sterility and seal	One set of spare bottles	NA
First aid kit/field kits	Before each sampling date	Visual for integrity, adequate number/amount of all items	Extras all supplies	Replace supplies as needed.

SAP content: note any differences.

B9. Data Acquisition Requirements

Requirement: provide detailed information for any non-project data used

Any data from *other* sources used by this project should be of documented quality and should be consistent with project data quality objectives. Typical external data sources include the USGS National Water Information System (for streamflow data), NOAA's Climate Data Online and Tides and Currents, and the NWS Cooperative Observer Program stations. To verify the quality of external data, the following "metadata" will be provided for each data source ("metadata" are defined as the important information associated with sample data; examples include sampling location, date, time, type of sample, etc.):

- Title of document or descriptive name of the information
- Source of information
- Internet sources should include the data downloaded
- Notes on quality of data, including whether it has a QAPP or some other means of demonstrating quality of the data
- As applicable, a statement on planned restrictions in use of the data because of questions about data quality.

Specific information regarding non-project data shall be provided in the project SAP.

B10. Data Management

Requirement: the project shall include a data management system.

The internal data management procedures must be documented in the SAP for each project; include the elements described below. The project SAP shall describe any program-specific data management systems - e.g. spreadsheets, databases (preferably compatible with Microsoft Excel and Access), statistical or graphical software packages, location of data records (paper and electronic), and examples of forms and checklists.

Data Recording

Field observations will be recorded using permanent pen or marker on appropriate data sheets or logbooks for each sampling site. Corrections on original field sheets or logs will be made by crossing out the error and writing in the correct value; all corrections are initialed. Field sheets will be reviewed for legibility, errors, and questionable values; any questions are referred to the collector for clarification.

Analytical sampling results will be entered from lab reports into the project database or data files. Data management systems should be sufficient to track field data, lab data, and all associated metadata. Metadata should include: sampling date, sampling time, sample locations (including short description and GPS location), analytical methods used, MRLs, lab used, and associated QC samples. Data quality control steps will be taken at several stages, as outlined in Table 12. Data quality indicators should be calculated and recorded with the project data as described in section B5.

Data Tracking, Storage, Retrieval, and Delivery

The organization will be responsible for data storage, management, and retrieval. The project-specific data storage, provisions for backup, and method for data submittal to MassDEP should be described in the project SAP.

GROUP C: ASSESSMENT AND OVERSIGHT

C1. Assessment and Response Actions

Requirement: The project shall have a defined process for identifying and effectively addressing issues that affect data quality, personal safety, and other important project components.

The progress and quality of the monitoring program shall be continuously assessed to ensure that its objectives are being accomplished. Planned assessments should include the elements listed in Table 11.

Table 11: Planned Assessments

Assessment Type	Frequency	Person(s) Responsible
Project surveillance	Ongoing	Monitoring Coordinator
Field audit of volunteers	Annually or more frequently if needed	Monitoring Coordinator
Laboratory Technical systems	Annually	Laboratory Coordinator
Laboratory Performance Evaluation	Annually	Monitoring Coordinator
Data Verification & Validation	Ongoing and Annually	Monitoring Coordinator
Data Quality Assessment	Annually	Project QA Officer
MassDEP Review of Data Submitted	As submitted	MassDEP staff

SAP content: specify project-specific planned assessments.

C2. Reports

Requirement: The project shall include a reporting mechanism for project data. Reporting shall include raw data, QC data and important metadata.

Table 12: Reports

Type of Report	Frequency	Delivery Date	Person(s) Responsible	Report Recipient
Preliminary data	As needed by project	As needed	Monitoring Coordinator	General Public

QC reports	Annually	Annually	Monitoring Coordinator	QA Officer, and available upon request
Final report	Annually, on completion of data collection & reviews	Annually	Monitoring Coordinator or Project Manager	MassDEP, general public, towns, other funders
Electronic Data Delivery	Annually	Annually	Monitoring Coordinator or Project Manager	MassDEP
Electronic Data Delivery via EPA's WQP/WQX	Annually	Annually	Monitoring Coordinator or Project Manager	MassDEP/ EPA

SAP content: specify project-specific planned reports.

Data that have passed preliminary QC analysis (data verification) may be posted on the organization's web site, shared with the local media, or shared at other venues as appropriate to the project. A caveat will accompany any data released on a provisional basis, explaining that they are subject to correction after completion of a full data review.

The written QC report will include: project quality objects, summary of major/critical problems encountered and their resolution, raw QC data and QC data summary, and reconciliation of project data with project quality objectives. Any censored data should not be included in final data reporting (but an indication of censored data should be reported, e.g. using the symbol ##).

Fully QC-checked data to be submitted to MassDEP should be emailed to WQData.submit@mass.gov. Instruction and templates for data submittals are available at https://www.mass.gov/guides/external-data-submittals-to-the-watershed-planning-program. Alternatively, fully QC-ed data may be submitted to MassDEP by uploading to the EPA National Water Quality Portal (WQX) and sending email notification to MassDEP WQData.Submit@mass.gov.

GROUP D: DATA VALIDATION AND UASBILITY

D1. Data Review, Validation and Verification Requirements

Requirement: All project data, metadata and quality control data shall be critically reviewed to look for problems that may compromise data usability.

The Monitoring Coordinator will review field and laboratory data after each sampling run and take corrective actions as described in Table 13Table 11. At least once during the season, at end of the season and if questions arise, the Monitoring Coordinator will share the data with the QA Officer to determine if the data appear to meet the objectives of the QAPP. Together, they will decide on any actions to take if problems are found.

SAP content: describe activity to be performed in the project SAP.

D2. Validation and Verification Methods

Requirement: all project data and metadata are reviewed and approved as usable data (and as un-usable when the data are questionable for any reason).

The goal of data *verification* is to ensure that the data are what they purport to be, that is, that the reported results reflect what was done, and to document that the data fulfill applicable requirements. The goal of data *validation* is to identify and evaluate the impact of any technical non-compliance or quality control non-conformances on the complete data set. Data verification and validation for all data will be the combined responsibility of the Monitoring Program Coordinator and the project QA Officer.

Data validation and verification will occur as described in Table 13.

SAP content: Verify activity to be performed using project SAP. The project SAP should list the data qualifiers that will be used to indicate QC non-compliance issues.

Table 13: Data Verification/Validation Process

Input	Action	Responsible Parties	Corrective action, if needed
Field Forms	Check bottle labels just prior to sampling, to ensure correct labeling. At time of sampling, record data, sign field sheets. Fill out, sign chain of custody (COC) forms for any samples going to lab.	Field sampler	Correct label or change container. Coordinate with sampler on missing/unclear information. Correct and initial field sheets.
Raw Field Data	Initial data check: Upon receipt of field sheets, check for reasonableness to expected range, completeness, accuracy, and legibility.	Field or Monitoring Coordinator	Confer with field sampler(s) immediately or within 24 hours. Resample if feasible; otherwise, flag suspect data.
Sample Documentation	Check COCs for completeness/correctness: Upon receipt of samples and COC forms, check to see that the number and condition of samples correspond to the information on COC forms.	Lab Coordinator, Field or Monitoring Coordinator	Confer with field/monitoring coordinator. Contact field samplers as needed to locate missing samples, data records. In case of missing/spoiled samples or data records, authorize resembling as needed and feasible. If re-sampling is not feasible, flag all suspect data.
Lab Data	Initial lab data review: Upon completion of laboratory analyses, fill out lab sheets, including data on QC tests. Review for reasonableness to expected range, completeness.	Lab Coordinator	Re-analyze if possible. If not, confer with monitoring coordinator. Flag all suspect data.
Lab Data	Initial lab data review: review lab reports for completeness and legibility.	Monitoring/Data Mgt. Coordinator	Confer with lab coordinator.
Preliminary Data	Data verification: Upon completion of data entry, print out raw data. Compare with field/lab sheets for accuracy. Data entry personnel may review their own work, but a different person should perform the final accuracy comparison.	Monitoring/Data Mgt. Coordinator	Correct entered data; document corrections.

Input	Action	Responsible Parties	Corrective action, if needed
Verified Data	Data validation: perform QC calculations (individual sample runs and season-total compilations), run statistical analyses, and/or prepare graphical summaries of data. Check for agreement with QC objectives.	Monitoring/Data Mgt. Coordinator. Technical Advisory Committee.	Confer with QA Officer. Flag or discard suspect data. Decide upon any restrictions in use of data with respect to original data use goals; indicate the data affected and to describe data use restrictions.
Validated Data	Check for agreement with QC objectives. Recheck data and statistical analyses for reasonableness, errors, other problems.	QA Officer	Confer with Monitoring Coordinator and/or Technical Advisory Committee to address specific problems. Review QAPP and SAP if needed.
Final Data	Report final data as appropriate for project.	Project Manager; Monitoring Coordinator	Confer with Project QA Officer and/or Technical Advisory Committee
Final Data	Submit data to MassDEP. Include QC data and report in data submittal; review for formatting consistency with submittal templates and completeness.	Project Manager; Monitoring Coordinator	Confer with MassDEP QA Officer for major project changes.
All Data and Documents	Back up all data and documents (online backup system or off-site backups), and ensure that systems are working	Project Manager, Monitoring Coordinator	Fix or replace backup system.

D3. Reconciliation with Data Quality Objectives

Requirement: Describe a process for comparing field and QC data with the planned data quality objectives.

At the conclusion of the sampling season, after all in-season quality control checks, assessment actions, validation and verification checks and corrective actions have been taken, the resulting data set will be compared with the program's data quality objectives (DQOs). This review will include, for each parameter, calculation of the following:

- Completeness goals: overall % of samples passing QC tests vs. number proposed
- Percent of samples exceeding accuracy and precision limits
- Average departure from accuracy and precision targets.

SAP content: describe activity to be performed.

After reviewing these calculations and taking into consideration such factors as clusters of unacceptable data (e.g. whether certain parameters, sites, dates, volunteer teams etc. produced poor results), the Monitoring Coordinator, QA Officer, and TAC members (as applicable) will evaluate overall program attainment.

Organizations are ultimately responsible for determining how they qualify and use data that does not meet some or all of their data quality objectives.

External data submitted electronically to MassDEP Watershed Planning Program are reviewed using defined and consistent procedures (available upon request). NOTE: QAPP approval, submittal of the data integrity statement and/or submittal of monitoring data does not guarantee that the data will be used by the WPP in its CWA 305(b) use assessment decisions. MassDEP reviews data as needed for assessment uses and does not guarantee review within a set time period.

APPENDICES

APPENDIX I: General Quality Assurance Project Plan Adoption Form

MassDEP General Bacterial Monitoring Quality Assurance Project Plan QAPP Adoption Form

We, the undersigned, have read and understand the QA procedures and requirements outlined in the Massachusetts DEP General Bacterial Monitoring QAPP, and establish that this project meets the overall intent and requirements set forth. Sign (below), scan, and send to Suzanne.flint@mass.gov with the listed attachments.

Submittal checklist: We understand that for final project approval the following documentation must be submitted for approval in conjunction with this QAPP Adoption form:

☐ Project-specific Sampling and Analysis Plan (SAP)

☐ Project-specific field SOPs for all sample collection methods

☐ Laboratory-specific SOPs for each analysis method proposed

SIGNATURES

Project Manager

Name Date

Address

Phone Email

Monitoring Program Coordinator

Name Date

Address

Phone Email

Project QA Officer

Name Date

Address

Phone Email

MassDEP QA Officer

Suzanne Flint Date

MassDEP, 8 New Bond Street, Worcester, MA 01606

508-767-2789 suzanne.flint@mass.gov

APPENDIX II: Glossary of Quality Control Terms

Accuracy: A data quality indicator, accuracy is the extent of agreement between an observed value (sampling result) and the accepted, or true, value of the parameter being measured. High accuracy can be defined as a combination of high precision and low ***bias***. Accuracy checks are typically done in the laboratory. For some indicators, the only available means of checking accuracy is to compare results with another "trusted" lab or with a taxonomic expert.

Analyte: Within a medium, such as water, an analyte is a property or substance to be measured. Examples of analytes would include pH, dissolved oxygen, bacteria, and heavy metals.

Bias: Often used as a data quality indicator, bias is the degree of systematic error or inaccuracy present in the assessment or analysis process. When bias is present, the sampling result value will differ from the accepted, or true, value of the parameter being assessed in one direction.

Blank Plate. For bacteria samples. Rinse water is used instead of field sample, otherwise processed just as a field sample. Result should be "0". Each batch of samples should include at least one blank and one positive check sample.

Blind Sample: A blind sample is a sample submitted to an analyst without their knowledge of its identity or composition. Blind samples are used to test the analyst's or laboratory's expertise in performing the sample analysis.

Calibration Blank: Reagent-grade, purified water (deionized/distilled) used as a zero standard. Used to "zero" lab instruments, evaluate instrument drift and check for sample contamination of field blanks.

Calibration Check Standard: A standard used to check the calibration of an instrument between periodic recalibrations.

Censored Data: Data that has been found to be unacceptable as a result of the data validation process, including review for conformance to the approved QAPP and data quality objectives for the project (e.g., required holding times for analysis, required frequency of field blanks and duplicates/splits, acceptability of precision estimates (***standard deviation***, or relative percent difference (RPD)).

Chain-of-Custody: Used for routine sample control for regulatory and non-regulatory monitoring. The chain-of-custody form contains the following information: sample IDs, collection date/time/samplers, sample matrix, preservation requirements, delivery persons/date/time, etc. Used also as a general term to include sample labels, field logging, field sheets, lab receipt and assignment, disposal and all other aspects of sample handling from collection to ultimate analysis.

Comparability: A data quality indicator, comparability is the degree to which different methods, data sets, and/or decisions agree or are similar.

Completeness: A data quality indicator that is generally expressed as a percentage, completeness is the amount of valid data obtained compared to the amount of data planned.

Data Quality Objectives (DQOs): Data quality objectives are quantitative and qualitative statements describing the degree of the data's acceptability or utility to the data user(s). They include indicators such as accuracy, precision, representativeness, comparability, completeness, and sensitivity (PARCCS). DQOs specify the quality of the data needed in order to meet monitoring project goals.

Data Users: The organization(s) that will be applying the data results for some purpose. Data users can include the principle investigators, as well as government agencies, schools, universities, watershed organizations, and business and community groups.

Detection Limits: Applied to both methods and equipment, detection limits are descriptions of the lowest concentration of a target analyte that a given method or piece of equipment can reliably ascertain as greater than zero. Specific detection limits include: Instrument detection limit, level of quantitation, lower level of detection, method detection limit, practical quantitation limit and reporting detection limit.

Duplicate Sample: Used for quality control purposes, field/lab duplicate samples are two samples taken generally at the same time from, and representative of, the same site/sample that are carried through all assessment and analytical procedures in an identical manner. Field duplicate samples are used to measure natural variability as well as the precision of field sampling and lab analytical methods. Lab duplicates are used as a measure of method precision. Field duplicates can be: side-by-side and simultaneous (generally, two people will take samples or readings simultaneously); sequential (i.e. sample once, then sample again immediately afterwards at the same location); split from a large volume sample (take a sample, then pour a portion of the sample (an aliquot) from the sampling container into another). More than two duplicate samples are referred to as replicate samples.

Environmental Sample: An environmental sample is a specimen of any material collected from an environmental source, such as water or macroinvertebrates collected from a stream, lake, or estuary.

Equipment or Rinsate Blank: Used for quality control purposes, equipment or rinsate blanks are types of field blanks used to check specifically for carryover contamination from reuse of the same sampling equipment (see field blank).

Exotic species: A species that is the result of direct or indirect introduction of the species by humans, and for which introduction permitted the species to cross a natural barrier to dispersal.

Field Blank: A field blank is created by filling a clean sample bottle with deionized or distilled water in the field during sampling activities. The sample is treated the same as other samples taken from the field. Field blanks are submitted to the lab along with all other samples and are used to detect any contaminants that may be introduced during sample collection, fixing, storage, analysis, and transport.

Field Composite Sample: A sample taken by mixing equal volumes of a pre-determined number of grab samples from the same location at different times, i.e. a time-composite. Used to assess average conditions present between the first and last grab samples that are composites. Use time-composite sampling only for those parameters that can be shown to remain unchanged under the specific conditions of composite sample collection. Flow-weighted composite sampling is a variation to time-composite sampling, in which sample volume adjustments are made to each grab based on variations in flow, such as, during stormwater monitoring loading studies.

Field Integrated Sample: A sample taken by simultaneously combining a matrix across vertical or horizontal strata as an evaluation of average composition within the boundaries of the integration (ex. photic zone sampling for chlorophyll a). Sampling tubes can sample continuous, integrated media.

Field Split: A second sample generated from the same sampling location and at the same time by splitting a large volume sample from one sampler deployment into two equal volume samples. Used to measure precision, except that associated with actual sample collection, and excludes natural variability. Also referred to as duplicate subsample.

Field Duplicate (sequential): A second sample generated from the same sampling location as the initial sample, but from a second sampler deployment immediately after the first. Used to measure overall field sampling precision and includes an unknown amount of natural variability (spatial and temporal), if present.

Field Duplicate (simultaneous): A second sample generated from the same sampling location and at the same exact time as the other sample by simultaneous deployment of two identical sampling devices or by the simultaneous filling of two separate sample bottles. Used to measure overall field sampling precision and includes an unknown amount of natural variability (spatial), if present. Also referred to as a co-located duplicate.

Grab Sample: A manually collected sample at a specific location and time. Given practical constraints and budget limitations, assumptions are usually made that the natural variation is small enough over space/time to consider the grab to be representative of conditions over a greater expanse and/or longer period. In some cases, these assumptions may not always be valid.

Instrument Detection Limit (IDL): The concentration that produces a signal greater than five times the signal/noise ratio of the instrument.

Introduced species: A species that has been transported by human activities into a region in which it did not occur in historical time and which is now reproducing in the wild.

Invasive species: A species that displaces native species and has the ability to dominate an ecosystem, or a species that enters an ecosystem beyond its natural range and causes economic or environmental harm.

Known Samples: An internal check that compares your results against another analyst or a "known." The true or expected concentration of the analyte is known prior to performing the analysis.

Lab Fortified Blank: Known concentration of target analyte(s) introduced to clean reference matrix and processed through the entire analytical procedure; used as an indicator of method performance and accuracy. Also known as Spike Blank.

Lab Fortified Matrix: Difference in analyte concentration between a spiked sample and the non-spiked sample should be equivalent to the amount added to the spiked sample. Lab QC sample used to assess sample matrix effects on recovery of target analyte and evaluate accuracy. Also known as Matrix Spike. Duplication of this sample is referred to as matrix spike duplicate or lab-fortified matrix duplicate.

Lab Split: A sample that has been divided into two or more subsamples. Splits are submitted to different analysts or laboratories and are used to measure the precision of the analytical methods. Lab splits are an external QC protocol.

Lab Duplicate: A sample that has been divided into two or more subsamples. It is processed concurrently and identically with the initial sample by the same laboratory. It is used to measure the precision of the analytical methods. Lab duplicates are also referred to as lab splits. At least 10% replication is advised

Level of Quantitation (LOQ): The concentration that produces a signal sufficiently greater than the blank that it can be detected; typically the concentration that produces a signal 10 times above the blank signal (SM, 1998).

Lower Level of Detection (LLD): Measurement level reproducible with 99% certainty; typically twice the IDL.

Matrix: A matrix is a specific type of medium, such as surface water or sediment, in which the analyte of interest may be contained.

Matrix Spike: A sample to which a known concentration of target analyte has been added. When analyzed, the difference in analyte concentration between a spiked sample and the non-spiked sample should be equivalent to the amount added to the spiked sample. Lab QC sample used to assess sample matrix effects on recovery of target analyte and evaluate accuracy. Also known as Lab-fortified matrix. Duplication of this sample is referred to as matrix spike duplicate or lab-fortified matrix duplicate.

Measurement Range: The measurement range is the extent of reliable readings of an instrument or measuring device, as specified by the manufacturer.

Method Blank: An aliquot of clean reference matrix carried through the analytical process to assess the degree of laboratory contamination and indicate accuracy.

Method Detection Limit (MDL): The MDL is the concentration that produces a signal with a 99% probability that it is different from the blank, after going through the entire method. The smallest amount that can be detected above the noise in a procedure and within a stated confidence level. Typically, four times the IDL.

Method Validation: Testing procedure for existing, new and modified methods, in which several evaluation steps are typically employed: determinations of MDL, method precision, method accuracy, and sensitivity to variation in method steps ("method ruggedness", SM, 1998).

Native species: A species that occurs naturally in an area, and has not been introduced by humans.

Non-native species: A species that has been introduced to an area or bioregion.

Nuisance species: A nonindigenous species that threatens the diversity or abundance of native species or the ecological stability of infested area, or human activities dependent on such resources

Performance Audit: Unscheduled evaluation of field sampling QC or laboratory QC procedures by a third party not directly involved in the taking, transport and analysis of the samples; used to detect deviations from accepted SOPs. Audits can take many forms. Submittal of identical check samples to two different labs is an example of an external, blind performance audit. Lab inter-comparison samples can also be used to test the lab's proficiency in relation to other labs. Results of audits are documented and any necessary corrections recommended.

Performance Evaluation (PE) Samples: A sample of known concentration submitted "blind" (without lab's knowledge) to the analyst. PE samples are provided to evaluate the ability of the analyst or laboratory to produce analytical results within specified limits, and as an indicator of method accuracy. Also called a laboratory control sample.

Positive plate: a sample known to contain bacteria (e.g. waste-water treatment plant influent) is processed along with field samples. Determines if a lab procedural error inhibits bacterial growth.

Results should be "too numerous to count." Each batch of samples should include at least one blank and one positive check sample.

Practical Quantitation Limit (PQL): The level that several labs can achieve using the same method and samples; typically, ten times the IDL, and 3-5 times the MDL.

Precision: A data quality indicator, precision measures the level of agreement or variability among a set of repeated measurements, obtained under similar conditions. Precision is usually expressed as a

standard deviation in absolute or relative terms. Precision checks are primarily accomplished through replicate sampling and analysis in the field and lab.

Proficiency Testing (Unknown Samples): Concentrations are known to an auditor but not to the person performing the analysis.

Protocols: Protocols are detailed, written, standardized procedures for field and/or laboratory operations.

Qualifier: Used to indicate additional information about the data, and generally denoted as capital letters in data reports. Qualifier acronyms or terms are unique to each laboratory.

Quality Assurance (QA): QA is an integrated management system designed to ensure that a product or service meets defined standards of quality with a stated level of confidence. QA activities involve planning quality control, quality assessment, reporting, and quality improvement. These activities can be internal (within the main organization) or external (involving outside parties).

Quality Assurance Project Plan (QAPP): A QAPP is a formal written document describing the detailed quality control procedures that will be used to achieve a specific project's data quality requirements. A QAPP is a planning tool to ensure that project goals are achieved. Typically, QAPPs are finalized prior to monitoring activities and any deviations from the final QAPP made during the actual monitoring are noted in a subsequent task, such as the data-reporting phase of the project. QAPPs can be of two main types:

-- A "project-specific QAPP" provides a QA blueprint specific to one project or task and is considered the sampling and analysis plan/workplan for the project.

-- A "generic program QAPP" is an overview-type plan that describes program data quality objectives, and documents the comprehensive set of sampling, analysis, QA/QC, data validation and assessment SOPs specific to the program. An example is a macroinvertebrate monitoring program performed throughout many watersheds within a State.

Quality Control (QC): QC is the overall system of technical activities designed to measure quality and limit error in a product or service. A QC program manages quality so that data meets the needs of the user as expressed in a quality assurance project plan. Specific quality control samples include blanks, check samples, matrix spikes and replicates.

Quality Control Sample: An uncontaminated sample matrix spiked with known amounts of analytes from a source independent of the calibration standards. Generally used to establish intra- laboratory or analyst-specific precision and bias or to assess the performance of all or a portion of the measurement system.

Quality Control Standard: See Quality Control Sample

Random Sample: A sample chosen such that the choice of each event in the sample is left entirely to chance; an unbiased sample generally representative of the population. Randomness is a property of a sample that must exist for almost any statistical test, but may not be appropriate for all sampling designs (ex. Non-random site selection based on targeting specific conditions or based on practical considerations).

Reference collection: An exact duplicate of a voucher collection (a preserved collection of each type (i.e. taxon) of specimen found in a water body). Used regularly as reference when identifying new specimens. Reference collections should be verified by an expert.

Relative Standard Deviation (RSD): A measure of precision calculated by dividing the std. deviation by the mean, expressed as a percentage. Used when sample number exceeds two.

Relative Percent Difference (RPD): A measure of precision used for duplicate sample results. It is calculated by dividing the absolute value of the difference between the two results by the mean of the two results, expressed as a percentage ((|A-B|)/((A+B)/2))*100. Used when sample number equals two.

Reporting Detection Limit (RDL): The lower limit that the lab feels comfortable reporting with a high level of certainty. For practical purposes, the RDL is often equivalent to the MDL.

Representativeness: A data quality indicator, representativeness is the degree to which data accurately and precisely portray the actual or true environmental condition measured.

Sensitivity: Related to detection limits, sensitivity refers to the capability of a method or instrument to discriminate between measurement responses.

Spike Blank: Known concentration of target analyte(s) introduced to clean reference matrix and processed through the entire analytical procedure; used as an indicator of method performance and accuracy. Also known as Lab-fortified blank.

Spiked Samples: Sample is split into 2. A known amount of the indicator (e.g. phosphorous) is added to one. Analysis of samples should show spiked sample with exactly the known amount increase over unspiked.

Standard Reference Materials (SRM): An SRM is a certified material or substance with an established, known and accepted value for the analyte or property of interest. Employed in the determination of bias, SRMs are used as a gauge to correctly calibrate instruments or assess measurement methods. SRMs are produced by the U. S. National Institute of Standards and Technology (NIST) and characterized for absolute content independent of any analytical method.

Standard Deviation(s): Used in the determination of precision, standard deviation is the most common calculation used to measure the range of variation among repeated measurements. The standard deviation of a set of measurements is expressed by the positive square root of the variance of the measurements.

Standard Operating Procedures (SOPs): An SOP is a written, official document detailing the prescribed and established methods used for performing project operations, analyses, or actions.

Trend: Systematic tendency over time in a specific direction in time series data, ideally collected at uniform intervals, collected and analyzed using the same (or comparable) methods and containing no gaps in periodic data.

Trip blanks: A sample container filled in the lab with de-ionized water. It accompanies other samples to field and returned unopened to the lab and is analyzed at the lab as if it were a regular sample. For most analyses, field blanks are preferred over trip blanks.

True Value: In the determination of accuracy, observed measurement values are often compared to true, or standard, values. A true value is one that has been sufficiently well established to be used for the calibration of instruments, evaluation of assessment methods or the assignment of values to materials.

Unknown Samples (Proficiency Testing): Concentrations are known to an auditor but not to the person performing the analysis.

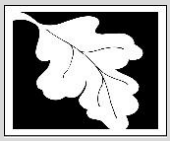
Variance: A statistical term used in the calculation of standard deviation, variance is the sum of the squares of the difference between the individual values of a set and the arithmetic mean of the set,

divided by one less than the numbers in the set.

Voucher collection is a preserved collection of each type (i.e. taxon) of specimen found in your water body. Maintained in archival condition by a trained curator. Voucher reference collections should be verified by an expert.

Wetland: Under the Clean Water Act, the term wetlands means "those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas." Definition taken from the EPA Regulations listed at 40 CFR 230.3(t).

APPENDIX III. MassDEP-DWM Data Submittal Guidelines

Monitoring Method Guidance CN 0.72 (January 2020)	**DATA SUBMITTAL GUIDELINES & EXTERNAL DATA REVIEW PROCESS FOR CLEAN WATER ACT 305(B)/303(D) REPORTING PURPOSES** **Massachusetts Department of Environmental Protection** **Division of Watershed Management- Watershed Planning Program** 8 NEW BOND STREET, WORCESTER, MA. 01606	

Purpose: To provide guidance to non-DEP groups regarding the submittal of quality-assured environmental monitoring data and supporting information to the Massachusetts Department of Environmental Protection, Division of Watershed Management (DWM), Watershed Planning Program (WPP), and to provide information on DWM-WPP's review procedures for such "external" data.

Background: In addition to using data collected internally, DWM-WPP often uses quality-assured data from other groups to assess waterbody health and develop cleanup plans for impaired waterbodies. In order to be considered usable by DWM-WPP for these purposes, these data must meet certain submittal requirements (as explained below) AND undergo detailed review to help evaluate the accuracy, precision and representativeness of the data. Potential external data providers include, but are not limited to, grant recipients; local, state and/or Federal agencies; environmental consultants and volunteer monitoring organizations.

When to submit data: For grant programs, please check the reporting requirements listed in the grant contract.

For MassDEP's CWA 305(b) and 303(d) (Integrated List) assessment and reporting purposes, submittals of surface water quality or quantity data are welcome at any time. However, check the deadlines (listed here https://www.mass.gov/guides/external-data-submittals-to-the-watershed-planning-program) for submittals to be considered for inclusion in the current assessment cycle. Data submitted after the dates listed, including during the public comment period, will not be considered for the current assessment cycle, but will be reviewed and considered in the subsequent cycle. MassDEP's goal is to submit Integrated Reports to EPA in the Spring of even-numbered years.

What to submit: Guidance, templates and forms identified below (in #2, #3 and #5) can be found here: *https://www.mass.gov/guides/external-data-submittals-to-the-watershed-planning-program*

1) Cover letter or email.
2) Statement of Data Integrity. See WPP's external data web page (*link provided above*).
3) Data Files. Quality-assured monitoring data must be sent electronically using DWM-WPP's data submittal template, available via WPP's external data web page (*link provided above*). Data sent using other formats may not be reviewed for usability by DWM-WPP. The Excel data file(s) can be sent via e-mail, acceptable file transfer protocol or CD. Data file(s) should include quality control data. Graphic displays are optional.
4) Copy of Approved QAPP or QAPP Adoption Form (signed).
5) Summary Report (optional). In addition to the final data submittal, a summary report may also be provided. Suggested content for data reports can be found on the external data web page (*link provided above*).
6) Supporting documentation (as appropriate). Other information supporting the data may also be provided (or may be requested by WPP).
7) **Where to submit data**: Electronic data files can be sent via e-mail to the following address: **WQData.Submit@mass.gov**. For regular mail delivery, information can be sent to:

External Data Coordinator
Massachusetts Department of Environmental Protection
Division of Watershed Management-Watershed Planning Program
8 New Bond Street, Worcester, MA 01606

Pre-requisite guidelines for submittal of data for potential use in DWM-WPP's waterbody assessments and TMDLs (Clean Water Act, Sections 305(b) and 303(d)):

1. ***Monitoring data shall be generated through implementation of a DEP- or EPA-approved Quality Assurance Project Plan (QAPP) or Adoption of the Bacterial Monitoring General QAPP with approved Sampling and Analysis Plan (SAP).***

   The project QAPP shall follow applicable DEP and/or EPA guidance for monitoring QAPPs. QAPP guidance is provided here: *https://www.epa.gov/sciencematters/new-epa-citizen-science-quality-assurance-handbook-provides-best-practices-citizen-0; and https://www.mass.gov/guides/water-quality-monitoring-for-volunteers#-guidance-on-quality-assurance-project-plan-(qapp)-* Approved QAPPs/SAPs shall include current laboratory Standard Operating Procedures (SOPs) for each analysis method from the analytical laboratory, as well as project protocols for sample collection, training, quality control sampling and data management. Stated project objectives should be consistent with DWM's use of data for waterbody assessment and/or TMDL development purposes.

2. ***Analytical data shall be provided by an analytical laboratory certified by the Commonwealth of Massachusetts in the applicable analyses, or a laboratory with documented and acceptable Standard Operating Procedures (SOPs).***

   Use of a State-certified laboratory for all sample analyses is highly recommended, but is not always possible. Lab data and metadata generated by non-certified labs may receive a higher level of scrutiny than those from certified labs. A list of State-certified labs is available at: *https://www.mass.gov/how-to/find-a-certified-laboratory-for-water-testing*.

3. ***Quality-assured data (and metadata) shall be provided in sufficient detail for DWM-WPP to evaluate the usability of the data.***

4. ***QC data should be provided in electronic format using DWM-WPP's standard template available at:*** *https://www.mass.gov/guides/external-data-submittals-to-the-watershed-planning-program*. All data should include the appropriate metadata (i.e., sampling and analytical information related to the data). Graphic and textual data analyses are optional.

DWM-WPP's external data review process: Quality-assured data from non-DEP groups are reviewed by DWM-WPP using the following general criteria (as appropriate) and best professional judgment, in order to evaluate their potential for use by DWM-WPP. All data submittals should be citable. Submittal of data does not guarantee its use by DWM-WPP.

1. Overall clarity, organization and detail of the data submittal.
2. Overall precision, accuracy, representativeness, comparability and completeness of the data, in comparison to QAPP data quality objectives and DWM-WPP data quality needs.
3. Estimated accuracy of lab analyses, using Quality Control/Performance Evaluation (QC/PE) samples, spiked sample matrices, and positive/negative controls (for bacteria samples), as compared to project DQOs.
4. Overall evaluation of QAPP implementation (i.e., documentation of actual QC measures to ensure data quality, such as the frequency of instrument calibration and maintenance, problem identification and response, and personnel training)
5. Method consistency/variability among project participants and over time throughout the duration of the project.
6. Evaluation of any field audit information, side-by-side sampling results and/or inter-laboratory QC audit information, if available, to assess inter-group and/or inter-lab precision.
7. Availability of personal communication with project lead(s) and/or QC officer(s), if needed.

A standard external data review format is used for all DWM-WPP reviews. The data usability assessment begins with assembling all available information from the submittal, which may include data reports, data files, QC information, email, etc. For information deemed missing, the contact for the external data group is contacted to see if the information is available. The initial preliminary review determines if the recommended pre-requisites, as identified above, were met.

The subsequent detailed review involves reviewing the data in more detail, specifically looking at the following, when and if available, and as appropriate:

- Consistency and accuracy of all data elements (e.g. site descriptions, GPS locations, reported units, use of data qualifiers).
- Likeliness of data (e.g. no pH readings of <0 or >14), or explanation of outliers.
- Analytical holding time violations

- Frequency of QC samples (blank and duplicates) taken for each survey compared to QAPP Data Quality Indicator goals.
- Field blank sample results to verify lack of contamination.
- Field duplicate sample results to verify acceptable precision.
- Laboratory records (lab notebooks, lab bench sheets, if available) for potential effects on data quality, including multi-probe calibration books for potential effects on data quality.
- Quality control results contained in laboratory data reports for potential implications to data quality (based on lab accuracy and precision data), and lab analytical performance during survey period based on results of any QC/PE testing.
- Miscellaneous documentation (training records, e-mails, phone records, pers. comms., etc.) to highlight any potential problems affecting data quality.
- Overall quality of other data, as available (e.g., benthic macroinvertebrates, fish toxics, other "biological" data).

Communication with data providers regarding data completeness, missing information and other questions takes place as necessary. Based on the review (and any follow-up), conclusions regarding the usability of the data are documented on the data review form, and become the basis for DWM-WPP's use or non-use of the submitted data. Based on the review, data are categorized as Level 1, 2 or 3. Some or all of the data deemed to be Level 3 (potentially suitable for use in waterbody assessments) by WPP can be accepted, accepted with caveat/qualification and/or not used, depending on the circumstances.

APPENDIX IV: Example Forms and SOPs

Examples of field forms and field and laboratory SOPs are available here:
https://www.mass.gov/guides/water-quality-monitoring-for-volunteers#-volunteer-resources-

SAMPLE CHAIN OF CUSTODY FORM

Organization		Project		Laboratory	
Name		Name		Name	
Address		Contact		Address	
Phone #		Contact Phone #		Phone #	

Sample Field ID	Site Name	Sample Matrix Code*	Collector (last name, first initial)	Collection		Preserv. Code**	High bacterial load suspected? (yes/no)	Analysis Requested
				Date	Time			

Comments:

Relinquished by:				Received by:			
Printed name	*Signature*	*Date*	*Time*	*Printed name*	*Signature*	*Date*	*Time*

Cooler temperature on receipt	°C / °F

*** MATRIX CODES: DW = drinking water; SW = non-potable surface water; MW = marine or estuarine water**
**** PRESERVATIVE/THIOSULFATE CODES 1 = cooled to 1 – 6°C; 2 = thiosulfate added**

EXAMPLE BOTTLE LABEL

ORGANIZATION/PROJECT

Site ID _____

Date _____

Time _____

Analysis _____

Sampler's Initials_____