+++ IF 4 < 3 +++

**Color key for this file**

* **Purple text is important information that will be turned into Developer code**
* Do not touch the developer code that looks like “**+++INS `${title}`+++**”
* Do not touch the developer code that is green highlighted
* Must be provided before the QAPP is considered complete.

+++ END-IF +++

+++EXEC

determine = (mtype, wtype, name, method) => parameters.some((param) => mtype !== '' ? param.monitoringCategory.toLowerCase() === mtype.toLowerCase() : wtype !== '' ? param.waterType.toLowerCase() === wtype.toLowerCase() : name !== '' ? param.parameter.toLowerCase() === name.toLowerCase() : method !== '' ? param.method.toLowerCase() === method.toLowerCase() : false);

determineConcern = (label) => waterConcerns.some((concern) => concern.label.toLowerCase() === label.toLowerCase());

+++

**Quality Assurance Project Plan**

**for**

**+++INS `${title}`+++**

**Prepared by**

**+++INS `${preparedBy}`+++**

*This Quality Assurance Project Plan was generated by AquaQAPP, a tool managed by Massachusetts Bays National Estuary Partnership and developed with funding from the United States Environmental Protection Agency and the Massachusetts Department of Environmental Protection.*

Date generated: +++INS `${dateGenerated}`+++

**Disclaimer:** This plan was generated by AquaQAPP, a web-based application created by the Massachusetts Bays National Estuary Partnership (MassBays). AquaQAPP generates tailored Quality Assurance Project Plans (QAPPs) for marine and freshwater water quality and benthic monitoring efforts in the Commonwealth of Massachusetts and is intended to assist volunteer monitoring programs in collecting quality-assured data.

This plan does not define, or otherwise limit, the purpose for which organizations may seek to use the plan or apply their data. A goal of the AquaQAPP project, however, is to bring more citizen science data to decision makers, including MassBays, the Massachusetts Department of Environmental Protection (DEP), and the Environmental Protection Agency (EPA).

Use of AquaQAPP is not required. By using AquaQAPP to document and plan for collection of quality assured data, the monitoring program’s QAPP is considered pre-approved by DEP and deemed acceptable by EPA, and agency review is not required prior to sampling. This pre-approval is valid so long as samples are collected and analyzed in strict accordance with the QAPP generated by the application which itself has not been significantly altered from the original output. “Not significantly altered” means that the user has not made or will not make changes to sample collection protocols, analytical methods, or other substantive content included in the generated QAPP. Changes such as addition of project roles and responsibilities, or additional detail regarding data quality indicators are not considered significant alterations.

Where new or revised methods, additional parameters, or other substantial changes are included beyond the content generated by AquaQAPP, and a stated objective of the monitoring effort is to submit the resulting data to DEP, DEP requires QAPP review prior to implementation. The modified QAPP can be submitted to:

Suzanne Flint (Suzanne.Flint@mass.gov)

Bureau of Water Resources, Watershed Planning Program

Massachusetts Department of Environmental Protection

8 New Bond Street, Worcester, MA 01606

DEP retains sole discretion as to what extent the agency will use data or information produced or resulting from use of this document.

Monitoring programs funded by EPA or DEP must follow agency requirements for quality assurance, and a QAPP generated with AquaQAPP may or may not meet those requirements. QAPPs for monitoring programs to support or influence discharge permits or TMDLs will also require additional review. Please check with the funding agency for guidance in these cases.

# Section A. Project Management Elements

## A1 Title and Certification Page

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Plan Title:** | +++INS `${title}`+++ | | | |
| **Name of Organization(s) Implementing Project:** | | | | ++ INS `${organization}`++ |
| **Prepared by:** | | +++INS `${preparedBy}`+++ | | |
| **Effective Dates of Plan:** | | |  | |

+++FOR person IN projectOrganization +++

+++IF $person.primaryContact !== 'X'+++

**+++ INS $person.titlePosition+++:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Name:** | +++INS $person.fullName+++ | |  | **Phone:** | +++INS $person.telephone+++ |
| **Signature:** | |  |  | **Date:** |  |

+++END-IF+++

+++END-FOR person+++

+++FOR person IN projectOrganization +++

+++IF $person.primaryContact === 'X'+++

**Primary Contact:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Name:** | +++INS $person.fullName+++ | |  | **Phone:** | +++INS $person.telephone+++ |
| **Signature:** | |  |  | **Date:** |  |

I +++INS $person.fullName+++ certify that +++INS $person.organization+++ [ ] has [ ] has not made changes to methods, or added monitoring parameters beyond the content generated by AquaQAPP.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Signature:** |  |  | **Date:** |  |

+++END-IF+++

+++END-FOR person+++

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## A3 Distribution List

The following individuals and their respective organizations will hold copies of the approved QAPP:

Table A3.1. QAPP Distribution List

| Project Role | Name, Organization |
| --- | --- |
| +++FOR person IN projectOrganization.filter((person) => person.distributionList === 'X')+++ |  |
| +++INS $person.roles.map((role) => role.label).join(', ')+++ | +++ **INS $**person.fullName+++, +++ **INS $**person.organization+++ |
| +++END-FOR person +++ |  |

+++FOR person IN projectOrganization +++

+++IF $person.distributionList === 'X'+++

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Name:** | | +++ **INS $**person.fullName+++ | | | | | | | | | |
| **Title:** | +++ **INS $**person.titlePosition+++ | | | | | | | | | | |
| **Organization** | | | | | +++ **INS $**person.organization+++ | | | | | | |
| **Address:** | | | +++ **INS $**person.address+++ | | | | | | | | |
| **City:** | +++ **INS $**person.city+++ | | | | | | | | | | |
| **State:** | | +++ **INS $**person.state+++ | | | | | |  | **Zip:** | | +++ **INS $**person.zip+++ |
| **Telephone:** | | | | +++ **INS $**person.telephone+++ | |  | **Email:** | | | +++ **INS $**person.email+++ | |

+++END-IF+++

+++END-FOR person +++

## A4 Program Organization and Task Responsibilities

Table A4.1. Project Organization and Responsibilities

|  |  |  |
| --- | --- | --- |
| Personnel name and title | Project Role | Responsibilities |
| +++FOR person IN projectOrganization +++ |  |  |
| +++ **INS $**person.titlePosition+++  +++ **INS $**person.fullName+++ | +++FOR role IN $person.roles+++   1. +++ **INS $**role.label+++   +++END-FOR role+++ | +++FOR role IN $person.roles+++   1. +++ **INS $**role.responsibilities+++   +++END-FOR role+++ |
| +++END-FOR person +++ |  |  |

## A5 Problem Definition/Background

### A5.1 Problem Definition

+++INS `${problemDefinition}`+++

### A5.2 Problem Background

+++INS `${projectBackground}`+++

## A6 Project Description and Timeline

### A6.1 Project Description

***Project Objectives***

+++INS `${projectObjective}`+++

***Study Area***

+++INS `${projectStudyArea}`+++

***Time Period***

+++INS `${projectTimePeriod}`+++

***Parameters***

+++INS `${projectParameters}`+++

***Data Users***

+++INS `${projectDataUsers}`+++

***Rationale***

+++INS `${samplingRationale}`+++

### A6.2 Map(s) of Area, Waterbody, and Sampling Sites

A map with sampling locations labeled is included as an attachment. The map includes a legend, scale, and compass direction.

Table A6.1. Sampling Locations

| **Location ID** | **Location Name** | **Latitude/Longitude** |
| --- | --- | --- |
| +++FOR location IN monitoringLocations +++ |  |  |
| +++ **INS $**location.locationId+++ | +++ **INS $**location.locationName+++ | +++ **INS $**location.locationLat+++ / +++ **INS $**location.locationLong+++ |
| +++END-FOR location +++ |  |  |

### A6.3 Anticipated Schedule

Table A6.2. Program Schedule

| Activity | J | F | M | A | M | J | J | A | S | O | N | D |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| +++FOR activity IN projectActivities +++ |  |  |  |  |  |  |  |  |  |  |  |  |
| +++ **INS $**activity.activity+++ | +++ **INS $**activity.january+++ | +++ **INS $**activity.february+++ | +++ **INS $**activity.march+++ | +++ **INS $**activity.april+++ | +++ **INS $**activity.may+++ | +++ **INS $**activity.june+++ | +++ **INS $**activity.july+++ | +++ **INS $**activity.august+++ | +++ **INS $**activity.september+++ | +++ **INS $**activity.october+++ | +++ **INS $**activity.november+++ | +++ **INS $**activity.december+++ |
| +++END-FOR activity +++ |  |  |  |  |  |  |  |  |  |  |  |  |

## A7 Data Quality Objectives

+++INS `${dataQualityObjectives}`+++

Requirements for ensuring that the data are useable for their intended purpose (that is, are of suitable quality) include accuracy, precision, representativeness, comparability, and completeness. When these requirements are met, the final data product is technically defensible. Data elements for this project are discussed in terms of the appropriate characteristics, defined as:

|  |  |
| --- | --- |
| **Accuracy:** | The extent of agreement between a measured value and the true value of interest. |
| **Precision:** | The extent of mutual agreement among independent, similar, or related measurements. |
| **Representativeness:** | The extent to which measurements represent true systems. |
| **Comparability:** | The extent to which data from one study can be compared directly to similar studies. |
| **Completeness:** | The measure of the amount of data acquired versus the amount of data required to fulfill the statistical criteria for the intended use of the data. |

Quality indicators are listed in Table A7.2 and described below. Details of how these criteria are met for each component of the monitoring program’s monitoring tasks are presented in Section B5.

+++INS `${dataQualityIndicators}`+++

Table A7.2. Data Quality Indicators

| Parameter - Method | Units | Accuracy | Overall Precision (RPD) | Approx. Expected Range |
| --- | --- | --- | --- | --- |
| +++FOR parameter IN parameters+++ |  |  |  |  |
| +++ **INS $**parameter.label+++ | +++ **INS $**parameter.units+++ | +++ **INS $**parameter.accuracy+++ | +++ **INS $**parameter.precision+++ | +++ **INS $**parameter.expectedRange+++ |
| +++END-FOR parameter +++ |  |  |  |  |

At the close of the project, the QA Manager will produce a report detailing how the resulting dataset compares with the monitoring program’s data quality objectives. This review will include, for each parameter, calculation of the following:

* Percent of samples exceeding Accuracy and Precision limits.
* Average departure from Accuracy and Precision targets.
* Overall percent of samples passing QC tests vs. number proposed in Table A7.2 (Completeness).

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 Project Manager and/or QA Manager will evaluate the overall attainment of data quality objectives and determine what limitations to place on the use of the data, or if a revision of the data quality objectives is allowable. This finding will be included in the final Data Quality Report (see Sections A9 and D2).

## A8 Training Requirements

Training on all aspects of project data collection and management will be provided to project participants and will be documented—including trainer(s), dates of training, and subject matter—in a Training Log (sample attached).

All members of the project team will be required to attend training/workshops appropriate to the type of monitoring they will conduct. The Field 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.

Names of all training participants will be documented on a Training Check-in Form (attached), with documentation in a final report.

The Field Coordinator will enter training data into the project database and records the following information: subject matter (i.e., what type of monitoring and procedures are covered), training course title, type of training materials, date and agenda, name and qualification of trainers, and names of participants trained. Volunteers shall be trained in monitoring protocols and be able to document pertinent environmental data for the evaluation site.

## A9 Documentation and Records

### A9.1 Documentation

Initially, all data will be recorded onto paper data forms. All data collection notes will be made in permanent ink, initialed, and dated, and no erasures or obliterations will be made. Completed Field Data Forms, Sampling Logs, or other types of hand-entered data will be signed and dated by the individual entering the data. Data will be subsequently recorded electronically onto computer storage media. Direct-entry and electronic data entries will indicate the person collecting or entering the data as shown in the Data Entry QC Check Form (attached). Secondary data used will be documented in the Secondary Data Form, attached. The table below details record handling procedures for this project, including the content of the final Data Quality Report (also see Section D2).

Table A9.1. Record Handling Procedures

| Activity | Details |
| --- | --- |
| +++FOR procedure IN recordHandling+++ |  |
| +++ **INS $**procedure.activity+++ | +++ **INS $**procedure.details+++ |
| +++END-FOR procedure +++ |  |

### A9.2 Field Records

Data Forms will provide the primary means of recording the data collection activities performed during the sampling surveys. Entries will be described in as much detail as possible so that events occurring the survey can readily be reconstructed after the fact. At the beginning of each survey, the date, start time, weather, and names of all sampling team members present will be entered, along with information about the samples, on a Data Form. Forms to be used for this project are listed in the table(s) below; samples are attached.

Table A9.2. Project-Specific Datasheets, Labels, and Forms for All QAPPs

| Form Name | Description |
| --- | --- |
| Field Data, *in situ* WQ parameters, Marine/Freshwater | Records field measurement (e.g. YSI) and sample collection info, site location and ID, crew names, weather conditions, etc. |
| Site Assessment, Marine/Freshwater | Records findings of a site assessment/verification visit |
| Laboratory Data | Documents lab results in bulk; include lab SOP number, data analysis, QA/QC and results. |
| Chain of Custody | Accompanies samples from collection sites to lab(s). |
| Sample Labels | Placed on all sample containers |
| Training Log | Compiles information on trainings offered |
| Training Check-in | Verifies attendance at trainings |
| Training Evaluation | Records feedback from participants after training session(s) |
| Instrument Calibration Log | Documents maintenance, calibration and testing on equipment |
| Water Quality Sample Collection Log | Maintains a list of water quality samples collected in the field. |
| Secondary Data Table | Documents other data sources employed to design and implement the monitoring program |
| Data Entry QC Check | Documents the accurate transcription of raw data into the project database and track batch data entry |
| Corrective Action Reporting | Documents actions taken during implementation to assure data quality |

+++IF determine('Saltwater Benthic', 'Saltwater', '', '') === true +++

Table A9.3. Project-Specific Datasheets, Labels, and Forms for Marine Benthic QAPPs

| Form Name | Description |
| --- | --- |
| Benthic Photo/Video Log | Documents photos or video taken during benthic surveys |
| Marine Benthic Survey Log | Maintains a list of samples collected at each monitoring location |
| Marine Benthic Field Sheet | Documents individual benthic sample location, depth, and sediment characteristics |

+++END-IF+++

+++IF determine('Freshwater Benthic', 'Freshwater', '', '') === true+++

Table A9.4. Project-Specific Datasheets, Labels, and Forms for Freshwater Benthic QAPPs

| Form Name | Description |
| --- | --- |
| Flow Velocity Form | Documents flow measurements and calculations conducted onsite |
| Benthic Photo/Video Log | Documents photos or video taken during benthic surveys |
| Algal Biomass (viewing bucket) Field Sheet | Documents visual assessment of periphyton algae load on streambed using a viewing bucket. |
| Kick Sample Field Sheet | Documents sampling techniques and abundance measures for aquatic biota |
| Rock Basket Field Sheet | Documents sampling techniques, site characteristics, *in situ* water quality measures, and aquatic biota |
| Freshwater Benthic Survey Log | Maintains list of samples collected at each monitoring location |
| Invertebrate Sorting | Documents invertebrates during sorting, including QC and efficiency calculation |
| Physical Characteristics and Habitat Assessment Field Sheet | Documents site details including land uses, *in situ* measurements, hydrology, and sediment observations. |

+++END-IF+++

Field sheets for all samples will include:

* Station name and/or ID number
* Replicate number
* Time and date of sample collection
* Sample description (color, texture, etc.)
* Samplers’ initials
* Requested analyses
* Location (the geographic location where a sample is collected)

Supplementary data for every station sampled will be recorded in the comments section of the Field Sheets. Additional data may include notes on sampling difficulties, currents, and numbers and sizes of jars used for each sample.

+++IF determine('Saltwater Benthic', 'Saltwater', 'Grain size', 'Sediment grab samples') === true && determine('Saltwater Benthic', 'Saltwater', 'Total organic carbon (TOC)','Sediment grab samples') === true && determine('Saltwater Benthic', 'Saltwater', 'Infauna', 'Sediment grab samples') === true+++

### A9*.*3 Infaunal and Sediment Data Analyses—Marine Benthic Grab

The sediment data will be analyzed using a variety of statistical and graphical methods to assess temporal and spatial trends in sediment data as appropriate.

Prior to analysis of the infaunal data, some modifications to the dataset will be made based on the objectives of the project. Those individuals identified to species level will be included in statistical analyses (e.g., number of species, diversity, evenness, multivariate analyses).

Two categories of diversity indices will be calculated: (1) species richness indices and (2) indices based on the proportional abundances of species—e.g., Shannon-Weiner index (H’), Pielou evenness index (J’), Margalef’s index, and/or Total Taxonomic Distinctness).

Changes in infaunal community structure between assessments may be evaluated by comparing community structure differences between stations through time, and gauging changes in community structure if comparable data are available.

+++END-IF+++

+++IF determine('Saltwater Benthic', 'Saltwater', 'Infauna', 'Sediment grab samples') === true+++

### A9.4 Infaunal Data Analyses—Marine Benthic Grab

Prior to analysis of the infaunal data, some modifications to the dataset will be made. For example, some taxa (e.g., incidental pelagic faunal, encrusting, or non-benthic taxa) may be eliminated from all calculations. Other taxa may be included in calculations of abundance but not diversity; such taxa are usually those infaunal organisms that cannot be identified to species level. Only those individuals identified to species level will be included in all remaining calculations (e.g., number of species, diversity, evenness, multivariate analyses).

+++END-IF+++

+++IF determine('Freshwater Water Quality', 'Freshwater', '', '') === true+++

# Section B. Fresh Water/Water Quality Data Generation and Acquisition

## B1 Sampling Design

+++INS `${samplingDesignOverview}`+++

+++IF determineConcern('Eutrophication (Nutrients)') === true || determineConcern('Illicit Connections') === true || determineConcern('Stormwater') === true+++

### B1.1 Sampling Site Selection

Monitoring locations include stations upstream and downstream of the source, as well as reference stations. Sites selected are in an area where reasonable opportunity for mixing of the effluent has occurred. Where a mixing zone has been defined in a license for discharge, sampling will be conducted immediately downstream of it. In cases where the effluent plume channels down one bank for great distances (>1 km), or where localized effluent impact is expected to be severe for a distance beyond the zone of initial dilution, sampling locations are upstream of the source, one or more in the plume, and at least two farther downstream. Monitoring locations have been selected to ensure that the physical characteristics among sites are similar, and are representative of the stream reach. Reference sampling sites are minimally impaired, and located in the same ecoregion, size class, and stream type (width, depth, gradient). Site assessment forms (sample attached) will be completed for each location.

+++END-IF+++

+++IF determineConcern('General Environmental Health: Physical/Chemical Water Quality') === true || determineConcern('Recreation (Swimming and/or Boating)') === true || determineConcern('Harmful Algal Blooms (HABs) (Algal toxins)') === true || determineConcern('General Environmental Health: Benthic') === true+++

### B1.1 Sample Site Selection

Routine sampling activities will consist of collecting in-stream samples. Routine sampling is expected to be representative of overall water quality and sites are relatively unchanging over time to allow comparison to past and future investigations. Sites were selected at the downstream ends and/or key segmentation points of major tributaries, and at or near locations where there is a longstanding data record. Site assessment forms (sample attached) will be completed for each location.

+++END-IF+++

### B1.2 Location

See Section A6 for a description of the sampling locations. A map is attached.

### B1.3 Sample Collection Methods

Samples will be collected via grab sampling and direct measurements using electronic instruments in the field. The details of the sampling design are described in the table below.

Table B1.1. Freshwater Quality Field Sampling Summary

| Parameter - Method | Frequency |
| --- | --- |
| +++FOR parameter IN sampleDesign.filter((param) => param.monitoringCategory === 'Freshwater Water Quality') +++ |  |
| +++ **INS $**parameter.sampleParameter+++ | +++ **INS $**parameter.frequency+++ |
| +++END-FOR parameter +++ |  |

## B2 Sampling Methods: Sample Collection and Storage

The table below summarizes sample collection and storage for parameters included in this monitoring program. Standard Operating Procedures (SOPs) for sample collection and storage are attached.

Table B2.1. Equipment Preparation, Sample Processing, and Storage Requirements

| Parameter - Method | Sample collection method | Container Type and Preparation | Minimum Sample Quantity | Sample Preservation | Maximum Holding Time |
| --- | --- | --- | --- | --- | --- |
| +++FOR parameter IN parameters.filter((param) => param.monitoringCategory === 'Freshwater Water Quality')+++ |  |  |  |  |  |
| +++ **INS $**parameter.label+++ | +++ **INS $**parameter.sampleCollectionMethod+++ | +++ **INS $**parameter.sampleContainer+++ | +++ **INS $**parameter.sampleVolume+++ | +++ **INS $**parameter.samplePreservation+++ | +++ **INS $**parameter.maxHoldingTime +++ |
| +++END-FOR parameter +++ |  |  |  |  |  |

\*Pre-cleaned – acid washed with 10% HCL

\*\**in situ*: single and/or multiple probe

+++IF determine('Freshwater Water Quality', 'Freshwater', 'Conductivity', 'Multi-parameter probe meter') === true || determine('Freshwater Water Quality', 'Freshwater', 'Conductivity', 'Conductivity meter') === true || determine('Freshwater Water Quality', 'Freshwater', 'Dissolved oxygen', 'Multi-parameter probe meter') === true || determine('Freshwater Water Quality', 'Freshwater', 'Dissolved oxygen', 'DO meter') === true || determine('Freshwater Water Quality', 'Freshwater', 'Oxygen saturation', 'Multi-parameter probe meter') === true || determine('Freshwater Water Quality', 'Freshwater', 'Oxygen saturation', 'DO meter') === true || determine('Freshwater Water Quality', 'Freshwater', 'pH', 'Multi-parameter probe meter') === true || determine('Freshwater Water Quality', 'Freshwater', 'pH', 'pH meter') === true || determine('Freshwater Water Quality', 'Freshwater', 'Station depth', 'in situ') === true || determine('Freshwater Water Quality', 'Freshwater', 'Temperature', 'Multi-parameter probe meter') === true || determine('Freshwater Water Quality', 'Freshwater', 'Temperature', 'Thermometer') === true || determine('Freshwater Water Quality', 'Freshwater', 'Turbidity', 'Multi-parameter probe meter') === true || determine('Freshwater Water Quality', 'Freshwater', 'Turbidity', 'Turbidity meter') === true +++

### B2.1 Water Quality Monitoring

#### Equipment/Instrument Calibration

Prior to field use, the multi-parameter or individual sensors will be calibrated in accordance with the manufacturer’s instruction manual. If no instructions specific to the instrument are available, general calibration methods as described in the Field Operations Manual will be followed and documented on an Instrument Calibration Log (sample attached).

+++IF determine('Freshwater Water Quality', 'Freshwater', 'Conductivity', 'Multi-parameter probe meter') === true || determine('Freshwater Water Quality', 'Freshwater', 'Dissolved oxygen', 'Multi-parameter probe meter') === true || determine('Freshwater Water Quality', 'Freshwater', 'Oxygen saturation', 'Multi-parameter probe meter') === true || determine('Freshwater Water Quality', 'Freshwater', 'pH', 'Multi-parameter probe meter') === true || determine('Freshwater Water Quality', 'Freshwater', 'Temperature', 'Multi-parameter probe meter') === true || determine('Freshwater Water Quality', 'Freshwater', 'Turbidity', 'Multi-parameter probe meter') === true +++

#### Multi-Parameter Unit Deployment

*In situ* measurements will be made using a calibrated water quality multi‐parameter unit at each station. Measurement of temperature, conductivity, dissolved oxygen, and pH will be taken at surface at riverine sites; at lake sampling sites deeper than 2m, a hydrographic profile will be obtained. Measurements will be collected as the multi-parameter unit is lowered down to 0.5 m from the bottom. A Water Quality Sample Collection Log and Field Data Form for *in situ* WQ Parameters will be completed for each monitoring location (samples attached).

+++END-IF+++

+++END-IF+++

## B3 Sample Handling and Custody

The attached SOPs describe handling of samples while in the field, including storage requirements.

Labels with the following information will be attached to sample containers:

* Sample number
* Site ID
* Time and date of collection
* Preservation requirements
* Name of sampler and organization

Samples for shipment will be prepared as follows:

* All samples will be appropriately preserved and packaged for transport.
* If obtainable samples are missing, the Project Manager and Field Coordinator will determine corrective action (e.g., reschedule a site visit or return to the site that same day to complete collection of the missing samples).
* All samples will be labeled and the labels checked for completeness, legibility, accuracy, and consistency.
* Labels and forms will be reviewed to ensure consistent sample ID information.
* Each sample container will be inspected to make sure there are no leaks and that all containers are properly sealed.

The Field Coordinator will complete the Chain of Custody Form(s) for samples shipped to a laboratory. Copies of custody forms will be made and retained by the team. The original form will be sent in the container with the sample. Copies of all custody forms will be included in the coolers when the Field Coordinator sends samples to the labs. Sample labels and Chain of Custody Forms are attached.

## B4 Analytical Methods

*In situ* parameters measured by calibrated sensors on site, including temperature, dissolved oxygen, conductivity, pH and turbidity, do not require analytical methods. Laboratory analysis of discrete samples will be conducted as indicated in the table below.

Table B4.1. Approved Analytical Methods

| Parameter - Method | MDL (mg/l unless stated) |
| --- | --- |
| +++FOR parameter IN parameters.filter((param) => param.monitoringCategory === 'Freshwater Water Quality' && param.mdl !== '')+++ |  |
| +++ **INS $**parameter.label+++ | +++ **INS $**parameter.mdl+++ |
| +++END-FOR parameter +++ |  |

## B5 Field and Analytical Laboratory Quality Control

The monitoring project will include appropriate field and laboratory QC samples to assess general data quality issues, as well as specific data quality objectives. The following sections, including summary tables, describe QC measures to be undertaken.

### B5.1 Field Duplicates

Duplicates will be taken side by side and simultaneously. Field duplicates are submitted to the laboratory along with all other samples. Field duplicates will be taken for 10% of all water quality samples taken per sampling event.

Table B5.1. Quality Control Measures

| Location ID | Parameter - Method | Precision Check: Field duplicate frequency | Accuracy Check: Field blank frequency | Precision Check: Lab duplicate frequency | Accuracy Check: Lab blank frequency | Precision Check: Lab spike frequency |
| --- | --- | --- | --- | --- | --- | --- |
| +++FOR parameter IN sampleDesign.filter((param) => param.monitoringCategory === 'Freshwater Water Quality') +++ |  |  |  |  |  |  |
| +++ **INS $**parameter.sampleLocationId+++ | +++ **INS $**parameter.sampleParameter+++ | +++ **INS $**parameter.fieldDuplicates+++ | +++ **INS $**parameter.fieldBlanks+++ | +++ **INS $**parameter.labDuplicates+++ | +++ **INS $**parameter.labBlanks+++ | +++ **INS $**parameter.labSpikes+++ |
| +++END-FOR parameter +++ |  |  |  |  |  |  |

+++IF determine('Freshwater Water Quality', 'Freshwater', 'Conductivity', 'Multi-parameter probe meter') === true || determine('Freshwater Water Quality', 'Freshwater', 'Conductivity', 'Conductivity meter') === true || determine('Freshwater Water Quality', 'Freshwater', 'Dissolved oxygen', 'Multi-parameter probe meter') === true || determine('Freshwater Water Quality', 'Freshwater', 'Dissolved oxygen', 'DO meter') === true || determine('Freshwater Water Quality', 'Freshwater', 'Oxygen saturation', 'Multi-parameter probe meter') === true || determine('Freshwater Water Quality', 'Freshwater', 'Oxygen saturation', 'DO meter') === true || determine('Freshwater Water Quality', 'Freshwater', 'pH', 'Multi-parameter probe meter') === true || determine('Freshwater Water Quality', 'Freshwater', 'pH', 'pH meter') === true || determine('Freshwater Water Quality', 'Freshwater', 'Temperature', 'Multi-parameter probe meter') === true || determine('Freshwater Water Quality', 'Freshwater', 'Temperature', 'Thermometer') === true || determine('Freshwater Water Quality', 'Freshwater', 'Turbidity', 'Multi-parameter probe meter') === true || determine('Freshwater Water Quality', 'Freshwater', 'Turbidity', 'Turbidity meter') === true +++

Table B5.2. Field Quality Control (measured using sensors)

| Parameter - Method | Check Description | Frequency | Acceptance Criteria | Corrective Actions |
| --- | --- | --- | --- | --- |
| +++FOR parameter IN parameters.filter((param) => param.monitoringCategory === 'Freshwater Water Quality' && param.method.includes('meter'))+++ |  |  |  |  |
| +++ **INS $**parameter.label+++ | +++ **INS $**parameter.checkDescription+++ | +++ **INS $**parameter.frequency+++ | +++ **INS $**parameter.acceptanceCriteria+++ | +++ **INS $**parameter.correctiveActions+++ |
| +++END-FOR parameter +++ |  |  |  |  |

+++END-IF+++

+++IF determine('Freshwater Water Quality', 'Freshwater', 'Total phosphorus', '') === true || determine('Freshwater Water Quality', 'Freshwater', 'Total nitrogen', '') === true || determine('Freshwater Water Quality', 'Freshwater', ' Ammonia-N', '') === true || determine('Freshwater Water Quality', 'Freshwater', 'Nitrate-Nitrite-N', '') === true || determine('Freshwater Water Quality', 'Freshwater', 'Orthophosphate', '') === true+++

Table B5.3. Field Quality Control: Nutrients

| Quality Control Activity | Description and Requirements | Corrective Action |
| --- | --- | --- |
| Water Chemistry Container and Preparation | Rinse collection bottles 3x with ambient water before collecting water samples. | Discard sample. Rinse bottle and refill. |
| Sample Storage | Store samples in darkness at 4°C. Confirm cooler/sample temperature on delivery to lab (e.g. use temperature blank).  Deliver to laboratory within hold time. | Qualify sample as suspect for all analyses. |

+++END-IF+++

+++IF determine('Freshwater Water Quality', 'Freshwater', 'Chlorophyll-a', '') === true+++

Table B5.4. Field Quality Control: Chlorophyll *a*

| Quality Control Activity | Description and Requirements | Corrective Action |
| --- | --- | --- |
| Chlorophyll-*a* Containers and Preparation | Rinse collection bottles 3x with ambient water before collecting water samples. | Discard sample. Rinse bottle and refill |
| Holding Time | 24 hours | Qualify samples |
| Sample Storage | Samples are shipped on wet ice | Qualify sample as suspect |

+++END-IF+++

Table B5.5. Data Validation Quality Control for Water Chemistry

| Activity | Requirements and Corrective Action |
| --- | --- |
| Range checks, summary statistics, and/or exploratory data analysis | Current reporting errors or qualify as suspect of invalid |
| Review holding times | Qualify value for additional reviews |
| Review data from QA samples | Determine impact and possible limitations on overall data usability |

+++IF determine('Freshwater Water Quality', 'Freshwater', 'E. coli', '') === true+++

Table B5.6. Field Quality Control: Fecal Indicator

| Quality Control Activity | Description and Requirements | Corrective Action |
| --- | --- | --- |
| Check integrity of sample containers and labels | Clean, intact containers and labels. | Obtain replacement supplies. |
| Sterility of sample containers | Sample collection bottle and filtering apparatus are sterile and must be unopened prior to sampling. Nitrile gloves must be worn during sampling and filtering. | Discard sample and recollect in the field. |
| Sample Collection | Collect sample at the last transect to minimize holding time before filtering and freezing. | Discard sample and recollect in the field. |
| Sample holding | Sample is held in a cooler on wet ice until filtering. | Discard sample and recollect in the field. |
| Field Processing | Sample is filtered within 6 hours of collection and placed on dry ice. | Discard sample and recollect in the field. |

Table B5.7. Data Validation Quality Control: *E. coli*

| Check Description | Frequency | Acceptance Criteria | Corrective Action |
| --- | --- | --- | --- |
| Duplicate sampling | Duplicate composite samples collected at 10% of sites | Measurements should be within 10 percent | Review data for reasonableness; determine if acceptance criteria need to be modified |

+++END-IF+++

+++IF determine('Freshwater Water Quality', 'Freshwater', 'Microcystins', '') === true+++

Table B5.8. Field Quality Control: Microcystins

| Quality Control Activity | Description and Requirements | Corrective Action |
| --- | --- | --- |
| Holding time | Hold sample on wet ice and freeze immediately upon return to base. Keep frozen until shipping. | Quality samples |
| Sample storage | Store samples in darkness and frozen (-200C).  Monitor temperature daily. | Qualify samples as suspect |

Table B5.9. Data Validation Quality Control: Microcystins

| Activity or Procedure | Requirements and Corrective Action |
| --- | --- |
| Range checks, summary statistics, and/or exploratory data analysis | Current reporting errors or qualify as suspect of invalid |
| Review holding times | Qualify value for additional reviews |
| Review data from QA samples | Determine impact and possible limitations on overall data usability |

+++END-IF+++

## B6 Instrument/Equipment Inspection and Testing

All equipment used to collect or analyze ambient or collected samples will undergo periodic maintenance and calibration verification performed by manufacturer’s representatives or service consultants. These procedures will be documented by date and the signature of person performing the inspection. (For example, multi-parameter probes will receive annual [or as needed] maintenance and calibration checks by manufacturers or certified service centers.) All other sampling gear and laboratory instrumentation will be maintained in good repair as per manufacturer’s recommendations to ensure proper function. The following table lists typical procedures to be undertaken.

Records of equipment inspection, maintenance, repair, and replacement will be kept in a logbook, along with standard operating procedures for instrument maintenance and calibration.

Table B6.1. Typical Instrument/Equipment Inspection and Testing Procedures

| Parameter | Equipment | Inspection frequency | Type inspection | Maintenance, Corrective Action | Person (Role) Responsible |
| --- | --- | --- | --- | --- | --- |
| Total N, Nitrate-Nitrite-N, Ammonium-N, Total P, Orthophosphates, chlorophyll-*a*, chlorides, total suspended solids, *E. coli*, microcystins | Sample bottles | Before each use | Visual for integrity, cleanliness | Acid washed prior to use (or clean-certified from manufacturer or lab) |  |
| Total N, Nitrate-Nitrite-N, Ammonium-N, Total P, Orthophosphates, chlorophyll-*a*, *E. coli*, microcystins | Filtering apparatus | Before each use | Proper functioning, clean storage | Spare filters, syringe |  |
| Temperature, conductivity, DO, pH, turbidity | Meters | Before each use | Battery life, DO membrane | Spare batteries, spare membranes |  |
| Geographical coordinates | GPS | Before each use | Battery life | Repair, replace, spare batteries on hand. |  |

## B7 Field Equipment/Maintenance, Inspection, and Calibration

### B7.1 Pre-measurement Instrument Checks and Calibration

Field instruments will be tested and calibrated prior to sampling, either prior to departure for the site or at the site, and documented on an Instrument Calibration Log (sample attached)

Site location will be verified using a GPS receiver. Field crews will have access to backup instruments if any instruments fail the manufacturer performance tests or calibrations.

+++IF determine('Freshwater Water Quality', 'Freshwater', 'Conductivity', 'Multi-parameter probe meter') === true || determine('Freshwater Water Quality', 'Freshwater', 'Dissolved oxygen', 'Multi-parameter probe meter') === true || determine('Freshwater Water Quality', 'Freshwater', 'Oxygen saturation', 'Multi-parameter probe meter') === true || determine('Freshwater Water Quality', 'Freshwater', 'pH', 'Multi-parameter probe meter') === true || determine('Freshwater Water Quality', 'Freshwater', 'Temperature', 'Multi-parameter probe meter') === true || determine('Freshwater Water Quality', 'Freshwater', 'Turbidity', 'Multi-parameter probe meter') === true +++

#### Multi-Parameter unit

The dissolved oxygen, pH, temperature, and conductivity sensor functions of the multi-parameter unit or individual sensors will be calibrated prior to departure to the sampling site(s) as described in the following table documented on an Instrument Calibration Log (sample attached). A single calibration will be considered sufficient for the day.

Table B7.1. Instrument Calibration Procedures

| Parameter - Method | Instrument | Type of Inspection | Inspection and Calibration Frequency | Standard of Calibration Used | Corrective Action |
| --- | --- | --- | --- | --- | --- |
| +++FOR parameter IN parameters.filter((param) => param.monitoringCategory === 'Freshwater Water Quality' && param.method === 'Multi-parameter probe meter') +++ |  |  |  |  |  |
| +++ INS $parameter.label+++ | +++ INS $parameter.instrument+++ | +++ INS $parameter.typeOfInspection+++ | +++ INS $parameter.calibrationFrequency+++ | +++ INS $parameter.calibrationStandard+++ | +++ INS $parameter.correctiveAction+++ |
| +++END-FOR parameter +++ |  |  |  |  |  |

“External standards” refers to standards of reliable quality obtained from reputable commercial or other suppliers; “known standards” refers to those where the value is known before calibration.

### B7.2 Post-measurement Calibration Check—Multi-Parameter unit

After all sensor measurements have been completed for the sampling day, a post-measurement calibration check of the parameter sensor will be performed and documented on an Instrument Calibration Log (sample attached).

+++END-IF+++

### B7.3 Instrument/Equipment Inspection, Testing Procedures

Equipment maintenance will be conducted routinely. Records of equipment inspection, maintenance, repair, and replacement will be recorded in a logbook.

## B8 Inspection/Acceptance of Supplies and Consumables

The Field Coordinator will be responsible for ensuring correct sample handling by:

* Ensuring availability of all required sampling supplies in the field.
* Properly labeling all sample containers for biological samples in the field.
* Recording all relevant sampling information on the Sample Collection Log, Field Sheets and Forms, and Chain of Custody Forms (samples attached).
* Coordinating the transfer of all samples from the field to laboratories for analysis.
* Delegating tasks as indicated in the table below.

**Table B8.1. Critical Field Supplies, Acceptance Criteria, and Responsibility for Critical Field Supplies**

| Critical Supplies and Consumables | Inspection Requirements  and Acceptance Criteria | Person (Role) Responsible |
| --- | --- | --- |
| Sample containers | Visually inspected for cracks, breakage, and cleanliness. May be reused. |  |
| Multi-parameter units; individual sensors | Functional checks to ensure proper calibration and operating capacity. |  |
| Sampling equipment | Visually inspected for obvious defects, damage, and contamination. |  |

## B9 Data Acquisition Requirements

Secondary data (historical reports, maps, literature searches, and previously collected analytical data) may be used in the preparation of the sampling plan. These data may come from sources such as:

* Prior reports specific to the area.
* Results of state agency or other studies water quality monitoring data.
* Pertinent data collected by federal agencies, such as USGS bathymetry data and NOAA weather records.
* Surveys completed in the embayment or embayment system of interest, including those identified through MassBays’ Inventory of Plans and Assessments (<https://www.mass.gov/service-details/massbays-inventory-of-plans-and-assessments>).

Secondary data used will be documented in the Secondary Data Table, attached, according to Sections A9 and C2.

## B10 Data Management

Data quality control steps will be taken at several stages. Documentation of data recording and handling, including all problems and corrective actions, shall be included in all preliminary and final reports (Corrective Action Reporting Form attached). See Section A9 for recording handling and storage procedures.

### B10.1 Process and Procedures

+++INS `${dataManagementProcess}`+++

### B10.2 Data Handling

+++INS `${dataHandling}`+++

### B10.3 Management Requirements

+++INS `${dataManagementRequirements}`+++

+++END-IF+++

+++IF determine('Freshwater Benthic', 'Freshwater' , '', '') === true+++

# Section B. Fresh Water/Benthic Data Generation and Acquisition

## B1 Sampling Design

+++INS `${samplingDesignOverview}`+++

+++IF determineConcern('Eutrophication (Nutrients)') === true || determineConcern('Illicit Connections') === true || determineConcern('Stormwater') === true+++

### B1.1 Sampling Site Selection

Monitoring locations include stations upstream and downstream of the source, as well as reference stations. Locations selected are in an area where reasonable opportunity for mixing of the effluent has occurred. Where a mixing zone has been defined in a license, sampling will be conducted immediately downstream of it. In cases where the effluent plume channels down one bank for great distances (>1 km), or where localized effluent impact is expected to be severe for a distance beyond the zone of initial dilution, monitoring locations are upstream of the source, one or more in the plume, and at least two farther downstream.

Monitoring locations have been selected to ensure that the physical characteristics among sampling sites are similar, and are representative of the stream reach. Reference monitoring locations are minimally impaired, and located in the same ecoregion, size class, and stream type (width, depth, gradient).

All monitoring locations will be visited prior to monitoring, and a Site Assessment Form completed for each (sample form attached).

+++END-IF+++

+++IF determineConcern('General Environmental Health: Physical/Chemical Water Quality') === true || determineConcern('Recreation (Swimming and/or Boating)') === true || determineConcern('Harmful Algal Blooms (HABs) (Algal toxins)') === true || determineConcern('General Environmental Health: Benthic') === true+++

### B1.2 Sampling Site (Reach) Selection and Assessment

For biological and habitat assessment, sampling will provide a representative picture of the ecological community.

To meaningfully evaluate biological condition, sampling locations were selected to ensure generally comparable physical habitat. Appropriate reaches and substrates suitable for sampling will be assessed for all monitoring locations and described using a Site Assessment Form (sample attached)

+++END-IF+++

## B2 Sampling Methods

Standard Operating Procedures (SOPs) for sample collection and storage are attached.

### B2.1 Site Photographs

At all sample reaches, photographs—at least one upstream and one downstream—will be taken with a digital camera. These and any additional photos will be recorded in the Photo Log (sample attached) with a brief description.

### B2.2 Flow Velocity

Flow velocity will be determined using the float method, with calculations documented in a Flow Velocity Form (attached).

+++IF determine('Freshwater Benthic', 'Freshwater', 'Benthic algal biomass', '') === true+++

## B2 Sampling Method—Viewing Bucket

Standard Operating Procedures (SOPs) for sample collection and storage are attached.

## B3 Sample Handling—Algal Biomass

Filamentous algae not able to be identified in the field will be subsampled, transferred to a plastic bag with clean stream water, and labeled with the sample number, site ID, and name of sampler. The algal sample will be held on ice for transport to the sample analysis site.

## B4 Analytical Methods—Algal Biomass

1. Any algae collected will be observed under a dissecting microscope within 72 hours of collection for identification to the genus level.
2. Density of algae on substrate may be determined using the following statistics:[[1]](#footnote-2)
3. Maximum length of each type of macroalgae.
4. Maximum density of each type of microalgae on suitable substrate (i.e., categories Mat 0 through Mat 5 as described in the SOPs).
5. Average percent cover of the habitat by each type of macroalgae:

% cover = 100 × *Dm/Dt*

*Dt* = total number of grid points (dots) evaluated at the site

*Dm* = number of grid points (dots) over macroalgae

1. Mean density (i.e., thickness rank) of each type of macroalgae on suitable substrate (listed in SOPs under categories Mat 0 to Mat 5):

mean density = ∑*diri/dt*

*dt* = total number of grid points (dots) over suitable substrate for microalgae at the site

*di* = number of grid points over microalga of different thickness ranks for each type of microalga

*ri* = thickness rank

+++END-IF+++

+++IF determine('Freshwater Benthic', 'Freshwater', 'Macroinvertebrates', 'Kick sampling') === true+++

## B2 Sampling Methods—Kick Sampling

Standard Operating Procedures (SOPs) for sample collection and storage are attached.

### B2.1 Method Summary

Benthic macroinvertebrate samples will be collected using a net with 500 µm mesh openings. All field operations and abundance measures will be documented in a Kick Sample Field Sheet (attached). Samples will be preserved, then sorted and sent to the laboratory for identification.

+++END-IF+++

+++IF determine('Freshwater Benthic', 'Freshwater', 'Macroinvertebrates', 'Rock baskets') === true+++

## B2 Sampling Method—Rock Baskets

Standard Operating Procedures (SOPs) for sample collection and storage are attached.

### B2.1 Method Summary

Rock baskets will be deployed where stream substrates are not ideal for kick sampling (too deep, benthic substrates consisting of fines or ledge), or where passive collection of macroinvertebrates can provide a more complete assessment of the system. Baskets contain roofing stone of a specific size class and are left in place and undisturbed for six to eight weeks. Deployment and sample collection for each monitoring location will be documented in a Rock Basket Field Sheet (attached). Composite samples from multiple sites will be preserved, then sorted and sent to the laboratory for identification.

+++END-IF+++

+++IF determine('Freshwater Benthic', 'Freshwater', 'Macroinvertebrates', '') === true+++

## B2 Sample Processing (Sorting)

Sample processing involves separating macroinvertebrates from other materials in the sample. Fauna will be:

[ ] sorted by trained personnel in the organization prior to delivery to the taxonomist for identification. The protocol developed by the Charles River Watershed Association[[2]](#footnote-3) will be employed (attached), and sorting activities documented using an Invertebrate Sorting Form (attached), which includes QC and efficiency calculations. Sorting will be completed within 72 hours.

[ ] sent to an accredited laboratory or taxonomist for sorting and identification within 72 hours.

For stream biomonitoring, identification will align with MassDEP‘s definition of “macroinvertebrate,” to include:

* All aquatic *Annelida*
* All aquatic *Mollusca*
* Aquatic macro *Crustacea* (except as noted below)
* All aquatic *Arachnida*
* The aquatic life stages of *Insecta* except *Hemiptera* and adult *Coleoptera* other than *Elmidae*

Macroinvertebrates excluded from the above list are not used for one of three reasons: there is insufficient ecological information on them to make them useful for biomonitoring, they are surface film dwellers, or they are capable of escaping the aquatic environment at will to avoid temporarily unfavorable conditions. One further exception is crayfish (class *Crustacea,* family *Cambaridae*), which often are seen evacuating the immediate area as kick-sampling begins and even swimming out of the kick-net. Crayfish species are noted when present in the sample but are not counted toward total numbers.

## B3 Sample Handling and Custody

The attached SOPs describe handling of samples while in the field, including storage requirements.

The lids on the sample jars will be taped and the jars inserted individually into large zip-locked or tied plastic bags lined with absorbent padding. Macroinvertebrate samples (stored in sturdy coolers) will be delivered by a survey crew member to the contracted laboratory. A crew member will contact laboratory staff to arrange a time for sample dropoff. This will allow laboratory staff to be prepared for sample receipt. Chain of Custody forms (template attached) will accompany all samples.

## B4 Analytical Methods

Analytical methods for macroinvertebrate identification will be carried out by a taxonomist according to Massachusetts DEP document CN 226.0, Section 12 (available at <https://www.mass.gov/guides/water-quality-monitoring-quality-management-program>; listed incorrectly as CN 266.0 as of August 1, 2019). Specimens will be identified to genus or species as allowed by available keys, specimen condition, and specimen maturity. Based on the taxonomy various community, population, and functional parameters, or “metrics,” are calculated, which allow an investigator to measure important aspects of the biological integrity of the community.

## B5 Field Quality Control

### B5.1 Field Sampling Quality Control

The table in this section summarizes field quality control. Duplicate samples are preserved in a separate sample bottle marked “duplicate” and with all other information regarding station location. Duplicate samples will be used in the calculation of precision of the benthos data.

Table B5.1. Macroinvertebrate Sampling Quality Control

| Field QC | Frequency Number | Corrective Action (CA) | Person Responsible for CA |
| --- | --- | --- | --- |
| Post-sampling rinse, inspection, and pick of nets, sieves, and pans | At all stations | Discard sample and re-sample if not performed |  |
| Pre-sampling rinse, inspection, and pick of nets, sieves, and pans | At all stations | Discard sample and re-sample if not performed |  |
| On-site sample preservation (95% ethanol-macroinvertebrates) | All macroinvertebrate samples | Preserve at lab within or discard |  |
| Collection of duplicate samples at various stations to assess the consistency of the collection effort | 10% of total number of samples collected for each watershed | Re-sample if not performed |  |

Sample Labels will be properly completed, including the sample identification code, date, stream name, sampling location, and collector’s name, and placed into the sample container. The outside of the container will be labeled with the same information. Chain of Custody forms and the Sample Log will be checked to ensure they include the same information as the Sample Labels. Samples of all forms are attached.

After sampling has been completed at a given site, all nets, pans, etc., that have come in contact with the sample will be rinsed thoroughly, examined carefully, and picked free of organisms or debris. Any additional organisms found will be placed into the sample containers. The equipment will be examined again prior to use at the next sampling site.

### B5.2 Quality Control for Sorting/Picking

Ten percent of the sorted samples in each lot will be examined by laboratory QC personnel or trained and qualified staff (QC worker). (A lot is defined as a special study, basin study, entire index period, or individual sorter.) The QC worker will examine the grids chosen and tray used for sorting and will look for organisms missed by the sorter. Organisms found will be added to the sample vials.

If the QC worker finds fewer than 10 organisms (or 10% in larger subsamples) remaining in the grids or sorting tray, the sample passes; if more than 10 (or 10%) are found, the sample fails. If the first 10% of the sample lot fails, the QC worker will check a second 10% of the sample lot. Sorters in-training will have their samples 100% checked until the trainer decides that training is complete. This QC will be documented on the Invertebrate Sorting Form, attached.

After processing is complete for a given sample, all sieves, pans, trays, etc., that have come in contact with the sample will be rinsed thoroughly, examined carefully, and picked free of organisms or debris; organisms found will be added to the sample residue.

+++END-IF+++

+++IF determine('Freshwater Benthic', 'Freshwater', 'Stream characteristics', '') === true+++

## B2 Sampling Method—Physical Habitat Assessment

### B2.1 Method Overview

Physical Habitat Assessment will be carried out using the visual method described in EPA, 1999. General habitat conditions at the biomonitoring stations will be evaluated using a series of physical parameters, listed below and described in the attached SOPs.[[3]](#footnote-4) Each of these parameters will be numerically scored after visual observation of the stream reach, using a Physical Characterization and Habitat Assessment Form (sample attached). The numerical scores for all parameters will be summed; the cumulative value places the stream within a category ranging from poor to optimal.

1. Epifaunal substrate/available cover

2a. Embeddedness (low-gradient streams)

2b. Pool substrate characterization (high-gradient streams)

3a. Velocity/depth regimes (low-gradient streams)

3b. Pool variability (high-gradient streams)

4. Sediment deposition

5. Channel flow status

6. Channel alteration

7a. Riffle frequency (low-gradient streams)

7b. Channel sinuosity (high-gradient streams)

8. Bank stability

9. Bank vegetative protection

10. Riparian vegetative zone width

## B3 Sample Handling and Custody

No samples are collected for physical habitat assessment.

## B4 Analytical Methods

No samples are collected for physical habitat assessment.

## B5 Quality Control—Physical Habitat Assessment

Multiple observers (at least two, and ideally three) will perform the habitat assessment at each biomonitoring station. Habitat assessment training will be required to minimize variability in final conclusions. A standardized Physical Characterization and Habitat Assessment Form (attached) will be completed at all biomonitoring stations. Disagreement in habitat parameter scoring will be discussed and resolved before the form can be considered complete.

+++END-IF+++

## B6 Instrument/Equipment Testing, Inspection, and Maintenance Requirements

Decontamination of equipment will follow procedures described in the Standard Operating Procedures (SOPs) attached, and according to the sensitivity of the water body sampled.[[4]](#footnote-5)

## B7 Field Equipment/Maintenance, Inspection, and Calibration

### B7.1 Pre-measurement Instrument Checks and Calibration

Field instruments will be tested and calibrated prior to sampling, either prior to departure for the site or at the site, and documented on the Instrument Calibration Log (attached). Site location will be verified using a GPS receiver. Field crews will have access to backup instruments if any instruments fail the manufacturer performance tests or calibrations.

#### Multi-Parameter sensor

The dissolved oxygen, pH, temperature, and conductivity sensor functions of the multi-parameter sensor or individual sensors will be calibrated prior to departure to the sampling site(s) per the table below. A single calibration will be considered sufficient for the day.

Table B7.1. Instrument Calibration Procedures

| Parameter - Method | Instrument | Type of Inspection | Inspection and Calibration Frequency | Standard of Calibration Used | Corrective Action |
| --- | --- | --- | --- | --- | --- |
| +++FOR parameter IN parameters.filter((param) => param.monitoringCategory === 'Freshwater Water Quality' && param.method === 'Multi-parameter probe meter') +++ |  |  |  |  |  |
| +++ INS $parameter.label+++ | +++ INS $parameter.instrument+++ | +++ INS $parameter.typeOfInspection+++ | +++ INS $parameter.calibrationFrequency+++ | +++ INS $parameter.calibrationStandard+++ | +++ INS $parameter.correctiveAction+++ |
| +++END-FOR parameter +++ |  |  |  |  |  |

“External standards” refers to standards of reliable quality obtained from reputable commercial or other suppliers;

“known standards” refers to those where the value is known before calibration.

### B7.2 Post-measurement Calibration Check—Multi-Parameter sensor

After all sensor measurements have been completed for the sampling day, a post-measurement calibration check of the parameter sensor will be performed according to the Field Operations/Standard Operating Procedures Manual. To do this, pH, conductivity, and DO of one of each of the respective calibration standards that were used earlier in the day to calibrate the instrument will be measured and values recorded. If significant drift is detected (as defined the manufacturer), the sensor may need service; data collected since the last successful calibration and post-measurement calibration check will be flagged.

### B7.3 Instrument/Equipment Inspection, Testing Procedures

Equipment maintenance will be conducted routinely. Records of equipment inspection, maintenance, repair, and replacement will be recorded in a logbook.

## B8 Inspection/Acceptance of Supplies and Consumables

The Field Coordinator will be responsible for ensuring correct sample handling by:

* Ensuring availability of all required sampling supplies in the field.
* Properly labeling all sample containers for biological samples in the field.
* Recording all relevant sampling information on the Sample Collection Log, Field Data Sheets, and Chain of Custody Forms.
* Coordinating the transfer of all samples from the field to laboratories for analysis.
* Delegating tasks listed in the table below as identified.

Table B8.1. Critical Field Supplies, Acceptance Criteria, and Responsibility for Critical Field Supplies

| Critical Supplies and Consumables | Inspection Requirements  and Acceptance Criteria | Person (Role) Responsible |
| --- | --- | --- |
| Jars for macrofaunal samples | Visually inspected for cracks, breakage, and cleanliness. May be reused. |  |
| 95% ethanol | Visually inspected for proper labeling, expiration dates, appropriate grade. |  |
| Sampling equipment | Visually inspected for obvious defects, damage, and contamination. |  |
| Navigation instruments, digital camera | Functional checks to ensure proper calibration and operating capacity. |  |

## B9 Data Acquisition Requirements (Non-direct Measurements)

Secondary data (historical reports, maps, literature searches, and previously collected analytical data) may be used in the preparation of the sampling plan. These data may come from sources such as:

* Prior reports specific to the area
* Results of state agency or other water quality monitoring data
* Pertinent data collected by federal agencies, such as USGS bathymetry data and NOAA weather records
* Survey completed in the embayment or embayment system of interest, including those identified through MassBays’ Inventory of Plans and Assessments (<https://www.mass.gov/service-details/massbays-inventory-of-plans-and-assessments>)

Secondary data used will be documented according to Section A9 and C2.

## B10 Data Management

Data quality control steps will be taken at several stages. Documentation of data recording and handling, including all problems and corrective actions, shall be included in all preliminary and final reports. (Corrective Action Reporting Form attached.) See Section A9 for recording handling and storage procedures.

### B10.1 Process and Procedures

+++INS `${dataManagementProcess}`+++

### B10.2 Data Handling

+++INS `${dataHandling}`+++

### B10.3 Management Requirements

+++INS `${dataManagementRequirements}`+++

+++END-IF+++

+++IF determine('Saltwater Benthic', 'Saltwater', '', '') === true+++

# Section B. Marine/Benthic Data Generation and Acquisition

## B1 Sampling Design

The rationale for the sampling design is provided in Section A6. Benthic monitoring is used to determine current benthic community conditions and, with repeated monitoring, long-term trends in sediment quality and benthic communities over time.

+++INS `${samplingDesignOverview}`+++

## B2 Sampling

### B2.1 Processing and Storage of Field Samples

All ecological sampling activities performed for benthic monitoring will be conducted following a Massachusetts Division of Marine Fisheries Scientific Collector’s Permit and any local permits that are required. The Project Manager will request the appropriate permits to allow sampling; a copy will be provided to the Field Coordinator prior to the survey.

Standard Operating Procedures (SOPs) for sample collection and storage are attached. The table below summarizes activities around processing and storage of samples.

+++IF determine('Saltwater Benthic', 'Saltwater', ' Grain size', 'Sediment grab samples') === true && determine('Saltwater Benthic', 'Saltwater', ' Total organic carbon (TOC)', 'Sediment grab samples') === true && determine('Saltwater Benthic', 'Saltwater', 'Infauna', 'Sediment grab samples') === true+++

Table B2.1. Processing and Storage of Field Samples taken on Marine Benthic Monitoring Surveys

| Activity | Sediment and Infaunal Survey |
| --- | --- |
| Stations | See Survey Plan |
| Station location and time | Record location, time of station visit, and location of individual samples |
| Weather/sea state/ bottom depth | Record general conditions; record bottom depth to nearest 0.5 m |
| Sampling: Gear | 0.04-m2 Ted Young-modified Van Veen grab sampler |
| Sampling: Measurements | Record penetration depth to nearest 0.5 cm and sediment volume to nearest 0.5 L  Water quality profile: temperature, DO, salinity, pH |
| Sampling: Sediment texture, color, odor | Describe qualitatively |
| Faunal Samples: Processing | Rinse over 500-µm-mesh sieve; fix with 90% ethanol to a final approximate concentration of 70% ethanol |
| Faunal Samples: Storage | Clean, labeled glass or plastic jar; ambient temperature |
| Chemistry Samples: Number | 1 at each station |
| Chemistry Samples: Processing | Use a scoop to collect upper 0–2 cm from the grab, homogenize, and collect ~500 mL subsample for grain size and ~50 mL for TOC. |
| Chemistry Samples: Storage | Clean, labeled, wide-mouth glass jar (500 mL for grain size and 125 mL for TOC); refrigerate grain size, freeze TOC.  Holding time is 28 days for both grain size and TOC. |

+++END-IF+++

+++IF determine('Saltwater Benthic', 'Saltwater', ' Grain size', 'Sediment grab samples') === false && determine('Saltwater Benthic', 'Saltwater', ' Total organic carbon (TOC)', 'Sediment grab samples') === false && determine('Saltwater Benthic', 'Saltwater', 'Infauna', 'Sediment grab samples') === true+++

Table B2.2. Processing and Storage of Field Samples taken on Marine Benthic Monitoring Surveys

| Activity | Infaunal group only Survey |
| --- | --- |
| Stations | See Survey Plan |
| Station location and time | Record location, time of station visit, and location of individual samples |
| Weather/sea state/ bottom depth | Record general conditions; record bottom depth to nearest 0.5 m |
| Sampling: Gear | 0.04-m2 Ted Young-modified Van Veen grab sampler |
| Sampling: Measurements | Record penetration depth to nearest 0.5 cm and sediment volume to nearest 0.5 L  Water quality profile: temperature, DO, salinity, pH |
| Sampling: Sediment texture, color, odor | Describe qualitatively |
| Faunal Samples: Processing | Rinse over 500-µm-mesh sieve; fix with 90% ethanol to a final approximate concentration of 70% ethanol |
| Faunal Samples: Storage | Clean, labeled glass or plastic jar; ambient temperature |
| Chemistry Samples: Number | NA |
| Chemistry Samples: Processing | NA |
| Chemistry Samples: Storage | NA |

+++END-IF+++

+++IF determine('Saltwater Benthic', 'Saltwater', ' Grain size', 'Sediment grab samples') === true && determine('Saltwater Benthic', 'Saltwater', ' Total organic carbon (TOC)', 'Sediment grab samples') === true && determine('Saltwater Benthic', 'Saltwater', 'Infauna', 'Sediment grab samples') === false+++

Table B2.3. Processing and Storage of Field Samples taken on Marine Benthic Monitoring Surveys

| Activity | Grain size and/or TOC only Survey |
| --- | --- |
| Stations | See Survey Plan |
| Station location and time | Record location, time of station visit, and location of individual samples |
| Weather/sea state/ bottom depth | Record general conditions; record bottom depth to nearest 0.5 m |
| Sampling: Gear | 0.04-m2 Ted Young-modified Van Veen grab sampler |
| Sampling: Measurements | Record penetration depth to nearest 0.5 cm and sediment volume to nearest 0.5 L  Water quality profile: temperature, DO, salinity, pH |
| Sampling: Sediment texture, color, odor | Describe qualitatively |
| Faunal Samples: Processing | NA |
| Faunal Samples: Storage | NA |
| Chemistry Samples: Number | 1 at each station |
| Chemistry Samples: Processing | Use a scoop to collect upper 0–2 cm from the grab, homogenize, and collect ~500 mL subsample for grain size and ~50 mL for TOC. |
| Chemistry Samples: Storage | Clean, labeled, wide-mouth glass jar (500 mL for grain size and 125 mL for TOC); refrigerate grain size, freeze TOC.  Holding time is 28 days for both grain size and TOC. |

+++END-IF+++

+++IF determine('Saltwater Benthic', 'Saltwater', ' Grain size', 'Sediment grab samples') === true && determine('Saltwater Benthic', 'Saltwater', ' Total organic carbon (TOC)', 'Sediment grab samples') === true && determine('Saltwater Benthic', 'Saltwater', 'Infauna', 'Sediment grab samples') === true+++

## B2 Marine Benthic Sample Collection, Processing, and Storage

Standard Operating Procedures (SOPs) for sample collection and storage are attached.

### B2.1 Soft-Bottom Grab Sample Collection

A 0.04 m2 Ted Young-modified Van Veen grab sampler will be used to collect bottom sediment samples. At each station, two grab samples will be collected for infaunal analysis (one to be analyzed at the lab and one archived) and one grab sample will be collected for total organic carbon and grain size analysis.

Sample collection will be documented using a Benthic Survey Log, and individual sample location, depth, and sediment characteristics will be recorded on a Marine Benthic Field Sheet (both attached). These samples will be delivered to the contracted laboratory for analysis within 24 hours of survey completion.

## B3 Sample Handling and Custody

The attached SOPs describe handling of samples while in the field, including storage requirements.

### B3.1 Sample Handling

The lids on the sample jars will be taped and the jars inserted individually into large zip-locked or tied plastic bags lined with absorbent padding. Following the soft-bottom benthic survey, the infaunal samples (stored in sturdy coolers) will be delivered to the contracted laboratory according to a pre-arranged schedule for sample dropoff. At the laboratory, one sample from each infaunal station will be randomly selected to archive (see Section B3.2) and the other will be processed. The sediment chemistry samples collected during the benthic survey must be kept cold (sediment grain size samples) or frozen (total organic carbon samples). After the survey is completed, a survey crew member will deliver the sediment chemistry samples to the contracted laboratory according to a pre-arranged schedule for sample drop off. If circumstances dictate that the samples must be shipped to the laboratory, they will be shipped by overnight express. In that case, the samples that were frozen after collection will be placed on dry ice with protective layers of foam or bubble wrap to ensure that they remain intact and frozen during shipment.

The maximum holding time in the laboratory for grain size samples will be 28 days with refrigeration and samples for TOC analysis will be 28 days frozen. These time frames are consistent with several standard EPA Methods and ensures that samples are analyzed in a timely manner to prevent or minimize analyte degradation and interferences.

### B3.2 Sample Custody

#### Sample Tracking

Sample custody will be tracked through external and internal Sample Labels, Field Data Form for *in situ* Water Quality Parameters, a Sample Collection Log, Field Sheets, and Chain of Custody Forms (samples of each form attached).

The Field Coordinator is responsible for verifying that information on the Sample Labels matches the information on the Sample Log and Chain of Custody prior to delivering the samples to the contracted laboratory.

The survey crew will fill out the Field Data Form at each station. During field collection, a Sample Log and Chain of Custody Forms also will be completed. The Chain of Custody Forms will include the unique information from the corresponding label on the sample container, ensuring the tracking of sample location and status.

#### Sample Custody

Samples will be in the custody of project staff from collection until they are transferred to the contracted laboratory. Transfer of samples will be documented on the Chain of Custody forms. Any discrepancies between Sample Labels and Sample Collection Log, the condition of the samples upon receipt, and any unusual events or deviations from the QAPP will be documented in detail on the Chain of Custody Form, and the Project Manager notified. Copies of completed Chain of Custody Forms will be delivered (scanned and emailed or faxed) to the Project Manager within 24 hours of receipt.

#### Sample Archival Policies

One randomly selected sample from each soft-bottom infaunal station will be archived, and the other will be processed. Archived soft-bottom infaunal samples will be rinsed with fresh water over 500 µm mesh screens and transferred to reagent alcohol for storage at the laboratory.

Macrofauna samples (both archived and processed samples) will be held until the Project Manager accepts the laboratory report. Reference collection specimens will be clearly identified, labeled with the project name and unique identification number, and stored under appropriate conditions for the length of the storage period.

## B4 Analytical Methods

Macrobiological measures (community measures such as abundance, numbers of species, and diversity) are based on the species-level identifications of the soft-bottom infauna as summarized in the table below.

Table B4.1. Marine Benthic Survey Sample Analyses, Infauna

| Parameter | Unit of Measurement | Method | Reference |
| --- | --- | --- | --- |
| Infaunal Analysis | Count/species  (# per grab) | ID and Enumeration | Sweeny and Rutecki, 2019 |

Sediment geophysical properties, including sediment grain size and total organic carbon, are based on laboratory assessment of soft-bottom grab samples as summarized in the table below.

Table B4.2. Marine Benthic Survey Sample Analyses, Sediment

| **Parameter** | **Unit of Measurement** | **Method** | **Reference** |
| --- | --- | --- | --- |
| TOC | %C by dry weight | Lloyd Kahn | Kahn, 1988[[5]](#footnote-6) |
| Sediment Grain Size | % dry weight | Folk, 1974[[6]](#footnote-7)  FGDC, 2012[[7]](#footnote-8) | Sweeny and Rutecki, 2019[[8]](#footnote-9) |

## B5 Soft-Bottom Grab Sampling Quality Control

All samples will be collected with a 0.04 m2 Young-modified Van Veen grab sampler as described in the attached Field Operations Manual/SOPs. A single grab sample, collected by this grab sampler, will provide adequate quantities of sediment for grain size and total organic carbon analysis. Samples will be kept undisturbed through careful attention to established deployment and recovery procedures. Procedures used by survey crews will cover the following aspects of deployment and recovery:

* Thorough wash-down of the grab before each deployment.
* Control of penetration by adding or removing weights to the frame and adjusting descent rate.
* Slow recovery until the grab is free of the bottom.
* Inspection for signs of leakage.
* Securing the grab on the dock or pier.

Each grab sample will be inspected for signs of disturbance. The following criteria identify ideal characteristics for an acceptable grab sample:

* Sampler is not overfilled with sediment, the sediment surface is intact and relatively level over the entire area of the grab. The jaws must be fully closed and the top of the sediment must be below the level of the opening doors.
* Overlying water is present and not excessively turbid.
* Sediment depth at the center of the sampler is at least 7 cm, indicating that the desired penetration was achieved.

Mild overfill may be acceptable according to the following standards:

* The sediment surface is intact.
* There is no evidence that the surface sediment has pushed through the grid surface of the grab—i.e., no visible imprint from the screening outside of that grid.
* There is no evidence that sediment has pushed out through the hinge or the edges of the grab.

The overall condition of the grab will be documented on the station log.

### B5.1 Sampling Quality Control for Benthic Infauna

#### Accuracy, Precision, and Representativeness

There will be no subsampling. Consequently, the accuracy, precision, and representativeness of the sampling will depend upon the factors discussed above under Section A7.

#### Comparability

Procedures for washing, sieving, and preserving the samples will be consistent with methods described in Section B2. Samples will be collected only by trained staff, volunteers under the supervision of a staff person, or volunteers with experience in the collection of benthic infaunal samples.

#### Completeness

All required samples will be collected at all of the stations specified in the sampling design. The entire sample will be sieved, and all material retained on the 500 µm mesh screen will be fixed for analysis.

### B5.2 Sampling Quality Control for Sediment

#### Accuracy, Precision, and Representativeness

These qualities will be ensured by the sampling plan and by ensuring that samples are well homogenized and subsampled and preserved following methods detailed in Section B2.

#### Comparability

Procedures for collecting and preserving the samples will be consistent with methods described in Section B2. Procedures for sampling and subsampling are comparable to those used in other investigations in Massachusetts coastal waters.

#### Completeness

All required samples will be collected at all of the stations specified in the monitoring program sampling design.

### B5.3 Benthic Analysis Laboratory Quality Control

#### Benthic Infauna

Details on infaunal sample analysis methods to be undertaken by taxonomists are provided in the selected laboratory’s QAPP (attached).

##### Accuracy

Benthic macrofauna will be identified by experienced taxonomists at a contracted laboratory. In cases where different taxonomists identify replicates from the same station, discrepancies in species identifications will be recognized during data entry and reviewed. Taxonomic discrepancies will be addressed by communication among the taxonomists. In the case of questions about organisms in specific taxonomic groups, specimens may be sent to recognized experts for a second opinion on the identification. Standard taxonomic references will be used, and selected specimens of newly found species will be retained as part of the reference collection.

##### Precision

Sorting technicians will remove all organisms from the samples and separate them into major taxonomic groups. All residual material will be labeled and stored for QC analysis. Samples will be divided into batches of approximately 10. Approximately 10% of the samples from each batch will then be randomly chosen for an independent QC check. If more than 5% of the total organisms in the QC sample have been missed, all remaining samples from that batch will be re-sorted.

##### Representativeness

Because all of the sample will be analyzed, representativeness will be determined by sampling factors.

##### Completeness

Since one sample from each station will be archived, the loss of one sample will still permit data to be obtained from the archived sample for that station. One hundred percent completeness is expected.

##### Comparability

Methods of analysis will be comparable to those used in other investigations conducted in Massachusetts coastal waters. Comparability of the identifications will be ensured through use of standard taxonomic references. Taxonomists will be familiar with fauna from Massachusetts waters and those of the surrounding regions. A reference collection will be maintained and, if new species are identified, expanded. Any new species that have not been reported in previous studies conducted in the Massachusetts coastal waters will be checked against similar taxa in the reference collection and carefully verified with recognized experts.

#### Sediment

##### Accuracy

Sediment samples collected will be analyzed for sediment grain size and TOC by a contracted laboratory. No field-collected QC samples, including field duplicates, or equipment and field blanks for sediment chemistry are required.

Details on sediment sample analysis methods are provided in the selected laboratory’s QAPP (attached). The laboratory will follow all QC/QA procedures for the analytical method being followed.

##### Representativeness

Because all of the sample will be analyzed, representativeness will be determined by sampling factors.

##### Completeness

Adequate sediment will be collected for the analytical laboratories to perform the required analyses.

## B6 Instrument/Equipment Testing, Inspection, and Maintenance Requirements

No analytical laboratory instruments are covered by this QAPP.

## B7 Instruments

No analytical laboratory instruments are covered by this QAPP.

## B8 Inspection/Acceptance of Supplies and Consumables

Critical supplies for field activities will be the responsibility of the Project Manager.

If unacceptable supplies or consumables are found, the Project Manager will repair or replace measurement equipment and/or replace defective or inappropriate materials, delegating tasks as indicated in the table below.

Table B8.1. Supplies, Acceptance Criteria, and Responsibility for Critical Field Supplies

| Critical Supplies and Consumables | Inspection Requirements  and Acceptance Criteria | Person (Role) Responsible |
| --- | --- | --- |
| Jars for macrofaunal samples | Visually inspected for cracks, breakage, and cleanliness. May be reused. |  |
| Sample bottles for sediment chemistry | Visually inspected upon receipt for cracks, breakage, and cleanliness. Must be accompanied by certificate of analysis. |  |
| Chemicals and reagents | Visually inspected for proper labeling, expiration dates, appropriate grade. |  |
| Sampling equipment (grabs) | Visually inspected for obvious defects, damage, and contamination. |  |

## B9 Data Acquisition Requirements

Secondary data (historical reports, maps, literature searches, and previously collected analytical data) may be used in the preparation of the sampling plan. These data may come from sources such as:

* Prior reports specific to the area.
* Results of state agency or other studies water quality monitoring data.
* Pertinent data collected by federal agencies, such as USGS bathymetry data and NOAA weather records.
* Surveys completed in the embayment or embayment system of interest, including those identified through MassBays’ Ecosystem Delineation and Assessment (https://www.mass.gov/service-details/ecosystem-delineation-and-assessment) and Inventory of Plans and Assessments (<https://www.mass.gov/service-details/massbays-inventory-of-plans-and-assessments>).

Secondary data used will be documented in the Secondary Data Form (attached), according to Sections A9 and C2.

## B10 Data Management

Data quality control steps will be taken at several stages. Documentation of data recording and handling, including all problems and corrective actions, shall be included in all preliminary and final reports. (Corrective Action Reporting form attached.) See Section A9 for recording handling and storage procedures.

### B10.1 Process and Procedures

+++INS `${dataManagementProcess}`+++

### B10.2 Data Handling

+++INS `${dataHandling}`+++

### B10.3 Management Requirements

+++INS `${dataManagementRequirements}`+++

### B10.4 Macrofaunal Analysis

The contracted laboratory will include the scientific name for each taxon in the macrofaunal abundance data submitted to the Project Manager.

Macrofaunal data will be analyzed for t community parameters, for example: abundance, Shannon-Wiener diversity index (H'), Pielou's evenness (J'), Margalef’s diversity index (DMg), Simpson, and/or total taxonomic distinctness.

The results of all statistical analyses will be combined and tabulated into an Excel spreadsheet for delivery to the Project Manager.

### B10.5 Sediment Physiochemical Analysis

The contracted laboratory will include sediment grain size and percentage of total organic carbon in the sediment data submitted to the Project Manager. After data verification, sediment samples can be disposed of following internal laboratory protocols. Sediment samples with known toxins (e.g., PCBs, dioxin, and PAHs) will be disposed of properly following local, state, and federal laws.

### B10.6 Laboratory Data and Data Reduction

All data generated by contracted laboratories will be either electronically transferred from the instrument or manually read from the instrument display (optical field of a microscope or video monitor) and entered directly into an electronic format or entered into Laboratory Data Forms (sample attached) and then manually entered into an electronic format. All manually entered data will receive 100% verification or will be entered and checked using double data entry.

Data reduction is the process of converting raw numbers (e.g., numbers of organisms per replicate) into data that can be displayed graphically, summarized in tables, or compared statistically for differences between mean values for sampling stations or times. Macrofauna data analysis discussed below require that some data be derived from the raw numbers for the laboratory report. All data reduction will be performed electronically, either by the instrument software or in a spreadsheet, and will be validated according to procedures described in Section D2.

The format for final data submission is described in Sections A9 and C2.

+++END-IF+++

+++IF determine('Saltwater Benthic', 'Saltwater', ' Grain size', 'Sediment grab samples') === false && determine('Saltwater Benthic', 'Saltwater', ' Total organic carbon (TOC)', 'Sediment grab samples') === false && determine('Saltwater Benthic', 'Saltwater', 'Infauna', 'Sediment grab samples') === true+++

## B2 Benthic Sample Collection, Processing, and Storage

Processing and storage requirements for all samples collected for the benthic monitoring tasks are outlined below and detailed in the attached Standard Operating Procedures (SOPs). Sample collection will be documented using a Benthic Survey Log, and individual sample location, depth, and sediment characteristics will be recorded on a Marine Benthic Field Sheet (both attached).

### B2.1 Soft-Bottom Grab Sample Collection

A 0.04 m2 Ted Young-modified Van Veen grab sampler will be used to collect bottom sediment samples. At each station, two grab samples will be collected for infaunal analysis (one to be analyzed at the lab and one archived).

### B2.2 Sample Storage

All benthic infaunal samples will be handled gently during the sieving process and fixed with 90% ethanol as quickly as possible (final ethanol concentration approximately 70%) to prevent deterioration of the fauna; all sample jars will be labeled accurately. Following each benthic survey, the infauna samples will be stored in sturdy coolers and delivered to the contracted laboratory within 48 hours.

## B3 Sample Handling and Custody

The attached SOPs describe handling of samples while in the field, including storage requirements.

### B3.1 Sample Handling

Following the soft-bottom benthic survey, the infaunal samples (stored in sturdy coolers) will be delivered by a survey crew member to the contracted laboratory According to a prearranged schedule for sample dropoff. Alternatively, the samples, while still in approximately 70% ethanol, can be shipped by ground (or two-day express delivery if necessary) for delivery to the contracted laboratory. The lids on the sample jars will be taped and the jars inserted individually into large zip-locked or tied plastic bags lined with absorbent padding. At the laboratory, one sample from each infaunal station will be randomly selected to archive (see Section B3.2) and the other will be processed.

### B3.2 Sample Custody

#### Sample Tracking

Sample custody will be tracked through external and internal Sample Labels, Field Data Forms, a Sample Log, and Chain of Custody Forms (sample forms are attached).

Sample Labels for macrofaunal samples will be affixed to the sample containers in the field. The sampling station, sample type, replicate number, date, and time will be entered manually onto the label. One additional label will be prepared on waterproof paper and inserted inside the sample container. If multiple sample containers are needed for a single infaunal replicate, the sample information will be manually entered on blank labels, and the containers will be numbered (e.g., “1 of 2,” “2 of 2”).

The survey crew will fill out the Marine Benthic Field Sheet at each station. The form includes headers for entering pertinent information about each station, such as arrival time, bottom depth, and weather observations. The form also contains spaces for specific grab data, such as penetration depth and general descriptions. The forms will be kept in the project files. During field collection, a Survey Log and Chain of Custody Forms also will be completed. The Chain of Custody Forms will include the unique information from the corresponding label on the sample container, ensuring the tracking of sample location and status. The Sample Log will include a list of samples collected. The Field Coordinator is responsible for verifying that information on the Sample Labels matches the information on the Survey Log and Chain of Custody prior to delivering the samples to the contracted laboratory.

#### Sample Custody

Infauna samples will be in the custody of the survey Field Coordinator or a crew member from collection until they are transferred to the contracted laboratory. Chain of Custody Forms will accompany the samples. One complete (copied) set of the infauna Chain of Custody Forms will be included in each shipping container and the original Chain of Custody Forms will be returned to Project Manager after the samples have been logged in at the contracted laboratory. The signed original custody forms will be retained in the project files. Sample processing will occur in the contracted laboratory. After the samples are processed, the laboratory will store the appropriate samples and specimens for the specific length of time for re-identification QC, voucher, or unforeseen circumstances.

Transfer of benthic infaunal samples will be documented on the Chain of Custody forms. All samples will be distributed to the appropriate laboratory personnel by hand or by a shipping service. A copy of the Chain of Custody Form will be retained by the field sample custodian in the field log. The original will accompany the samples to the laboratory for subsequent sample transfer. When samples arrive at the laboratory, custody will be relinquished to the laboratory staff. The laboratory staff will verify that the custody seals on the cooler are intact. The laboratory staff will then examine the samples, verify that sample-specific information recorded on the Chain of Custody Form is accurate and that the sample integrity is uncompromised, log the samples into their laboratory tracking system, and complete and sign the Chain of Custody Form so that transfer of custody of the samples is complete. Any discrepancies between Sample Labels and Survey Log, the condition of the samples upon receipt, and any unusual events or deviations from the QAPP will be documented in detail on the Chain of Custody Form, and the Project Manager notified. Copies of completed custody forms will be delivered (scanned and emailed or faxed) to the Project Manager within 24 hours of receipt.

#### Sample Archival Policies

One randomly selected sample from each soft-bottom infaunal station will be archived, and the other will be processed. Archived soft-bottom infaunal samples will be rinsed with fresh water over 500 µm mesh screens and transferred to reagent alcohol for storage at the laboratory.

Macrofauna samples (both archived and processed samples) will be held until the Project Manager accepts the laboratory report. If subsequent surveys will be conducted within six years, reference collection specimens will be retained by the contracted laboratory. Reference collection specimens will be clearly identified, labeled with the project name and unique identification number, and stored under appropriate conditions for the length of the storage period.

## B4 Soft-Bottom Infaunal Analysis

Macrobiological measures (community measures such as abundance, numbers of species, and diversity) are based on the species-level identifications of the soft-bottom infauna as summarized in the table below.

Table B4.1. Marine Benthic Survey Sample Analyses, Infauna

| Parameter | Unit of Measurement | Method | Reference |
| --- | --- | --- | --- |
| Infaunal Analysis | Count/species  (# per grab) | ID and enumeration | Sweeny and Rutecki, 2019 |

## B5 Soft-Bottom Grab Sampling Quality Control

All sediment samples to be used for faunal analyses will be collected with a 0.04 m2 Young-modified Van Veen grab sampler. Samples will be kept undisturbed through careful attention to established deployment and recovery procedures. Procedures used by survey crews will cover the following aspects of deployment and recovery:

* Thorough wash-down of the grab before each deployment.
* Control of penetration by adding or removing weights to the frame and adjusting descent rate.
* Slow recovery until the grab is free of the bottom.
* Inspection for signs of leakage.
* Securing the grab on the dock or pier.

Each grab sample will be inspected for signs of disturbance. The following criteria identify ideal characteristics for an acceptable grab sample:

* The sampler is not overfilled with sediment, the sediment surface is intact and relatively level over the entire area of the grab. The jaws must be fully closed and the top of the sediment must be below the level of the opening doors.
* Overlying water is present and not excessively turbid.
* Sediment depth at the center of the sampler is at least 7 cm, indicating that the desired penetration was achieved.

Mild overfill may be acceptable according to the follow standards:

* The sediment surface is intact.
* There is no evidence that the surface sediment has pushed through the grid surface of the grab—i.e., no visible imprint from the screening outside that grid.
* There is no evidence that sediment has pushed out through the hinge or the edges of the grab.

The overall condition of the grab will be documented on the Marine Benthic Field Sheet (sample attached).

### B5.1 Soft-Bottom Grab Field Sampling Quality Control

#### Accuracy, Precision, and Representativeness

There will be no subsampling. Consequently, the accuracy, precision, and representativeness of the sampling will depend upon the factors discussed above under Section A7.1.3.

#### Comparability

Procedures for washing, sieving, and preserving the samples will be consistent with methods described in Section B2. Samples will be collected only by trained staff under the supervision of a Field Coordinator with experience in the collection of benthic infaunal samples.

#### Completeness

All required samples will be collected at all of the stations specified in the project sampling plan. The entire sample will be sieved and all material retained on the 500 µm mesh screen will be fixed for analysis.

### B5.2 Benthic Infauna Analysis Laboratory Quality Control

Details on infaunal sample analysis methods to be undertaken by taxonomists are provided in the laboratory’s QAPP (attached).

#### Accuracy

Benthic macrofauna will be identified by experienced taxonomists at a contracted laboratory. In cases where different taxonomists identify replicates from the same station, discrepancies in species identifications will be recognized during data entry and reviewed. Taxonomic discrepancies will be addressed by communication among the taxonomists. In the case of questions about organisms in specific taxonomic groups, specimens may be sent to recognized experts for a second opinion on the identification. Standard taxonomic references will be used, and selected specimens of newly found species will be retained as part of the reference collection.

#### Precision

Sorting technicians will remove all organisms from the samples and separate them into major taxonomic groups. All residual material will be labeled and stored for QC analysis. Samples will be divided into batches of approximately 10. Approximately 10% of the samples from each batch will then be randomly chosen for an independent QC check. If more than 5% of the total organisms in the QC sample have been missed, all remaining samples from that batch will be re-sorted.

#### Representativeness

Because all of the sample will be analyzed, representativeness will be determined by sampling factors.

#### Completeness

Since one sample from each station will be archived, the loss of one sample will still permit data to be obtained from the archived sample for that station. One hundred percent completeness is expected.

#### Comparability

Methods of analysis will be comparable to those used in other investigations conducted in Massachusetts coastal waters. Comparability of the identifications will be ensured through the use of standard taxonomic references. Taxonomists will be familiar with fauna from Massachusetts waters and those of the surrounding regions. The reference collection will be maintained and, if new species are identified, expanded.

## B6 Instrument/Equipment Testing, Inspection, and Maintenance Records

No analytical laboratory instruments are utilized for the benthic community assessment.

## B7 Instruments

No analytical laboratory instruments are utilized for the benthic community assessment.

## B8 Inspection/Acceptance of Supplies and Consumables

Critical supplies for field activities will be the responsibility of the Project Manager.

If unacceptable supplies or consumables are found, the Project Manager may repair or replace measurement equipment and/or replace defective or inappropriate materials, delegating tasks as indicated in the table below.

Table B8.1. Supplies, Acceptance Criteria, and Responsibility for Critical Field Supplies

| Critical Supplies and Consumables | Inspection Requirements  and Acceptance Criteria | Person (Role) Responsible |
| --- | --- | --- |
| Jars for macrofaunal samples | Visually inspected for cracks, breakage, and cleanliness. May be reused. |  |
| Sample bottles for sediment chemistry | Visually inspected upon receipt for cracks, breakage, and cleanliness. Must be accompanied by certificate of analysis. |  |
| Chemicals and reagents | Visually inspected for proper labeling, expiration dates, appropriate grade. |  |
| Sampling equipment (grabs) | Visually inspected for obvious defects, damage, and contamination. |  |

## B9 Data Acquisition Requirements

Secondary data (historical reports, maps, literature searches, and previously collected analytical data) may be used in the preparation of the sampling plan. These data may come from sources such as:

* Prior reports specific to the area.
* Results of state agency or other studies water quality monitoring data.
* Pertinent data collected by federal agencies, such as USGS bathymetry data and NOAA weather records.
* Surveys completed in the embayment or embayment system of interest, including those identified through MassBays’ Ecosystem Delineation and Assessment (https://www.mass.gov/service-details/ecosystem-delineation-and-assessment ) and Inventory of Plans and Assessments (<https://www.mass.gov/service-details/massbays-inventory-of-plans-and-assessments>).

Secondary data used will be documented in the Secondary Data Table (attached), according to Sections A9 and C2.

## B10 Data Management

Data quality control steps will be taken at several stages. Documentation of data recording and handling, including all problems and corrective actions, shall be included in all preliminary and final reports. (Corrective Action Reporting Form attached.) See Section A9 for recording handling and storage procedures.

### B10.1 Process and Procedures

+++INS `${dataManagementProcess}`+++

### B10.2 Data Handling

+++INS `${dataHandling}`+++

### B10.3 Management Requirements

+++INS `${dataManagementRequirements}`+++

+++END-IF+++

+++IF determine('Saltwater Benthic', 'Saltwater', ' Grain size', 'Sediment grab samples') === true && determine('Saltwater Benthic', 'Saltwater', ' Total organic carbon (TOC)', 'Sediment grab samples') === true && determine('Saltwater Benthic', 'Saltwater', 'Infauna', 'Sediment grab samples') === false +++

## B2 Benthic Sample Collection, Processing, and Storage Overview

Processing and storage requirements for all samples collected for the benthic monitoring tasks are outlined below and detailed in the attached SOPs. Sample collection will be documented using a Benthic Survey Log, and individual sample location, depth, and sediment characteristics will be recorded on a Marine Benthic Field Sheet (both attached).

### B2.1 Soft-Bottom Grab Sample Collection

A 0.04 m2 Ted Young-modified Van Veen grab sampler will be used to collect bottom sediment samples. At each station, one grab sample will be collected for total organic carbon and grain size analysis.

## B3 Sample Handling and Custody

The attached SOPs describe handling of samples while in the field, including storage requirements.

### B3.1 Sample Handling

Sediment chemistry samples must be kept cold (sediment grain size samples) or frozen (total organic carbon samples). After the survey is completed, a survey crew member will deliver the sediment chemistry samples to the contracted laboratory according to a pre-arranged schedule for sample dropoff. If circumstances dictate that the samples must be shipped to the laboratory, they will be shipped by overnight express. In that case, the samples that were frozen after collection will be placed on dry ice with protective layers of foam or bubble wrap to ensure that they remain intact and frozen during shipment.

### B3.2 Sample Custody

#### Sample Tracking

Sample custody will be tracked through external and internal Sample Labels, Marine Benthic Field Sheets, Survey Log, and Chain of Custody Forms (samples attached).

Sediment samples collected under this QAPP will be processed by a contracted laboratory. The contracted laboratory will provide the sample containers and sample labels. Sample Labels will contain or have spaces for following information: station location, survey type, analysis, preservative, date/time collected, and collector’s name.

The survey crew will fill out the Marine Benthic Field Sheet at each station. The form includes headers for entering pertinent information about each station, such as arrival time, bottom depth, and weather observations. The form also contains spaces for specific grab data, such as penetration depth and general descriptions. The forms will be kept in the project files. During field collection, a Survey Log and Chain of Custody Forms also will be completed. The Chain of Custody Forms will include the unique information from the corresponding label on the sample container, ensuring the tracking of sample location and status. The Survey Log will include a list of samples collected. The Field Coordinator is responsible for verifying that information on the Sample Labels matches the information on the Sample Log and Chain of Custody prior to delivering the samples to the contracted laboratory.

#### Sample Custody

Sediment samples will be in the custody of the survey Field Coordinator or a crew member from collection until they are transferred to the contracted laboratory. Transfer of sediment samples will be documented on the custody forms. All samples will be distributed to the appropriate laboratory personnel by hand or by a shipping service. The field sample custodian will retain a copy of the Chain of Custody Form. The original will accompany the samples to the laboratory for subsequent sample transfer. When samples arrive at the laboratory, custody will be relinquished to the laboratory staff. The laboratory staff will verify that the custody seals on the cooler are intact. The laboratory staff will then examine the samples, verify that sample-specific information recorded on the Chain of Custody Form is accurate and that the sample integrity is uncompromised, log the samples into their laboratory tracking system, and complete and sign the Chain of Custody Form so that transfer of custody of the samples is complete. Any discrepancies between Sample Labels and Survey Log, the condition of the samples upon receipt, and any unusual events or deviations from the QAPP will be documented in detail on the Chain of Custody Form, and the Project Manager notified. Copies of completed custody forms will be delivered (scanned and emailed or faxed) to the Project Manager within 24 hours of receipt.

## B4 Analytical Methods

Sediment geophysical properties, including sediment grain size and total organic carbon, are based on laboratory assessment of soft-bottom grab samples as indicated below.

Table B4.1. Marine Benthic Survey Sample Analyses, Sediment

| **Parameter** | **Unit of Measurement** | **Method** | **Reference** |
| --- | --- | --- | --- |
| TOC | %C by dry weight | Lloyd Kahn | Kahn, 1988[[9]](#footnote-10) |
| Sediment Grain Size | % dry weight | Folk, 1974[[10]](#footnote-11)  FGDC, 2012[[11]](#footnote-12) | Sweeny and Rutecki, 2019[[12]](#footnote-13) |

## B5 Quality Control

### B5.1 Field Sampling Quality Control

#### Accuracy, Precision, and Representativeness

These qualities will be assured by compliance with the sampling plan and by ensuring that samples are well homogenized and subsampled and preserved following methods detailed in Section B2.

#### Comparability

Procedures for sampling and subsampling are comparable to those used in other investigations in Massachusetts coastal waters.

#### Completeness

All required samples will be collected at all of the stations specified in the program sampling plan.

### B5.2 Soft-Bottom Grab Sampling Quality Control

All sediment samples to be used for grain size and total organic carbon analysis will be collected with a 0.04 m2 Young-modified Van Veen grab sampler. Samples will be kept undisturbed through careful attention to established deployment and recovery procedures. Procedures used by survey crews will cover the following aspects of deployment and recovery:

* Thorough wash-down of the grab before each deployment.
* Control of penetration by adding or removing weights to the frame and adjusting descent rate.
* Slow recovery until the grab is free of the bottom.
* Inspection for signs of leakage.
* Securing the grab on deck.

Each grab sample will be inspected for signs of disturbance. The following criteria identify ideal characteristics for an acceptable grab sample:

* The sampler is not overfilled with sediment; the sediment surface is intact and relatively level over the entire area of the grab. The jaws must be fully closed and the top of the sediment must be below the level of the opening doors.
* Overlying water is present and not excessively turbid.
* Sediment depth at the center of the sampler is at least 7 cm, indicating that the desired penetration was achieved.

Mild overfill may be acceptable if:

* The sediment surface is intact.
* There is no evidence that the surface sediment has pushed through the grid surface of the grab—i.e., no visible imprint from the screening outside that grid.
* There is no evidence that sediment has pushed out through the hinge or the edges of the grab.

The overall condition of the grab will be documented on the Marine Benthic Field Sheet.

## B6 Instrument/Equipment Testing, Inspection, and Maintenance Requirements

No analytical laboratory instruments are included in this QAPP; see Laboratory QAPP attached.

## B7 Instruments

No analytical laboratory instruments are included in this QAPP; see Laboratory QAPP attached.

## B8 Inspection/Acceptance of Supplies and Consumables

Critical supplies for field activities will be the responsibility of the Project Manager.

If unacceptable supplies or consumables are found, the Project Manager will repair or replace measurement equipment and/or replace defective or inappropriate materials, delegating tasks as indicated in the table below.

Table B8.1. Supplies, Acceptance Criteria, and Responsibility for Critical Field Supplies

| Critical Supplies and Consumables | Inspection Requirements  and Acceptance Criteria | Person (Role) Responsible |
| --- | --- | --- |
| Sample bottles for sediment chemistry | Visually inspected upon receipt for cracks, breakage, and cleanliness. Must be accompanied by certificate of analysis. |  |
| Chemicals and reagents | Visually inspected for proper labeling, expiration dates, appropriate grade. |  |
| Sampling equipment (grabs) | Visually inspected for obvious defects, damage, and contamination. |  |

## B9 Data Acquisition Requirements

Secondary data (historical reports, maps, literature searches, and previously collected analytical data) may be used in the preparation of the sampling plan. These data may come from sources such as:

* Prior reports specific to the area.
* Results of state agency or other studies water quality monitoring data.
* Pertinent data collected by federal agencies, such as USGS bathymetry data and NOAA weather records.
* Surveys completed in the embayment or embayment system of interest, including those identified through MassBays’ Ecosystem Delineation and Assessment (https://www.mass.gov/service-details/ecosystem-delineation-and-assessment) and Inventory of Plans and Assessments (<https://www.mass.gov/service-details/massbays-inventory-of-plans-and-assessments>).

Secondary data used will be documented in the Secondary Data Table, attached, according to Sections A9 and C2.

## B10 Data Management—Sediment Analysis

Data quality control steps will be taken at several stages. Documentation of data recording and handling, including all problems and corrective actions, shall be included in all preliminary and final reports. (Corrective Action Reporting Form attached.) See Section A9 for recording handling and storage procedures.

### B10.1 Process and Procedures

+++INS `${dataManagementProcess}`+++

### B10.2 Data Handling

+++INS `${dataHandling}`+++

### B10.3 Management Requirements

+++INS `${dataManagementRequirements}`+++

+++END-IF+++

+++IF determine('Saltwater Benthic', 'Saltwater', ' Grain size', 'Sediment grab samples') === true && determine('Saltwater Benthic', 'Saltwater', ' Total organic carbon (TOC)', 'Sediment grab samples') === false && determine('Saltwater Benthic', 'Saltwater', 'Infauna', 'Sediment grab samples') === false +++

## B2 Benthic Sample Processing and Storage Overview

Processing and storage requirements for all samples collected for the benthic monitoring tasks are outlined below and detailed in the attached SOPs. Sample collection will be documented using a Benthic Survey Log, and individual sample location, depth, and sediment characteristics will be recorded on a Marine Benthic Field Sheet (both attached).

### B2.1 Soft-Bottom Grab Sample Collection

A 0.04 m2 Ted Young-modified Van Veen grab sampler will be used to collect bottom sediment samples. At each station, one grab sample will be collected for grain size analysis.

## B3 Sample Handling and Custody

The attached SOPs describe handling of samples while in the field, including storage requirements.

The sediment grain size samples collected during the benthic survey must be kept cold. After the survey is completed, a survey crew member will deliver the sediment samples to the contracted laboratory according to a pre-arranged schedule for sample dropoff. If circumstances dictate that the samples must be shipped to the laboratory, they will be shipped by overnight express.

The maximum holding time for sediment samples in the laboratory will be 28 days with refrigeration. This time frame is consistent with a number of standard EPA Methods and ensures that samples are analyzed in a timely manner to prevent or minimize analyte degradation and interferences.

### B3.1 Sample Custody

#### Sample Tracking

Sample custody will be tracked through external and internal Sample Labels, Field Data Forms, a Sample Log, and Chain of Custody Forms.

Sediment samples collected under this QAPP will be processed by a contracted laboratory. The contracted laboratory will provide the sample containers and sample labels. Sample Labels will contain or have spaces for following information: station location, survey type, analysis, preservative, date/time collected, and collector’s name.

The survey crew will fill out the Field Data Form at each station. The form includes headers for entering pertinent information about each station, such as arrival time, bottom depth, and weather observations. The form also contains spaces for specific grab data, such as penetration depth and general descriptions. The forms will be kept in the project files. During field collection, a Sample Log and Chain of Custody Forms also will be completed. The Chain of Custody Forms will include the unique information from the corresponding label on the sample container, ensuring the tracking of sample location and status. The Sample Log will include a list of samples collected. The Field Coordinator is responsible for verifying that information on the Sample Labels matches the information on the Sample Log and Chain of Custody prior to delivering the samples to the contracted laboratory.

#### Sample Custody

Sediment samples will be in the custody of the survey Field Coordinator or a crew member from collection until they are transferred to the contracted laboratory. Transfer of sediment samples will be documented on the custody forms. All samples will be distributed to the appropriate laboratory personnel by hand or by a shipping service. The field sample custodian will retain a copy of the Chain of Custody Form in the field log. The original will accompany the samples to the laboratory for subsequent sample transfer. When samples arrive at the laboratory, custody will be relinquished to the laboratory staff. The laboratory staff will verify that the custody seals on the cooler are intact. The laboratory staff will then examine the samples, verify that sample-specific information recorded on the Chain of Custody Form is accurate and that the sample integrity is uncompromised, log the samples into their laboratory tracking system, and complete and sign the Chain of Custody Form so that transfer of custody of the samples is complete. Any discrepancies between Sample Labels and Sample Log, the condition of the samples upon receipt, and any unusual events or deviations from the QAPP will be documented in detail on the Chain of Custody Form, and the Project Manager notified. Copies of completed custody forms will be delivered (scanned and emailed or faxed) to the Project Manager within 24 hours of receipt.

## B4 Analytical Methods

Sediment grain size determination is based on laboratory assessment of soft-bottom grab samples as indicated below.

Table B4.1. Marine Benthic Survey Sample Analyses, Sediment

| **Parameter** | **Unit of Measurement** | **Method** | **Reference** |
| --- | --- | --- | --- |
| Sediment Grain Size | % dry weight | Folk, 1974[[13]](#footnote-14)  FGDC, 2012[[14]](#footnote-15) | Sweeny and Rutecki, 2019[[15]](#footnote-16) |

## B5 Field Sampling Quality Control

### B5.1 Sediment Sample Quality Control

#### Accuracy, Precision, and Representativeness

These qualities will be assured by the sampling plan and by ensuring that samples are well homogenized and subsampled and preserved following methods detailed in the Field Operations Manual/SOPs attached.

#### Comparability

Procedures for sampling and subsampling are comparable to those used in other investigations in Massachusetts coastal waters.

#### Completeness

All required samples will be collected at all of the stations specified in the embayment-specific study plan.

### B5.2 Soft-Bottom Grab Sampling Quality Control

All sediment samples to be used for grain size analysis will be collected with a 0.04 m2 Young-modified Van Veen grab sampler. Samples will be kept undisturbed through careful attention to established deployment and recovery procedures. Procedures used by survey crews will cover the following aspects of deployment and recovery:

* Thorough wash-down of the grab before each deployment
* Control of penetration by adding or removing weights to the frame and adjusting descent rate
* Slow recovery until the grab is free of the bottom
* Inspection for signs of leakage
* Securing the grab on deck

Each grab sample will be inspected for signs of disturbance. The following criteria identify ideal characteristics for an acceptable grab sample:

* The sampler is not overfilled with sediment; the sediment surface is intact and relatively level over the entire area of the grab. The jaws must be fully closed and the top of the sediment must be below the level of the opening doors.
* Overlying water is present and not excessively turbid.
* Sediment depth at the center of the sampler is at least 7 cm, indicating that the desired penetration was achieved.

Mild overfill may be acceptable if:

* The sediment surface is intact.
* There is no evidence that the surface sediment has pushed through the grid surface of the grab—i.e., no visible imprint from the screening outside that grid.
* There is no evidence that sediment has pushed out through the hinge or the edges of the grab.

The overall condition of the grab will be documented on the Marine Benthic Field Sheet.

## B6 Instrument/Equipment Testing, Inspection, and Maintenance Requirements

No analytical laboratory instruments are included in this QAPP; see Laboratory QAPP attached.

## B7 Instruments

No analytical laboratory instruments are included in this QAPP; see Laboratory QAPP attached.

## B8 Inspection/Acceptance of Supplies and Consumables

Critical supplies for field activities will be the responsibility of the Project Manager.

If unacceptable supplies or consumables are found, the Project Manager will repair or replace measurement equipment and/or replace defective or inappropriate materials, delegating tasks as indicated in the table below.

Table B8.1. Supplies, Acceptance Criteria, and Responsibility for Critical Field Supplies

| Critical Supplies and Consumables | Inspection Requirements  and Acceptance Criteria | Person (Role) Responsible |
| --- | --- | --- |
| Sample bottles for sediment chemistry | Visually inspected upon receipt for cracks, breakage, and cleanliness. Must be accompanied by certificate of analysis. |  |
| Sampling equipment (grabs) | Visually inspected for obvious defects, damage, and contamination. |  |

## B9 Data Acquisition Requirements

Secondary data (historical reports, maps, literature searches, and previously collected analytical data) may be used in the preparation of the sampling plan. These data may come from sources such as:

* Prior reports specific to the area.
* Results of state agency or other studies water quality monitoring data.
* Pertinent data collected by federal agencies, such as USGS bathymetry data and NOAA weather records.
* Surveys completed in the embayment or embayment system of interest, including those identified through MassBays’ Inventory of Plans and Assessments (<https://www.mass.gov/service-details/massbays-inventory-of-plans-and-assessments>).

Secondary data used will be documented in the Secondary Data Form, attached, according to Sections A9 and C2.

## B10 Data Management

Data quality control steps will be taken at several stages. Documentation of data recording and handling, including all problems and corrective actions, shall be included in all preliminary and final reports. (Corrective Action Reporting form attached.) See Section A9 for recording handling and storage procedures.

### B10.1 Process and Procedures

+++INS `${dataManagementProcess}`+++

### B10.2 Data Handling

+++INS `${dataHandling}`+++

### B10.3 Management Requirements

+++INS `${dataManagementRequirements}`+++

+++END-IF+++

+++IF determine('Saltwater Benthic', 'Saltwater', ' Grain size', 'Sediment grab samples') === false && determine('Saltwater Benthic', 'Saltwater', ' Total organic carbon (TOC)', 'Sediment grab samples') === true && determine('Saltwater Benthic', 'Saltwater', 'Infauna', 'Sediment grab samples') === false+++

## B2 Benthic Sample Processing and Storage

Processing and storage requirements for all samples collected for the benthic monitoring tasks are outlined below and detailed in the attached Field Operations Manual/SOPs. Sample collection will be documented using a Benthic Survey Log, and individual sample location, depth, and sediment characteristics will be recorded on a Marine Benthic Field Sheet (both attached).

### B2.1 Soft-Bottom Grab Sample Collection

A 0.04 m2 Ted Young-modified Van Veen grab sampler will be used to collect bottom sediment samples. At each station, one grab sample will be collected for total organic carbon analysis.

## B3 Sample Handling and Custody

The attached SOPs describe handling of samples while in the field, including storage requirements.

### B3.1 Sample Handling

The sediment chemistry samples collected during the benthic survey must be kept frozen. After the survey is completed, a survey crew member will deliver the sediment chemistry samples to the contracted laboratory according to a pre-arranged schedule for sample drop off. If circumstances dictate that the samples must be shipped to the laboratory, they will be shipped by overnight express. In that case, the samples that were frozen after collection will be placed on dry ice with protective layers of foam or bubble wrap to ensure that they remain intact and frozen during shipment.

The maximum holding time for sediment samples in the laboratory will be 28 days frozen. This time frame is consistent with a number of standard EPA Methods and ensures that samples are analyzed in a timely manner to prevent or minimize analyte degradation and interferences.

### B3.2 Sample Custody

#### Sample Tracking

Sample custody will be tracked through external and internal Sample Labels, Field Data Forms, a Survey Log, Marine Benthic Field Sheet, and Chain of Custody Forms.

Sediment samples collected under this QAPP will be processed by a contracted laboratory. The contracted laboratory will provide the sample containers and sample labels. Sample Labels will contain or have spaces for following information: station location, survey type, analysis, preservative, date/time collected, and collector’s name.

The survey crew will fill out the Marine Benthic Field Sheet at each monitoring location. The form includes headers for entering pertinent information about each location, such as arrival time, bottom depth, and weather observations. The form also contains spaces for specific grab data, such as penetration depth and general descriptions. The forms will be kept in the project files. During field collection, a Survey Log and Chain of Custody Forms also will be completed. The Chain of Custody Forms will include the unique information from the corresponding label on the sample container, ensuring the tracking of sample location and status. The Sample Log will include a list of samples collected. The Field Coordinator is responsible for verifying that information on the Sample Labels matches the information on the Survey Log and Chain of Custody prior to delivering the samples to the contracted laboratory.

#### Sample Custody

Sediment samples will be in the custody of the survey Field Coordinator or a crew member from collection until they are transferred to the contracted laboratory. Transfer of sediment samples will be documented on the custody forms. All samples will be distributed to the appropriate laboratory personnel by hand or by a shipping service. The field sample custodian will retain a copy of the Chain of Custody Form in the field log. The original will accompany the samples to the laboratory for subsequent sample transfer. When samples arrive at the laboratory, custody will be relinquished to the laboratory staff. The laboratory staff will verify that the custody seals on the cooler are intact. The laboratory staff will then examine the samples, verify that sample-specific information recorded on the Chain of Custody Form is accurate and that the sample integrity is uncompromised, log the samples into their laboratory tracking system, and complete and sign the Chain of Custody Form so that transfer of custody of the samples is complete. Any discrepancies between Sample Labels and Survey Log, the condition of the samples upon receipt, and any unusual events or deviations from the QAPP will be documented in detail on the Chain of Custody Form, and the Project Manager notified. Copies of completed custody forms will be delivered (scanned and emailed or faxed) to the Project Manager within 24 hours of receipt.

## B4 Analytical Methods

Sediment total organic carbon analysis is based on laboratory assessment of soft-bottom grab samples as indicated below.

Table B4.1. Marine Benthic Survey Sample Analyses, Sediment

| **Parameter** | **Unit of Measurement** | **Method** | **Reference** |
| --- | --- | --- | --- |
| TOC | %C by dry weight | Lloyd Kahn | Kahn, 1988[[16]](#footnote-17) |

## B5 Field Sampling Quality Control

### B5.1 Sediment Samples Quality Control

#### Accuracy, Precision, and Representativeness

These qualities will be assured by compliance with the sampling plan and ensuring that samples are well homogenized and subsampled and preserved following methods detailed in Section B2.

#### Comparability

Procedures for sampling and subsampling are comparable to those used in other investigations in Massachusetts coastal waters.

#### Completeness

All required samples will be collected at all of the stations specified in the program sampling plan.

### B5.2 Soft-Bottom Grab Sampling Quality Control

All sediment samples to be used for total organic carbon analysis will be collected with a 0.04 m2 Young-modified Van Veen grab sampler. Samples will be kept undisturbed through careful attention to established deployment and recovery procedures. Procedures used by survey crews will cover the following aspects of deployment and recovery:

* Thorough wash-down of the grab before each deployment
* Control of penetration by adding or removing weights to the frame and adjusting descent rate
* Slow recovery until the grab is free of the bottom
* Inspection for signs of leakage
* Securing the grab on deck

Each grab sample will be inspected for signs of disturbance. The following criteria identify ideal characteristics for an acceptable grab sample:

* The sampler is not overfilled with sediment; the sediment surface is intact and relatively level over the entire area of the grab. The jaws must be fully closed and the top of the sediment must be below the level of the opening doors.
* Overlying water is present and not excessively turbid.
* Sediment depth at the center of the sampler is at least 7 cm, indicating that the desired penetration was achieved.

Mild overfill may be acceptable if:

* The sediment surface is intact.
* There is no evidence that the surface sediment has pushed through the grid surface of the grab—i.e., no visible imprint from the screening outside that grid.
* There is no evidence that sediment has pushed out through the hinge or the edges of the grab.

The overall condition of the grab will be documented on the Marine Benthic Field Sheet.

## B6 Instrument/Equipment Testing, Inspection, and Maintenance Requirements

No analytical laboratory instruments are covered by this QAPP; see Laboratory QAPP attached.

## B7 Instruments

No analytical laboratory instruments are covered by this QAPP; see Laboratory QAPP attached.

## B8 Inspection/Acceptance of Supplies and Consumables

Critical supplies for field activities will be the responsibility of the Project Manager.

If unacceptable supplies or consumables are found, the Project Manager will repair or replace measurement equipment and/or replace defective or inappropriate materials, delegating tasks as indicated in the table below.

Table B8.1. Supplies, Acceptance Criteria, and Responsibility for Critical Field Supplies

| Critical Supplies and Consumables | Inspection Requirements  and Acceptance Criteria | Person (Role) Responsible |
| --- | --- | --- |
| Sample bottles for sediment chemistry | Visually inspected upon receipt for cracks, breakage, and cleanliness. Must be accompanied by certificate of analysis. |  |
| Sampling equipment (grabs) | Visually inspected for obvious defects, damage, and contamination. |  |

## B9 Data Acquisition Requirements

Secondary data (historical reports, maps, literature searches, and previously collected analytical data) may be used in the preparation of the sampling plan. These data may come from sources such as:

* Prior reports specific to the area.
* Results of state agency or other studies water quality monitoring data.
* Pertinent data collected by federal agencies, such as USGS bathymetry data and NOAA weather records.
* Surveys completed in the embayment or embayment system of interest, including those identified through MassBays’ Ecosystem Delineation and Assessment (<https://www.mass.gov/service-details/ecosystem-delineation-and-assessment>) and Inventory of Plans and Assessments (<https://www.mass.gov/service-details/massbays-inventory-of-plans-and-assessments>).

Secondary data used will be documented in the Secondary Data Table, attached, according to Sections A9 and C2.

## B10 Data Management

Data quality control steps will be taken at several stages. Documentation of data recording and handling, including all problems and corrective actions, shall be included in all preliminary and final reports. (Corrective Action Reporting form attached.) See Section A9 for recording handling and storage procedures.

### B10.1 Process and Procedures

+++INS `${dataManagementProcess}`+++

### B10.2 Data Handling

+++INS `${dataHandling}`+++

### B10.3 Management Requirements

+++INS `${dataManagementRequirements}`+++

+++END-IF+++

+++END-IF+++

+++IF determine('Saltwater Water Quality', 'Saltwater', '', '') === true+++

# Section B. Marine/Water Quality Data Generation and Acquisition

## B1 Sampling Design

+++IF determineConcern('Eutrophication (Nutrients)') === true || determineConcern('Illicit Connections') === true || determineConcern('Stormwater') === true+++

### B1.1 Sampling Site Selection

Monitoring locations selected are in an area where reasonable opportunity for mixing of the effluent has occurred. Where a mixing zone has been defined in a license for discharge, sampling will be conducted immediately outside of it. In cases where localized effluent impact is expected to be severe for a distance beyond the zone of initial dilution, monitoring locations are upstream of the source, one or more in the plume, and at least two farther downstream.

Monitoring locations have been selected to ensure that the physical characteristics among sampling sites are similar. Reference monitoring locations are minimally impaired, and located in the same ecoregion.

All monitoring locations will be visited prior to monitoring, and a Site Assessment Form completed for each location (sample form attached).

+++END-IF+++

+++IF determineConcern('General Environmental Health: Physical/Chemical Water Quality') === true || determineConcern('Recreation (Swimming and/or Boating)') === true || determineConcern('Harmful Algal Blooms (HABs) (Algal toxins)') === true || determineConcern('General Environmental Health: Benthic') === true+++

### B1.1 Sampling Site Selection

For water quality condition assessment, routine sampling activities consist of collecting samples. Routine sampling will be representative of overall water quality and stays relatively unchanged over time to allow comparison to past and future investigations. Sites will be generally selected at or near locations where there is a longstanding data record.

Monitoring locations have been selected to ensure that the physical characteristics among sampling sites are similar. Reference monitoring locations are minimally impaired, and located in the same ecoregion.

All monitoring locations will be visited prior to monitoring, and a Site Assessment Form completed for each location (sample form attached).

+++END-IF+++

## B2 Sampling Methods: Sample Collection, Processing, and Storage

### B2.1 Sample Collection Methods

Sample types include grab samples and direct measurements using electronic instruments in the field. Water quality parameters that are measured/observed *in situ* as well as indicators to be analyzed in the laboratory are listed in the tables below.

Table B2.1. Marine Field Sampling Summary

| Parameter - Method | Frequency |
| --- | --- |
| +++FOR parameter IN sampleDesign.filter((param) => param.monitoringCategory === 'Saltwater Water Quality') +++ |  |
| +++ **INS $**parameter.sampleParameter+++ | +++ **INS $**parameter.frequency+++ |
| +++END-FOR parameter +++ |  |

Table B2.2. Equipment Preparation, Sample Processing, and Storage Requirements

| Parameter | Sample collection method | Container Type and Preparation | Minimum Sample Quantity | Sample Preservation | Maximum Holding Time |
| --- | --- | --- | --- | --- | --- |
| +++FOR parameter IN parameters.filter((param) => param.monitoringCategory === 'Saltwater Water Quality')+++ |  |  |  |  |  |
| +++ **INS $**parameter.label+++ | +++ **INS $**parameter.sampleCollectionMethod+++ | +++ **INS $**parameter.sampleContainer+++ | +++ **INS $**parameter.sampleVolume+++ | +++ **INS $**parameter.samplePreservation+++ | +++ **INS $**parameter.maxHoldingTime +++ |
| +++END-FOR parameter +++ |  |  |  |  |  |

Prior to sample collection, Sample Labels (including station location, replicate number, and date) will be taped to the outside of sample containers. The labels may be pre-printed and taped on using clear tape or written directly on write-on colored tape or a pre-printed adhesive label. Once the sampling crew is on station and coordinates have been verified, the sampling measuring or collection device will be deployed.

+++IF determine('Saltwater Water Quality', 'Saltwater', 'Conductivity', 'Multi-parameter probe meter') === true || determine('Saltwater Water Quality', 'Saltwater', 'Conductivity', 'Conductivity meter') === true || determine('Saltwater Water Quality', 'Saltwater', 'Dissolved oxygen', 'Multi-parameter probe meter') === true || determine('Saltwater Water Quality', 'Saltwater', 'Dissolved oxygen', 'DO meter') === true || determine('Saltwater Water Quality', 'Saltwater', 'Oxygen saturation', 'Multi-parameter probe meter') === true || determine('Saltwater Water Quality', 'Saltwater', 'Oxygen saturation', 'DO meter') === true || determine('Saltwater Water Quality', 'Saltwater', 'pH', 'Multi-parameter probe meter') === true || determine('Saltwater Water Quality', 'Saltwater', 'pH', 'pH meter') === true || determine('Saltwater Water Quality', 'Saltwater', 'Temperature', 'Multi-parameter probe meter') === true || determine('Saltwater Water Quality', 'Saltwater', 'Temperature', 'Thermometer') === true || determine('Saltwater Water Quality', 'Saltwater', 'Turbidity', 'Multi-parameter probe meter') === true || determine('Saltwater Water Quality', 'Saltwater', 'Turbidity', 'Turbidity meter') === true +++

### B2.2 *In Situ* Water Quality Monitoring

#### Equipment/Instrument Calibration

Prior to field use, the multi-parameter or individual units will be calibrated in accordance with the manufacturer’s instruction manual. If no instructions specific to an instrument are available, the following general calibration methods will be followed.

+++ENDIF+++

## B3 Sample Handling and Custody

The attached SOPs describe handling of samples while in the field, including storage requirements.

Labels with the following information will be attached to sample containers:

* Sample number
* Site ID
* Time and date of collection
* Preservation requirements
* Name of sampler and organization

Samples for shipment will be prepared as follows:

* All samples will be appropriately preserved and packaged for transport.
* If obtainable samples are missing, the Project Manager will determine corrective action (e.g., reschedule a site visit or return to the site that same day to complete collection of the missing samples).
* All samples will be labeled and the labels checked for completeness, legibility, accuracy, and consistency.
* Sample Labels and Survey Log will be reviewed to ensure consistent sample ID information.
* Each sample container will be inspected to make sure there are no leaks and that all containers are properly sealed.

The Field Coordinator will complete the Chain of Custody Form(s) for samples shipped to a laboratory. A copy of each custody form will be made and retained by the team. The original form will be sent in the container with the sample. Copies of all custody forms will be included in the coolers when samples are sent to the laboratory.

## B4 Analytical Methods

Field and laboratory analyses will be conducted according to the methods listed in the table below. This does not apply to *in situ* parameters measured using sensors in the field (i.e., temperature, pH, dissolved oxygen, salinity, and turbidity).

Table B4.1. Approved Analytical Methods

| Parameter - Method | MDL (mg/l unless stated) |
| --- | --- |
| +++FOR parameter IN parameters.filter((param) => param.monitoringCategory === 'Saltwater Water Quality' && param.mdl !== '') +++ |  |
| +++ **INS $**parameter.label+++ | +++ **INS $**parameter.mdl+++ |
| +++END-FOR parameter +++ |  |

## B5 Field Sampling Quality Control

The monitoring project will include appropriate QC samples to assess general data quality issues, as well as specific data quality objectives. Field QC samples will be taken for 10% of all water quality samples taken per sampling event. The table below summarizes Field QA/QC activities:

Table B5.1. Field Quality Assurance/Quality Control Summary

| Location ID | Parameter - Method | Precision Check: Field duplicate frequency | Accuracy Check: Field blank frequency | Precision Check: Lab duplicate frequency | Accuracy Check: Lab blank frequency | Precision Check: Lab spike frequency |
| --- | --- | --- | --- | --- | --- | --- |
| +++FOR parameter IN parameters.filter((param) => param.monitoringCategory === 'Saltwater Water Quality') +++ |  |  |  |  |  |  |
| +++ **INS $**parameter.sampleLocationId+++ | +++ **INS $**parameter.sampleParameter+++ | +++ **INS $**parameter.fieldDuplicates+++ | +++ **INS $**parameter.fieldBlanks+++ | +++ **INS $**parameter.labDuplicates+++ | +++ **INS $**parameter.labBlanks+++ | +++ **INS $**parameter.labSpikes+++ |
| +++END-FOR parameter +++ |  |  |  |  |  |  |

### B5.1 Field Duplicates

Duplicates will be taken side by side and simultaneously. Field duplicates are submitted to the laboratory along with all other samples. Field duplicates will be collected from 10% of the total samples to detect both natural variability in the environment and that cased by field sampling methods.

### B5.2 Quality Control Procedures: Field Operations

Field data quality is addressed, in part, by application and consistent performance of valid procedures documented in the standard operating procedures. Field crews will verify that all sample containers are uncontaminated and intact, and that all sample labels are legible and intact.

Before leaving the field, the crew will:

* Check sample labels to ensure that all written information is complete and legible.
* Place a strip of clear packing tape over the label, covering the label completely.
* Record the sample ID number assigned to the water chemistry sample on the sample collection form.
* Enter a flag code and provide comments on the Field Data Form if there are any problems in collecting the sample or if conditions occur that may affect sample integrity.
* Store the samples on wet ice in a cooler. Keep chlorophyll *a* filters frozen until shipping on wet ice.
* Recheck all forms and labels for completeness and legibility.

+++IF determine('Saltwater Water Quality', 'Saltwater', 'Temperature', 'Multi-parameter probe meter') === true || determine('Saltwater Water Quality', 'Saltwater', 'pH', 'Multi-parameter probe meter') === true || determine('Saltwater Water Quality', 'Saltwater', 'Dissolved oxygen', 'Multi-parameter probe meter') === true || determine('Saltwater Water Quality', 'Saltwater', 'Oxygen saturation', 'Multi-parameter probe meter') === true || determine('Saltwater Water Quality', 'Saltwater', 'Salinity', 'Multi-parameter probe meter') === true || determine('Saltwater Water Quality', 'Saltwater', 'Turbidity', 'Multi-parameter probe meter') === true+++

### B5.3 Field Quality Control: Multi-Parameter Units

For *in situ* measurements, each field instrument (e.g., multi-parameter unit) used by the crews will be calibrated, inspected prior to use, and operated according to manufacturer specifications. For instruments that are factory calibrated and checked, teams shall ensure that factory-certified diagnostics have been completed according to manufacturer specifications (preferably conducted immediately prior to the sampling season). Sensors such as these do not require the daily calibration steps or the weekly diagnostic/QC solution checks; QC for sensors are compiled in the table below.

Table B5.2. Field Quality Control: Summary, Multi-Parameter Unit

| Parameter - Method | Check Description | Frequency | Acceptance Criteria | Corrective Action |
| --- | --- | --- | --- | --- |
| +++FOR parameter IN parameters.filter((param) => param.monitoringCategory === 'Saltwater Water Quality' && param.method === 'Multi-parameter probe meter')+++ |  |  |  |  |
| +++ **INS $**parameter.label+++ | +++ **INS $**parameter.checkDescription+++ | +++ **INS $**parameter.frequency+++ | +++ **INS $**parameter.acceptanceCriteria+++ | +++ **INS $**parameter.correctiveAction+++ |
| +++END-FOR parameter +++ |  |  |  |  |

Table B5.3. Data Validation Quality Control, Multi-Parameter Units

| Check Description | Frequency | Acceptance Criteria | Corrective Actions |
| --- | --- | --- | --- |
| Verify performance of temperature probe using wet ice. | Prior to initial sampling, daily thereafter | Functionality = ±0.50C | See the manufacturer’s directions. |
| Verify depth against markings on cable | Daily | ± 0.2 m | Re-calibrate |
| pH – Internal electronic check if equipped; if not check against Quality Check Solution | At the beginning and end of each day | Alignment with instrument manufacturer’s specifications; or QCS measurement in range | AM: Re-calibrate  PM: Flag day’s data. pH probe may need maintenance. |
| Check DO calibration in field against atmospheric standard | At the beginning and end of each day | ±1.0 mg/l | AM: Re-calibrate  PM: Flag day’s data. Change membrane |
| Conductivity – internal electronic check if equipped; if not check against QCS | At the beginning and end of each day | Alignment with instrument manufacturer’s specifications | AM: Re-calibrate  PM: Flag day’s data. Instrument may need repair. |

+++END-IF+++

+++IF determine('Saltwater Water Quality', 'Saltwater', 'Water transparency (Secchi depth)', '') === true+++

### B5.4 Field Quality Control: Secchi Depth

No field calibration procedures are required for the Secchi disk. QC procedures include designating a specific crew member as the Secchi depth reader, taking all measurements from the shady side of the boat, and not wearing sunglasses or hats when taking Secchi readings.

+++END-IF+++

+++IF determine('Saltwater Water Quality', 'Saltwater', 'Chlorophyll-a', '') === true || determine('Saltwater Water Quality', 'Saltwater', 'Total Kjeldahl nitrogen', '') === true || determine('Saltwater Water Quality', 'Saltwater', 'Total nitrogen', '') === true || determine('Saltwater Water Quality', 'Saltwater', 'Ammonia-N', '') === true || determine('Saltwater Water Quality', 'Saltwater', 'Nitrate-Nitrite-N', '') === true || determine('Saltwater Water Quality', 'Saltwater', 'Total phosphorus', '') === true || determine('Saltwater Water Quality', 'Saltwater', 'Orthophosphate', '') === true+++

### B5.5 Field Quality Control: Chlorophyll *a* and Nutrients

Field data quality is addressed, in part, by application and consistent performance of valid procedures documented in the standard operating procedures. That quality is enhanced by the training and experience of project staff and documentation of sampling activities. Field crews will verify that all sample containers are uncontaminated and intact, and that all sample labels are legible and intact. Before leaving the field, the crews will: check the label to ensure that all written information is complete and legible, place a strip of clear packing tape over the label, record the sample ID number assigned to the sample on the Water Quality Sample Collection Log, provide comments on the Field Data Form if there are any problems in collecting the sample or if conditions occur that may affect sample integrity. Samples will be stored on wet ice in a cooler.

The table below summarizes field QC procedures.

+++IF determine('Saltwater Water Quality', 'Saltwater', 'Chlorophyll-a', '') === true+++

Field data quality is addressed, in part, by application and consistent performance of valid procedures documented in the standard operating procedures. That quality is enhanced by the training and experience of project staff and documentation of sampling activities. Field crews will verify that all sample containers are uncontaminated and intact, and that all Sample Labels are legible and intact. Before leaving the field, the crews will: check the label to ensure that all written information is complete and legible, place a strip of clear packing tape over the label, record the sample ID number assigned to the sample on the Water Quality Sample Collection Log, provide comments on the Field Data Form if there are any problems in collecting the sample or if conditions occur that may affect sample integrity. Samples will be stored on wet ice in a cooler.

Table B5.4. Field Quality Control Activities: Chlorophyll-*a*

| Quality Control Activity | Description and Requirements | Corrective Action |
| --- | --- | --- |
| Chlorophyll-*a* Containers and Preparation | Rinse collection bottles 3x with ambient water before collecting water samples. | Discard sample. Rinse bottle and refill. |
| Holding Time | 24 hours | Qualify samples. |
| Sample Storage | Chl *a* samples are shipped on wet ice. | Qualify sample as suspect. |
| Filtration | Use Whatman 0.7 μm GF/F filter. Filtration pressure should not exceed 3.4 psig to avoid rupture of fragile algal cells.  Rinse sample bottle for dissolved nutrient 3x with 10-20 mL of filtrate before collecting 250 mL of filtrate for analysis. | Discard and refilter. |

+++END-IF+++

+++IF determine('Saltwater Water Quality', 'Saltwater', 'Total Kjeldahl nitrogen', '') === true || determine('Saltwater Water Quality', 'Saltwater', 'Total nitrogen', '') === true || determine('Saltwater Water Quality', 'Saltwater', 'Ammonia-N', '') === true || determine('Saltwater Water Quality', 'Saltwater', 'Nitrate-Nitrite-N', '') === true || determine('Saltwater Water Quality', 'Saltwater', 'Total phosphorus', '') === true || determine('Saltwater Water Quality', 'Saltwater', 'Orthophosphate', '') === true+++

Table B5.5. Sample Field Processing Quality Control Activities: Nutrients

| Quality Control Activity | Description and Requirements | Corrective Action |
| --- | --- | --- |
| Water Chemistry Container and Preparation | Rinse collection bottles 3x with ambient water before collecting water samples. | Discard sample. Rinse bottle and refill. |
| Sample Storage | Store samples in darkness at 4°C.  Ship on wet ice within 24 hours of collection. | Qualify sample as suspect for all analyses. |

+++END-IF+++

Table B5.6. Data Validation Quality Control: Chlorophyll-*a* and Nutrients

| Activity or Procedure | Requirements and Corrective Action |
| --- | --- |
| Range checks, summary statistics, and/or exploratory data analysis | Current reporting errors or qualify as suspect of invalid |
| Review holding times | Qualify value for additional review |
| Review data from QA samples | Determine the impact and possible limitations on overall data usability |

+++END-IF+++

+++IF determine('Saltwater Water Quality', 'Saltwater', 'Enterococci', '') === true+++

### B5.6 Field Quality Control: Enterococci

Quality control activities for enterococci are listed in the following tables.

Table B5.7. Field Quality Control Activities: Enterococci

| Quality Control Activity | Description and Requirements | Corrective Action |
| --- | --- | --- |
| Check integrity of sample containers and labels | Clean, intact containers and labels. | Obtain replacement supplies. |
| Sterility of sample containers | Sample collection bottles and filtering apparatus are sterile and must be unopened prior to sampling. Nitrile gloves must be worn during sampling and filtering. | Discard sample and recollect in the field. |
| Sample Collection | Collect sample at the last transect to minimize holding time before filtering and freezing. | Discard sample and recollect in the field. |
| Sample holding | Sample is held in a cooler on wet ice until filtering. | Discard sample and recollect in the field. |
| Field Processing | Sample is filtered within 6 hours of collection and filters are frozen on dry ice. | Discard sample and recollect in the field. |

Table B5.8. Data Validation Quality Control: Enterococci

| Check Description | Frequency | Acceptance Criteria | Corrective Action |
| --- | --- | --- | --- |
| Duplicate sampling | Duplicate composite samples collected at 10% of sites. | Measurements should be within 10 percent. | Review data for reasonableness; determine if acceptance criteria need to be modified. |

+++END-IF+++

+++IF determine('Saltwater Water Quality', 'Saltwater', 'Microcystins', '') === true+++

### B5.7 Field Quality Control: Microcystins

Quality control activities for microcystins are listed in the following tables.

Table B5.9. Field Quality Control Activities: Microcystins

| QC Activity | Description and Requirements | Corrective Action |
| --- | --- | --- |
| Check integrity of sample containers and labels | Clean, intact containers and labels | Obtain replacement supplies |
| Holding time | Hold sample on wet ice and freeze immediately upon return to base. Keep frozen until shipping | Quality samples |
| Sample storage | Store samples in darkness and frozen (-20C)  Monitor temperature daily | Qualify samples as suspect |

Table B5.10. Data Validation Quality Control: Microcystins

| Activity or Procedure | Requirements and Corrective Action |
| --- | --- |
| Range checks, summary statistics, and/or exploratory data analysis | Current reporting errors or qualify as suspect of invalid |
| Review holding times | Qualify value for additional reviews |
| Review data from QA samples | Determine impact and possible limitations on overall data usability |

+++END-IF+++

## B6 Instrument/Equipment Inspection and Testing

All equipment used to *in situ* parameters or collect samples will undergo periodic maintenance and calibration verification performed by manufacturer’s representatives or service consultants. These procedures will be documented by date and the signature of the person performing the inspection and kept in good repair as per manufacturer’s recommendations to ensure proper function. Records of equipment inspection, maintenance, repair, and replacement will be kept in a logbook, along with standard operating procedures for instrument maintenance and calibration. The following table lists typical procedures to be undertaken.

Table B6.1. Typical Instrument/Equipment Inspection and Testing Procedures

| Equipment | Inspection frequency | Type inspection | Maintenance, Corrective Action |
| --- | --- | --- | --- |
| Nutrient sample bottles | Before each use | Visual for integrity, cleanliness | Acid washed prior to use |
| Filtering apparatus | Before each use | Proper functioning, clean storage | Spare filters, syringe |
| Secchi disk, calibrated line | Before each use | Visual for integrity, cleanliness | Wipe tape. Spare disk, spare line. |
| Meters | Before each use | Battery life, membrane condition | Spare batteries, spare membranes |
| Sampling device | Before each use | Visual for integrity, cleanliness | Repair, replace if necessary |

+++IF determine('Saltwater Water Quality', 'Saltwater', 'Temperature', '') === true || determine('Saltwater Water Quality', 'Saltwater', 'pH', '') === true || determine('Saltwater Water Quality', 'Saltwater', 'Dissolved oxygen', '') === true || determine('Saltwater Water Quality', 'Saltwater', 'Oxygen saturation', '') === true || determine('Saltwater Water Quality', 'Saltwater', 'Salinity', '') === true || determine('Saltwater Water Quality', 'Saltwater', 'Turbidity', '') === true || determine('Saltwater Water Quality', 'Saltwater', 'Water transparency (Secchi depth)', '') === true+++

## B7 Field Equipment Calibration

This section describes how continued quality performance of equipment and instruments is ensured. No analytical laboratory instruments are covered by this QAPP.

### B7.1 Pre-measurement Instrument Checks and Calibration

Field instruments shall be tested and calibrated prior to sampling, and documented on an Instrument Calibration Log (attached). Equipment may be calibrated either prior to departure for the site or at the site. The site location will be verified using a GPS. Field crews will have access to backup instruments if any instruments fail the manufacturer performance tests or calibrations. The dissolved oxygen, pH, temperature and conductivity sensor functions of the multi-parameter or individual sensor units will be calibrated prior to departure to the sample site(s). A single calibration is sufficient for the day.

Table B7.1. Instrument Calibration Procedures

| Parameter - Method | Instrument | Type of Inspection | Inspection and Calibration Frequency | Standard of Calibration Used | Corrective Action |
| --- | --- | --- | --- | --- | --- |
| +++FOR parameter IN parameters.filter((param) => param.monitoringCategory === 'Saltwater Water Quality' && param.method.includes('meter')) +++ |  |  |  |  |  |
| +++ INS $parameter.label+++ | +++ INS $parameter.instrument+++ | +++ INS $parameter.typeOfInspection+++ | +++ INS $parameter.calibrationFrequency+++ | +++ INS $parameter.calibrationStandard+++ | +++ INS $parameter.correctiveAction+++ |
| +++END-FOR parameter +++ |  |  |  |  |  |

### B7.2 Post-Measurement Calibration Check

#### Multi-Parameter Unit

After the *in situ* measurements have been completed for the sampling day, a post-measurement calibration check of the multi-parameter unit will be performed by measuring the pH and conductivity of one of each of the respective calibration standards that were used earlier in the day to calibrate the instrument, and the values recorded. If significant drift is detected (as defined the manufacturer), the sensor may need service; data collected since the last successful calibration and post-measurement calibration check will be flagged. Any sensor that is not functioning properly will not be used.

### B7.3 Instrument/Equipment Inspection, Testing Procedures

Equipment maintenance will be conducted routinely. Records of equipment inspection, maintenance, repair. and replacement will be recorded in a logbook.

+++END-IF+++

## B8 Inspection/Acceptance of Supplies and Consumables

The Field Coordinator will be responsible for ensuring correct sample handling by:

* Ensuring availability of all required sampling supplies in the field.
* Properly labeling all sample containers for biological samples in the field.
* Recording all relevant sampling information on the Sample Log, Field Data Forms, and Chain-of- custody Forms.
* Coordinating the transfer of all samples from the field to laboratories for analysis.

Delegating tasks as indicated in the table below.

Table B8.1. Critical Field Supplies, Acceptance Criteria, and Responsibility for Critical Field Supplies

| Critical Supplies and Consumables | Inspection Requirements  and Acceptance Criteria | Person (Role) Responsible |
| --- | --- | --- |
| Sample containers | Visually inspected for cracks, breakage, and cleanliness. May be reused. |  |
| Multi-parameter units; individual sensors | Functional checks to ensure proper calibration and operating capacity. |  |
| Sampling equipment | Visually inspected for obvious defects, damage, and contamination. |  |

## B9 Data Acquisition Requirements

Secondary data (historical reports, maps, literature searches, and previously collected analytical data) may be used in the preparation of the sampling plan. These data may come from sources such as:

* Prior reports specific to the area.
* Results of state agency or other water quality monitoring data.
* Pertinent data collected by federal agencies, such as USGS bathymetry data and NOAA weather records.
* Surveys completed in the embayment or embayment system of interest, including those identified through MassBays’ Ecosystem Delineation and Assessment (https://www.mass.gov/service-details/ecosystem-delineation-and-assessment) and Inventory of Plans and Assessments (<https://www.mass.gov/service-details/massbays-inventory-of-plans-and-assessments>).

A Secondary Data Table (attached) will be included with the data quality evaluation package.

## B10 Data Management

Data quality control steps will be taken at several stages. Documentation of data recording and handling, including all problems and corrective actions, shall be included in all preliminary and final reports. (Corrective Action Reporting Form attached.) See Section A9 for recording handling and storage procedures.

### B10.1 Process and Procedures

+++INS `${dataManagementProcess}`+++

### B10.2 Data Handling

+++INS `${dataHandling}`+++

### B10.3 Management Requirements

+++INS `${dataManagementRequirements}`+++

+++END-IF+++

# Section C. Assessment and Oversight

## C1 Assessment and Response Actions

This section identifies the number, frequency, and type of planned assessment activities that will be performed to ensure implementation of this QAPP. These activities will be overseen by the Project Manager.

### C1.1 Assessments

#### Field Sampling Readiness Review

A field survey plan will reference the specific field activities to be conducted and lists of equipment provided.

#### Field Sampling Internal Audit

The Project Manager in coordination with the Field Coordinator will be responsible for periodic internal audits to verify that field sampling procedures and measurements are properly followed. The internal field audit checklist will include examination of the following:

* Field sampling records
* Sample collection, handling, and packaging procedures
* Adherence to the SOPs and this QAPP
* QA procedures
* Chain of custody
* Sample documentation

Results of internal field audits will be documented in QA reports to the Project Manager (Section C2).

#### Laboratory Audits

System audits are performed as described in each laboratory’s QA manual for internal auditing. Laboratory audits may be conducted by the contracted laboratory’s QA/QC Manager at the project start up and then periodically as part of its analytical monitoring program. The laboratory audit checklist will review the following:

* QA organization and procedures
* Personnel training and qualifications
* Sample log-in procedures
* Sample storage facilities
* Analyst technique
* Adherence to laboratory SOPs and this QAPP
* Compliance with QA/QC objectives
* Instrument calibration and maintenance
* Facility security
* Waste management
* Data recording, reduction, review, reports, and archival
* Cleanliness and housekeeping

Preliminary results of the systems audit will be discussed with the laboratory management staff. A written report that summarizes audit findings and recommends corrective actions as relevant will be prepared and submitted to the Laboratory Director for response and to the Project Manager. The results of the audit, including resolution of any deficiencies, will be included in the QA reports, as described in Section C2.

+++IF determine('Saltwater Benthic', 'Saltwater', 'Infauna', 'Sediment grab samples') === true+++

#### Performance Evaluation Sample Assessment

Proficiency testing for infaunal taxonomic analyses is accomplished through regular communication and inter-calibration of infaunal samples among taxonomists.

+++END-IF+++

#### Data Audits

Data will be audited under the direction of the QA Manager as part of the data validation process (Section D1). Raw data will be reviewed for completeness and proper documentation. Errors noted in the data audits will be communicated to analyses and laboratory management and corrected data will be verified. Audits of the data collection procedures at contracted laboratory will be the responsibilities of the laboratories. Each laboratory is fully responsible for the verification and validation of the data it submits. Data must be submitted in QAPP-prescribed formats only. While work is in progress, the contracted laboratory’s QA Manager or his/her designee will conduct an inspection to evaluate the laboratory data-production process. All data must be reviewed by the contracted laboratories’ QA Manager or designee prior to submission to the Project Manager.

### C1.2 Assessment Findings and Corrective Action Responses

All technical personnel share responsibilities for identifying and resolving problems encountered in the routine performance of their duties. Issues that affect the schedule, cost, or performance of project tasks will be reported to the Project Manager. The Project Manager will be accountable for overall implementation of the Project. The Project Manager will be responsible for identifying and resolving problems that (1) have not been addressed in a timely manner or successfully at a lower level, (2) influence multiple components of the projects, or (3) require consultation with contracted laboratories. The Project Manager will be responsible for evaluation of the overall impact of the problem on the project and for developing and implementing corrective actions. The Project Manager will also identify and resolve problems that may necessitate changes to this QAPP. Problems identified by the Field Coordinator and the QA Manager will be reported to the Project Manager and corrected as described in Section C2.

The QA Manager will generate and/or review all corrective actions required during the project and monitor their effectiveness in meeting project quality objectives. Corrective action is the process of identifying, recommending, approving, and implementing measures to counter unacceptable procedures or out-of-limit QC performance that can affect data quality. Corrective action can occur during field activities, laboratory analyses, data validation and assessment. All corrective action proposed and implemented should be documented in the QA reports to the Project Manager. A copy of the QA/QC Corrective Action Log (template attached) will be provided as described in Section C2.

#### Field Corrective Action

Corrective action in the field may be needed when the sample frequency is changed (i.e., more/fewer samples, sample locations other than those specified in the Study Plan), or when sampling procedures and/or field analytical procedures require modification due to unexpected conditions. The survey crew may identify the need for corrective action. The Project Manager and QA Manager will approve the corrective measure and ensure that the survey crew implements the corrective action.

Corrective action resulting from internal field audits will be implemented immediately if data may be adversely affected due to unapproved or improper use of approved methods. A corrective action issue which directly impacts the project DQOs will be reported to the Project Manager. Corrective action will be documented in QA reports to project management (Section C2). Corrective actions will be implemented and documented as follows:

* A description of the circumstances that initiated the corrective action
* The action taken in response
* The final resolution
* Any necessary approvals
* Effectiveness of corrective action

#### Laboratory Corrective Action

Corrective action in the laboratory is specified in laboratory SOPs and may occur prior to, during, and after initial analyses. Following consultation with laboratory analysts and supervisory personnel, it may be necessary for the QA Manager to approve the implementation of corrective action. If the problem makes it impossible to achieve project objectives, the laboratory manager will be notified, who will in turn notify the Project Manager.

Corrective actions will be performed prior to release of the data from the contracted laboratory. The corrective action will be documented in both the laboratory’s corrective action files, and in the data report generated by the laboratory. If the corrective action does not rectify the situation, the laboratory will contact the Project Manager, who will determine the action to be taken.

#### Corrective Action during Data Validation and Data Assessment

The need for corrective action may be identified during either data validation or data assessment. Potential types of corrective action may include re-sampling by the survey crew or reanalysis of samples by the laboratory. These actions are dependent upon the ability to mobilize the survey crew and whether the data to be collected are necessary to meet the required QA objectives. If the data validator or data assessor identifies a corrective action situation that impacts the achievement of the project objectives, the Project Manager will be notified.

## C2 Reports

Data that have passed preliminary QC analysis (Section B5) will be uploaded to WQX and shared with interested audience. Any data uploaded or released will be accompanied by the caveat that they are for review purposes only and subject to correction after completion of a full data review at the end of the sampling season.

The Project Manager will prepare a final report which will be shared with the QAPP distribution list. The final report will include tables and graphs developed for initial data distribution efforts and will describe the program goals, methods, quality control results, data interpretation, and recommendations and include:

* Raw data
* QC data
* Secondary data used
* Associated metadata
* Questionable data flagged
* Preliminary or final report
* Other reports or supporting documentation deemed relevant by the Project Manager

# Section D. Data Review and Usability

## D1 Data Review and Validation

A review protocol is developed to ensure that data validation and verification is conducted in an objective and consistent manner. The review will include the required number, frequency and types of assessments (peer reviews, management systems reviews, technical systems audits, performance evaluations, and data quality reviews), and names of staff responsible for this task.

#### Field Data

The field data verification includes verification of sampling design, sample collection procedures, and sample handling. Field data will be reviewed regularly by the Data Manager to ensure that the records are complete, accurate, and legible and to verify that the sampling procedures are in accordance with the protocols specified in the QAPP (refer to Section D2.1 for the specific elements reviewed).

#### Laboratory Data

Prior to the release of any data from a contracted laboratory, the data will be reviewed and approved by laboratory personnel. The review will consist of a tiered approach (Section D2.2) that will include reviews by the person performing the work, by a qualified peer, and by supervisory and/or QA personnel.

#### Data Management

The review process will include verification of manually entered data and QC checks run in a software application prior to submitting the data to WQX. Detailed descriptions of these processes are included in Sections B10 and D2.

## D2 Verification and Valuation Methods

Data verification methods will ensure that the reported results reflect what was actually done and document that the data fulfill applicable requirements. Validation will further identify and evaluate the impact of any technical non-compliance or quality control non-conformance on the complete data set.

#### Field Data

Field records will be reviewed by the Project Manager to ensure that:

* Logbooks and standardized forms have been filled out completely and that the information recorded accurately reflects the activities that were performed.
* Records are legible and in accordance with good recordkeeping practices, i.e., entries are signed and dated, data are not obliterated, changes are initialed, dated, and explained.
* Equipment calibration, sample collection, handling, preservation, storage, and shipping procedures were conducted in accordance with the protocols described in this QAPP, and that any deviations were documented and approved.
* DQIs are calculated and results compared with DQOs for review by the QA Manager; and data compares well to historic data or checking its “reasonableness.”

#### Laboratory Data

As a part of data validation, contracted laboratories will ensure that:

* The QC checks specified in Sections A7 and B5 were conducted and met the acceptance criteria.
* All data that are hand-entered (i.e., typed) will be 100% validated prior to use in calculations or submission to the Project Manager.
* All manual calculations will be performed by a second staff member to verify that calculations are accurate and appropriate.
* Calculations performed by software will be independently verified at a frequency sufficient to ensure that the formulas are correct, appropriate, and consistent, and that calculations are accurately reported.

Once data have been generated and compiled in the laboratory, laboratory personnel will review the data to identify and make professional judgments about any suspicious values. All suspect data will be flagged and reported. These data may not be used in calculations or data summaries without the review and approval of the appropriate senior staff. No data measurements will be eliminated from the reported data or database and data gaps will never be filled with other existing data. The loss of any samples during shipment or analysis will be noted in the database.

#### Data Management

Laboratory data will be reviewed by the Data Manager prior to the electronic submission to WQX. Data review may include methods such as plots, logical checks, and range checks to identify suspect values. Routine system back-ups are performed daily. Data provided electronically to facilitate data handling will be verified against the hard copy data. Detailed description of data management and review is provided in section B10 of this QAPP.

#### Project Deliverables

Upon completion of the verification/validation process, a dataset packet will be prepared for submittal to WQX. The data will be in the format prescribed for submission to WQX. This documentation will include the following elements (see Section A9):

* Cover letter that includes a description of any problems.
* List of problems encountered, and corrective action taken.
* List of samples/images planned versus collected, or measurements planned versus reported.
* Quality Assurance Statement including a checklist of QA actions, and notes on deviations and corrective actions.
* Table(s) of data submitted.

## D3 Reconciliation with User Requirements

This section describes how the verified/validated project data will reconcile with the project DQOs, how data quality issues will be addressed, and how limitations on the use of the data will be reported and handled. To meet these DQOs, a combination of qualitative evaluations and statistical procedures will be used to check the quality of the data. These procedures will be used by the laboratory generating the data, and by the Project Manager or a designee.

The data generated must meet the project DQOs defined in Section A7 of this QAPP. The primary objectives for assessing the usability of the data are to ensure that (1) data denote conditions and habitat quality in the area being studied, (2) all datasets are complete and defensible, and (3) data are of the quality needed to meet the overall objectives of the program.

### D3.1 Comparison to Measurement Criteria

#### Accuracy and Precision Assessment

The accuracy and precision of the data generated during this project will be assessed by comparison to the DQOs specified in Table A7.2. Comparison of laboratory control samples will provide accuracy assessments. Relative Percent Difference (RPD) between duplicates will represent precision, and is defined by the following equation:

*where*

RPD = Relative Percent Difference (as %)

|X1 -X2|= Absolute value (always positive) of X1 – X2

X1 = Original sample concentration

X2 = Duplicate sample concentration

Data that fail to meet the data quality criteria may necessitate sample reprocessing, analysis of archival material, sample recollection, or flagging of the data, depending on the magnitude of the nonconformance, logistical constraints, schedule, and cost.

#### Representativeness Assessment

Representativeness of the field data will be assessed by verifying that the sampling program was implemented as proposed and that proper sampling techniques were used. The assessment of representativeness in the laboratory will consist of verifying that the proper analytical procedures and appropriate methods were used.

#### Completeness Assessment

Completeness is the ratio of the number of valid sample results to the total number of results planned for collection. The overall completeness goal for the monitoring program is 80% of planned samples to be collected and analyzed. The Project Manager will assess the completeness of the overall data generation against the project goals. Following completion of the sampling, analysis, and data review, the percent completeness will be calculated and compared to the project objectives stated in Table A7 using the following equation:

*where*

%C = Completeness (as %)

N = Number of usable results

T = Targeted number of samples planned to be collected

If the goal is not met, data gaps will require evaluation to determine the effect on the intended use of the data. Sample re-analysis, analysis of archived material, and/or re-collection of the sample may be appropriate depending on criticalness of the missing data, logistical constraints, cost, and schedule.

### D3.2 Overall Assessment of Environmental Data

Data assessment will involve an evaluation to determine if the data collected are of the appropriate quality, quantity, and representativeness for the purposes required by project as well as for submission to WQX. This evaluation will be performed by the Program Manager in concert with other users of the data. Data generated in association with QC results that meet these objectives will be considered usable. Data that do not meet the objectives and/or the data validation criteria might still be usable. This assessment may require various statistical procedures to establish outliers, correlations between data sets, adequate sampling location coverage, etc., in order to assess the effect of qualification or rejection of data. The effect of the qualification of data or loss of data deemed unacceptable for use, for whatever reason, will be discussed and decisions made on corrective action for potential data gaps.

1. EPA (U.S. Environmental Protection Agency), 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Peryphyton, Benthic Macroinvertebrates, and Fish. Section Edition. EPA-841-B-99-02. 344 pp. https://www.epa.gov/sites/production/files/2019-02/documents/rapid-bioassessment-streams-rivers-1999.pdf [↑](#footnote-ref-2)
2. CRWA (Charles River Watershed Association), 2017. Macroinvertebrate Water Quality Monitoring: Field Guide for Citizen Scientists. 22 pp. [↑](#footnote-ref-3)
3. NH DEP (New Hampshire Department of Environmental Protection), 2017. Habitat assessment. https://www.des.nh.gov/organization/divisions/water/wmb/biomonitoring/habitat.htm [↑](#footnote-ref-4)
4. Maine Department of Environmental Protection. 2014*, Protocols for Decontaminating Biomonitoring Sampling Equipment*. DEPLW-0919A-2014 https://www.maine.gov/dep/water/monitoring/biomonitoring/materials/sop\_dea\_decontamination.pdf [↑](#footnote-ref-5)
5. Kahn, L. 1988. Determination of Total Organic Carbon in Sediment (Lloyd Kahn Method). Edison, New Jersey: U.S. Environmental Protection Agency, Region II, Environmental Services Division, Monitoring Management Branch. 4 pp. www.nj.gov/dep/srp/guidance/rs/lloydkahn.pdf [↑](#footnote-ref-6)
6. Folk, R.L., 1974. Petrology of Sedimentary Rocks. Austin, TX: Hemphill Publishing Company. 184 pp. https://repositories.lib.utexas.edu/handle/2152/22930 [↑](#footnote-ref-7)
7. FGDC (Federal Geographic Data Committee), 2012. Coastal and Marine Ecological Classification Standard. June 2012. FGDC-STD-018-2012. 343 pp. https://www.fgdc.gov/standards/projects/cmecs-folder/CMECS\_Version\_06-2012\_FINAL.pdf/view [↑](#footnote-ref-8)
8. Sweeny, M. and D.A. Rutecki, 2019 (in review). Laboratory Standard Operating Procedures for Massachusetts Department of Environmental Protection’s Massachusetts Estuaries Project: Benthic Monitoring. [↑](#footnote-ref-9)
9. Kahn, L. 1988. Determination of Total Organic Carbon in Sediment (Lloyd Kahn Method). Edison, New Jersey: U.S. Environmental Protection Agency, Region II, Environmental Services Division, Monitoring Management Branch. 4 pp. www.nj.gov/dep/srp/guidance/rs/lloydkahn.pdf [↑](#footnote-ref-10)
10. Folk, R.L., 1974. Petrology of Sedimentary Rocks. Austin, TX: Hemphill Publishing Company. 184 pp. https://repositories.lib.utexas.edu/handle/2152/22930 [↑](#footnote-ref-11)
11. FGDC (Federal Geographic Data Committee), 2012. Coastal and Marine Ecological Classification Standard. June 2012. FGDC-STD-018-2012. 343 pp. https://www.fgdc.gov/standards/projects/cmecs-folder/CMECS\_Version\_06-2012\_FINAL.pdf/view [↑](#footnote-ref-12)
12. Sweeny, M. and D.A. Rutecki, 2019 (in review). Laboratory Standard Operating Procedures for Massachusetts Department of Environmental Protection’s Massachusetts Estuaries Project: Benthic Monitoring. [↑](#footnote-ref-13)
13. Folk, R.L., 1974. Petrology of Sedimentary Rocks. Austin, TX: Hemphill Publishing Company. 184 pp. https://repositories.lib.utexas.edu/handle/2152/22930 [↑](#footnote-ref-14)
14. FGDC (Federal Geographic Data Committee), 2012. Coastal and Marine Ecological Classification Standard. June 2012. FGDC-STD-018-2012. 343 pp. https://www.fgdc.gov/standards/projects/cmecs-folder/CMECS\_Version\_06-2012\_FINAL.pdf/view [↑](#footnote-ref-15)
15. Sweeny, M. and D.A. Rutecki, 2019 (in review). Laboratory Standard Operating Procedures for Massachusetts Department of Environmental Protection’s Massachusetts Estuaries Project: Benthic Monitoring. [↑](#footnote-ref-16)
16. Kahn, L. 1988. Determination of Total Organic Carbon in Sediment (Lloyd Kahn Method). Edison, New Jersey: U.S. Environmental Protection Agency, Region II, Environmental Services Division, Monitoring Management Branch. 4 pp. www.nj.gov/dep/srp/guidance/rs/lloydkahn.pdf [↑](#footnote-ref-17)