Casco Bay Estuary Partnership Programmatic QAPP

Prepared by: Casco Bay Estuary Partnership

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List of Acronyms

CBEP - Casco Bay Estuary Partnership
DQI – Data quality indicators
DQO – Data quality objective
EI – Environmental information
EIO – Environmental information operations
EPA – Environmental Protection Agency
NERRS - National Estuarine Research Reserve System
NHCP - New Hampshire Coastal Program
NHDES - New Hampshire Department of Environmental Services
NOAA - National Oceanic and Atmospheric Administration
PARCCS – Precision, accuracy, representativeness, comparability, completeness, sensitivity
PO – Project Officer
QA – Quality assurance
QAM – Quality assurance manager
QAPP – Quality Assurance Project Plan
QC – Quality control
RPD – Relative percent difference
RSD – Relative standard deviation
rSET - Rod sediment elevation tables
RTK GPS - Real time kinematic GPS
SHARP - Saltmarsh Habitat and Avian Research Program
SAP - Sampling and Analysis Plan
SOP – Standard Operating Procedure
USGS - United States Geological Survey

A. Project Management and Data Quality Objectives

1. Project Organization, Personnel, and Training

Casco Bay Estuary Partnership is a collaborative partnership that works with local and state government, non-governmental organizations, non-profits, and academic institutions around Maine to protect and preserve Casco Bay. This involves long-term monitoring of a number of important ecological indicators, and periodic data collection for numerous other projects as the needs arise.

Dr. Curtis Bohlen is the Executive Director of CBEP and will serve as the project director. Bohlen will review and approve SAPs and QA/QC protocols and will support data archiving, processing, and analysis. Bohlen also leads annual vegetation monitoring.

Matt Craig is the Habitat Program Manager for CBEP and the project manager for marsh restoration monitoring. He develops marsh monitoring protocols and SAPs, coordinates with other partners, carries out monitoring activities, and manages data, reporting, and staff for all marsh work.

Dr. Janelle Goeke is the Staff Scientist for CBEP and the project manager for eelgrass, water quality, and ecological health monitoring. She develops monitoring protocols for internal and external use, coordinates with partners to ensure monitoring follows established protocols, carries out monitoring activities, develops SAPs, and manages data, reporting, and staff for all eelgrass work. She is also responsible for annual QAPP amendments and review.

Natalie Bingham is the Program Coordinator for CBEP and is the Quality Assurance Manager. She is responsible for ensuring compliance with the QAPP and overseeing data QA/QC procedures. She is independent from the project managers and reports directly to the project director.

Lauren Tisdale, EPA Project Officer for CBEP coordinates QAPP review and approval between the QA Manager and EPA.

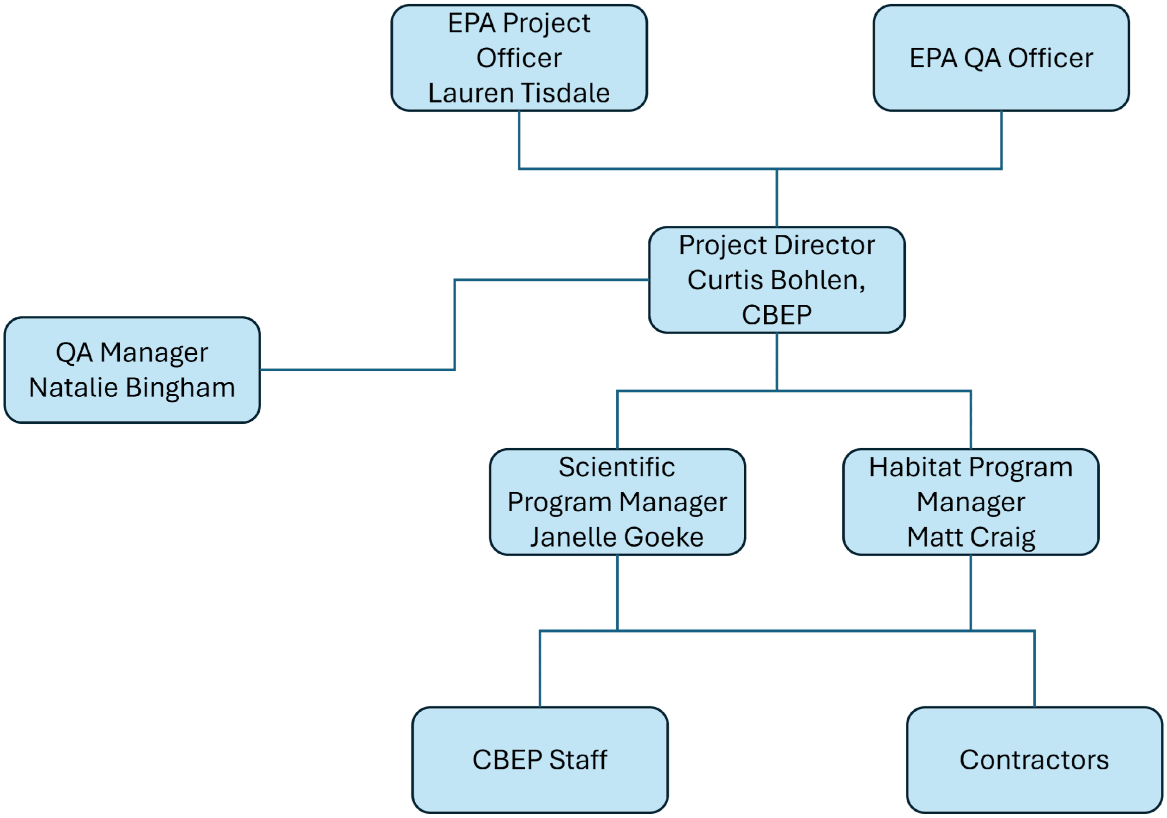


Figure 1: Program organizational workflow

Other organizations that CBEP frequently partners with may carry out projects under this QAPP and its contained SOPs if CBEP lacks the capacity to do so. At the start of any project occurring under this QAPP, the QAPP and all appendices will be distributed to project partners. CBEP or a partner organization will develop an SAP following the template in this QAPP (**Appendix A**) and submit the SAP and any required additional documentation to EPA prior to commencing any project activities under this QAPP. This does not apply to Rapid Assessments, which are carried out following Rapid Assessment SOPs (**Appendices B - D**) without prior submission of an SAP.

Additional information on project partners and contact information will be provided in SAPs, but a list of common partners and contact information is included below.

Table 1: Frequent partners of CBEP who may submit SAPs under this QAPP.

Organization	Description	Contact Information
Friends of Casco Bay	Marine water quality monitoring, water quality monitoring of eelgrass beds	Mike Doan, Staff Scientist mdoan@cascobay.org
Presumpscot Regional Land Trust	Presumpscot river water quality monitoring	Toby Jacobs, Program Manager

Maine Coast Heritage Trust	Tidal marsh monitoring and restoration	Tatia Bauer, Marsh Restoration Program Manager
Trout Unlimited	Stream barrier monitoring and restoration	Lauren Pickford, Maine Project Manager
Ducks Unlimited	Tidal marsh monitoring and restoration	Bri Benvenuti, Regional Biologist
Bowdoin College	Water quality monitoring in eelgrass beds and eelgrass restoration	Jaret Reblin, Bowdoin SCSC Associate Director for Science jreblin@bowdoin.edu
Kennebec Estuary Land Trust	Tidal marsh monitoring and restoration	Ruth Indrick, Project Director rindrick@kennebecestuary.org
Collaborative for Bioregional Action Learning and Transformation	Eelgrass phenology monitoring and restoration	Glenn Page, Executive Director gpage@sustainametrix.com
Manomet	Green crab monitoring, for eelgrass projects and other goals	Marissa McMahan, Senior Director of Fisheries mmcmahan@manomet.org
University of Maine Marine Water Quality Laboratory	Lab at the Darling Marine Center that is accredited by the State of Maine for nutrient analyses (Kjedahl total nitrogen, nitrates, and total phosphorus) and chlorophyll-a analysis. Specific lab protocols will be included with the SAP for any project using their services and they and will adhere to all quality assurance requirements found in this QAPP.	Kathleen Thornton, MWQL Research Scientist kthornton@maine.edu

No specialized certifications are required for the majority of the data collection operations carried out or supported by CBEP. The exception is drone flights to collect aerial imagery, which require a valid pilot's license. CBEP does not maintain a drone or use drones for data collection directly, but partner organizations may. For projects that require drone use, the partner organization will provide proof of a valid pilot's license or a plan to obtain one to CBEP during the project planning stage.

CBEP program managers are experienced in all other data collection protocols frequently employed and will be responsible for training field staff and project partners as needed. Matt Craig has over 20 years of experience in habitat mapping, restoration, and monitoring, with expertise in tidal marshes and freshwater streams and is responsible for oversight of tidal marsh projects. Janelle Goeke has 10 years of experience in scientific study design, environmental monitoring, and program and data management, with an expertise in coastal ecology and plants and is responsible for oversight of eelgrass and water quality projects. Program managers are responsible for providing training to or confirming knowledge of any organizations or staff that will be collecting data under their programs. The QA manager is responsible for ensuring program managers are carrying out trainings as necessary.

3. Project Purpose, Problem Definition, and Background

As one of 28 National Estuary Programs under Section 320 of the Clean Water Act, Casco Bay Estuary Partnership is broadly tasked to protect and preserve the health of Casco Bay in a way that serves both the environment and the local communities. The Casco Bay watershed contains just over 3% of the land in Maine, but almost 25% of the population, housed in 42 different communities. Habitats in Casco Bay include upper watershed forests and mountains, intertidal marshes and rocky landscapes, coastal bluffs, and eelgrass meadows. Our work encompasses water as it flows from the region's 191 lakes, through five major rivers and numerous smaller streams, out into inner Casco Bay, and past the bay's 785 islands, islets, and ledges on its way to the open ocean.

In order to preserve the health of these water resources and the benefits they provide, CBEP carries out various monitoring and restoration activities to establish the baseline condition of local systems, watch for threats, and address threats as they are identified to protect the benefits these systems provide. This involves collecting environmental information on a huge variety of potential stressors (e.g., sea level rise, flow restrictions, water quality impairments, warming temperatures, etc.), and monitoring for metrics of ecosystem health (e.g., plant cover, faunal use, sediment characteristics, water quality, etc.). The basis for these activities is outlined in CBEP's Comprehensive Conservation and Management Plan (CBEP 2024), but details of these activities and locations where they occur shifts frequently, and often with little warning, in order to address emerging threats in the watershed.

The majority of monitoring and restoration activities currently being carried out by CBEP serves one of three purposes: 1) assessing general site conditions, 2) pre- and post-restoration monitoring to evaluate restoration success, or 3) long-term monitoring to detect ecosystem trends. These activities are carried out on different time scales and for different reasons. Assessments of general site conditions are done in locations where no data has been collected within the last 3 years but there is an interest in understanding the site conditions, usually to evaluate the site for potential involvement in restoration or another project, or in response to an emerging threat or stressor. These assessments frequently need to be done with little warning as a project starts moving forward, at request of a partner, or in response to an environmental threat, so CBEP maintains standard protocols that can be used to quickly evaluate site conditions. Pre- and post- restoration monitoring is done in association with specific restoration projects carried out by CBEP or partners. Monitoring may occur at nearby reference sites in addition to the restoration sites and will occur over multiple years (typically from 1 - 3 years pre-restoration to 3 - 5 years post-restoration) but will typically have a planned project end date from the start. Long-term monitoring is carried out at selected sites of interest to monitor system trends over time. These sites are typically those where CBEP or partners have been collecting data annually for > 5 years or are beginning data collection with no planned end date.

The majority of monitoring and restoration carried out by CBEP occurs in tidal marshes, eelgrass beds, or freshwater streams. This focus is due to a combination of factors including the areas of expertise held by CBEP staff, needs and restoration priorities in the watershed, and the threats facing these systems. CBEP will also support general water quality monitoring and assessment of water bodies throughout the watershed.

There is overlap in some of the methods used across these systems, while other methods are habitat specific. The purpose of this QAPP is to provide a description of approaches CBEP and partners use to collect environmental data to monitor the activities and habitats described above. These include methods for site visits that are not a part of larger projects ("rapid assessments"; any site visit that has no intended follow-up), in-depth site characterization, and short-term and long-term monitoring for restoration evaluation or trend detection. The intention is to enable rapid assessments to be conducted as needed by ensuring they follow the SOPs and the Rapid Assessment protocols laid out in this QAPP (**Appendices B - D**). If, as a result of a rapid assessment or other decisions, a need for more extensive data collection over multiple site visits is identified, then a Sampling and Analysis Plan (SAP) will be developed. SAPs will also draw on methods in the SOPs included as appendices to this QAPP (**Appendices E - T**), but will provide additional information on the need for data collection at a site, sampling site locations, SOPs to be implemented in a project, sampling frequency, lab analysis protocols, quality control procedures, and more for a given project. SAPs will follow the templates laid out in **Appendix A** of this QAPP, and will be written on an as needed basis as project needs are identified. If the work outlined in an SAP has no pre-planned end date and is expected to continue for five years or more, then it is considered "long-term monitoring" and will be added to the long-term monitoring list in the QAPP during the next annual update. Existing long-term monitoring sites overseen by CBEP are included in this QAPP with a full description of the work that occurs at each site.

This QAPP will be amended on an annual basis, at which time methods will be updated to meet current best practices, any new data collection methods CBEP is considering will be added, and new long-term monitoring projects will be added and ones that have concluded will be removed.

4. Project Task Description and Schedule

Data collection by CBEP and partners under this QAPP will take the form of a rapid assessment, a project with a specified term, or long-term monitoring. Rapid assessments are done with limited advance planning as they are flexible by design to meet the changing needs of the watershed and the partnership. They occur in a single site visit, collect limited qualitative data, can be done quickly, and while the exact nature of the data collected is dependent on site characteristics and needs, the assessment will draw on a set of standardized protocols detailed in the Rapid Assessment SOPs (**Appendices B - D**). Projects with specified terms may be initiated as the result of a rapid assessment or triggered by other actions (e.g., obtaining a grant, community or partner interest). Many dimensions of the project, including the timeline and schedule, will be highly project specific, so each of these projects will require development of an SAP prior to the start of project tasks. This SAP will provide project-specific information, but will still draw upon the approved standardized methods laid out in the SOPs included with this QAPP (**Appendices E - T**). SAPs will be developed following the SAP template in **Appendix A.** Long-term monitoring is data collection that extends past its intended end date or has no set end date when it begins and is intended to capture information on trends in the Casco Bay watershed. Data collection for these programs will once again follow the SOPs included with the QAPP and schedule will be dependent on project goals, but generally involve collecting data on an annual basis.

4.1 Generalized Work Summaries and Products

Rapid assessment of sites is done to collect data sufficient to qualitatively evaluate the condition of the site and the ecological and engineering feasibility/necessity of restoration, project involvement, or long-term monitoring. They may also be done to provide basic information on the condition of a habitat, sometimes at the request of a partner to provide technical assistance. Rapid assessment of water quality in a water body involves a one-time collection of a suite of basic parameters to gain a broad idea of the condition of a water body and potential threats to water quality. The SOP and cover sheet used for water quality rapid assessments are included in **Appendices D and U**. In marsh sites, rapid assessments may include collection of data on marsh hydroperiod, surface water salinity, anthropogenic structures, vegetation, and marsh surface elevation. The SOP and cover sheet used for tidal marsh rapid assessments is included in **Appendices B and U**. In eelgrass beds, rapid assessments include collection of data on eelgrass condition, including density, fouling, and canopy height, and potential disturbances including water quality and light. The SOP and cover sheet used for eelgrass bed rapid assessments is included in **Appendices C and U**. Rapid assessment methods are intended to be flexible, inexpensive, and fast, and will produce mostly qualitative information. All collected information will be maintained in site-specific databases by CBEP in case the need arises for additional data collection. A formal SAP will be produced if CBEP decides to pursue additional data collection.

Water quality data may be collected in any water body in the Casco Bay watershed. Most commonly, it is collected in tidal marshes, eelgrass beds, freshwater streams, and tidal mudflats. Water quality data collection follows standardized protocols, but differs in the parameters collected between freshwater, brackish, and marine environments. Freshwater parameters measured include temperature, dissolved oxygen (DO), conductivity, depth, pH, nutrients, chlorophyll a, and chlorides. Saltwater/brackish parameters measured include temperature, salinity, depth, pH, total alkalinity (TA), nutrients, chlorophyll a, and light. Data are generally analyzed to produce summary statistics and may be shared in CBEP's Annual Report. Additional data analysis may be done as required by project goals.

Continuous water quality may sometimes be collected through short-term (< 1 month) or seasonal logger deployments. Data collected by these loggers may include water temperature, water level, salinity or conductivity, turbidity, chlorophyll a, and dissolved oxygen. Continuous loggers are typically deployed in locations where they will be continuously submerged, meaning streams, lakes, or coastal areas (including eelgrass beds), and not intertidal areas such as marshes and mudflats. Continuous data collection in eelgrass meadows may also include light. Data are generally analyzed to produce summary statistics and may be shared in CBEP's Annual Report. Additional data analysis may be done as required by project goals.

Marsh geomorphology and channel morphology are assessed through longitudinal channel profiles and monumented cross sections. Monumented cross sections measure changes in the width, geometry, and volume of a stream or tidal channel while longitudinal channel profiles measure changes in the depth of a channel. The combination of these factors allow assessment of site hydrology, geomorphological impacts of tidal restrictions, and monitoring of hydrology restoration. Data are generally analyzed to produce channel profiles and assess the impacts of channel features. Results may be shared in CBEP's Annual Report. Additional data analysis may be done as required by project goals.

RTK GPS and a Total Station are both highly adaptable surveying tools that can be used to measure high-precision elevation data. CBEP typically employs these tools in geomorphological surveys of tidal marshes or in surveys of stream or tidal barriers. Protocols for using both tools can vary greatly depending on equipment manufacturer, whether or not benchmarks have been established at a site, and site geomorphology, so SOPs for these methods are complex and involved. Which tool is used depends on site characteristics, as RTK GPS requires a satellite connection and cell signal in order to accurately mark points. CBEP owns a Leica TS-07 Total Station, but does not own an RTK GPS. RTK GPS are owned and frequently used by partner organizations, and may be lent to CBEP. RTK GPS and Total Station both primarily produce digital data, such as recordings of coordinates and elevations, which are output from the tools into site-specific databases and used to inform other data collection at the site. If a site is being monitored over multiple years, elevation data may be analyzed separately to detect elevation changes. Results may be shared in CBEP's Annual Report. Additional data analysis may be done as required by project goals.

Sediment dynamics, particularly accretion, can be informed by use of RTK GPS and Total Stations, but are also measured through deployment of feldspar marker horizons and sediment traps. Feldspar marker horizons and sediment traps provide information on the balance of accretion and erosion at a site by allowing direct measurement of sediment build up. Data are generally analyzed to produce summary statistics and may be shared in CBEP's Annual Report. Additional data analysis may be done as required by project goals.

Sediment grain size can impart important information about water energy at a site, sediment mobility, and site history. Sediment grain size is most commonly assessed in stream sites using field surveys and can help assess the need for or potential impacts of restoration or barrier removal at a site. Data are analyzed to produce summary statistics and may be shared in CBEP's Annual Report. Additional data analysis may be done as required by project goals.

Hydrology data are collected by CBEP staff and partners to understand the resilience of marsh habitats, detect impacts of tidal restrictions, and determine the success of marsh restoration projects. Surface water hydrology is assessed through measurements of surface water levels and salinity and analysis of marsh surface microtopography that can lead to areas of subsidence. Groundwater hydrology data collection requires the installation of sealed groundwater wells, but collects similar information as surface assessments otherwise. Data are generally analyzed to produce summary statistics and may be shared in CBEP's Annual Report. Additional data analysis may be done as required by project goals.

Porewater salinity data are collected to monitor soil salinity, which is a driver of salt marsh plant community composition and can offer insight into tidal influence on a site. Porewater salinity is measured in monitoring wells that are established in a marsh area at the beginning of a project. Data are generally analyzed to produce summary statistics and may be shared in CBEP's Annual Report. Additional data analysis may be done as required by project goals.

Photo Stations are a qualitative method to investigate changes in a site over seasons or multiple years. They require photographs to be taken from identified locations in consistent ways to produce a visual record of the site. Photographs will be kept in a site-specific database and will be carefully labeled and kept with associated metadata to track locations and dates on which photographs were taken. Qualitative observations from photo stations may be shared in CBEP's Annual Report.

Vegetation monitoring may be done as part of long-term monitoring in tidal marshes. Vegetation data provides information on site environmental conditions and can be used to track ecological changes in a site in response to restoration or a disturbance. Permanent transects with set locations for monitoring will be established as part of the first monitoring visit. Vegetation data collected in tidal marshes includes species presence, percent cover, and height. Periodically, aerial imagery from drones or satellites may be used to supplement on the ground or in the water measurements of plant cover. Any aerial imagery used will be appropriately ground truthed. Data are generally analyzed to produce summary statistics and community composition information and may be shared in CBEP's Annual Report. Additional data analysis may be done as required by project goals.

Surveys for Plant Species of Concern (PSC) are done to detect the presence and extent of non-native/invasive plants, salt tolerant or intolerant species, or monotypic plant stands. The locations and extent of these plants can serve as important indicators of site condition and disturbance. Results are largely qualitative and include sketch maps. The area of monotypic stands may be calculated from GPS data. Maps or summary statistics may be shared in CBEP's Annual Report. Additional data analysis may be done as required by project goals.

Surveys of eelgrass beds collect data including percent cover of eelgrass and macroalgae, density of eelgrass shoots, shoot height, and shoot reproductive status. This data is all collected in underwater non-destructive surveys. This data provides information on bed conditions and can help understand the impact of potential stressors on an eelgrass bed. Data are generally analyzed to produce summary statistics and may be shared in CBEP's Annual Report. Additional data analysis may be done as required by project goals.

Eelgrass biomass is measured by collecting field samples and bringing them to a lab to measure dry shoot biomass. This provides additional information on bed condition and stressor impacts, and can provide data on the fouling load of a bed through assessment of epiphyte weights. Data are generally analyzed to produce summary statistics and community composition information and may be shared in CBEP's Annual Report. Additional data analysis may be done as required by project goals.

Eelgrass reproduction and phenology is assessed through repeated site visits over the course of a season to track flower and seed development. Knowledge on reproductive output and the timing of flowering and seeding is important for identifying potential seed sources for reproduction and comparing reproduction of eelgrass in Casco Bay with that from other areas. Data are generally analyzed to produce seasonal time series of reproduction at each site and may be shared in CBEP's Annual Report. Additional data analysis may be done as required by project goals.

Populations of crabs species of interest (green crabs, *Carcinus maenas* and blue crabs, *Callinectes sapidus*) are monitored through deployment of crab traps in habitats throughout Casco Bay from April - November. The crab traps are left in place for 1 day in subtidal eelgrass habitats and 1 week in marsh habitats. The traps used are non-specific and facilitate capture of most larger (carapace width >1 inch) crab species, including both target species. All crabs are counted, sexed, and released following capture. Trapping results are generally analyzed to produce summary statistics and may be shared in CBEP's Annual Report. Additional data analysis may be done as required by project goals.

Nekton monitoring in salt marshes is done to assess use of tidal creeks and marsh pools by different faunal species. This information is important for understanding impacts of restoration on a site, and nekton monitoring is typically performed pre- and post-restoration. Nekton are surveyed through active netting methods, species and size of captured individuals is recorded, then all individuals are released. CBEP does not currently lead nekton monitoring, but may assist partners. Data are generally analyzed to produce summary statistics and community composition information and may be shared in CBEP's Annual Report. Additional data analysis may be done as required by project goals.

Fish monitoring is done to understand the impact of stream blockages on migratory fish. Monitoring is done through observational counts of fish at stream restrictions or fish passage structures. Monitoring is largely conducted by volunteers associated with partner networks, such as the River Herring Network, but may occasionally be conducted by CBEP staff. Data are generally analyzed to produce summary statistics and may be shared in CBEP's Annual Report. Additional data analysis may be done as required by project goals.

CBEP partners interested in saltmarsh restoration often include consideration of saltmarsh sparrow habitat potential, site use, or populations following protocols from SHARP. The SHARP database of SOPs and data sheets can be accessed online. Partners may follow individual SHARP protocols for sparrow habitat assessment, capture, banding, and body condition assessment. CBEP does not perform these surveys directly. Any data obtained by partners may be reported to CBEP and analyzed to produce summary statistics and may be shared in CBEP's Annual Report. Additional data analysis may be done as required by project goals.

Unmanned aerial vehicles (UAVs), or drones, are used to collect aerial imagery of sites. This aerial imagery can provide important information on ratios of unvegetated to vegetated land cover for marshes, bed area and % cover for eelgrass beds, and general site information for all habitats. CBEP does not own a drone or collect aerial imagery directly, but works with partner organizations that do. Partner organizations with drones are responsible for collecting, processing, and analysis of imagery. CBEP may share results in CBEP's Annual Report. Additional data analysis may be done as required by project goals.

Data from monitoring activities will be analyzed and summarized every five years as part of CBEP's "State of the Bay" report as appropriate. In between reports, data may be presented at regional and national conferences and published on CBEP's website or as part of their annual reports. Annual reports are shared with Management Committee members and the general public to and serve as a way to update interested parties on CBEP's monitoring and restoration efforts over the past year. The "State of the Bay" reports produced by CBEP every five years are shared broadly with partners and are well-regarded as a source of high-quality, trustworthy data, and we aim to continue to meet those standards.

4.2 Schedule

Rapid Assessments can occur at any time of year. Project-specific timelines will be detailed in project SAPs or in the description of long-term monitoring projects in section ***B.1.3*** below. Timeline for general QAPP upkeep and revision is detailed in **Table 2**

Table 2: QAPP annual schedule

Activity	Anticipated Time Frame	Result
QAPP Amendment and SAP Preparation	January – March each year	QAPP and SAPs
Field work	April – October each year	Data recorded on data sheets and in electronic files, samples collected and placed in long-term storage or sent to labs for analysis
Data Quality Audit	November – January each year	QA/QC checked data from previous field season and summary of any QAPP discrepancies from the past year.
Annual report production	December - January each year	Annual report on select CBEP activities from the previous year, to be shared with Management Committee and community members, containing high quality result from recent impactful projects.
Data analysis and report preparation for State of the Bay Report	Ongoing, finalized once every five years	State of the Bay report

4.3 Study Areas

CBEP is conducting long-term monitoring at the sites listed in **Table 3** below.

Table 3: Long-term monitoring site information

Study Site	Monitoring Goal	Latitude	Longitude	Monitoring Start Year
Long Marsh	Track ongoing ecosystem response to flow restoration	43.84014	-69.9194	2013

5. Data Quality Objectives

Projects carried out under this QAPP will aim to collect data of sufficient quality to meet their goals of characterizing the physical and ecological conditions of the sites being monitored, assessed, or restored. Rapid assessments aim to collect data that is primarily qualitative, so have very broad data quality objectives that aim to identify the presence/absence of features or conditions at a site. Focused projects and long-term monitoring aim to collect data of sufficient quality to detect statistically significant changes in site conditions, either as a result of restoration or trajectories of change in response to stressors. The quality of data needed to achieve these goals is dependent on individual site and project characteristics, but all projects will strive to meet the data quality indicators outlined in **Table 4**, which outlines the most stringent data quality indicators that may be needed to meet project objectives. All data will be collected according to established protocols that account for representativeness, precision, bias, accuracy, and comparability.

Comparability: All protocols relating to collection of a given type of data are shared and standardized amongst partners that commonly collect data of the sort to ensure comparability. Equipment may differ between partners, but careful equipment checks, cross-equipment comparisons, and careful standardization of methods allows comparability across data collected by different instruments.

Representativeness of samples will be guaranteed through careful sampling site selection that guarantees samples capture the spatial and temporal variability present in the habitat. For sites undergoing long-term monitoring, samples will be collected from the same location at each sampling event, unless required otherwise by the SOP. Representativeness of samples for each monitoring project can be assessed through the SAP.

Bias in samples will be minimized by careful training of staff and maintenance of equipment by CBEP Program Managers. All new staff will be trained on protocols by the appropriate program managers. For data collection dependent on observation (e.g., vegetation cover, water depth, species identification) or individual judgment (e.g., sensor placement or sample collection location), all individuals participating in data collection will attend a monitoring event with the program lead annually to check for consistency and minimize bias across observers. Equipment will be calibrated at or above the frequency recommended by the manufacturer. Pre and post-calibration comparisons will identify any instrument bias or drift over long deployments, and any identified bias will be corrected.

Precision and accuracy will strive to meet the DQIs outlined in **Table 4**. Precision and accuracy will be assessed through collection of field or lab duplicates as appropriate, and careful calibration of equipment. Necessary frequency of duplicate collection and equipment calibration vary between protocols and between equipment types. For protocols that require duplicate collection or equipment calibration, the necessary frequency is detailed in SOPs. For SOPs where the frequency of duplicate collection or equipment calibration is variable based on project goals, these frequencies will be detailed in project SAPs.

Completeness and sensitivity will be verified through checks of collected data to ensure no data is missing without a valid reason (such as field equipment failure) and that data is recorded to the correct level of detail (e.g., correct number of decimal places) to allow the necessary analyses to take place.

Table 4: Data quality indicators

Group	Parameter	Precision	Accuracy	Completeness	Sensitivity
Water Quality	Temperature	± 0.5 °C	± 0.2 °C	90%	0.1 °C
	Dissolved oxygen	± 0.2 mg/L or 20%	± 0.2 mg/L	90%	0.1 mg/L
	Dissolved oxygen saturation	± 2%	± 5%	90%	0.1%
	Water depth	± 2 cm	± 5 %	90%	0.5 cm
	Salinity by logger Salinity by refractometer	± 20% 1 ‰	± 3% < 3,000 µS/cm ± 5% > 3,000 µS/cm ± 1 ‰	90% 90%	1 µS/cm 1 ‰
	Chlorophyll	± 25%	75-125% for QC std	90%	0.1 µg/L
	Light (PAR sensor) Light (lux sensor)	± 25% ± 25%	R^2 of PAR - depth correlation >0.95 ± 10%	80% 80%	4 µA/ 1,000 µmol s^1 m^2 Dependent on light brightness
	Flow*	± 25%	± 1% of measured value	90%	0.1 cm/sec
	Total Alkalinity	± 0.1 µM/kg	± 0.1 µM/kg	90%	0.1 µM/kg
	pH	± 0.1 pH or <10%	± 0.3 pH	90%	0.01 pH
	Turbidity	± 0.5 NTU if less than 1 NTU or ± 20% if more than 1 NTU	90 - 110% recovery of turbidity std	90%	0.01 NTU
	Conductivity	± 5%	± 1% of range	90%	1 uS/cm

Water Quality (Lab)	Nutrients (Total Nitrogen, Total Kjedahl Nitrogen, Nitrate, Nitrite, Total Phosphorus, Orthophosphate)	± 30%	85% - 115% recovery	90%	Nutrient specific (1-10 ppb)
	Bacteria (*E. coli, Enterococcus*, Fecal Coliform)	Lab blank must result in 0/100mL	± 30% (for log10 transformed duplicate data)	90%	1/100 mL
Eelgrass	Vegetation % cover	± 5% cover	± 10% of actual cover	90%	± 1%
	Eelgrass metrics Shoot Density Shoot Height	± 25%	± 10%	90%	1 shoot 0.05 m
	Eelgrass Phenology	NA	NA	100%	NA
Tidal marshes	Longitudinal chanel profile	± 3 mm	± 3 cm vertical, ± 7.5 cm horizontal	100%	1 mm
	Monumented channel cross section	± 3 mm	± 3 cm vertical, ± 7.5 cm horizontal	100%	1 mm
	Surface and ground water level	± 0.02 ft	± 0.02 ft	90%	0.005 ft
	Marsh surface elevation; built structures	± 3 mm	± 3 cm vertical, ± 7.5 cm horizontal	100%	1 mm
	Vegetation % Cover	± 5%	± 10% of actual cover	90%	1%
	Vertical sediment accretion - marker horizon	± 1 mm	± 5 mm	100%	1 mm
	Sediment deposition - sediment trap	± .1 g	± 1 g	100%	0.01 g
	Sediment Grain Size	NA	NA	100%	NA

Fauna	Nekton species surveys	± 2%	± 5% total count	95%	1 individual
	Crabs (blue/green)	NA	Exact count	90%	1 individual
	Avian species	NA	Exact count	90%	1 individual

* Listed DQOs are for flow calculated from direct measurement of water movement. Flow may also be calculated through post-processing of time series photos in which case only the completeness DQI is applicable.

6. Documentation and Records Management

In order to ensure production of high-quality data for projects carried out or overseen by CBEP, CBEP will maintain this QAPP and all associated Standard Operating Procedures (SOPs) and Sampling and Analysis Plans (SAPs). This QAPP includes SOPs for commonly used methods in the appendices (**Appendices B - T**). The QAPP and all SOPs will be approved by EPA and revised on an annual basis. SAPs do not have to be pre-approved by EPA as long as they use only SOPs that have been approved as part of the QAPP, but will be submitted to EPA prior to project start. For any project where data collection will span multiple years, the SAP will be included in the QAPP as an appendix at the next revision and location of the project site will be included in study area maps in section A.4.3. If data collection is planned to occur over 5 years or more, then the site will be included in the long-term monitoring sites listed in the QAPP and shown on the associated maps and site details and protocols will be included in the QAPP under section B.1.3.

The QAPP and all appendices, including SOPs and SAPs for sites where long term data collection is occurring, will be revised by CBEP and submitted to EPA for approval on an annual basis. CBEP will maintain the QAPP and all produced data sheets and sample records. The CBEP Staff Scientist will be responsible for maintaining the QAPP and providing copies of the QAPP and any updates to project personnel, with oversight from the CBEP QA Manager. CBEP Program Managers will be responsible for maintaining data sheets and records from their programs.

<u>Field Data Sheets</u>
Blank field data sheets are included in **Appendix U**. Paper data sheets are filled out in the field then returned to the Program Manager. Data is digitized (typically as Excel Spreadsheets), and digital copies of files are saved to CBEPs external hard drive, with regular backup. All paper data sheets are given to the CBEP QA Officer for storage.

<u>Laboratory Data</u>
Samples sent to external laboratories for analysis will be accompanied by clear documentation of sample provenance and a chain of custody form (**Appendix V**). Sample analysis results are generally returned to CBEP in digital data sheets via email then saved to project-specific folders. All laboratory results will be maintained by both CBEP and the analyzing labs.

<u>Electronic Data</u>

Some types of data, such as direct downloads from continuous data loggers, may exist only as electronic records. These electronic records will be saved and stored in the same way as digitized paper records, and version control will be implemented to track any changes to the records. The original records will be saved and backed up in a separate location than any working versions to ensure there will always be a copy of the original data.

Archiving

Relevant SAPs and SOPs will be maintained electronically and on paper for five years following the conclusion of a project. Any additional field notebooks or paper-only records will also be maintained by five years. All data sheets, electronic data records, laboratory results, or other project data will be stored indefinitely on paper and electronically, as appropriate. All paper records will be maintained by the CBEP QA Officer. All electronic records will be uploaded to the CBEP external hard drive, which is maintained and regularly backed up by the University of Southern Maine.

B. Environmental Information Operations

1. Sampling Design and Rationale

Monitoring activities carried out by CBEP are intended to assess and monitor the conditions of ecosystems in the Casco Bay watershed. This allows CBEP to stay aware of habitat conditions, note new threats and disturbances, and evaluate the need for restoration.

1.1 Rapid Assessments

Rapid assessments may be done on water bodies (lakes, rivers, and estuaries), tidal marshes, and eelgrass beds anywhere within the Casco Bay watershed following a standard set of methods and protocols outlined in **Appendices B - D**. The exact methods from the standard set of protocols used at a given site will be tailored to fit site conditions and disturbances, but the types of data collected will be identified on the rapid assessment cover sheet, which will be included with any collected data or notes. General areas of monitoring within a site may be selected in advance based on desktop assessments or pre-visit collection of site data. Specific monitoring locations within sites are chosen in the field based on site observations and are selected based on a number of factors including safe access, representativeness, historical data collection, and proximity to points of interest or disturbances, such as tidal restrictions or heavily trafficked areas.

1.1.1 Water Quality Rapid Assessment Protocols

Rapid assessment of water quality in a water body will occur as a one-time sampling event to evaluate the suite of water quality parameters that may be of interest at a site or establish a baseline data reading for a potential site of interest. These may include temperature, salinity, conductivity, depth, dissolved oxygen, turbidity, light, pH, total nitrogen, chlorophyll, and flow. Selection of sampling parameters will depend on freshwater vs. saltwater, suspected disturbances, and importance of the water body for humans and other organisms. One data reading or sample will be collected from each selected monitoring location at each site, except where a duplicate sample is needed to comply with quality assurance guidelines outlined in the Discrete Water Sampling SOP (**Appendix E**). A rapid assessment of water quality cover sheet (included in **Appendix U**) should be filled out for any rapid assessment that is done and all collected data should be attached.

1.1.2 Tidal Marsh Rapid Assessment Protocols

Methods employed in rapid assessment of tidal marsh sites include qualitative surveys to inspect for indicators of altered hydrology, photo documentation of the site, and collection of baseline environmental data. Baseline environmental data may include some or all of the following: elevation, porewater salinity, hydrology, and channel morphology. As part of the rapid assessment, a desktop assessment may be done using publicly available geospatial data, such as that available from the State of Maine GIS database and Google Earth. Geospatial data considered as part of a desktop assessment may include some or all of the following: wetland status, parcel information, adjacent land use, visual indicators of human use or tidal barriers, presence of infrastructure including utilities and houses. One sample/data point will be collected from each selected monitoring station at each site, except where a duplicate sample is needed to comply with quality assurance guidelines. A rapid assessment of marsh sites cover sheet (included in **Appendix U**) should be filled out for any rapid assessment that is done and all collected data should be attached.

1.1.3 Eelgrass Rapid Assessment Protocols

Methods employed in rapid assessment of eelgrass beds include qualitative surveys to evaluate eelgrass coverage and bed extent, which may be conducted by snorkeling, diving, or boating, photo documentation of the site, and collection of baseline environmental data. Parameters collected as baseline environmental data include some or all of the following: light (PAR) measurements, temperature, salinity, dissolved oxygen, turbidity, pH, chlorophyll, and water depth. One sample will be collected from each pre-selected monitoring station at each site, except where a duplicate sample is needed to comply with quality assurance guidelines. A rapid assessment of eelgrass sites cover sheet (included in **Appendix U**) should be filled out for any rapid assessment that is done and all collected data should be attached.

If rapid assessments indicate that additional data collection at a site would be beneficial, then a Site Analysis Plan will be developed. This SAP will draw upon the standard SOPs included in the appendices here and will detail the SOPs to be used at a site and how they will be implemented, including sample collection frequency, types of samples to be collected, quality control samples, and precise sampling locations. All SAPs will be developed following the template in **Appendix A**.

1.2 SAPs

SAPs will be developed for projects where 1) CBEP or partners determine additional data collection is needed on the basis of a rapid assessment, 2) CBEP or partners receive a grant to carry out a project at a specific site or sites, or 3) the need for a specific project is identified through other pathways. The reasons for this additional data collection, how this decision was reached, and how the protocols to use for the site were selected will all be detailed in the introduction to the SAP. SAPs will contain project sampling details, including specific sampling locations within a site, how protocols will be implemented, partners involved with sample and data collection, how collected data and samples will be handled and analyzed, lab where samples will be sent and protocols that will be followed, and QC targets. SAPs will be reviewed and approved by CBEP Program

Managers and QA Managers then will be submitted to EPA Region 1 prior to any project activities taking place. All submitted SAPs will be included as appendices to this QAPP during the next annual revision.

1.3 Long Term Monitoring

Long-term monitoring sites listed in **Table 3** are those CBEP has a vested interest in monitoring and intends to collect data in for the foreseeable future. Monitoring of sites is dependent on funding and capacity, so may not happen every year, but will follow the same protocol whenever it does occur. Sampling locations within these sites are detailed in **Section 4.3**. Handheld GPS units are used to navigate to the sampling points in each site during each visit, and the presence of landmarks and previously established markers is used to find the precise sampling location. If a precise sampling location cannot be found during a visit (e.g., natural landmarks have changed, placed markers have disappeared), then field staff will use the handheld GPS, photos from past visits, and their site knowledge to get as close as possible to the previous site and will establish a new marker.

1.3.1 Long-Term Water Quality Monitoring

CBEP does not currently engage in long-term water quality monitoring of any water bodies.

1.3.2 Long-Term Eelgrass Monitoring

CBEP does not currently engage in long-term monitoring of any eelgrass beds.

1.3.3 Long-Term Marsh Monitoring

CBEP has been participating in long-term monitoring of select marsh sites since around 2010. Work at these sites was previously described under a project-specific QAPP.

The design of long-term marsh monitoring is structured around sampling at key locations around the marsh, which CBEP calls "Stations." Stations are established to monitor certain parameters, usually channel cross section, vegetation characteristics, and pore water salinity. The number of Stations on a site will vary to suit site-specific conditions, especially the size and complexity of the site. As few as three stations (lower marsh, mid marsh, and head of tide) may be established on small sites with little spatial heterogeneity. A more typical site monitoring plan will include ten Stations, which strikes a balance between sampling spatial variability and keeping the workload reasonable. Vegetation sampling at ten Stations typically can be completed over two days in the field, while it is possible (although sometimes difficult, depending on site geometry) to visit 10 stations to collect pore water salinity data over a single tide.

Where a formal Project Area has been specified (as is typical for restoration projects), Stations (with the exception of reference Stations) will be drawn from within that area. Supplemental Stations may be added outside of the Project Area to help characterize system-wide response. Where no Project Area has been designated, Stations will be located within an area extending from head of tide to the valley mouth.

For restoration sites, a reference area will be established in an area not directly influenced by the restoration activity. The reference Stations will be located within the contiguous marsh system if practicable. If no contiguous marsh area exists downstream, a reference area and one or more reference Stations will be established in a nearby wetland. For tidal restoration projects, the reference area may consist only of one or more reference Stations downstream (to seaward) of the tidal restoration site.

Selection of locations for sampling Stations is based on spatially structured random sampling. The majority of Casco Bay's tidal wetland area is located in tidal wetland complexes that form in drowned glacial valleys or post-glacial erosion features carved into Presumpscot Formation silt-clay deposits. These geomorphological contexts impose strong longitudinal and lateral gradients in physical and biological environment within Casco Bay tidal wetlands. CBEP's approach to sampling couples the advantages of random sampling with sufficient structure to ensure that we sample across both longitudinal and lateral gradients.

To identify station locations, CBEP will utilize Generalized Random Tessellation Stratified (GRTS) Sampling (Kincaid and Olsen 2016), or a comparable randomized spatial sampling tool. GRTS software facilitates drawing of probability-based samples based on location. Given specific geographic locations to sample (e.g., a marsh area, or a channel network), a GRTS sample can be drawn so that all locations within a study area have well-defined (in the case of simple random sampling, equal) probability of being sampled and yet guarantee that sample points are distributed throughout possible sampling locations.

In tidal wetlands with a strong upstream-downstream gradient and a central channel (like most of Casco Bay's larger wetlands), Stations are selected as a spatially balanced sample of points distributed along a line drawn down the length of the tidal valley. Data collected at each station characterizes the wetland along a cross section from channel to upland.

An area-based random sample is not used because it would locate Stations proportional to area, thus concentrating them where the wetland is widest, typically at the downstream end of the marsh. A sample drawn on a linear support distributes samples more evenly along the longitudinal gradient from valley mouth to head of tide.

Once a location along the valley axis is identified using GRTS, if a central channel is present, the Station is established on one side of the channel. Where possible, the side is selected at random. However, practical considerations may prevent randomization. For example, the channel may meander close to the upland, leaving insufficient area to set up a monitoring station on one side, or one side of the channel may be inaccessible.

In tidal wetlands without a clear longitudinal axis (e.g., fringing marshes), Stations are established following a similar logic, using spatial random sampling to locate anchor points for sampling stations.

CBEP currently carries out long-term monitoring of one tidal marsh at Long Marsh.

1.3.3.1 Long Marsh

Table 5: Protocols followed for monitoring of Long Marsh

Habitat type	Site names	Protocols followed	Sampling frequency
Tidal Marsh	Long Marsh	Marsh Vegetation SOP (**Appendix N**)	Once every other year

		Monumented Cross Section (**Appendix G**)	in summer at low tide
		Longitudinal Channel Profiles (**Appendix H**)	
		Plants Species of Concern (**Appendix O**)	
		Photo Stations (**Appendix M**)	

CBEP conducts long-term monitoring at Long Marsh every other summer to measure ongoing ecosystem changes in response to flow restoration. Monitoring of the site began in 2013 and currently has no planned end date. The original goal of monitoring was to document the changes in the marsh following a culvert replacement project that resulted in increased salt water delivery to the marsh. CBEP collected data pre- and post-culvert replacement, and now continues to monitor the site to observe continuing changes. The SOPs used at this site are those that monitor aspects of the system likely to be experiencing continuing long-term change in response to the increased tidal exchange, namely vegetation community and tidal creek morphology. Previous years of the project monitored porewater salinity and erosion as well, but these sampling methods have been dropped from the long-term monitoring plan.

Sampling locations are based around 12 stations, which were selected following the procedure described above. Stations 1 - 10 are shown in **Figure 2.** Stations 11 and 12 were added to the sampling design later and are not shown on the figure, but are located at the coordinates in **Table 6.** Monumented cross sections, vegetation transects, and photo stations are located at each of the 12 stations. These sampling features were established as described in their associated SOPs, and are monitored using standard methods with no deviations from the SOP. A longitudinal channel profile is measured from station 1 to 3. The longitudinal channel profile was established and is monitored following the methods described in the SOP. Plant species of concern are documented through meander surveys in the marsh, following the procedures outlined in the SOP, and have no set start or end location. Two species of concern, *Phragmites australis* and *Lythrum salicaria* have previously been identified at Long Marsh. Monumented cross sections, longitudinal channel profiles, marsh vegetation, plant species of concern, and photo stations are all monitored every other year during the same sampling event. Sampling events typically take 2 - 3 days to complete, and occur over a period of days with mid-day low tides to maximize site access. Only field data observations are conducted as part of this monitoring, so no samples are collected and no laboratory analyses are done.

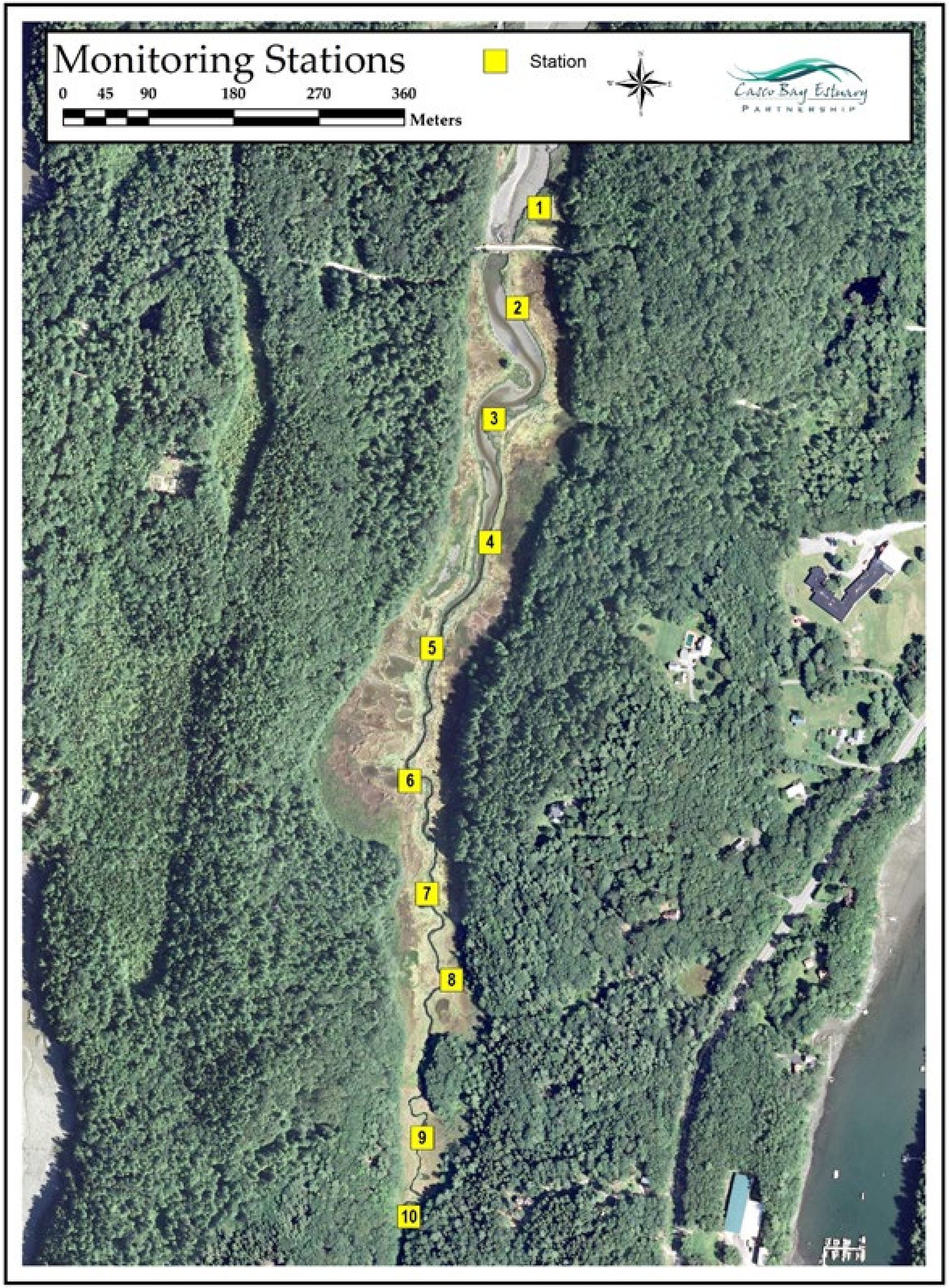
Table 6: Long Marsh additional station coordinates

Station #	Latitude	Longitude
11	43.829233	-69.921448
12	43.826921	-69.922271

The field observation nature of data collection means there is no purpose of collecting field or lab duplicates of data. Lack of bias and cross-year precision are ensured by careful training and supervision of field technicians by the Program Manager. If there is doubt in a measurement collected by a field technician, the Program Manager will take a repeat measurement, and if there is a difference between the two, will mark the field technician gathered data as questionable.

Past monitoring results for Long Marsh were reported on to Maine Department of Transportation, who carried out the culvert replacement, but their monitoring of the site has concluded. CBEP does not currently report on the results of monitoring at this site on a regular basis. Results are shared with partners as requested, and may be included in annual reports or the State of the Bay reports as appropriate.

Figure 2: Locations of Stations 1 – 10 at Long Marsh


Monitoring Stations
Station
0 45 90 180 270 360
Meters
Casco Bay Estuary
PARTNERSHIP
1
2
3
4
5
6
7
8
9
10

2. Methods

Methods are detailed in the SOPs appended to this QAPP (**Appendices B - T**). All methods were developed or adapted by CBEP except for those listed in **Appendix T**, which are protocols CBEP follows that are developed and maintained by external organizations.

SOPs include information on recommended sampling containers and volumes. Further details, including spatial and temporal resolution of collected data will be provided in SAPs.

The Quality Assurance Manager will be responsible for ensuring project actions comply with all relevant SOPs. If a lack of compliance is noticed during sampling activities or the annual QA Review, the Quality Assurance Manager will note them and talk to the appropriate Program Manager about corrective actions. Corrective actions include retraining in sampling techniques or data handling practices, or if there are repeated quality assurance concerns with an individual's work, they may be switched off the project.

3. Integrity of Environmental Information

Program Managers will be responsible for tracking sampling handling and chain of custody for their programs. Each sample will have a unique identifier, and the data sheets associated with each sample will be used to track chain of custody including date of collection, date of shipment/transport, date of reception, date of analysis, and the parties responsible for each action for all samples that are not internally processed

Details on sample handling are included in the SOPs related to collection of those samples. In general, samples that must remain cold are placed in coolers immediately following collection, and samples that need to be frozen are placed in a freezer within 8 hours of collection. Samples will stay cold/frozen (as appropriate) until they are analyzed by CBEP or delivered to an external laboratory. Samples that require fixation/preservation through other methods will be fixed/preserved in the field immediately following collection, as described in the sampling SOPs. Collection and storage of internally analyzed samples will be noted on field data sheets. Samples delivered for external analysis will be tracked with chain of custody forms.

Additional information on sample preservation methods, holding times, and analytical methods for lab samples will be provided in SAPs for specific projects, as they may vary based on lab protocols.

4. Quality Control

CBEP follows a general protocol of collecting/analyzing quality control samples for 10% of all samples where appropriate. However, many of the SOPs followed by CBEP rely heavily on field observations or direct counts, where duplicate samples are not necessary. Duplicate samples are primarily collected for water quality and hydrology monitoring. Additional details on the collection of QC samples for these protocols can be found in the associated SOPs (Water Quality: **Appendices E and F**, Hydrology: **Appendix K**) and QC specifics for individual projects will be provided in project SAPs.

5. Equipment/Instrument Calibration, Testing, Inspection, and Maintenance

All data collection and sampling equipment will be inspected and tested at least annually to ensure it is in proper working order before commencement of annual data collection. Procedures for annual inspection, testing, and calibration will follow manufacturer's recommendations. Manuals and calibration requirements for commonly used equipment are detailed in SOPs. Equipment requiring periodic servicing, recalibration or adjustment by the manufacturer will be checked at least annually to determine whether servicing is needed.

All equipment and instruments will be inspected for damage and signs of excess wear before each use or deployment. Problems will be corrected before deployment or use. If problems can not be resolved, equipment shall not be placed into service.

All sample collection and data collection equipment will be maintained and calibrated according to the manufacturer's recommendations. Details of maintenance and calibration procedures will be described in the SOPs. Deviations from calibration and maintenance protocols described in the SOPs, if needed, will be described in an SAP.

6. Environmental Information Management

The primary products of a rapid field assessment are the raw field notes themselves, improved staff understanding of site conditions, and a completed rapid assessment data sheet of the appropriate type. Rapid assessment data will be largely qualitative and consist of yes/no or presence/absence questions. CBEP staff may prepare a narrative site description, summarizing observations and preliminary interpretations to share with partners. If data analysis occurs, it emphasizes graphical methods and mapping to facilitate understanding of site conditions.

Any decisions made on the basis of a rapid assessment (need for future activities or need to develop an SAP) will be listed in the conclusions section of the rapid assessment cover sheet. The site introduction section of any developed SAP will include information on why a site was selected from the rapid assessment or other sources, and why the chosen protocols are being used.

A variety of recording methods are used across the SOPs appended to this QAPP, including use of a field notebook, data sheets, camera, voice recorder, electronic data entry platforms (such as Survey 123) or loose-leaf paper on a clipboard. All primary field records are dated, transcribed if necessary, and archived. Electronic records, including photographs, are stored in a site-specific electronic folder on CBEP computers or servers.

Program Managers will be responsible for maintaining data sheets and records from their programs. All field notebooks and paper-only records will also be maintained for five years. All data sheets, electronic data records, laboratory results, or other project data will be stored indefinitely on paper and electronically, as appropriate. All paper records will be maintained by CBEP. All electronic records will be uploaded to the CBEP external hard drive, which is maintained and regularly backed up by the University of Southern Maine.

Protocol specific data management and analysis approaches are detailed in the SOPs appended to this QAPP.

7. Inspection/Acceptance of Supplies and Services

All supplies such as sampling materials and calibration solutions shall be inspected upon receipt by the appropriate Program Manager to ensure they were not damaged during shipping. If materials received match the invoice and appear to be intact, they will be accepted for use. If there is evidence of damage to exterior packaging, the contents of the shipment shall be inspected to determine if the damage affects useability, including the need to avoid contamination. Damaged supplies will not be used.

C. Assessment, Response Actions, and Oversight

1. Assessments, Oversight, and Response Actions

Program Managers track project status and progress. The Program Manager for a project will hold an annual training/refresher at the beginning of each field season to review the protocols to be implemented in the coming season. Program Managers review field data as it comes in to assess consistency with protocols. Field assessments are conducted monthly during the field season to ensure continued protocol compliance. The Program Manager will notify the field crew of assessment findings and instruct field crews of any changes that need to be made in practices to comply with protocols.

The Program Manager will flag questionable data and using best professional judgement, determine whether to discard data and/or resurvey a specific parameter.

The Program Manager will note any protocol compliance issues, questionable data, and corrective actions or re-trainings in the project files.

2. Reports to Management

The Program Managers and the QA Manager prepare an annual report to the CBEP Director reviewing QA/QC practices. The report describes QA/QC practices as implemented during the year on a project by project basis. The report identifies challenges complying with QA/QC procedures or meeting data quality objectives. The report may also recommend changes to address QA/QC deficiencies or challenges. Recommendations may include limiting collection of certain types of data, changes in data quality objectives, additional training requirements, or implementation of new or different QA/QC procedures. This report will also be shared with the EPA program officer.

D. Data Review and Usability

1. Data Review

Checks for Completeness

All data is reviewed within 10 days of receipt to ensure it is complete. Data sheets are checked to ensure data on sampling location, sampling date and time, and field staff collecting the data are complete. EDDs are checked to ensure sample identifiers are consistent and uniquely determine sample collection time and place. Notes and sketch maps are reviewed to identify any incomplete information. Photographs are checked to ensure they can be properly aligned with data sheets and field notes. Problems are resolved as soon as possible.

Checks for Consistency

Data consistency review rests in part on systematic search for signs of data that fails internal consistency checks. Those checks fall into several categories:

(1) All data is inspected to ensure values fall within expected ranges (e.g., pH of ocean water is between pH 6.5 and 8.5).
(2) Data is inspected to look for extreme values and outliers. Outliers are checked to be sure they represent real data (and not transcription or other errors).
(3) Multivariate data is plotted to search for multivariate outliers, for example, dissolved oxygen data with high dissolved oxygen at high water temperatures).
(4) All time series or "continuous" data are graphed to look for data discontinuities and search for sections with "constant" or near-constant values that may reflect equipment malfunctions.

All anomalies found via the consistency review are traced back to their origin. If a problem is identified that can be corrected (e.g., a misplaced decimal point traceable to a transcription error), the data will be corrected, with a note added to the data record. If the reason for the anomaly can not be found, or the problem can not be corrected in the electronic record, the data will be flagged and unused in subsequent data analysis.

If consistency checks indicate a potential problem, related data will be reviewed to determine the extent of the problem. The Project Manager reviews the data and decides whether the problem is limited to specific samples, or reflects a more general problem. If consistency checks suggest a long-term problem with data collection, the Project Manager or the QA Manager may choose to "flag" additional samples and limit or restrict their use in subsequent analyses.

QA/QC Samples

Field blanks, field duplicates, laboratory blanks, laboratory duplicate and other QA/QC samples or measurements will be evaluated to determine whether data meets data quality criteria. Data associated with QA/QC samples that fail data quality checks is flagged, with a comment added to the record. Flagged data can not be used in subsequent analyses without approval from the Project Manager and QA Manager.

If QA/QC samples indicate a potential QA problem, data will be reviewed to determine the extent of the problem. The Project Manager reviews the data and decides whether the QA/QC samples indicate a problem limited to a few samples, a specific sampling day, specific equipment, etc. or a more general problem with a particular parameter or data source.

2. Project Evaluation – Usability Determination (D2)

Study success will be evaluated based on execution of the SOPs, alignment with SAPs or long-term monitoring plan, and appropriate data analysis and data documentation yielding high confidence in results. SAPs along with all relevant field methods and quality assurance measures, will be reported on to the QA Manager and EPA Project Officer on an annual basis to ensure continued confidence in data collection methods. Project-specific reports will be shared with project partners on an as-needed basis and will be reported on more broadly annually in CBEP Annual Reports and once every five years in the State of the Bay report. Study success will be evaluated based on execution of the sampling plan, data analysis, data documentation, and analysis yielding high confidence in results. Survey designs, along with all relevant field methods and quality assurance measures, will be reported on to the EPA Project Officer along with state and regional conservation partners to provide them with high quality data and protocols for collection of eDNA for diadromous fish. These reports will contain information on presence/absence, estimated abundances (if possible), and run timing of diadromous fish in the sampled streams. If eDNA monitoring was carried out in response to a stream barrier removal, the report will also contain information on the impact of the barrier removal on fish presence and activities.

References

Casco Bay Estuary Partnership. 2024. Casco Bay Plan 2024. Portland, ME. https://www.cascobayestuary.org/wp-content/uploads/2024/09/CBEP-Updated-CCMP-4.5_Final.pdf.

List of Appendices

Included in QAPP

Appendix A: SAP Template

Appendix Supplement 1 – SOPs

Appendices B – T: SOPs

Appendix Supplement 2 – Data sheets and chain of custody form

Appendix U: Data Sheets
Appendix V: Chain of Custody Form

Appendix A

Casco Bay Estuary Partnership SAP Template

Work done under this SAP will follow the Casco Bay Estuary Partnership Programmatic QAPP

Project/Site Name: ____

Organization doing work: ____

PI/Program Manager: ____

SAP Submittal to EPA Date: ____

Dates of Proposed Work: ____

Approvals:

*(Name and Date)*____________	*(Name and Date)*______________	*(Name and Date)*________________
CBEP Program Manager	CBEP QA Manager	EPA R1 Approver

1. Project Rationale

Describe why this project or additional data collection at this site is necessary, and what led to that decision. If the decision was made on the basis of a Rapid Assessment or other prior data collection, briefly describe the results of that data collection here. What are the goals of this project?

2. Sampling Plan

2.1 SOPs

What SOPs from the QAPP will be employed in data collection for this project/site? List them below.

____

____

____

____

Why were these SOPs selected? (standard data collection methods, address a particular concern, etc.)

2.2 Sampling Details

Sampling Locations: Provide a narrative description of the location of any sites that will be established for repeated sample collections. Include:

- **A brief description of how these sites were chosen**
- **A map showing sampling locations**
- **Any additional relevant photos, coordinates, or features that can help identify site locations in the field.**

[Note that permanent sampling locations only need to be identified for methods that rely on repeated visits to a precise location (monumented cross sections, porewater salinity wells, photo stations, etc.). Sampling methods that do not rely on collection of data at the same precise locations (vegetation monitoring, species of concern meander surveys, water quality monitoring) only need to have general data collection areas or transect/survey start locations identified.]

Sampling Details: Broadly describe the work to be done. Include:

- **A schedule of when/at what frequency samples will be collected**
- **The number of samples that will be collected**
- **Any planned deviations from protocols as they are outlined in the SOPs**
- **Any laboratory analyses will be done. If laboratory analyses are planned, identify the lab that samples will be sent to and attach the appropriate lab protocols to this SAP.**

Quality Control: Describe the approach that will be followed for quality control of the data, including, as appropriate, the frequency of field/lab duplicates, use of blanks, equipment calibration procedures (if not outlined in SOPs), and handling and preservation methods for lab samples.

[The below tables may be used if helpful, but are not required as long as the information is provided in some way. Note that not all SAPs will require the inclusion of Table 2, as it is specific to lab analyses.]

Table 1: Quality control sample summary

Matrix	**Parameter**	**QC Sample Type**	**QC Sample Frequency**	**Acceptance Criteria**	**Corrective Actions**
* Example: Water *	* Secchi Depth *	* Duplicate *	* 10% *	* +/- 0.2 meters *	* repeat measurements *

Table 2: Handling and analysis details for lab samples

Matrix	**Parameter/Analyte Group**	**# of Samples**	**QC Samples**	**Analytical Method/ SOP**	**Sample Container**	**Preservation Method**	**Holding Time**
* Example: Water *	* Total Suspended solids *	* 9 *	* 1 blank + 1 duplicate *	* SOP-TSS-01 *	* 1 L HDPE pre-cleaned *	* 1-6 °C *	* 7 days *.

3. Analysis and Reporting

Describe how data will be analyzed and reported on. Include a brief summary of any planned data analysis that is needed to address the project questions/goals as stated above and a description of how data will be summarized and reported on to CBEP, EPA, or other oversight organizations.

Note that the QAPP requires that all raw data be shared with and stored by CBEP in paper data sheets and/or commonly accessible electronic formats. Check SOPs for additional information.