Quality Assurance Project Plan

PFAS Concentrations in Fish, Shellfish, Invertebrates, and Surface Water from Selected Coastal and Freshwater Locations in Massachusetts

Prepared for:

Massachusetts Department of Environmental Protection
Watershed Planning Program

Prepared by:

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PFAS Concentrations in Fish, Shellfish, Invertebrates, and Surface Water from Selected Coastal and Freshwater Locations in Massachusetts

May 2024

Red Text: Updated to reflect modifications during sample collection: February 2025 (V4)

Approved by:	**Date:**
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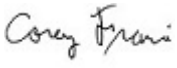 Corey Francis, Normandeau	2/5/2025

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ACRONYMS

A-CAL	lowest calibration point for PFAS analyte (SGS AXYS)
BAF	bioaccumulation factor
BWR	Bureau of Water Resources
CASRN	Chemical Abstract System Registry Numbers
C-CAL	laboratory limit of quantification (SGS AXYS)
COC	chain-of-custody
DFG	Massachusetts Department of Fish and Game
DI	deionized
DPH	Massachusetts Department of Public Health
DMF	Massachusetts Division of Marine Fisheries
DWM	Division of Watershed Management
DQO	data quality objective
EDD	electronic data deliverables
EJ	environmental justice

EPA	United States Environmental Protection Agency
EQuIS	Environmental Quality Information System
ERG	Eastern Research Group, Inc.
LLOPR	low level ongoing precision and recovery HASP health and safety plan
HDPE	high density polyethylene
LDPE	low density polyethylene
MassDEP	Massachusetts Department of Environmental Protection
MassGIS	Massachusetts Bureau of Geographic Information
MassWildlife	Massachusetts Division of Fisheries and Wildlife
MDL	method detection limit
MRL	method reporting limit
Normandeau	Normandeau Associates
OPR	ongoing precision and recovery
PFAS	per- and polyfluoroalkyl substances
ppt	parts per trillion
RL	reporting limit
RPD	relative percent difference
SAP	sampling and analysis plan
SGS AXYS	SGS AXYS Analytical Services Ltd
SOP	standard operating procedures
SFY24	state fiscal year 2024
SFY25	state fiscal year 2025
SERDP	Strategic Environmental Research and Development Program
USGS	United States Geological Survey
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
WES	MassDEP William X. Wall Experiment Station
WPP	Watershed Planning Program
ww	wet weight

Changes to the QAPP and to protocols implemented during Phase 1 and Phase 2 of the project are indicated in red text; strikethroughs indicate deleted text. These changes were incorporated in February 2025.

1.0 Introduction

The Massachusetts Department of Environmental Protection (MassDEP) has funded a project to measure levels of per- and polyfluoroalkyl substances (PFAS) contamination in fish, shellfish, invertebrates, and surface water in selected lakes, rivers, and coastal locations across the state.[1] MassDEP selected Eastern Research Group, Inc. (ERG) as the contractor to implement this study.
ERG developed this quality assurance project plan (QAPP) following the U.S. Environmental Protection Agency's (EPA's) guidance for QAPPs for the purpose of environmental data collection and analysis (EPA, 2002). ERG also considered additional guidance documents (e.g., ITRC, 2023; MI EGLE, 2022) and QAPPs for other similar sampling programs (e.g., MassDEP, 2022).

This QAPP outlines the procedures to be used to ensure that environmental sampling data will be collected and analyzed to meet project requirements and will be of a known and high quality. This QAPP addresses the following main topics:

- Project management, objectives, and approaches (Section 2.0)
- Methods for generating data, including methods for field collection of samples and laboratory analysis (Section 3.0)
- Data validation and assessment of data usability (Section 4.0)

2.0 Project Management

2.1 Distribution List

The Watershed Planning Program (WPP) within the Division of Watershed Management (DWM) and the Bureau of Water Resources (BWR) is managing the project for MassDEP. The MassDEP project lead is Richard Chase and he will ensure distribution of the draft and final QAPP to the personnel listed below.

MassDEP
Richard Chase, MassDEP Project lead, richard.f.chase@mass.gov
Rama Pulicharla, WPP Emerging Contaminants Coordinator, rama.pulicharla@mass.gov
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[1] For the purposes of this QAPP, all references to "shellfish" are specific to shellfish collected at coastal sampling locations. All references to "invertebrates" are specific to invertebrates collected at freshwater sampling locations.

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ERG
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Donna Tedder, Quality Assurance (QA) Manager, donna.tedder@erg.com
Anna Stanley-Lee, Data Manager and Field Sampling Coordinator, anna.stanley@erg.com
Kortney Kirkeby, Senior Biologist, kortney.kirkeby@erg.com

Normandeau Associates, Inc. (Normandeau)
Sean Stimmel, Normandeau Project Manager and Field Crew Lead, sstimmell@normandeau.com
Corey Francis, Field Crew Lead and Site Safety Coordinator, cfrancis@normandeau.com

2.2 Project Organization

MassDEP WPP is managing and funding this project. MassDEP WPP officials will seek input on the project from the Department's Office of Research and Standards (ORS) and the Department's environmental laboratory, the William X. Wall Experiment Station Wall Experiment Station (WES). MassDEP will also consult with various state agency partners on project details, including DPH and DFG.

MassDEP has issued a contract to ERG to conduct the field work and summarize PFAS measurements. ERG has issued subcontracts to Normandeau, who will conduct sample collection, and SGS AXYS Analytical Services Ltd. (SGS AXYS), who will conduct laboratory analyses. Dr. Rebecca DeVries (ERG) will serve as project manager for the contractor team, with Mr. John Wilhelmi (ERG) as deputy project manager and Ms. Donna Tedder (ERG) as QA manager. Ms. Anna Stanley-Lee (ERG) will serve as data manager and field sampling coordinator; she will direct and oversee sample collection by Normandeau,

coordinate sample analysis with SGS AXYS, and manage data as they are received from SGS AXYS. Mr. Sean Stimmel and Mr. Corey Francis (Normandeau) will serve as field crew leads, with Mr. Francis also serving as site safety coordinator. Mr. Tim Fitzpatrick and Mr. Sean Campbell are the contracting and technical points of contact, respectively, for SGS AXYS. Table 1 further outlines project roles and responsibilities.

Table 1. Organization of Key Project Staff and Responsibilities

Staff	Project Role	Project Responsibilities
Richard Chase MassDEP Bureau of Water Resources Email: richard.f.chase@mass.gov	MassDEP Project Lead	Directing all project activities; reviewing, approving, and distributing the QAPP; reviewing the final report; and coordinating with state agency partners.
Rama Pulicharla MassDEP Bureau of Water Resources Email: rama.pulicharla@mass.gov	MassDEP Alternate Project Lead	Assuming all MassDEP project lead responsibilities during times when the MassDEP project lead is not available.
Richard Carey MassDEP Bureau of Water Resources Email: richard.carey@mass.gov	Project oversight	Review of technical report; general guidance
Rebecca DeVries ERG Email: rebecca.devries@erg.com	ERG Project Manager	Managing all sampling and analysis activities, including subcontracts with Normandeau and SGS AXYS; coordinating with the ERG team to develop the QAPP; leading data analyses; and authoring the final project report.
John Wilhelmi ERG Email: john.wilhelmi@erg.com	ERG Deputy Project Manager	Assisting the ERG project manager with assigned responsibilities and assuming project management responsibilities when she is not available.
Anna Stanley-Lee ERG Email: anna.stanley@erg.com	ERG Data Manager and Field Sampling Coordinator	Reviewing, tracking, and compiling laboratory data in the project database and scheduling and coordinating all field sampling activity.
Donna Tedder ERG Email: donna.tedder@erg.com	ERG QA Manager	Reviewing the QAPP and all revisions; ensuring adherence to the QAPP; and assisting with

Staff	Project Role	Project Responsibilities
		reviewing and verifying PFAS measurements from the laboratory.
Kortney Kirkeby ERG Email: kortney.kirkeby@pgenv.com	ERG Senior Biologist	Contributing to the sampling and analysis plan (SAP) in the QAPP and providing supplemental field sampling support, if needed.
Sean Stimmel Normandeau Associates Email: sstimmell@normandeau.com	Normandeau Project Manager and Field Crew Lead	Assisting with development of the QAPP and SAP and managing field crews that collect and process samples.
Corey Francis Normandeau Associates Email: cfrancis@normandeau.com	Field Crew Lead and Site Safety Coordinator	Obtaining scientific collection permits and overseeing field crews that collect and process samples.
Tim Fitzpatrick SGS AXYS Email: timothy.fitzpatrick@sgs.com	SGS AXYS Project Lead	Managing subcontract and ensuring all samples are received, logged, and analyzed in a timely manner.
Sean Cambell SGS AXYS Email: sean.campbell@sgs.com	SGS AXYS Technical Lead	Delivering validated data packages to ERG's data manager and answering any technical questions.

2.3 Problem Definition/Background

PFAS are of nationwide concern due to their persistence, toxicity, and ubiquitous presence in various environmental media. In response, environmental and public health agencies at all government levels have continued to investigate the nature and extent of PFAS contamination and its effects on human health and the environment.

Massachusetts agencies have conducted many steps to characterize the nature and extent of PFAS contamination in various environmental media. For surface waters, MassDEP and the U.S. Geological Survey (USGS) completed a PFAS river sampling study in 2020 (USGS, 2021) where PFAS were detected in all 27 of the rivers sampled. Concentrations of the sum of all 24 PFAS included in the analysis method ranged between 0.3 and 399 parts-per-trillion (ppt) across the sampling locations. DPH measured PFAS in surface water collected from 16 lakes and ponds on Cape Cod in 2021 (DPH, 2021a). At five locations, DPH also collected fish for PFAS analysis – at all of which DPH subsequently issued issuing fish consumption advisories based on the PFAS measurements (DPH, 2021b). In 2022, DPH tested fish from state parks around Massachusetts, which resulted in the issuance of freshwater fish consumption advisories at 13 waterbodies (DPH,2023). Also in 2022, MassDEP's WPP conducted a study to measure the concentration of PFAS in

edible fish tissue and surface water at 52 freshwater lakes and rivers across the state, 46 of where were located near known or suspected sites of PFAS contamination and six of which were defined as "reference" locations (MassDEP, 2023). PFAS were detected in the surface water and in at least one fish tissue sample from all waterbodies, including reference locations. PFOA was the most frequently detected PFAS in water and PFOS was the most frequently detected PFAS in fish tissue.
While these sampling activities have resulted in important advances in understanding environmental PFAS contamination in the Commonwealth, additional work is needed to further characterize the nature and extent of PFAS contamination in freshwater systems and to begin to understand PFAS contamination in coastal systems. The current project will help fill these gaps.

The principal goals of the current project are to characterize the nature and extent of PFAS contamination in 1) coastal (marine) water and edible fish and shellfish tissue, and 2) freshwater whole-body fish and invertebrates at selected locations in Massachusetts. Primary objectives include:

- For coastal locations, surface water, finfish (edible tissue only), and shellfish will be collected in such a manner to allow assessment of public health risks associated with consumption. The data will also be compared to EPA's ~~draft/~~final Acute Benchmarks for the Protection of Aquatic Life in Estuarine/Marine Waters, as published in the agency's ~~draft~~ Aquatic Life Ambient Water Quality Criteria documents for select PFAS ~~PFOA and PFOS~~.
- For freshwater locations, surface water, finfish (whole-body and boneless, skinless fillets), and benthic invertebrate samples will be collected such that PFAS measurements can be directly compared to EPA's ~~draft/~~final National Recommended Freshwater Aquatic Life Ambient Water Quality Criteria for select PFAS ~~PFOA and PFOS~~. These data will ultimately enhance MassDEP's understanding of ambient PFAS levels with respect to assessment of the aquatic life designated use and the potential for development of surface water quality standards.

This project has multiple secondary objectives. Secondary uses of the fish tissue and water quality data for PFAS include derivation of species-specific PFAS bioaccumulation factors (BAF) at coastal and freshwater locations. Surface water PFAS data may also be used to inform public health evaluations due to incidental ingestion during recreational activities. Additionally, data across multiple media may be used to assess interlaboratory differences in PFAS measurements between MassDEP's WES laboratory and the commercial laboratory contracted to support this study (SGS AXYS).

Note that this is believed to be the first project in Massachusetts to characterize PFAS concentrations in freshwater invertebrates; similar studies have been conducted in North and South Carolina, the Hudson River, and Lake Ontario (Penland et al., 2020; Brase et al., 2022; Ren et al., 2022). This is also believed to be the first study to characterize PFAS

concentrations in shellfish in Massachusetts; similar studies have been conducted in Galveston, Texas and San Diego, California (Nolan et al., 2022; Talley et al., 2023).

2.4 Project Tasks

When executing this project, MassDEP and the ERG team will perform a range of tasks that fall into three general categories, listed below. This section summarizes the main tasks to be completed under these categories and identifies the project team entity(ies) responsible for executing them. Later sections of the QAPP present further details on these and additional tasks.

Planning

- Developing a comprehensive QAPP and SAP to guide sample collection, sample analysis, data management, and data analysis (*ERG*).
- Coordinating with SGS AXYS to determine schedule, logistics of sample transport and delivery, electronic reporting expectations, and all other details for measuring PFAS concentrations in water, fish, invertebrate, and shellfish samples (*ERG*).
- Proposing 10 freshwater and 20 coastal sample collection locations in Massachusetts *(ERG*).
- Obtaining a scientific collection permit from MassWildlife to allow for collection of fish from the selected freshwater locations and from DMF for the collection of fish and shellfish from the selected coastal locations (*Normandeau*).

Sample collection and analysis

- Creating a sampling schedule for Phase 1 and Phase 2 of the project (*ERG*).
- Collecting surface water, fish, and invertebrate samples at the 10 targeted freshwater locations and using "PFAS-free protocols" to process, package, and transport samples (*Normandeau*).
- Collecting surface water, fish, and shellfish samples at the 20 targeted coastal locations and using "PFAS-free protocols" to process, package, and transport samples (*Normandeau)*.
- Compiling field observations and ancillary data for collected water, fish, shellfish, and invertebrate samples and managing field documentation *(ERG and Normandeau)*.
- Using EPA Method 1633 to measure concentrations of 40 PFAS in water, fish, shellfish, and invertebrate samples, validating analytical results, and reporting results to ERG including full lab QC results *(SGS AXYS)*.

Data management, analysis, and reporting

- Assembling all project data, including field data sheets, fish, shellfish, and invertebrate identification and measurements, and other ancillary data generated by the project (*ERG*).

- Reviewing field quality control (QC) sample results as they are received to ensure project QC criteria are met (*ERG*).
- Providing project updates periodically to MassDEP
- Reviewing data reported by the analytical laboratory *(ERG and MassDEP)*.
- Analyzing and summarizing results in a final report (*ERG*).
- Preparing analytical results for upload to MassDEP's Environmental Quality Information System (EQuIS) database (*ERG*).

2.4.1 Project Schedule

The project will be conducted in two phases. Phase 1 will be completed in state fiscal year 2024 (SFY24), which ends on June 30, 2024. This phase will include sampling and laboratory analysis of water, fish, shellfish, and invertebrate samples collected from 10 waterbodies. Phase 2 will be completed in state fiscal year 2025 (SFY25), which runs from July 1, 2024 to June 30, 2025. This phase will include sampling and laboratory analysis of the same types of environmental samples collected from 20 additional waterbodies and preparation of a final report. Phase 2 might also include conducting an interlaboratory study with MassDEP's WES and preparing a brief report describing that effort (dependent on WES lab availability and capability within the project timeframe). This QAPP covers activities planned for both project phases. Table 2 lists tasks to be conducted during Phase 1 and Phase 2 and the anticipated dates during which activities will take place.

Table 2. Project Schedule

Task	Performance Period
Phase 1 (SFY24)	
Develop QAPP for Phase 1	January 15 to March 30, 2024
Sample collection at up to 10 targeted locations (freshwater and coastal)	April to June 2024
Laboratory analysis of samples	As samples are collected and delivered
Update and finalize QAPP for Phase 2 sampling and analysis	June 1 to June 30, 2024
Prepare data deliverables from Phase 1 sampling	As lab results are received
Phase 2 (SFY25)	
Sample collection at the remaining 20 locations (freshwater and coastal)	July to ~~October~~ November 2024
Laboratory analysis of samples from the remaining 20 waterbodies	As samples are collected
~~Interlaboratory comparison study of PFAS analyses for a subset of fish tissue and surface water samples~~	~~September to October 2024~~

Task	Performance Period
Data deliverables with all analytical results	December 2024 to March 2025
Draft and final report	January 2025 to June 2025

2.5 Quality Objectives and Criteria for Measurement Data

When evaluating aquatic life and public health risks associated with environmental contamination, it is essential to use sampling data that are of known and high quality. Measurements made during this project that meet the published analytical method quality control specifications will be considered suitable for meeting the project's principal objectives. This section defines and describes the quality specifications that apply to this project.

2.5.1 Quality Indicators

Table 3 lists the data quality indicators that apply to this project's PFAS measurements. Some data quality indicators will be evaluated qualitatively and others quantitatively. Later sections of the QAPP provide further detail on the topics covered in this table.

Table 3. Data Quality Indicators

Data Quality Indicator and Purpose	Project-specific Requirements
Representativeness To ensure the PFAS measurements adequately characterize waterbody and organism conditions. Also, that the data characterize the range of PFAS levels found in water and biota in both freshwater and coastal areas in Massachusetts.	*Freshwater sampling* ▪ Sampling locations will include a mix of rivers/streams and lakes/ponds in each of the four MassDEP regions. ▪ Sampling locations will represent a range of waterbody sizes. ▪ Sampling locations will be informed by areas of known or suspected point and non-point sources of PFAS contamination. Reference locations will also be included. ▪ Fish and invertebrates kept for analysis will represent a range of species at each sampling location. *Coastal sampling* ▪ Sampling locations will be distributed along the Massachusetts coastline. Some locations will be near the mouths of major rivers or in highly developed areas where PFAS contamination is assumed to be likely. Other locations will be in more isolated areas assumed to represent reference locations.

Data Quality Indicator and Purpose	Project-specific Requirements
	▪ Sampling will target coastal locations that are known to be fished for both fish and shellfish. Sampling will exclude areas with consumption advisories or where fishing or harvesting shellfish is prohibited or conditionally prohibited. ▪ Sampling will be limited to the fish and shellfish that recreational fishers are most likely to keep and consume (see species lists for fish and shellfish in Table 15 and Table 16, respectively).
Comparability To ensure this program's PFAS measurements (1) allow for comparisons of PFAS levels across waterbodies in Massachusetts, (2) allow for comparisons of PFAS measurements made by other parties using similar methods, and (3) allow for comparison to EPA's draft Aquatic Life Ambient Water Quality Criteria for PFOA and PFOS (where applicable).	▪ Field sampling crews will use standard and reproducible sampling methodologies. ▪ Samples will be collected in a manner that ensures results can be compared to EPA's ~~draft/~~final Aquatic Life Ambient Water Quality Criteria for PFOA and PFOS in water and tissue. ▪ A commercial laboratory will analyze samples according to the specifications of a published analytical method. ▪ PFAS measurements will be reviewed to ensure analyses have been conducted according to the published analytical method and any supplemental data quality requirements in this QAPP.
Completeness To ensure that sufficient data are collected to meet this program's objectives (consistent with the total project sample numbers described in the RFR) and to minimize the likelihood of missing, invalid, or incomplete data.	▪ Field sampling crews will review this QAPP and be trained on proper collection, storage, processing, and tracking of samples. ▪ Field sampling crews will reschedule sampling as soon as possible should inclement weather or other unforeseen circumstances interfere with data collection. ▪ ERG will maintain contingency plans and backup sampling locations should there be an unforeseen inability to sample a selected location or should sampling be unsuccessful. ▪ Sampling design and sample allocation throughout the project will strive to meet the estimated sample count in the project RFR of approximately 400 total samples. ▪ Measurement data reported by the analytical laboratory will be immediately and thoroughly

Data Quality Indicator and Purpose	Project-specific Requirements
	reviewed. The laboratory will be asked to clarify invalid results or missing data. ▪ The minimum target completeness percentage for surface water samples is 90%, meaning more than 90% of the samples collected will result in valid measured concentrations for the target PFAS analytes. ▪ The minimum target completeness percentage for fish, invertebrate, and shellfish samples is 90%, meaning more than 90% of the waterbodies sampled will result in valid measured concentrations for the target PFAS analytes for at least one fish species, one shellfish species, or one invertebrate sample.
Sensitivity To generate PFAS measurements of a known and high quality at concentrations recommended in EPA's analytical method.	▪ SGS AYXS will report results to levels equal to the method detection limits (MDLs) shown in their SOP. ▪ The project team will review field and laboratory QC samples against data usability criteria. ▪ Potential for matrix interferences will be evaluated.
Precision To confirm that this project's PFAS measurements are highly repeatable.	▪ At approximately 25% of the locations sampled, the field sampling crew will collect field duplicates for surface water and fish tissue (boneless, skinless fillets only). Duplicates will not be collected for whole-body fish, invertebrates, or shellfish as duplicate samples would represent different organisms than the parent species. Replicates will be collected as part of the study design for invertebrates and whole-body fish. Additional replicates for QC purposes will be collected for shellfish at up to three waterbodies. ▪ PFAS analytes measured at concentrations at least five times the MDL, the target relative percent difference (RPD), averaged across all duplicate samples, will be 40 percent. For individual duplicate results, if the concentration is ≥5 times the MDL, the RPD must be ≤40 percent. If the concentration is <5 times the MDL, the RPD must be ≤100 percent. ▪ The approximately 25% of waterbodies where duplicates are collected will represent both freshwater and coastal locations. At all locations where duplicates are collected, field teams will

Data Quality Indicator and Purpose	Project-specific Requirements
	prepare one surface water duplicate and two fish (boneless skinless filet) duplicates. Duplicates will be collected to represent 10% of the total target sample count.
Accuracy To confirm that this project's PFAS measurements are free from random error or bias.	▪ The laboratory will use analytical methods documented to be reliable and will employ rigorous QC procedures. ▪ The laboratory will report the results of one procedural blank and one spiked matrix sample per batch of approximately 20 samples, as indicators of accuracy. ▪ The field sampling crew will use PFAS-free best practices for sampling and new, clean sampling materials and supplies at each sampling point to reduce potential for cross contamination. ▪ Performance evaluation samples will be prepared by MassDEP and submitted to AXYS double-blind to evaluate lab accuracy for known QC samples. ▪ The project team will confirm that the deionized (DI) water used for decontamination in the field and for equipment-rinsate blanks is PFAS-free prior to sampling. ▪ The field teams will prepare field blanks (surface water) and equipment rinsate blanks (for fish tissue, shellfish, and invertebrates sample and processing) at 10% of waterbodies. A total of 15 blank samples will be collected for this project. ▪ Equipment rinsate blank results will meet data quality objectives for little or no cross-contamination between samples during sample preparation.

2.5.2 Criteria for Analytical Parameters

Laboratory analyses of all surface water, fish, invertebrate, and shellfish samples will be conducted by SGS AXYS using their Method MLA-110. Performance and quality procedures of SGS AXYS MLA-110 meet the requirements of EPA Method 1633 for PFAS, which was finalized in January 2024 (EPA, 2024a). In fact, EPA Method 1633 was developed by SGS AXYS, based on SGS AXYS Method MLA-110, following multi-laboratory validation.

The chemical names, CAS Registry Numbers (CAS RNs), and SGS AXYS' MDLs and method reporting limits (MRLs) for the 40 PFAS to be measured in surface water and tissue are presented in Table 4 and Table 5, respectively. SGS AXYS will report results down to a

concentration equal to the lowest calibration point for each PFAS, or the "A-CAL" as defined in SGS AYXS' SOP. Detections between those concentrations and the laboratory's limit of quantification, defined by SGS AXYS as the C-CAL, will be flagged with a "J" qualifier. Note that for the purposes of this project, we have defined SGS AXYS A-CAL values as the MDLs and C-CAL values as the MRLs.

Table 6 summarizes additional details for sampling each media. Section 4.0 provides information on laboratory validation of PFAS measurements and the project team's data verification procedures.

Table 4. MDLs and MRLs for Surface Water Samples

PFAS Analyte	Acronym	CAS RN	MDL (A-CAL) (ng/L)	MRL (C-CAL) (ng/L)
Perfluorobutanoic acid	PFBA	375-22-4	1.6	6.4
Perfluoropentanoic acid	PFPeA	2706-90-3	0.8	3.2
Perfluorohexanoic acid	PFHxA	307-24-4	0.4	1.6
Perfluoroheptanoic acid	PFHpA	375-85-9	0.4	1.6
Perfluorooctanoic acid	PFOA	335-67-1	0.4	1.6
Perfluorononanoic acid	PFNA	375-95-1	0.4	1.6
Perfluorodecanoic acid	PFDA	335-76-2	0.4	1.6
Perfluoroundecanoic acid	PFUnA	2058-94-8	0.4	1.6
Perfluorododecanoic acid	PFDoA	307-55-1	0.4	1.6
Perfluorotridecanoic acid	PFTrDA	72629-94-8	0.4	1.6
Perfluorotetradecanoic acid	PFTeDA	376-06-7	0.4	1.6
Perfluorobutanesulfonic acid	PFBS	375-73-5	0.4	1.6
Perfluoropentansulfonic acid	PFPeS	2706-91-4	0.4	1.6
Perfluorohexanesulfonic acid	PFHxS	355-46-4	0.4	1.6
Perfluoroheptanesulfonic acid	PFHpS	375-92-8	0.4	1.6
Perfluorooctanesulfonic acid	PFOS	1763-23-1	0.4	1.6
Perfluorononanesulfonic acid	PFNS	68259-12-1	0.4	1.6
Perfluorodecanesulfonic acid	PFDS	335-77-3	0.4	1.6
Perfluorododecanesulfonic acid	PFDoS	79780-39-5	0.4	1.6
1H,1H, 2H, 2H-Perfluorohexane sulfonic acid	4:2FTS	757124-72-4	1.6	6.4
1H,1H, 2H, 2H-Perfluorooctane sulfonic acid	6:2FTS	27619-97-2	1.6	21.3
1H,1H, 2H, 2H-Perfluorodecane sulfonic acid	8:2FTS	39108-34-4	1.6	6.4
Perfluorooctanesulfonamide	PFOSA	754-91-6	0.4	1.6
N-methyl perfluorooctanesulfonamide	NMeFOSA	31506-32-8	0.4	1.6
N-ethyl perfluorooctanesulfonamide	NEtFOSA	4151-50-2	0.4	1.6
N-methyl perfluorooctanesulfonamidoacetic acid	NMeFOSAA	2355-31-9	0.4	1.6
N-ethyl perfluorooctanesulfonamidoacetic acid	NEtFOSAA	2991-50-6	0.4	1.6
N-methyl perfluorooctanesulfonamidoethanol	NMeFOSE	24448-09-7	4	16

PFAS Analyte	Acronym	CAS RN	MDL (A-CAL) (ng/L)	MRL (C-CAL) (ng/L)
N-ethyl perfluorooctanesulfonamidoethanol	NEtFOSE	1691-99-2	4	16
Hexafluoropropylene oxide dimer acid	HFPO-DA	13252-13-6	1.6	6.4
4,8-Dioxa-3H-perfluorononanoic acid	ADONA	919005-14-4	1.6	6.4
Perfluoro-3-methoxypropanoic acid	PFMPA	377-73-1	1.6	6.4
Perfluoro-4-methoxybutanoic acid	PFMBA	863090-89-5	0.8	3.2
Nonafluoro-3,6-dioxaheptanoic acid	NFDHA	151772-58-6	0.8	3.2
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	9Cl-PF3ONS	756426-58-1	1.6	6.4
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	11Cl-PF3OUdS	763051-92-9	1.6	6.4
Perfluoro(2-ethoxyethane)sulfonic acid	PFEESA	113507-82-7	0.4	1.6
3-Perfluoropropyl propanoic acid	3:3FTCA	356-02-5	1.6	6.4
2H,2H,3H,3H-Perfluorooctanoic acid	5:3FTCA	914637-49-3	10	40
3-Perfluoroheptyl propanoic acid	7:3FTCA	812-70-4	10	40

Table 5. MDLs and MRLs for Tissue Samples

PFAS Analyte	Acronym	CAS RN	MDL (A-CAL) (ng/L)	MRL (C-CAL) (ng/L)
Perfluorobutanoic acid	PFBA	375-22-4	0.4	1.6
Perfluoropentanoic acid	PFPeA	2706-90-3	0.2	0.8
Perfluorohexanoic acid	PFHxA	307-24-4	0.1	0.4
Perfluoroheptanoic acid	PFHpA	375-85-9	0.1	0.4
Perfluorooctanoic acid	PFOA	335-67-1	0.1	0.4
Perfluorononanoic acid	PFNA	375-95-1	0.1	0.4
Perfluorodecanoic acid	PFDA	335-76-2	0.1	0.4
Perfluoroundecanoic acid	PFUnA	2058-94-8	0.1	0.4
Perfluorododecanoic acid	PFDoA	307-55-1	0.1	0.4
Perfluorotridecanoic acid	PFTrDA	72629-94-8	0.1	0.4
Perfluorotetradecanoic acid	PFTeDA	376-06-7	0.1	0.4
Perfluorobutanesulfonic acid	PFBS	375-73-5	0.1	0.4
Perfluoropentansulfonic acid	PFPeS	2706-91-4	0.1	0.4
Perfluorohexanesulfonic acid	PFHxS	355-46-4	0.1	0.4
Perfluoroheptanesulfonic acid	PFHpS	375-92-8	0.1	0.4
Perfluorooctanesulfonic acid	PFOS	1763-23-1	0.1	0.4
Perfluorononanesulfonic acid	PFNS	68259-12-1	0.1	0.4
Perfluorodecanesulfonic acid	PFDS	335-77-3	0.1	0.4
Perfluorododecanesulfonic acid	PFDoS	79780-39-5	0.1	0.4

PFAS Analyte	Acronym	CAS RN	MDL (A-CAL) (ng/L)	MRL (C-CAL) (ng/L)
1H,1H, 2H, 2H-Perfluorohexane sulfonic acid	4:2FTS	757124-72-4	0.4	1.6
1H,1H, 2H, 2H-Perfluorooctane sulfonic acid	6:2FTS	27619-97-2	0.4	8.7
1H,1H, 2H, 2H-Perfluorodecane sulfonic acid	8:2FTS	39108-34-4	0.4	1.6
Perfluorooctanesulfonamide	PFOSA	754-91-6	0.1	0.4
N-methyl perfluorooctanesulfonamide	NMeFOSA	31506-32-8	0.1	0.4
N-ethyl perfluorooctanesulfonamide	NEtFOSA	4151-50-2	0.1	0.4
N-methyl perfluorooctanesulfonamidoacetic acid	NMeFOSAA	2355-31-9	0.1	0.4
N-ethyl perfluorooctanesulfonamidoacetic acid	NEtFOSAA	2991-50-6	0.1	0.4
N-methyl perfluorooctanesulfonamidoethanol	NMeFOSE	24448-09-7	12	11.0
N-ethyl perfluorooctanesulfonamidoethanol	NEtFOSE	1691-99-2	12	48
Hexafluoropropylene oxide dimer acid	HFPO-DA	13252-13-6	0.4	1.6
4,8-Dioxa-3H-perfluorononanoic acid	ADONA	919005-14-4	0.4	1.6
Perfluoro-3-methoxypropanoic acid	PFMPA	377-73-1	0.2	0.8
Perfluoro-4-methoxybutanoic acid	PFMBA	863090-89-5	0.1	0.4
Nonafluoro-3,6-dioxaheptanoic acid	NFDHA	151772-58-6	0.2	0.8
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	9Cl-PF3ONS	756426-58-1	0.4	1.6
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	11Cl-PF3OUdS	763051-92-9	0.4	1.6
Perfluoro(2-ethoxyethane)sulfonic acid	PFEESA	113507-82-7	0.1	0.4
3-Perfluoropropyl propanoic acid	3:3FTCA	356-02-5	0.4	1.6
2H,2H,3H,3H-Perfluorooctanoic acid	5:3FTCA	914637-49-3	2.5	10
3-Perfluoroheptyl propanoic acid	7:3FTCA	812-70-4	2.5	10

Table 6. Additional Sampling and Analysis Details for SGS AXYS MLA-110

Analysis	Matrix	Method	Sampling Container	Sample Condition Upon Lab Receipt	Storage Condition	Sample Volume/ Mass[1]	Maximum Hold Time before Extraction (Days)[2]	Extract Hold Time[3]
PFAS	Surface water	SGS AXYS MLA-110	500 and 60 mL high density polyethylene (HDPE) jar	0-6 °C, dark	≤-20 °C, dark	500 mL; 60 mL	90 days	30 days
	Whole-body Invertebrate or shellfish tissue		250 mL HDPE or (amber glass jar			2 g wet weight (ww)		
	Whole body Fish or fish tissue		Low density polyethylene (LDPE) bag			2 g ww		

[1] The sample volume/mass shown is the absolute minimum required for laboratory analysis. The laboratory has asked ERG to provide at least 1,000 mL for surface water (two 500 mL sample jars and one 60 mL jar) and 15 g for tissue to ensure there is sufficient mass/volume to run all necessary QC analyses.
[2] Hold time from time of sampling. The hold time for aqueous samples is based on SGS AXYS' storage stability studies.
[3] Hold time from time of extraction with storage at 4°C. This extraction hold time is a guideline and longer hold times may be accepted based on professional judgement.

2.5.3 Criteria for Field Measurements

The principal observations and measurements made in the field for freshwater whole fish and fish tissue sampling and for coastal fish collection will be documenting the species of fish collected and recording the length and weight of each fish. Species identification will be performed by field sampling crew members experienced with the taxonomy of freshwater and coastal fish in Massachusetts. Field sampling crew members will use a measuring board to measure the fish length to the nearest millimeter; and they will use a digital scale to measure the weight (grams, wet weight).

For shellfish, the field sampling crew will record the species, weight, and length of each organism after being collected and before being shucked. Lengths will be measured to the nearest millimeter (as specified in the SAP) and weights will be measured to the nearest gram. The field sampling crew will shuck the shellfish and prepare composite samples (each comprised of three to five similar sized organisms of the same species) at Normandeau's facility in Bedford, NH. The field team will record the total weight of the composite sample in grams (wet weight).

For freshwater invertebrates, the field sampling crew will attempt to separate collected mass by class, contingent on site-specific conditions and catch. For the collection of invertebrates with sufficient mass to prepare a sample, the field sampling crew will record the weight (to the nearest gram) and identify the types of organisms included in each composite sample, to the extent possible. Additional details are provided in Section 3.1.3.3 and the SAP.

Beyond ensuring that an adequate volume of surface water is collected (i.e., that the bottles provided by SGS AXYS are filled), no field measurements will be recorded for the surface water samples.

Section 2.8.1 lists other observations (not measurements) that will be recorded by the field sampling crew when collecting samples.

2.5.4 Action Limits and Comparison Values

In 2024, EPA published Recommended Aquatic Life Ambient Water Quality Criteria for Select PFAS in the water column, whole-body fish, fish muscle, and whole-body invertebrates from freshwaters (EPA, 2024c). For the water column concentrations, EPA has issued acute and chronic criteria for PFOS and PFOA. For tissue-based concentrations, EPA has issued chronic criteria for PFOS and PFOA only. Additionally, EPA

has published acute estuarine/marine water column benchmarks for PFOA and PFOS and acute freshwater aquatic life benchmarks for eight additional PFAS. All of these water column and tissue criteria are intended to be independently applicable and no one criterion takes primacy. All of the above recommended criteria and benchmarks are intended to be protective of aquatic life. These criteria and benchmarks are applicable throughout the year.

EPA's recommended criteria and benchmarks for PFOA/PFOS in water and tissue are shown in Table 7 and Table 8, respectively. Data from this project will be compared to all applicable values.

Table 7: EPA Recommended Aquatic Life Ambient Water Quality Criteria: Water Column

PFAS Analyte	Freshwater Acute Water Column (CMC[1])	Freshwater Chronic Water Column (CCC[2])	Estuarine/Marine Acute Water Column (CMC[1])[3]
PFOA	3.1 mg/L	0.10 mg/L	7.0 mg/L
PFOS	0.071 mg/L	0.00025 mg/L	0.55 mg/L
PFBA[4]	5.3 mg/L	--	--
PFHxA[4]	4.8 mg/L	--	--
PFNA[4]	0.65 mg/L	--	--
PFDA[4]	0.50 mg/L	--	--
PFBS[4]	5.0 mg/L	--	--
PFHxS[4]	0.21 mg/L	--	--
8:2 FTUCA[4]	0.037 mg/L	--	--
7:3 FTCA[4]	0.012 mg/L	--	--

[1]Criterion Maximum Concentration for a 1-hour average concentration not to be exceeded more than once in three years.
[2]Criterion Continuous Concentration for a 4-day average concentration not to be exceeded more than once in three years.
[3]The estuarine/marine values represent benchmarks (not criteria) by EPA.
[4]These values represent benchmarks (not criteria).

Table 8: EPA Recommended Aquatic Life Ambient Water Quality Criteria: Freshwater Organisms

PFAS Analyte	Chronic Invertebrate Whole Body	Chronic Fish Whole Body	Chronic Fish Muscle
PFOA	1.18 mg/kg ww	6.49 mg/kg ww	0.133 mg/kg ww
PFOS	0.028 mg/kg ww	0.201 mg/kg ww	0.087 mg/kg ww

EPA published Draft PFAS Human Health Water Quality Criteria in 2024 (EPA, 2024d). We will also compare our results, as applicable, with these draft criteria, which include organism-only and organism-and-water criteria for PFOA, PFOS, and PFBS.

There are currently no federal or Massachusetts health-based standards for PFAS in surface water, fish, or shellfish. However, DPH has derived draft health-based screening values for recreational exposures to surface water and consumption of fish, as described

below (not published). Data collected from coastal and freshwater sampling locations will be compared to these draft screening values, where appropriate. Note that these unpublished/draft values supersede previously published draft values (DPH, 2021) and are the same screening values used in MassDEP's 2022 "PFAS in Freshwater and Fish Tissue" project (MassDEP, 2023). Data from this project will only be compared to these values as an initial screening step. The data may be further used by DPH in public health risk assessments.

- For surface water, the sum of measurements for six PFAS (PFHxS, PFHpA, PFOA, PFOS, PNFA, and PFDA, collected referred to as "PFAS6") will be compared to the guidelines listed below. These values are protective of recreational exposure at beaches (e.g., incidental ingestion while wading or swimming at a public beach).
    - PFAS6 $\leq$20 ng/L: no restrictions
    - PFAS6 >20ng/L to 90 ng/L: notifications required (e.g., posting signage)
    - PFAS6 >90 ng/L to 500 ng/L: site specific evaluation required
    - PFAS6 >500 ng/L: no swimming
- For fish tissue, individual measurements of seven PFAS (i.e., PFBS, PFHxS, PFOA, PFOS, PFNA, GenX, and PFBA) will be compared to DPH's draft candidate fish action level of 0.22 ng/g.

2.6 Special Training and Certifications

All personnel supporting the field sampling and laboratory analyses for this project must have the necessary knowledge, qualifications, and experience to ensure that the measured PFAS concentrations are of a known and high quality. Sampling team members will also be required to read the QAPP (including the SAP) at least two weeks before being deployed to the field.

Normandeau will provide this project's field sampling crews. Normandeau's staff have extensive prior experience in collecting, processing, storing, and transporting environmental samples; in identifying fish, shellfish, and invertebrates from Massachusetts waterbodies; in operating the various watercraft types expected to be used in this project; and in using a wide range of fish and invertebrate sampling equipment. Their field sampling crew members are fully prepared to collect fish, shellfish, invertebrate, and surface water samples with the methods outlined in this QAPP and described in greater detail in the SAP. ERG will coordinate sample collection and work closely with the Normandeau field crew leads to ensure field sampling crew members are fully trained on all relevant details in this QAPP, especially steps to process fish, shellfish, and invertebrate samples before shipment to the laboratory in a manner that will minimize the likelihood of PFAS cross contamination.

Specific to freshwater sampling locations, all Normandeau field staff who will support this project have been fully trained in electrofishing procedures. This training includes orientation to the electrofishing equipment, procedures, and risks involved. In addition, all

field biologists using electrofishing techniques have read and understand the Electrofishing Safety Guidance provided by the American Fisheries Society (excerpt from the 2008 American Fisheries Society Professional Safety Committee Fisheries Safety Handbook). Furthermore, Normandeau field staff have completed the U.S. Fish and Wildlife Service's course on Principles and Techniques of Electrofishing (CSP2201), offered through the National Conservation Training Center.

SGS AXYS will use their Method MLA-110 (comparable to EPA Method 1633) to measure PFAS concentrations in the surface water, fish, shellfish, and invertebrate samples collected in the field. Laboratory personnel will be qualified to perform the analysis according to the method requirements, according to specifications in this QAPP, and according to the laboratory's internal method competency requirements. This project does not require any mandatory certifications for laboratory chemists, but SGS AXYS holds accreditations through the National Environmental Laboratory Accreditation Program, the Canadian Association for Laboratory Accreditation, and the Department of Defense Environmental Laboratory Accreditation Program.

2.7 Health and Safety

Normandeau field sampling crews will follow Normandeau's corporate Health and Safety Plan (HASP). That HASP covers general safety and operational guidelines (e.g., personal protective equipment, first aid, safety equipment); specific safety measures for boating safety, electrical safety, field safety, and hot/cold weather conditions; and emergency procedures for three different types of electrofishing equipment: 1) electrofishing boat; 2) towed electrofishing barge; and 3) backpack electrofishing unit.
All field sampling personnel, whether from Normandeau or ERG, will be required to read and adhere to the HASP if supporting or overseeing sampling activities in the field.

SGS AXYS has its own HASP that must be followed when receiving, handling, analyzing, and discarding environmental samples.

2.8 Documents and Records

This project will generate multiple types of documents and records, including (1) records generated in the field during sampling activities (see Section 2.8.1); (2) records generated by the laboratory during analysis of samples (see Section 2.8.2); and (3) additional documents and records maintained by the ERG project management team for contract management and other purposes. Clear, thorough, and complete documentation is required for all three types of records. All documentation related to sampling, lab analyses, and supporting data will be provided to MassDEP at the end of the project.

2.8.1 Field Documentation

Field sampling will generate three types of records, described below.

Field Sheets and Field Logbooks

Field sampling personnel will use field sheets provided by MassDEP WPP to document general site conditions and other information on the samples collected at each location. The team will use specific field sheets to document conditions at freshwater and coastal locations and for the various types of environmental samples to be collected as part of this program. Section 4.0 of the SAP includes detailed instructions on how to populate the various field sheets and sample logs. These include:

- River/Stream Sampling Location Field Sheet
- Lake/Pond or Coastal Sampling Location Field Sheet
- Surface Water Sample Log
- Fish Sample Log
- Shellfish Sample Log
- Invertebrate Sample Log

Prior to every sampling event, Normandeau will assign which field team member is responsible for (1) completing the field sheets while the team is collecting samples in the field and (2) documenting further information when the team is processing samples at Normandeau's facility in Bedford, New Hampshire (NH). Another team member will be responsible for reviewing the field sheets, and this review will take place as soon as possible after the field sampling event, preferably on the same day. Once Normandeau has finished reviewing the field sheets for a given sampling event, they will scan the forms into PDF and either email them to the ERG data manager or upload them to a designated folder on ERG's password-protected project SharePoint site.

We expect all field sampling documentation will occur on the project-specific field sheets. However, if observations cannot be documented on the field sheets, the field personnel will document additional observations on loose plain paper in an aluminum clipboard. Field personnel will follow standard documentation practices for these sheets (e.g., sequentially numbering pages, using legible handwriting in ink, using the unique identification numbers when referring to specific samples, and noting the dates and times of all observations). Due to the potential for PFAS cross-contamination, field sampling crews will use PFAS-free pens, and they will not use any waterproof/treated paper or field books.

Photographs

At every sampling location, photographs will be taken to record sampling activities, general site conditions, and location-specific features. At each location, field sampling crews will take at least one photograph of the site conditions (e.g., weather, water surface) and at least one photograph of sampling activity (e.g., fishing, shellfishing, collecting surface water, or collecting invertebrates). Multiple photos are preferred at each site. High quality photographs will be taken in digital format, either using a cell phone or a camera. Field

personnel will upload the electronic files to ERG's SharePoint site on the same day that photographs are taken.

Chain-of-Custody Forms and Shipping Forms
Chain-of-custody (COC) forms will be used to document collection, retention, storage, and transfer of samples. These forms will also contain information on the requested laboratory analyses. A copy of this project's COC forms is included as an appendix to the SAP. Before shipping samples to SGS AXYS, Normandeau will scan the COC forms that they prepared and email to the ERG data manager for review. SGS AXYS will include the final COC forms in the analytical reports that are submitted to MassDEP. ERG will retain copies of all final COC forms until the project is completed.

2.8.2 Laboratory Documentation

SGS AXYS will generate two types of records, as described below. These files will be emailed to the ERG data manager and saved to the project SharePoint site, which will be accessible to MassDEP.

Analytical reports
SGS AXYS will provide reports that contain quantitative results, units, MDLs, dilution factors, and qualifier flags. The reports will also include case narratives, a crosswalk of laboratory and client sample IDs, and results for all QC parameters. These reports, by default, are typically in PDF format.

Electronic data deliverables (EDDs)
SGS AXYS will provide EDDs with analytical results and QC results in the MassDEP format specified for this project and including all required fields for WPP's EQuIS database. SGS AXYS will send the results and QC results in the same spreadsheet. ERG will then separate the two different types of results (i.e., one spreadsheet in an Excel workbook will have results for field samples and another spreadsheet will have results for QC data). SGS AXYS will include the data elements listed in Table 9 in their EDDs for this project. Note that fields flagged as "conditional" (e.g., lab qualifiers) are not required for every sample and will only be entered when certain conditions are met (e.g., a laboratory qualifier is only included if the sample result requires one).

Table 9. Required Data Elements for Laboratory EDDs

Data Elements	Description	Required or Conditional
SAMPLE_NO	Sample description (e.g., sample ID, blank)	Required
AXYS_ID	Lab sample ID	Required
ANALYSIS_DATE	Lab analysis date	Required
COMPOUND	Analytical target	Required
CAS_NO	CAS RN for analytical target	Required
LAB_FLAG[1]	Laboratory qualifier	Conditional

Data Elements	Description	Required or Conditional
CONC_FOUND	Result (numeric)	Required
DETECTION_LIMIT	Reporting limit	Required
UNIT	Unit of CONC_FOUND and DETECTION_LIMIT	Required
SAMPLE_SIZE	Size of the sample analyzed	Required
SAMPLE_SIZE_UNIT	Unit of the sample size	Required
EXTRACTION_DATE	Extraction date	Required
RECEIVED_DATE	Date the lab received the sample	Required
COLLECTION_DATE	Date the sample was collected	Required
PROJECT_ID	SGS AXYS assigned project ID	Required
MATRIX	Analysis matrix	Required
METHOD	Analysis method	Required
WORKGROUP	Workgroup (i.e., batch)	Required
SAMPLE_TYPE	Field sample, one spiked matrix (OPR), method blank (MB), certified reference material (CRM)	Required
ANALYTE_TYPE	Indicates regular (reg) or surrogate (surr)	Required

[1]SGS AXYS Laboratory qualifiers include: "U"=not detected; "J"=detected below the practical limit of quantitation; "B"=analyte found in sample and associated blank; "N"=authentic recovery not within the method control limits; "V"=surrogate recovery not within the method control limits; "E"=exceeds calibrated linear range; and "NQ"=data not quantifiable.

3.0 Data Generation

3.1 Sampling Design

This section documents decisions made regarding the project's overall sampling design and presents the rationale for each decision. All sampling design decisions were made to ensure PFAS measurement data will meet this project's principal objective: to characterize the nature and extent of PFAS contamination in water, fish, shellfish, and invertebrates in Massachusetts fresh and coastal waters. The goal is to generate data that can be used to assess the health of aquatic life at freshwater locations and better understand human health risks associated with consumption of fish and shellfish from coastal locations.

3.1.1 Selected Sampling Locations

This section presents 30 proposed sampling locations and the criteria that ERG used to select them. This includes 20 coastal locations, 10 freshwater locations, and 21 backup locations. Ten percent of waterbodies were selected as "reference" locations (i.e., areas assumed to have no or limited nearby PFAS sources). The remainder of this section describes the approach used to select sampling locations, first for freshwater and then for coastal sampling locations.

Freshwater Sampling Locations

ERG used the data it had previously compiled to support site selection for MassDEP's 2022 "PFAS in Freshwater and Fish Tissue" project to identify a subset of waterbodies in Massachusetts that are suitable candidates for the current project (MassDEP, 2022). For that 2022 effort, the project team compiled and reviewed data from MassWildlife's "GoFishMA!" database, the PFAS Interagency Task Force's 2022 report titled "PFAS in the Commonwealth of Massachusetts*"* EPA's PFAS Analytic Tools web application (EPA, 2024b), the USGS StreamStats web application, the Massachusetts Executive Office of Energy and Environmental Affairs' (EEA's) environmental justice (EJ) census block designations, and additional research findings for individual waterbodies (MassWildlife, 2024; PFAS Interagency Task Force, 2022; EPA, 2024b; USGS, 2024; MassGIS, 2021). Specifically, ERG first extracted data for the 526 waterbodies contained within MassWildlife's "GoFishMA!". ERG then developed a GIS database of known and suspected PFAS sources to inform the site selection process and used the locations of those sources to assign a "PFAS Score" to each waterbody from "GoFishMA!". ERG assigned "PFAS scores" based on proximity to known or suspected PFAS sources, with higher scores indicating a higher potential for PFAS contamination[2]. The score was calculated based on the total number of sources located within a 2-mile radius of the waterbody, with "known sources" given a weighting factor of three and "suspected sources" given a weighting factor of one. The "PFAS Score" was calculated as the sum of scores from all sources within the 2-mile radius. ERG then reviewed each waterbody by order of decreasing PFAS Score using the USGS StreamStats web application to determine whether any of the PFAS sources located within a 2-mile radius fell within the drainage basin of the waterbody. ERG did this for the nearly 150 waterbodies that had a PFAS score greater than zero and found 29 waterbodies with a known or suspected PFAS source in their drainage basin. As part of this effort, ERG also determined whether each location was within one a mile radius of an EJ census block, as defined by EEA, and identified the watershed and MassDEP region of each location. Additional information on this methodology is provided in MassDEP (2022).

For the current project, ERG started with the same universe of 526 waterbodies identified for MassDEP's 2022 "PFAS in Freshwater and Fish Tissue" and the information that was compiled for those waterbodies as part of that project (e.g., "PFAS Scores, MassDEP regions, watersheds, proximity to EJ census blocks). ERG sought to select two or three waterbodies within each of the four MassDEP regions for sampling. To achieve this, we first

[2] Known sources include (1) sources listed in Appendix G of the Final Report of the PFAS Interagency Task Force, titled PFAS in the Commonwealth of Massachusetts and issued on April 20, 2022 and (2) sites or locations with known PFAS contamination from EPA's PFAS Analytic Tool, including superfund sites with reported PFAS detections, federal locations with known or suspected PFAS contamination, spill locations reported to the National Response Center referencing aqueous film forming foam, facilities reporting onsite released of PFAS to EPA's Toxic Release Inventory. Suspected sources included commercial service airports in the mainland Commonwealth, a subset of municipal or combined wastewater treatment plants, municipal solid waste landfills, sites that are accepting diverted food materials, and sites or locations with suspected PFAS contamination from EPA's PFAS Analytic Tool, including historic and current manufacturers of PFAS and facilities generating or receiving Resource Conservation and Recovery Act waste containing PFAS).

separated waterbodies by MassDEP region (i.e., West, Central, Northeast, and Southeast). One site, Studleys Pond in the Southeast region, was selected for resampling from MassDEP's 2022 project due to the high levels of PFAS detected in fish tissue. All other waterbodies sampled in the MassDEP 2022 project were excluded from consideration here. That left 89 waterbodies in the Central region, 71 waterbodies in the Northeast region, 144 in the Southeast region, and 153 in the West region for consideration. To select sites that are more likely to be impacted by PFAS contamination, we then excluded sites with a PFAS score of 0, which led to 30 candidate locations in the Central region, 35 in the Northeast region, 50 in the Southeast region, and 34 in the West region.

The remaining sites from each region were then sorted by PFAS score, and sites with the five highest PFAS scores in each region were grouped into a list of 20 candidate locations. Each of these locations was then assessed for suitability for sampling for this program. Factors such as accessibility for field crews, proximity to EJ census blocks, and geographic coverage across the state were considered. We also ensured that all freshwater sampling locations are outside of the tidal zone, fall within an existing MassDEP freshwater assessment unit (AU), are not routinely sampled for mercury by MassDEP, were not sampled previous for PFAS analysis by MassDEP or DPH (with the exception of Studleys Pond), and are not located on Martha's Vineyard or Nantucket (due to logistical constraints). After applying these criteria, eight sites near areas of known or suspected PFAS contamination and six alternate sites remained.

Separately, ERG identified two freshwater reference locations (one lake and one river, both located in the West region). To do so, we first limited the list of possible locations to those in the West region with a PFAS score of 0 (n=118 locations). We then sorted those sites by population within a one-mile radius and prioritized sites with the lowest surrounding population density. After considering other factors, such as shoreline and proximal development (from aerial imagery), inclusion in other sampling programs, and access, we selected one reference lake and one reference river. We also identified three additional alternate reference locations.

The 10 freshwater locations that ERG proposes for sampling include two waterbodies in the Central region, two in the Northeast region, three in the Southeast region, and three in the West region. The waterbodies fall within eight different watersheds and are evenly split into lakes/rivers and ponds/lakes. Seventy percent of the waterbodies are within two miles of a designated EJ census tract. Table 10 presents characteristics of the ten waterbodies that ERG proposes for sampling, and presents similar information for the nine alternate waterbodies. The locations of the ten proposed (and alternate) freshwater sampling sites are shown in **Table 10** and **Table 11.** All locations are also shown in Figure 1.
None of the alternate locations (Table 11) were sampled.

Table 10. Proposed Freshwater Sampling Locations

# on Fig 1	Project Phase	Waterbody Name (town)	AU ID[1]	Approx. Lat.	Approx. Long.	MassDEP Region	Watershed	Type	Boat Access	PFAS Impact[2]	Ref	EJ[3]
1	1	Charles River	MA72-05	42.15789	-71.3318	Central	Charles	Stream or river	Canoe	9	No	No
2	1	Merrimack River	MA84A-01	42.64163	-71.378	Northeast	Merrimack	Stream or river	Paved ramp	4	No	Yes
3	1	Johns Pond (Carver)	MA62096	41.90727	-70.7854	Southeast	Taunton	Lake or pond	Gravel ramp	4	No	Yes
4	1	Sheomet Lake	MA35074	42.67784	-72.2829	West	Millers	Lake or pond	None	0	Yes	Yes
5	2	Spectacle Pond (Lancaster)	MA81132	42.5128	-71.6829	Central	Nashua	Lake or pond	Cartop	3	No	Yes
6	2	Lake Gardner	MA84018	42.8617	-70.941	Northeast	Merrimack	Lake or pond	None	3	No	Yes
7	2	Canoe River	MA62-65/ MA62-66	41.9738	-71.1384	Southeast	Taunton	Stream or river	None	5	No	No
8	2	Studleys Pond[4]	MA94151	42.12043	-70.9184	Southeast	South Coastal	Lake or pond	None	2	No	Yes
9	2	Powdermill Brook	MA32-09	42.13674	-72.7379	West	Westfield	Stream or river	None	5	No	Yes
10	2	Green River (Leyden)	MA33-28	42.66872	-72.6356	West	Deerfield	Stream or river	None	0	Yes	No

[1] MassDEP assessment unit ID, as defined here: https://www.mass.gov/info-details/massgis-data-massdep-2022-integrated-list-of-waters-305b303d.

[2] Number of known or suspected sources of PFAS contamination within a two-mile radius.

[3] Within a two-mile radius of an EJ census block, as defined by the Massachusetts Executive Office of Energy and Environmental Affairs.

[4] Repeat location from 2022 PFAS study for comparison purposes

The exact latitudes and longitudes of these sites may differ for the purpose of the final report due to using the approximate centroid for each waterbody.

Table 11. Proposed Freshwater Sampling Location Alternates

# on Fig 1	Waterbody Name (town)	AU ID[1]	Approx. Lat.	Approx. Long.	MassDEP Region	Watershed	Type	Boat Access	PFAS Impact[2]	Ref	EJ[3]
B1	Merino Pond	MA42036	42.05028	-71.8996	Central	French	Lake or pond	None	3	No	Yes
B2	Brookline Reservoir	MA72010	42.32696	-71.1363	Northeast	Charles	Lake or pond	None	7	No	Yes
B3	White Pond	MA82118	42.42821	-71.3906	Northeast	Concord	Lake or pond	Yes	3	No	No
B4	Clapps Pond	MA96035	42.05266	-70.2113	Southeast	Cape Cod	Lake or pond	None	3	No	Yes
B5	Fourmile Brook	MA34-56	42.62093	-72.4658	West	Connecticut	Stream or river	None	1	No	No
B6	Lake Lorraine	MA36084	42.14581	-72.5137	West	Chicopee	Lake or pond	None	2	No	Yes
B7	Prospect Lake	MA21084	42.19502	-73.4522	West	Housatonic	Lake or pond	Yes	0	Yes	No
B8	Shaw Pond	MA31036	42.25163	-73.1231	West	Farmington	Lake or pond	Yes	0	Yes	No
B9	Deerfield River	MA33-02	42.61943	-72.7637	West	Deerfield	Stream or river	None	0	Yes	Yes

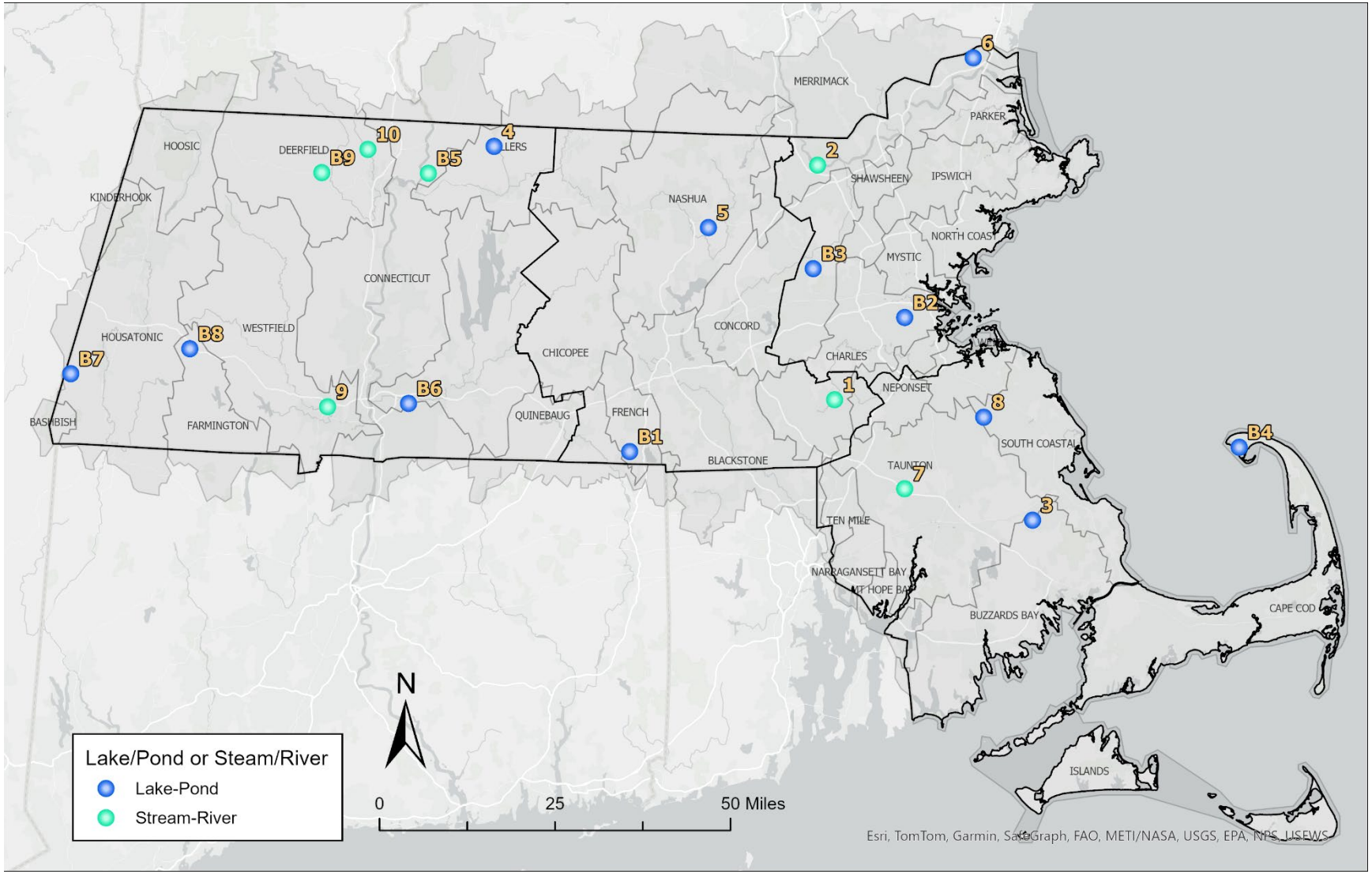
[1] MassDEP assessment unit ID, as defined here: https://www.mass.gov/info-details/massgis-data-massdep-2022-integrated-list-of-waters-305b303d.

[2] Number of known or suspected sources of PFAS contamination within a two-mile radius.

[3] Within a two-mile radius of an EJ census block, as defined by the Massachusetts Executive Office of Energy and Environmental Affairs.

None of these alternate locations were sampled as part of this project.

Figure 1. Proposed and Alternate Freshwater Sampling Locations



Coastal Sampling Locations

ERG selected sites for coastal sampling based primarily on the following criteria:

- Sites must be distributed across the Massachusetts coastline, based on five regions identified by the Massachusetts Office of Coastal Zone Management (CZM) (CZM, 2024).
- Sites should represent locations where coastal recreational fishers are known to collect fish and/or shellfish, with reasonable confidence. (Note: This project is not targeting fish typically caught via recreational vessels in deeper waters.) Sites must allow for shellfish and diadromous or marine finfish to be collected within a reasonable distance (roughly within one mile) of one another. Note that the Boston Harbor CZM region has no areas where recreational shellfishing is permitted. For this region, we therefore selected three sites with high fishing pressure where we will plan to collect only fish, unless special permission is granted by DMF to also collect shellfish.
- Sites must be accessible to the sampling team (i.e., parking lots are within reasonable walking distance of coastal access points and/or sites can be easily accessed by boat).

ERG started by compiling popular fishing locations from MassWildlife's GoFishMA! database of fishing access points and DFG's Office of Fishing and Boating Access (OFBA) database of boat ramps and fishing piers. We identified 75 popular fishing locations within a half-mile of the coast from the OFBA database and 61 sites from the GoFishMA database (MassWildlife, 2024; OFBA, 2024). ERG then excluded sites located along or off the coast of Massachusetts islands (e.g., Nantucket, Martha's Vinyard) and any sites that were freshwater ponds or lakes near the coastline; we then removed duplicate entries from the OFBA and GoFishMA! databases. This resulted in 63 candidate fish sampling locations along the Massachusetts coastline, including some in each of the CZM regions: 12 are located in the North Shore region, 10 in the Boston Harbor region, 4 in the South Coastal region, 21 on the Cape Cod and Islands region, and 16 in the South Coast region.

ERG then assessed each site for nearby shellfishing suitability and popularity and proximity to other potential sampling sites in the region. To support this assessment, ERG relied on resources such as the 302 shellfish classification area maps published by DMF (DMF, 2024); satellite imagery; and town shellfishing websites. Any sites without access to shellfish growing areas designated by DMF as either "approved" or "conditionally approved" were excluded to ensure that the project generates data to inform human health risks associated with consumption of recreationally caught shellfish. Note that this dramatically limited the number of potential sampling locations. Additionally, and as noted above, no sites in the Boston Harbor region met this criterion (i.e., shellfishing is not permitted in any candidate coastal location); in this region, we therefore proposed three popular fishing locations where we will only collect fish. In these locations, field teams will be directed to keep additional fish – since shellfish will not be collected and analyzed for PFAS from this area.

At this point, because of a limited number of viable sampling locations in certain areas of the coastline, ERG added sites identified from other sources to increase regional representation and ensure that the selected sites reflect popular shellfishing and fishing locations. ERG used the Massachusetts Shellfish Initiative 2020 Assessment Report's tally of recreational permits granted by coastal towns to prioritize sites in towns that granted the most recreational permits and that were not already represented in the GoFishMA and OFBA fishing access lists (DMI Assessment Committee, 2020). ERG also used information from tourism websites and online hobbyist resources that identify popular shellfishing locations in Massachusetts, such as the Buzzard's Bay Coalition website on shellfishing (Buzzards Bay Coalition, 2024) to further inform identification of popular fishing and shellfishing locations.

Using this approach, ERG selected 20 sites for coastal sampling of both fish and shellfish, listed in Table 12. These sites cover the five CZM regions and 15 are within 2 miles of an EJ census block. ERG also identified 12 alternate sites suitable for both fishing and shellfishing, as shown in Table 13. Figure 2 shows the proposed and alternate coastal sampling locations.

Note that ERG recognizes that another site selection criterion defined in MassDEP's Request for Quotes for this project was proximity to known or suspected PFAS sources. We explored several options for assessing this criterion for these coastal sites, however, given the limited nature of viable sampling locations (largely due to shellfishing restrictions), we focused on identifying locations where we have the greatest confidence that recreational fishers collect and keep fish and shellfish for consumption. Furthermore, assessing potential for PFAS contamination is challenging in marine and estuarine waters for many reasons. Because of this, and in agreement with MassDEP, ERG prioritized regional representation over areas of suspected or known areas of PFAS contamination. That said, many of the selected sites are located near large harbor areas or at the mouths of major rivers, where we expect to see PFAS impacts from upstream sources. Based on what is known about PFAS contamination, we designated two sampling locations as reference sites based on their distances from the outlets of major rivers, their distances from known or suspected inland sources of PFAS as mapped for MassDEP's 2022 "PFAS in Freshwater and Fish Tissue" project, and their minimal nearby residential or commercial coastline development.

Table 12. Proposed Coastal Sampling Locations

# on Fig 2	Project Phase	Site Name	Approx. Lat.	Approx. Long.	CZM Region	Shellfish Classification Area(s)	Watershed	Ref[1]	EJ
1	1	Deer Island Sportfishing Pier	42.3542	-70.9676	Boston Harbor	N/A	Mystic		Yes
2	1	Great Bay (Great Pond)	41.555	-70.583	Cape and Islands	SC8.0	Cape Cod		Yes
	1	**Bournes Pond[2]**	**41.56528**	**-70.55321**	**Cape and Islands**		**Cape Cod**		**Yes**
3	1	~~**Merrimack River (Joppa Flats)**~~ **Plum Island**	42.8063	-70.8576	North Shore	N3.0	Merrimack		Yes
4	1	Annisquam River (Corliss Landing)	42.6335	-70.6852	North Shore	N9.7	North Coast		Yes
5	1	Wareham River	41.750311	-70.7005	South Coastal	BB36.0	Buzzards Bay		Yes
6	**2** ~~1~~	Center Hill Preserve	41.8567	-70.5264	South Shore	CCB39.0	South Coastal	X	No
7	2	Fore River (Houghs Neck)	42.2717	-70.951	Boston Harbor	N/A	Weir		Yes
8	2	Castle Island[2]	42.3392	-71.0101	Boston Harbor	N/A	Charles		Yes
9	2	Megansett Harbor	41.6567	-70.6257	Cape and Islands	BB50.0	Cape Cod		Yes
10	2	Barnstable Harbor (Blish Point)/ Maraspin Creek	41.7079	-70.2993	Cape Cod and Islands	CB31.2; CB31.0	Cape Cod		Yes
11	2	Rock Harbor	41.8006	-70.0066	Cape Cod and Islands	CCB9.0; CCB17.0	Cape Cod	X	Yes
12	2	Popponesset Beach Shore Fishing Area	41.5772	-70.458	Cape Cod and Islands	SC17.0; SC19.0	Cape Cod		No
13	2	Bass River	41.6606	-70.1861	Cape Cod and Islands	SC29.0	Cape Cod		Yes
14	2	Marblehead Harbor (Riverhead Beach/Devereux Beach)	42.4904	-70.8574	North Shore	N21.2	North Coast		Yes
15	2	Pavilion Beach	42.6977	-70.7917	North Shore	N4.0	Parker	X	No
16	2	Apponagansett Bay	41.5853	-70.9459	South Coastal	B12.0	Buzzards Bay		Yes
17	2	Little Harbor	41.72602	-70.675	South Coastal	BB37.0	Buzzards Bay		Yes
18	2	Cole River	41.72658	-71.2232	South Coastal	MHB4.1	Mt Hope Bay		No
19	2	Plymouth Harbor	41.9632	-70.6424	South Shore	CCB42.0; CCB41.0	South Coastal		Yes

# on Fig 2	Project Phase	Site Name	Approx. Lat.	Approx. Long.	CZM Region	Shellfish Classification Area(s)	Watershed	Ref[1]	EJ
B10	2	Back River/Duxbury Beach[3]	42.04192	-70.64600	South Shore	CCB47.0	South Coastal		No
~~20~~	~~2~~	~~South River[4]~~	~~42.1379~~	~~-70.6898~~	~~South Shore~~	~~MB4.0; MB6.1~~	~~South Coastal~~		~~No~~
B12	2	Westport River[3]	41.51650	-71.08153	South Coastal	BB3.0	Buzzards Bay		No
B7	2	Lewis Bay[3]	41.63050	-70.25224	Cape and Islands	SC28.0	Cape Cod		Yes
B6	2	Allen Harbor[3]	41.66292	-70.08910	Cape and Islands	SC37.0	Cape Cod		Yes
B9	2	Buttermilk Bay[3]	41.74630	-70.623451	Cape Cod and Islands	BB44.0	Buzzards Bay		Yes
B4	2	Mill Creek[3]	41.67523	-70.02006	Cape Cod and Islands	SC44.0; SC42.0	Cape Cod		Yes
B1	2	Sesuit Harbor[3]	41.756	-70.153	Cape and Islands	CCB23.0	Cape Cod		Yes

[1]Reference sites are relatively remote areas of coastline further away from the mouths of large rivers and away from identified inland known or suspected sources of PFAS.

[2]Bournes Pond is near Great Bay/Great Pond. Shellfishing was prohibited in Great Bay/Great Pond at the time of sampling, so we collected shellfish from Bournes Pond.

[3]These sites were added from the list of alternate locations to achieve the target sample counts and based on ability to fit more sites into the project budget.

[4]South River was removed from the sampling list as the Shellfish Constable indicated that shellfishing was closed at that location. An alternate was chosen where both shellfish and fish could be collected at the same time.

Note that the final latitudes and longitudes in the final report may differ based on field-collected latitudes and longitudes for different media.

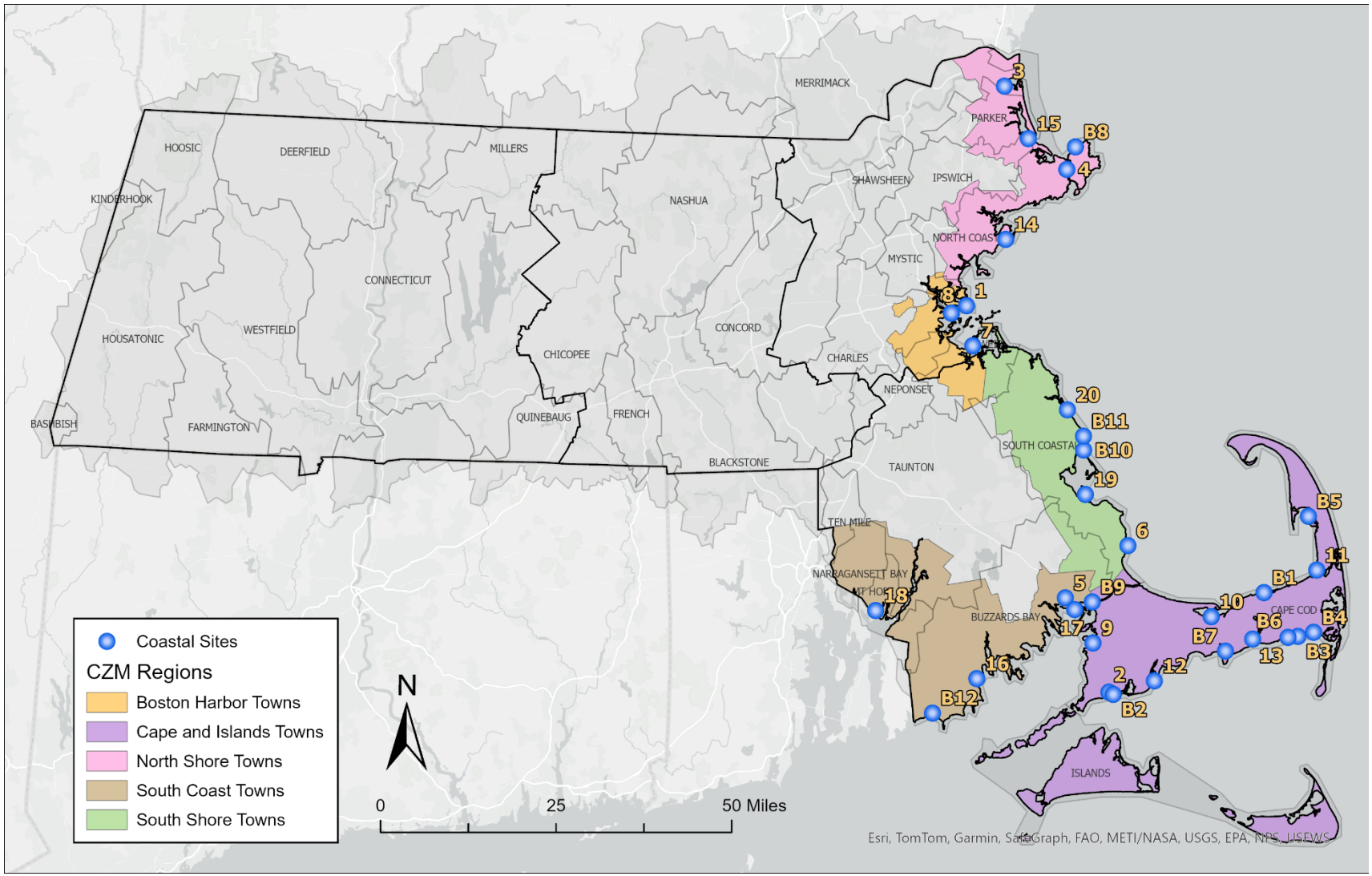
Table 13. Coastal Sampling Location Alternates

# on Fig 2	Site Name	Approx. Lat.	Approx. Long.	CZM Region	Shellfish Classification Area(s)	Watershed	Ref[1]	EJ
~~B1~~	~~Sesuit Harbor~~	~~41.756~~	~~-70.153~~	~~Cape and Islands~~	~~CCB23.0~~	~~Cape Cod~~		~~Yes~~
B2	Green Pond	41.5503	-70.5713	Cape and Islands	SC8.0	Cape Cod		Yes
B3	Saquatucket Harbor	41.6646	-70.0615	Cape and Islands	SC37.0	Cape Cod		Yes
~~B4~~	~~Mill Creek~~	~~41.6725~~	~~-70.018~~	~~Cape Cod and Islands~~	~~SC44.0; SC42.0~~	~~Cape Cod~~		~~Yes~~
B5	Wellfleet Harbor	41.9118	-70.027	Cape and Islands	CCB11.0	Cape Cod	X	No
~~B6~~	~~Allen Harbor~~	~~41.6629~~	~~-70.0888~~	~~Cape and Islands~~	~~SC37.0~~	~~Cape Cod~~		~~Yes~~
~~B7~~	~~Lewis Bay (Englewood Beach)~~	~~41.6366~~	~~-70.2615~~	~~Cape and Islands~~	~~SC28.0~~	~~Cape Cod~~		~~Yes~~
B8	Lanes Cove	42.6798	-70.6604	North Shore	N10.0	North Coast		No
~~B9~~	~~Buttermilk Bay~~	~~41.7414~~	~~-70.6264~~	~~Cape Cod and Islands~~	~~BB44.0~~	~~Buzzards Bay~~		~~Yes~~
~~B10~~	~~Back River/Duxbury Beach~~	~~42.0547~~	~~-70.6459~~	~~South Shore~~	~~CCB47.0~~	~~South Coastal~~		~~No~~
B11	Green Harbor	42.0833	-70.646	South Shore	MB2.0	South Coastal		No
~~B12~~	~~Westport River~~	~~41.51469~~	~~-71.0681~~	~~South Coastal~~	~~BB3.0~~	~~Buzzards Bay~~		~~No~~

[1]Reference sites are relatively remote areas of coastline further away from the mouths of large rivers and away from identified inland known or suspected sources of PFAS.

Sites that have a strike through were moved to Table 12 because they were sampled during this project.

Figure 2. Proposed and Alternate Coastal Sampling Locations



3.1.2 Targeted Species

This section lists the species targeted for sampling, which will appear on our scientific collection permits. These lists are intentionally inclusive so as not to limit our field crews in their ability to achieve successful catches.

3.1.2.1 Fish Species

At each freshwater location, field crews will collect up to eight legal-sized fish (target of four fish per waterbody for each of two species); for each species, two will be analyzed as whole fish and two will be prepared and analyzed as boneless-skinless fillets. Table 14 lists the freshwater fish species that the field team may collect for this project. If fish from more than the target number of species are collected, the sampling team will keep the species caught with the greatest numbers and release the others.

Table 14. Targeted Freshwater Fish Species

Family Name	Common Name	Scientific Name
Alosidae	American shad	*Alosa sapidissim*
	Blueback herring	*Alosa aestivali*
Anguillidae	American eel	*Anguilla rostrata*
Catostomidae	White sucker	*Catostomus commersonii*
	Longnose sucker	*Catostomus catostomus*
	Creek chubsucker	*Erimyzon oblongus*
Centrarchidae	Largemouth bass	*Micropterus salmoides*
	Smallmouth bass	*Micropterus dolomieu*
	Black crappie	*Pomoxis nigromaculatus*
	Redbreast sunfish	*Lepomis auritus*
	Bluegill	*Lepomis macrochirus*
	Pumpkinseed	*Lepomis gibbosus*
Cyprinidae	Common carp	*Cyprinus carpio*
	Common Dace	***Leuciscus leuciscus***
	Fallfish	*Semotolus corporalis*
	Golden shiner	*Notemigonus crysoleucas*
	Common shiner	*Luxilus cornutus*
	Spottail shiner	*Notropis hudsonius*
	Creek chub	*Semotilus atromaculatus*
Esocidae	Chain pickerel	*Esox niger*
	Northern pike	*Esox Lucius*
Ictaluridae	Brown bullhead	*Ameiurus nebulosus*
	Yellow bullhead	*Ameiurus natalis*
	Black bullhead	*Ameiurus melas*

Family Name	Common Name	Scientific Name
	White catfish	*Ameirus catus*
Moronidae	White perch	*Morone americana*
Percidae	Yellow perch	*Perca flavescens*
	Walleye	*Stizostedion vitreum*
Salmonidae	Brook trout	*Salvelinus fontinalis*
	Brown trout	*Salmo trutta*
	Rainbow trout	*Oncorhynchus mykiss*

At each coastal location, field staff will collect up to six legal-sized fish (target of two fish per waterbody for each of three target species, prepared as skinless, boneless fillets). Coastal sampling will focus on fish that people are most likely to consume. Table 15 lists the coastal fish species that the field team may collect for this project. If fish from more than the target number of species are collected, the sampling team will keep the species caught with the greatest numbers and release the others. For both freshwater and coastal locations, the field crew will sample until the maximum number of fish for a given waterbody is collected or they will sample for four hours, whichever comes first.

Table 15. Targeted Coastal Fish Species

Family Name	Common Name	Scientific Name
Alosidae	American shad	*Alosa sapidissim*
Anguillidae	American eel	*Anguilla rostrata*
Alosidae	**Atlantic menhaden/peanut bunker**	***Brevoortia tyrannus***
Labridae	Tautog	*Tautoga onitis*
	Cunner	***Tautogolabrus adspersus***
Lophiidae	Monkfish	*Lophius piscatorius*
Merluccidae	**Silver hake/whiting**	***Merluccius bilinearis***
Moronidae	White perch	*Morone americana*
	Striped bass	*Morone saxatilis*
Osmeridae	Rainbow smelt	*Osmerus mordax*
Paralichthyidae	Summer flounder	*Paralichthys dentatus*
Pleuronectidae	Plaice	*Hippoglossoides platessoides*
	Winter flounder	*Pseudopleuronectes americanus*
	Yellow tail flounder	*Limanda ferruginea*
	Grey sole	*Glyptocephalus cynoglossus*
Pomatomidae	Blue fish	*Pomatomus saltatrix*
Rajidae	**Little Skate**	***Leucoraja erinacea***
Sciaendae	Weak fish	*Cynoscion regalis*
Scombridae	Atlantic mackerel	*Scomber scombrus*
	Atlantic bonito	***Sarda sarda***
Serraninae	Black sea bass	*Centropristis striata*

Sparidae	Scup	*Stenotomus chrysops*
Squalidae	**Smooth dogfish**	***Mustelus canis***
Triglidae	**Striped sea robin**	***Prionotus evolans***

3.1.2.2 Shellfish Species

At each coastal location, the field crew will collect up to 15 shellfish across up to three different target species, and composite samples will be prepared from shellfish of the same species. The list of targeted shellfish species is intentionally inclusive to increase the likelihood of a successful catch, and it focuses on species most likely to be collected by recreational fishers. Table 16 lists the target shellfish species.

Table 16. Targeted Shellfish Species

Family Name	Common Name	Scientific Name
Mydae	Soft shell clam	*Mya arenaria*
Veneridae	Quahog	*Mercenaria mercenaria*
Mytilidae	Blue mussel	*Mytilus edulis*
Ostreoidea	Oyster	*Crassostrea virginica*
Echinidae	Sea urchin	*Lytechinus variegatus*
Buccinidae	Channeled whelk	*Busycotypus canaliculatus*
	Knobbed whelk	*Busycon carica*
Pharidae	Razor clam	*Ensis leei*
Mactridae	Surf clam	*Spisula solidissima*
Pectinidae	Bay scallop	*Argopecten irradian`*

3.1.2.3 Invertebrate Types

At each freshwater location, invertebrates will be collected and prepared as composite samples. Due to the mass required for PFAS analysis and to minimize handling of samples, field crews will sort organisms in the field, to the extent possible and by the naked eye, into classes of (1) aquatic insects, (2) crustaceans (crayfish only), and (3) gastropods (snails and clams) – and ideally attempt to collect two composite samples for each of these three classes at every location. Additional classes will be considered on a case-by-case basis depending on what it encountered in the field. ERG will communicate with the MassDEP Project Lead on what is caught in the field and what should be kept, especially during Phase 1 sampling activities. Approaches will be revisited for Phase 2 based on experiences and lessons learned from Phase 1.

If only one category is encountered (e.g., aquatic insects) at a given location, field teams will attempt to collect multiple composite samples of insects. If total catch abundance is so low that no category would achieve five grams of sample on its own, field teams will combine all collected organisms into a sample that represents “combined benthic invertebrates.” These procedures will increase the likelihood of a successful sampling event while still generating data that meet the project’s primary objectives. In cases of low

total catch abundance, the collection of the minimum sample mass for all invertebrate samples will take priority over taxonomic sorting of the invertebrates.

3.1.3 Sampling Methods

This section describes the sampling and processing methods for each media. More detailed procedures are described in Section 3.6 the SAP, which is included as Attachment A to this QAPP. At all sites, field sampling crews will collect samples for a period of up to eight hours (i.e., roughly four hours for fish and four hours for invertebrates at freshwater locations, and four hours for fish and four hours for shellfish at coastal sampling locations).

3.1.3.1 Fish Sampling and Processing

Freshwater fish will be sampled from 10 locations across Massachusetts. The selected sites will have varying size, access, and ecological characteristics, which will determine the fishing methods used at each waterbody. For example, at larger lakes and rivers with boat ramps, we will use an electrofishing boat to collect fish samples. At smaller ponds and streams, we will use hook-and-line angling or backpack electrofishing. At each freshwater site, we will aim to collect four fish for two species. If other fish are collected during sampling, they will be humanely returned to the waterbody before the field sampling crew leaves the site.

After sample collection is complete, the fish will be placed into individual PFAS-free LDPE bags and transported in coolers on ice to the Normandeau facility in Bedford, New Hampshire, where Normandeau staff will process the fish. Processing will involve weighing and measuring the length of each fish with PFAS-free equipment; and the equipment will be decontaminated between processing each sample. Two fish of each species will be wrapped with PFAS-free aluminum foil and placed into PFAS-free LDPE bags as whole fish, labeled, and frozen. The other two fish of each species will be skinned and filleted. Field staff will wrap the fillet in separate sheets of PFAS-free aluminum foil, and then place each foil-wrapped fish into a separate PFAS-free LDPE bag. These bags will be labeled and frozen, after which Normandeau will ship them to SGS AXYS on ice (<6° C).

Note that at freshwater sites, the field crew will collect fish before sampling for invertebrates. They will spend up to four hours fishing before collecting invertebrate samples. If they are not able to catch the target number of fish within the four-hour time period, they will call the ERG project manager and arrive at a joint decision on whether to continue fishing at that waterbody on the same day, return to that waterbody on another day, or select an alternate sampling site to be visited on another day.

Fish will also be collected from the 20 coastal sampling locations. For these sites, we anticipate using hook-and-line angling from docks, piers, boats, or the shoreline (depending on the site), but we may use additional methods, such as seines, at the discretion of Normandeau and when appropriate. At each coastal site, we will aim to collect up to six fish

for up to three species (i.e., two fish from each of three species). If fish from more than the target number of species are collected, the sampling team will keep the species caught with the greatest numbers and release the others. After sample collection is complete, the fish will be placed into individual PFAS-free LDPE bags and transported in coolers on ice to the Normandeau facility. There, they will be processed into boneless-skinless fillets and prepared for shipment following the approach described above for freshwater fillets. Once frozen, Normandeau staff will ship the fillets to SGS AXYS on ice (<6° C).

Note that at coastal sites, the order of fishing and shellfishing will depend on the tidal schedule. Shellfish must be collected at low tide while fish can be collected at any time. If the field sampling crew does not catch the target number of fish or shellfish over an approximate four-hour time period for which ever environmental media they begin with, they will call the ERG project manager before continuing to attempt to collect samples for the other environmental media. They will jointly decide whether they should continue sampling at the coastal location, return to the same coastal location on another day, or select an alternate coastal sampling location to be visited on another day.

3.1.3.2 Shellfish Sampling and Processing

Normandeau will select shellfish species based on site conditions, known local species, and field observations. Shellfish will be collected using methods appropriate to the targeted species (e.g., clam rakes, shovels, hands) and during low tide. At each location, the field crew will collect a maximum of 15 shellfish to be composited into a maximum of three samples, each comprised of three to five organisms of the same species. The field crew will aim to collect samples of three different species of shellfish. Normandeau will release any excess shellfish caught back into the environment from which they were collected. A maximum of four hours will be dedicated to shellfishing.

Shellfish will be placed in PFAS-Free LDPE bags and placed in a cooler on ice for transport to the Normandeau facility in Bedford for processing. Each shellfish will be weighed and measured before shucking for edible portions. Mussels and clams will be shucked with a shucking knife. For sea urchins, scissors will be used to remove the beak, after which the shell will be pried apart, and the gonads will be removed and rinsed. Normandeau will process all shellfish specimens of a single species before processing the next shellfish species. The edible tissue from the individual shellfish used in a composite will be combined into a single HDPE jar provided by SGS AXYS and labeled. Between composites, all processing equipment will be decontaminated with PFAS-free DI water. Each composite sample will be weighed and must be at least 5 grams (ideally, 15 grams) before being sent to the analytical laboratory. Composite samples will be frozen on ice (<6° C) before shipment to SGS AXYS.

3.1.3.3 Invertebrate Sampling and Processing

Invertebrates will be collected primarily using D-frame kick-nets, though field crews may also use Ponar grab samplers in certain environments. At each location, field crews will wade into the water and aim to collect six composite invertebrate samples, each with a total mass of at least 5 grams, but ideally 15 grams. Field crews will sort and weigh invertebrates in the field, ideally grouping them by classes of (1) insects, (2) crustaceans, and (3) gastropods, provided sufficient sample mass is collected. As noted above, additional classes will be considered on a case-by-case basis depending on what is encountered in the field. The field crew will use a portable scale to weigh the collected invertebrates. The composite samples will then be placed on ice in a cooler for transport to Normandeau's Bedford, NH facility, where samples will be frozen completely before shipment on ice (<6° C) to SGS AXYS. Detailed procedures for collecting, sorting, and processing invertebrate samples are described in Section 3.6 of the SAP.

3.1.3.4 Surface Water Sampling

Field crews will collect one unfiltered surface water grab sample at each sampling location. At a given location, this sample will be collected in the immediate vicinity of where the first productive fishing activities occurred (i.e., the surface water sample will be co-located with the initial fish collection). The grab sample will be collected at a depth of 1 to 1.5 feet beneath the surface, and sediments will not be disturbed during sample collection.

All surface water samples will be collected in 500 and 60 mL HDPE bottles (two 500 ml and one 60 mL per sample) provided by the laboratory. The collected samples will be immediately placed on ice inside a cooler (<6° C). The field sampling crews will bring the surface water samples to the Normandeau office, document the samples, freeze them, and ship them on ice (<6° C) to SGS AXYS.

3.1.4 Criteria for a Successful Sampling Event

A waterbody will be considered successfully sampled if it meets the criteria laid out in this section. For freshwater locations, a site will be considered successfully sampled if the following criteria are met: (1) a surface water sample is collected and sent to the laboratory for analysis, (2) at least two fish of two species are sent to the laboratory for analysis and, (3) at least two composite invertebrate samples are sent to the laboratory for analysis. For coastal locations, a site will be considered successfully sampled if the following criteria are met: (1) a surface water sample is collected and sent to the laboratory for analysis, (2) at least three fish of one or more species are collected and sent to the laboratory for analysis, and (b) at least two shellfish composite samples are sent to the laboratory for analysis.

If these criteria are not met, ERG will notify MassDEP; proceed with all remaining Phase 1 and Phase 2 sampling; and return to as many waterbodies that project resources allow to collect additional samples. When resampling, ERG will examine the factors that led to unsuccessful sampling and determine if a site should be revisited or an alternate site should be chosen for sampling. (Note: The field sampling crew will spend up to eight hours

at every waterbody and collect as many fish, shellfish, and invertebrate samples as possible, up to the maximum quantities noted earlier.

3.1.5 Field Measurements Methods

In addition to collecting fish and surface water samples, field sampling crews will collect additional measurements at the 30 waterbodies. Following specifications in the SAP, they will:

- Record the GPS coordinates of where samples are collected using a handheld GPS.
- Use a fish measuring board to measure fish length and a digital scale to measure fish weight.
- Use a measuring board to measure shellfish length and width and a digital scale to weigh the shellfish.
- Use a portable digital scale to weigh the invertebrates in the field and again in the laboratory.
- Use a handheld multimeter to measure water conductivity where electrofishing is used.

The previous list documents measurements that field sampling crews will make. As described earlier, the field sampling crew will also identify fish species, take photographs, and document numerous observations on the sampling forms, but none of those activities involve taking additional measurements.

3.2 Sample Handling and Custody

Project surface water, fish, shellfish, and invertebrate samples will be handled in a consistent fashion; and they will only be handled by the members of the project team and by SGS AXYS. (We intend to use Federal Express to ship the samples, but they will not be "handling" them.) Immediately after collection at a waterbody, fish and shellfish will be put in sealable plastic bags provided by SGS AXYS, placed in coolers, and stored on ice. Invertebrates will be placed in 250-mL bottles and stored on ice and surface water will be put in 500-mL and 60-mL bottles provided by SGS AXYS and placed in coolers on ice. Field sampling crews will transport coolers from sampling locations to Normandeau's Bedford facility.

At the Bedford facility, samples will be processed as outlined in section 3.1.3 of the QAPP and described in detail in Section 3.6 of the SAP (e.g., sample measurements will be recorded, some fish will be filleted, and shellfish will be shucked and composited). Frozen samples will be shipped in coolers via overnight delivery to SGS AXYS. Water and fish fillet samples will be shipped to SGS AXYS' facility in British Columbia, Canada; and whole fish, shellfish, and invertebrate samples will be shipped to SGS AXYS' facility in North Carolina. Note that whole fish, shellfish, and invertebrates will be shipped to SGS AXYS' North Carolina facility for processing so that the samples can be shipped across the U.S.-

Canadian border. SGS AXYS will then ship the processed samples (extracts) to their facility in British Columbia for PFAS analysis. The field sampling crew will be instructed to ship coolers containing samples as soon as possible following sample collection, but not before the samples are completely frozen. ERG will track each shipment to ensure that it arrives at SGS AXYS in a timely manner; and we will confirm that samples were received in good condition.

Another important element of sampling handling is maintaining COC documents to demonstrate that samples have only been handled and transferred by designated parties. COC forms will be completed when field samples are collected and when they are transferred from Normandeau to SGS AXYS. Field sampling crews will place COC forms inside Ziploc bags, which will then be placed in the sampling coolers. Normandeau will make an electronic image of COC forms before shipping sample coolers, and SGS AXYS will similarly make such images after receiving and analyzing samples. All images will be sent electronically to ERG, who will use COC forms to track samples and will include all completed COC forms in the final project record. Refer to the SAP for blank COC forms that SGS AXYS will provide for this project.

3.3 Analytical Methods

All samples will be analyzed for 40 PFAS using SGS AXYS' Method MLA-110, which is equivalent to EPA Method 1633 (EPA, 2024a). This method involves preparing and extracting environmental samples and then analyzing the sample extracts by LC-MS/MS in the multiple reaction monitoring (MRM) mode. Sample concentrations are determined by isotope dilution or extracted internal standard quantification using isotopically labeled compounds added to the samples before extraction (EPA, 2024a). A current copy of SGS AXYS SOPs is provided in Attachment B.

A high-level overview of laboratory processing and analysis of fish and surface water samples is provided below. Additional details are available in the SGS AXYS SOPs. The laboratory will document in its reports any deviations from the analytical method and provide sufficient documentation to allow for independent validation and verification of the analytical results. Note that all results will be reported to the A-CAL; results under the C-CAL threshold will be qualified with a "J" flag.

Fish Fillet Samples
Frozen fish fillet samples will be sent directly to the SGS AXYS British Columbia laboratory and arrive on ice. The laboratory will homogenize each sample before PFAS analysis and report concentrations in units of nanogram PFAS analyte per gram of fish (ww).

Whole Fish Samples
Frozen whole fish will be sent to the SGS AXYS North Carolina laboratory on ice. This laboratory will homogenize and extract each sample. The laboratory will then freeze and

send sample eluates to the SGS AXYS British Columbia laboratory for PFAS analysis. PFAS concentrations will be reported in units of nanogram PFAS analyte per gram of fish (ww).

Shellfish Samples
Frozen shellfish composite samples will be sent to the SGS AXYS North Carolina laboratory on ice, where each sample will be homogenized and extracted. This laboratory will then freeze and send sample eluates to the SGS AXYS British Columbia laboratory for PFAS analysis. Results will be reported in units of nanogram PFAS analytes per gram of shellfish (ww).

Invertebrate Samples
Frozen composite invertebrate samples will be sent to the SGS AXYS North Carolina laboratory on ice. This laboratory will homogenize and extract each sample, and then freeze and ship the eluates to the SGS AXYS British Columbia laboratory for PFAS analysis. Results will be reported in units of nanogram PFAS analytes per gram of invertebrate (ww).

Surface Water Samples
Frozen water samples will be sent directly to the SGS AXYS British Columbia laboratory on ice for PFAS analysis. Results will be reported in units of nanogram PFAS analyte per liter of sampled water.

3.3.1 Interlaboratory Comparison Study

Conditional on the MassDEP's Wall Experiment Station's (WES) preparedness for analyzing samples via EPA Method 1633, Phase 2 of this study will include collection of samples for an interlaboratory comparison study. Duplicate samples will be collected from up to five waterbodies during Phase 2 and sent to SGS AXYS and WES for analysis. At each of the selected waterbodies, a duplicate surface water sample and duplicate fish fillets from up to two fish will be collected using the same methods as field duplicate QC samples (see Section 3.4 of this QAPP and Section 6.0 of the SAP). These will be collected as split samples – i.e., surface water duplicates will prepared from the same volume of collected water and fish tissue duplicates will be prepared from opposite side fillets of the same fish. Should WES not be able to analyze water or tissue samples immediately, the samples will be frozen for later analysis. MassDEP will arrange for transport of the aforementioned samples between Normandeau's Bedford facility and WES.

Should the results from both laboratories be received before the end of SFY25, ERG will calculate RPDs for all detected PFAS analytes between corresponding samples sent to each laboratory.

During this project period, WES was not ready to receive field samples for analysis with method 1633. However, WES prepared eight samples with known PFAS concentrations for laboratory validation purposes. ERG facilitated the transport of these samples to the laboratory and DEP reviewed the data and accuracy of the results.

3.4 Quality Control Procedures

Quality control for this project will be maintained by the use of trained and experienced personnel in all aspects of the program, including sample collection and laboratory analysis. Various field and laboratory QC samples will be collected and analyzed to characterize the precision and accuracy of the results.

3.4.1 Field Sampling Quality Control

This section outlines the field QC samples to be collected.

PFAS-Free DI Water Blank
Prior to the onset of sample collection, MassDEP will send DI water from its Worcester offices to SGS AXYS for analysis. This testing is needed to confirm that the DI water is PFAS-free. If so, it will be used for field blanks and decontamination for the duration of the current project. (Note that this water was previously tested in 2022 for PFAS, with no detections reported.)

Additionally and throughout the project, if any QC field sampling data suggest the possibility of PFAS contamination in the DI water (e.g., repeated PFAS detections in the field or equipment blanks), ERG will immediately submit another DI water sample to the laboratory for analysis; and if necessary, ERG will identify an alternate source of DI water and test it to ensure the water is PFAS-free.

Field Blanks
Field blanks will be collected and analyzed to assess the potential for PFAS cross-contamination introduced during the sampling process. Field blanks will be generated under field conditions and subjected to the same aspects of sample collection, field processing, preservation, transport, and laboratory handling as the environmental samples. Surface water field blank samples and tissue processing equipment rinsate blanks will be collected to represent five percent of the total samples collected. These blanks will be prepared for two waterbodies during Phase 1 (one freshwater and one coastal) and three waterbodies (one freshwater and two coastal) during Phase 2. This plan will be revisited throughout sample collection to ensure that we collect sufficient QC data. Section 6.1 of the SAP describes the process for collecting these blank samples.

Field Duplicates
A field duplicate is a second sample collected from the field at the same time and place under identical circumstances as the parent field sample, and the parent sample and duplicate sample are then treated the same throughout laboratory procedures. Field duplicates will be collected to assess reproducibility in both the field collection and laboratory analysis processes at roughly 25% of waterbodies sampled. Field QC duplicates will be collected for fish tissue (boneless-skinless filets only) and surface water samples; field QC duplicate samples will not be collected for whole fish, invertebrates, or shellfish

(information on laboratory and field precision will be gleaned for these media for replicates collected in the field as part of the study design [with the exception of shellfish]).

Duplicate samples will be collected from four locations in Phase 1 and from four location in Phase 2. For shellfish, field teams will attempt to collect enough organisms to create additional replicate samples at two waterbodies in Phase 1 and one waterbody in Phase 2. The RPD will be calculated between duplicates to assess precision.

See SAP for procedures for duplicate collection for each sample type.

Other
Travel or trip blanks will not be collected unless a problem is identified with the field blanks. Transport of unopened bottles is unlikely to introduce contamination.

3.4.2 Laboratory Analysis Quality Control

Laboratory QC data that will be generated are listed below. These analyses will be run at a minimum frequency of one per batch of samples processed or, in the case of larger batches of samples, per every twenty field samples. These samples are standard for the SGS AXYS' Method MLA-110 and are run to evaluate lab accuracy and precision.

- Procedural blank
- Ongoing precision and recovery (OPR) spiked matrix sample
- Low level OPR (LLOPR)
- Surrogate standards
- Lab duplicates

If QC data fall outside of SGS AXYS' acceptance limits, SGS AXYS will take corrective actions such as reanalyzing, re-extracting, and flagging outliers. SGS AXYS will use in-house limits for OPR recovery, LLOPR recovery, and surrogate recovery in samples. OPR, LLOPR, and surrogate recovery ranges for QC specification are provided in Section 5 of the lab's SOP (Attachment B). The QC acceptance limit for procedural blanks requires that no analytes be detected at the greater amount of half of the detection limit or one tenth the amount measured in any sample. Instruments will be calibrated as necessary.
SGS AXYS will document any deviations from the analytical method in its laboratory reports and provide sufficient documentation to allow for independent verification of analytical results. Corrective actions for laboratory analytical failures are specified in the laboratory analytical method SOPs.

3.4.3 Performance Evaluation QC Samples

MassDEP/WES intends to prepare four performance evaluation QC samples in the fall of 2024 (or as feasible). These samples will be prepared with known concentrations of PFAS, but the magnitude of those concentrations and the sample type will not be known to SGS

AXYS (i.e., double-blind). These samples will be used to evaluate the accuracy of the laboratory analyses.

3.5 Instrument/Equipment Testing and Inspection

Instruments and equipment that the field sampling crew will use during sample collection include conductivity probes and electrofishing units. These devices will be inspected for damage or malfunction prior to the start of sample collection and when returned from use by the field sampling crew. Needed repairs or operational problems will be reported to the Normandeau field crew lead. He will also (or instruct appropriate staff to) examine equipment at least quarterly for operational status, even if no sampling using that equipment is immediately planned. All equipment will be checked for operation in accordance with manufacturers' specifications.

Equipment will be inspected and calibrated at the start of each month when samples are to be collected. The field sampling crew will remove any equipment from service that does not meet calibration requirements or is determined to be defective. The field sampling crew will:

- Read the applicable user's manuals.
- Confirm factory calibration with equipment inspection prior to use in the field.
- Familiarize themselves with the use of all field equipment.
- Follow instructions for calibration and testing of equipment prior to daily sampling activities.
- Ensure that batteries are fully recharged before each day's work.
- Carry extra batteries and back-up equipment (e.g., an additional conductivity meter) to the site.

Other instruments and equipment that the field crew will use include boats and additional fishing and shellfishing gear. Equipment used at multiple waterbodies will be decontaminated between uses following the procedures described in the project SAP.

The laboratory will perform instrument calibration consistent with the procedures set forth by the analytical method used for this project and as outlined in the laboratory's SOPs (see Attachment B). The laboratory is responsible for ensuring that its equipment functions properly.

3.6 Inspection/Acceptance of Supplies and Consumables

Normandeau field crew leads will be responsible for ensuring that field supplies are examined for completeness, damage, and suitability for use as they are received and upon use. Checks will include the following:

- Sample containers from the laboratory should be appropriately sealed, visibly clean, and intact.
- Gloves, coolers, and ice packs should be checked for condition and integrity before use.
- All supplies should be of appropriate materials (PFAS-free) to avoid contaminating samples. See Section 3.2 of the SAP for further detail.

Missing, damaged, or incorrect field supplies will be noted and immediately reported to the ERG project manager, who will then work with the field crew leads to contact the appropriate suppliers or SGS AXYS to replace damaged or missing items.

The analytical laboratory maintains internal SOPs for inspecting and quality checking supplies.

3.7 Data Management

As described in Section 2.8, this project will generate multiple types of records during field sampling activities and during laboratory analysis of samples. This section describes the data management procedures, from initial collection or recording to the final database. It also describes the files and information that will be delivered to MassDEP.

Normandeau will email scanned copies of all documents containing project data (i.e., field data sheets, photographs, and COC forms) to the ERG data manager or upload them to ERG's project-specific SharePoint site. The ERG data manager will enter field data into a project database in Excel and catalog photographs in site-specific folders. ERG will maintain these records throughout the project on a SharePoint site that is accessible to the MassDEP project lead. ERG will also submit these files to MassDEP at the end of SFY24 for Phase 1 activities and at the end of SFY25 for all sampling activities.
Laboratory data will be recorded by SGS AXYS according to their protocols. SGS AXYS will send analytical reports (as PDFs) and EDDs (as Excel files or CSVs) to ERG. These files will contain environmental sample results and laboratory QC results; and they will include all fields required by WPP for seamless integration with WPP's EQuIS database (see Section 2.8). The ERG project manager and ERG data manager will receive results from SGS AXYS through email and then save them to the project SharePoint site that is accessible to MassDEP. ERG can also forward these files via email to the MassDEP project lead via email upon request.

ERG will review laboratory reports for completeness and quality concerns (see Section 4.2) within no more than two business days of receiving data. If any reporting elements are missing from the laboratory data package, ERG will follow-up with SGS AXYS and notify the MassDEP project lead. After reviewing the laboratory reports, ERG will load the PFAS concentration data into a project database with linked sample metadata (e.g., sampling locations and dates; length and weight for fish samples).

The data and files that ERG will provide to MassDEP via email or ERG's SharePoint site include:

- Completed field sheets
- Photographs of field sampling activities
- COCs
- Final lab reports
- Final lab EDDs
- Sample planning worksheets
- Sample tracking log
- Draft (working) and final project database
- Relevant communications potentially affecting data quality
- GIS shape file containing final locations of all sampling sites
- Final project PPT summarizing results
- Draft and final project report.

3.8 Project Assessment and Oversight

This section describes oversight protocols to ensure that this QAPP is being implemented properly.

3.8.1 Assessments and Response Actions

Field sampling activities will be directed by Normandeau's field crew leads, with oversight by ERG's field sampling coordinator. Both have extensive experience collecting environmental samples for laboratory analysis and are familiar with the overall objectives and QA/QC goals of this project. They also thoroughly understand the procedures needed to eliminate potential for cross contamination when collecting samples for PFAS analysis. The field crew leads will communicate directly with the field staff and will ensure that appropriate response actions are taken in the field to address any problems or issues that may arise.

Members of ERG's project team or MassDEP's project team may join the field sampling crew during initial field activities in Phase 1 to confirm that all sample collection procedures are being strictly followed. They may also join during sample collection at selected waterbodies in Phase 2 to ensure that the field sampling crew continues to follow all protocols outlined in the QAPP and SAP.
The analytical laboratory staff will follow their internal procedures for performing project oversight, and they will institute appropriate response actions, when necessary.

3.8.2 Reports to Management

ERG will submit monthly progress reports to MassDEP detailing work completed over the previous month and identifying any issues needing resolution. These issues will be

discussed during biweekly conference calls with the MassDEP project lead, ERG project manager, and ERG data manager/field sampling coordinator.

During Phase 1, ERG will prepare brief summaries of data as they are received from the laboratory. These summaries will include descriptive statistics of the results received (e.g., minimum, maximum, and arithmetic mean PFAS concentrations) and summarize any field QC sample results received against the criteria outlined in this QAPP. These summaries will help ensure the project meets QC targets and allow appropriate actions to be swiftly taken to remediate potential issues as sampling continues.
ERG will submit a draft and final project summary report by the end of SFY25. In this report, ERG will describe the project in detail and summarize the PFAS results across environmental media. See Section 4.4 for details on anticipated statistical analyses for this report.

4.0 Data Review and Usability

The analytical results will be validated and verified before use. The purpose of this review will be to review laboratory documentation regarding the stated methods and acceptability of results as well as relevant field documentation that may pertain to data integrity. The analytical data review will be conducted according to the standards and criteria set forth in the standard methods and protocols being used by the analytical laboratory. The review process will evaluate the degree to which the analytical laboratory followed the prescribed methods, results of internal QC sample analyses, and implications for data usability or any deviations from the prescribed methods. Additional details on the data validation by the laboratory and data verification by the project team are provided in Sections 4.1 and 4.2, respectively.

4.1 Laboratory Data Validation

SGS AXYS will be responsible for validating and verifying internal laboratory QA/QC metrics as described in the laboratory's SOPs. SGS AXYS analysts will check procedural blanks, OPRs, and LLOPRs against SOP QC acceptance limits and take corrective actions when QC acceptance limits are not met. Procedural blanks, OPRs, and LLOPRs will be run at a ratio of one per batch or per twenty samples, whichever is smaller. Surrogate recovery will be checked on a per-sample basis. Laboratory duplicates will also be run at an approximate rate of five percent (i.e., one duplicate per batch of 20 samples) and checked to ensure that they meet the laboratory's QC criteria for laboratory duplicate samples.

4.2 Project Team Data Review and Verification

The ERG project manager and ERG data manager will be responsible for reviewing the data provided by SGS AXYS prior to conducting any statistical analyses. They will ensure that all required data have been calculated, recorded, and transmitted correctly. For this, the team will confirm that the laboratory provided the items listed below for each sample. If any

items are missing, the ERG data manager or the ERG project manager will contact SGS AXYS to request that the laboratory reissue the data package with all necessary elements.

- Signed COC forms
- Analytical results summary for all samples included in the chain-of-custody
- Batch QC data summary (e.g., recoveries, analytical replicates)
- Case narrative (if needed)
- EDDs with analytical results for the environmental samples and laboratory QC samples in the required format (see Section 2.8.2).

The ERG data manager will review analytical results for all field QC samples, including field/equipment blanks and field duplicates, as follows:

- ***Field/equipment blanks***: The potential for sample contamination will be evaluated based on the results of field blanks and equipment blanks. If PFAS are detected in either type of blank sample, ERG will immediately follow up with the laboratory and notify the MassDEP project lead. The project team will revisit all sampling procedures and ask the laboratory to do the same to identify the source of cross contamination. The field sampling crew will collect another field blank at the next sampling event for confirmation. The ERG project manager, ERG data manager, and MassDEP project lead will determine whether the other data collected on the day of the contaminated blank are "fit for use."
- ***Field duplicates:*** Field precision will be evaluated through RPD calculations of surface water and fish tissue duplicates. Equation 1 shows how the RPDs will be calculated. If a concentration is greater than or equal to five times the laboratory RL, the RPD must be below 40 percent. If the concentration is less than five times the RL, the RPD must be below 100 percent. The project team will evaluate any duplicate data that do not meet these criteria and determine whether the data are deemed "fit for use."

$$RPD\ (\%) = \text{Absolute value of: } [(x_1 - x_2) / (x_1 + x_2)/2] * 100\% \qquad \textbf{[Equation 1]}$$

Where:

x_1 = Concentration observed in the original sample

x_2 = Concentration observed in the duplicate sample

Before data are considered final, WPP will complete its own data validation process. This process will mirror the review process used for the agency's review of the data collected in MassDEP's 2022 "PFAS in Freshwater and Fish Tissue" project. This review will include review of the laboratory SOPs, laboratory reports and QC data, assigned laboratory qualifiers, COCs, field sheets, field QC sample results, and Performance Evaluation sample results. As part of the review, MassDEP may decide to add project data qualifiers or, for results with egregious QC issues, determine that specific datapoints are not fit for use and should be censored.

4.3 Reconciliation with User Requirements

If samples do not meet lab or method requirements (e.g., failed holding or handling time, exceedance of temperature preservation requirement) or data validation criteria specified above, the MassDEP project lead and ERG project manager/data manager will evaluate whether the analytical data results are appropriate for characterizing PFAS levels in surface water, fish, shellfish, and invertebrates.

These evaluations will be conducted in conference calls between the ERG/DEP data team, with appropriateness of analytical data assessed on a case-by-case basis. DEP's final data will be the source data for the final report and associated data analyses.

4.4 Reporting, Analysis, and Use of Project Data

The principal objective of the current project is to characterize the nature and extent of PFAS contamination in surface water, fish, shellfish, and invertebrates at selected locations in Massachusetts.

To achieve this goal, ERG will complete the analyses listed below – where data permit. Note that it is impossible to predict what species will be collected on a given day at each of the 30 waterbodies and what the final data set for analyses will contain.

- ***Descriptive statistics***. ERG will generate descriptive statistics for PFAS concentrations measured in each environmental media. These statistics will be presented separately for samples from coastal locations and freshwater locations. For fish, shellfish, and invertebrate results, descriptive statistics will also be generated by species or group. Depending on available data quantity, statistics will include frequency of detection, measures of central tendency (e.g., arithmetic means, geometric means), measures of variability (e.g., standard deviation [SD], log SD, range of detected values), percentiles (e.g., 90^{th} percentiles, 95^{th} percentiles), and the percent of results over applicable health- or ecological-based screening values. Based on available data, statistics will also be stratified by various factors, such as the type of waterbody, region, and whether the waterbody is near areas of known or suspected PFAS contamination.
- ***Statistical comparisons***. ERG will use t-tests and analysis of variance tests to compare sample mean PFAS concentrations across species or group, between regions, between areas of suspected PFAS contamination and reference locations, and between sampling locations in EJ areas and those not in EJ areas. Similar tests will be run for surface water sample results.
- ***Comparisons to other benchmarks***. ERG will compare measured PFAS concentrations to EPA's ~~draft~~ Recommended Aquatic Life Ambient Water Quality Criteria for select PFAS ~~PFOS and PFOA~~ and available health-based screening values, as described in Section 2.5.4.
- ***Context***. We will also discuss how results from this project relate to findings from similar studies conducted in Massachusetts and across the country.

A potential secondary use of the data is to derive species-specific PFAS BAFs for both freshwater and coastal species. For example, should enough fish of a single species be collected, we will calculate BAFs using fish and surface water samples collected at the same time from the same location. BAFs will be derived separately for whole body fish and fish fillets. For each sample, BAFs specific to a given sample will be calculated for detected PFAS using Equation 2. BAFs will only be calculated for PFAS analytes that have a sufficient percentage of detected results for both surface water and fish to produce meaningful results.

$$BAF\ (\frac{L}{Kg}) = C_{fish}/C_{water}\ \text{ X 1,000} \qquad \textbf{[Equation 2]}$$

Where:

C_{fish}= PFAS concentration measured in fish tissue (ng/g)

C_{water} = PFAS concentration measured in the co-located water sample (ng/l)

Calculated BAFs will be in units of (L/kg). An overall species or trophic-level (TL) BAF may then be calculated for given waterbodies, provided multiple samples of a given species are available. This calculation may also be done across all waterbodies where that species was collected. In these cases, the overall species or TL BAFs will be calculated as the geometric mean of the individual BAFs within each category.

Results from these analyses will be summarized in the final project report.

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