Lower Duwamish Waterway Group

Port of Seattle / City of Seattle / King County / The Boeing Company

FISH, CRAB, CLAM, AND SURFACE WATER PERIODIC MONITORING QUALITY ASSURANCE PROJECT PLAN FOR THE LOWER DUWAMISH WATERWAY

FINAL

For submittal to

The US Environmental Protection Agency
Region 10
Seattle, WA

April 12, 2023

Prepared by:

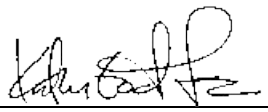
Windward environmental LLC
200 First Avenue West • Suite 500
Seattle, Washington • 98119

in association
with

ANCHOR QEA
1201 3rd Avenue • Suite 2600
Seattle, Washington • 98101

TITLE AND APPROVAL PAGE

Periodic Monitoring Quality Assurance Project Plan

Windward Project Manager		April 12, 2023
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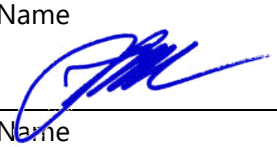
Windward Field Coordinator		April 12, 2023
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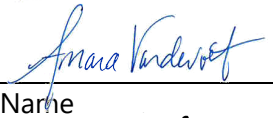
Windward QA/QC Manager		April 12, 2023
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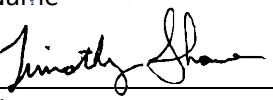
Anchor QEA Project Manager		April 12, 2023
	Name	Date
Anchor QEA Health and Safety Officer		April 12, 2023
	Name	Date
EPA Project Manager		
	Name	Date
EPA Regional QA Manager		
	Name	Date

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Appendix B Field Forms
Appendix C Analytical Data Quality Indicators
Appendix D Standard Operating Procedures
Appendix E Archaeological Monitoring and Inadvertent Discovery Plan

ABBREVIATIONS

abbreviation	definition
95UCL	95% upper confidence limit (on the mean)
Alpha	Alpha Analytical Laboratories, Inc.
ALS	ALS Environmental-Kelso
Anchor QEA	Anchor QEA LLC
AOC	Administrative Order on Consent
ARL	Analytical Resources Laboratory
Axys	SGS-Axys Analytical Services Ltd.
BEHP	bis(2-ethylhexyl) phthalate
BHC	benzene hexachloride
Brooks Applied	Brooks Applied Labs
Cape Fear	Cape Fear Analytical, LLC
COPC	contaminant of potential concern
cPAH	carcinogenic polycyclic aromatic hydrocarbon
DCM	dichloromethane
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DL	detection limit
DQI	data quality indicator
DQO	data quality objective
EPA	US Environmental Protection Agency
FC	field coordinator
GC/ECD	gas chromatography/electron capture detection
GC/MS	gas chromatography/mass spectrometry
GPC	gel permeation chromatography
GPS	global positioning system
HCB	hexachlorobenzene
HpCDD	heptachlorodibenzo-*p*-dioxin
HpCDF	heptachlorodibenzofuran
HRGC/HRMS	high-resolution gas chromatography/high-resolution mass spectrometry
HSO	health and safety officer
HSP	health and safety plan
HxCDD	hexachlorodibenzo-*p*-dioxin
HxCDF	hexachlorodibenzofuran

IC-ICP-CRC-MS	ion chromatography-inductively coupled plasma-collision reaction cell-mass spectrometry
ICP-MS	inductively coupled plasma
ID	identification
LDW	Lower Duwamish Waterway
LDWG	Lower Duwamish Waterway Group
MLLW	mean lower low water
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
OCDD	octachlorodibenzo-*p*-dioxin
OCDF	octachlorodibenzofuran
PCB	polychlorinated biphenyl
PCP	pentachlorophenol
PE	polyethylene
PeCDD	pentachlorodibenzo-*p*-dioxin
PeCDF	pentachlorodibenzofuran
PSEP	Puget Sound Estuary Program
PM	project manager
PRC	performance reference compound
PVC	polyvinyl chloride
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
RI	remedial investigation
RL	reporting limit
RM	river mile
ROD	Record of Decision
SDG	sample delivery group
SIM	select ion monitoring
SOP	standard operating procedure
SVOC	semivolatile organic compound
TBT	tributyltin
TCDD	tetrachlorodibenzo-*p*-dioxin
TCDF	tetrachlorodibenzofuran
TM	task manager
TTL	target tissue level
UCT-KED	universal cell technology-kinetic energy discrimination

USFWS	US Fish and Wildlife service
WDFW	Washington State Department of Fish and Wildlife
Windward	Windward Environmental LLC

1 Introduction

This document presents a supplemental quality assurance project plan (QAPP)[1] to conduct periodic monitoring of fish, crab, and clam tissues and surface water in 2023 in the Lower Duwamish Waterway (LDW) under the Fourth and Fifth Amendments to the Administrative Order on Consent (AOC). With a few minor exceptions detailed herein, this monitoring will follow the methods and study designs presented in the QAPPs for fish and crabs (Windward 2017a), clams (Windward 2018) and surface water (Windward 2017b) prepared for baseline monitoring as part of the pre-design studies conducted in 2017 and 2018 under the Third Amendment to the AOC.

The results of the baseline monitoring were presented in the pre-design studies data evaluation report (Windward 2020), along with recommendations for a few minor modifications to the study design. The baseline results represented conditions after early action sediment cleanups and source control actions had been conducted between 1999 and 2016 and before the start of the sediment remedy specified in the US Environmental Protection Agency's (EPA) LDW Record of Decision (ROD) (EPA 2014b).

This QAPP provides the data quality objectives (DQOs) and all methods and procedures needed to collect fish, crab, and clam tissue samples in 2023, analyze those samples for the baseline suite of contaminants, and deploy passive samplers in two LDW locations to determine freely dissolved polychlorinated biphenyl (PCB) concentrations in surface water. The baseline QAPPs contain additional details regarding the study design rationale, but all information needed for the 2023 sampling and analysis is presented in this QAPP.

EPA guidance for QAPPs was followed in preparing this document (EPA 2002). The remainder of this QAPP is organized into the following sections.

- Section 2 – Project Objectives and Description
- Section 3 – Project Organization and Responsibilities
- Section 4 – Data Generation and Acquisition
- Section 5 – Assessment and Oversight
- Section 6 – Data Validation and Usability
- Section 7 – References

This QAPP has five appendices. Appendix A is a health and safety plan (HSP) designed to protect on-site personnel from physical, chemical, and other hazards posed by the field sampling effort. Field collection forms are included as Appendix B. Laboratory methods and the associated reporting limits

[1] The QAPP is supplemental because it is combines and updates the methods and study designs outlined in three different QAPPs in order to conduct periodic monitoring in 2023.

(RLs) are provided in Appendix C. Appendix D presents standard operating procedures (SOPs). Appendix E contains the Archaeological Monitoring and Inadvertent Discovery Plan.

2 Project Objectives and Description

The section presents the DQOs and schedule for the 2023 periodic monitoring elements.

2.1 Data Quality Objectives

The DQOs for the 2023 periodic monitoring are based largely on the DQOs established in the QAPPs developed for baseline monitoring. The seven-step DQO process is summarized in Table 2-1 for each of the three DQOs.

- **DQO 1**: Calculate site-wide 95% upper confidence limit (on the mean) (95UCL) concentrations of human health risk drivers in fish, crabs, and clams in 2023 for comparison to target tissue levels (TTLs)[2] presented in the 2014 ROD, explanation of significant differences (EPA 2021), or *Compilation and Assessment of Fish and Shellfish Tissue to Refine Background Concentrations* (Windward and Anchor QEA 2022) (if adopted).
- **DQO 2**: Calculate site-wide mean concentrations of contaminants with TTLs in fish, crab, and clam tissues in 2023, for use in trends assessment as sediment remediation and source control continue.
- **DQO 3**: Calculate freely dissolved PCB concentrations in surface water, for use in trends assessment as sediment remediation and source control continue.

[2] The site-wide 95UCL is the statistic selected in the Record of Decision (ROD) for comparison to TTLs to measure progress toward achieving Remedial Action Objective 1 (seafood consumption) (EPA 2014b). TTLs are not cleanup levels; rather, they are to be used for informational purposes to assess ongoing risks associated with the consumption of resident LDW fish and shellfish.

Table 2-1
Periodic Monitoring DQOs and Stepped Analysis

DQO Step	DQO 1	DQO 2	DQO 3
STEP 1: State the problem	Data are needed to determine current site-wide 95UCL concentrations in tissue as sediment remediation and source control continue.	Data are needed to determine current site-wide mean concentrations in tissue to assess concentration trends as sediment remediation and source control continue.	Data are needed to determine current freely dissolved PCB concentrations to assess trends in surface water as sediment remediation and source control continue.
STEP 2: Identify the goals of the study	The goal is to establish the current site-wide 95UCL concentrations for comparison to TTLs.	The goal is to establish current site-wide mean tissue concentrations for assessing trends.	The goal is to establish current freely dissolved PCB concentrations in surface water for assessing trends.
STEP 3: Identify the information inputs	Existing RI and baseline fish and crab tissue data from the LDW and associated statistics (e.g., variance) were used to determine the appropriate sample sizes needed to achieve the statistical power of the sampling design necessary to evaluate trends. Locations where clams had been collected previously were used to determine clam tissue collection areas. Information regarding the number of clams needed per composite sample per area was based on the weights of previously collected clams and the amount needed for chemical analysis.		Variance estimates from baseline data were used to determine the appropriate number of replicate passive samplers per location/depth to achieve target statistical power.
STEP 4: Define the boundaries of the study	The boundary of the overall study was defined by the ROD. The LDW was divided into reaches for RI and baseline fish and crab sampling (Map 2-1). Reach 1 extends from RM 0.0 to RM 2.9, and Reach 2 extends from RM 2.9 to RM 5.0. Crab and English sole will be collected from the two reaches, and shiner surfperch will be collected from two subreaches within each of the two reaches for a total of four subreaches, each of which will be approximately one-quarter of the LDW (Map 2-2). Within the LDW, a total of 11 clam tissue collection areas were identified based on RI and baseline sampling (Map 2-3).		The boundary of the study was defined by the ROD. Two locations, shown on Map 2-4, were identified within the LDW that a) have the permanence required to make deployed samplers less likely to be lost due to vessel traffic and b) will provide spatial information.

DQO Step	DQO 1	DQO 2	DQO 3
STEP 5: Develop the analytical approach	All fish and crab samples will be analyzed for PCBs, dioxins/furans, and inorganic arsenic. Because of the ability of fish to metabolize cPAHs (Collier et al. 2013), only crabs will be analyzed for cPAHs. Each sample will be a composite of 5 to 15 individuals, depending on the species. In addition to analyzing all samples for risk drivers, a subset of samples will be analyzed for other COPCs, as specified in the ROD. These analytes will include BEHP, PCP, TBT, vanadium, and organo-chlorine pesticides. Clams will be analyzed for the four human health risk drivers. cPAHs, PCBs, and dioxins/furans will be analyzed in whole-body clam composite samples. Inorganic arsenic will be analyzed in separate composite samples of siphon skin and remainder tissue, because inorganic arsenic is known to accumulate preferentially in siphon skin tissue. In addition, whole-body intertidal segment-wide clam composite samples (i.e., one for each of the three intertidal segments; Map 2-3) will be analyzed for non-risk driver chemicals specified in the ROD (including vanadium, TBT, select SVOCs [BEHP, carbazole, HCB, and PCP], and organochlorine pesticides).		Passive samplers will be analyzed for PCB congeners.
STEP 6: Specify performance or acceptance criteria	Performance or acceptance criteria, including field quality control and laboratory quality control samples, and DQIs for laboratory analyses (precision, accuracy, representativeness, completeness, and comparability) are described in Appendix C.		
STEP 7: Develop the detailed plan for obtaining data	Following approval of this QAPP, clams will be collected in May or June 2023, and fish and crab will be collected in August 2023. A high-rise otter trawl will be used to target both crabs and fish. Crab traps may also be used, depending on trawl results.		Passive samplers will be deployed 1 m above the sediment surface at two locations during the dry season. Five replicate samplers will be analyzed from each location to capture the variability of passive sampler analysis. Four additional samplers (for a total of 9) will be deployed in case any passive samplers are lost.

Notes:
95UCL: 95% upper confidence limit for the mean
BEHP: bis[2-ethylhexyl] phthalate
COPC: contaminant of potential concern
cPAH: carcinogenic polycyclic aromatic hydrocarbon
DQI: data quality indicator
DQO: data quality objective
HCB: hexachlorobenzene
LDW: Lower Duwamish Waterway
PCB: polychlorinated biphenyl

PCP: pentachlorophenol
QAPP: quality assurance project plan
RI: remedial investigation
RM: river mile
ROD: Record of Decision
SVOC: semivolatile organic carbon
TBT: tributyltin
TTL: target tissue level

2.2 Project Approach and Schedule

This section provides a brief overview of the approach and schedule for each of the 2023 monitoring elements. Additional sampling and analysis details are presented in Section 4. The overall sampling schedule is follows:

- Clam tissue sampling – May or June 2023 (approximately one week)
- Fish/crab tissue sampling – August 2023 (approximately one week)
- Surface water passive sampling – August 2023 (30-day deployment)

2.2.1 Fish and Crab Sampling and Analyses

English sole and crab tissue will be collected in two reaches and shiner surfperch will be collected in four subreaches. Reach and subreach boundaries are shown on Maps 2-1 and 2-2.

Fish and crab tissue sampling in the LDW will take place in August 2023. Fish and crab will be collected using a high-rise otter trawl. In addition, crab may be collected using crab traps, depending on trawl results (see Section 4.1.1).

Chemical analysis of the fish and crab composite samples will be performed after the compositing scheme has been approved by EPA and homogenization has been completed (which may take several weeks longer for crabs because of the extra time needed to extract the edible tissue). Chemical analysis will require approximately four weeks, and data validation will be completed approximately three weeks after receipt of the chemistry data.

2.2.2 Clam tissue sampling and Analyses

Clam tissue (Eastern softshell*)* will be collected from 11 areas located between RM 0.0 and RM 5.0 of the LDW, as shown on Map 2-3. Clam tissue samples will be hand collected using shovels during low tides in May or June 2023 (Table 2-2). Because these clams are primarily found near the low tide line, sampling will occur when tides are at or below 0 ft mean lower low water (MLLW). The four potential sampling windows are shown in Table 2-2. Sampling will take place during one of these sampling windows, with a preference for June 4 to June 8, 2023, because of the lowest tides. The final sampling dates will be selected in consultation with EPA.

Table 2-2
Potential Sampling Dates for Clam Collection

Date	Low Tide (ft MLLW)	Time of Low Tide	Approximate Time Range when Tide ≤ 0 ft MLLW	Duration of Sampling (hrs)
Potential early May sampling dates				
May 6, 2023 (Saturday)	-1.91	12:18 PM	10:30 AM – 2:00 PM	3.5
May 7, 2023 (Sunday)	-2.47	12:58 PM	11:00 AM – 3:00 PM	4
May 8, 2023 (Monday)	-2.69	1:41 PM	11:30 AM – 4:00 PM	4.5
May 9, 2023 (Tuesday)	-2.54	2:29 PM	12:15 PM – 4:45 PM	4.5
May 10, 2023 (Wednesday)	-2.06	3:22 PM	1:15 PM – 5:15 PM	4
May 11, 2023 (Thursday)	-1.31	4:20 PM	2:30 PM – 6:00 PM	3.5
Potential mid/late May sampling dates				
May 18, 2023 (Thursday)	-1.43	11:06 AM	9:30 AM–12:45 PM	3.25
May 19, 2023 (Friday)	-2.06	11:40 AM	9:45 AM–1:30 PM	3.75
May 20, 2023 (Saturday)	-2.32	12:15 PM	10:15 AM–2:15 PM	4
May 21, 2023 (Sunday)	-2.25	12:51 PM	10:45 AM–2:45 PM	4
May 22, 2023 (Monday)	-1.93	1:29 PM	11:30 AM–3:30 PM	4
May 23, 2023 (Tuesday)	-1.42	2:10 PM	12:30 PM–4:00 PM	3.5
Potential early June sampling dates				
June 2, 2023 (Friday)	-1.50	10:36 AM	9:00 AM–12:30 PM	3.5
June 3, 2023 (Saturday)	-2.48	11:13 AM	9:15 AM–1:15 PM	4
June 4, 2023 (Sunday)	-3.17	11:53 AM	9:30 AM–2:30 PM	5
June 5, 2023 (Monday)	-3.51	12:37 PM	10:15 AM–3:15 PM	5
June 6, 2023 (Tuesday)	-3.49	1:24 PM	10:45 AM–3:45 PM	5
June 7, 2023 (Wednesday)	-3.07	2:14 PM	11:45 AM–4:30 PM	4.75
June 8, 2023 (Thursday)	-2.27	3:06 PM	1:00 PM–5:15 PM	4.25
Potential mid/late June sampling dates				
June 15, 2023 (Thursday)	-1.42	10:04 AM	8:30 AM–11:45 AM	3.25
June 16, 2023 (Friday)	-2.00	10:41 AM	8:45 AM–12:45 PM	4
June 17, 2023 (Saturday)	-2.27	11:16 AM	9:15 AM–1:30 PM	4.25
June 18, 2023 (Sunday)	-2.29	11:52 AM	9:45 AM–2:00 PM	4.25
June 19, 2023 (Monday)	-2.12	12:29 PM	10:30 AM–2:30 PM	4
June 20, 2023 (Tuesday)	-1.81	1:07 PM	11:15 AM–3:00 PM	3.75
June 21, 2023 (Wednesday)	-1.38	1:46 PM	12:00 PM–3:15 PM	3.25

Notes:
Source: NOAA Tides and Currents (Duwamish Waterway, Eighth Avenue South; Station 9447029) (NOAA 2022).
MLLW: mean lower low water
NOAA: National Oceanic and Atmospheric Administration

Chemical analysis of the clam composite samples will be performed after the compositing scheme has been approved by EPA and homogenization has been completed. Chemical analysis will require approximately four weeks, and data validation will be completed approximately three weeks after receipt of the chemistry data.

2.2.3 Surface Water Passive Sampling and Analyses

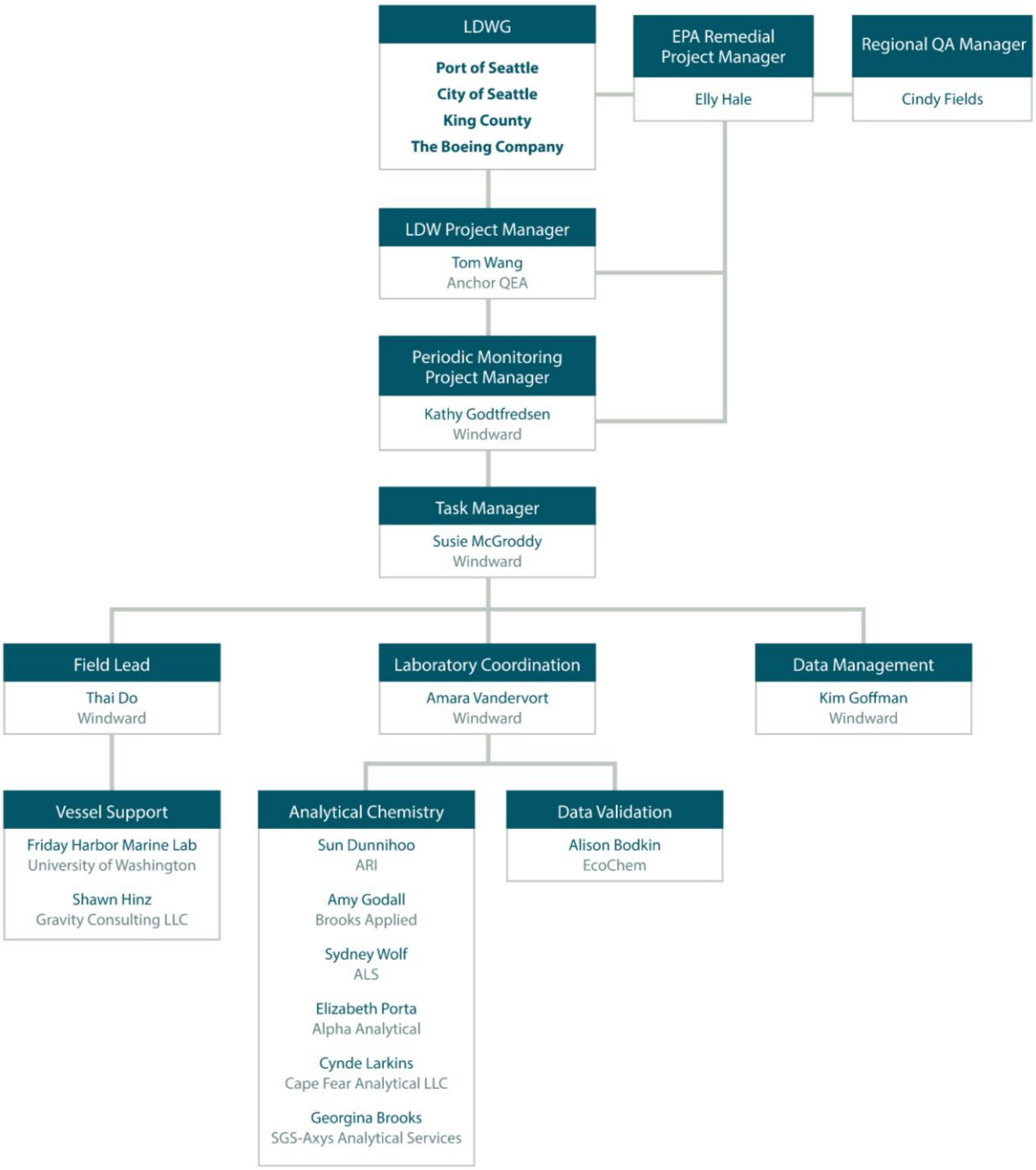
PCB concentration trends in surface water will be evaluated using passive samplers to calculate freely dissolved PCB concentrations over time. Passive samplers will be deployed at two locations in the LDW for a 30-day period to target dry season baseflow conditions. Passive samplers will be deployed 1 m above the sediment surface at RM 1.9 W and RM 3.3 during dry baseflow conditions in August 2023.

Chemical analysis of the samples may require approximately four months, based on the latest estimate from the analytical laboratory, SGS-Axys Analytical Services Ltd. (Axys). Updated estimates will be requested in spring 2023. Data validation will be completed approximately three weeks after receipt of the chemistry data.

3 Project Organization and Responsibilities

Overall project organization and the individuals responsible for the various tasks required for tissue sample collection and analysis are shown in Figure 3-1.

Figure 3-1
Project Organization and Team Responsibilities



3.1 Project Management

Both the Lower Duwamish Waterway Group (LDWG) and EPA are involved in all aspects of this project, including discussion, review, and approval of this QAPP and interpretation of the results of the investigation. Elly Hale is the EPA remedial project manager (PM) for the LDW.

Tom Wang is the Anchor QEA LLC (Anchor QEA) PM for the consultant team undertaking this work to address the scope in the Fourth and Fifth Amendments to the AOC on behalf of LDWG. In this capacity, he will be responsible for providing oversight for planning and coordination, all project deliverables, and performance of the administrative tasks needed to provide timely and successful completion of the project. Mr. Wang can be reached as follows:

Mr. Tom Wang
Anchor QEA LLC
1201 3rd Avenue, Suite 2600
Seattle, WA 98101
Telephone: 206.903.3314
Email: twang@anchorqea.com

Kathy Godtfredsen is the Windward Environmental LLC (Windward) PM for the periodic monitoring effort. In this capacity, she will be responsible for project coordination and providing oversight. Dr. Godtfredsen can be reached as follows:

Dr. Kathy Godtfredsen
Windward Environmental LLC
200 First Avenue West, Suite 500
Seattle, WA 98119
Telephone: 206.577.1283
Email: kathyg@windwardenv.com

Susan McGroddy (Windward) is the task manager (TM). As such, she will be responsible for communications on the progress of project tasks and any deviations, and she will coordinate all parties involved in the field effort. Significant deviations from the QAPP will be further reported to representatives of LDWG and EPA. Dr. McGroddy can be reached as follows:

Dr. Susan McGroddy
Windward Environmental LLC
200 First Avenue West, Suite 500
Seattle, WA 98119

Telephone: 206.812.5421
Email: susanm@windwardenv.com

3.2 Field and Laboratory Coordination

Thai Do is the field coordinator and health and safety officer (FC/HSO) for Windward; he will be responsible for managing field sampling activities and general field and providing quality assessment/quality control (QA/QC) oversight. He will oversee sample collection, preservation, and holding times, and he will coordinate delivery of environmental samples to the designated laboratories for chemical analyses. Mr. Do will familiarize field staff with the field SOPs attached to the QAPP, including any updates, if needed. Mr. Do will report deviations from this QAPP to the TM for consultation. Windward will report significant deviations from the QAPP to representatives of LDWG and EPA. Mr. Do can be reached as follows:

Mr. Thai Do
Windward Environmental LLC
200 First Avenue West, Suite 500
Seattle, WA 98119
Telephone: 206.812.5407[3]
Email: thaid@windwardenv.com

Amara Vandervort is the Windward QA/QC coordinator. In this capacity, she will oversee coordination of the field sample processing and laboratory programs, and she will supervise data validation and project QA coordination, including coordination with the analytical laboratories and the EPA QA chemist, Don Matheny. Mr. Matheny is the EPA contact for tissue and surface water periodic monitoring and works on behalf of the QA manager, Cindy Fields. Ms. Vandervort will also maintain the official approved QAPP; the Windward PM will coordinate the distribution of any updated versions of the QAPP to EPA. Ms. Vandervort can be reached as follows:

Ms. Amara Vandervort
Windward Environmental LLC
200 First Avenue West, Suite 500
Seattle, WA 98119
Telephone: 206.812.5415
Email: amarav@windwardenv.com

[3] This is Mr. Do's office phone number. A mobile phone number will be provided prior to field sampling.

Mr. Matheny can be reached as follows:

Mr. Don Matheny
US Environmental Protection Agency, Region 10
1200 6th Avenue
Seattle, WA 98101
Telephone: 206.553.2599
Email: matheny.don@epa.gov

EcoChem, Inc. will provide independent third-party chemical data review and validation. The PM at EcoChem can be reached as follows:

Ms. Alison Bodkin
EcoChem, Inc.
500 Union Street, Suite 1010
Seattle, WA 98101
206.508.2104
Email: abodkin@ecochem.netcom

3.3 Laboratory Responsibilities

Alpha Analytical Laboratories, Inc. (Alpha) will perform fish and crab tissue processing. Analytical Resources Laboratory (ARL) will perform all chemical analyses on tissue samples, with the exception of analyses for PCB congeners, dioxins/furans, inorganic arsenic, carcinogenic polycyclic aromatic hydrocarbons (cPAHs), and organochlorine pesticides. Cape Fear Analytical, LLC (Cape Fear) will perform PCB congener and dioxin/furan analyses. Brooks Applied Labs (Brooks Applied) will perform inorganic arsenic analyses, and ALS Environmental-Kelso (ALS) will perform cPAH and organochlorine pesticide analyses. Axys will perform passive sampler PCB congener analysis.

The laboratory PM at Alpha can be reached as follows:

Ms. Elizabeth Porta
Alpha Analytical Laboratories, Inc.
320 Forbes Boulevard
Mansfield, MA 02048
Telephone: 508.844.4124
Email: eporta@alphalab.com

The laboratory PM at ARL can be reached as follows:

Ms. Susan Dunnihoo
Analytical Resources, LLC
4611 South 134th Place
Tukwila, WA 98168
Telephone: 206.695.6207
Facsimile: 206. 695.6201
Email: limsadm@arilabs.com

The laboratory PM at Cape Fear can be reached as follows:

Ms. Cynde Larkins
Cape Fear Analytical, LLC
3306 Kitty Hawk Road, Suite 120
Wilmington, NC 28405
Telephone: 910.795.0421
Email: cyndelarkins@cfanalytical.com

The laboratory PM at Brooks Applied can be reached as follows:

Ms. Amy Goodall
Brooks Applied Labs
13751 Lake City Way NE, Suite 108
Seattle, WA 98125
Telephone: 206.753.6110
Facsimile: 206.632.6017
Email: amy@brooksapplied.com

The laboratory PM at ALS can be reached as follows:

Ms. Sydney Wolf
ALS Environmental-Kelso
1317 13th Avenue South
Kelso, WA 98626
Telephone: 360.577.7222
Facsimile: 360.636.1068
Email: Sydney.Wolf@alsglobal.com

The laboratory PM at Axys can be reached as follows:

Ms. Georgina Brooks
SGS-Axys Analytical Services Ltd.
2045 West Mills Road
Sidney, British Columbia V8L 5X2
Canada
Telephone: 250.655.5801
Facsimile: 250.655.5811
Email: gbrooks@axys.com

The laboratories will meet the following requirements:

- Adhere to the methods outlined in this QAPP, including those methods referenced for each procedure.
- Adhere to documentation, custody, and sample logbook procedures.
- Implement QA/QC procedures defined in this QAPP.
- Meet all reporting requirements.
- Deliver electronic data files as specified in this QAPP.
- Meet turnaround times for deliverables as described in this QAPP.
- Allow EPA and the QA/QC manager, or a representative, to perform laboratory and data audits.

3.4 Data Management

Kim Goffman of Windward will oversee data management; she will ensure that analytical data are incorporated into the LDW database with appropriate qualifiers following acceptance of the data validation. Ms. Goffman can be reached as follows:

Ms. Kim Goffman
Windward Environmental LLC
200 First Avenue West, Suite 500
Seattle, WA 98119
Telephone: 206.812.5414
Email: kimg@windwardenv.com

3.5 Special Training/Certification

The Superfund Amendments and Reauthorization Act of 1986 required the Secretary of Labor to issue regulations through the Occupational Safety and Health Administration providing health and

safety standards and guidelines for workers engaged in hazardous waste operations. Accordingly, 29 Code of Federal Regulations 1910.120 requires that employees be given the training necessary to provide them with the knowledge and skills to enable them to perform their jobs safely and with minimum risk to their personal health. All sampling personnel will have completed the 40-hr HAZWOPER training course and 8-hr refresher courses, as necessary, to meet Occupational Safety and Health Administration regulations.

ARL, Cape Fear, Brooks Applied, ALS, and Axys laboratories all have current environmental laboratory accreditation from the Washington State Department of Ecology.

Three tissue collection sampling permits are needed for the sampling described in this QAPP (Table 3-1). The Washington State Department of Fish and Wildlife (WDFW) requires a permit for any scientific collection of organisms, and the service agencies (National Marine Fisheries Service [NMFS] and US Fish and Wildlife Service [USFWS]) require permits for the incidental take of threatened fish species (i.e., Chinook salmon and bull trout). The FC or leader of each sampling team will be in possession of a copy of each permit, as required by the permits. Copies of permits will be available upon request.

Table 3-1
Permits Required for Sampling

Permit	Contact Person/ Permit Holder	Permit Number
USFWS recovery permit for threatened and endangered species (bull trout); required even though this species is not targeted for collection because individuals may be caught incidentally in the sampling gear	Thai Do, Windward	Recovery Permit PER0042930 (Legacy ES088853-3) (expires 08/03/27)
NMFS incidental take permit for threatened and endangered species (Chinook salmon); required even though this species is not targeted for collection because individuals may be caught incidentally in the sampling gear	Thai Do, Windward	Scientific Research Permit (pending)
WDFW scientific collection permit	Thai Do, Windward	Scientific Collection Permit (pending)

Notes:
NMFS: National Marine Fisheries Service
USFWS: US Fish and Wildlife Service
WDFW: Washington Department of Fish and Wildlife
Windward: Windward Environmental LLC

In addition to the three tissue collection sampling permits required for fish, crab, and clam tissue sampling, a general Special Use Permit is required for the use of King County property in which King County has an ownership interest. The King County Special Use Permit will also be obtained for deploying and affixing the passive samplers to the wing wall at South Park Bridge.

3.6 Documentation and Records

All field activities and laboratory analyses will be documented following the protocols described in Section 3.7 of the baseline fish and crab QAPP (Windward 2017a), Section 3.7 of the baseline clam QAPP (Windward 2018), and Section 3.7 of the baseline surface water QAPP (Windward 2017b). Field forms are provided in Appendix B of this QAPP.

4 Data Generation and Acquisition

This section presents an overview of data generation and acquisition for the elements of the 2023 periodic monitoring program. The sampling and analysis approach for periodic monitoring is the same as that for the 2017/2018 baseline monitoring program, with three revisions based on recommendations in Section 9 of the pre-design studies data evaluation report (Windward 2020).

1) An additional composite will be collected from each clam tissue collection area for inorganic arsenic analysis.

2) The ultra-trace method will be used in the analysis of cPAHs in clam tissue.

3) Nine passive sampler replicates will be deployed at each location (with 5 analyzed), whereas 15 were deployed (with 9 analyzed) in baseline sampling.

The subsections that follow present an overview of the design and approach for each of the periodic monitoring elements and discuss the rationale for each of the three changes. The following details are included in this section to guide sampling and analysis:

- Sample collection methods, custody, and shipping requirements
- Sample identification
- Laboratory methods and handling

Tables (some with minor updates) with laboratory methods and QA/QC requirements are provided in Appendix C. Other items, such as whole body calculation methods, have not been updated; see the baseline QAPPs for details.

The following subsections from the baseline QAPPs required no revision, and will be followed for the periodic monitoring.

- Decontamination procedures, and field-derived waste disposal (Sections 4.3.4 and 4.3.5 in baseline QAPPs)

- Instrument/equipment testing, inspection, and maintenance (Section 4.7 in fish and crab and surface water QAPPs, Section 4.8 in clam QAPP)

- Instrument/equipment calibration and frequency (Section 4.8 in fish and crab and surface water QAPPs, Section 4.9 in clam QAPP)

- Inspection/acceptance of supplies and consumables (Section 4.9 in fish and crab and surface water QAPPs, Section 4.10 in clam QAPP)

4.1 Fish and Crab Tissue

4.1.1 Fish and Crab Tissue Sampling Design

This section presents the sampling design for the fish and crab samples that will be collected and analyzed to evaluate DQOs 1 and 2. Sampling design components—including targeted species, sampling reaches and subreaches, number of composite samples per reach or subreach, compositing scheme, and target sizes for collected fish and crabs—are summarized in Table 4-1 and detailed in the following sections. The sampling design is consistent with the baseline sampling for fish and crab (Windward 2017a), except for the target crab species. In the baseline event (2017), insufficient numbers of Dungeness crab were available and graceful crab were collected as the approved alternate crab species.[4] There are early indications that Dungeness crab populations in Washington and Oregon may be smaller than usual in 2023 due to low oxygen levels during the summer months (Marquis 2022). Therefore, graceful crabs will be collected in 2023 as the target crab species for trend analysis. Dungeness crabs will be analyzed for analytes with TTLs for human health communication purposes, if sufficient crabs are collected during trawling.[5]

Table 4-1
Overview of Fish and Crab Tissue Sampling Design

Design Component	Approach by Species Group			Rationale
	Benthic Fish	Pelagic Fish	Crab[1]	
Target species	English sole (*Parophrys vetulus*)[2]	Shiner surfperch (*Cymatogaster aggregate*)	Graceful crab (*Metacarcinus gracilis*) (Dungeness crab [*Metacarcinus magister]* for human health communication if available in sufficient numbers)	Graceful crab will be the target crab species to be consistent with baseline and because of low numbers of Dungeness crab expected in 2023
Sampling areas[3]	Two reaches	Four subreaches	Two reaches	Consistent with baseline sampling; see Maps 2-1 and 2-2
Number of composite samples	12 composites (6 per reach)	12 composites (3 per subreach)	12 composites (6 per reach)	Consistent with baseline sampling
Individuals per composite	10	15	Graceful crab: 7[4]	Consistent with baseline sampling

[4] Based on the results of the stable isotope evaluation (Appendix I of the pre-design studies data evaluation report (Windward 2020), graceful crab and Dungeness crab occupy similar trophic positions.
[5] Crab traps can also be deployed to collect a few additional crabs if needed.

Design Component	Approach by Species Group			Rationale
	Benthic Fish	Pelagic Fish	Crab[1]	
Target number of individuals	60 per reach (120 total)	90 per subreach (180 total)	Graceful crab: 42 per reach (84 total)	Consistent with baseline sampling
Tissue types	Fillet and remainder (i.e., whole-body minus fillet)[5]	Whole-body	Edible meat and hepatopancreas[5]	Consistent with baseline sampling
Target size[6]	≥ 20 cm	≥ 8 cm	≥ 9 cm	Consistent with baseline sampling

Notes:
1. Male crabs will be collected and used in compositing in order to be consistent with fishing regulations and baseline sampling.
2. During the RI and baseline sampling effort, starry flounder was identified as an alternate for English sole. Given that sufficient English sole have been collected during past efforts (see Table 4-3), starry flounder will not be retained.
3. Reaches and subreaches are defined as follows: Reach 1 (RM 0.0 to RM 2.9), Reach 2 (RM 2.9 to RM 5.0), Subreach 1a (RM 0.0 to RM 1.25), Subreach 1b (RM 1.25 to RM 2.5), Subreach 2a (RM 2.5 to RM 3.75), and Subreach 2b (RM 3.75 to RM 5.0).
4. Composites for hepatopancreases samples will include twice the number of crab (i.e., one-half the total number of composites will be created). The number of individual Dungeness crabs per composite will be determined based on available mass and individuals.
5. The whole-body concentrations will be calculated mathematically based on the fraction of the whole body represented by each tissue type, as described in the fish and crab QAPP (Windward 2017a).
6. Size is the total length for fish and the carapace width for crabs.
QAPP: quality assurance project plan
RI: remedial investigation
RM: river mile

4.1.2 Fish and Crab Tissue Sampling Methods

Sample identification and field sampling of fish and crab will be performed following the protocols described in this section, which are consistent with those in the baseline QAPP for fish and crabs (Windward 2017a).

Contingencies may arise during field activities that require modification of the general procedures outlined herein. Such modifications will be at the discretion of the FC after consultation with the Windward TM and PM, the boat captain, and the EPA representative in the field, if applicable. LDWG and EPA will be consulted if significant deviations from the sampling design are required. All modifications will be recorded in the protocol modification form in Appendix B.

4.1.2.1 Sample Identification

Unique alphanumeric ID numbers will be assigned to each individually wrapped fish or crab specimen in the field and recorded on the target fish and crab species form. The sample ID for individual fish and crab will include the following:

- Project area ID (i.e., LDW) and two-digit year (23)
- Tissue sampling area, including subarea, if applicable: R1 or R2 for English sole, Dungeness crab, and graceful crab; R1A, R1B, R2A, or R2B for shiner surfperch

- Two-letter species code (ES, SS, DC, or GC, representing English sole, shiner surfperch, Dungeness crab, or graceful crab, respectively) and a three-digit number indicating the sequential number of the specimen captured during the sampling event

For example, the 11th English sole captured in Reach 1 would be identified as LDW23-R1-ES011. All relevant information for each individually wrapped and labeled target specimen—including specimen ID, length, weight, external abnormalities, sample date, sample time, and location number—will be recorded on the target fish and crab species collection form (Appendix B) and included as an appendix in the final data report. Therefore, all pertinent data associated with each individual fish or crab specimen will be tracked.

Composite samples will be identified using a similar convention. Their IDs will include the following:

- Project area ID (i.e., LDW) and two-digit year (23)
- Tissue sampling area, including subarea, if applicable: R1 or R2 for English sole, Dungeness crab, and graceful crab; R1A, R1B, R2A, or R2B for shiner surfperch
- Two-letter species code (ES, SS, DC, or GC) and a two-letter tissue type code (WB, FL, RM, EM, or HP for whole body, skin-on fillet, remainder [after removal of the fillet], edible meat, or hepatopancreas samples, respectively)
- Composite ID (i.e., comp and a two-digit sequential composite number)

For example, the second fillet English sole composite sample collected from Reach 1 would be identified as LDW23-R1-ESFL-comp02.

4.1.2.2 Level of Effort and Sampling Approach

As with the baseline sampling effort, periodic monitoring fish and crab tissue collection in 2023 will have a maximum level of effort of eight days. The 2017 baseline sampling event, which had the same scope as the 2023 periodic monitoring, was completed in four days. The 2004, 2005, and 2007 sampling efforts all required fewer than eight days of trawling and crab trap deployment to complete (Table 4-2). EPA will be kept informed throughout the sampling event.

Table 4-2
Level of Effort for Trawling in Previous LDW Sampling Events

Year	Month	Total Trawls	Trawl Days	Trawls per Day
2004	August	121	7	17
2005	August/September	93	6	16
2007	September	109	7	16

Year	Month	Total Trawls	Trawl Days	Trawls per Day
2017	August/September	36	4	9

LDW: Lower Duwamish Waterway

The catch totals of target species for previous sampling events are summarized in Table 4-3. The existing data suggest that the greatest difficulty may be in collecting sufficient numbers of English sole and crab in Reach 2. Therefore, the initial plan for sampling (which may change depending on field conditions) is as follows:

- **Begin sampling in Reach 2** – Sampling effort will begin with three days of sampling in Reach 2 (or until target numbers of organisms are collected) in order to estimate the potential total level of effort that could be required to achieve the target numbers in this reach.
- **Conduct sampling in Reach 1** – Sampling will then be conducted in Reach 1 until sampling is complete (no more than three days). During this time, numbers of Dungeness crab collected will be assessed by LDWG and EPA to determine if crab traps should be deployed.
- **Resume sampling in Reach 2, as needed** – Following the completion of Reach 1 sampling, Reach 2 sampling will resume.

Table 4-3
Summary of Level of Effort and Catch Totals for Target Species in Previous LDW Tissue Sampling Events and 2023 Periodic Monitoring

Target Species	Sampling Areas	RI Sampling Areas	2004		2005		2007		2017		2023
			Actual[1]	Target	Actual[1]	Target	Actual[1]	Target	Actual[1]	Target	Target
English sole	Reach 1	T1	83	30	30	30	46	30	60	60	60
		T2	66	30	37	30	45	30			
	Reach 2	T3	40	30	30	30	45	30	70	60	60
		T4	45	30	16	15	**5[2]**	**15**			
Shiner surfperch	Subreach 1a	T1	79	30	60	60	63	60	60	45	45
	Subreach 1b	T2	111	30	62	60	60	60	60	45	45
	Subreach 2a	T3	157	30	70	60	60	60	60	45	45
	Subreach 2b	T4	121	30	45	40	40	40	60	45	45
Dungeness crab	Reach 1	T1	33	30	6	5	**4[2]**	**15**	**1[2]**	**30**	30[3]
		T2	**1[2]**	**30**	23	5	**0[2]**	**15**			
	Reach 2	T3	**16[2]**	**30**	11	5	16	15	**8[2]**	**30**	30[3]
		T4	**6[2]**	**30**	20	5	**1[2]**	**5**			
Graceful crab[4]	Reach 1	T1	117	na	174[5]	na	47[5]	na	56	42	42
		T2	82	na	255[5]	na	19[5]	na			
	Reach 2	T3	33	na	42[5]	na	2[5]	na	48	42	42
		T4	40	na	12[5]	na	0	na			

Notes:
Bold text in shaded cells indicates that the target number of individual organisms was not collected for the study.
1. Actuals include only those species that were retained during the collection effort, unless otherwise noted.
2. Graceful crab were analyzed as an alternate species for this area, because the target number of Dungeness crab was not attained.
3. Graceful crab are the target species in 2023 monitoring for trends analysis. Dungeness crab will be analyzed for human health communication if a sufficient number of crabs is available (see Section 4.1.1).
4. The status of graceful crab as a target species varied by year during the RI sampling efforts. Graceful crab were retained during the 2004 effort but were generally not retained during the 2005 and 2007 efforts (except in areas where Dungeness crab were less abundant).
5. Because graceful crab was not a target species for this effort, counts include both individuals that were retained for possible analysis and those of target size that were not retained.
LDW: Lower Duwamish Waterway
RI: remedial investigation

After each day of sampling, the locations and catch will be summarized and shared with LDWG and EPA. Using this information, the sampling plan for the next day will be devised to ensure coverage of the reach, to the extent feasible.

4.1.2.3 Sampling Methods

Fish and crabs will be collected from the LDW primarily using a high-rise otter trawl. Crab traps will also be deployed to supplement the sampling effort, if deemed appropriate by LDWG and EPA based on the catch of Dungeness crab in the trawls.

4.1.2.3.1 High-rise Otter Trawl

Trawling methods used for fish and crab collection are designed to systematically sample reaches and subreaches. Trawling will be conducted using the vessel R/V *Kittiwake* (operated by the University of Washington Friday Harbor Laboratory), or a similar vessel if necessary. If the R/V *Kittiwake* is not available for trawling, the trawl specifications for the alternate vessel will be similar to those for the R/V *Kittiwake*.[6]

Each trawl line will be conducted within the bounding coordinates of the reaches or subreaches. Trawling will not be conducted in waters shallower than 6 ft (at the time of trawling), because the high-rise otter trawl is impractical in shallower areas (Eaton 2004). The specific trawl line and order in which the reaches or subreaches will be sampled will be determined by the boat captain and FC based on logistical considerations.

The trawl will be deployed to the bottom using a winch. When the trawl reaches the bottom, the "dog" of the winch will be set (stopping the release of cable from the winch), and the vessel will begin the trawl. When the vessel reaches the end of the trawl line, the dog of the winch will be released and the trawl will be hauled aboard, allowing the captured species to be processed. The date, time, and location of the trawl will be recorded on the fish and crab tissue collection form (Appendix B) after each trawl is hauled out of the water.

Trawl start and end points will be recorded using a digital GPS with 1- to 2-m accuracy. When the trawl is deployed on the bottom, GPS and clock readings will be taken to mark the starting point of the trawl. Final GPS and clock readings will be made when net retrieval begins. The length of the line out from the trawl will also be recorded to correct for the final trawl length and endpoint.

[6] The high-rise otter trawl on the R/V *Kittiwake* consists of a 25-ft (7.6-m) headrope and 29-ft (8.8-m) footline, side panels with 1.5-in. mesh that open to 5 ft at the wing tips, and 24- x 36-in. V-shaped galvanized steel trawl doors. The footline consists of 0.5-in. combination poly/wire with 5.33-oz seine leads interspersed with 2-in. rubber discs, and the headrope has eight 5-in. plastic floats. The 1.25-in. mesh codend also has a knotless nylon codend liner with 0.25-in. mesh. The trawl will progress upstream at a constant speed of 2.5 knots. The spread of the trawl will be approximately 4.7 m, with a rise of approximately 1.5 m.

Trawling will be conducted using a live sampling technique, which will minimize the non-target species mortalities through species sorting and processing prioritization. Upon completion of an individual trawl, the catch will be hauled aboard and immediately emptied into a large plastic tub filled with site water. Field technicians will sort the catch by species and size into numerous smaller tubs, also containing site water. Target species will be separated from non-target species and processed as described in Section 4.2.3. Non-target species will be identified to the lowest practical taxon and their numbers estimated, and the fish will be returned to the LDW as quickly as possible (without collecting length, weight, or gender). For target species, any prey in the fish's mouth will be assumed to have been consumed in the trawl and will be removed from the fish's mouth before processing.

The trawl results will be reported daily to the Windward TM and PM, who will provide input on priorities for the subsequent day's sampling effort. In the event that there are issues with sufficient catch, LDWG and EPA will be consulted.

Trawling will be discontinued in a given reach or subreach when the target numbers of fish and crabs have been collected. All fish and crab of target sizes will be archived pending compositing (see Section 4.1.3).

4.1.2.3.2 Crab Traps

If needed to collect a few Dungeness crabs to enable analysis for human health communication purposes, crab traps will be deployed at maximally dispersed locations outside of the navigation channel within a reach. Traps will be placed at locations where they will not interfere with vessel navigation, and where they will remain continuously submerged.[7] Up to 12 traps per day is a feasible effort based on Windward's previous experience in quarterly crab and shrimp sampling in the LDW (Windward 2004a). Fewer or more traps may be set in a given reach depending on the success of the trawling effort during the first few days of sampling. Only one reach will be sampled each day. The specific reach to be sampled using traps will be determined primarily based on crab targets and sampling logistics related to the concurrent trawl effort.

Trap sampling locations will be recorded using a digital GPS with 1- to 2-m accuracy. Coordinates will be taken at the deployment location for each trap. The FC will ensure that specimens are collected within the specified tissue reaches (Map 2-1).

If deployed, crabs will be collected using Ladner© 30-in. stainless steel rubber-wrapped crab traps. Each trap will be deployed on an individual float at the chosen sampling location. Crab bait, a mixture of fish scraps and squid, will be placed in mesh bait bags and tied to the inside of the trap so that the bag cannot be opened and its contents consumed. All traps will soak for a minimum of

[7] Generally, traps will be placed in locations deeper than -2 ft MLLW; however, traps may be placed in shallower water if high tides coincide with sampling.

two hours before retrieval.[8] All traps will be retrieved in the same order they were deployed. The field crew will monitor the traps, to the extent possible, when deployed in areas of high vessel traffic. Any trap(s) determined by the FC to be a hazard to navigation will be moved to a new location within the same sampling subarea, away from vessel traffic. Any traps lost during sampling will be replaced, and all traps will be outfitted with a degradable latch to ensure that escape holes will open if the trap is lost. The degradable latch will ensure that lost traps will not continue to catch indefinitely, thereby harming local crab or fish. The date, time, and location of the trap will be recorded during both deployment and retrieval.

During the trap retrieval phase, captured organisms will be sorted by species into decontaminated bins filled with site water. All non-target species will be returned to the LDW after they have been identified to the lowest practical taxon and their number estimated.

4.1.2.4 Compositing Scheme

At the conclusion of the sampling event, all individual fish and crab will be archived frozen, and a compositing memorandum will be prepared for EPA review. The compositing memorandum will identify the individuals selected for inclusion in each composite. In order to create representative composites, the individuals within the composites will be balanced in terms of the size of the fish and crab, collection location within each reach/subreach, and gender of fish (if known).

4.1.3 Fish and Crab Tissue Sample Handling Procedures

Fish and crab processing will be conducted either in the field or off-site. Fish or crabs from each sampling effort (i.e., a single trawl or crab trap from a given reach or subreach) will be kept separate from one another and processed one at a time to ensure that individual specimens are tracked properly. Each target species will be individually wrapped in heavy-duty aluminum foil; enclosed in individual, resealable plastic bags with an ID label (also enclosed in a resealable bag); and immediately stored in coolers with wet ice. Crabs will be double wrapped in heavy-duty aluminum foil to minimize punctures in the aluminum foil or plastic bag. If processing occurs off-site, specimens transported to the facility will be unpacked from coolers, measured, and weighed using an analytical scale accurate to 0.5 g.

The FC will be responsible for reviewing count, length, weight, gender, and external abnormality information for all species recorded on the field collection forms (Appendix B) and will correct any improperly recorded information. All fish and crabs will be placed on ice, packed into coolers, and sent to ARL to be held, frozen. Specimen labels will be included with each shipment.

[8] If catch rates are low, increased soak times may be considered; overnight soaks will not be used due to potential loss from vessel traffic and trap theft.

Sample labels will contain the project number, sampling personnel, date, time, specimen ID, and comments (Appendix B). All of the pertinent information about the specimen, including the specific trawl or trap the specimen came from and the specific reach or subreach, will be traceable through the sample label. A complete sample label will be affixed to each individual sample as described above.

The specimens included in each composite sample will be tracked using a composite sample form (Appendix B). This form will include the composite sample ID, the individual sample ID of each specimen included in the composite, and the length and weight of each specimen.

At each laboratory, a unique sample identifier will be assigned to each sample. The laboratory will ensure that a sample tracking record follows each sample through all stages of laboratory processing. The sample tracking record must contain, at a minimum, the name/initials of responsible individuals performing the analyses, dates of sample extraction/preparation and analysis, and type of analysis being performed.

4.1.4 Laboratory Methods

Laboratories will meet the sample handling requirements and follow the procedures described in this section and in Appendix C.

4.1.4.1 Laboratory sample handling

Samples will be stored initially at ARL and held, frozen at -10°C, until all fish or crabs have been collected. Individual tissue samples will remain frozen and will be organized into composite groups by Windward personnel. The individual fish or crabs included in each composite sample will be determined based on the scheme described in the final compositing memorandum. Fish and crabs selected for each composite sample will be grouped into labeled, resealable plastic bags. Fish and crabs will remain frozen and will be delivered to Alpha via courier.

Tissue homogenization will be conducted by Alpha. The laboratory SOP for tissue homogenization is presented in Appendix D. During the compositing and homogenization process, fish and crab specimens will be processed one at a time to ensure that individual specimens are tracked properly.

4.1.4.1.1 Creation of Fish Composites

For English sole fillet samples, partially thawed whole fish will be filleted with the skin on. A lengthwise cut will be made along the dorsal region adjacent to the spine using a solvent-rinsed scalpel or pre-cleaned razor blade. The muscle tissue will be carefully separated from the ribs until the entire muscle fillet has been removed, including as much tissue behind the gill flap to the tail fin as possible. Care will be taken to not puncture any internal organs during this process. The weight of the fillet and the remainder of each individual fish will be measured prior to homogenization. The fillet composite and the remainder composite will be composed of equal

aliquots by weight of the homogenized tissue from the same 10 fish. Each composite will be homogenized after the aliquots are combined and stored frozen.

Whole shiner surfperch will be partially thawed prior to processing. Equal aliquots by weight of individually homogenized fish will be combined and homogenized to create each composite sample. Homogenized composites will be numbered and labelled based on procedures in Section 4.1.2.1 and stored frozen.

4.1.4.1.2 Creation of Crab Composites

Crab samples will be at least partially thawed before processing. The hepatopancreas tissue and edible meat tissue will be dissected and separated into respective samples using surgical scalpels, forceps, shears, picks, and/or razor blades. The shell will be removed from the belly of the crab by pulling up on the back end of the shell, thereby exposing the crab's internal organs. The hepatopancreas tissue, which is typically yellow/brown, will be removed, ensuring its separation from all other tissue (e.g., white, spongy gill tissue). All edible meat tissue (as much as is reasonably possible) will be removed from the crab's upper body, legs, and claws, making sure not to include any shell or muscle in contact with hepatopancreas tissue. The weight of the edible meat and hepatopancreas will be measured for each individual crab prior to compositing. Equal aliquots by weight of homogenized edible meat or hepatopancreas will be combined and homogenized to create each composite. In the event that the equal aliquots are not sufficient to achieve the required analytical mass (Appendix C), an alternate compositing approach may be used to include all available tissue. Homogenized composites will be stored frozen.

4.1.4.2 Homogenization

Individual fish and crab specimens will be homogenized using a blender, chopper, and/or meat grinder following Alpha's SOPs (Appendix D). Solvent-rinsed knives or razor blades may be used to cut the tissue into smaller pieces (i.e., 3-in. slices) prior to chopping or blending to ensure that the tissue is homogenized into a creamy paste with no discernable bits remaining (e.g., no large pieces of bones or fins). Then, equal aliquots by weight from each individual homogenate will be combined to create a composite sample. The composited, homogenized tissue subsample selected for extraction or analysis must be representative of the entire composite sample. The final compositing scheme will be determined in consultation with EPA.

Container materials, storage temperatures, and holding times are provided in Table 4-5. Any remaining homogenates (either of individual fish included in composite samples or of the composited samples themselves) will be archived at Alpha.

Whole fish and crabs not homogenized will be archived, frozen, for up to one year from collection. Homogenized fish and crabs will be archived, frozen, for up to one year from collection; after that

time, the samples will be discarded because they will be outside of their analytical holding times (Table 4.5).

Alpha will ship frozen subsamples of selected tissue sample homogenates to ARL, Brooks Applied, Cape Fear, and ALS laboratories for chemical and conventional, total and inorganic arsenic, cPAH and organochlorine pesticide analyses, and dioxins/furans and PCB congener analyses, as presented in Section 4.1.5 and 4.2.5. The minimum mass required for each analysis is provided in Appendix C (Table C-3).

4.1.5 Analytical Methods

Chemical analyses of fish and crab tissue will be conducted at four different laboratories (ARL, Brooks Applied, Cape Fear, and ALS) (Table 4-4). All fish and graceful crab samples will be analyzed for PCBs as congeners, dioxins/furans, and inorganic arsenic. All graceful crab samples will also be analyzed for cPAHs. A subset of samples will also be analyzed for chemicals listed in ROD Table 14, and the appropriate chemicals listed in ROD Table 18 (Table 4-5).[9] The contaminants of potential concern (COPCs) include selected SVOCs (bis[2-ethylhexyl] phthalate, PCP, carbazole, and HCB), tributyltin (TBT), vanadium, and selected organo-chlorine pesticides. The methods for these analytes are listed in Table 4-6. If Dungeness crab samples are created, they will be analyzed for PCB congeners and dioxins/furans.

Table 4-4
Laboratory to Conduct Specific Tissue Analyses

Laboratory	Analyses to be Conducted	Individual Analytes
ARL	Conventionals	Lipids and percent moisture
	Metals	Vanadium
	SVOCs	BEHP, PCP, carbazole, and HCB
	TBT	TBT
Brooks Applied	Inorganic arsenic	Inorganic arsenic
Cape Fear	PCB congeners	All 209 congeners (refer to Appendix C)
	Dioxin/furan congeners	2,3,7,8-TCDD, 1,2,3,7,8-PeCDD, 1,2,3,4,7,8-HxCDD, 1,2,3,6,7,8-HxCDD, 1,2,3,7,8,9-HxCDD, 1,2,3,4,6,7,8-HpCDD, OCDD, 2,3,7,8-TCDF, 1,2,3,7,8-PeCDF, 2,3,4,7,8-PeCDF, 1,2,3,4,7,8-HxCDF, 1,2,3,6,7,8-HxCDF, 1,2,3,7,8,9-HxCDF, 2,3,4,6,7,8-HxCDF, 1,2,3,4,6,7,8-HpCDF, 1,2,3,4,7,8,9-HpCDF, and OCDF

[9] See Section 2.1.

Laboratory	Analyses to be Conducted	Individual Analytes
ALS	cPAHs	Benz[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene
	Organochlorine pesticides	Aldrin, alpha-BHC, beta-BHC, total chlordane (alpha-chlordane, cis-nonachlor, gamma-chlordane, oxychlordane, trans-nonachlor), total DDTs (2,4'-DDD, 2,4'-DDE, 2,4'-DDT, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT) dieldrin, gamma-BHC, heptachlor, and heptachlor epoxide

Notes:
ALS: ALS Environmental-Kelso
ARL: Analytical Resources Laboratory
BEHP: bis(2-ethylhexyl) phthalate
BHC: benzene hexachloride
Cape Fear: Cape Fear Analytical, LLC
Brooks Applied: Brooks Applied Labs
cPAH: carcinogenic polycyclic aromatic hydrocarbon
DDD: dichlorodiphenyldichloroethane
DDE: dichlorodiphenyldichloroethylene
DDT: dichlorodiphenyltrichloroethane
HCB: hexachlorobenzene
HpCDD: heptachlorodibenzo-p-dioxin
HpCDF: heptachlorodibenzofuran
HxCDD: hexachlorodibenzo-p-dioxin
HxCDF: hexachlorodibenzofuran
OCDD: octachlorodibenzo-p-dioxin
OCDF: octachlorodibenzofuran
PCB: polychlorinated biphenyl
PCP: pentachlorophenol
PeCDD: pentachlorodibenzo-p-dioxin
PeCDF: pentachlorodibenzofuran
SVOC: semivolatile organic compound
TBT: tributyltin
TCDD: tetrachlorodibenzo-p-dioxin
TCDF: tetrachlorodibenzofuran

Table 4-5
Numbers of Composite Samples per LDW Sampling Area to be Analyzed for Each Analyte Group

Analyte	English Sole		Shiner Surfperch	Graceful Crab[1]	
	Remainder	Fillet	Whole Body	Edible Meat	Hepatopancreas
PCB congeners	12	12	12	12	6
Inorganic arsenic	12	12	12	12	6
cPAHs	na[2]	na[2]	na[2]	12	6
Dioxins/furans congeners	12	12	12	12	6
Selected SVOCs	2	2	2	2	1
TBT	2	2	2	2	1
Vanadium	2	2	2	2	1

Analyte	English Sole		Shiner Surfperch	Graceful Crab[1]	
	Remainder	Fillet	Whole Body	Edible Meat	Hepatopancreas
Selected organochlorine pesticides	2	2	2	2	1

Notes:
1. Dungeness crab samples, if collected, will be analyzed for PCB congeners and dioxins/furans for human health communication purposes.
2. cPAHs are not analyzed in fish tissue because they are metabolized (Collier et al. 2013).
cPAH – carcinogenic polycyclic aromatic hydrocarbon
LDW – Lower Duwamish Waterway
na – not applicable
PCB – polychlorinated biphenyl
SVOC – semivolatile organic compound
TBT – tributyltin

Table 4-6
Analytical Methods and Sample Handling Requirements for Tissue Samples

Parameter[1]	Method	Reference	Extraction Solvent	Cleanup	Laboratory	Container	Preservative	Sample Holding Time
Lipids	Gravimetric extraction	Bligh and Dyer (1959) (mod)	DCM/ acetone	na	ARL	Aluminum foil (whole specimen) glass jar (tissue homogenate)	Freeze to ≤ -10°C	1 year
Percent moisture	Drying oven	PSEP (1997)	na	na	ARL	Aluminum foil (whole specimen) glass jar (tissue homogenate)	Freeze to ≤ -10°C	6 months
Vanadium	ICP-MS	EPA 6020B UCT-KED	na	na	ARL	Aluminum foil (whole specimen) glass jar (tissue homogenate)	Freeze to ≤ -10°C	6 months
TBT	GC/MS	EPA 3350-C Mod EPA 8270E-SIM	0.10% tropolone/ DCM	Hexylmagnesium bromide in diethyl ether alumina or silica gel	ARL	Aluminum foil (whole specimen) glass jar (tissue homogenate)	Freeze to ≤ -10°C	1 year to extract; extract within 14 days of thawing; analyze within 40 days of extraction
Inorganic arsenic	IC-ICP-CRC-MS	Lab SOP BAL4100-001e	na	na	Brooks Applied Labs	Aluminum foil (whole specimen) glass jar (tissue homogenate)	Freeze to ≤ -10°C	1 year
Other SVOCs	GC/MS	EPA 3350-C Mod EPA 8270E	DCM/ acetone	GPC	ARL	Aluminum foil (whole specimen) glass jar (tissue homogenate)	Freeze to ≤ -10°C	1 year to extract; extract within 14 days of thawing; analyze within 40 days of extraction
cPAHs	HRGC/ HRMS	GC/HRMS Isotope Dilution	DCM/ acetone	GPC (optional) silica gel (manual)	ALS	Aluminum foil (whole specimen) glass jar (tissue homogenate)	Freeze to ≤ -10°C	1 year to extract; extract within 14 days of thawing; analyze within 40 days of extraction

Parameter[1]	Method	Reference	Extraction Solvent	Cleanup	Laboratory	Container	Preservative	Sample Holding Time
Organochlorine pesticides	GC/MS	EPA 3541 EPA 8270E/1699 Mod	DCM	GPC carbon	ALS	Aluminum foil (whole specimen) glass jar (tissue homogenate)	Freeze to ≤ -10°C	1 year to extract; extract within 14 days of thawing; analyze within 40 days of extraction
PCB congeners	HRGC/ HRMS	Soxhlet extraction EPA 1668C	DCM	Biobead multi-layered acid/base silica alumina florisil	Cape Fear	Aluminum foil (whole specimen) glass jar (tissue homogenate)	Freeze to ≤ -10°C	1 year to extract; extract within 14 days of thawing; analyze within 1 year of extraction if extracts are stored in the dark at < -10°C
Dioxins/ furans	HRGC/ HRMS	Soxhlet extraction EPA 1613B	DCM/ hexane	Biobead multi-layered acid/base silica florisil alumina carbon/celite	Cape Fear	Aluminum foil (whole specimen) glass jar (tissue homogenate)	Freeze to ≤ -10°C	1 year to extract; extract within 14 days of thawing; analyze within 1 year of extraction if extracts are stored in the dark at < -10°C

Notes
Analytical methods for passive samplers are discussed in Section 4.5.3.
1. Individual analytes are listed in Table 4-4.
ALS: ALS Environmental-Kelso
ARL: Analytical Resources Laboratory
Cape Fear: Cape Fear Analytical, LLC
cPAH: carcinogenic polycyclic aromatic hydrocarbon
DCM: dichloromethane
EPA: US Environmental Protection Agency
GC/MS: gas chromatography/mass spectrometry
GPC: gel permeation chromatography
HRGC/HRMS: high-resolution gas chromatography/high-resolution mass spectrometry
IC-ICP-CRC-MS: ion chromatography-inductively coupled plasma-collision reaction cell-mass spectrometry
ICP-MS: inductively coupled plasma-mass spectrometry
na: not applicable
PCB: polychlorinated biphenyl
PSEP: Puget Sound Estuary Program
SIM: select ion monitoring
SVOC: semivolatile organic compound
TBT: tributyltin
UCT-KED: universal cell technology-kinetic energy discrimination

Project- and/or method-specific QC measures, such as matrix spikes and matrix spike duplicates or laboratory duplicates, will be analyzed per sample delivery group (SDG) preparatory batch, or per analytical batch as specified in Appendix C. An SDG is defined as no more than 20 samples or a group of samples received at the laboratory within a 2-week period. Although an SDG may span two weeks, all holding times specific to each analytical method will be met for each sample in the SDG.

4.2 Clam Tissue

4.2.1 Clam Tissue Sampling Design

This section presents the sampling design for the clam composite samples that will be collected to evaluate DQOs 1 and 2. Table 4-7 presents an overview of the sampling design, which is consistent with that in the baseline QAPP for clams (Windward 2018), except where noted.

Table 4-7
Overview of Clam Tissue Sampling Design

Design Component	Approach	Description
Target species	Eastern softshell clams (*Mya arenaria*)	Consistent with baseline sampling (Windward 2018), sampling in the RI (Windward 2010), and the species with TTLs in the ROD (EPA 2014b).
Organism size	≥ 2 cm in width[1] (as measured from valve to valve)	Consistent with baseline sampling (Windward 2018) and the RI tissue dataset.
Collection areas	11 intertidal areas	Consistent with baseline sampling (Windward 2018), which was based on the areas sampled as part of the RI; see Map 2-1.
Analytes and composites	PCBs, cPAHs, dioxins/furans: 11 total composites; 1 whole-body composite per area (10 clams each)	Consistent with the approach for baseline sampling (Windward 2018).
	Inorganic arsenic: 4 total composites per area: 2 siphon skin and 2 remainder tissue composites per area (3 clams each)[2]	Consistent with the approach for baseline sampling (Windward 2018), except that 4 inorganic arsenic composites will be created and analyzed for each area (i.e., rather than 2 per area as was done during the baseline sampling effort).
	Non-risk driver chemicals: 3 total whole-body composites (one for each intertidal segment)[3]	Consistent with the approach for baseline sampling (Windward 2018).

Notes:
1. As with baseline sampling (Windward 2018), if insufficient clams are available, smaller clams (e.g., ≥ 1.5 cm in width) will be collected and considered for analysis.
2. As done for baseline sampling (Windward 2018), siphon skin and remainder composites analyzed for inorganic arsenic will be mathematically combined to represent whole-body clams based on the fraction of the whole body represented by each tissue type for the three clams in that composite.
3. Non-risk driver chemicals for the LDW, as specified in the ROD (EPA 2014b), include vanadium, TBT, select SVOCs (BEHP, carbazole, HCB, and PCP), and organochlorine pesticides. The three intertidal segments are from RM 0.0 to RM 1.3, from RM 1.3 to RM 2.6, and above RM 2.6 (Map 2-3). The segment-wide composite samples will contain equal portions of tissue from each of the

clam tissue collection areas within the given segment (i.e., a portion of the whole-body clam homogenate created for cPAHs, PCBs, and dioxins/furans). See Section 4.2.4.2.
BEHP: bis(2-ethylhexyl) phthalate
cPAH: carcinogenic polycyclic aromatic hydrocarbon
HCB: hexachlorobenzene
LDW: Lower Duwamish Waterway
PCB: polychlorinated biphenyl
PCP: pentachlorophenol
RI: remedial investigation
RM: river mile
ROD: Record of Decision
SVOC: semivolatile organic compound
TBT: tributyltin
TTL: target tissue level

4.2.2 Clam Tissue Sampling Methods

This section describes the methods used to collect clam samples and identify them. These methods are consistent with those in the baseline QAPP (Windward 2018), except for the collection of an additional composite sample where possible for inorganic arsenic analysis.

Contingencies may arise during activities that will require modification of the general procedures outlined herein. Such modifications will be at the discretion of the FC after consultation with the Windward TM and PM, the boat captain (for transport), and the EPA representative in the field, if applicable. LDWG and EPA will be consulted if significant deviations from the sampling design are required. All modifications will be recorded in the protocol modification form (Appendix B).

4.2.2.1 Sample Identification

This section presents sample identification information for individual clams and clam composite samples.

Individual clams: Unique alphanumeric identifications (IDs) will be assigned to each individual clam in the field and recorded on the target clam species form. The sample ID for each individual clam will include the following:

- Project area ID (i.e., LDW) and two-digit year (23)
- Clam tissue collection area (i.e., C01 through C11)
- Two-letter species code (i.e., CL for clam) and three-digit number indicating the sequential number of the specimen captured during the sampling event

For example, the 11th clam collected in clam tissue collection area 1 will be identified as LDW23-C01-CL011. All relevant information for each individually wrapped and labeled clam—including specimen ID, width, sample date, sample time, and location (including global positioning system [GPS] coordinates[10])—will be recorded manually or electronically on the target clam species

[10] High-accuracy GPS units (e.g., units estimated to have an accuracy of 1- to 2-m under optimal conditions) will be used during clam tissue sampling. However, accuracy under typical field conditions can be diminished by structures and other circumstances.

collection form (Appendix B). This information will be included as an appendix to the data report. Therefore, all pertinent data associated with each individual clam specimen will be tracked.

Composite samples: Composite clam samples will be identified using a similar convention; their IDs will include the following:

- Project area ID (i.e., LDW) and two-digit year (23)
- Clam tissue collection area (i.e., C01 through C11)
- Species code (i.e., CL for clam) and a two-letter tissue type code (i.e., WB, SP, or RM for whole body, siphon skin, or remainder [after removal of the siphon skin], respectively)
- Composite ID (i.e., comp and a one-digit sequential composite number)

For example, the first whole-body clam composite sample collected from clam tissue collection area 1 will be identified as LDW23-C01-CLWB-comp1.

For the segment-wide intertidal composite samples that will be analyzed for non-risk driver chemicals, the composite IDs will be similar to those for the clam composites, except that the clam tissue collection area portion of the ID will be replaced by an intertidal segment ID (i.e., S1, S2, and S3 for segment 1 [RM 0.0 to RM 1.3], segment 2 [RM 1.3 to RM 2.6], and segment 3 [above RM 2.6], respectively). For example, the whole-body clam composite sample collected from intertidal segment 2 will be identified as LDW23-S2-CLWB-comp1.

4.2.2.2 Clam Search and Level of Effort

Upon arriving at a given clam tissue collection area, field team members will begin searching for clams. Because *M. arenaria* are located primarily near the low tide line, search efforts will focus on that vicinity. Team members will search near the low tide line for the length of the clam tissue collection area to ensure that, to the extent possible, clam samples are spatially distributed throughout the area where they are present. Parts of the clam tissue collection areas where substrate is too soft to allow team members to search safely for clams (and in which clams are unlikely to be present) will be avoided during sample collection.[11]

For each clam tissue collection area, a maximum level of effort to collect the target number of clams was identified in the baseline clam QAPP (Windward 2018), based on the area's approximate length in river miles (Table 4-8). Although it is likely that the field team will successfully locate the target numbers of clams in each area in less than the maximum allotted time, the specified maximum level of effort provides a cutoff in the case that relatively few clams are present in a given clam tissue collection area. If fewer than the target number of clams is found at a given intertidal area (as specified in Section 4.2.2.3), the field team will continue searching for the duration of the

[11] Specifically, field staff members will not attempt to collect clams in soft substrate areas where staff sink to deeper than mid-calf.

maximum level of effort specified.[12] However, if no siphon hole shows have been observed by the three-person field team after the first hour of searching within a given clam tissue collection area, the field crew will stop searching in that area and proceed to the next area. In this case, no clam tissue composites will be collected from the area in question. If any shows are observed or if any clams are collected, the field crew will continue searching for the duration of the maximum level of effort for a given area. Prioritization in consultation with EPA may be needed if insufficient clams are found in a given clam tissue collection area.

Table 4-8
Maximum Level of Effort by Clam Tissue Collection Area

Clam Tissue Collection Area	Determination of Maximum Level of Effort		
	Approximate Area Length (miles)	Area Size Category[1]	Maximum Level of Effort Assuming a Three-person Field Team[2]
1	0.2	Medium	3 hours (i.e., 9 person-hours)
2	0.35	Large	4 hours (i.e., 12 person-hours)
3	0.2	Medium	3 hours (i.e., 9 person-hours)
4	0.1	Small	2 hours (i.e., 6 person-hours)
5	0.1	Small	2 hours (i.e., 6 person-hours)
6	0.05	Small	2 hours (i.e., 6 person-hours)
7	0.15	Medium	3 hours (i.e., 9 person-hours)
8	0.1	Small	2 hours (i.e., 6 person-hours)
9	0.45	Large	4 hours (i.e., 12 person-hours)
10	0.45	Large	4 hours (i.e., 12 person-hours)
11	0.1	Small	2 hours (i.e., 6 person-hours)

Notes:
1. Areas are categorized as small (≤ 0.1 miles in length), medium (> 0.1 to ≤ 0.3 miles in length), or large (> 0.3 miles in length) for the purposes of establishing the maximum level of effort for each clam tissue collection area.
2. The maximum level of effort is based on a three-person field team. If a different size field team is utilized during field collection efforts, the total number of person-hours (i.e., 1 person-hour is defined as the time spent searching by 1 individual for 1 hour) will be the same as specified herein. If no shows have been observed by the three-person field team after the first hour of searching within a given clam tissue collection area (including any adjacent areas identified as potentially containing clams), the field crew will stop searching in that area and proceed to the next area. In this case, the maximum level of effort will be 1 hour (i.e., 3 person-hours). In such cases, the logbook will include a description of the search in the area and the absence of clam shows, and it will include a description of substrate and other site characteristics that may be relevant to clam habitat.

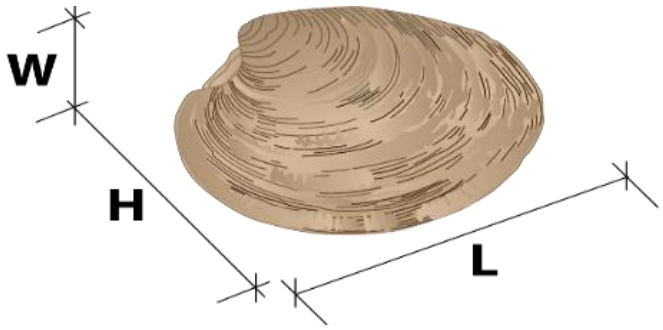
4.2.2.3 Clam Collection

Clams will be hand collected using shovels in the same manner as described in the baseline QAPP for clams (Windward 2018) and the benthic invertebrate QAPP for the RI (Windward 2004b). Clams will be collected at low tide (e.g., ideally targeting days with low tides of -1.5 ft MLLW or lower) following the method used in baseline QAPP. This method involves field crew members actively

[12] Although not anticipated, if the field team identifies an additional intertidal area just outside the clam tissue collection area that appears to potentially contain clams, and if additional clams are needed, the field team may determine that a greater maximum level of effort is required in that area (i.e., based on the new size of the clam collection area).

searching for and collecting clams from areas within the intertidal clam tissue collection areas where clams are present, as determined by evidence of shows. Unbroken (i.e., intact) clams ≥ 2 cm in width (as measured from valve to valve; Figure 4-1) will be retained. If insufficient clams are available from a given area, smaller clams (e.g., ≥ 1.5 cm in width) will be collected and considered for analysis.

Figure 4-1
Clam Dimension Measurements



At each location where a show is observed, field team members will:

- Carefully remove sediment around the clam using a shovel or small hand tool (e.g., trowel) and retain the clam.
- Place a pre-labeled survey flag (e.g., numbered 1 through 20) to serve as a temporary identifier of the clam's location and record the coordinates.
- Rinse excess sediment off the clam (using site water), wrap the clam in foil, and place the clam in a resealable plastic bag.
- Label the bag containing the clam with the number on the survey flag (i.e., temporary identifier) to track the clam collection location.
- Place the bagged and labeled clam in a cooler on ice and hold, in the dark, at ≤ 4 ± 2°C to await further processing once collection efforts in the clam collection area have been finished.

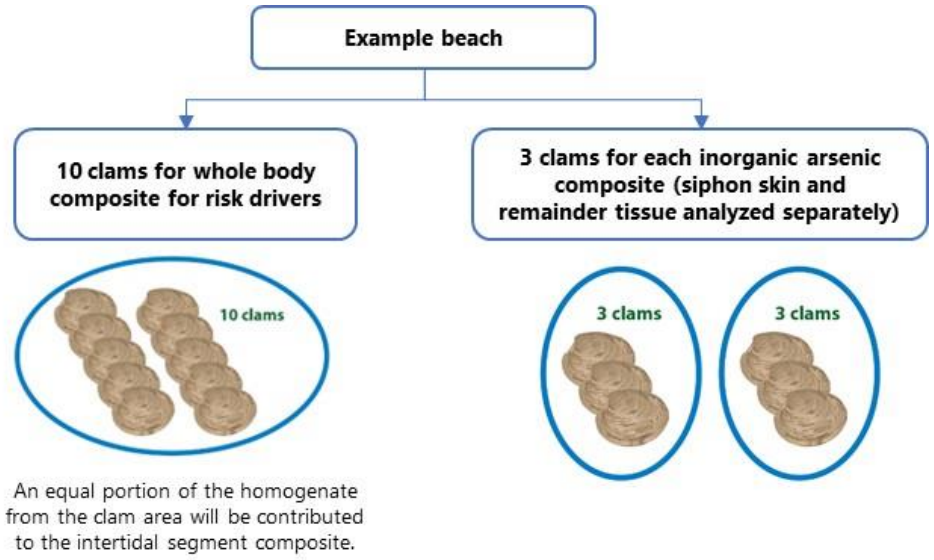
Because of the need for clams from a given area to be distributed into composite samples, the field team will document where all clams from a given clam tissue collection area were collected prior to leaving that area. The collection location for each clam will be recorded using a digital GPS with 1- to 2-m accuracy. Table 4-9 presents a summary of the numbers of clams needed in each clam tissue collection area, along with the numbers of clams collected during the 2018 baseline sampling effort. For the 2023 periodic monitoring, a total of 16 clams will be targeted for collection for each area, along with five extra clams if available (i.e., a total of 21 clams). Figure 4-2 presents an example compositing scheme for a single clam tissue collection area.

Table 4-9
Target Number of Clams per Tissue Collection Area

Clam Tissue Collection Area	Intertidal Segment-wide Composite	No. of Clams Needed by Composite		Target No. of Clams Needed[3]	Baseline Clam Tissue Collection (May 2018)	
		Clams for Primary Composite[1]	Clams for Two Inorganic Arsenic Composites[2]		Target	Actual
1	1	10	6	16	19	24[4]
2		10	6	16	19	24[4]
3		10	6	16	19	24[4]
4	2	10	6	16	19	24[4]
5		10	6	16	19	24[4]
6		10	6	16	16	21[4]
7	3	10	6	16	13	4
8		10	6	16	16	21[4]
9		10	6	16	25	7
10		10	6	16	16	19[4]
11		10	6	16	19	24[4]

Notes:
1. Target analytical mass for the area-specific composite includes sufficient mass for contribution to the intertidal segment composites to be analyzed for non-risk driver chemicals (including QC analyses).
2. The target number of clams for inorganic arsenic is based on two composites, each consisting of three clams.
3. In addition to the target numbers of clams specified, five additional clams may be retained to provide additional options for compositing.
4. The actual number of clams is equal to the target number plus up to five additional clams.
QC: quality control

Figure 4-2
Compositing Scheme for Clams Collected from an Example Clam Tissue Collection Area



4.2.2.4 Field processing of clams

Once the target numbers of clams in Table 4-9 have been collected from a given area, or the maximum level of effort has been reached at a given clam tissue collection area (defined by the size of the area, as shown in Table 4-8), the field crew will begin processing clams. All clams will be processed individually (i.e., assigned a sample ID, measured, and bagged with a label that contains this information). Location details (i.e., GPS coordinates) will be recorded for each clam to provide general information regarding the extent of the clam collection within a given area, and to assist in compositing decisions.

At the conclusion of the sampling event, all individual clams will be held frozen to avoid deterioration of the clam tissue prior to processing and analysis (see Section 4.2.4 for details). Decisions regarding the compositing of clams will be determined as part of a compositing memorandum, which will be prepared for EPA review. This memorandum will also discuss prioritizing analytes if sufficient clams are not collected.

4.2.2.5 Compositing Scheme

At the conclusion of the sampling event, all individual clams will be archived frozen, and a compositing memorandum will be prepared for EPA review. The compositing memorandum will identify the individuals selected for inclusion in each composite. In order to create representative composites, the individuals within the composites will be balanced in terms of the clam size and collection location within the area.

4.2.3 Clam Tissue Sample Handling Procedures

At each laboratory, a unique sample identifier will be assigned to each sample. The laboratory will ensure that a sample tracking record follows each sample through all stages of laboratory processing. The sample tracking record must contain, at a minimum, the names/initials of responsible individuals performing the analyses, dates of sample extraction/preparation and analysis, and types of analyses being performed.

4.2.4 Laboratory Methods

Laboratories will meet the sample handling requirements and follow the procedures described in this section. In addition, analytical methods and data quality indicator (DQI) criteria are provided in Appendix C.

4.2.4.1 Laboratory sample handling

Clam samples will be stored at ARL and held frozen until all clams have been collected. At the conclusion of the clam collection effort, the following will occur:

- All individual clams will remain frozen until finalization of the compositing memorandum, at which point clams will be organized into composite groups by Windward or its designee. The clams to be included in each composite sample will be determined based on the compositing scheme described in Section 4.2.2.3, as well as any required modifications determined in consultation with EPA.
- For clams identified for inclusion in the inorganic arsenic composite, dissection of siphon tissue will be performed by Windward staff.

During the compositing and homogenization process, tissue specimens from each clam tissue collection area will be kept separate from one another and processed one at a time to ensure that individual specimens are tracked properly.

4.2.4.2 Compositing of clam tissues

Clam samples will be at least partially thawed before processing. Clams will be rinsed with deionized water and opened. The main body of each clam will be removed from the shell, rinsed, weighed, and placed into a pre-labeled composite jar. The siphon skin of each clam to be analyzed for inorganic arsenic will be carefully dissected from the main body of clam tissue, rinsed, weighed, and placed into a pre-labeled composite jar.

A clam tissue composite will be created for each clam tissue collection area. The composite will include the whole bodies of all 10 clams collected within the clam tissue collection area (or all 3 clams for the arsenic composites). The tissue will be homogenized following the clam tissue homogenization SOP in Appendix D.

The creation of the intertidal segment composites will involve combining equal aliquots (by weight) of the homogenized whole-body clam sample from each clam tissue collection area within a given segment (see Section 4.2.1). Each segment composite will require 90 g for analysis. The mass requirements for each analysis are provided in Appendix C. An equal aliquot will be taken from each area within a segment in order to obtain a 90-g composite sample. For example, if there are three areas within a segment, then 30 g will be taken from each area sample to achieve a final mass of 90 g. Equipment will be cleaned between composites to avoid contaminating tissue samples during processing.

4.2.4.3 Clam homogenization

Clam composite samples will be homogenized using a blender or chopper following the ARL SOP. Homogenized samples will be blended into a creamy paste with no discernable bits remaining. ARL will ship frozen subsamples of clam tissue homogenates to Cape Fear, Brooks Applied, and ALS for analyses, as presented in Section 4.2.5.

4.2.5 Analytical Methods

Clam tissue composite samples will be analyzed for the human health risk drivers (inorganic arsenic, cPAHs, PCBs as congeners, and dioxins/furans) (Table 4-10). Lipids and percent solids will also be analyzed in each composite sample. In addition, three intertidal segment-wide composite samples will be analyzed for the non-risk driver chemicals listed in ROD Table 14. These chemicals include vanadium, TBT, select SVOCs (bis(2-ethylhexyl) phthalate [BEHP], carbazole, hexachlorobenzene [HCB], and pentachlorophenol [PCP]), and organochlorine pesticides. The methods for all analytes are the same as those used for fish and crab tissues and are listed in Table 4-6.

Table 4-10
Numbers of Composite Samples to be Analyzed in Each Analyte Group

Analyte	Target Number of Clam Tissue Composites[1]		
	Clams (Whole Body)	Clams (Siphon Skin)	Clams (Remainder)
Human health risk driver chemicals			
PCB Congeners	11	-	-
Dioxins/furans	11	-	-
cPAHs	11	-	-
Inorganic arsenic	-	22	22
Non-risk driver chemicals			
Vanadium	3	-	-
TBT	3	-	-
Selected SVOCs	3	-	-
Organochlorine pesticides	3	-	-

Analyte	Target Number of Clam Tissue Composites[1]		
	Clams (Whole Body)	Clams (Siphon Skin)	Clams (Remainder)
Conventionals			
Lipid	11	-	-
Percent solids	11	3	3

Notes:
1. The actual number of clam composites to be analyzed will depend on the actual number of clams collected during the sampling effort.
cPAH: carcinogenic polycyclic aromatic hydrocarbon
PCB: polychlorinated biphenyl
SVOC: semivolatile organic compound
TBT: tributyltin

Chemical analyses of clam tissue will be conducted at four different laboratories (ARL, Brooks Applied, Cape Fear, and ALS) (Table 4-4). Analytical methods and sample handling requirements for all measurement parameters are presented in Table 4-6.

4.3 Surface Water Passive Sampling

4.3.1 Surface Water Sampling Design

This section presents the passive sampler sampling design for PCBs to evaluate DQO 3. The passive sampler sampling design is summarized in Table 4-11. The design has a change in the number of replicates to be analyzed, which has been reduced from nine replicates in baseline sampling to five replicates in periodic monitoring. The change in the number of replicates is based on the relative variance estimate of 10% observed in the baseline sampling, as discussed in Appendix B of the pre-design studies data evaluation report (Windward 2020). Analyzing five passive samplers allows for sufficient replicates to confirm the normality of the data while still achieving a low minimum detectable difference (approximately 12%) for comparison to the baseline results. .

Table 4-11
Summary of Passive Sampler Conceptual Design and Rationale

Design Component	Approach	Rationale
Passive sampler material	PE	Consistent with baseline sampling
Deployment duration	1 month	Consistent with baseline sampling
Location	2 locations: RM 1.9 (Lineage Logistics) and RM 3.3 (South Park Bridge)	Consistent with baseline sampling
Season	Dry baseflow – summer (August)	Consistent with baseline sampling
Depth	1 m above sediment[1]	Consistent with baseline sampling
Number of replicates	9 replicates deployed and 5 replicates analyzed	In baseline, 15 were deployed and 9 were analyzed; the numbers have been reduced because of low variability in baseline results

Notes:
1. The water in the near-bottom layer has longer residence time during low flows, because there is less entrainment into the outflowing surface layer, thereby reducing the net inflow from Elliott Bay.
PE: polyethylene
RM: river mile

4.3.2 Surface Water Sampling Methods

Passive samplers consist of a stainless steel mesh envelope containing a low-density polyethylene (PE) strip attached to a polyvinyl chloride (PVC) frame. The PE strips are 25 µm thick and cut into 5 × 6 in. The stainless steel mesh envelope is customized to fit the PE strip (Figure 4-3), protecting it from loss and damage (passive sampler SOP in Appendix D).

Figure 4-3
Polyethylene Sampler and Holder for Surface Water Deployment

Axys will prepare the passive samplers by cleaning a known mass of PE sheeting using sequential extractions with solvent (e.g., dichloromethane [DCM], methanol). The mesh envelopes will be cleaned with DCM, methanol, and reagent water. Axys will cut the clean PE into 5- × 6-in. strips.

Clean PE strips will be loaded with performance reference compound (PRC) standards by equilibrating the strips with methanol:water PRC solutions in a glass container for at least seven days. Prior to deployment, the PE strips will be submerged in ultra-clean water for three days to remove the methanol. The PE strips will then be placed in stainless steel mesh envelopes to create the passive samplers. Each sampler will be wrapped in aluminum foil and placed in a resealable plastic bag at < 4°C for shipment to Windward for deployment in the LDW. A day-zero PE strip will be stored, wrapped in foil and frozen, at Axys; it will be analyzed with the sampler replicates.

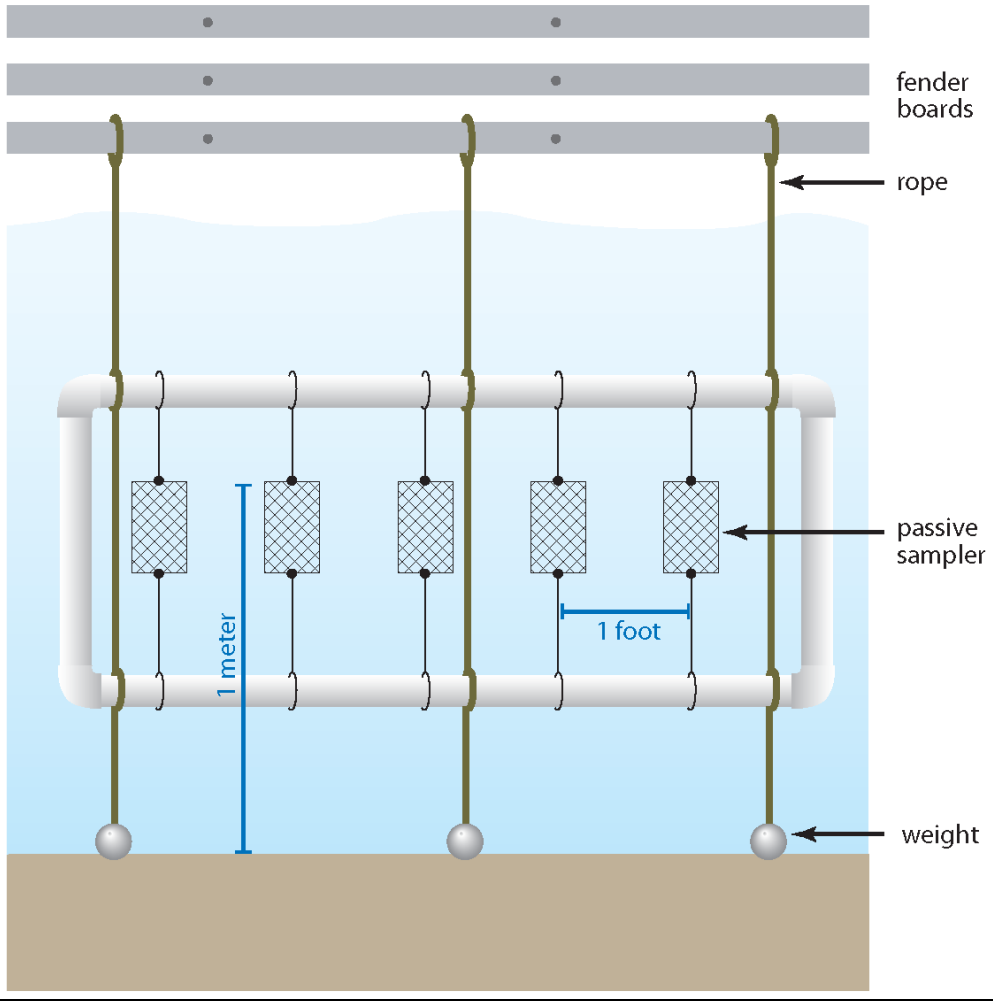
PRCs are used to allow non-equilibrium conditions between the PE and the water column to be quantified. Using PRCs, passive samplers can be deployed for time periods shorter than the time required for full equilibrium; this shorter deployment time has been found to decrease the risk of loss, damage, and biological fouling. The carbon-13-labelled PCBs to be used for PRCs will include ^{13}C-PCB28, ^{13}C-PCB47, ^{13}C-PCB70, ^{13}C-PCB80, ^{13}C-PCB111, ^{13}C-PCB141, and ^{13}C-PCB182. The PRC loading details will be recorded on a worksheet by the analyst. The worksheet will document the date, the list of PRCs used, and the concentrations in the soaking solution.

4.3.2.1 Field Deployment and Retrieval of Passive Samplers

Within 7 to 10 days of receipt, Windward will deploy the passive samplers. They will be transported to the field on ice in a cooler. Individual passive samplers will be unwrapped and attached to the passive sampling frame for deployment.

Passive samplers will be deployed at both locations, in groups of four to five (approximately 1 ft apart) attached to one sampling frame (Figure 4-4). At each location, two sampling frames will be deployed for a total of nine passive samplers. The deployment frames will be constructed from PVC pipe and used as the primary structure to suspend the passive samplers in the near-bottom layer of the water column. Three anchor weights will be attached across the bottom each frame to secure the samplers and minimize the agitation of nearby sediment. The loaded frames will then be deployed from a boat by lowering them to the sediment surface; they will be secured to the structures when the anchor weights reach the bottom.

Figure 4-4
Conceptual Design of Passive Sampler Deployment Frame



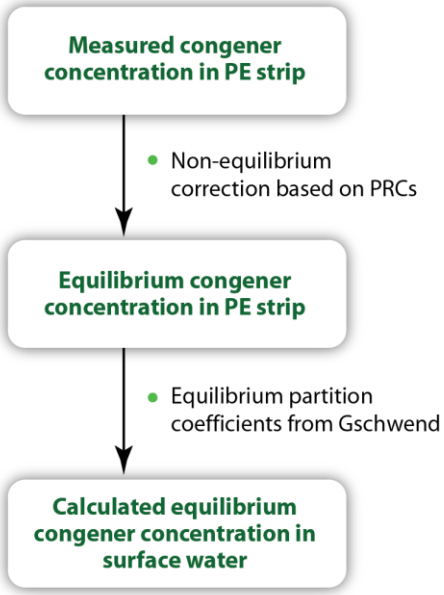
Multi-parameter data loggers will be deployed with the frames at the same depth as the passive samplers at each location. The data logger will collect *in situ* water quality data (e.g., conductivity, temperature, dissolved oxygen, and pH) for the duration of the sampling period.

After approximately 30 days, the passive sampler frames will be retrieved from the site. Each passive sampler will be detached from the frame but will be kept within its mesh envelope. The passive samplers will then be wrapped in aluminum foil, double-bagged in resealable plastic bags, and labelled with appropriate sample ID. Passive samplers will be placed on ice in a cooler for shipment to Axys. The multi-parameter data loggers will also be detached from the frame, and water quality data will be downloaded off-site.

4.3.2.2 Calculation of Freely Dissolved PCB Congener Concentrations

Following PCB congener analysis of the PE strips by Axys (see Section 4.3.4), PCB congener concentrations in the PE strips will be used to calculate the concentrations of freely dissolved PCB congeners present in the water column during the *in situ* exposure period, as summarized in Figure 4-5. The details of the calculation methods are provided in Appendix C of the baseline surface water QAPP (Windward 2017b).

Figure 4-5
Calculation Method for Freely Dissolved PCB Congeners in Water Column from Passive Sampler



4.3.3 Surface Water Sample Handling Procedures

Upon collection of the passive samplers, each PE strip replicate will remain in its stainless steel mesh envelope, which will be wrapped in aluminum foil and placed in a resealable, waterproof plastic bag with appropriate labels. Samples will be placed on ice after collection and for transport to Axys.

A field blank will be prepared at the same time and following the same methods as the passive samplers deployed in the LDW. It will be taken to the field and exposed to the atmosphere for the duration of both the deployment and the retrieval of the passive sampler replicates.

4.3.4 Surface Water Laboratory and Analytical Methods

The PE strips will be extracted and analyzed for PCB congeners following EPA method 1668c (Table 4-12). The sample handling and extraction protocols are provided in Appendix D. Prior to extraction, the PE strips will be cleaned with laboratory water or wipes to remove biofilm and weighed.

Table 4-12
Analytical Methods and Sample Handling Requirements for the Passive Samplers

Parameter	Method	Reference	Extraction Solvent	Cleanup	Labor-atory	Container	Preserv-ative	Sample Holding Time
PCB congeners	HRGC/ HRMS	EPA 1668c	DCM	Biobead multi-layered acid/base silica, alumina, florisil	Axys	PE strip/ aluminum foil	Cool to ≤ -4°C	na

Notes:
Axys: SGS-Axys Analytical Services Ltd.
DCM: dichloromethane
EPA: US Environmental Protection Agency
HRGC/HRMS: high-resolution gas chromatography/high-resolution mass spectrometry
na: not applicable
PCB: polychlorinated biphenyl
PE: polyethylene

The lowest possible detection limits (DLs) for PCB congeners in surface water based on the results from the PE passive samplers will be calculated based on the laboratory analytical DLs for the PE strips, the partition coefficients between surface water and PE (from Gschwend et al. 2014), and equilibrium assumptions. Preliminary DLs calculated for each congener (assuming 100% equilibrium) are provided in Appendix C. The more chlorinated PCB congeners will likely not achieve equilibrium; the actual DLs will be greater than those calculated for any PCB congener that does not reach equilibrium within the deployment period.

Project- and/or method-specific QC measures, such as surrogate spikes , will be analyzed per SDG preparatory batch, or per analytical batch as specified in Appendix C. A SDG is defined as no more than 20 samples or a group of samples received at the laboratory within a 2-week period. Although a SDG may span two weeks, all holding times specific to each analytical method will be met for each sample in the SDG.

4.4 Sample Custody Procedures

Samples will be considered to be in custody if they are: 1) in the custodian's possession or view, 2) in a secured place (under lock) with restricted access, or 3) in a container and secured with an official seal(s) such that the samples cannot be reached without breaking the seal(s). Custody procedures, described below, will be used for all samples throughout the collection, transportation, and analytical processes, and for all data and data documentation, whether in hard copy or electronic format. Custody procedures will be initiated during sample collection.

A chain of custody form will accompany all samples to the analytical laboratory. Each person who has custody of the samples will sign the chain of custody form and ensure that the samples are not left unattended unless properly secured. Minimum documentation of sample handling and custody will include:

- Sample location, project name, and unique sample ID
- Sample collection date and time
- Any special notations on sample characteristics or problems
- Name of the person who initially collected the sample
- Date sample was sent to the laboratory
- Shipping company name and waybill number

The FC or designee will be responsible for all sample tracking and custody procedures and final sample inventory and will maintain sample custody documentation. The FC or a designee will complete chain of custody forms prior to removing samples from the sample collection area. At the end of each day, and prior to sample transfer, chain of custody entries will be made for all samples. Information on the sample labels will be checked against sample log entries, and sample tracking forms and samples will be recounted. Chain of custody forms, which will accompany all samples, will be signed at each point of transfer. Copies of all chain of custody forms will be retained and included as appendices to QA/QC reports and data reports. Samples will be shipped in sealed coolers.

The laboratories will ensure that chain of custody forms are properly signed upon receipt of the samples, and they will note questions or observations concerning sample integrity on the chain of custody forms. The laboratories will contact the FC and project QA/QC coordinator immediately if discrepancies are discovered between the chain of custody forms and the sample shipment upon receipt.

4.5 Shipping Requirements

All samples will be transported by cooler. The original signed chain of custody forms for all samples will be placed in a sealed plastic bag and taped to the inside lid of the cooler. Fiber tape will be wrapped completely around the cooler. On each side of the cooler, a "This Side Up" arrow label will be attached; a "Handle with Care" label will be attached to the top of the cooler, and the cooler will be sealed with a custody seal in two locations.

The temperature inside the cooler containing the samples will be checked by the laboratory upon receipt of the samples. The laboratory will specifically note any cooler that does not contain ice packs, or that is not sufficiently cold (≤ 4 ± 2°C)[13] upon receipt. All samples will be handled so as to prevent contamination or sample loss.

Clams, fish, and crabs will be transported directly to ARL (i.e., by field staff or a courier)., where they will be stored frozen until compositing. Sample processing will occur as described in Section 4.1.4 for clams and Section 4.2.4 for fish and crabs.

Clams will be composited at ARL. Once clam tissue composite samples have been homogenized and frozen, subsamples will be shipped to ALS, Brooks Applied, and Cape Fear.

Fish and crabs will be stored, frozen, at ARL, and will remain frozen while they are organized into composite groups. Any remaining fish and crab that were not included in the composites will be held frozen at ARL and will be disposed of upon receipt of written notification by the Windward PM.

Fish and crab to be included in composite samples will be shipped, frozen, in coolers from ARL to Alpha and stored frozen until compositing. After composite samples are created, Alpha will ship subsamples to the other analytical laboratories. Shipment of subsamples will follow the same procedure as noted above.

Passive sampler replicates will be wrapped in foil, placed in resealable plastic bags, and securely packed inside a cooler with ice packs for shipment to Axys. The original signed chain of custody forms will be placed in a sealed plastic bag and taped to the inside lid of the cooler.

[13] As stated in validation guidance documents, sample shipping coolers should arrive at the laboratory with an internal temperature within the advisory range of 4 ± 2°C; however, due to the short transit distance and time from the site to ARL, the samples may not have reached this temperature by the time they arrive at the laboratory.

5 Assessment and Oversight

5.1 Compliance Assessments and Response Actions

EPA or its designees may observe field activities during each sampling event, as needed. If situations arise wherein there is a significant inability to follow the QAPP methods precisely, the Windward PM will determine the appropriate actions, or consult EPA if the issue is significant

5.1.1 Compliance Assessments

Laboratory and field performance assessments will consist of on-site reviews conducted by EPA of QA systems and equipment for sampling, calibration, and measurement. EPA personnel may conduct a laboratory audit prior to sample analysis. Any pertinent laboratory audit reports will be made available to the Project QA/QC coordinator upon request. Analytical laboratories will be required to have written procedures addressing internal QA/QC. All laboratories and QA/QC coordinators will be required to ensure that all personnel engaged in sampling and analysis tasks have appropriate training.

5.1.2 Response Actions for Field Sampling

The FC, or a designee, will be responsible for correcting equipment malfunctions throughout field sampling, and for resolving situations in the field that may result in nonconformance or noncompliance with this QAPP. All corrective measures will be immediately documented in the field logbook, and protocol modification forms will be completed.

5.1.3 Corrective Action for Laboratory Analyses

Analytical laboratories will be required to comply with their current written SOPs, laboratory QA plan, and analytical methods. All laboratory personnel will be responsible for reporting problems that may compromise the quality of the data. The analysts will identify and correct any anomalies before continuing with sample analysis. The laboratory PMs will be responsible for ensuring that appropriate corrective actions are initiated as required for conformance with this QAPP.

The project QA/QC coordinator will be notified immediately if any QC sample exceeds the DQIs provided in Appendix C and the exceedance cannot be resolved through standard corrective action procedures.

A description of the anomaly, the steps taken to identify and correct the anomaly, and the treatment of the relevant sample batch (i.e., recalculation, reanalysis, and re-extraction) will be submitted with the data package using the case narrative or corrective action form.

5.2 Reports to Management

Summaries of progress and any issues will be prepared and submitted to LDWG and EPA following each sampling week. LDWG and EPA will also be notified: 1) after sampling has been completed and samples have been submitted for analysis, 2) when information is received from the laboratory, and 3) when analyses are complete.

A data report that includes data evaluation will be submitted to EPA 60 days after receipt of all validated periodic monitoring data. Data will be submitted to EPA electronically 10 days after validated data for each medium (clams, fish/crab, passive samplers) are received. The calculated freely dissolved PCB concentrations will be provided within 30 days of the receipt of the validated passive sampler data. The data report will include field logs, photographs, chain of custody forms, laboratory reports and electronic data deliverables, and data validation reports. The validated data will be submitted to the Washington State Department of Ecology's Environmental Information Management system and EPA's Scribe 30 days after the data report is approved.

6 Data Validation and Usability

The data validation process will begin in the laboratory with the review and evaluation of data by supervisory personnel or QA specialists. The laboratory analyst will be responsible for ensuring that the analytical data are correct and complete, that appropriate procedures have been followed, and that QC results are within acceptable limits. The project QA/QC coordinator will be responsible for ensuring that all analyses performed by the laboratories are correct, properly documented, and complete, and that they satisfy the project DQOs specified in this QAPP.

Data will not be considered final until validated. Data validation will be conducted by Ecochem, Inc. following EPA guidance (EPA 2014a, 2020a, b, c). All chemistry data will undergo Stage 2B data validation, and a minimum of 10% or one SDG will undergo Stage 4 data validation. All discrepancies and requests for additional, corrected data will be discussed with the laboratories prior to issuance of the formal data validation report. The project QA/QC coordinator should be informed of all contact with the laboratories during data validation. Review procedures used and findings made during data validation will be documented on worksheets. The data validator will prepare a data validation report that will summarize QC results, qualifiers, and possible data limitations. This data validation report will be appended to the data report. Only validated data with appropriate qualifiers will be released for general use.

Data QA will be conducted by the project QA/QC coordinator in accordance with EPA guidelines (EPA 2020a, b, c). The results of the third-party independent review and validation will be reviewed, and cases wherein the project DQOs were not met will be identified. The usability of the data will be determined in terms of the magnitude of the DQO exceedance.

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FINAL

Appendix A
Health and Safety Plan

FINAL

Appendix B
Field Forms

FINAL

Appendix C
Analytical Data Quality Indicators

FINAL

Appendix D
Standard Operating Procedures

FINAL

Appendix E
Archaeological Monitoring and Inadvertent Discovery Plan